

Criticality Benchmark Guide for Light-Water-Reactor Fuel in Transportation and Storage Packages

Prepared by
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ABSTRACT

This report is designed as a guide for performing criticality benchmark calculations for light-water-reactor (LWR) fuel applications. The guide provides documentation of 180 criticality experiments with geometries, materials, and neutron interaction characteristics representative of transportation packages containing LWR fuel or uranium oxide pellets or powder. These experiments should benefit the U.S. Nuclear Regulatory Commission (NRC) staff and licensees in validation of computational methods used in LWR fuel storage and transportation concerns. The experiments are classified by key parameters such as enrichment, water/fuel volume, hydrogen-to-fissile ratio (H/X), and lattice pitch. Groups of experiments with common features such as separator plates, shielding walls, and soluble boron are also identified. In addition, a sample validation using these experiments and a statistical analysis of the results are provided. Recommendations for selecting suitable experiments and determination of calculational bias and uncertainty are presented as part of this benchmark guide.

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1 Introduction

This report is designed as a guide for performing criticality benchmark calculations for light-water-reactor (LWR) fuel applications. The guide provides documentation of 180 criticality experiments with geometries, materials, and neutron interaction characteristics representative of transportation packages containing LWR fuel or uranium oxide pellets or powder. These experiments should benefit the U.S. Nuclear Regulatory Commission (NRC) staff and licensees in validation of computational methods used in LWR fuel storage and transportation concerns. The experiments are classified by key parameters such as enrichment, water-to-fuel volume ratio, hydrogen-to-fissile ratio (H/X), and lattice pitch. Groups of experiments with common features such as separator plates, reflecting walls, and soluble boron are also identified. In addition, a sample validation using these experiments and a statistical analysis of the results are provided. Recommendations for selecting suitable experiments and determination of calculational bias and uncertainty are presented as part of this benchmark guide.

A literature survey was performed of low-enriched, LWR-type fuel critical experiment reports to select the experiments documented here. Table 1.1 presents a brief summary of the reports surveyed and the types and number of available experiments found. The table also indicates the number of experiments selected for inclusion in this report. This information may be useful to an analyst who wishes to perform a more extensive validation for a particular category of LWR fuel experiments.

Descriptions of the selected critical experiments are presented in Sect. 2 in sufficient detail for independent analysis by any computational tool that is appropriate for performing criticality safety analyses.

Section 3 documents benchmark calculations of these experiments performed with the SCALE code system¹ using the 44-group ENDF/B-V cross-section library.² Results include neutron multiplication factors (k_{eff}), presented individually and combined by experiment type. The SCALE input files used to generate the results of Sect. 3 are listed in Appendix A. Individual results based on the 238-group ENDF/B-V library³ are also presented for comparison in Appendix B.

Determinations of calculational biases and subcritical limits are discussed in Sect. 4. Statistical analyses of the SCALE calculational results are performed to parameterize trends. The purpose of these analyses is to determine the correlation of bias in calculated k_{eff} values to key parameters. The statistical results are then applied in the demonstration of two methods for establishing an upper subcritical limit (USL): (1) a 95% confidence band for a single future calculation with an administrative subcritical margin and (2) a lower tolerance band based on a 95% confidence band on 99.5% of all future calculations using the *uslstats* program documented in Appendix C.

Section 5 discusses the issue of areas of applicability in the validation of computational methods and presents guidance on how to select criticality experiments that are applicable to validate the computational method for the system of concern. Parameters that should be studied to demonstrate areas of applicability are discussed.

A summary of this benchmark guide is presented in Sect. 6.

Introduction

Table 1.1 Summary of available LWR critical experiments

Report	No. of available experiments	No. of selected experiments	Description of criticality experiments
ANS Transactions, Vol. 33, p.362 (Ref. 5)	25	9	4.74 wt % ^{235}U UO_2 fuel rods in square lattices of 1.35-cm pitch; fuel clusters separated by air, polystyrene, polyethylene, or water; fuel clusters submersed in aqueous NaNO_3 solution
BAW-1484 (Ref. 6)	37	10	2.46 wt % ^{235}U UO_2 fuel rods in square lattices of 1.636-cm pitch; the spacing between 3×3 array of LWR-type fuel assemblies is filled with water and B_4C pins, stainless steel sheets, or borated stainless steel sheets; lattices with borated moderator
EPRI-NP-196 (Ref. 7)	6	6	2.35 wt % ^{235}U UO_2 fuel rods in square lattices of 1.562-, 1.905-, and 2.210-cm pitch; lattices with borated moderator
NS&E, Vol. 71, p. 154 (Ref. 8)	26	6	4.74 wt % ^{235}U UO_2 fuel rods in square lattices of 1.26-, 1.60-, 2.10-, and 2.52-cm pitch; triangular and triangular with pseudo-cylindrical shape lattices of 1.35-, 1.72-, and 2.26-cm pitch; irregular hexagonal lattices of 1.35-cm pitch; lattices with water holes
PNL-2438 (Ref. 9)	48	6	2.35 wt % ^{235}U UO_2 fuel rods in square lattices of 2.032-cm pitch; Cd, Al, Cu, stainless steel, borated stainless steel, Boral, and Zircaloy separator plates between assemblies
PNL-2827 (Ref. 10)	23	9	2.35 and 4.31 wt % ^{235}U UO_2 fuel rods in square lattices of 2.032- and 2.540-cm pitch; reflecting walls of Pb or depleted uranium
PNL-3314 (Ref. 11)	142	27	2.35 and 4.31 wt % ^{235}U UO_2 fuel rods in square lattices of 1.684- and 1.892-cm pitch; stainless steel, borated stainless steel, Cd, Al, Cu, Boral, Boroflex, and Zircaloy separator plates between assemblies; lattices with water holes and voids
PNL-3926 (Ref. 12)	22	14	2.35 and 4.31 wt % ^{235}U UO_2 fuel rods in square lattices of 1.684- and 1.892-cm pitch; reflecting walls of Pb or depleted uranium
PNL-4267 (Ref. 13)	9	7	4.31 wt % ^{235}U UO_2 fuel rods in square lattices of 1.890- and 1.715-cm pitch; lattices with borated moderator
PNL-4976 (Ref. 14)	17	1	4.31 wt % (2.35 wt %) ^{235}U UO_2 fuel rods in hexagonal lattices of 2.398-, 1.801-, and 1.598-cm pitch; moderator contains Gadolinium
WCAP-3269 (Ref. 15)	157	9	2.7, 3.7, and 5.7 wt % ^{235}U UO_2 fuel rods in square lattices of 1.029-, 1.105-, and 1.422-cm pitch; lattices with Ag-In-Cd absorber rods, water holes, void tubes
WCAP-3385 (Ref. 16)	3	2	5.74 wt % ^{235}U UO_2 fuel rods in square lattices of 1.321-, 1.422-, and 2.012-cm pitch

Table 1.1 (continued)

Report	No. of available experiments	No. of selected experiments	Description of criticality experiments
BAW-1645 (Ref. 17)	21	8	2.46 wt % ^{235}U UO_2 fuel rods in close-packed triangular lattices of 1.209-cm pitch, close-packed square lattices of 1.209-cm pitch, and square lattices of 1.410-cm pitch
DSN 399/80 (Ref. 18)	4	4	4.74 wt % ^{235}U UO_2 fuel rods in square lattices of 1.6-cm pitch; hafnium separator plates between assemblies
PNL-2615 (Ref. 19)	32	7	4.31 wt % ^{235}U UO_2 fuel rods in square lattices of 2.540-cm pitch; stainless steel, borated stainless steel, Cd, Al, Cu, Boral, and Zircaloy separator plates between assemblies
PNL-6205 (Ref. 20)	19	1	4.31 wt % ^{235}U UO_2 fuel rods in square lattices of 1.891-cm pitch; Boral flux traps
PNL-7167 (Ref. 21)	9	4	4.31 wt % ^{235}U UO_2 fuel rods in square lattices of 1.891-cm pitch; Boral flux traps containing voids filled with Al plates, Al rods, or UO_2 fuel rods
PNL-3602 (Ref. 22)	49	26	2.35 and 4.31 wt % ^{235}U UO_2 fuel rods in square lattices of 2.032- and 2.540-cm pitch; reflecting walls of stainless steel; separator plates of stainless steel, borated stainless steel, Boral, Cu, Cd, and Boroflex between assemblies
Haon et al., PATRAM 80 (Ref. 23)	12	4	4.74 wt % $^{235}\text{UO}_2$ fuel rods in square lattices of 1.6-cm pitch; Boral separator plates; lead, steel, or water reflecting walls
BAW-1810 (Ref. 24)	23	10	2.46, 4.02, and 2.46 and 4.02 wt % ^{235}U UO_2 fuel rods in square lattices of 1.636-cm pitch; lattices with 1.94 wt % ^{235}U $\text{UO}_2\text{-Gd}_2\text{O}_3$ fuel rods, Ag-In-Cd and B_4C absorber rods, void rods
BAW-1231 (Ref. 25)	10	2	4.02 wt % ^{235}U UO_2 fuel rods in square lattices of 1.511-cm pitch; lattice with borated moderator
BAW-1273 (Ref. 26)	10	1	2.46 and 4.02 wt % ^{235}U UO_2 fuel rods in square lattices of 1.702, 1.511, and 1.450-cm pitch; lattice with borated moderator
Y-DR-14 (Ref. 27)	32	4	Paraffin reflected or unreflected rectangular parallelepipeds of paraffin and homogeneous $\text{U}(2)\text{F}_4$ or $\text{U}(3)\text{F}_4$
NUREG/CR-0674 (Ref. 28) NUREG/CR-1071 (Ref. 29) NUREG/CR-1653 (Ref. 30) NUREG/CR-2500 (Ref. 31)	20	3	Plastic reflected or concrete reflected fuel cans with 4.46 % enriched U_3O_8
Total	756	180	

2 Physical Description of Selected Low-Enriched Critical Experiments

This section provides descriptions of the materials and physical layouts of 180 low-enriched critical experiments⁵⁻²⁸ suitable for benchmarking LWR fuel analyses. The experiments were selected based on structural, material, poison, geometry, and spectral similarities to NRC-certified radioactive materials packages.⁴ The 180 experiments can be categorized as 173 LWR-type fuel pin lattice experiments and 7 homogeneous uranium experiments. Brief descriptions of the 180 experiments are presented in Table 2.1. More detailed descriptions and modeling assumptions are found in Sects. 2.1 and 2.2. All experimental data reported are nominal values. The reader may refer to the references for these experiments to obtain data regarding experimental uncertainties. Items that are noted as “not modeled” or “ignored” were generally located near the top or bottom of the experiment where neutron leakage was high. The volume occupied by these items in the experiment were modeled as the surrounding medium, either water or void. General modeling and calculational techniques used in the SCALE-4.3 calculations are discussed in Sect. 3.

2.1 LWR-Type Fuel Pin Lattice Experiments

The following sections present descriptions of experiments utilizing UO₂ LWR-type fuel in square and hexagonal lattices moderated by light water. The experiments are categorized as simple lattices (2.1.1), separator plates (2.1.2), reflecting walls (2.1.3), reflecting walls and separator plates (2.1.4), burnable absorber fuel rods (2.1.5), water holes (2.1.6), poison rods (2.1.7), and borated moderator (2.1.8).

2.1.1 Simple Lattice Experiments

This set of experiments consists of large single lattices (cores) and arrays of assemblies void of poisons, significant reflecting materials, water holes, etc. The experiments represent simple transportation packages with primary criticality control by means of controlling assembly interaction. Modeling of the experiments demonstrates the ability of the calculational techniques to predict the neutron multiplication factor of essentially infinite arrays of rods (cores) or neutronically interacting separated assemblies. The experiments provide baselines for comparisons to more complex problems.

2.1.1.1 Simple Lattice Experiments from ANS Transactions, Vol. 33 (Ref. 5)

ANS33SLG consists of a 2×2 array of fuel assemblies separated by 5.0 cm of water. The 4.742 wt % UO₂ fuel rod specifications are given in Table 2.2 and Fig. 2.1. The planar and end views of the experiment are shown in Fig. 2.2; the 0.3-cm-thick aluminum wall box was replaced by water in this experiment. Critical data for the experiment are located in Table 2.3.

Assumptions: The holes in the lower lattice grid plate for accommodating the fuel rods were taken to be 1.0 cm in diameter from Ref. 23. The aluminum box density, 2.651 g/cm³, was assumed from Ref. 23.

Model-experiment comparison: The spring of the fuel rods was modeled as void. The end plugs were modeled as 0.94-cm-diam aluminum cylinders. The fuel rods above the moderator were modeled by the method explained in Sect. 3.2.1.

2.1.1.2 Simple Lattice Experiments from BAW-1484 (Ref. 6)

BW1484SL consists of a 3×3 array of fuel assemblies separated by 6.544 cm of water. Details of the 2.459 wt % UO₂ fuel rod design are outlined in Table 2.4 and Fig. 2.3. The vertical dimensions for the experiment are found in Fig. 2.4. Absent from Fig. 2.4: the 1 in. (2.54 cm) between the base plate and core tank is mostly water and the core tank is 0.5 in. (1.27 cm) thick. Difficult to distinguish in Fig. 2.4 is that the fuel rod end plugs are located in

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0.125 in. (0.3175 cm) of water between the bottom grid plate and the base plate. The critical data for this experiment are located in Table 2.5.

Assumptions: The aluminum corner rods are believed to be of fuel rod length. The separation distance between assemblies is believed to have been measured from the cell boundaries of the assemblies. To accommodate fuel rods, square holes with 0.615-cm sides were assumed in the bottom grid plate.

Model-experiment comparison: The 22.9-cm × 22.9-cm × 2.54-cm aluminum top grid plate was not modeled. The fuel rods and separator plate above the moderator region were not modeled.

2.1.1.3 Simple Lattice Experiments from EPRI NP-196 (Ref. 7)

These experiments consist of large singular arrays of fuel rods. Specifications for the 2.35 wt % UO₂ fuel rods are presented in Fig. 2.5. Figure 2.6 is the axial arrangement of experiments **EPRU65** and **EPRU87**. Figure 2.7 is the axial arrangement of experiment **EPRU75**. The grid plate holes for EPRU75 are 0.586 in. (1.488 cm) in diameter. The specifications for the aluminum "eggcrate" grids seen in Fig. 2.6 are given in Fig. 2.8. The core layouts are shown in Figs. 2.9–2.11. The critical data are located in Table 2.6.

Model-experiment comparison: The soluble boron in the moderator was not modeled because of the low concentration. A 182.88-cm-diam, 274.32-cm-tall tank constitutes full-water reflection of the cores. The experiments were modeled with 6 in. (15.24 cm) of water above the lead shield and 30 cm of water below the aluminum solid plate.

2.1.1.4 Simple Lattice Experiments from NS&E, Vol. 71 (Ref. 8)

These experiments consist of large singular arrays of fuel rods in square or hexagonal lattices. Specifications for the 4.742 wt % UO₂ fuel rods are given in Table 2.2 and Fig. 2.1. The principal dimensions of the experiments are also given in Fig. 2.1. The layouts of the three hexagonal lattice cores are presented in Fig. 2.12. The critical data for the experiments are located in Table 2.7.

Assumptions: The holes in the lower grid plate to accommodate the fuel rods were taken to be 1.0 cm in diameter from Ref. 23.

Model-experiment comparison: The reported upper grid, missing from Fig 2.1, was ignored in the model due to insufficient data. The two grid plates were reportedly attached to the support plate by four fuel rods distanced more than 20 cm from the fuel. These rods were not modeled. The fuel rods above the moderator were modeled by the method explained in Sect. 3.2.1. The stainless steel support plate was modeled as 71.40 wt % Fe, 19.16 wt % Cr, and 9.44 wt % Ni. For **NSE71H1**, **NSE71H2**, and **NSE71H3**, 0.25 cm of the bottom end plug was homogenized with the surrounding lower grid plate and water. The remaining 1.55 cm of the bottom end plug was homogenized with the surrounding water.

2.1.1.5 Simple Lattice Experiments from PNL-2438 (Ref. 9)

P2438SLG consists of a 3 × 1 array of fuel assemblies separated by 8.39 cm of water. Details of the 2.35 wt % UO₂ fuel rods are outlined in Fig. 2.5. Planar and axial views of the experiment can be found in Fig. 2.13; the experiment was minus the poison plates and biological shielding walls shown in Fig 2.13. Critical data for the experiments are located in Table 2.8.

Model-experiment comparison: The 1.27-cm-thick acrylic grid plates were modeled as water because acrylic plastic has about the same density and neutron moderating characteristics as water. The carbon steel core tank was not modeled because the amount of water on the boundary of the array ensures a maximum increase in k_{eff} .

2.1.1.6 Simple Lattice Experiments from PNL-2827 (Ref. 10)

P2827SLG consists of a 3×1 array of fuel assemblies separated by 8.31 cm of water. Details of the 2.35 wt % UO_2 fuel rods are outlined in Fig. 2.5. Planar and axial views of the experiment can be found in Fig. 2.13; the experiment was minus the poison plates and biological shielding walls shown in Fig. 2.13. Critical data for the experiments are located in Table 2.9.

Model-experiment comparison: The 1.27-cm-thick acrylic grid plates were modeled as water because acrylic plastic has about the same density and neutron moderating characteristics as water. The carbon steel core tank was not modeled because the amount of water on the boundary of the array ensures a maximum increase in k_{eff} .

2.1.1.7 Simple Lattice Experiments from PNL-3314 (Ref. 11)

P3314SLG consists of a 2×2 array of fuel assemblies separated by 2.83 cm and 10.86 cm of water. Descriptions of the 4.31 wt % UO_2 fuel rods are provided in Fig. 2.14. Planar and axial views of the experiment are shown in Fig. 2.15. Figure 2.16a (c) illustrates the 2×2 assembly configuration. Critical data on the experiment are given in Table 2.10.

Model-experiment comparison: The minimum fuel rod pellet column length, 91.44 cm, was modeled. The two polypropylene (neutronic properties similar to water) grid plates were modeled as water. The carbon steel tank was not modeled because the amount of water on the boundary of the array ensures a maximum increase in k_{eff} .

2.1.1.8 Simple Lattice Experiments from PNL-3926 (Ref. 12)

The experiments consist of 3×1 arrays of fuel assemblies separated by 6.59 and 12.79 cm of water. Details of the 2.35 and 4.31 wt % UO_2 fuel rods are outlined in Figs. 2.5 and 2.14. Planar and axial views of the experiment can be found in Fig. 2.15. Absent in the experiments are the poison plates and biological shielding walls of Fig. 2.15. Critical data for the experiments are located in Table 2.11.

Model-experiment comparison: The minimum fuel rod pellet column length, 91.44 cm, was modeled for the 4.31 wt % UO_2 fuel rods. The 1.27-cm-thick polypropylene (0.904 g/cm^3) grid plates were modeled as water because polypropylene has about the same density and neutron moderating characteristics as water. The carbon steel core tank was not modeled because the amount of water on the boundary of the array ensures a maximum increase in k_{eff} .

2.1.1.9 PNL-4267 Simple Lattice Experiments from PNL-4267 (Ref. 13)

The experiments consist of single arrays of fuel rods. Specifications for the 4.31 wt % fuel rod are located in Fig. 2.14. The planar and elevation views of the experiments are illustrated in Fig. 2.17. The Plexiglas box is fully reflected on all four sides by **unborated** water. Critical data for the experiments are given in Table 2.12.

Model-experiment comparison: The minimum fuel rod pellet column length, 91.44 cm, was modeled.

The PNL-4267 experiments are subcritical configurations. The number of rods required to achieve critical are predicted by the approach-to-critical method. For **P4267SL1** and **P4267SL2**, the nearest whole number of rods

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required for criticality was modeled. The partial rod can be modeled if using CSAS2X. **P4267SL1** was modeled with 9 columns of 40 fuel rods, and 1 far left column of 37 fuel rods arbitrarily placed against the lower Plexiglas box side of Fig. 2.17 (planar view). The array was positioned along its length against the right side of the Plexiglas box with the array boundary next to the Plexiglas box surface. The array was centered along its width in the Plexiglas box. **P4267SL2** was modeled with 11 columns of 44 fuel rods, and 1 far left column of 25 fuel rods arbitrarily placed against the lower Plexiglas box side of Fig. 2.17 (planar view). The array was positioned along its length against the right side of the Plexiglas box with the array boundary next to the Plexiglas box surface. The array was centered along its width in the Plexiglas box.

A discrepancy in Fig. 2.17 was noticed. As displayed in the figure, the cell boundaries along the array width are 75.88 cm apart. Forty and 44 fuel rods placed in lattices of 1.890- and 1.715-cm pitch give rise to cell boundaries 75.6 and 75.46 cm apart, not 75.88 cm.

2.1.1.10 Simple Lattice Experiments from PNL-4976 (Ref. 14)

The experiment **P49-194** used a large singular array of fuel rods in a hexagonal lattice. Specifications for the 4.31 wt % UO₂ fuel rods are located in Fig. 2.14. The core assembly and experimental assembly elevations are illustrated in Figs 2.18 and 2.19. Missing from Fig. 2.19: The acrylic (1.185 g/cm³) is composed of 60 wt % C, 32 wt % O, and 8 wt % H; the polypropylene (0.905 g/cm³) lattice plates are 91.44 cm in diameter. The critical data for **P49-194** are given in Table 2.13.

Assumptions: With a core tank diameter of 152 cm, the core can be considered fully reflected by water laterally. The acrylic base plate is believed to have the same diameter as the polypropylene lattice plates.

Model-experiment comparison: The minimum fuel pellet column length, 91.44 cm, was used. The aluminum spacers, fiberglass tank bottom, carbon steel tank, and concrete floor were excluded from the model. The polypropylene lattice plates were modeled as polyethylene using hydrogen in a water thermal kernel.

2.1.1.11 Simple Lattice Experiments from WCAP-3269 (Ref. 15)

W3269SL1 and **W3269SL2** use large singular arrays of fuel rods. Descriptions of the 2.72 and 5.7 wt % UO₂ fuel rods are located in Table 2.14. The vertical dimensions of experiments **W3269SL1** and **W3269SL2** are shown in Figs. 2.20 and 2.21; the guide plates are aluminum. The absorber section of Fig. 2.20 was not part of experiment **W3269SL1**. Critical data for the experiments are located in Table 2.15.

Assumptions: The moderator height was believed to have been measured from the bottom of the fuel. The guide plate holes to accommodate fuel rods were assumed to be of fuel rod diameter. In Fig. 2.21, all plates were taken to be of assembly width and depth; full-water reflection was assumed on the sides of the experimental assembly; the 2.54-cm-thick plate below the bottom guide plate was assumed to be of aluminum. In Fig. 2.20, full-water reflector was assumed at the boundary of the assembly defined by the 60.96-cm-square guide plates.

Model-experiment comparison: The fuel rods above the moderator were modeled by the method explained in Sect. 3.2.1. In Fig. 2.21 (**W3269SL2**) the 6.35 cm above the aluminum base plate was modeled as water only. In Fig. 2.20 (**W3269SL1**) the top and center guide plates, in air for this experiment, were not modeled; the bottom end plugs in the bottom guide plate were modeled as aluminum; the bottom end plugs in the 0.188-in. (0.428-cm)-thick water slot and the top end plugs were not modeled.

2.1.1.12 Simple Lattice Experiments from WCAP-3385 (Ref. 16)

W3385SL1 and **W3385SL2** consist of large singular arrays of fuel rods. The 5.74 wt % UO₂ rods are described in Table 2.16. Vertical dimensions of the experiments are given in Fig. 2.22. Missing from, or hard to distinguish in, Fig. 2.22 is that: (1) all structures are made of aluminum, (2) the bottom grid plate rests on a 1-in. (2.54-cm)-thick aluminum slab above 2.5 in. (6.35 cm) of water and a 2-in. (5.08-cm)-thick aluminum slab, (3) the fuel pellet column ends are 0.5 in. (1.27 cm) above the bottom grid plate and 0.4 in. (1.016 cm) below the top grid plate, and (4) the stainless steel support rods are 0.4375 in. (1.1113 cm) in diameter with 0.625-in. (0.476-cm)-thick aluminum cladding. Figure 2.23 shows the location and size of the fuel rod holes and circulation holes of the grid plates of Fig. 2.22. Critical data for the experiments are located in Table 2.17.

Assumptions: The core tank is 121.92 cm in diameter constituting full-water reflection. The end plugs are believed to be of cladding material (i.e., 304 stainless steel).

Model-experiment comparison: The support rods were ignored. Homogenized water and aluminum were used to represent the center grid plate and circulation holes. The fuel rods above the moderator were modeled by the method explained in Sect. 3.2.1.

2.1.2 Separator Plate Experiments

These experiments have been selected to demonstrate the ability of the calculational techniques to predict the neutron multiplication factor of experiments with neutron absorbing or scattering materials (i.e., separator plates) between fuel assemblies. Separator plates are commonly used in transportation packages to limit neutron interaction and increased reactivity associated with the bringing into close proximity of fuel assemblies.

2.1.2.1 Separator Plate Experiments from ANS Transactions, Vol. 33 (Ref. 5)

The experiments consist of 2×2 arrays of fuel assemblies separated by aluminum boxes (four sides and a bottom) filled with water, polyethylene powder and balls, and expanded polystyrene. These experiments further test the ability of the calculation method to predict k_{eff} for assemblies with various hydrogenous compound moderators. Specifications of the 4.742 wt % fuel rods are given in Table 2.2 and Fig. 2.1. The planar and end views of the experiment are shown in Fig. 2.2. Critical data for the experiments are located in Table 2.18.

Assumptions: Holes to accommodate the fuel rods in the lower grid plate were taken to be 1.0 cm in diameter from Ref. 23. The aluminum box density, 2.651 g/cm³, was assumed from Ref. 23.

Model-experiment comparison: The spring of the fuel rods was modeled as void. The end plugs were modeled as 0.94-cm-diam aluminum cylinders. The fuel rods above the moderator were modeled by the method explained in Sect. 3.2.1.

2.1.2.2 Separator Plate Experiments from BAW-1484 (Ref. 6)

The experiments consist of 3×3 arrays of fuel assemblies separated by borated aluminum plates and water or 304-L stainless steel plates and water. Details of the 2.459 wt % UO₂ fuel rods are outlined in Table 2.4 and Fig. 2.3. The elevations of the experiments can be found in Fig. 2.24. The top grid was not used in the experiments. Missing from, or difficult to distinguish in, Fig. 2.24 is that (1) the fuel pellet column and fuel rod bottom end plugs extend 0.635 and 0.9525 cm into the aluminum bottom grid, respectively, (2) the aluminum bottom grid and aluminum bottom grid plate are 2.54 cm thick, (3) and 0.3175 cm of water exists between the aluminum bottom grid plate and the 5.08-cm-thick aluminum base plate. Critical data for the experiments are located in Table 2.19.

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Assumptions: The aluminum corner rods are assumed to be of fuel rod length. The separation distance between assemblies is believed to have been measured from the cell boundaries of the assemblies. Holes, 0.615 cm on a side, were assumed in the bottom grid plate to accommodate the fuel rods.

Model-experiment comparison: The 22.9-cm × 22.9-cm × 0.3175-cm aluminum center grid plate was not modeled. The fuel rods and separator plate above the moderator region were not modeled. In the model, the separator plates rest in a channel cut 0.635-cm deep into the bottom grid with the channel thickness equaling the separation distance of assemblies and channel length running the length of the assembly.

2.1.2.3 Separator Plate Experiments from BAW-1645 (Ref. 17)

The experiments consist of 5×5 arrays of fuel assemblies separated by (presumed) aluminum plates. Details of the 2.459 wt % UO₂ fuel rods are outlined in Table 2.4 and Fig. 2.3. Figure 2.25 is a planar view of the experiments showing the assemblies with mounted aluminum side sheets, or separator plates. Vertical dimensions of the experiments can be found in Fig. 2.26. Missing from, or difficult to distinguish in, Fig. 2.26 is that (1) the end plugs of the fuel rods extend 0.3175 cm into the 3.2-cm-thick aluminum bottom grid plate, (2) the aluminum base plate has dimensions of 122 cm × 122 cm × 8.9 cm, (3) the aluminum base plate is separated from the core tank by 2.86 cm of water, and (4) the separator plates extend vertically from the base of the bottom grid plate to the top of the top grid plate. Critical data for the experiments are located in Table 2.20.

Assumptions: The aluminum corner rods are assumed to be of fuel rod length. The separation distance between assemblies is believed to have been measured from the cell boundaries of the assemblies. The core tank is assumed to be 1.0-cm thick and constructed from carbon steel. With a 274-cm inside core tank diameter, the core is assumed to be fully reflected laterally by water.

Model-experiment comparison: The aluminum top and center grid plates were of unknown thickness and were not modeled. The fuel rods and separator plates above the moderator region and the core tank sides were ignored in the model. For experiments **BW1645T1**, **BW1645T1**, **BW1645T3**, **BW1645T4**, **BW1645S1**, and **BW1645S2**, the 3.2-cm-thick aluminum bottom grid plate has grooves for coolant flow. The top 0.3175 cm of the bottom grid plate around the end plugs was modeled as water only, the middle 1.067 cm of the plate was modeled as a mixture of 25% aluminum and 75% water by volume, and the bottom 1.815 cm was modeled as 100% aluminum by volume. For **B1645SO1** and **B1645SO2**, the 3.2-cm-thick aluminum bottom grid plate was modeled as water around the 0.3175-cm-long bottom end plugs and 2.882 cm of aluminum below the bottom end plugs.

2.1.2.4 Separator Plate Experiments from DSN No. 399/80 (Ref. 18)

The experiments consist of 2×2 arrays of fuel assemblies separated by water and hafnium plates, or single assemblies surrounded by hafnium plates. Specifications for the 4.742 wt % UO₂ fuel rods are outlined in Table 2.2 and Fig. 2.1. The elevations of the experiments are also given in Fig. 2.1. For **DSN399-1** and **DSN399-2**, a 0.4-cm-thick stainless steel assembly support plate (not shown in Fig. 2.1) is situated between the bottom plugs of the fuel rods and the 0.8-cm-thick stainless steel support plate. Cross-sectional views of the experiments are provided in Fig. 2.28. Critical data on the experiments are given in Table 2.21.

Assumptions: The assembly separation distances and plate-to-assembly distances are believed to have been measured from the cell boundaries of the assemblies. The holes in the lower lattice grid plate for accommodating the fuel rods were taken to be 1.0 cm in diameter from Ref. 23.

Model-experiment comparison: The fuel rods above the moderator were modeled by the method explained in Sect. 3.2.1. The separator plates were modeled as resting on top of the assembly support plate (**DSN399-1** and

DSN399-2) or support plate (**DSN399-3** and **DSN399-4**). The spring of the fuel rods was modeled as void. The upper grid plate of stainless steel, left out of Fig. 2.1, was reported as having an insignificant influence on k_{eff} ; therefore, it was not modeled. The stainless steel support plates were modeled as 71.40 wt % Fe, 19.16 wt % Cr, and 9.44 wt % Ni. The steel angle irons, shown in Fig. 2.29 (corner A is positioned at the center of the setup of Fig. 2.28a), of **DSN399-1** and **DSN399-2** were not modeled.

2.1.2.5 Separator Plate Experiments from PNL-2438 (Ref. 9)

The experiments consist of 3×1 arrays of fuel assemblies separated by aluminum, Boral-A, copper, stainless steel, or Zircaloy-4 plates and water. Table 2.22 describes the separator plates. Details of the 2.35 wt % UO_2 fuel rods are outlined in Fig. 2.5. Planar and axial views of the experiment can be found in Fig. 2.13; the experiments were minus the biological shielding walls shown in Fig. 2.13. Critical data for the experiments are located in Table 2.23.

Model-experiment comparison: The top and middle 1.27-cm-thick acrylic grid plates were modeled as water because acrylic plastic has about the same density and neutron moderating characteristics as water. The carbon steel core tank was not modeled. The separator plates were modeled as resting on top of the bottom 2.54-cm-thick acrylic grid plate.

2.1.2.6 Separator Plate Experiments from PNL-2615 (Ref. 19)

The experiments consist of 3×1 arrays of fuel assemblies separated by aluminum, Boral-B, cadmium, copper, stainless steel, and Zircaloy-4 plates and water. Table 2.22 describes the separator plates. Details of the 4.31 wt % UO_2 fuel rods are outlined in Fig. 2.14. Planar and axial views of the experiment can be found in Fig. 2.13; the experiments were minus the biological shielding walls shown in Figs. 2.30 and 2.15. Critical data for the experiments are located in Table 2.24.

Model-experiment comparison: The minimum fuel rod pellet column length, 91.44 cm, was modeled. The top and middle 1.27-cm-thick acrylic grid plates were modeled as water because acrylic plastic has about the same density and neutron moderating characteristics as water. The carbon steel core tank was not modeled because the amount of water on the boundary of the array ensures a maximum increase in k_{eff} . The separator plates were modeled as resting on top of the bottom 2.54-cm-thick acrylic grid plate.

2.1.2.7 Separator Plate Experiments from PNL-3314 (Ref. 11)

The experiments consist of 2×2 or 3×1 arrays of fuel assemblies separated by aluminum, Boral-A, Boral-C, Boroflex, cadmium, copper, copper-cadmium, borated stainless steel, stainless steel, and Zircaloy-4 plates and water. Descriptions of the 2.35 and 4.31 wt % UO_2 fuel rods are provided in Figs. 2.5 and 2.14. Planar and axial views of the 3×1 and 2×2 assembly experiments are shown in Figs. 2.30 ($G = 0$) and 2.15; the experiments were minus the biological shielding walls shown in Figs. 2.30 and 2.15. Figures 2.16(a) and 2.16(b) illustrate the assembly and fuel rod array configurations of the experiments. Separator plate data are given in Table 2.22. Critical data on the experiments are given in Table 2.25.

Model-experiment comparison: The minimum fuel rod pellet column length, 91.44 cm, was modeled for the 4.31 wt % UO_2 fuel rods. The two polypropylene (neutronic properties similar to water) grid plates were modeled as water. The carbon steel tank was not modeled because the amount of water on the boundary of the array ensures a maximum increase in k_{eff} . The separator plates were modeled as resting on top of the acrylic plate.

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2.1.2.8 Separator Plate Experiments from PNL-6205 (Ref. 20) and PNL-7176 (Ref. 21)

The experiments consist of 2×2 arrays of fuel assemblies separated by Boral plates and water. The Boral plates, detailed in Table 2.26, create a flux trap where epithermal neutrons passing through the Boral become thermalized in the water between the Boral plates. Aluminum plates, aluminum rods, and fuel rods were added to the water region of the flux trap in order to investigate the reactivity effect of voiding. The modeling of these experiments tests the ability of the calculation method to predict k_{eff} for assemblies with separator plates acting as flux traps and voiding materials. The 4.31 wt % UO_2 fuel rods are detailed in Fig. 2.14; the experimental elevations are provided in Fig. 2.31; and the critical data are located in Table 2.27. The assemblies for experiments **P62FT231**, **P71F14F3**, **P71F14V3**, **P71F14V5**, and **P71F214R** are displayed in Figs. 2.32-2.36.

Assumptions: The aluminum rods are assumed to be of fuel rod length. The aluminum voiding plates are assumed to be of Boral plate width and height.

Model-experiment comparison: The minimum fuel rod pellet column length, 91.44 cm, was modeled. The polypropylene lattice plates (0.90 g/cm^3) were modeled as water because of their neutron moderating similarities to water. The separator plates were modeled as resting on top of the base plate.

The PNL-6205 and PNL-7167 experiments are subcritical configurations. The number of rods required to achieve delayed critical is predicted by the approach- to-critical method. Table 2.28 shows the number of rods of the experiment (column 2), shown in Figs. 2.32-2.36, the predicted number of rods needed for delayed critical (column 3), and the number of rods modeled with CSAS25 (column 4). Note the partial rod of column 3 can be modeled if using CSAS2X instead of CSAS25. The extra rods modeled were arbitrary placed in one of the four assemblies. The modeled assembly sizes are listed in Table 2.28.

2.1.3 Reflecting Wall Experiments

Large transportation packages have reflectors in the form of biological shielding materials that are part of the packaging. The materials facilitate the return of neutrons leaking from the outer fissile material boundary. Modeling of these experiments demonstrates the ability of the calculational techniques to predict the neutron multiplication factor of water and lead-, steel-, or uranium-reflected assemblies.

2.1.3.1 Reflecting Wall Experiments from PNL-2827 (Ref. 10)

The experiments consist of 3×1 arrays of fuel assemblies separated by water and reflected by water and two lead or depleted uranium reflecting walls. Details of the 2.35 and 4.31 wt % UO_2 fuel rods are outlined in Figs. 2.5 and 2.14. Planar and axial views of the experiments can be found in Fig. 2.13. Absent in the experiments are the poison plates of Fig. 2.13. Details of the lead and uranium reflecting walls are provided in Figs. 2.37 and 2.38. Critical data for the experiments are located in Table 2.29.

Model-experiment comparison: The minimum fuel rod pellet column length, 91.44 cm, was modeled for the 4.31 wt % UO_2 fuel rods. The 1.27-cm-thick acrylic grid plates were modeled as water because acrylic plastic has about the same density and neutron moderating characteristics as water. The carbon steel core tank was not modeled because the amount of water on the boundary of the array ensures a maximum increase in k_{eff} .

2.1.3.2 Reflecting Wall Experiments from PNL-3602 (Ref. 22)

The experiments consist of 3×1 arrays of fuel assemblies separated by water and reflected by water and two steel reflecting walls. Details of the 2.35 and 4.31 wt % UO_2 fuel rods are outlined in Figs. 2.5 and 2.14. Planar and axial views of the experiments can be found in Fig. 2.30. Absent in the experiments are the poison plates of Fig. 2.30. Details of the steel reflecting walls are provided in Fig. 2.39. Critical data for the experiments are located in Table 2.30.

Model-experiment comparison: The minimum fuel rod pellet column length, 91.44 cm, was modeled for the 4.31 wt % UO_2 fuel rods. The 1.27-cm-thick acrylic and polypropylene grid plates were modeled as water because these materials have similar densities and neutron moderating characteristics as water. The carbon steel core tank was not modeled because the amount of water on the boundary of the array ensures a maximum increase in k_{eff} .

2.1.3.3 Reflecting Wall Experiments from PNL-3926 (Ref. 12)

The experiments consist of 3×1 arrays of fuel assemblies separated by water and reflected by water and two lead or depleted uranium reflecting walls. Details of the 2.35% and 4.31 wt % UO_2 fuel rods are outlined in Figs. 2.5 and 2.14. Planar and axial views of the experiments can be found in Fig. 2.15. However, these experiments do not contain poison plates as shown in the figure. Details of the lead and uranium reflecting walls are provided in Figs. 2.37 and 2.38. Critical data for the experiments are located in Table 2.31.

Model-experiment comparison: The minimum fuel rod pellet column length, 91.44 cm, was modeled for the 4.31 wt % UO_2 fuel rods. The 1.27-cm-thick polypropylene (0.904 g/cm^3) grid plates were modeled as water because polypropylene has about the same density and neutron moderating characteristics as water. The carbon steel core tank was not modeled because the amount of water on the boundary of the array is equivalent to an infinite water reflector.

2.1.4 Reflecting Wall-Separator Plate Experiments

These experiments have been selected to demonstrate the ability of the calculational techniques to predict the neutron multiplication factor of experiments with neutron absorbing or scattering materials (i.e., separator plates) between fuel assemblies reflected by water and steel. Separator plates are commonly used in transportation packages to limit neutron interaction and increased reactivity associated with the bringing into close proximity of fuel assemblies. In addition, large transportation packages may also have reflectors in the form of biological shielding materials that facilitates the return of neutrons leaking from the outer fissile material boundary.

2.1.4.1 Reflecting Wall-Separator Plate Experiments from PNL-3602 (Ref. 22)

The experiments consist of 3×1 arrays of fuel assemblies separated by water and Boral, cadmium, copper, borated and unborated stainless steel separator plates and reflected by water and two steel reflecting walls. Details of the 2.35 and 4.31 wt % UO_2 fuel rods are outlined in Figs. 2.5 and 2.14. Planar and axial views of the experiments can be found in Fig 2.30 ($G = 0$). Descriptions of the separator plates are provided in Table 2.22. Details of the steel reflecting walls are provided in Fig 2.39. Critical data for the experiments are located in Table 2.32.

Model-experiment comparison: The minimum fuel rod pellet column length, 91.44 cm, was modeled for the 4.31 wt % UO_2 fuel rods. The polypropylene grid plates were modeled as water because polypropylene has similar densities and neutron moderating characteristics as water. The carbon steel core tank was not modeled because the amount of water on the boundary of the array ensures a maximum increase in k_{eff} . The separator plates were modeled resting on top of the bottom 2.54-cm-thick acrylic plate.

Physical Description

2.1.4.2 Reflecting Wall-Separator Plate Experiments from PATRAM'80 (Ref. 23)

The experiments consist of 2×2 arrays of fuel assemblies separated by water and Boral plates and reflected by water and lead or steel reflecting walls. Details of the 4.742 wt % fuel rods are outlined in Figs. 2.1 and Table 2.2. The principal dimensions for the experiments are found in Fig. 2.1. A 0.4-cm-thick steel (composition specified on Fig. 2.1) assembly support plate, not shown in Fig. 2.1, is situated between the bottom plugs of the fuel rods and the 0.8-cm-thick support plate. The lower grid plate holes for accommodating the fuel rods are 1.0 cm in diameter. The planar view of a quarter of an experimental assembly is displayed in Fig. 2.40. Critical data for the experiments are located in Table 2.33.

Assumptions: The four stainless steel corner rods were assumed to be of fuel rod length.

Model-experiment comparison: The upper grid plate was ignored due to lack of information. The spring of the fuel rods was modeled as void. The lower grid plate around the corner rods was ignored. The fuel rods above the moderator were modeled by the method explained in Sect. 3.2.1.

2.1.5 Burnable Absorber Fuel Rod Experiments (Ref. 24)

Modeling these experiments demonstrates the ability of the calculational techniques to predict the neutron multiplication factors of experiments that have UO_2 fuel rods fabricated with gadolinia for extended burnup purposes. A set of five experiments were performed with various 2.459 or 2.459 and 4.020 wt % UO_2 and 1.944 wt % $\text{UO}_2\text{-Gd}_2\text{O}_3$ fuel rod configurations. The 2.459 wt % UO_2 rods are detailed in Table 2.4 and Fig. 2.3, the 4.020 wt % UO_2 rods are detailed in Table 2.34, and the 1.944 wt % $\text{UO}_2\text{-Gd}_2\text{O}_3$ rods are detailed in Table 2.35. The vertical dimensions are believed to be those presented in Fig. 2.4. In Fig. 2.4 the aluminum core tank is 1.27 cm thick and 152.4 cm in diameter. The core configurations for the experiments are located in Figs. 2.41-2.45. Critical data are located in Table 2.36. Note, these experiments contained borated water and water holes.

Assumptions: The vertical dimensions are believed to be those of Fig. 2.4. The 152.4-cm-diam core tank filled with water constitutes full-water reflection of the cores.

Model-experiment comparison: The fuel rods above the moderator were not modeled. The top and bottom grid plates were ignored.

2.1.6 Water Hole Experiments

LWR fuel elements have lattice positions, usually in a 5×5 matrix, filled by control rod and instrumentation clusters. The clusters are sometimes removed when the LWR fuel assemblies are shipped, leaving behind water holes that are richer in thermalized neutrons than the surrounding cells. The modeling of the experiments in this section tests the ability of the calculation techniques to handle cells with different degrees of moderation.

2.1.6.1 Water Hole Experiments from BAW-1810 (Ref. 24)

The experiments consist of 2.459 or 2.459 and 4.020 wt % UO_2 fuel rod configurations with water holes. The 2.459 wt % UO_2 rods are detailed in Table 2.4 and Fig. 2.3 and the 4.020 wt % UO_2 rods are detailed in Table 2.34. The vertical dimensions are believed to be those presented in Fig. 2.4. In Fig. 2.4 the aluminum core tank is 1.27 cm thick and 152.4 cm in diameter. The core configurations for the experiments are located in Figs. 2.46-2.48. Critical data are located in Table 2.37. Note, these experiments contained borated water.

Assumptions: The vertical dimensions are believed to be those of Fig. 2.4. The 152.4-cm-diam core tank filled with water constitutes full-water reflection of the cores.

Model-experiment comparison: The fuel rods above the moderator were not modeled. The top and bottom grid plates were ignored.

2.1.6.2 Water Hole Experiments from NS&E, Vol. 71 (Ref. 8)

The experiments consist of large singular arrays of 4.742 wt % UO₂ fuel rods with 5 × 5 and 8 × 8 matrices of water holes. Fuel rod specifications are given in Table 2.2 and Fig. 2.1. The principal dimensions of the experiments are also given in Fig. 2.1. The critical data for the experiments are located in Table 2.38.

Assumptions: The holes in the lower grid plate to accommodate the fuel rods were taken to be 1.0 cm in diameter from Ref. 23.

Model-experiment comparison: The reported upper grid, missing from Fig. 2.1, was ignored in the model due to insufficient data. The two grid plates were reportedly attached to the support plate by four fuel rods distanced more than 20 cm from the fuel. These rods were not modeled. The stainless steel support plate was modeled as 71.40 wt % Fe, 19.16 wt % Cr, and 9.44 wt % Ni. Figure 2.49 represents the cross-sectional view of the modeled assemblies.

2.1.6.3 Water Hole Experiments from PNL-3314 (Ref. 11)

The experiments consist of single lattices with 5 × 5 matrices of water holes. Descriptions of the 2.35 wt % and 4.31 wt % UO₂ fuel rods are provided in Figs. 2.5 and 2.14. Planar and axial views of the experiment setup are shown in Fig. 2.15. The cross-sectional view of the experimental setup showing water hole positions is presented in Fig. 2.50. Critical data on the experiment are given in Table 2.39.

Model-experiment comparison: **P3314W1** and **P3314W2** are subcritical configurations. The number of predicted rods to achieve criticality were obtained by the approach-to-critical method. The number of fuel rods modeled was rounded from the predicted number to the nearest whole number. Note: The partial predicted rod can be modeled if using CSAS2X. The geometric models for **P3314W1** and **P3314W2** are seen in Fig. 2.51. The partial row of fuel rods was arbitrarily located against the assembly left cell boundary. The two polypropylene (neutronic properties similar to water) grid plates were modeled as water. The carbon steel tank was not modeled because the amount of water on the boundary of the array ensures a maximum increase in k_{eff}.

2.1.6.4 Water Hole Experiments from WCAP-3269 (Ref. 15)

The experiments consist of large single arrays of fuel rods and water holes. Descriptions of the 2.72 and 5.7 wt % UO₂ fuel rods can be found in Table 2.14. The vertical dimensions of experiments **W3269W1** and **W3269W2** are shown in Figs. 2.20 and 2.21; the guide plates are aluminum. The absorber section of Fig. 2.20 was not part of the experiments. Core layouts showing water hole locations are given in Fig. 2.52. Critical data for the experiments are located in Table 2.40.

Assumptions: The moderator height was believed to have been measured from the bottom of the fuel. The guide plate holes to accommodate fuel rods were assumed to be of fuel rod diameter. In Fig. 2.21, all plates were taken to be of assembly width and depth; full-water reflection was assumed on the sides of the experimental assembly; the 2.54-cm-thick plate below the bottom guide plate was assumed to be of aluminum. In Fig. 2.20, full-water reflector was assumed at the boundary of the assembly defined by the 60.96-cm-square guide plates.

Physical Description

Model-experiment comparison: The fuel rods above the moderator were modeled by the method explained in Sect. 3.2.1. For **W3269W2** the 6.35-cm gap above the aluminum base plate was modeled as water only. For **W3269W1**, the top and center guide plates, in air for this experiment, were not modeled; the bottom end plugs in the bottom guide plate were modeled as aluminum; the bottom end plugs in the 0.188-in. (0.478-cm)-thick water slot and the top end plugs were not modeled.

2.1.7 Absorber Rod Experiments

Modeling of these experiments tests the ability of the calculational techniques to predict neutron multiplication factors of experiments simulating shipping packages of LWR assemblies with control rod clusters intact.

2.1.7.1 Absorber Rod Experiments from BAW-1484 (Ref. 6)

The experiments consist of a 3×3 array of fuel assemblies separated by a water gap containing B_4C absorber rods. Details of the 2.459 wt % UO_2 fuel rod design are outlined in Table 2.4 and Fig. 2.3. Details of the B_4C rods are outlined in Table 2.41. The vertical dimensions for the experiment are found in Fig. 2.4. Absent from Fig. 2.4: the 1 in. (2.54 cm) between the base plate and core tank is mostly water and the core tank is 0.5 in. (1.27 cm) thick. Difficult to distinguish in Fig. 2.4 is that the fuel rod end plugs are located in 0.125 in. (0.3175 cm) of water between the bottom grid plate and the base plate. Cross-sectional views of experiments **BW1484C1** and **BW1484C2** are located in Figs. 2.53 and 2.54. The critical data are located in Table 2.42.

Assumptions: The aluminum corner rods are taken to be of fuel rod length. The separation distance between assemblies is believed to have been measured from the cell boundaries of the assemblies. To accommodate the fuel rods, square holes with 0.615-cm sides were assumed in the bottom grid plate.

Model-experiment comparison: The 22.9-cm-wide \times 22.9-cm-long \times 2.54-cm-thick aluminum top grid plate was not modeled. The fuel rods and separator plate above the moderator region were not modeled.

2.1.7.2 Absorber Rod Experiments from BAW-1810 (Ref. 24)

The experiments consist of 2.459 or 2.459 and 4.020 wt % UO_2 fuel rod configurations with Ag-In-Cd and B_4C absorber rods. The 2.459 wt % UO_2 rods are detailed in Table 2.4 and Fig. 2.3. The 4.020 wt % UO_2 rods are detailed in Table 2.34. Properties of the Ag-In-Cd and B_4C rods are given in Tables 2.43 and 2.41. The vertical dimensions are believed to be those presented in Fig. 2.4. In Fig. 2.4 the aluminum core tank is 1.27 cm thick and 152.4 cm in diameter. The core configurations for the experiments are located in Figs. 2.55 and 2.56. Critical data are located in Table 2.44. Note, these experiments have borated water and water holes.

Assumptions: The vertical dimensions are those of Fig. 2.4. The 152.4-cm-diam core tank filled with water constitutes full-water reflection of the cores.

Model-experiment comparison: The fuel and absorber rods above the moderator were not modeled. The top and bottom grid plates were ignored.

2.1.7.3 Absorber Rod Experiments from WCAP-3269 (Ref. 15)

Experiments **W3269A** and **W3269C** used large single arrays of 5.7 and 2.72 wt % UO_2 fuel rods and Ag-In-Cd absorber rods. **W3269B1**, **W3269B2**, and **W3269B3** used large single arrays of 3.7 wt % UO_2 fuel rods and Ag-In-Cd absorber rods. Descriptions of the 2.72, 3.7, and 5.7 wt % UO_2 fuel rods can be found in Table 2.14. The vertical dimensions of experiments **W3269A** and **W3269C** are shown in Figs. 2.21 and 2.20. Figure 2.57

displays the vertical dimensions for **W3269B1**, **W3269B2**, and **W3269B3**. All experiments used aluminum guide plates. The core layouts of **W3269A** and **W3269C**, with water holes replaced by Ag-In-Cd rods, are given in Fig. 2.52. The core layouts of **W3269B1**, **W3269B2**, and **W3269B3** are given in Figs. 2.58-2.60. The cruciform in Figs. 2.58-2.60 are control rod fuel followers. Each cruciform has a center fuel rod and four vanes with nine fuel rods on a 0.418-in. (1.062-cm) pitch. Critical data for the experiments are located in Table 2.45.

Assumptions: The Ag-In-Cd rods are assumed to be of fuel rod length. The moderator height was believed to have been measured from the bottom of the fuel. The guide plate holes to accommodate fuel rods were assumed to be of fuel rod diameter. For **W3269A**, **W3269B1**, **W3269B2**, and **W3269B3** full water reflection was assumed laterally beyond the assembly boundary. For **W3269C**, full water reflection was assumed outside the assembly boundary defined by the 60.96-cm-square guide plates. In Fig. 2.21, the 2.54-cm-thick plate below the bottom guide plate was assumed to be of aluminum.

Model-experiment comparison: The fuel rods above the moderator were modeled by the method explained in Sect. 3.2.1. For **W3269A**, the 6.35 cm above the base plate was modeled as water only. For **W3269B1**, **W3269B2**, and **W3269B3**, no data were available on the fuel rod end plugs so the plugs were modeled as water; the center guide plate, 70.17 cm above the bottom of the fuel, was not modeled because it was above the moderator level; the eccentricity of the fuel follower was treated as described in Sect. 3.2.1. For **W3269C**, the top and center guide plates, in air for this experiment, were not modeled; the bottom end plugs in the bottom guide plate were modeled as aluminum; the bottom end plugs in the 0.188-in. (0.478-cm)-thick water slot and top end plugs were not modeled.

2.1.8 Soluble Boron Experiments

Boric acid is often used in shipping casks as an additional measure for preventing accidental criticality; boric acid is a strong absorber that can significantly affect the neutronics of a system. The experiments described in this section are used to test the ability of the calculational techniques to predict the neutron multiplication factors of systems with a borated water moderator.

2.1.8.1 Soluble Boron Experiments from BAW-1231 (Ref. 25)

The experiments consist of large arrays of fuel rods moderated by borated water. Properties of the 4.020 wt % fuel rods are given in Table 2.34. The core layouts and vertical dimensions of the experiments are given in Figs. 2.61 and 2.62. The top and bottom grid plates of Fig. 2.62 are aluminum. Critical data for the experiments are in Table 2.46.

Assumptions: Holes of fuel rod diameter were assumed in the grid plates. The core tank is 274.32 cm in diameter constituting full-water reflection. The end plugs are believed to be made of aluminum.

Model-experiment comparison: The fuel rods above the moderator were modeled by the method explained in Sect. 3.2.1. The top grid plate, top end plugs, and top end plugs above the top grid plate were modeled as a solid aluminum slab.

2.1.8.2 Soluble Boron Experiments from BAW-1273 (Ref. 26)

BW1273M consists of a large cylindrical array of fuel rods moderated by borated water. Properties of the 2.459 wt % UO₂ fuel rods are given in Table 2.4 and Fig. 2.3. The vertical dimensions of the experiment are given in Fig. 2.63. Missing from Fig. 2.63 are two 0.0625-in. (0.1588-cm)-thick aluminum midplane grid plates with bases 49 and 82 cm above the reference plane. Critical data for the experiments are in Table 2.47.

Assumptions: The 274.32-cm-diam core tank filled with water constitutes full-water reflection of the core. Square holes, 1.27 cm on a side, were assumed in each grid plate to accommodate the fuel rods.

Physical Description

Model-experiment comparison: The fuel rods above the moderator were modeled by the method explained in Sect. 3.2.1. The top grid plate was not modeled. Figure 2.64 shows a cross-sectional view of the modeled core for reference.

2.1.8.3 Soluble Boron Experiments from BAW-1484 (Ref. 6)

The experiments consisted of 3×3 arrays of fuel assemblies separated by water gaps and moderated with borated water. Details of the 2.459 wt % UO₂ fuel rods are outlined in Table 2.4 and Fig. 2.3. The elevations of experiments **BW1484B1** and **BW1484B2** can be found in Fig. 2.4. Absent from Fig 2.4: the 1 in. (2.54 cm) below the base plate is mostly water and the core tank is 0.5 in. (1.27 cm) thick. Difficult to distinguish in Fig. 2.4 is that the fuel rod end plugs are located in 0.125 in. (0.3175 cm) of water between the bottom grid plate and the base plate. The elevations of experiment **BW1484B3** are given in Fig. 2.24. The top grid of Fig. 2.24 was not used in the experiments. Missing from, or difficult to distinguish in, Fig. 2.24 is that: (1) the fuel pellet column and fuel rod bottom end plugs extend 0.635 and 0.9525 cm into the aluminum bottom grid, respectively, (2) the aluminum bottom grid and aluminum bottom grid plate are 2.54 cm thick, (3) and 0.3175 cm of water exists between the aluminum bottom grid plate and the 5.08-cm-thick aluminum base plate. Critical data for the experiments are located in Table 2.48.

Assumptions: The aluminum corner rods are taken to be of fuel rods length. The separation distance between assemblies is believed to have been measured from the cell boundaries of the assemblies. Holes, 0.615 cm on a side, were assumed in the bottom grid plate to accommodate the fuel rods.

Model-experiment comparison: The fuel rods above the moderator region were not modeled. The 22.9-cm-wide \times 22.9-cm-long \times 2.54-cm-thick aluminum top grid plate were not modeled.

2.1.8.4 Soluble Boron Experiments from EPRI NP-196 (Ref. 7)

These experiments consist of large singular arrays of fuel rods moderated by borated water. Specifications of the 2.35 wt % UO₂ fuel rods are presented in Fig. 2.5. Figure 2.6 shows the axial dimensions of experiments **EPRU65B** and **EPRU87B**. Figure 2.7 shows the axial dimensions of experiment **EPRU75B**. The grid plate holes for **EPRU75B** are 0.586 in. (1.488 cm) in diameter. The specifications for the aluminum "eggcrate" grids seen in Fig. 2.6 are given in Fig. 2.8. The core layouts are shown in Figs. 2.65–2.67. The critical data are located in Table 2.49.

Model-experiment comparison: A 182.88-cm-diam, 274.32-cm-tall tank contributes full-water reflection of the cores. The experiments were modeled with 6 in. (15.24 cm) of water above the lead shield and 30 cm of water below the aluminum solid plate.

2.1.8.5 Soluble Boron Experiments from PNL-4267 (Ref. 13)

The experiments consist of a single array of fuel rods moderated by borated water. Specifications of the 4.31 wt % UO₂ fuel rods are located in Fig. 2.14. The experimental setup is illustrated in Fig. 2.17. The box is full-water reflected on all four sides with **unborated** water. Critical data for the experiments are given in Table 2.50. The reader should be aware of the large uncertainty associated with some measured boron concentration values.

Model-experiment comparison: The minimum fuel rod pellet column length, 91.44 cm, was modeled.

The PNL-4267 experiments are subcritical configurations. The number of rods required to achieve critical are predicted by the approach-to-critical method. For **P4267SL1** and **P4267SL2**, the nearest whole number of rods required for criticality were modeled. The partial rod can be modeled if using CSAS2X. **P4267B1** was modeled with 23 columns of 40 fuel rods, and 1 far-left column of 3 fuel rods. **P4267B2** was modeled with 30 columns of

40 fuel rods and 1 far-left column of 37 fuel rods. **P4267B3** was modeled with 16 columns of 44 fuel rods and 1 far-left column of 33 fuel rods. **P4267B4** was modeled with 20 columns of 44 fuel rods and 1 far-left column of 37 fuel rods. **P4267B5** was modeled with 27 columns of 44 fuel rods and 1 far-left column of 4 fuel rods. The far-left columns of the arrays were arbitrarily placed against the lower Plexiglas box side of Fig. 2.17 (planar view). The arrays were positioned along their length against the right side of the Plexiglas box with the boundary next to the Plexiglas box surface. The arrays were centered along their width in the Plexiglas box.

A discrepancy in Fig. 2.17 was noticed. As marked, the cell boundaries along the array width are 75.88 cm apart. Forty and 44 fuel rods placed in lattices of 1.890- and 1.715-cm pitch give rise to cell boundaries 75.6 and 75.46 cm apart, not 75.88 cm.

2.2 Homogeneous Uranium

Modeling this set of experiments tests the ability of the calculational techniques to predict the neutron multiplication factors of homogeneous uranium systems such as shipping containers with low-enriched uranium oxide pellets or powder.

2.2.1 Homogenized Uranium in Paraffin

These experiments consisted of paraffin-reflected or unreflected parallelepipeds of homogeneous U_2F_4 or U_3F_4 and paraffin. The fuel atom densities for each experiment are listed in Table 2.51. Critical data of the experiments are located in Table 2.52.

2.2.2 Damp Uranium Oxide Experiments (Refs. 28-31)

The experiments **CR1071AS**, **CR1653AS**, and **CR2500S** consist of 42, 38, and 30 cans of damp uranium oxide moderated and reflected by Plexiglas. The fuel cans and damp uranium oxide for the three experiments are detailed in Table 2.53. Material compositions of the cans, moderator, and reflector are given in Table 2.54. Isometric drawings of the fuel can configurations are found in Fig. 2.68. Table 2.55 contains **CR1071AS** core, reflector, faceplate, frame extender, and filler dimensions corresponding to Fig. 2.69. Table 2.56 contains **CR1653AS** core, reflector, and filler dimensions corresponding to Fig. 2.70. The reflector end panel and frame dimensions of Fig. 2.70 are shown in Fig 2.71 for clarification. For **CR2500S**, Table 2.57 lists the cuboid dimensions corresponding to the three nested cuboids of Fig. 2.72.

Assumptions: All voids were assumed to be filled with nonfire-retardant Plexiglas in **CR2500S** except the void to the east of the north and south table cores. For all experiments, nearly 80% of the reflector is reported to be fire-retardant Plexiglas. The experimenter suggests that the north frame, south frame, and south end panel be modeled as fire-retardant Plexiglas and the north end panel, frame extensions, and filler blocks be modeled as nonfire-retardant Plexiglas.

Model-experiment comparison: The fuel can contents (i.e., U_3O_8 , H_2O , and polyethylene) were homogenized over the can cavity. The fuel can, vinyl tape, and mylar tape were homogenized over the fuel can shell volume.

Table 2.1 Case descriptions of LWR-type UO₂ fuel pin lattice critical benchmark experiments

Case No.	Case designation	Enrich. (wt %)	Pitch (cm)	H ₂ O/fuel volume	Description	Reference No.
1	ANS33AL1	4.74	1.35	2.302	H ₂ O filled Al cruciform boxes	5
2	ANS33AL2	4.74	1.35	2.302	H ₂ O filled Al cruciform boxes	5
3	ANS33AL3	4.74	1.35	2.302	H ₂ O filled Al cruciform boxes	5
4	ANS33EB1	4.74	1.35	2.302	Polyethylene balls in Al cruciform boxes	5
5	ANS33EB2	4.74	1.35	2.302	Polyethylene balls in Al cruciform boxes	5
6	ANS33EP1	4.74	1.35	2.302	Polyethylene powder in Al cruciform boxes	5
7	ANS33EP2	4.74	1.35	2.302	Polyethylene powder in Al cruciform boxes	5
8	ANS33SLG	4.74	1.35	2.302	Simple square lattice	5
9	ANS33STY	4.74	1.35	2.302	Expanded polystyrene in Al cruciform box	5
10	B1645SO1	2.46	1.410	1.015	Al separator plates, borated H ₂ O	17
11	B1645SO2	2.46	1.410	1.015	Al separator plates, borated H ₂ O	17
12	BW1231B1	4.02	1.511	1.139	Borated H ₂ O	25
13	BW1231B2	4.02	1.511	1.139	Borated H ₂ O	25
14	BW1273M	2.46	1.511	1.376	Borated H ₂ O	26
15	BW1484A1	2.46	1.636	1.841	Borated Al absorber plates, borated H ₂ O	6
16	BW1484A2	2.46	1.636	1.841	Borated Al absorber plates, borated H ₂ O	6
17	BW1484B1	2.46	1.636	1.841	Borated H ₂ O	6
18	BW1484B2	2.46	1.636	1.841	Borated H ₂ O	6
19	BW1484B3	2.46	1.636	1.841	Borated H ₂ O	6
20	BW1484C1	2.46	1.636	1.841	B ₄ C rods	6
21	BW1484C2	2.46	1.636	1.841	B ₄ C rods	6
22	BW1484S1	2.46	1.636	1.841	Stainless steel absorber plates, borated H ₂ O	6
23	BW1484S2	2.46	1.636	1.841	Stainless steel absorber plates, borated H ₂ O	6
24	BW1484SL	2.46	1.636	1.841	Simple square lattice	6
25	BW1645S1	2.46	1.209	0.383	Al separator plates, borated H ₂ O	17
26	BW1645S2	2.46	1.209	0.383	Al separator plates, borated H ₂ O	17
27	BW1645T1	2.46	1.209	0.148	Hexagonal lattice, Al separator plates, borated H ₂ O	17
28	BW1645T2	2.46	1.209	0.148	Hexagonal lattice, Al separator plates, borated H ₂ O	17
29	BW1645T3	2.46	1.209	0.148	Hexagonal lattice, Al separator plates, borated H ₂ O	17
30	BW1645T4	2.46	1.209	0.148	Hexagonal lattice, Al separator plates, borated H ₂ O	17
31	BW1810A	2.46	1.636	1.841	UO ₂ -Gd ₂ O ₃ rods, water holes, borated H ₂ O	24
32	BW1810B	2.46	1.636	1.841	UO ₂ -Gd ₂ O ₃ rods, water holes, borated H ₂ O	24
33	BW1810C	2.46 & 4.02	1.636	1.841 & 1.532	UO ₂ -Gd ₂ O ₃ rods, water holes, borated H ₂ O	24

Table 2.1 (continued)

Case No.	Case designation	Enrich. (wt %)	Pitch (cm)	H ₂ O/fuel volume	Description	Reference No.
34	BW1810D	2.46 & 4.02	1.636	1.841 & 1.532	UO ₂ -Gd ₂ O ₃ rods, water holes, borated H ₂ O	24
35	BW1810E	2.46 & 4.02	1.636	1.841 & 1.532	UO ₂ -Gd ₂ O ₃ rods, water holes, borated H ₂ O	24
36	BW1810F	2.46	1.636	1.841	Water holes, borated H ₂ O	24
37	BW1810G	2.46 & 4.02	1.636	1.841 & 1.532	Water holes, borated H ₂ O	24
38	BW1810H	2.46 & 4.02	1.636	1.841 & 1.532	Water holes, borated H ₂ O	24
39	BW1810I	2.46	1.636	1.841	Water holes, Ag-In-Cd rods, borated H ₂ O	24
40	BW1810J	2.46 & 4.02	1.636	1.841 & 1.532	Water holes, B ₄ C rods, borated H ₂ O	24
41	CR1071AS	4.46	2.43	0.77	U ₃ O ₈ fuel cans	28
42	CR1653AS	4.48	2.43	1.25	U ₃ O ₈ fuel cans	28
43	CR2500S	4.48	2.43	2.03	U ₃ O ₈ fuel cans	28
44	DSN399-1	4.74	1.6	3.807	Hafnium separator plates	18
45	DSN399-2	4.74	1.6	3.807	Hafnium separator plates	18
46	DSN399-3	4.74	1.6	3.807	Hafnium separator plates	18
47	DSN399-4	4.74	1.6	3.807	Hafnium separator plates	18
48	EPRU65	2.35	1.562	1.196	Simple square lattice	7
49	EPRU65B	2.35	1.562	1.196	Borated H ₂ O	7
50	EPRU75	2.35	1.905	2.408	Simple square lattice	7
51	EPRU75B	2.35	1.905	2.408	Borated H ₂ O	7
52	EPRU87	2.35	2.210	3.687	Simple square lattice	7
53	EPRU87B	2.35	2.210	3.687	Borated H ₂ O	7
54	NSE71H1	4.74	1.35	2.302	Simple hexagonal lattice	8
55	NSE71H2	4.74	1.72	4.619	Simple hexagonal lattice	8
56	NSE71H3	4.74	2.26	9.004	Simple hexagonal lattice	8
57	NSE71SQ	4.74	1.26	1.823	Simple square lattice	8
58	NSE71W1	4.74	1.26	1.823	Water holes	8
59	NSE71W2	4.74	1.26	1.823	Water holes	8
60	P2438AL	2.35	2.032	2.918	Aluminum separator plates	9
61	P2438BA	2.35	2.032	2.918	Boral-A separator plates	9
62	P2438CU	2.35	2.032	2.918	Copper separator plates	9

Table 2.1 (continued)

Case No.	Case designation	Enrich. (wt %)	Pitch (cm)	H ₂ O/fuel volume	Description	Reference No.
63	P2438SLG	2.35	2.032	2.918	Simple square lattice	9
64	P2438SS	2.35	2.032	2.918	Stainless steel separator plates	9
65	P2438ZR	2.35	2.032	2.918	Zircaloy-4 separator plates	9
66	P2615AL	4.31	2.540	3.883	Aluminum separator plates	19
67	P2615BA	4.31	2.540	3.883	Boral-A separator plates	19
68	P2615CD1	4.31	2.540	3.883	Cadmium separator plates	19
69	P2615CD2	4.31	2.540	3.883	Cadmium separator plates	19
70	P2615CU	4.31	2.540	3.883	Copper separator plates	19
71	P2615SS	4.31	2.540	3.883	Stainless steel separator plates	19
72	P2615ZR	4.31	2.540	3.883	Zircaloy-4 separator plates	19
73	P2827L1	2.35	2.032	2.918	Lead reflecting walls	10
74	P2827L2	2.35	2.032	2.918	Lead reflecting walls	10
75	P2827L3	4.31	2.540	3.883	Lead reflecting walls	10
76	P2827L4	4.31	2.540	3.883	Lead reflecting walls	10
77	P2827SLG	2.35	2.032	2.918	Simple square lattice	10
78	P2827U1	2.35	2.032	2.918	Uranium reflecting walls	10
79	P2827U2	2.35	2.032	2.918	Uranium reflecting walls	10
80	P2827U3	4.31	2.540	3.883	Uranium reflecting walls	10
81	P2827U4	4.31	2.540	3.883	Uranium reflecting walls	10
82	P3314AL	4.31	1.892	1.60	Aluminum separator plates	11
83	P3314BA	4.31	1.892	1.60	Boral-A separator plates	11
84	P3314BC	4.31	1.892	1.60	Boral-C separator plates	11
85	P3314BF1	4.31	1.892	1.60	Boroflex separator plates	11
86	P3314BF2	4.31	1.892	1.60	Boroflex separator plates	11
87	P3314BS1	2.35	1.684	1.60	Borated steel separator plates	11
88	P3314BS2	2.35	1.684	1.60	Borated steel separator plates	11
89	P3314BS3	4.31	1.892	1.60	Borated steel separator plates	11
90	P3314BS4	4.31	1.892	1.60	Borated steel separator plates	11
91	P3314CD1	4.31	1.892	1.60	Cadmium separator plates	11
92	P3314CD2	2.35	1.684	1.60	Cadmium separator plates	11
93	P3314CU1	4.31	1.892	1.60	Copper separator plates	11
94	P3314CU2	4.31	1.892	1.60	Copper separator plates	11

Table 2.1 (continued)

Case No.	Case designation	Enrich. (wt %)	Pitch (cm)	H ₂ O/fuel volume	Description	Reference number
95	P3314CU3	4.31	1.892	1.60	Copper separator plates	11
96	P3314CU4	4.31	1.892	1.60	Copper-cadmium separator plates	11
97	P3314CU5	2.35	1.684	1.60	Copper separator plates	11
98	P3314CU6	2.35	1.684	1.60	Copper-cadmium separator plates	11
99	P3314SLG	4.31	1.892	1.60	Simple square lattice	11
100	P3314SS1	4.31	1.892	1.60	Steel separator plates	11
101	P3314SS2	4.31	1.892	1.60	Steel separator plates	11
102	P3314SS3	4.31	1.892	1.60	Steel separator plates	11
103	P3314BS4	4.31	1.892	1.60	Steel separator plates	11
104	P3314BS4	2.35	1.684	1.60	Steel separator plates	11
105	P3314BS4	4.31	1.892	1.60	Steel separator plates	11
106	P3314W1	4.31	1.892	1.60	Water holes	11
107	P3314W2	2.35	1.684	1.60	Water holes	11
108	P3314ZR	4.31	1.892	1.60	Zircaloy-4 separator plates	11
109	P3602BA	4.31	1.892	1.60	Boral-B separator plates, steel reflecting walls	22
110	P3602BS1	2.35	1.684	1.60	Borated steel separator plates, steel reflecting walls	22
111	P3602BS2	4.31	1.892	1.60	Borated steel separator plates, steel reflecting walls	22
112	P3602CD1	2.35	1.684	1.60	Cadmium separator plates, steel reflecting walls	22
113	P3602CD2	4.31	1.892	1.60	Cadmium separator plates, steel reflecting walls	22
114	P3602CU1	2.35	1.684	1.60	Copper separator plates, steel reflecting walls	22
115	P3602CU2	2.35	1.684	1.60	Copper-cadmium separator plates, steel reflecting walls	22
116	P3602CU3	4.31	1.892	1.60	Copper separator plates, steel reflecting walls	22
117	P3602CU4	4.31	1.892	1.60	Copper-cadmium separator plates, steel reflecting walls	22
118	P3602N11	2.35	1.684	1.60	Steel reflecting walls	22
119	P3602N12	2.35	1.684	1.60	Steel reflecting walls	22
120	P3602N13	2.35	1.684	1.60	Steel reflecting walls	22
121	P3602N14	2.35	1.684	1.60	Steel reflecting walls	22
122	P3602N21	2.35	2.032	2.918	Steel reflecting walls	22
123	P3602N22	2.35	2.032	2.918	Steel reflecting walls	22
124	P3602N31	4.31	1.892	1.60	Steel reflecting walls	22

Table 2.1 (continued)

Case No.	Case designation	Enrich. (wt %)	Pitch (cm)	H ₂ O/fuel volume	Description	Reference number
125	P3602N32	4.31	1.892	1.60	Steel reflecting walls	22
126	P3602N33	4.31	1.892	1.60	Steel reflecting walls	22
127	P3602N34	4.31	1.892	1.60	Steel reflecting walls	22
128	P3602N35	4.31	1.892	1.60	Steel reflecting walls	22
129	P3602N36	4.31	1.892	1.60	Steel reflecting walls	22
130	P3602N41	4.31	2.540	3.883	Steel reflecting walls	22
131	P3602N42	4.31	2.540	3.883	Steel reflecting walls	22
132	P3602N43	4.31	2.540	3.883	Steel reflecting walls	22
133	P3602SS1	2.35	1.684	1.60	Steel separator plates, steel reflecting walls	22
134	P3602SS2	4.31	1.892	1.60	Steel separator plates, steel reflecting walls	22
135	P3926L1	2.35	1.684	1.60	Lead reflecting walls	12
136	P3926L2	2.35	1.684	1.60	Lead reflecting walls	12
137	P3926L3	2.35	1.684	1.60	Lead reflecting walls	12
138	P3926L4	4.31	1.892	1.60	Lead reflecting walls	12
139	P3926L5	4.31	1.892	1.60	Lead reflecting walls	12
140	P3926L6	4.31	1.892	1.60	Lead reflecting walls	12
141	P3926SL1	2.35	1.684	1.60	Simple lattice	12
142	P3926SL2	4.31	1.892	1.60	Simple lattice	12
143	P3926U1	2.35	1.684	1.60	Uranium reflecting walls	12
144	P3926U2	2.35	1.684	1.60	Uranium reflecting walls	12
145	P3926U3	2.35	1.684	1.60	Uranium reflecting walls	12
146	P3926U4	4.31	1.892	1.60	Uranium reflecting walls	12
147	P3926U5	4.31	1.892	1.60	Uranium reflecting walls	12
148	P3926U6	4.31	1.892	1.60	Uranium reflecting walls	13
149	P4267B1	4.31	1.890	1.59	Borated H ₂ O	13
150	P4267B2	4.31	1.890	1.59	Borated H ₂ O	13
151	P4267B3	4.31	1.715	1.090	Borated H ₂ O	13
152	P4267B4	4.31	1.715	1.090	Borated H ₂ O	13
153	P4267B5	4.31	1.715	1.090	Borated H ₂ O	13

Table 2.1 (continued)

Case No.	Case designation	Enrich. (wt %)	Pitch (cm)	H ₂ O/fuel volume	Description	Reference number
154	P4267SL1	4.31	1.890	1.59	Borated H ₂ O	13
155	P4267SL2	4.31	1.715	1.090	Borated H ₂ O	13
156	P49-194	4.31	1.598	0.509	Simple hexagonal lattice	14
157	P62FT231	4.31	1.891	1.60	Boral flux traps, no void material	20
158	P71F14F3	4.31	1.891	1.60	Boral flux traps, void material fuel rods	21
159	P71F14V3	4.31	1.891	1.60	Boral flux traps, void material Al plates	21
160	P71F14V5	4.31	1.891	1.60	Boral flux traps, void material Al rods	21
161	P71F214R	4.31	1.891	1.60	Boral flux traps, no void material	21
162	PAT80L1	4.74	1.6	3.807	Boral separator plates, lead reflecting walls	23
163	PAT80L2	4.74	1.6	3.807	Boral separator plates, lead reflecting walls	23
164	PAT80SS1	4.74	1.6	3.807	Boral separator plates, steel reflecting walls	23
165	PAT80SS2	4.74	1.6	3.807	Boral separator plates, steel reflecting walls	23
166	W3269A	5.7	1.422	1.93	Ag-In-Cd rods	15
167	W3269B1	3.7	1.105	1.432	Ag-In-Cd rods	15
168	W3269B2	3.7	1.105	1.432	Ag-In-Cd rods	15
169	W3269B3	3.7	1.105	1.432	Ag-In-Cd rods	15
170	W3269C	2.72	1.524	1.494	Ag-In-Cd rods	15
171	W3269SL1	2.72	1.524	1.494	Simple square lattice	15
172	W3269SL2	5.7	1.422	1.93	Simple square lattice	15
173	W3269W1	2.72	1.524	1.494	Water holes	15
174	W3269W2	5.7	1.422	1.93	Water holes	15
175	W3385SL1	5.74	1.422	1.932	Simple square lattice	16
176	W3385SL2	5.74	2.012	5.067	Simple square lattice	16
177	YDR14PL2	2.00	-	8.23	Homogenized U(2)F ₄ in paraffin	27
178	YDR14PL3	3.00	-	4.05	Homogenized U(3)F ₄ in paraffin	27
179	YDR14UN2	2.00	-	5.95	Homogenized U(2)F ₄ in paraffin	27
180	YDR14UN3	3.00	-	4.05	Homogenized U(3)F ₄ in paraffin	27

Physical Description

Table 2.2 Properties of UO₂ fuel rods from ANS Transactions, Vol. 33^a

Parameter	Value
Outside diameter, cm	0.94
Wall thickness, cm	0.06
Wall material	aluminum ^b
Pellet diameter, cm	0.790
Total fuel length, cm	100.0 ^c
Active fuel length, cm	90.0
Enrichment, ²³⁵ U/U wt %	4.742
Fuel density, g/cm ³	10.38

^a See Ref. 5.

^b 98.85 wt % Al, 0.47 wt % Mg, 0.43 wt % Si, 0.22 wt % Fe, 0.03 wt % Zn.

^c Includes 1.8-cm-long bottom end plug, 1.3-cm-long top end plug, and 6.9-cm-long spring above the pellet stack.

Table 2.3 Critical data for simple lattice experiment **ANS33SLG**^a

Experiment	Enrichment (wt %)	Pitch (cm)	Separation of assemblies ^b	No. of assemblies– assembly size (No. of rods)	Moderator height, ^c H _c (cm)
ANS33SLG	4.742	1.35	5.0 cm	4–18×18	31.47

^a See Ref. 5.

^b Perpendicular distance between cell boundaries of assemblies.

^c Measured from lower end of fuel rod pellet column.

Table 2.4 Properties of UO₂ fuel rods from BAW-1484^a

Parameter	Value
Outside diameter, cm	1.206
Wall thickness, cm	0.081
Wall material	aluminum
Pellet diameter, cm	1.030
Total length, cm	156.44 ^b
Active fuel length, cm	153.34
Enrichment, ²³⁵ U/U wt %	2.459
Fuel density, g/cm ³	10.22

^a See Ref. 6.^b Includes 0.3175-cm-long aluminum top and bottom end plugs and 2.464 cm of Ka wool above the pellet stack.Table 2.5 Critical data for simple lattice experiment **BW1484SL** from BAW-1484^a

Experiment	Enrichment (wt %)	Pitch (cm)	Separation of assemblies ^b	No. of assemblies– assembly size (No. of rods)	Moderator height, ^c H _c (cm)
BW1484SL	2.459	1.636	6.544 cm	9–14×14 ^d	129.65

^a See Ref. 6.^b Believed to be the perpendicular distance between cell boundaries of assemblies.^c Measured from the top of the aluminum base plate.^d Four corner rods of assemblies are 0.635-cm-radius aluminum rods.

Physical Description

Table 2.6 Critical data for simple lattice experiments from EPRI NP-196^a

Experiment	Enrichment (wt %)	Pitch (cm)	No. of rods	Moderator height ^b (cm)	Boron concentration (ppm)
EPRU65	2.35	1.562	708	111.76	0.9
EPRU75	2.35	1.905	383	112.08	0.5
EPRU87	2.35	2.210	342	111.76	0.9

^a See Ref. 7.

^b Measured from the top of the aluminum solid plate.

Table 2.7 Critical data for simple lattice experiments from NS&E, Vol. 71^a

Experiment	Enrichment (wt %)	Pitch (cm)	No. of assemblies– assembly size (No. of rods)	Moderator height, ^b H _c (cm)
NSE71H1	4.742	1.35 ^c	1–14 per side (547)	60.93
NSE71H2	4.742	1.72 ^c	1–10 per side (271)	68.06
NSE71H3	4.742	2.26 ^c	1–9 per side (217)	79.50
NSE71SQ	4.742	1.26	1–22×22	90.69

^a See Ref. 8.

^b Measured from lower end of fuel rod pellet column.

^c Hexagonal lattice.

Table 2.8 Critical data for simple lattice experiment **P2438SLG** from PNL-2438^a

Experiment	Enrichment (wt %)	Pitch (cm)	Separation of assemblies, ^b X _c (cm)	No. of assemblies- assembly size (No. of rods)
P2438SLG	2.35	2.032	8.39	3-20×16

^a See Ref. 9.^b Perpendicular distance between cell boundaries of assemblies.Table 2.9 Critical data for simple lattice experiment **P2827SLG** from PNL-2827^a

Experiment	Enrichment (wt %)	Pitch (cm)	Separation of assemblies, ^b X _c (cm)	No. of assemblies- assembly size (No. of rods)
P2827SLG	2.35	2.032	8.31	3-19×16

^a See Ref. 10.^b Perpendicular distance between cell boundaries of assemblies.Table 2.10 Critical data for simple lattice experiment **P3314SLG** from PNL-3314^a

Experiment	Enrichment (wt %)	Pitch (cm)	Separation of assemblies, ^b X _c ; Y _c (cm)	No. of assemblies- assembly size (No. of rods)
P3314SLG	4.31	1.892	2.83; 10.86	2-9×12; 2-9×1

^a See Ref. 11.^b Perpendicular distance between cell boundaries of assemblies.

Physical Description

Table 2.11 Critical data for simple lattice experiments from PNL-3926^a

Experiment	Enrichment (wt %)	Pitch (cm)	Separation of assemblies, ^b X _c (cm)	No. of assemblies- assembly size (No. of rods)
P3926SL1	2.35	1.684	6.59	2-20×18; 1-23×18 ^c
P3926SL2	4.31	1.892	12.79	3-12×16

^a See Ref. 12.

^b Perpendicular distance from outer rod surface to outer rod surface.

^c Center assembly.

Table 2.12 Critical data for simple lattice experiments from PNL-4267^a

Experiment	Enrichment (wt %)	Pitch (cm)	Array width (No. of rods)	Total No. of rods	
				Predicted ^b	Modeled
P4267SL1	4.31	1.890	40	356.8	357
P4267SL2	4.31	1.715	44	509.08	509

^a See Ref. 13.

^b Obtained by approach-to-critical method.

Table 2.13 Critical data for simple lattice experiment **P49-194** from PNL-4976^a

Experiment	Enrichment (wt %)	Pitch ^b (cm)	No. of assemblies- assembly size (No. of rods)
P49-194	4.31	1.598	1-1185

^a See Ref. 14.

^b Hexagonal lattice.

Table 2.14 Properties of UO₂ fuel rods from WCAP-3269^a

	2.72	3.7	5.7
Outer diameter, cm	1.1895	0.8600	0.9931
Wall thickness, cm	0.0799	0.0406	0.0762
Wall material	Zircaloy-4 ^b	304-stainless steel ^c	304-stainless steel ^c
Pellet diameter, cm	1.0160	0.7544	0.9068
Total fuel length, cm	139.65 ^d	— ^e	97.155 ^f
Active fuel length, cm	121.92	121.92	92.964
Enrichment, ²³⁵ U/U, wt %	2.72	3.7	5.7
Fuel density, g/cm ³	10.412	10.4120	10.1928

^a See Ref. 15.^b 98.20 wt % Zr, 1.4 wt % Sn, 0.21 wt % Fe, 0.10 wt % Cr.^c 18.54 wt % Cr, 9.44 wt % Ni, 1.76 wt % Mn, 69.46 wt % Fe.^d Includes 3.81-cm-long bottom and at least 13.92-cm-long top 304-stainless steel end plugs.^e No data available on end plug lengths.^f Includes 1.905-cm-long bottom and at least 2.286-cm-long top Zircaloy-4 end plugs.Table 2.15 Critical data for simple lattice experiments from WCAP-3269^a

Experiment	Enrichment (wt %)	Pitch (cm)	No. of assemblies— assembly size (No. of rods)	Moderator height ^b (cm)
W3269SL1	2.72	1.524	1–31×31	38.58
W3269SL2	5.7	1.422	1–27×17	52.97

^a See Ref. 15.^b Believed to have been measured from the bottom of fuel, see Figs. 20 and 21.

Physical Description

Table 2.16 Properties of UO₂ fuel rods from WCAP-3385^a

Parameter	Value
Outside diameter, cm	0.993
Wall thickness, cm	0.038
Wall material	304-stainless steel
Pellet diameter, cm	0.907
Total fuel length, cm	97.155 ^b
Active fuel length, cm	92.96
Enrichment, ²³⁵ U/U wt %	5.74
Fuel density, g/cm ³	10.19

^a See Ref. 16.

^b Includes 1.905-cm-long bottom and 2.286-cm-long top end plugs believed to be of 304-stainless steel.

Table 2.17 Critical data for simple lattice experiments from WCAP-3385^a

Experiment	Enrichment (wt %)	Pitch (cm)	No. of assemblies– assembly size ^b (No. of rods)	Moderator height ^c (cm)
W3385SL1	5.74	1.42	1–19×19	83.71
W3385SL2	5.74	2.012	1–13×14	90.60

^a See Ref. 16.

^b Obtained by approach-to-critical method.

^c Reference from bottom of fuel rod pellet column.

Table 2.18 Critical data for separator plate experiments from ANS Transactions, Vol. 33^a

Experiment	Enrichment (wt %)	Pitch (cm)	Plate material	Plate thickness (cm)	Separation of assemblies ^b (cm)	No. of assemblies— assembly size (No. of rods)	Moderator height, ^c H _c (cm)	Interstitial compound	Interstitial Compound density (g/cm ³)
ANS33AL1	4.742	1.35	aluminum	0.3	2.5	4-18×18	25.66	H ₂ O	1.0
ANS33AL2	4.742	1.35	aluminum	0.3	5.0	4-18×18	32.78	H ₂ O	1.0
ANS33AL3	4.742	1.35	aluminum	0.3	10.0	4-18×18	64.12	H ₂ O	1.0
ANS33EB1	4.742	1.35	aluminum	0.3	2.5	4-18×18	25.54	(CH ₂) _n	0.5540
ANS33EB2	4.742	1.35	aluminum	0.3	5.0	4-18×18	30.73	(CH ₂) _n	0.5796
ANS33EP1	4.742	1.35	aluminum	0.3	2.5	4-18×18	26.98	(CH ₂) _n	0.2879
ANS33EP2	4.742	1.35	aluminum	0.3	5.0	4-18×18	30.16	(C ₈ H ₈) _n	0.3335
ANS33STG	4.742	1.35	aluminum	0.3	2.5	4-18×18	28.61	(C ₈ H ₈) _n	0.0323

^aSee Ref. 5.^bPerpendicular distance between cell boundaries of assemblies.^cMeasured from lower end of fuel rod pellet column.

Table 2.19 Critical data for separator plate experiments from BAW-1484^a

Experiment	Enrichment (wt %)	Pitch (cm)	Plate material	Plate dimensions (cm)	Separation of assemblies ^b (cm)	Plate-to-center assembly distance ^c (cm)	No. of assemblies- assembly size ^d (No. of rods)	Moderator height, ^e H (cm)	Boron concentration (ppm)	
BW1484A1	2.459	1.636	1.614 wt % B aluminum ^f	91.6×155.6×0.645	1.636	0.3725	9-14×14	150.27	15	
BW1484A2	2.459	1.636	0.100 wt % B aluminum ^f	91.6×155.6×0.645	4.908	0.3725	9-14×14	151.69	72	
34	BW1484S1	2.459	1.636	304-L stainless steel	91.6×155.6×0.462	1.636	0.4525	9-14×14	149.90	514
	BW1484S2	2.459	1.636	304-L stainless steel	91.6×155.6×0.462	1.636	0.4525	9-14×14	100.89	432

^aSee Ref. 6.^bBelieved to be the perpendicular distance between cell boundaries of assemblies.^cPerpendicular distance between cell boundary of assembly and near surface of plate.^dFour corner rods of assemblies are 0.635-cm-radius aluminum rods.^eMeasured from the top of the aluminum base plate.^fDensity of 2.7 g/cm³.

Table 2.20 Critical data for separator plate experiments from BAW-1645^a

Experiment	Enrichment (wt %)	Pitch (cm)	Plate ^b material	Plate dimensions (cm)	Separation of assemblies (cm)	Plate-to- assembly distance (cm)	No. of assemblies- assembly size (No. of rods)	Moderator height, ^c H _c (cm)	Boron concentration (ppm)
BW1645S1	2.459	1.2090	aluminum	15.24 × 159.32 ^e × 0.0762	1.778 × 1.778 ^f	0.0	9–15 × 15	100.24	746
BW1645S2	2.459	1.2090	aluminum	15.24 × 159.32 ^e × 0.0762	1.778 × 1.778 ^f	0.0	9–15 × 15	145.00	886
B1645SO1	2.459	1.4097	aluminum	15.24 × 159.32 ^e × 0.0762	1.792 × 1.792 ^f	0.0	9–15 × 15	101.81	1068
B1645SO2	2.459	1.4097	aluminum	15.24 × 159.32 ^e × 0.0762	1.792 × 1.792 ^f	0.0	9–15 × 15	144.85	1156
BW1645T1	2.459	1.2093 ^d	aluminum	15.24 × 159.32 ^e × 0.0762	1.778 × 1.945 ^g	0.0	25–247 ^h	104.82	335
BW1645T2	2.459	1.2093 ^d	aluminum	15.24 × 159.32 ^e × 0.0762	1.778 × 1.945 ^g	0.0	25–247 ^h	143.96	435
BW1645T3	2.459	1.2093 ^d	aluminum	15.24 × 159.32 ^e × 0.0762	2.539 × 2.709 ^g	0.0	25–247 ^h	142.54	361
BW1645T4	2.459	1.2093 ^d	aluminum	15.24 × 159.32 ^e × 0.0762	3.807 × 3.976 ^g	0.0	25–247 ^h	145.64	121

^aSee Ref. 17.^bAssumed to be aluminum.^cMeasured from lower end of pellet column of fuel rods.^dHexagonal lattice.^eMinimum height.^fBelieved to be the perpendicular distance between outermost fuel rods of assemblies.^gPerpendicular distance between outermost fuel rods of assemblies, see Fig. 2.27.^hNine rows of 15, 8 rows of 14, 4 corner rods are aluminum, see Fig. 2.27.

Table 2.21 Critical data for separator plate experiments from DSN No. 399/80^a

Experiment	Enrichment (wt %)	Pitch (cm)	Plate material ^b	Plate dimensions (cm)	Separation of assemblies ^d (cm)	Plate-to- assembly distance (cm)	No. of assemblies- assembly size (No. of rods)	Moderator height, ^d H _c (cm)
DSN399-1	4.742	1.35	hafnium	100×100×0.1046	1.8	0.9 ^e	4-18×18	37.66
DSN399-2	4.742	1.35	hafnium	100×100×0.1046	5.8	2.9 ^e	4-18×18	53.40
DSN399-3	4.742	1.60	hafnium	50×100×0.1046	-	0.8 ^f	1-21×21	49.99
DSN399-4	4.742	1.60	hafnium	50×100×0.1046	-	2.4 ^f	1-20×20	52.83

^aSee Ref. 18.^bDensity of 13.29 g/cm³.^cBelieved to be the perpendicular distance between cell boundaries of assemblies.^dMeasured from lower end of fuel rod pellet column.^eBelieved to be the perpendicular distance between cell boundaries of assemblies and center of plate.^fPerpendicular distance between cell boundary of assembly and near surface of plate.

Table 2.22 Description of separator plates from PNL-2438^{a,b}

Element	Separator plate, wt %						
	Boral-A, Boral-B, Boral-C	Cu-Cd, Cu	Al	Zr-4	Steel: 0.0 wt % B, 1.1 wt % B, 1.6 wt % B	Cd	Boroflex
Al	62.39, 61.21, 59.26,		97.15				
B	28.70, 30.36, 31.88	0.005, 0.0			0.0, 1.05, 1.62		32.74
C	7.97, 8.43, 8.86	0.002, 0.340					21.13
H							2.65
Cd		0.989, 0.0				99.7	
Cr	0.05, 0.0, 0.0		0.21	0.13	18.56, 19.03, 19.60		0.03
Cu	0.09, 0.0, 0.0	98.685, 99.60	0.12		0.27, 0.28, 0.26		
Fe	0.33, 0.02, 0.05	0.020, 0.004	0.82	0.21	68.24, 68.04, 66.40		0.05
Mg	0.05, 0.01, 0.01	0.0, 0.002					
Mn	0.05, 0.0, 0.0	0.009, 0.0	0.21		1.58, 1.58, 1.69		
Mo					0.26, 0.49, 0.31		
Na	0.02, 0.02, 0.02	0.0, 0.002					
Ni	0.02, 0.0, 0.0	0.01, 0.0			11.09, 9.53, 10.12		
O		0.019, 0.03					21.01
Si	0.2, 0.0, 0.06	0.004, 0.02	0.82				22.39
Sn		0.25, 0.0		1.5			
S	0.03, 0.0, 0.0	0.0, 0.002	0.06				
Ti			0.61				
Zn	0.10, 0.0, 0.0	0.007, 0.0				0.3	
Zr				98.16			
Density, g/cm ³	2.49, 2.50, 2.47	8.910, 8.913	2.692	6.32	7.930, 7.900, 7.770	8.650	1.731
Thickness, cm	0.713 ^c , 0.292 ^d , 0.231 ^e	0.357, 0.646 or 0.337 ^f	0.625	0.652	0.485 or 0.302, 0.298, 0.298	0.061	0.546, ^g 0.772 ^g

^aSee Ref. 9.^bSeparator plates are 91.5 cm long by 35.6 cm wide.^cIncludes 0.102-cm-thick aluminum on sides of Boral-A.^dIncludes 0.038-cm-thick aluminum on sides of Boral-B.^eIncludes 0.025-cm-thick aluminum on sides of Boral-C.^fSeparator plate is 30.6 cm wide.^gIncludes 0.160-cm-thick Plexiglas on sides of Boroflex.

Table 2.23 Critical data for separator plate experiments from PNL-2438^a

Experiment	Enrichment (wt %)	Pitch (cm)	Plate material	Plate thickness (cm)	Separation of assemblies, ^b X _c (cm)	Plate-to- assembly distance, ^c G (cm)	No. of assemblies- assembly size (No. of rods)
P2438AL	2.35	2.032	aluminum	0.625	8.67	0.645	3-20×16
P2438BA	2.35	2.032	Boral-A	0.713	5.05	0.645	2-22×16;1-20×16 ^d
P2438CU	2.35	2.032	copper	0.646	6.62	0.645	3-20×16
P2438SS	2.35	2.032	stainless steel	0.485	6.88	0.645	3-20×16
P2438ZR	2.35	2.032	Zircaloy-4	0.652	8.79	0.645	3-20×16

^aSee Ref. 9.^bPerpendicular distance between cell boundaries of assemblies.^cPerpendicular distance between cell boundary of center assembly and near surface of plate.^dCenter assembly.

Table 2.24 Critical data for separator plate experiments from PNL-2615^a

Experiment	Enrichment (wt %)	Pitch (cm)	Plate material	Plate thickness (cm)	Separation of assemblies, ^b X _c (cm)	Plate-to-assembly distance, ^c G (cm)	No. of assemblies- assembly size (No. of rods)
P2615AL	4.31	2.540	aluminum	0.625	10.72	0.105	3-15×8
P2615BA	4.31	2.540	Boral-A	0.713	6.72	3.277	3-15×8
P2615CD1	4.31	2.540	cadmium	0.2006	7.28	3.277	3-15×8
P2615CD2	4.31	2.540	cadmium	0.2006	5.68	0.529	3-15×8
P2615CU	4.31	2.540	copper	0.646	8.15	0.084	3-15×8
P2615SS	4.31	2.540	stainless steel	0.485	8.58	0.245	3-15×8
P2615ZR	4.31	2.540	Zircaloy-4	0.652	10.92	0.078	3-15×8

^aSee Ref. 19.^bPerpendicular distance between cell boundaries of assemblies.^cPerpendicular distance between cell boundary of center assembly and near surface of plate.

Table 2.25 Criticality data for separator plate experiments from PNL-3314^a

Experiment	Enrichment (wt %)	Pitch (cm)	Plate material	Plate thickness (cm)	Separation of assemblies, ^b X _c ; Y _c (cm)	No. of assemblies- assembly size (no. of rods)
P3314CU5	2.35	1.684	Copper	0.337	5.24	2-20×18;1-25×18 ^c
P3314CU6	2.35	1.684	Copper-Cd	0.357	2.60	2-20×18;1-25×18 ^c
P3314CD2	2.35	1.684	Cadmium	0.061	3.04	2-17×20;1-25×20 ^c
P3314BS4	2.35	1.684	Steel, 0.0 wt % B	0.302	7.80	2-17×20;1-25×20 ^c
P3314BS1	2.35	1.684	Steel, 1.1 wt % B	0.298	3.86	2-17×20;1-25×20 ^c
P3314BS2	2.35	1.684	Steel, 1.6 wt % B	0.298	3.46	2-17×20;1-25×20 ^c
P3314CU3	4.31	1.892	Copper	0.337	10.36	3-12×16
P3314CU4	4.31	1.892	Copper-Cd	0.357	7.61	3-12×16
P3314BS4	4.31	1.892	Steel, 0.0 wt % B	0.302	10.52	3-12×16
P3314BS3	4.31	1.892	Steel, 1.1 wt % B	0.298	7.23	3-12×16
P3314BS4	4.31	1.892	Steel, 1.6 wt % B	0.298	6.63	3-12×16
P3314CU1	4.31	1.892	Copper	0.337	2.83, 5.94	2-9×12; 2-9×7
P3314CU2	4.31	1.892	Copper	0.646	2.83, 2.67	2-9×12; 2-9×5
P3314CD1	4.31	1.892	Cadmium	0.061	2.83, 5.30	2-11×14; 2-11×13
P3315SS1	4.31	1.892	Steel, 0.0 wt % B	0.302	2.83, 3.38	2-9×12; 2-9×2
P3314SS2	4.31	1.892	Steel, 0.0 wt % B	0.302	2.83, 11.55	2-9×12; 2-9×13
P3314SS3	4.31	1.892	Steel, 0.0 wt % B	0.485	2.83, 4.47	2-9×12; 2-9×5
P3314BS4	4.31	1.892	Steel, 0.0 wt % B	0.485	2.83, 8.36	2-9×12; 2-9×12
P3314AL	4.31	1.892	Aluminum	0.625	2.83, 9.04	2-9×12; 2-9×1
P3314ZR	4.31	1.892	Zircaloy-4	0.652	2.83, 11.04	2-9×12; 2-9×1
P3314BF1	4.31	1.892	Boroflex	0.546	2.83, 3.60	2-11×14; 2-11×14
P3314BF2	4.31	1.892	Boroflex	0.772	2.83, 4.94	2-11×14; 2-11×16
P3314BC	4.31	1.892	Boral-C	0.231	2.83, 3.53	2-11×14; 2-11×14
P3314BA	4.31	1.892	Boral-A	0.713	2.83, 4.80	2-11×14; 2×11×16

^aSee Ref. 11.^bPerpendicular distance between cell boundaries of assemblies.^cCenter assembly.

Table 2.26 Description of Boral separator plates in experiments from PNL-6205 and PNL-7167^a

Element	Separator plate, wt %	
	PNL-6205	PNL-7167
Al	54.33	62.54
B	35.63	29.22
C	9.95	8.16
O	0.07	0.06
Fe	0.02	0.02
Core density, g/cm ³	2.64	2.64
Core thickness, cm	0.683 ^b	0.673 ^b
Length, cm	96	96
Width, cm	45	45

^aSee Refs. 21 and 22.^bIncludes two 0.1015-cm-thick aluminum side plates.

Table 2.27 Critical data for separator plate experiments from PNL-6205 and PNL-7167^a

Experiment	Enrichment (wt %)	Pitch (cm)	Plate material 1	Plate thickness ^b (cm)	Separation of assemblies ^c (cm)	Plate-to- assembly distance ^d (cm)	No. of assemblies- assembly size (No. of rods)	Void material in flux trap
P62FT231	4.31	1.891	Boral	0.683	5.19	0.057	4-16×15	None
P71F14F3	4.31	1.891	Boral	0.673	5.19	0.057	3-14×15; 1-15×15	14 fuel rods on 1.891-cm pitch
P71F14V3	4.31	1.891	Boral	0.673	5.19	0.057	3-14×15; 1-15×15	3-0.63-cm-thick equally spaced aluminum plates
P71F14V5	4.31	1.891	Boral	0.673	5.19	0.057	3-15×15; 1-15×16	14-1.27-cm-diam aluminum rods on 1.891-cm pitch
P71F214R	4.31	1.891	Boral	0.673	5.19	0.057	3-16×15; 1-15×15	None

^aSee Refs. 20 and 21^bIncludes two 0.1015-cm-thick aluminum side plates.^cPerpendicular distance between cell boundaries of assemblies.^dPerpendicular distance between cell boundaries of assemblies and near surface of plate.

Table 2.28 Modeled assemblies of PNL-6205 and PNL-7167 separator plate experiments

Experiment	No. of rods, experiment	No. of rods, delayed critical (predicted)	No. of rods modeled	Modeled assemblies (No. rows × fuel rods per row)			
				Top left	Top right	Bottom left	Bottom right
P62FT231	960	963	963	15×16	15×16	15×16	12×16, 3×17 ^a
P71F14F3	855	858.5	858	12×14, 3×15 ^a	15×14	15×15	15×14
P71F14V3	855	862.1	862	15×14	15×15	15×14	8×14, 7×15 ^a
P71F14V5	915	924.9	925	1×10 ^b , 15×15 ^a	16×15	15×15	15×15
P71F214R	945	952	952	15×16	15×16	15×16	7×16, 8×15 ^a

^aBottom rows.^bAligned against right assembly boundary.

Table 2.29 Critical data for reflecting wall experiments from PNL-2827^a

Experiment	Enrichment (wt %)	Pitch (cm)	Reflector material	Separation of assemblies, ^b X_c (cm)	Wall-to-assembly distance, ^c Y (cm)	No. of assemblies- assembly size (No. of rods)
P2827L1	2.35	2.032	lead	13.27	0.66	3-19×16
P2827L2	2.35	2.032	lead	11.25	2.616	3-19×16
P2827L3	4.31	2.540	lead	20.78	0.66	3-13×8
P2827L4	4.31	2.540	lead	19.04	1.321	3-13×8
P2827U1	2.35	2.032	depleted uranium	11.83	0.0	3-19×16
P2827U2	2.35	2.032	depleted uranium	14.11	1.956	3-19×16
P2827U3	4.31	2.540	depleted uranium	15.38	0.0	3-13×8
P2827U4	4.31	2.540	depleted uranium	15.32	1.956	3-13×8

^a See Ref. 10.^b Perpendicular distance from outer rod surface to outer rod surface of assemblies.^c Perpendicular distance between cell boundaries of assemblies and near surface of reflecting walls.

Table 2.30 Critical data for reflecting wall experiments from PNL-3602^a

Experiment	Enrichment (wt %)	Pitch (cm)	Reflector material	Separator of assemblies, ^b X _c (cm)	Wall-to- assembly distance, ^c Y(cm)	No. of assemblies- assembly size (No. of rods)	Grid plates material
P3602N11	2.35	1.684	steel	8.98	0.0	2-20×18; 1-25×18 ^d	polypropylene
P3602N12	2.35	1.684	steel	9.58	0.66	2-20×18; 1-25×18 ^d	polypropylene
P3602N13	2.35	1.684	steel	9.66	1.684	2-20×18; 1-25×18 ^d	polypropylene
P3602N14	2.35	1.684	steel	8.54	3.912	2-20×18; 1-25×18 ^d	polypropylene
P3602N21	2.35	2.032	steel	11.20	0.66	2-20×18; 1-25×18 ^d	polypropylene
P3602n22	2.35	2.032	steel	10.36	2.616	3-19×16	acrylic
P3602N31	4.31	1.892	steel	14.87	0.0	3-19×16	acrylic
P3602N32	4.31	1.892	steel	15.74	0.66	3-12×16	acrylic
P3602N33	4.31	1.892	steel	15.87	1.321	3-12×16	polypropylene
P3602N34	4.31	1.892	steel	15.84	1.956	3-12×16	polypropylene
P3602N35	4.31	1.892	steel	15.45	2.616	3-12×16	polypropylene
P3602N36	4.31	1.892	steel	13.82	5.405	3-13×8	polypropylene
P3602N41	4.31	2.540	steel	12.89	0.0	3-13×8	acrylic
P3602N42	4.31	2.540	steel	14.12	1.321	3-13×8	acrylic
P3602N43	4.31	2.540	steel	12.44	2.616	3-13×8	acrylic

^a See Ref. 22.^b Perpendicular distance from outer rod surface to outer rod surface of assemblies.^c Perpendicular distance between cell boundary of assembly and near surface of reflecting wall.^d Center assembly.

Table 2.31 Critical data for reflecting wall experiments from PNL-3926^a

Experiment	Enrichment (wt %)	Pitch (cm)	Reflector material	Separation of assemblies, ^b X _c (cm)	Wall-to-assembly distance, ^c Y(cm)	No. of assemblies- assembly size (No. of rods)
P3926L1	2.35	1.684	lead	10.06	0.0	2-20×18; 1-23×18 ^d
P3926L2	2.35	1.684	lead	10.11	0.66	2-20×18; 1-23×18 ^d
P3926L3	2.35	1.684	lead	8.50	3.276	2-20×18; 1-23×18 ^d
P3926L4	4.31	1.892	lead	17.74	0.0	3-12×16
P3926L5	4.31	1.892	lead	18.18	0.66	3-12×16
P3926L6	4.31	1.892	lead	17.43	1.956	3-12×16
P3926U1	2.35	1.684	depleted uranium	8.06	0.0	2-20×18; 1-23×18 ^d
P3926U2	2.35	1.684	depleted uranium	9.50	1.321	2-20×18; 1-23×18 ^d
P3926U3	2.35	1.684	depleted uranium	9.19	3.912	2-20×18; 1-23×18 ^d
P3926U4	4.31	1.892	depleted uranium	15.33	0.0	3-12×16
P3926U5	4.31	1.892	depleted uranium	19.24	1.956	3-12×16
P3926U6	4.31	1.892	depleted uranium	18.78	3.276	3-12×16

^a See Ref. 12.^b Perpendicular distance from outer rod surface to outer rod surface of assemblies.^c Perpendicular distance between cell boundary of assemblies and near surface of reflecting walls.^d Center assembly.

Table 2.32 Critical data for reflecting wall-separator plate experiments from PNL-3602^a

Experiment	Enrichment (wt %)	Pitch (cm)	Plate material	Plate thickness (cm)	Reflecting wall material	Separation of assemblies, ^b X_c (cm)	Wall-to- assembly distance, ^c Y (cm)	No. of assemblies- assembly size (No. of rods)
P3602BB	4.31	1.892	Boral-B	0.292	steel	8.30	1.956	3-12×16
P3602BS1	2.35	1.684	1.1 wt % B steel	0.298	steel	4.80	1.321	2-20×18; 1-25×18 ^d
P3602BS2	4.31	1.892	1.1 wt % B steel	0.298	steel	9.83	1.956	3-12×16
P3602CD1	2.35	1.684	cadmium	0.061	steel	3.86	1.321	2-20×18; 1-25×18 ^d
P3602CD2	4.31	1.892	cadmium	0.061	steel	8.94	1.956	3-12×16
P3602CU1	2.35	1.684	copper	0.337	steel	7.79	1.321	2-20×18; 1-25×18 ^d
P3602CU2	2.35	1.684	99 wt % copper- 1 wt % cadmium	0.357	steel	5.43	1.321	2-20×18; 1-25×18 ^d
P3602CU3	4.31	1.892	copper	0.337	steel	13.47	1.956	3-12×16
P3602CU4	4.31	1.892	99 wt % copper- 1 wt % cadmium	0.357	steel	10.57	1.956	3-12×16
P3602SS1	2.35	1.684	steel	0.302	steel	8.28	1.321	2-20×18; 1-25×18 ^d
P3602SS2	4.31	1.892	steel	0.302	steel	13.75	1.956	3-12×16

^a See Ref. 22.^b Perpendicular distance from outer rod surface to outer rod surface of assemblies.^c Perpendicular distance between cell boundary of assemblies and near surface of reflecting walls.^d Center assembly.

Table 2.33 Critical data for reflecting wall-separator plate experiments^a

Experiment	Enrichment (wt %)	Pitch (cm)	Plate material ^b	Plate thickness ^c (cm)	Reflector material	Reflector thickness, E (cm)	Separation of assemblies ^d (cm)	Plate-to- assembly distance ^e (cm)	Wall-to- assembly distance ^f (cm)	No. of assemblies- assembly size ^g (No. of rods)	Moderator height, ^h H _c (cm)
PAT80L1	4.742	1.6	Boral	0.65	lead ⁱ	10.0	4.9	0.8	1.68	4-18×18	53.98
PAT80L2	4.742	1.6	Boral	0.65	lead ⁱ	10.0	4.9	0.8	3.95	4-18×18	63.85
PAT80SS1	4.742	1.6	Boral	0.65	steel ^j	15.0	4.9	0.8	1.68	4-18×18	51.55
PAT80SS2	4.742	1.6	Boral	0.65	steel ^j	15.0	4.9	0.8	3.95	4-18×18	61.84

^a See Ref. 23.^b Boral (2.6189 g/cm³): 71.63 wt % Al, 22.20 wt % B, and 6.17 wt % C.^c Includes 0.11-cm-thick aluminum (2.651 g/cm³) sides.^d Perpendicular distance between the center of outer rods of assemblies.^e Perpendicular distance between the center of outer rods of assemblies and near surface of plates.^f Perpendicular distance between the center of outer rods of assemblies and near surface of reflecting walls.^g Includes four 1.0-cm-diam stainless steel corner rods.^h Measured from lower end of fuel rod pellet column.ⁱ Lead (11.34 g/cm³).^j Steel (7.8 g/cm³): 99.66 wt % Fe, 0.20 wt % Si, and 0.14 wt % C.

Table 2.34 Physical properties of UO₂ fuel rods from BAW-1810^a

Parameter	Value
Outside diameter, cm	1.2078
Wall thickness, cm	0.0406
Wall material	304 stainless steel
Fuel diameter, cm	1.128
Total length, cm	181.6 ^b
Active fuel length, cm	169.4
Enrichment, ²³⁵ U/U, wt %	4.020
Fuel density, g/cm ³	9.46

^aSee Ref. 24.^bIncludes approximately 5.967-cm-long stainless steel end plugs.Table 2.35 Physical properties of UO₂-Gd₂O₃ fuel rods from BAW-1810^a

Parameter	Value
Outside diameter, cm	1.207
Wall thickness, cm	0.081
Wall material	aluminum
Fuel pellet diameter, cm	1.030
Total length, cm	160.02 ^b
Active fuel length, cm	153.42
Enrichment, ²³⁵ U/U, wt %	1.944
Gadolinia, wt %	4.00
UO ₂ density, g/cm ³	10.24
Gd ₂ O ₃ density, g/cm ³	0.410
Gd density, g/cm ³	0.356
O density, g/cm ³	0.054

^aSee Ref. 24.^bIncludes 0.3175-cm-long aluminum end plugs and 5.97 cm of void above the 153.42-cm-long pellet stack (active fuel).

Table 2.36 Critical data for $\text{UO}_2\text{-Gd}_2\text{O}_3$ rod experiments from BAW-1810^a

Experiment	Enrichment (wt %)	Pitch (cm)	No. of 2.459 wt % ^{235}U rods	No. of 4.020 wt % ^{235}U rods	No. of $\text{UO}_2\text{-Gd}_2\text{O}_3$ rods	No. of water holes	Moderator height, ^b H (cm)	Boron concentration (ppm)
BW1810A	2.459	1.636	4788	0	20	153	145.0	1239.3
BW1810B	2.459	1.636	4772	0	36	153	145.0	1170.7
BW1810C	2.459 and 4.020	1.636	3676	912 ^c	32	180	145.0	1499.0
BW1810D	2.459 and 4.020	1.636	3920	860 ^d	28	153	145.0	1653.8
BW1810E	2.459 and 4.020	1.636	3920	852 ^e	36	153	145.0	1579.4

^aSee Ref. 24.^bMeasured from the top of the 5.08-cm-thick aluminum base plate.^cInner 32 × 32 lattice positions including 80 water holes and 32 Gd_2O_3 rods.^dInner 31 × 31 lattice positions including 73 water holes and 28 Gd_2O_3 rods.^eInner 31 × 31 lattice positions including 73 water holes and 36 Gd_2O_3 rods.

Table 2.37 Critical data for water hole experiments from BAW-1810^a

Experiment	Enrichment (wt %)	Pitch (cm)	No. of 2.459 wt % ^{235}U rods	No. of 4.020 wt % ^{235}U rods	No. of water holes	Moderator height, ^b H (cm)	Boron concentration (ppm)
BW1810F	2.459	1.636	4808	0	153	145.0	1337.9
BW1810G	2.459 and 4.020	1.636	3676	944 ^c	180	145.0	1776.8
BW1810H	2.459 and 4.020	1.636	3920	888 ^d	153	145.0	1899.3

^a See Ref. 24.^bMeasured from the top of the 5.08-cm-thick aluminum base plate.^cInner 32 × 32 lattice positions including 80 water holes.^dInner 31 × 31 lattice positions including 73 water holes.

Table 2.38 Critical data for **NSE71W1** and **NSE71W2** water hole experiments^a

Experiment	Enrichment (wt %)	Pitch (cm)	No. of assemblies— assembly size (No. of positions)	No. of fuel rods	No. of water holes	Frequency of water holes	Moderator height, ^b H _c
NSE71W1	4.742	1.26	1–22×22	459	25	1 in 5 positions	81.36
NSE71W2^c	4.742	1.26	1–22×22	420	64	1 in 3 positions	73.05

^aSee Ref. 8.^bMeasured from lower end of fuel rod pellet column.^cGiven as an example in Ref. 8.

Table 2.39 Critical data for water hole experiments from PNL-3314^a

Experiment	Enrichment (wt %)	Pitch (cm)	No. of assemblies- assembly size (No. of positions)	No. of fuel rods		No. of water holes
				Predicted ^b	Modeled	
P3314W1	4.31	1.892	1-14×14	167.6	168	25
P3314W2	2.35	1.684	1-23×23	485.8	486	25

^aSee Ref. 11.^bObtained by approach-to-critical method.Table 2.40 Critical data for water hole experiments from WCAP-3269^a

Experiment	Enrichment (wt %)	Pitch (cm)	No. of assemblies- assembly size (No. of positions)	No. of fuel rods	No. of water holes	Moderator height, ^b H _c
W3269W1	2.72	1.524	1-31×31	945	16	37.21
W3269W2	5.7	1.422	1-27×17	453	6	51.93

^aSee Ref. 15.^bBelieved to have been measured from the bottom of fuel, see Figs. 2.20 and 2.21.Table 2.41 Properties of B₄C absorber rods from BAW-1484^a

Parameter	Value
Outside diameter, cm	1.113
Wall thickness, cm	0.089
Wall material	aluminum
Total length, cm	177.5 ^b
Active length, cm	177.18
B ₄ C powder density, g/cm ³	1.28

^aSee Ref. 6.^bIncludes 0.3175-cm-long aluminum bottom end plug.

Table 2.42 Critical data for B₄C absorber rod experiments from BAW-1484^a

Experiment	Enrichment (wt %)	Pitch (cm)	Separation of assemblies ^b (cm)	No. of assemblies- assembly size ^c (No. of rods)	No. of absorber rods	Moderator height, ^d H (cm)
BW1484C1	2.459	1.636	1.636	9–14×14	84	145.68
BW1484C2	2.459	1.636	4.908	9–14×14	34	111.49

^aSee Ref. 6.^bBelieved to be the perpendicular distance between cell boundaries of assemblies.^cFour corner rods of assemblies are 0.635-cm-radius aluminum rods.^dMeasured from the top of the aluminum base plate.

Table 2.43 Properties of Ag-In-Cd absorber rods from BAW-1810^a

Parameter	Value
Outside diameter, cm	1.207
Wall thickness, cm	0.081
Wall material	aluminum
Length, cm	157.56 ^b
Wt % Ag	79.68
Wt % In	15.09
Wt % Cd	5.2
Wt % Cu	0.05
Wt % Zr	0.02
Density, g/cm ³	10.15

^aSee Ref. 25.^bMinus the 0.3175-cm-long aluminum bottom end plug.

Table 2.44 Critical data for absorber rod experiments from BAW-1810^a

Experiment	Enrichment (wt %)	Pitch (cm)	No. of 2.459 wt % ^{235}U rods	No. of 4.020 wt % ^{235}U rods	Absorber rod	No. of absorber rods	No. of water holes	Moderator height, ^b H (cm)	Boron concentration (ppm)
BW1810I	2.459	1.636	4808	0	Ag-In-Cd	16	137	145.0	1250.0
BW1810J	2.459 and 4.020	1.636	3920	888 ^c	B_4C	16	137	145.0	1635.4

^a See Ref. 24.^bMeasured from the top of the 5.08-cm-thick aluminum base plate.^cInner 31 × 31 positions include 57 water holes and 16 B_4C rods.

Table 2.45 Critical data for Ag-In-Cd absorber rod experiments from WCAP-3269^a

Experiment	Enrichment (wt %)	Pitch (cm)	No. of assemblies- assembly size (No. of rods)	No. of fuel rods	No. of Ag-In-Cd rods ^b	Ag-In-Cd rod diameter (cm)	Moderator height ^c (cm)
W3269A	5.7	1.422	1-27×17	453	6	1.024	88.27
W3269B1	3.7	1.105	1-47×47 ^d	2221	12	0.838	55.41
W3269B2	3.7	1.105	1-47×47 ^d	2209	24	0.838	64.56
W3269B3	3.7	1.105	1-47×47 ^d	2185	48	0.838	57.00
W3269C	2.72	1.524	1-31×31	945	16	1.024	89.75

^aSee Ref. 15.^bRods taken to be 79.6 wt % Ag, 15.17 wt % In, 5.08 wt % Cd with a density of 9.91 g/cm³.^cBelieved to have been measured from the bottom of the fuel, see Figs. 2.20 and 2.21.^dIncludes 24 fuel follower rods positioned outside the array (see Figs. 2.58, 2.59, and 2.60).

Physical Description

Table 2.46 Critical data for soluble boron experiments from BAW-1231^a

Experiment	Enrichment (wt %)	Pitch (cm)	No. of fuel rods	Moderator height ^b (cm)	Boron concentration (ppm)
BW1231B1	4.020	1.511	936	167.5	1152
BW1231B2	4.020	1.511	4904	146.65	3389

^aSee Ref. 25.

^bMeasured from the bottom of the active fuel or reference plane of Fig. 2.62.

Table 2.47 Critical data for soluble boron experiment **BW1273M**^a

Experiment	Enrichment (wt %)	Pitch (cm)	No. of fuel rods	Moderator height, ^b H (cm)	Boron concentration (ppm)
BW1273M	2.459	1.511	5137	93.2	1675

^aSee Ref. 26.

^bMeasured from the bottom of the active fuel or reference plane in Fig. 2.63.

Table 2.48 Critical data for soluble boron experiments from BAW-1484^a

Experiment	Enrichment (wt %)	Pitch (cm)	Separation of assemblies ^b (cm)	No. of assemblies- assembly size ^c (No. of rods)	Moderator height ^d (cm)	Boron concentration (ppm)
BW1484B1	2.459	1.636	0.0	9–14×14	144.29	1037
BW1484B2	2.459	1.636	1.636	9–14×14	100.32	702
BW1484B3	2.459	1.636	4.908	9–14×14	149.12	143

^aSee Ref. 6.

^bBelieved to be the perpendicular distance between cell boundaries of assemblies.

^cFour corner rods of assemblies are 0.635-cm-radius aluminum rods.

^dMeasured from the top of the aluminum base plate.

Table 2.49 Critical data for soluble boron experiments from EPRI NP-196^a

Experiment	Enrichment (wt %)	Pitch (cm)	No. of rods	Moderator height ^b (cm)	Boron concentration (ppm)
EPRI65B	2.35	1.562	1201	111.76	463.8
EPRI75B	2.35	1.905	1201	112.08	568
EPRI87B	2.35	2.210	885	111.76	285.8

^aSee Ref. 7.

^bMeasured from the base of the aluminum solid plate.

Table 2.50 Critical data for soluble boron experiments PNL-4267^a

Experiment	Enrichment (wt %)	Pitch (cm)	Array width (No. of rods)	Total No. of rods		Boron concentration (g/l)
				Predicted ^b	Modeled	
P4267B1	4.31	1.890	40	922.8	923	2.15±0.35
P4267B2	4.31	1.890	40	1236.8	1237	2.55±0.07
P4267B3	4.31	1.715	44	737.0	737	1.03±0.05
P4267B4	4.31	1.715	44	916.96	917	1.82±0.30
P4267B5	4.31	1.715	44	1191.96	1192	2.55±0.21

^aSee Ref. 13.^bObtained by approach-to-critical method.Table 2.51 Atom densities (atoms/b-cm) of fuel in critical experiments from Y-DR-14^a

Experiment	²³⁵ U	²³⁸ U	H	C	F
YDR14UN2	1.330E-4	6.437E-3	3.910E-2	1.880E-2	2.628E-2
YDR14PL2	1.119E-4	5.415E-3	4.547E-2	2.186E-2	2.211E-2
YDR14PL3	2.349E-4	7.500E-3	3.134E-2	1.507E-2	3.094E-2
YDR14UN3	2.349E-4	7.500E-3	3.134E-2	1.507E-2	3.094E-2

^aSee Ref. 27.Table 2.52 Criticality data for homogenized uranium experiments from Y-DR-14^a

Experiments	Enrichment (wt %)	Fuel form	Fuel dimensions (cm)	Reflector
YDR14PL2	2.00	U(2)F ₄	53.67×53.67×54.29	15.2-cm paraffin on top and sides 15.2-cm Plexiglas ^b on bottom
YDR14PL3	3.00	U(3)F ₄	43.47×43.47×86.39	15.2-cm paraffin on top and sides 15.2-cm Plexiglas ^b on bottom
YDR14UN2	2.00	U(2)F ₄	56.22×56.22×122.47	none
YDR14UN3	3.00	U(3)F ₄	56.47×56.47×86.64	none

^aSee Ref. 27.^bVolume fraction: 0.918 Plexiglas, 0.062 aluminum, 0.01 void.

Table 2.53 Cuboid fuel can descriptions for **CR1071AS, CR1653AS, CR2500S^a**

Parameter	CR1071AS	CR1653AS	CR2500S
Can			
Material ^b	aluminum	aluminum	aluminum
Can volume, cm ³	(15.28) ³	(15.24) ³	(15.24) ³
Wall thickness, ^c cm	0.15	0.16	0.16
Cavity volume, cm ³	(14.98) ³	(14.92) ³	(14.92) ³
Vinyl tape mass, g	3	3.0	3.4
Mylar tape mass, g	4	4.0	5.9
Cavity contents			
U ₃ O ₈ mass, g	15088	15084	15081
H ₂ O mass, g	314	533.4	905.3
C ₂ H ₄ mass, g	53	53.0	53.0
U₃O₈ enrichment			
²³⁴ U, wt %	0.03	0.030	0.03
²³⁵ U, wt %	4.46	4.481	4.48
²³⁶ U, wt %	0.08	0.089	0.09
²³⁸ U, wt %	95.43	95.399	95.40

^aSee Refs. 28-31.^bDensity of 2.713 g/cm³.^cWalls have water injection holes (56 total) of 0.64 cm diameter.

Table 2.54 Materials for damp uranium oxide experiments^a

Element, wt %	Fire- retardant Plexiglas	Glue ^b	Vinyl tape	Mylar tape	Nonfire- retardant Plexiglas	Paper ^b	Polyethylene
Al			0.5				
Br	7.10						
C	52.03	86.29	45.91	65.50	59.52	42.17	84.90
Ca			6.9				
Cl	1.81		25.73				
H	7.16	11.67	5.92	6.83	7.84	6.48	14.01
N	0.16		0.16				
O	29.82	1.20	10.82	27.02	32.23	49.50	1.20
P	1.02						
Pb			1.1				
Si			0.6				
Ti			1.6				
Zn			0.1				
Density, g/cm ³	1.284	0.728	1.310	1.11	1.185	0.766	0.824

^aSee Ref. 29.^bPlates of both Plexiglas types covered with paper (0.49 wt %) and glue (0.16 wt %).

Table 2.55 Cuboid dimensions^a (cm) of Fig. 2.69 for CR1071AS^b

Core				Reflector interior				Reflector exterior				Faceplate thickness		Frame extender thickness		Gap		Filler thickness						
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
68.0	34.4	34.4	50.6	68.0	34.7	34.7	50.6	128.4	65.3	74.5	133.6	1.23	1.23	7.4	-	-	-	8.5	8.5	4.9	12.2	7.3	7.3	26.1

^aCalculated from photograph.^bSee Ref. 29.^cDimensions for plastic reflector of shape seen in Figure 2.72.

Table 2.56 Cuboid dimensions (cm) of Fig. 2.70 for CR1653AS^a

Core					Reflector interior					Reflector exterior					
L	M	N	O	P ^b	G	H	I	J	K	A ^c	B ^c	C	D	E	F
33.3	33.3	68.9	50.9	1.26	33.5	33.6	69.0	69.2	69.2	60.0	73.5	128.3	134.4	-	0.5

^aSee Ref. 30.^bVoid.^cIncludes 1.23-cm-thick nonfire-retardant Plexiglas on mating face.

Physical Description

Table 2.57 Cuboid dimensions for **CR2500S^a**

	Cuboid		Dimension (cm)
Core ^b	North table	East/west	50.8
		North/south	33.3
		Vertical	51.1
	South table	East/west	51.1
		North/south	33.4
		Vertical	51.1
Reflector interior ^c	North table	East/west	77.6
		North/south	33.5
		Vertical	51.1
	South table	East/west	77.4
		North/south	33.9
		Vertical	51.1
Reflector exterior ^c	North table	East/west	128.3
		North/south	59.7 ^{d,e}
		Vertical	132.5
	South table	East/west	128.4
		North/south	74.4 ^d
		Vertical	134.6
Core location ^f	North table	West	25.3
		Bottom	55.1
	South table	West	25.8
		Bottom	55.4

^aSee Ref. 31.

^bPlanar and elevation views of core seen in Fig. 2.70.

^cDimensions for plastic reflector of shape seen in Fig. 2.72.

^dIncludes 1.215-cm-thick faceplate.

^eIncludes thickness of plastic inserted between frame and end panel.

^fLocates the lower west corner of the core relative to the reflector exterior.

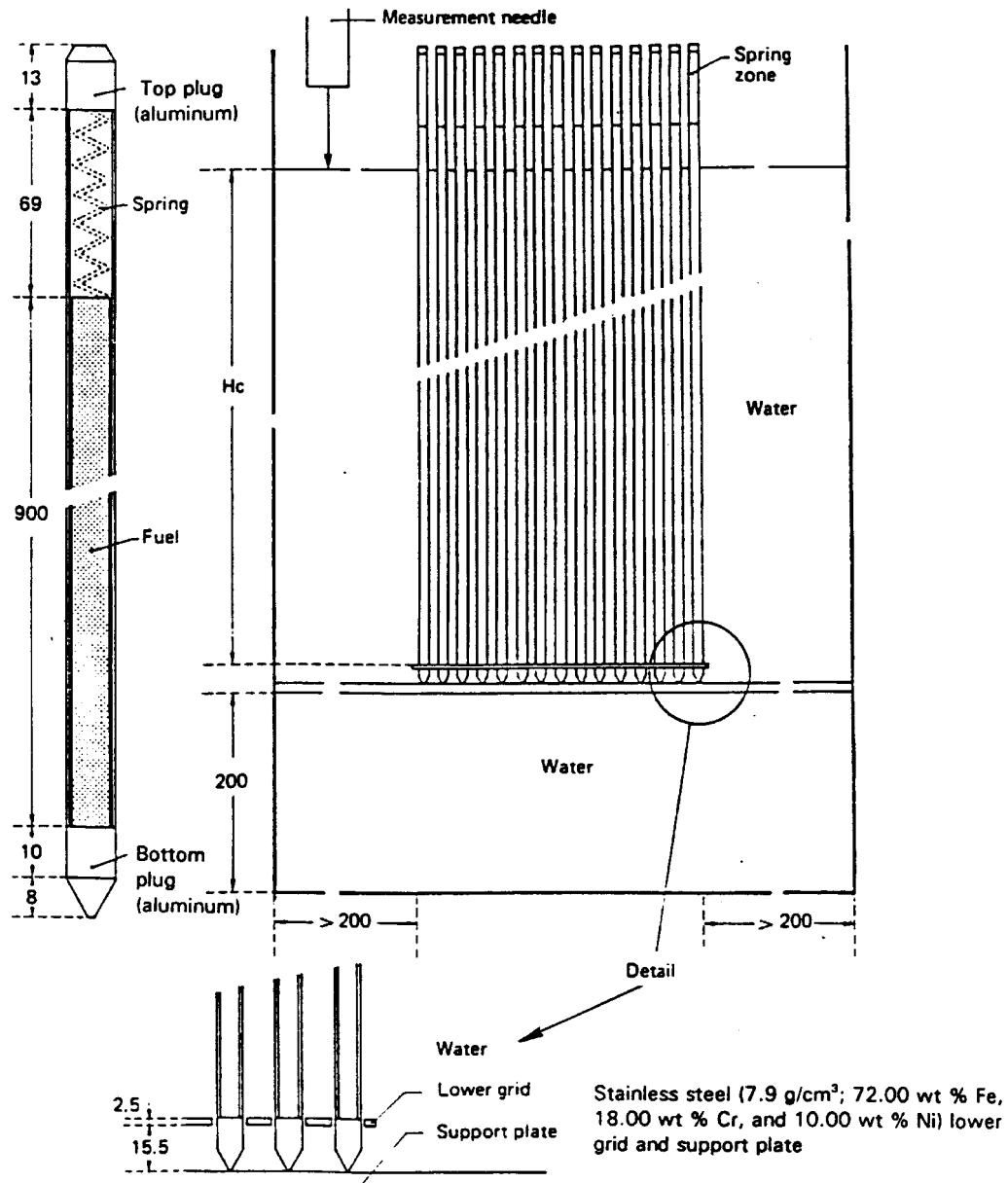


Figure 2.1 Principal dimensions (in centimeters) of 4.742 wt % UO_2 fuel rods for ANS Transactions, Vol. 33, and NS&E, Vol. 71, and assembly for NS&E, Vol. 71. Source: Refs. 5 and 8 (Reprinted with permission by author).

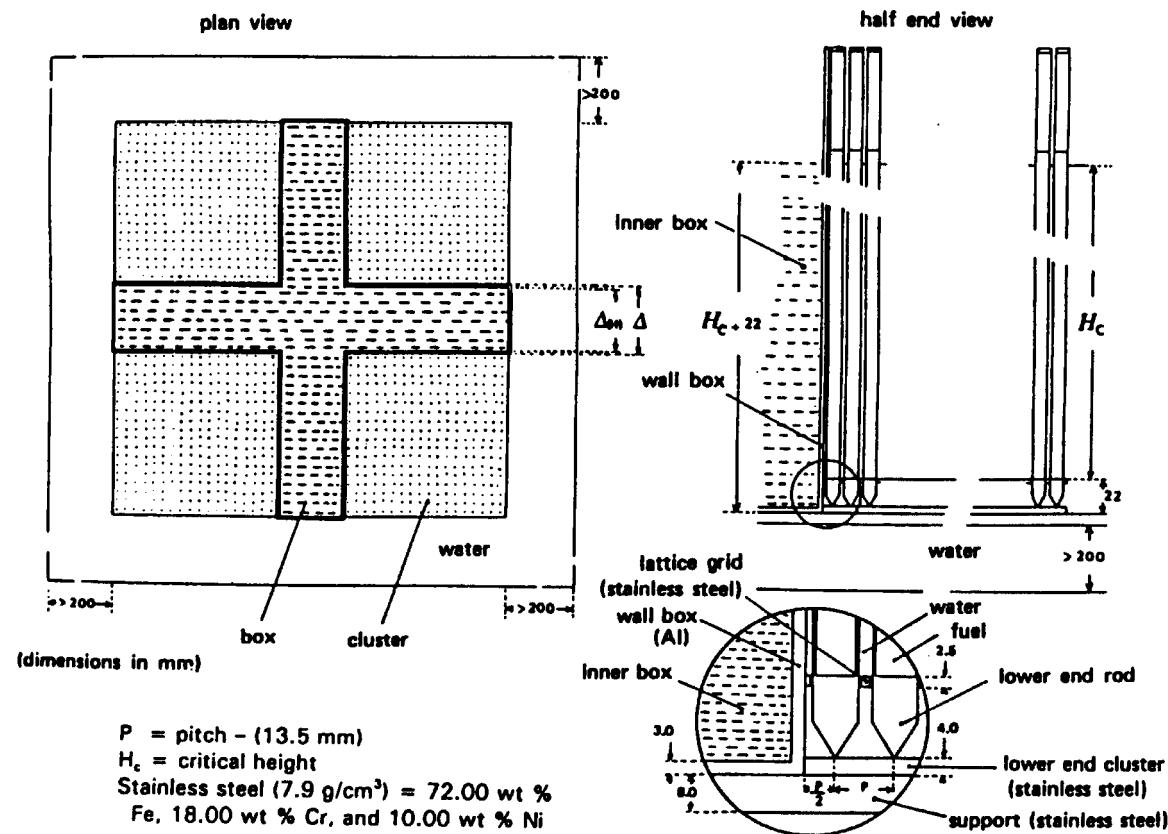


Figure 2.2 Planar and half-end view of experiments from ANS Transactions, Vol. 33 (dimensions in millimeters).
Source: Ref. 5

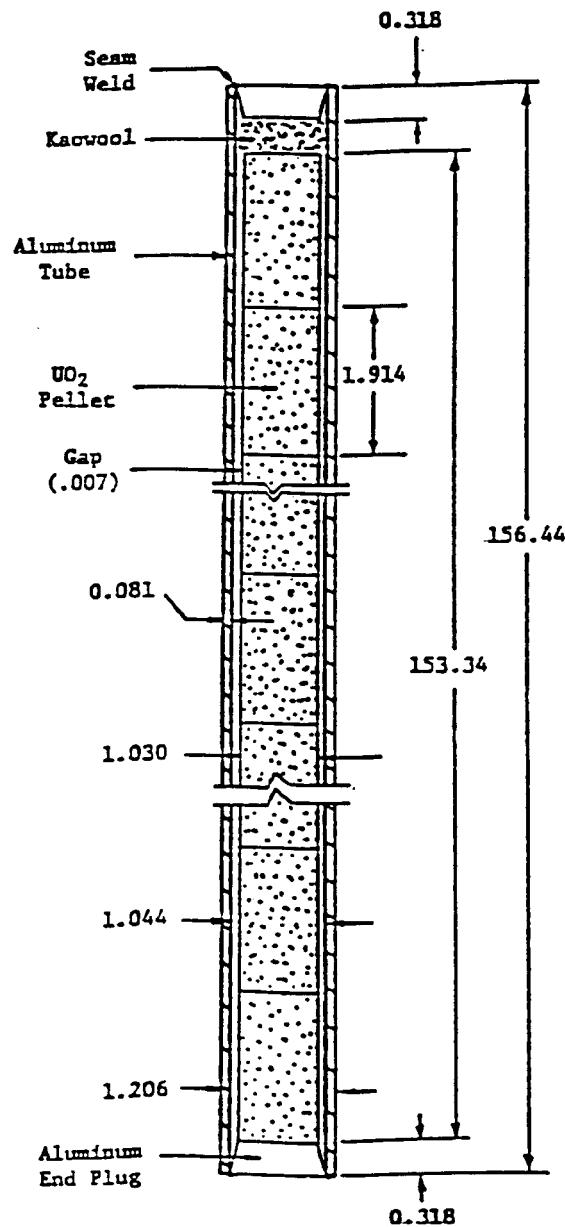


Figure 2.3 Dimensions (in centimeters) of 2.459 wt % UO_2 fuel rods for BAW-1484 experiments.
Source: Ref. 6

Physical Description

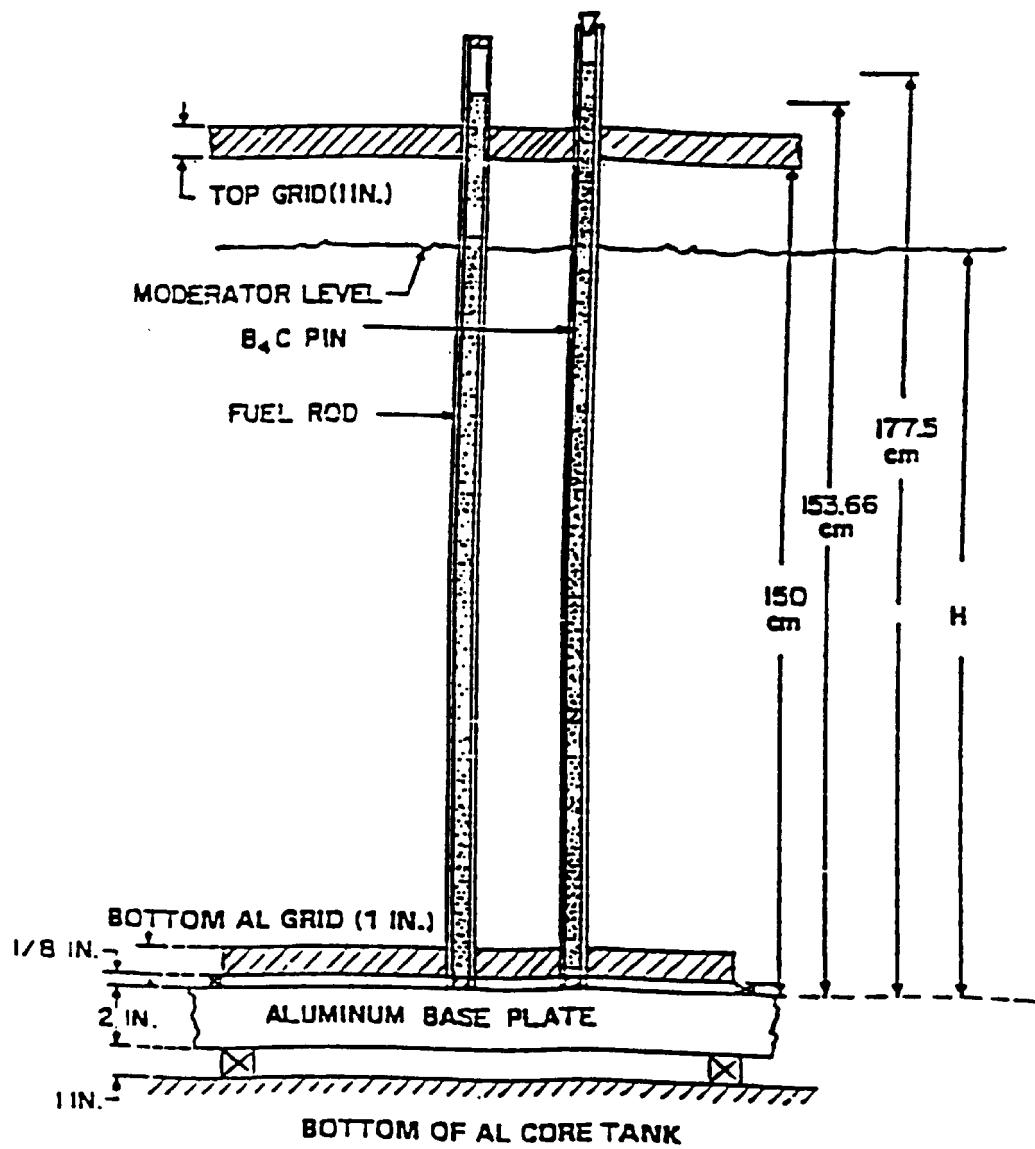
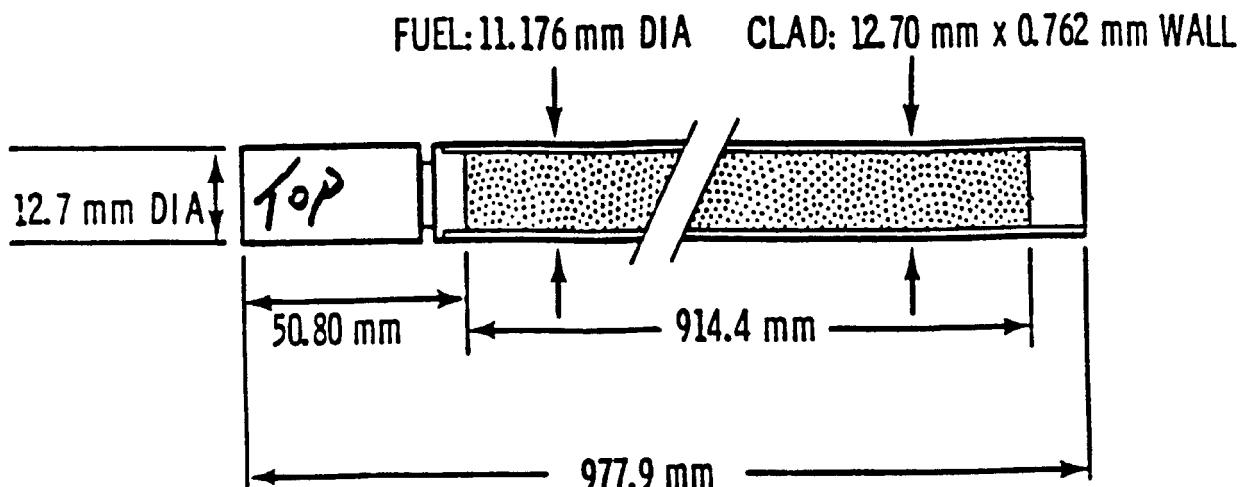


Figure 2.4 Experiment BW1484SL vertical dimensions. *Source:* Ref. 6

DESCRIPTION OF 2.35 wt% ^{235}U ENRICHED UO_2 RODS



CLADDING: 6061 ALUMINUM TUBING SEAL WELDED WITH A LOWER END PLUG OF 5052-H32 ALUMINUM AND A TOP PLUG OF 1100 ALUMINUM

TOTAL WEIGHT OF LOADED FUEL RODS: 917 gm (AVERAGE)

LOADING:

825 gm OF UO_2 POWDER / ROD, 726 gm OF U/ROD, 17.08 gm OF U-235/ROD
 ENRICHMENT - 2.35 ± 0.05 w/o U-235
 FUEL DENSITY - 9.20 mg/mm³ (84% THEORETICAL DENSITY)

Figure 2.5 Description of 2.35 wt % UO_2 fuel rods used in experiments from EPRI NP-196.

Source: Ref. 7 (Copyright © 1976. Electric Power Research Institute. EPRI NP-196. *Clean Critical Experiment Benchmarks for Plutonium Recycle in LWRs*. Reprinted with Permission)

Physical Description

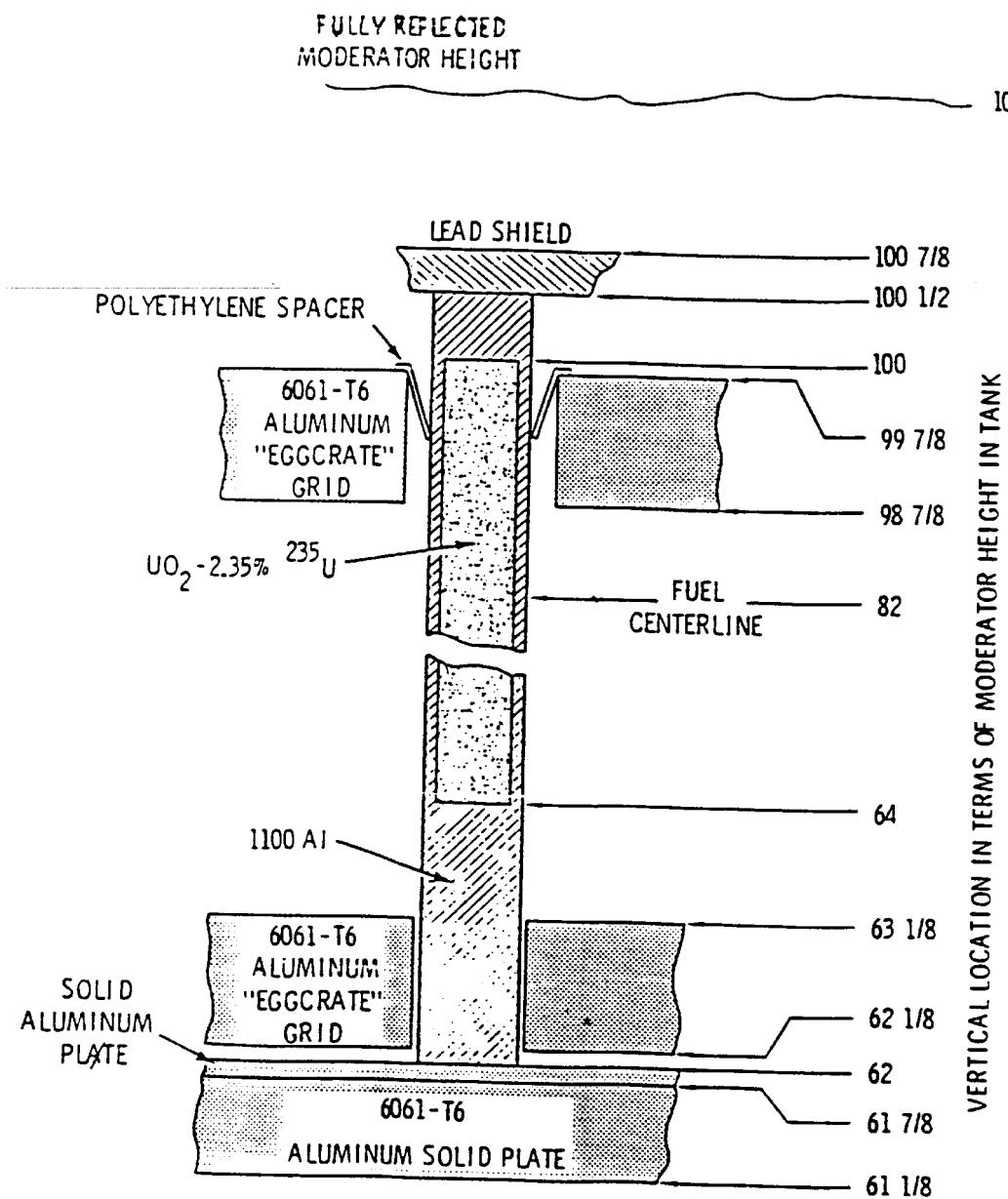


Figure 2.6 Axial core structure dimensions (in inches) for EPRU65 and EPPRU87. *Source:* Ref. 7
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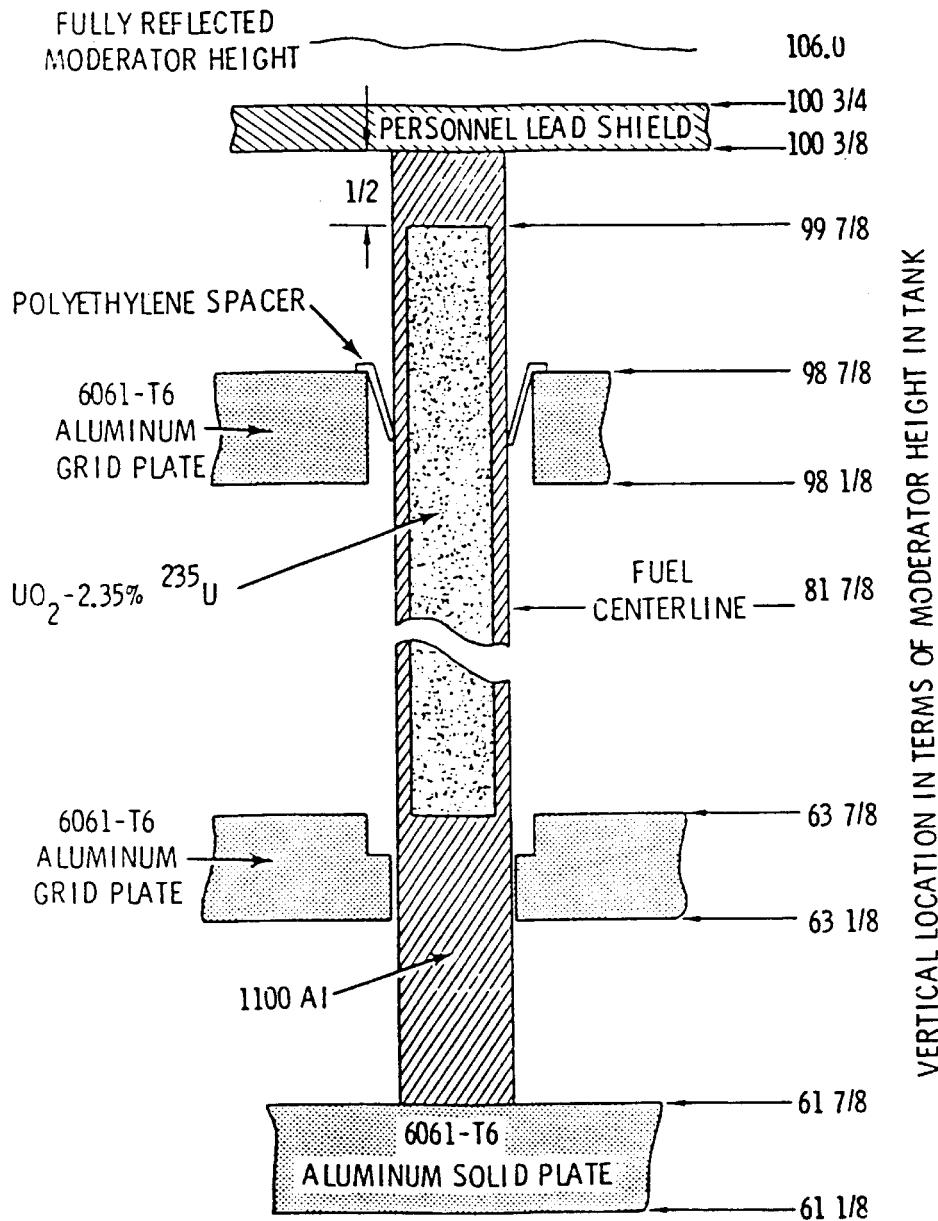
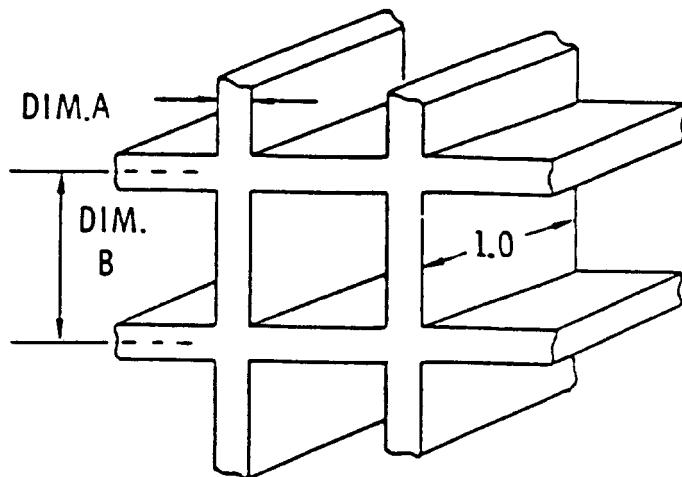


Figure 2.7 Axial core structure dimensions (in inches) for EPRU75. *Source:* Ref. 7 (Copyright © 1976. Electric Power Research Institute. EPRI NP-196. *Clean Critical Experiment Benchmarks for Plutonium Recycle in LWRs*. Reprinted with Permission)

Physical Description



FUEL TYPE	PITCH	GRID	DIM.A	DIM B
UO_2 - 2.35% ^{235}U	0.615 0.87	UPPER LOWER	0.032 0.090	0.615

Figure 2.8 Dimensions (in inches) of “eggcrate” lattice grids for EPRU65 and EPRU87. *Source:* Ref. 7 (Copyright © 1976. Electric Power Research Institute. EPRI NP-196. *Clean Critical Experiment Benchmarks for Plutonium Recycle in LWRs.* Reprinted with Permission)

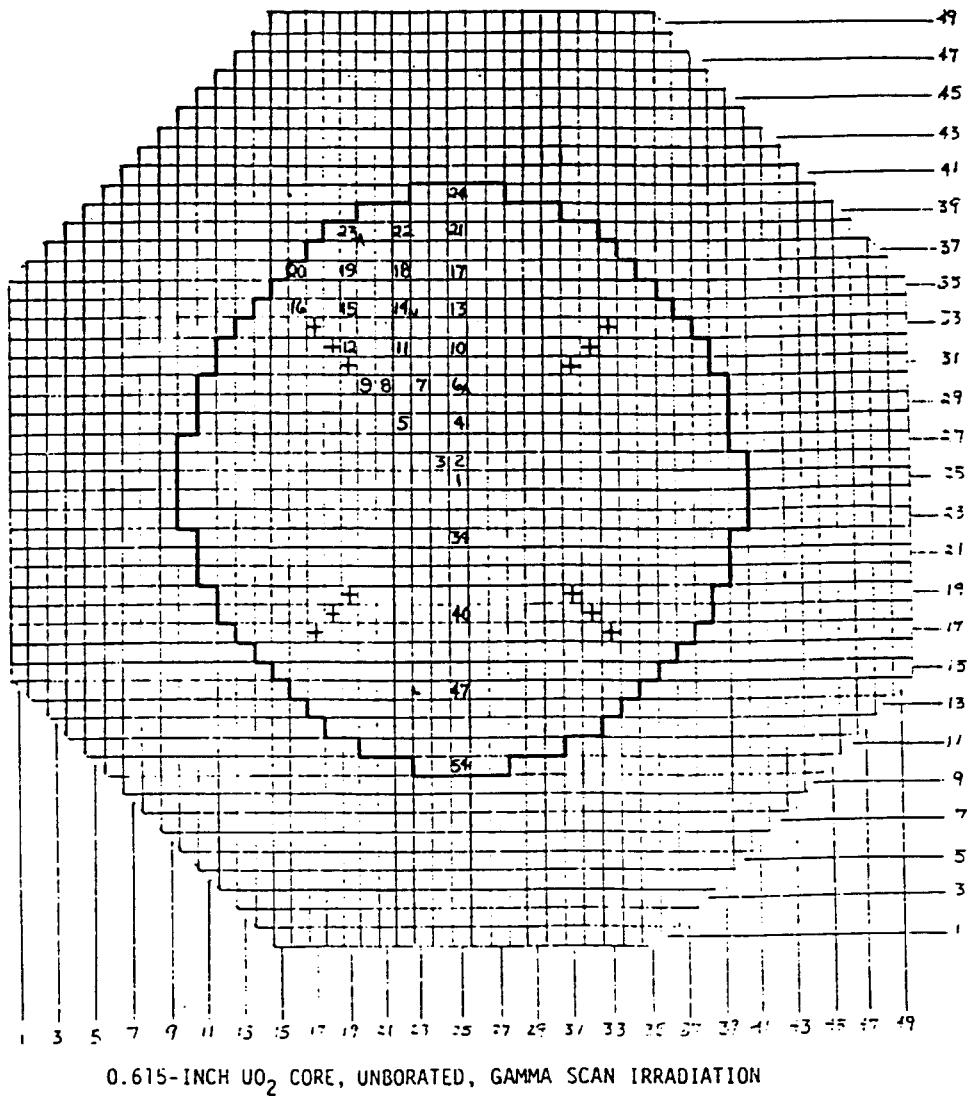


Figure 2.9 Core layout for **EPRU65**. *Source:* Ref. 7 (Copyright © 1976. Electric Power Research Institute. EPRI NP-196. *Clean Critical Experiment Benchmarks for Plutonium Recycle in LWRs*. Reprinted with Permission)

Physical Description

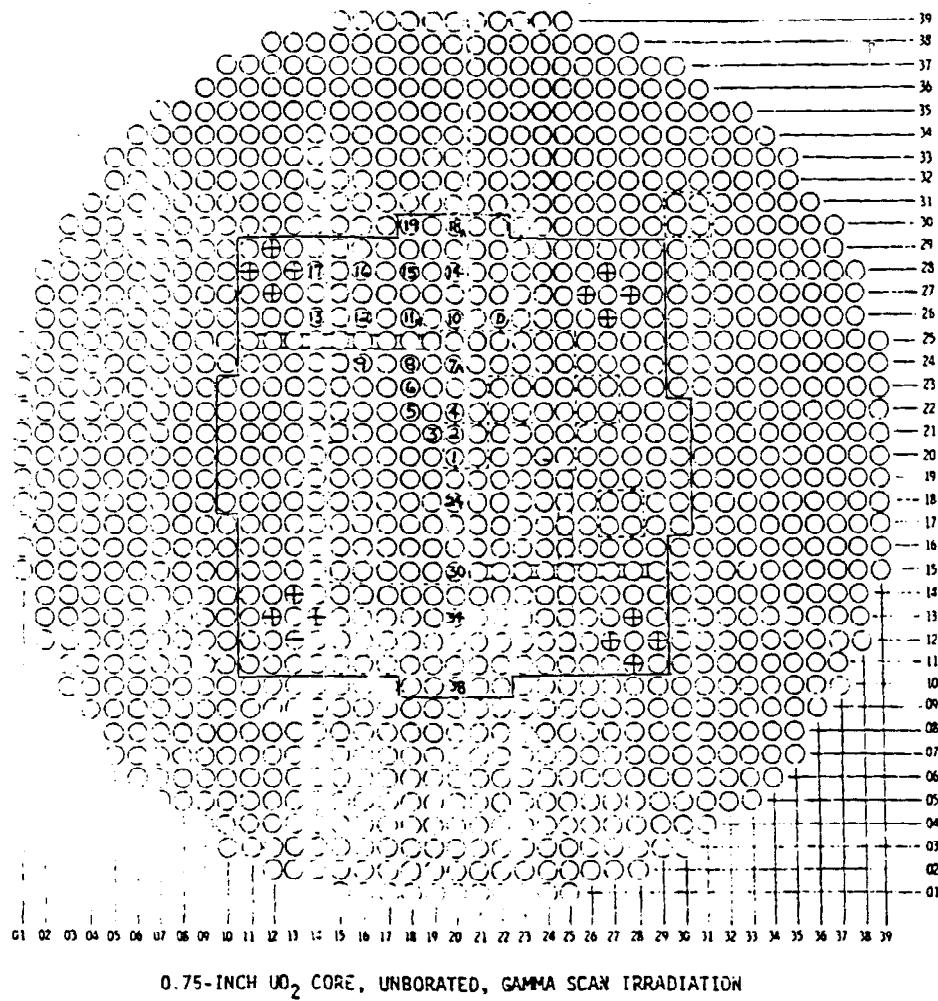


Figure 2.10 Core layout for **EPRU75**. *Source.* Ref. 7 (Copyright © 1976. Electric Power Research Institute. EPRI NP-196. *Clean Critical Experiment Benchmarks for Plutonium Recycle in LWRs*. Reprinted with Permission)

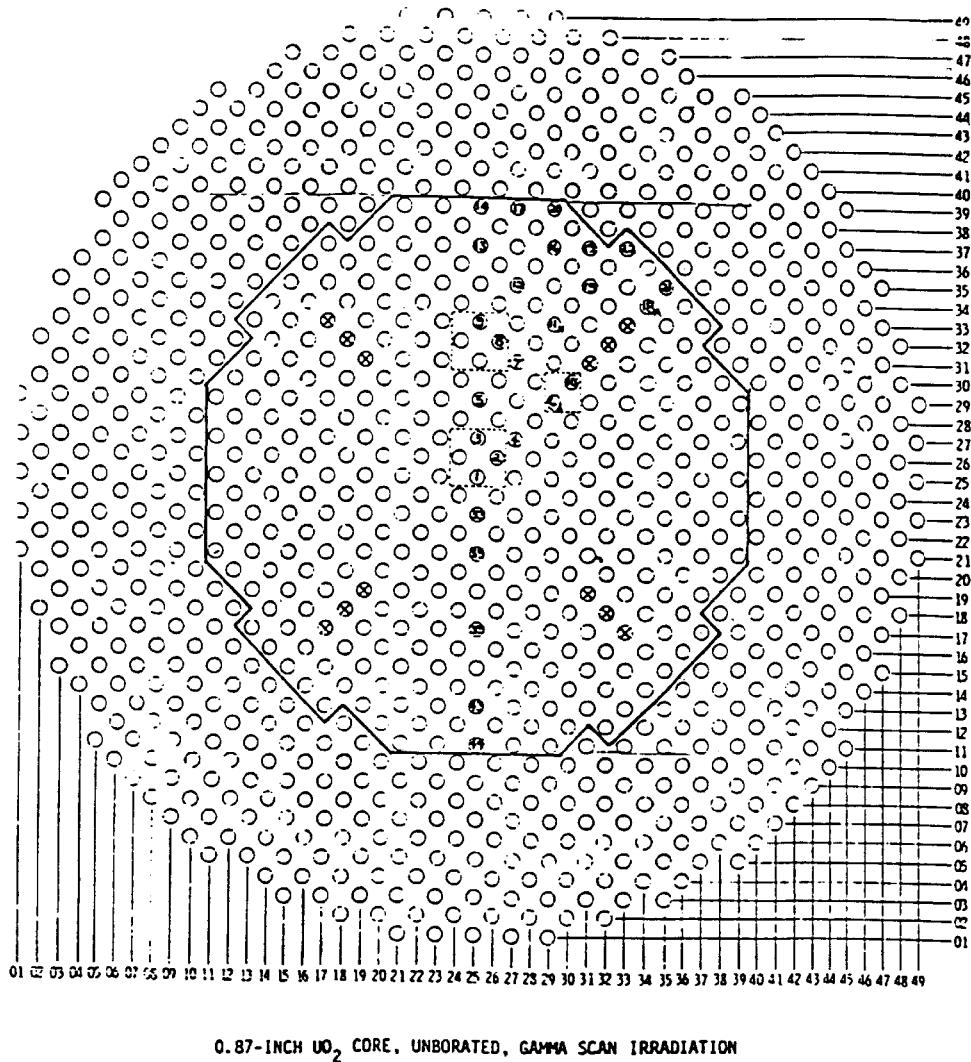


Figure 2.11 Core layout for EPRU87. *Source:* Ref. 7 (Copyright © 1976. Electric Power Research Institute. EPRI NP-196. *Clean Critical Experiment Benchmarks for Plutonium Recycle in LWRs*. Reprinted with Permission)

Physical Description

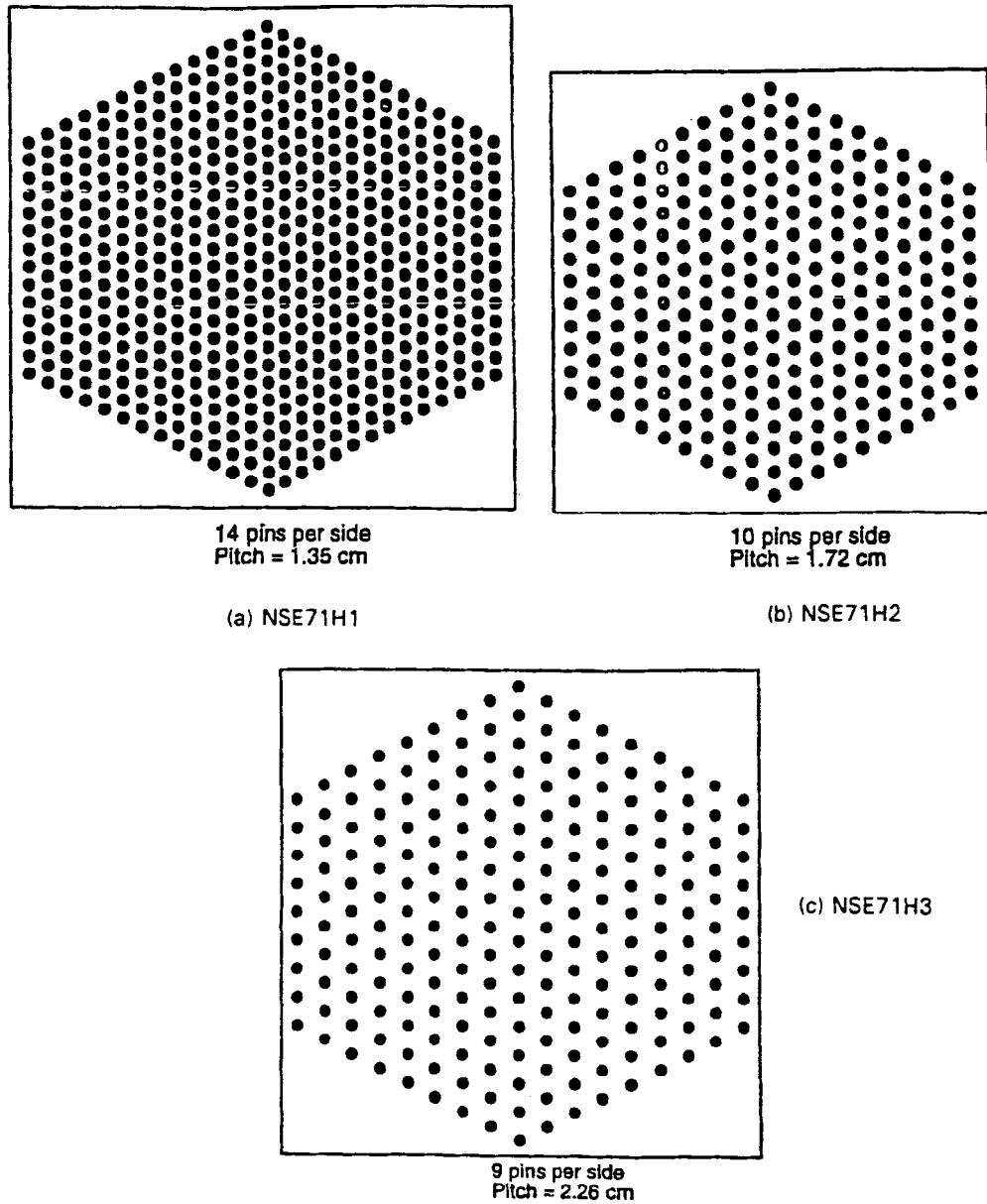


Figure 2.12 Core configurations for three hexagonal lattice experiments from NS&E, Vol. 71.
Source: Ref. 8 (Reprinted with permission by author)

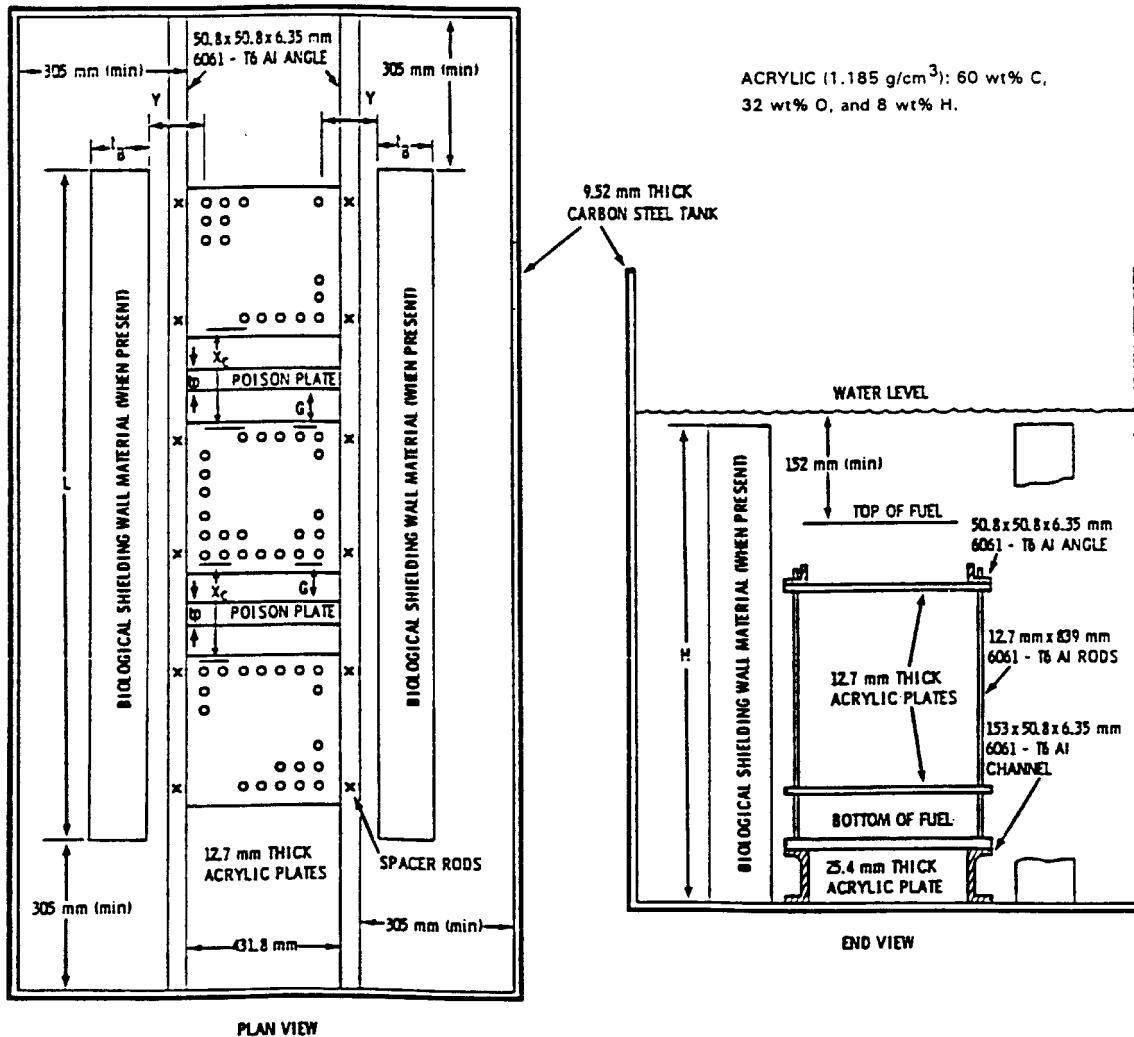
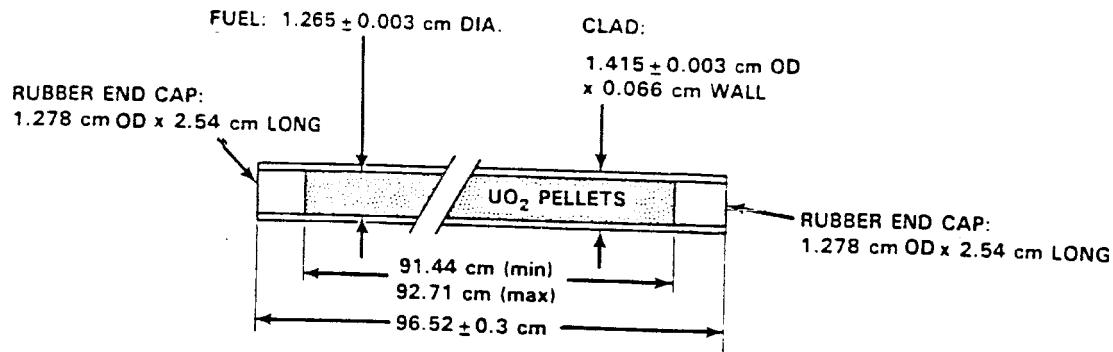


Figure 2.13 Planar and end views of experiments from PNL-2438. Source: Ref. 9 (Reprinted with permission from authors)

Physical Description



CLADDING: 6061 ALUMINUM TUBING

LOADING

ENRICHMENT - $4.306 \pm 0.013\%$ ^{235}U
 OXIDE DENSITY - 10.40 ± 0.06 g/cm 3
 UO_2 - 1203.38 ± 4.12 g/ROD
 U - 1059.64 ± 4.80 g/ROD

URANIUM COMPOSITION:

^{234}U - 0.022 ± 0.002
 ^{235}U - 4.306 ± 0.013
 ^{236}U - 0.022 ± 0.002
 ^{238}U - 95.650 ± 0.017

END CAP:

C-58 \pm 1 WT%	S-1.7 \pm 0.2 WT%
H-6.5 \pm 0.3 WT%	0-22.1 WT% (BALANCE)
Ca-11.4 \pm 1.8 WT%	Si-0.3 \pm 0.1 WT%

NOTES:

1. ERROR LIMITS ARE ONE STANDARD DEVIATION
2. END CAP DENSITY IS 1.321 g/cm 3

Figure 2.14 Description of 4.31 wt % UO_2 fuel rods used in experiments from PNL-3314.

Source: Refs. 11 and 14 (Reprinted with permission from authors)

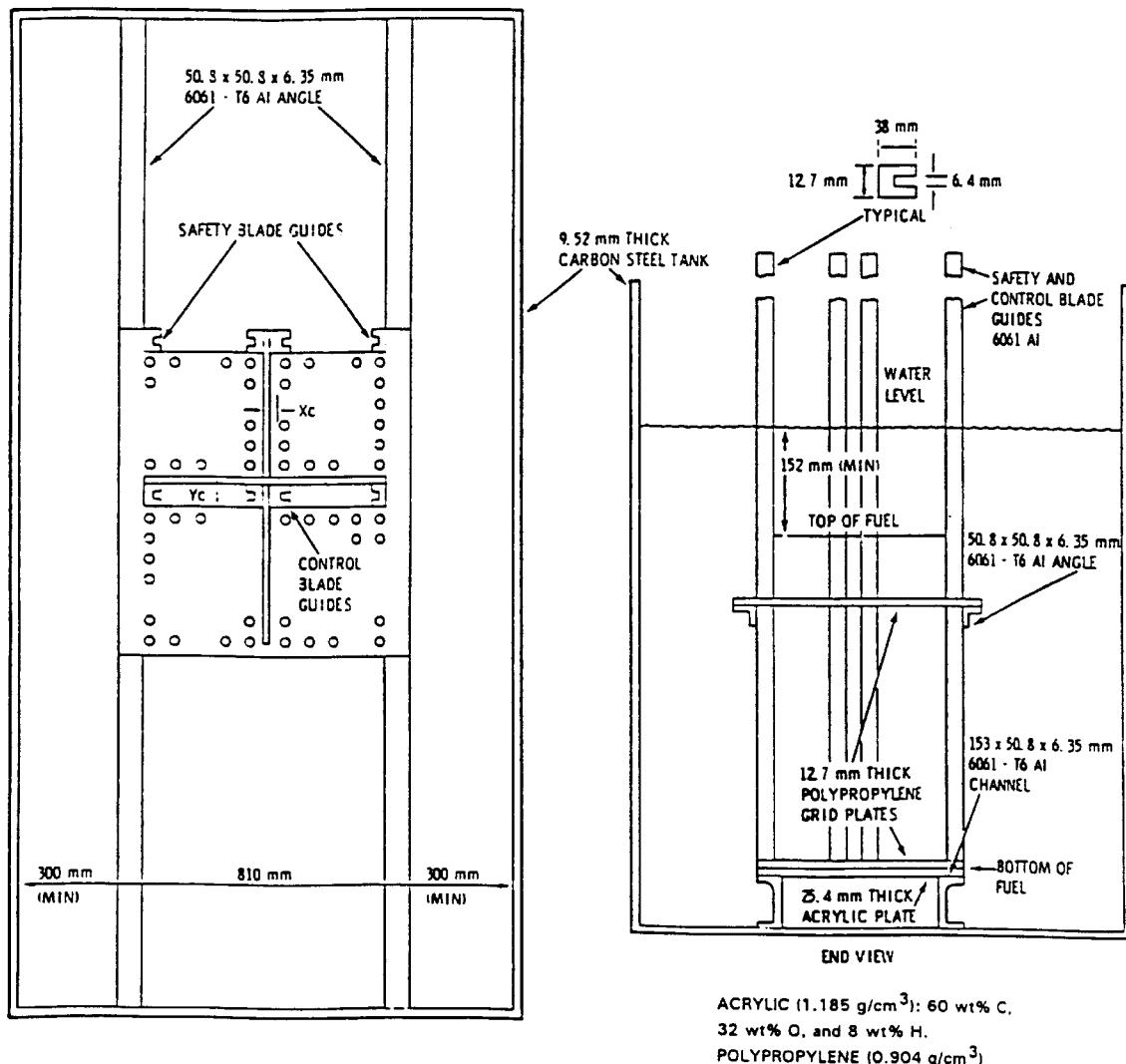


Figure 2.15 Planar and end view of experiments with four-assembly geometry from PNL-3314.

Source: Ref. 11 (Reprinted with permission from author)

Physical Description

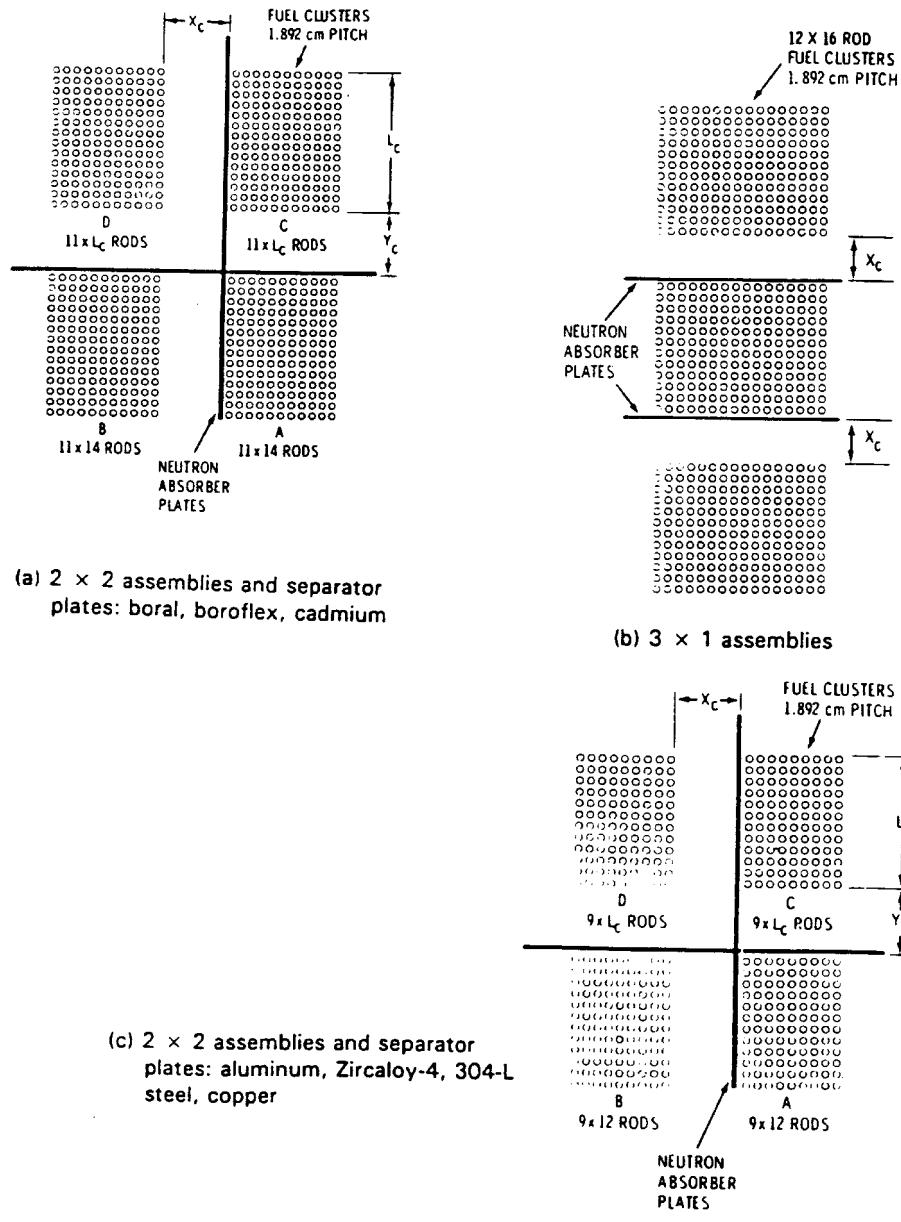


Figure 2.16a Fuel assemblies and absorber plate configurations for experiments with 4.31 wt % UO_2 fuel rods from PNL-3314. Source: Ref. 11 (Reprinted with permission from author)

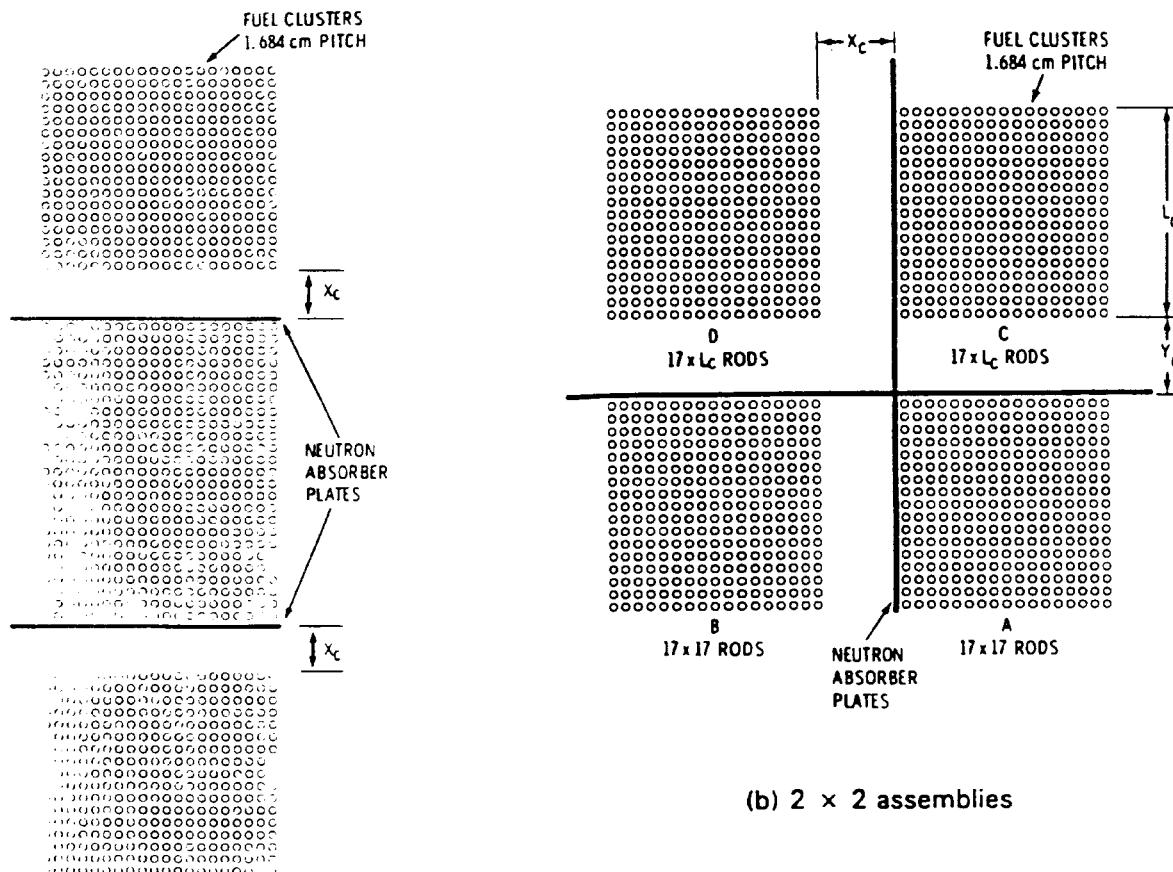


Figure 2.16b Fuel assemblies and absorber plate configurations for experiments with 2.35 wt % UO_2 fuel rods from PNL-3314. *Source:* Ref. 11 (Reprinted with permission from author)

Physical Description

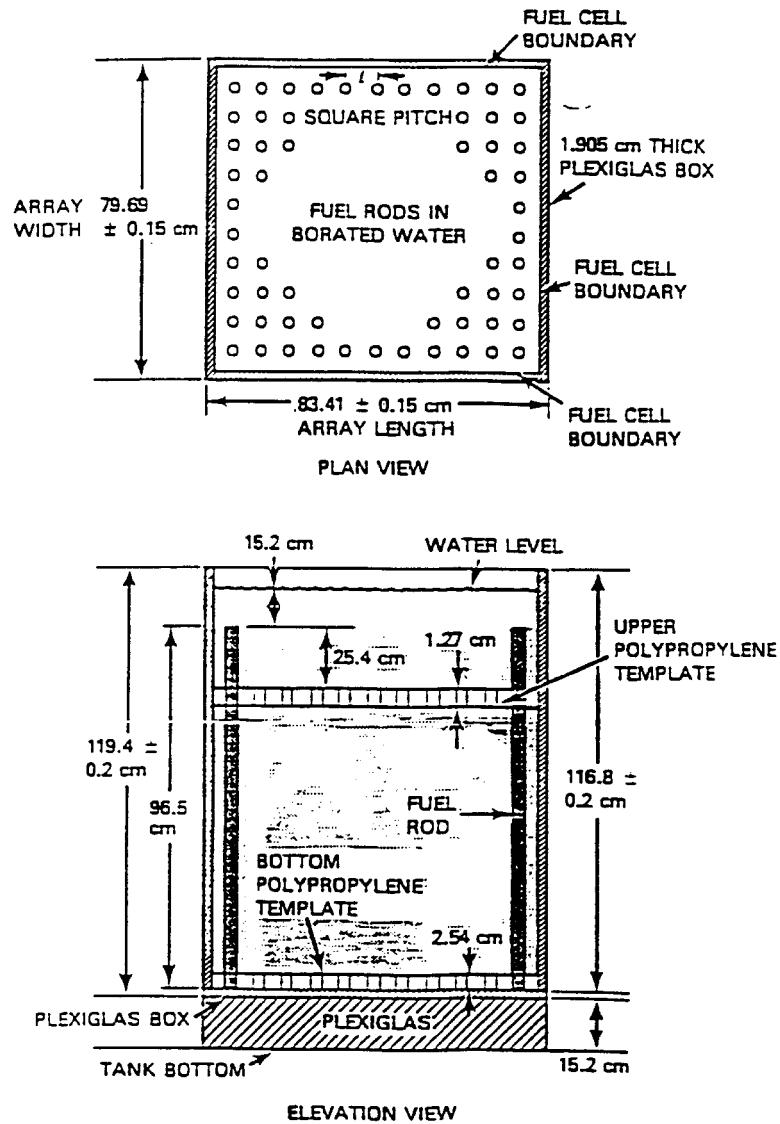


Figure 2.17 Experimental setup for experiments from PNL-4267. *Source:* Ref. 13 (Reprinted with permission from author)

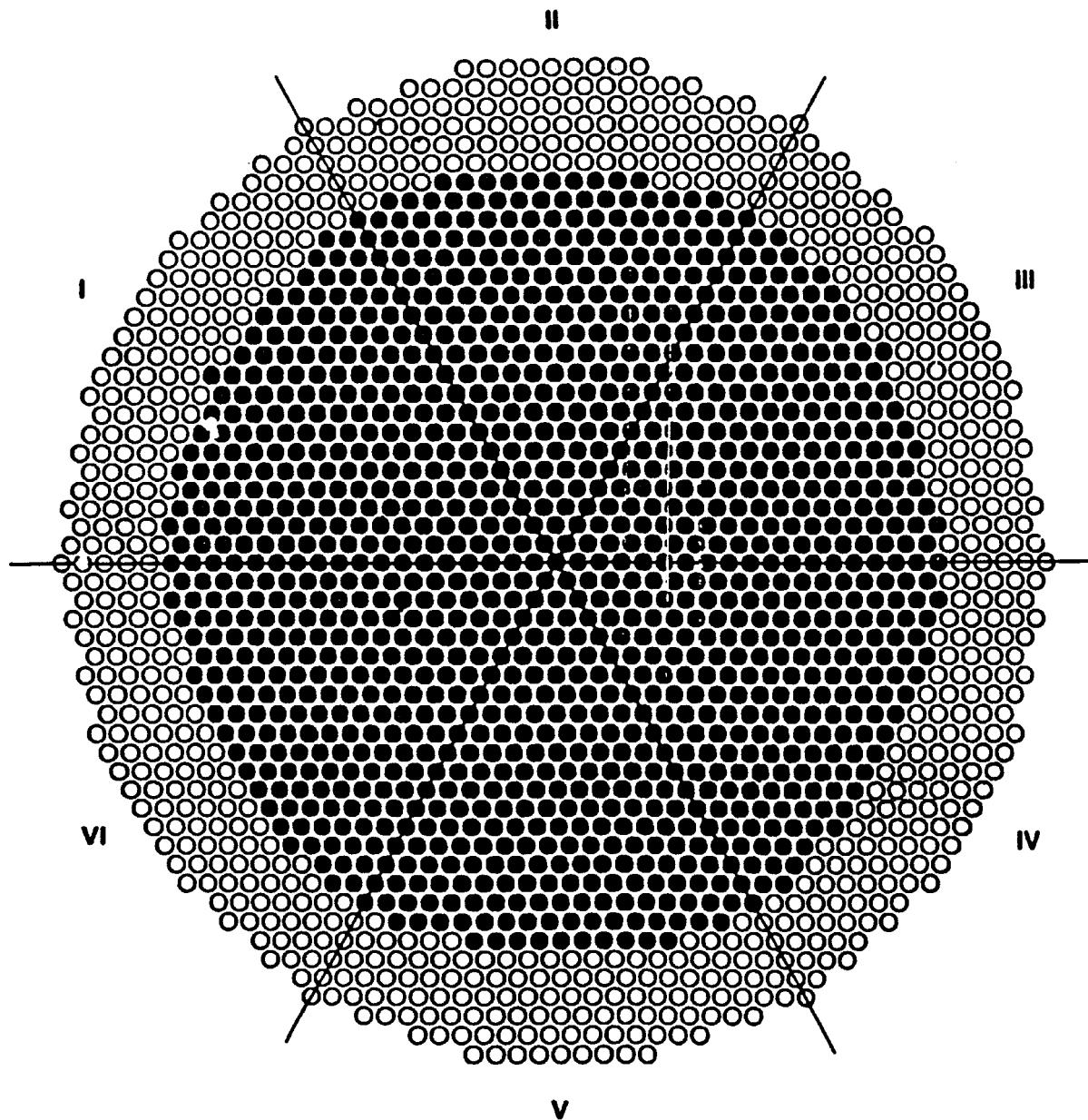


Figure 2.18 Core assembly for P49-194. *Source:* Ref. 14 (Reprinted with permission from author)

Physical Description

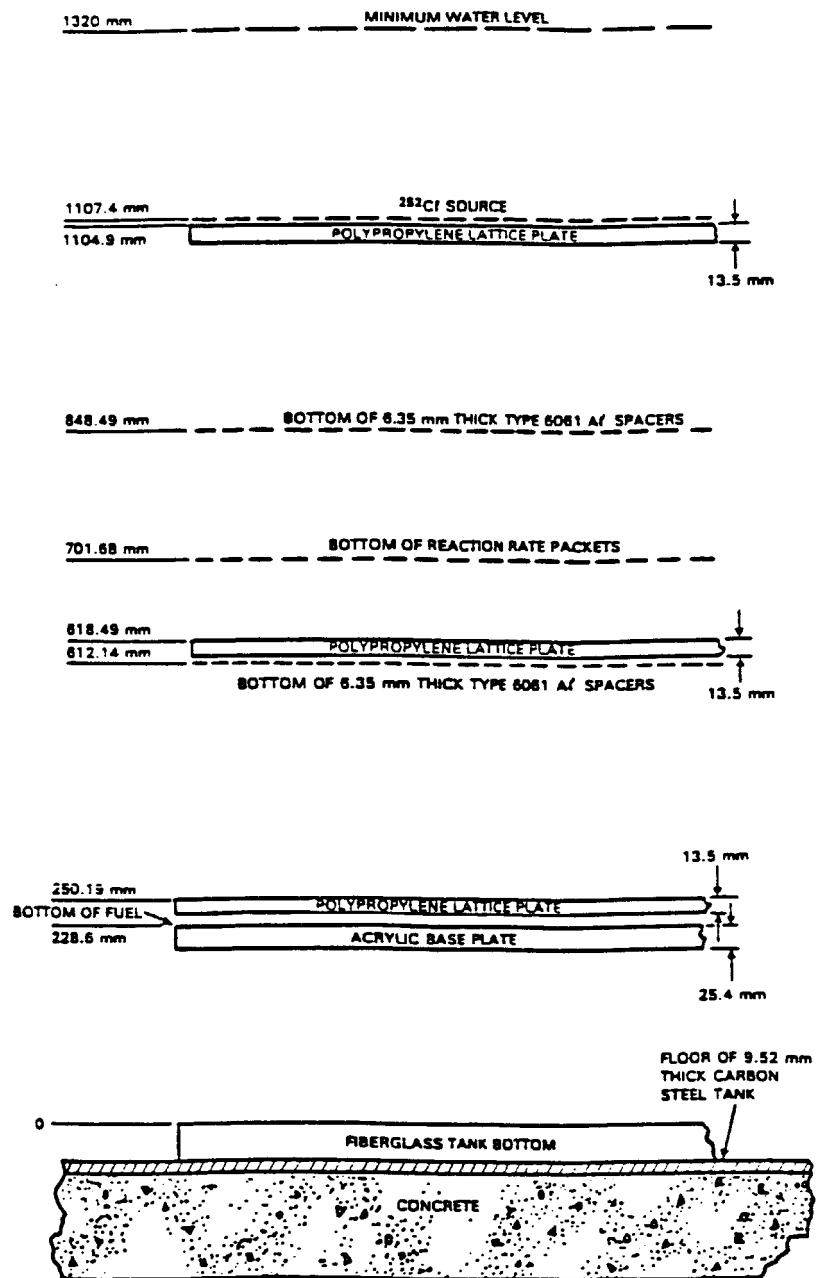


Figure 2.19 Experimental assembly elevations for P49-194. *Source:* Ref. 14 (Reprinted with permission from author)

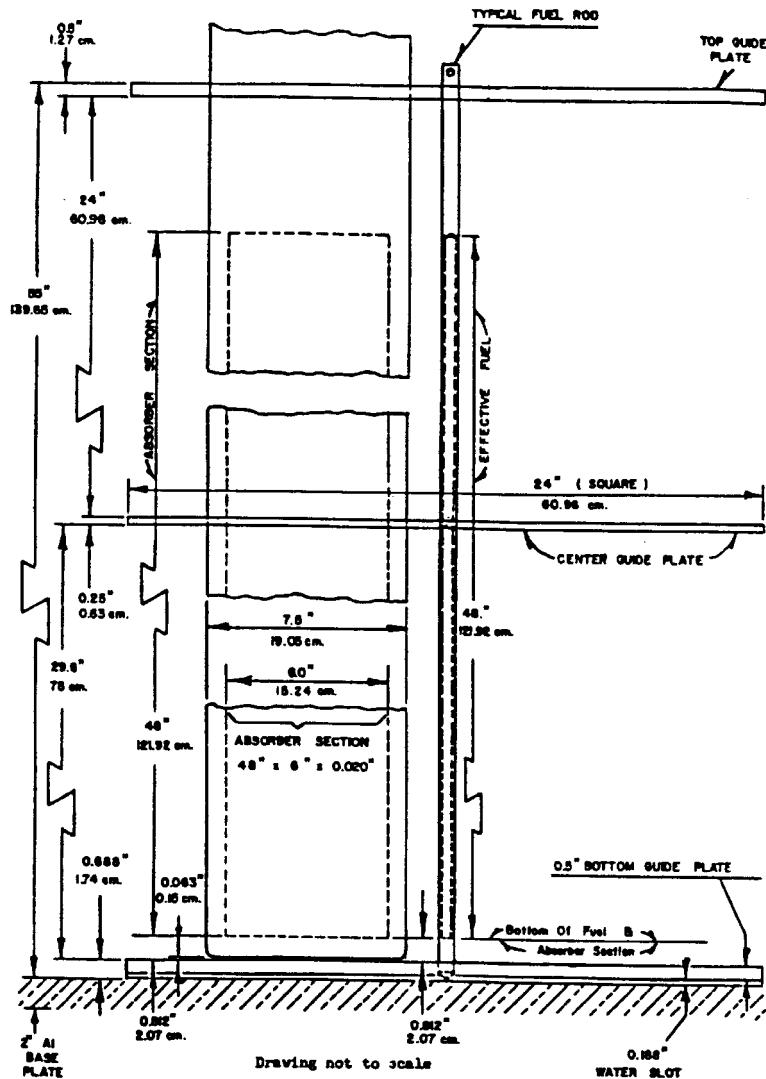


Figure 2.20 Vertical dimensions of experimental assembly for W3269SL1. *Source:* Ref. 15

Physical Description

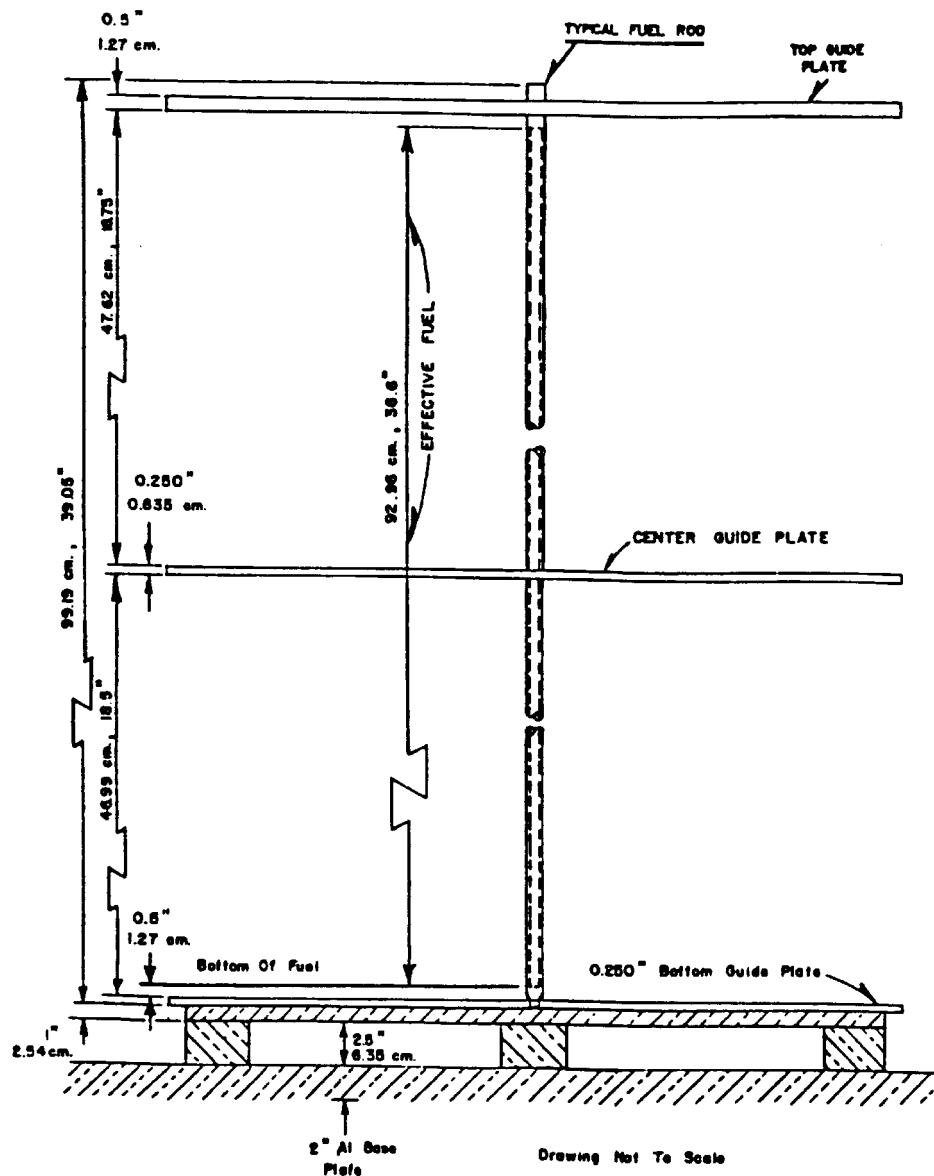


Figure 2.21 Vertical dimensions of experimental assembly for W3269SL2. *Source:* Ref. 15

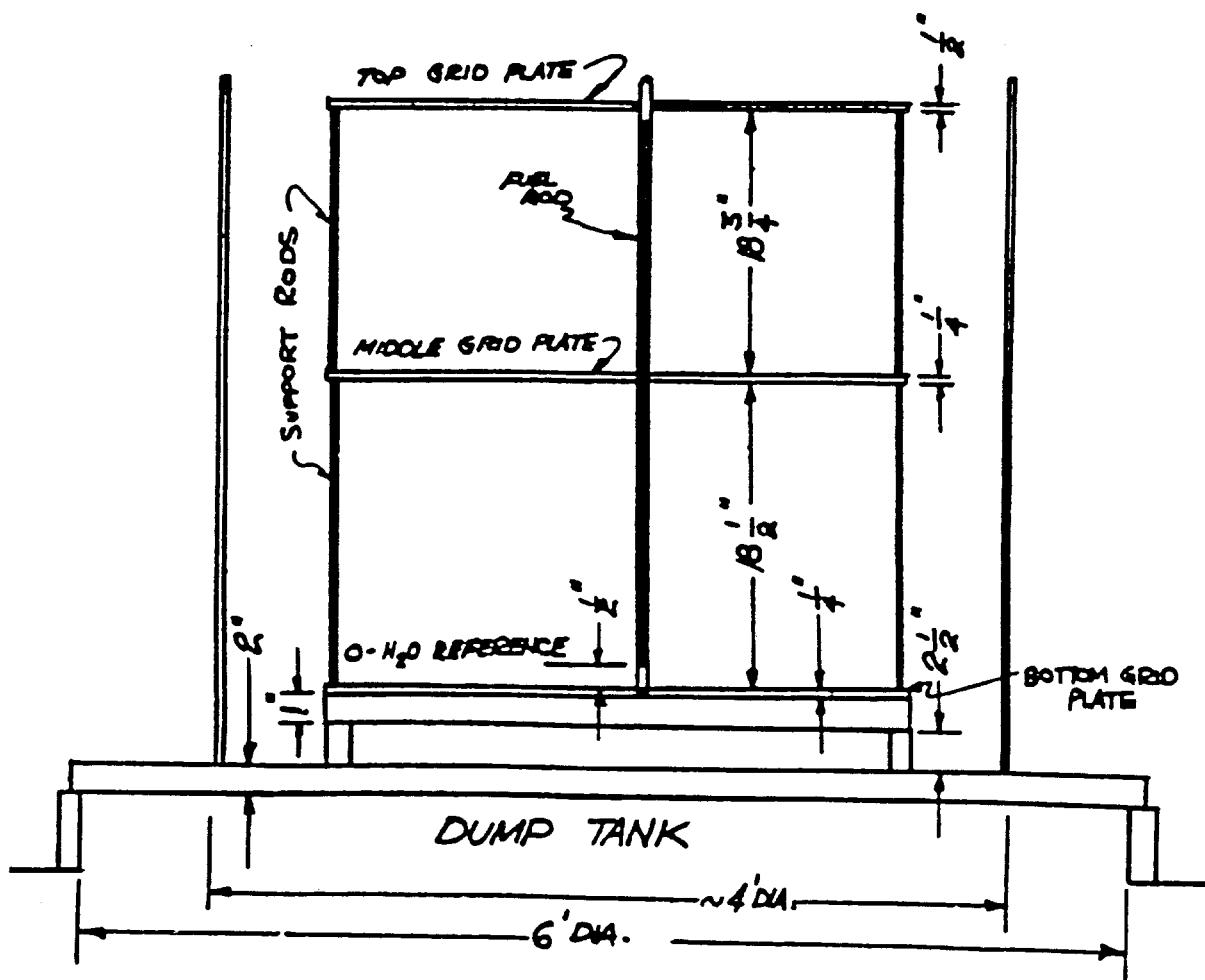
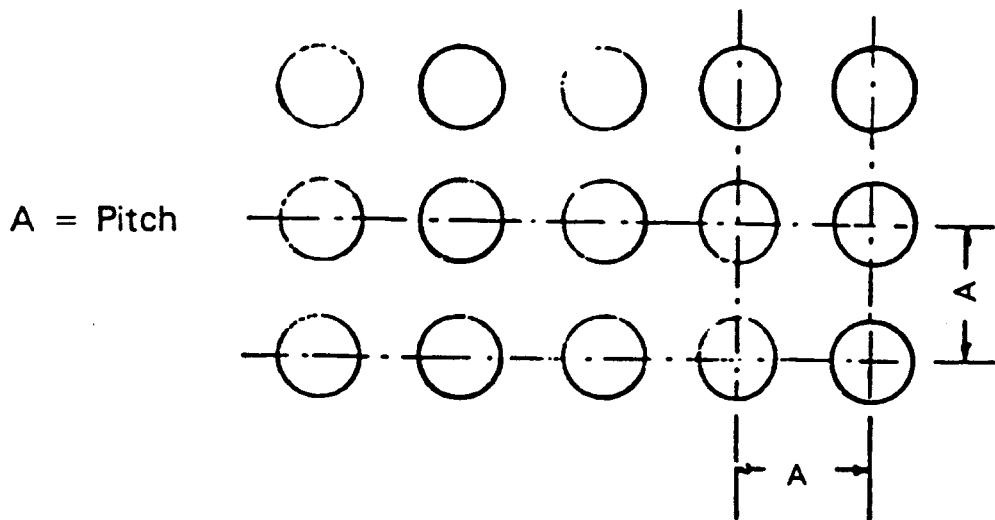


Figure 2.22 Vertical dimensions of experiments from WCAP-3385. *Source:* Ref. 16

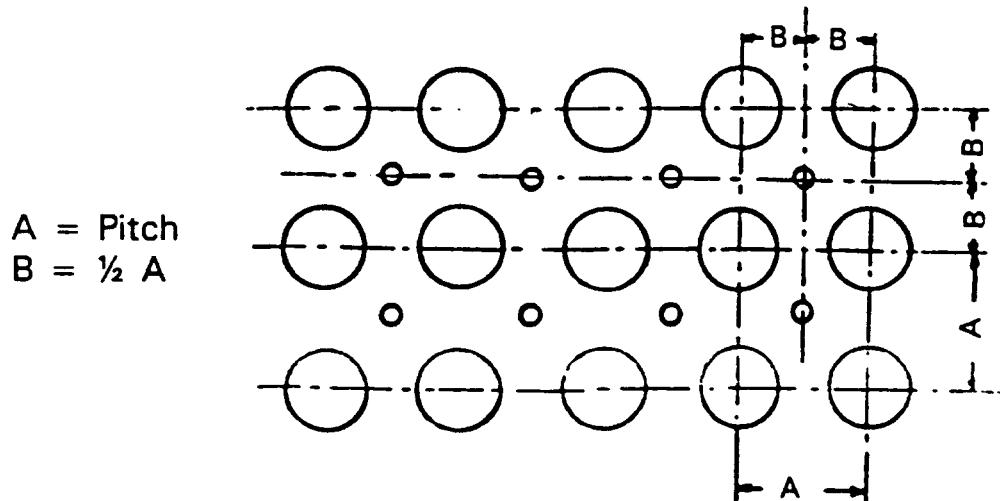
Physical Description

Top and bottom grid plate



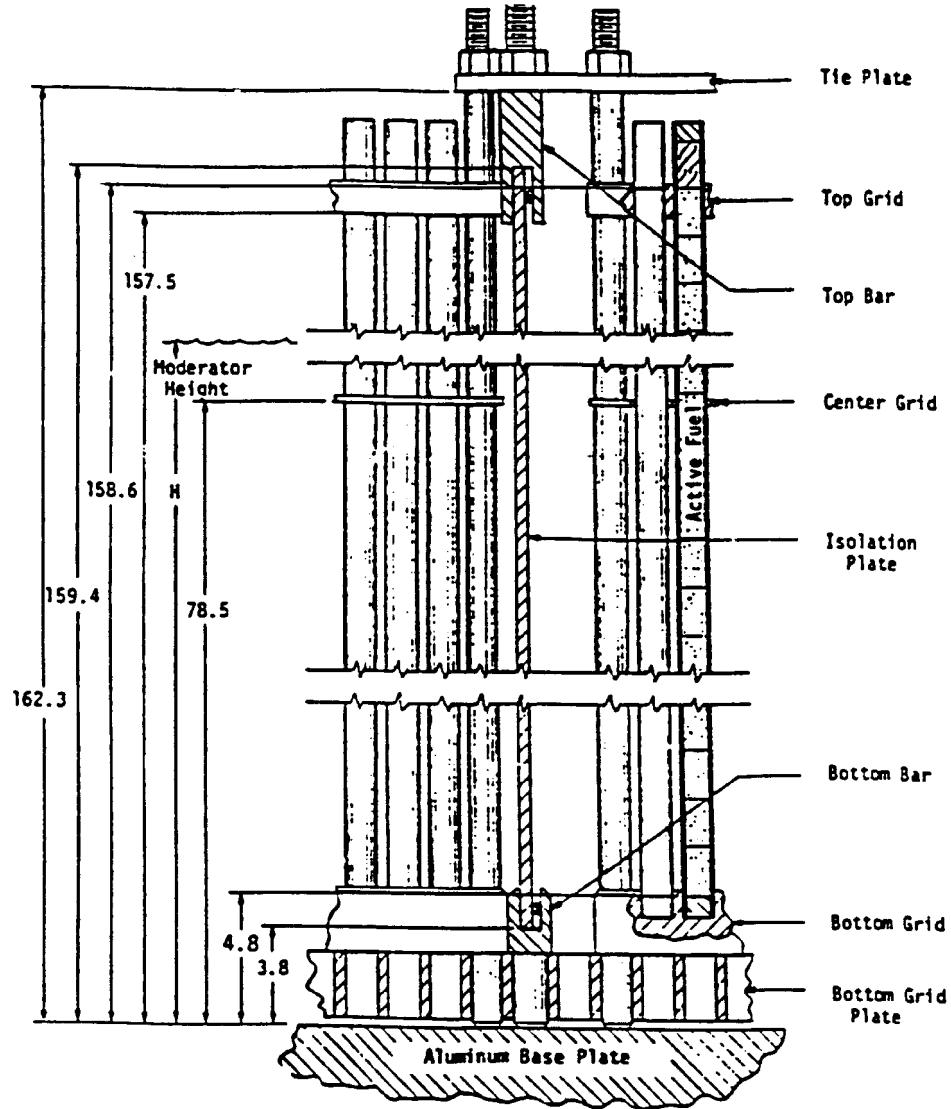
Fuel rod holes = 0.397 ± 0.002 in. diam

Center grid plate



Fuel rod holes = 0.397 ± 0.002 in. diam
 Circulation holes = 0.193 ± 0.001 in. diam

Figure 2.23 Grid plate layouts for experiments from WCAP-3385. *Source:* Ref. 16



Note: Dimensions given in centimeters.

Figure 2.24 Vertical dimensions for separator plate experiments from BAW-1484. Source: Ref. 6

Physical Description

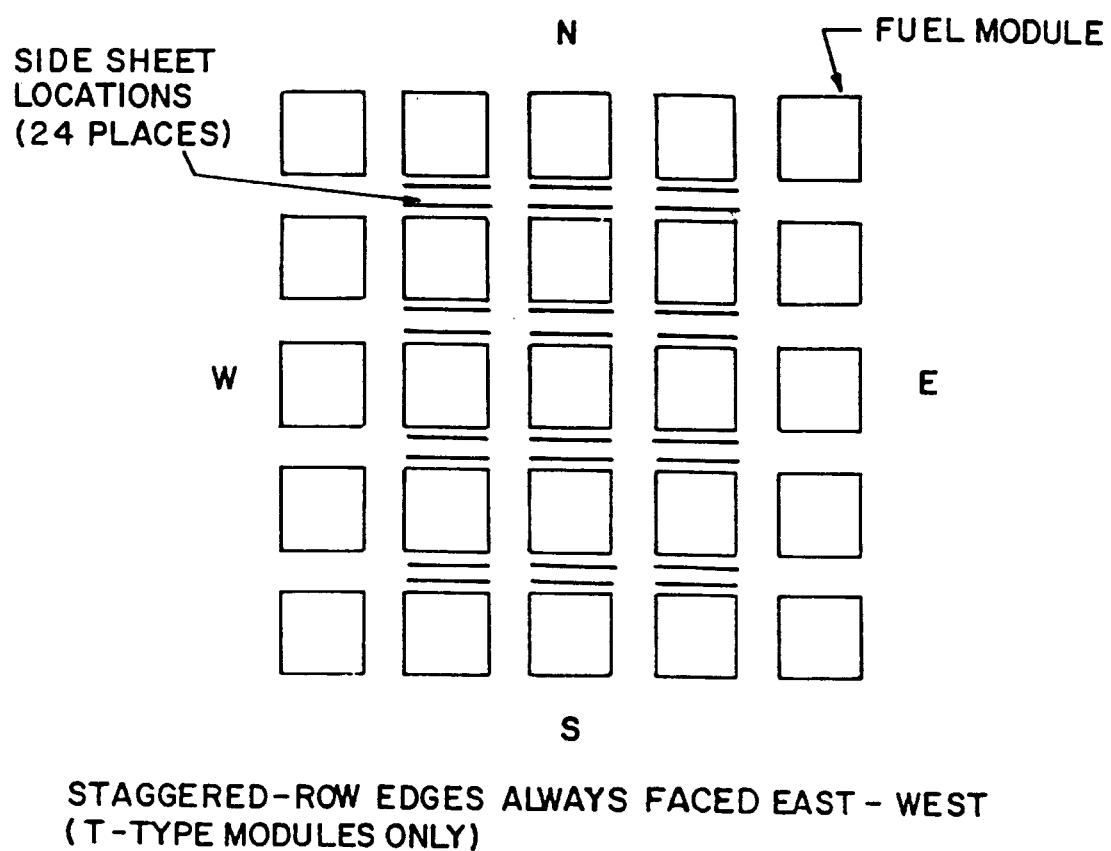


Figure 2.25 Side sheet locations for separator plate experiments from BAW-1645. *Source:* Ref. 17

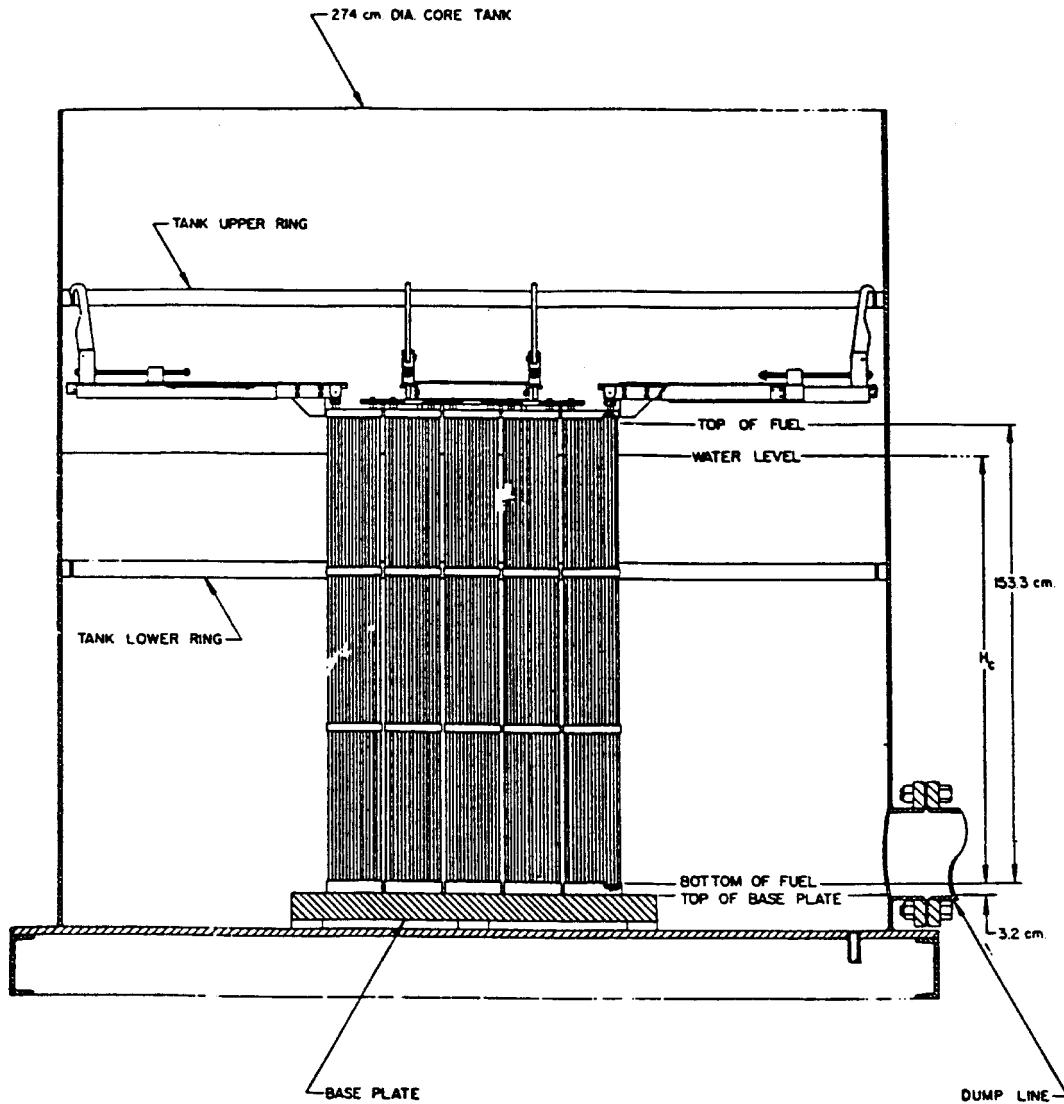


Figure 2.26 Vertical dimensions of experiments from BAW-1645. *Source:* Ref. 17

Physical Description

T - TYPE INTERMODULAR SPACING QUOTED AS $a \times b$

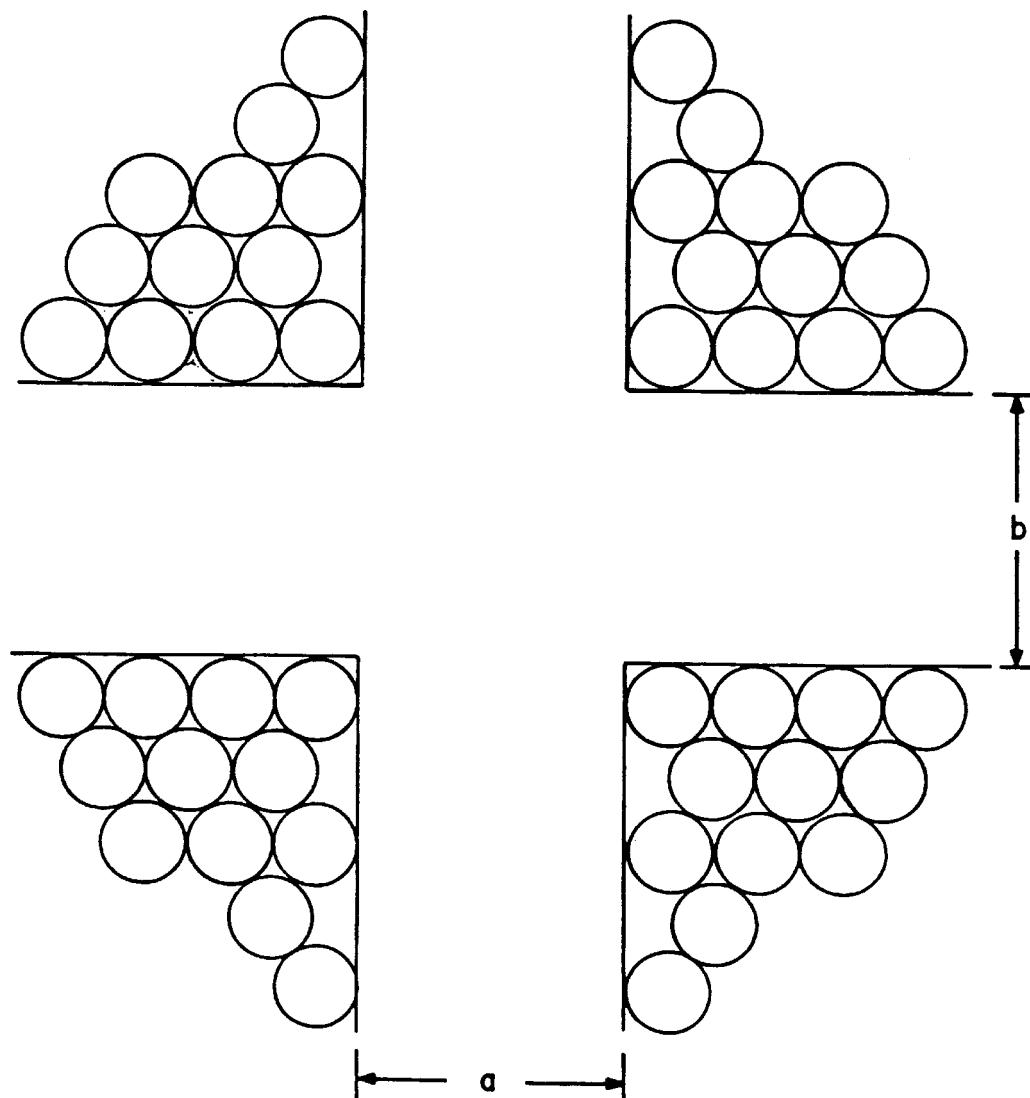


Figure 2.27 Intermediate spacing for **BW1645T1**, **BW1645T2**, **BW1645T3**, and **BW1645T4**. *Source:* Ref. 17

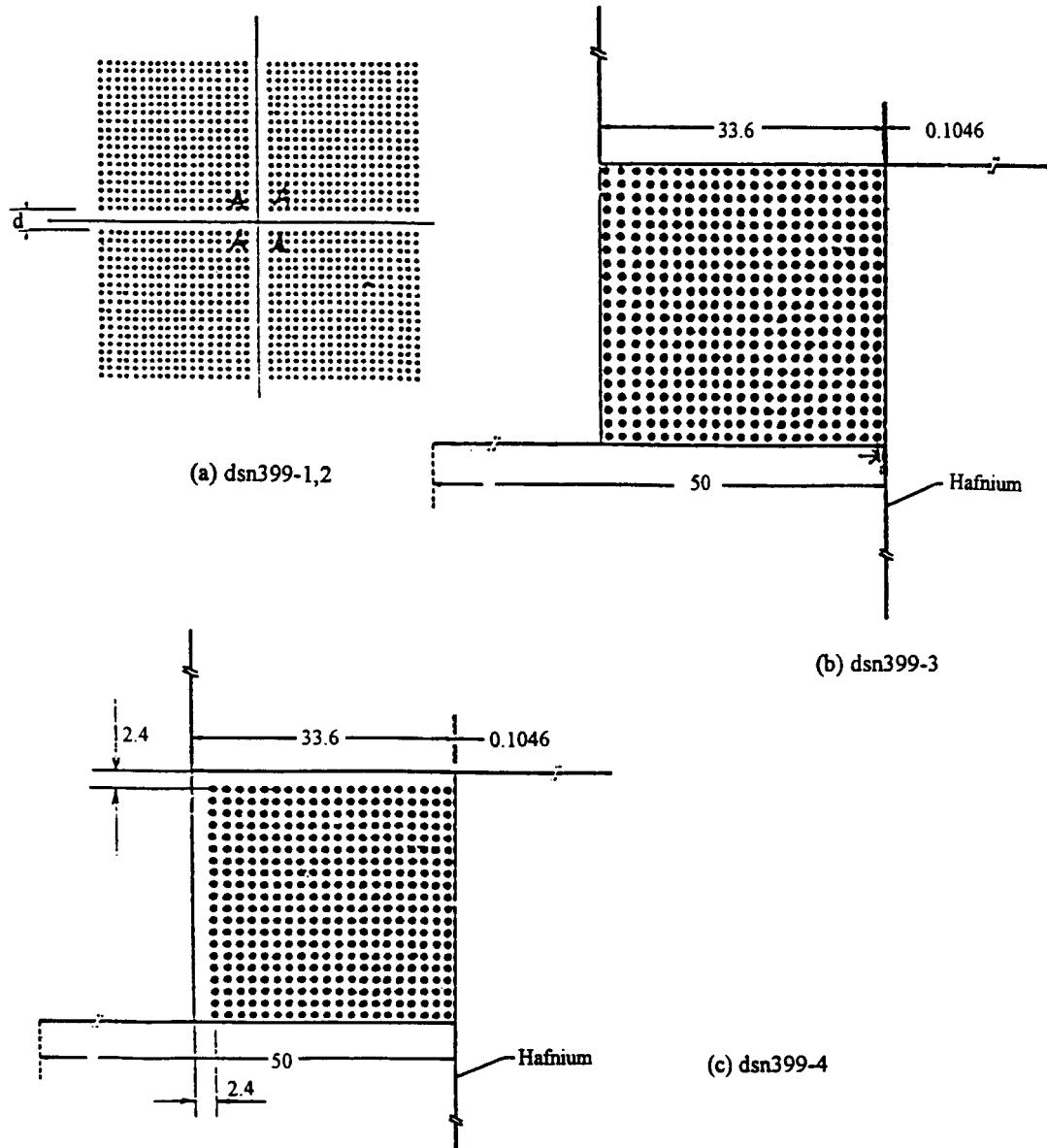


Figure 2.28 Cross-sectional view of separator plate experiments from DSN No. 399/80 (dimensions in cm).
Source: Ref. 18

Physical Description

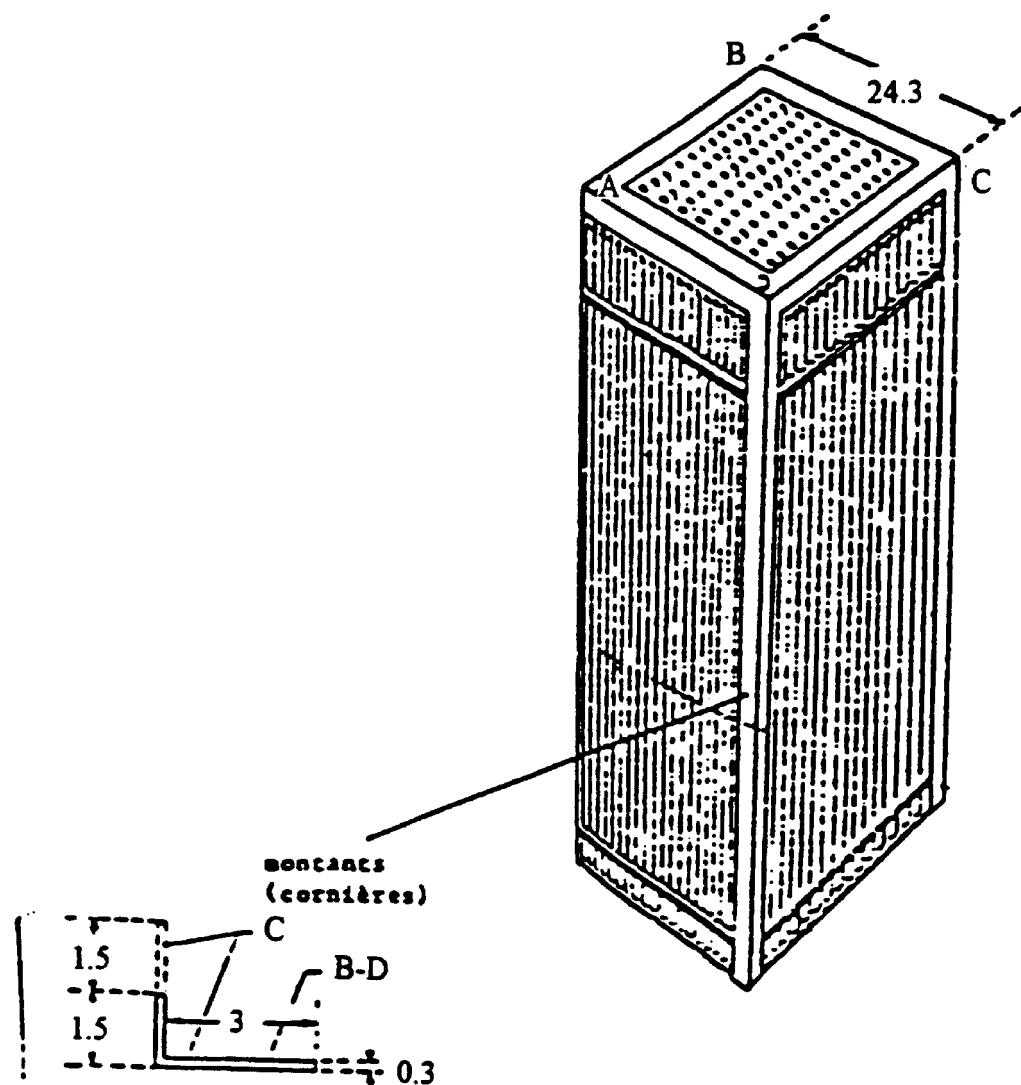


Figure 2.29 Fuel cluster and steel angle iron for DSN399-1 and DSN399-2 (dimensions in cm). *Source:* Ref. 18

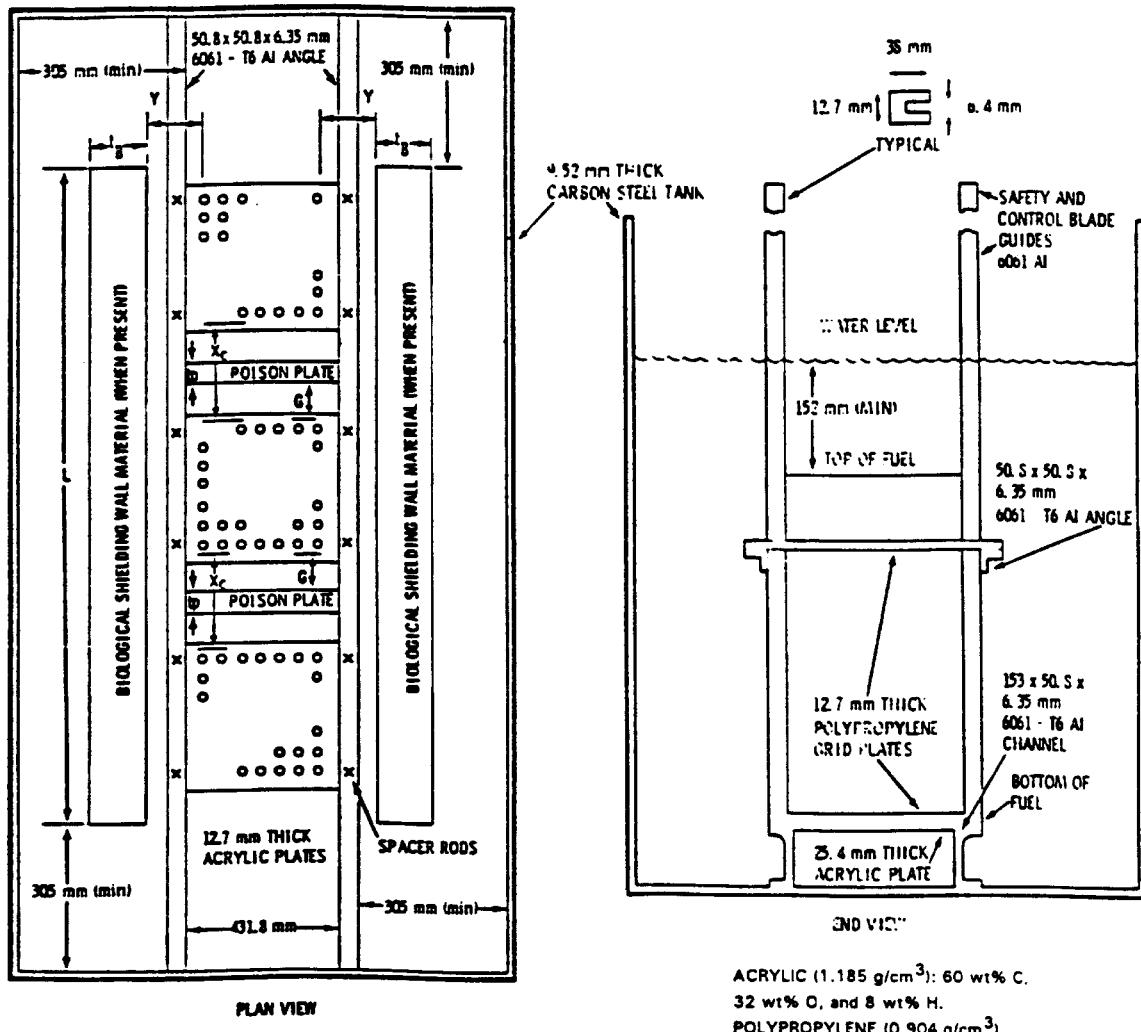


Figure 2.30 Planar and end view of experiments with three-assembly geometry from PNL-3314.
Source: Ref. 11

Physical Description

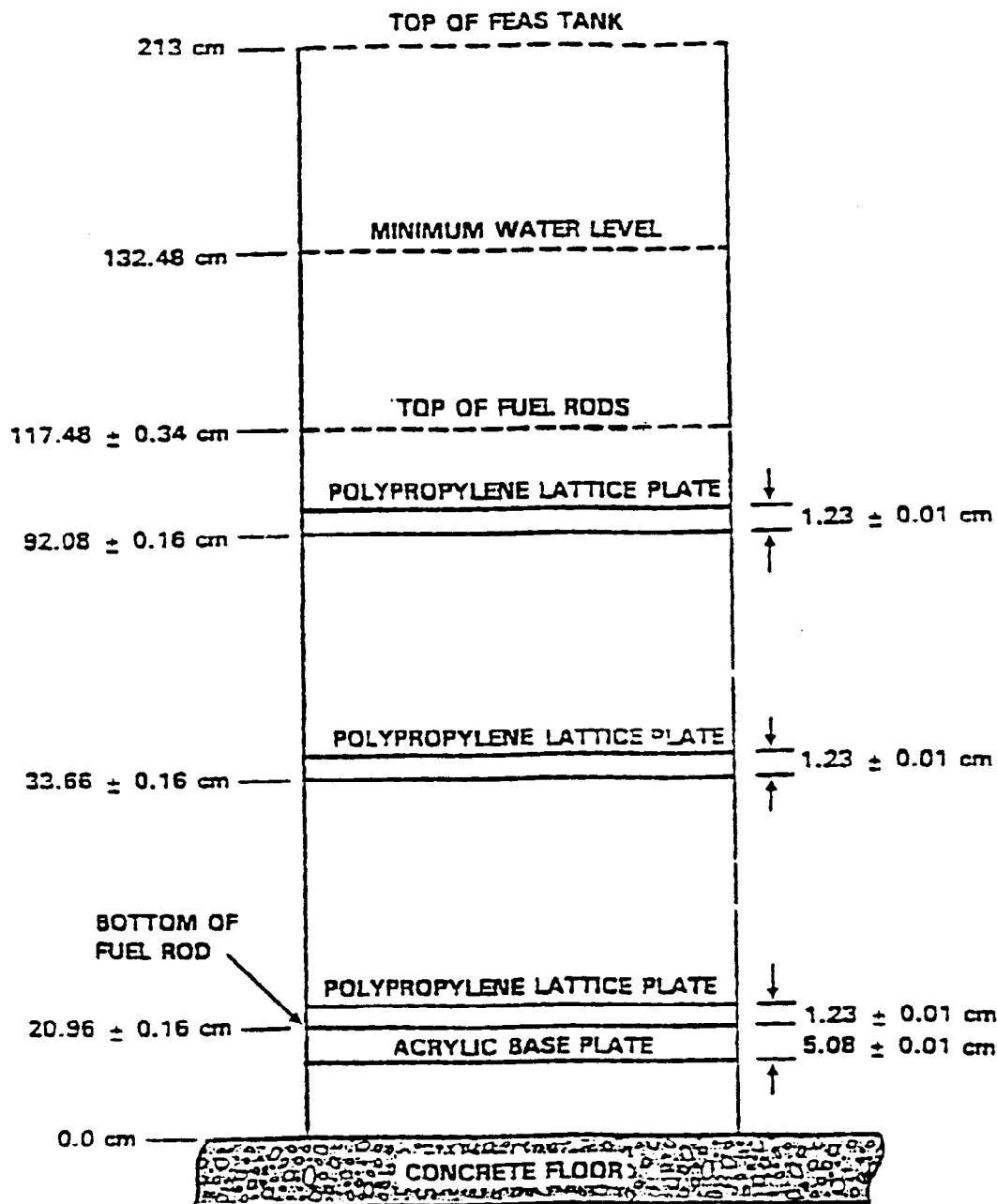
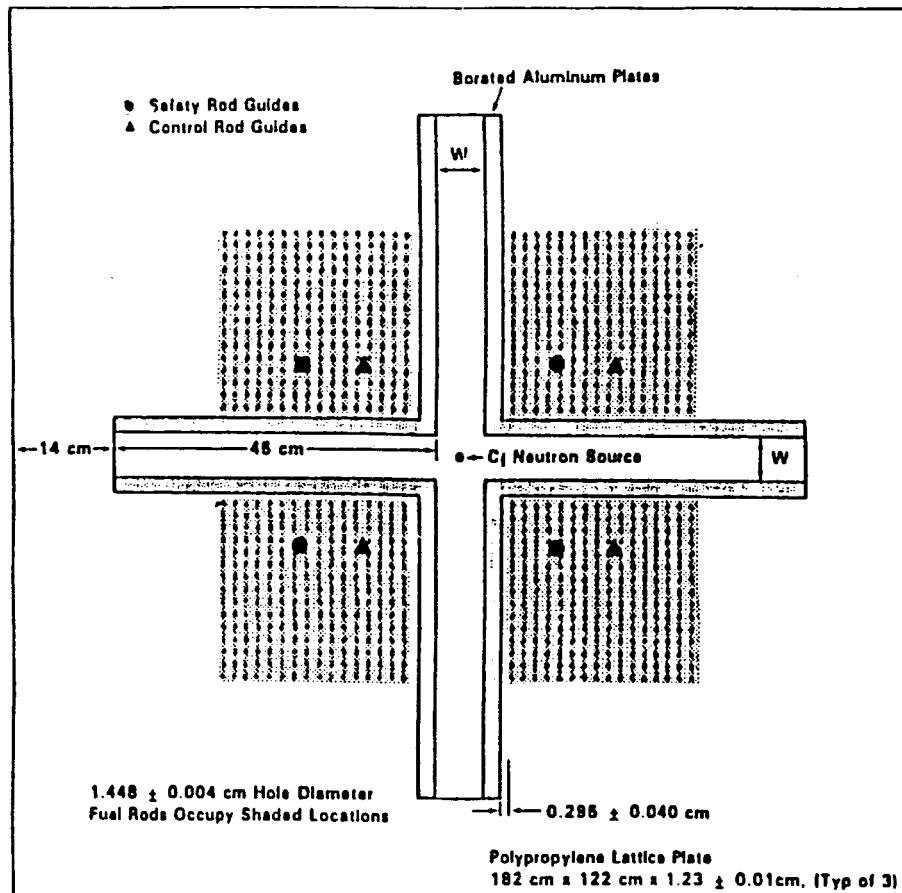


Figure 2.31 Experimental assembly evaluations for experiments from PNL-6205 and PNL-7176.
Source: Refs. 20 and 21 (Reprinted with permission from authors)

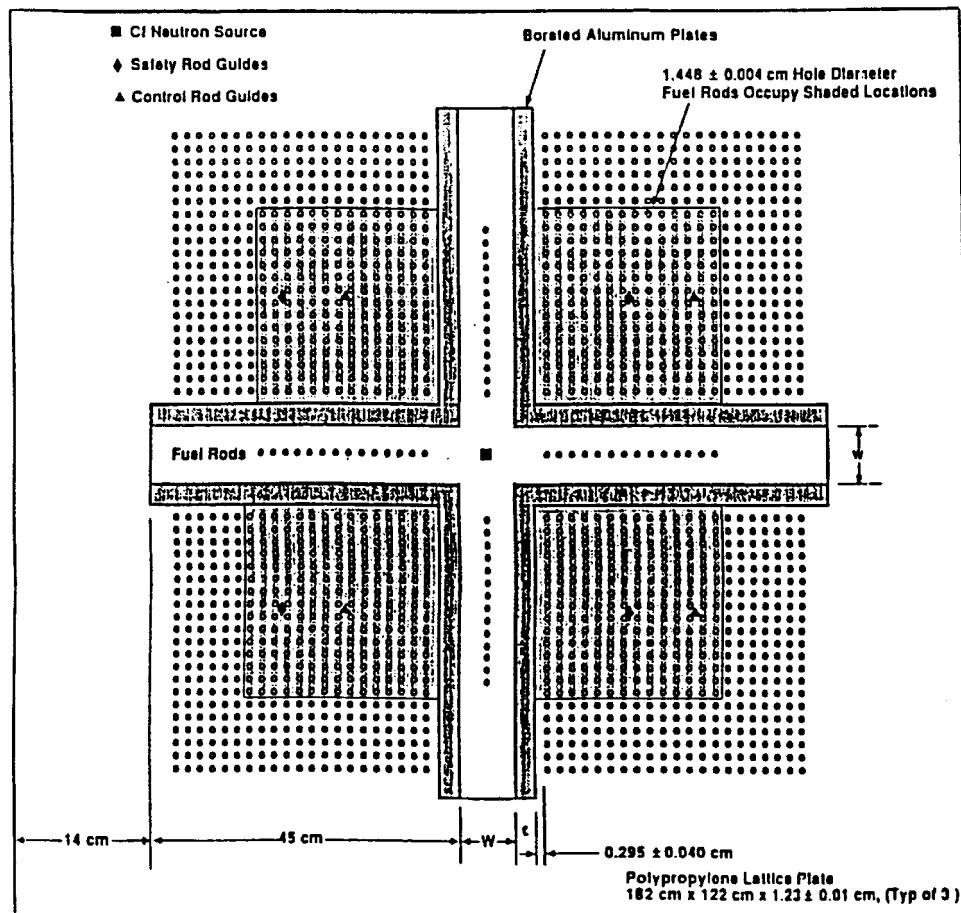


Assembly Number : 231
Lattice Pitch : 1.891 ± 0.001 cm
Safety Rods : Out of System
Control Rods : Out of System

Fuel Rods : 960
Fuel : 4.31 wt % ²³⁵U Enriched UO₂
Flux Trap Width, W : 3.71 ± 0.020
Plates : 0.46 ± 0.01 g/cm²
Boron : Boral
k_{eff} : See Comments
Comments : 963 Rods Predicted for Delayed Criticality

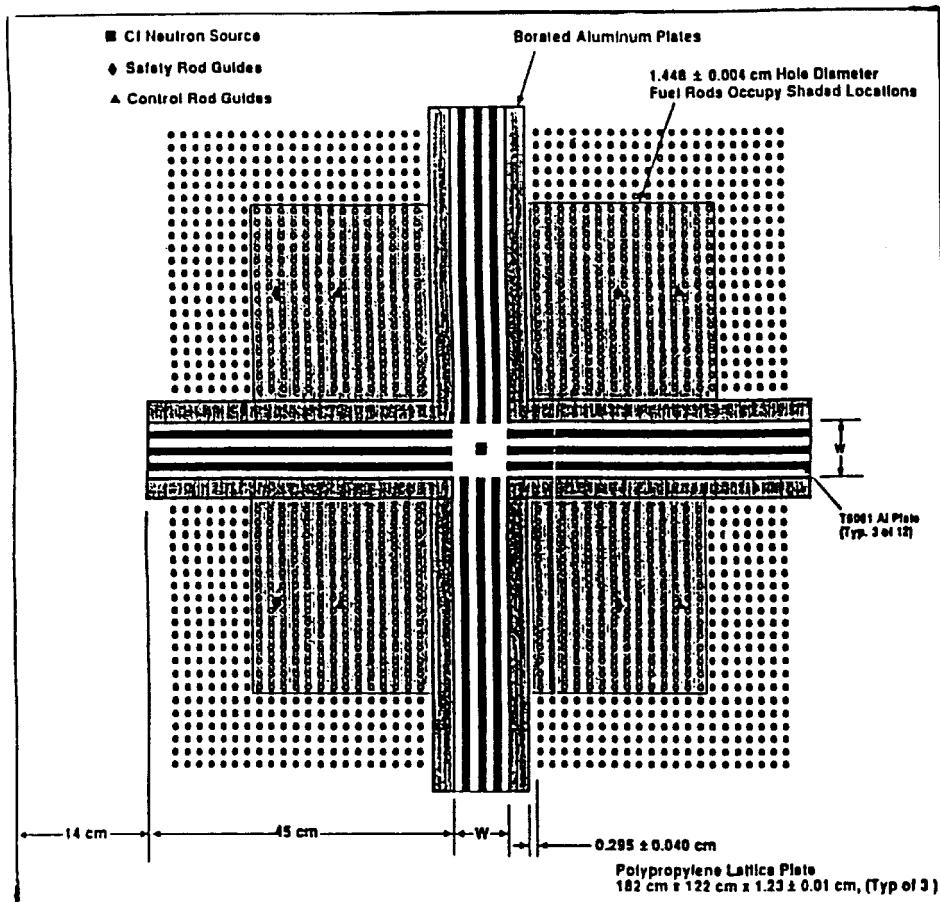
Figure 2.32 Experimental assembly for **P62FT231**. *Source:* Ref. 20 (Reprinted with permission from author)

Physical Description



Assembly Number	: 2141-3
Lattice Pitch	: $1.891 \pm 0.001 \text{ cm}$
Safety Rods	: Out of System
Control Rods	: Out of System
Fuel Rods	: 855 (see comments)
Fuel	: 4.31 wt% ^{235}U Enriched UO_2
Flux Trap Width, W	: $3.73 \pm 0.02 \text{ cm}$
Plates	: Borat
Boron	: $0.36 \pm 0.02 \text{ g/cm}^2$
Voiding Material	: Fuel Rods
Comments	: 858.5 ± 0.1 Rods Predicted for Delayed Criticality (does not include fuel in flux trap regions)

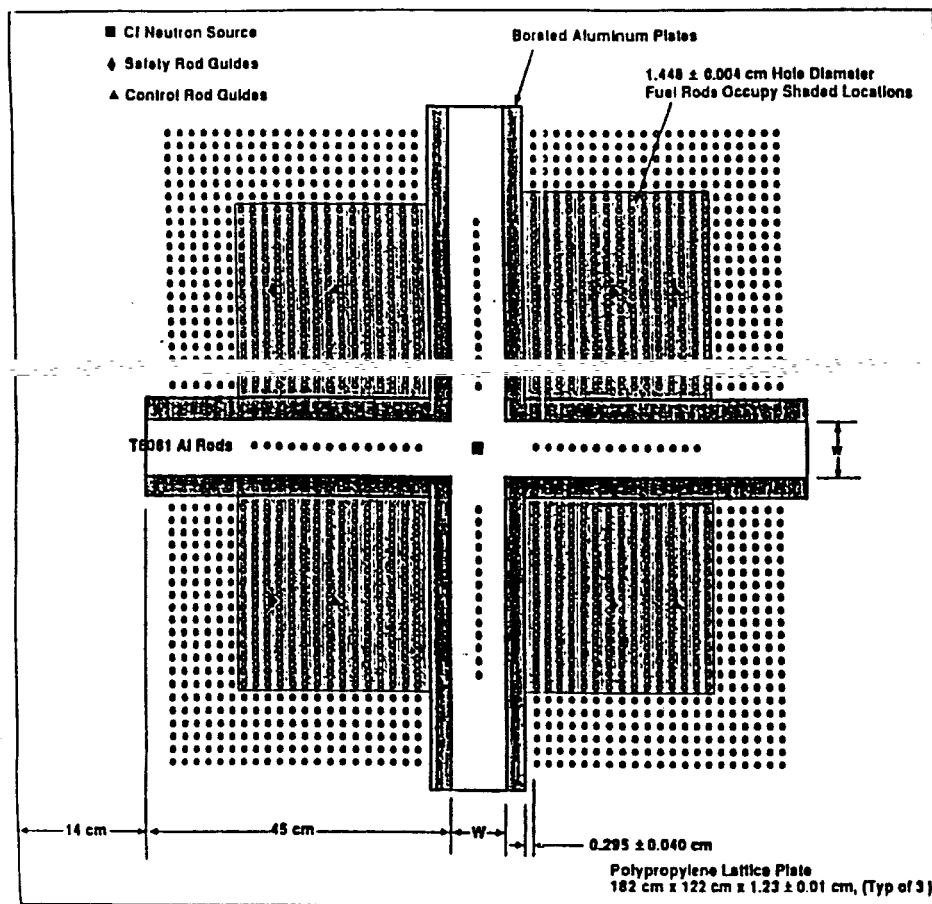
Figure 2.33 Experimental assembly for P71F14F3. *Source:* Ref. 21 (Reprinted with permission from authors)



Assembly Number	: 214V3
Lattice Pitch	: 1.891 ± 0.001 cm
Safety Rods	: Out of System
Control Rods	: Out of System
Fuel Rods	: 855 (see comments)
Fuel	: 4.31 wt% 235 U Enriched UO ₂
Flux Trap Width, W	: 3.73 ± 0.02 cm
Plates	: Boral
Boron	: 0.38 ± 0.02 gB/cm ³
Voiding Material	: 0.63 ± 0.001 cm tk Al Plate
Comments	: 862.1±1.2 Rods Predicted for Delayed Criticality

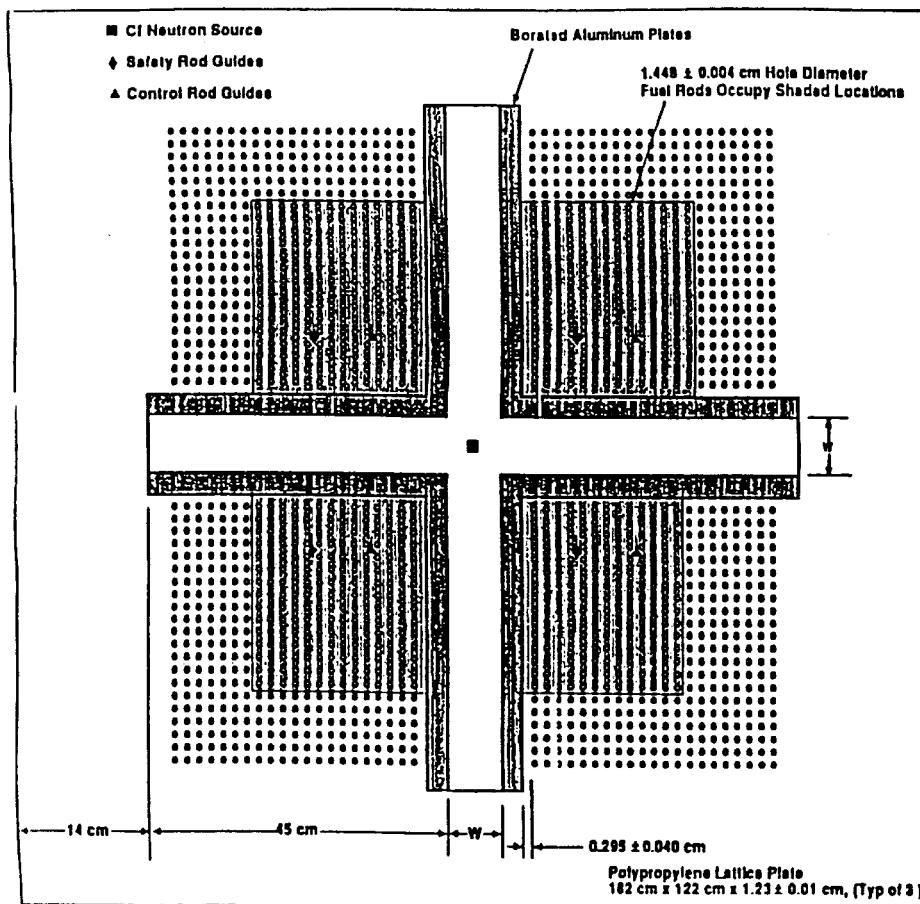
Figure 2.34 Experimental assembly for P71F14V3. *Source:* Ref. 21 (Reprinted with permission from authors)

Physical Description



Assembly Number	: 214V5
Lattice Pitch	: $1.891 \pm 0.001 \text{ cm}$
Safety Rods	: Out of System
Control Rods	: Out of System
Fuel Rods	: 615 (see comments)
Fuel	: 4.31 wt% ^{235}U Enriched UO_2
Flux Trap Width, W	: $3.73 \pm 0.02 \text{ cm}$
Plates	: Boral
Boron	: $0.38 \pm 0.02 \text{ gB/cm}^2$
Voiding Material	: $1.27 \pm 0.005 \text{ cm dia. Al Rods}$
Comments	: 924.8 ± 1.6 Rods Predicted for Delayed Criticality

Figure 2.35 Experimental assembly for **P71F14V5**



Assembly Number	: 214R
Lattice Pitch	: 1.891 ± 0.001 cm
Safety Rods	: Out of System
Control Rods	: Out of System
Fuel Rods	: 945 (see comments)
Fuel	: 4.31 wt% 235 U Enriched UD_2
Flux Trap Width, W	: 3.73 ± 0.02 cm
Plates	: Boral
Boron	: 0.36 ± 0.02 g/cm ³
Voiding Material	: None
Comments	: 952 Rods Predicted for Delayed Criticality

Figure 2.36 Experimental assembly for P71F214R

Physical Description

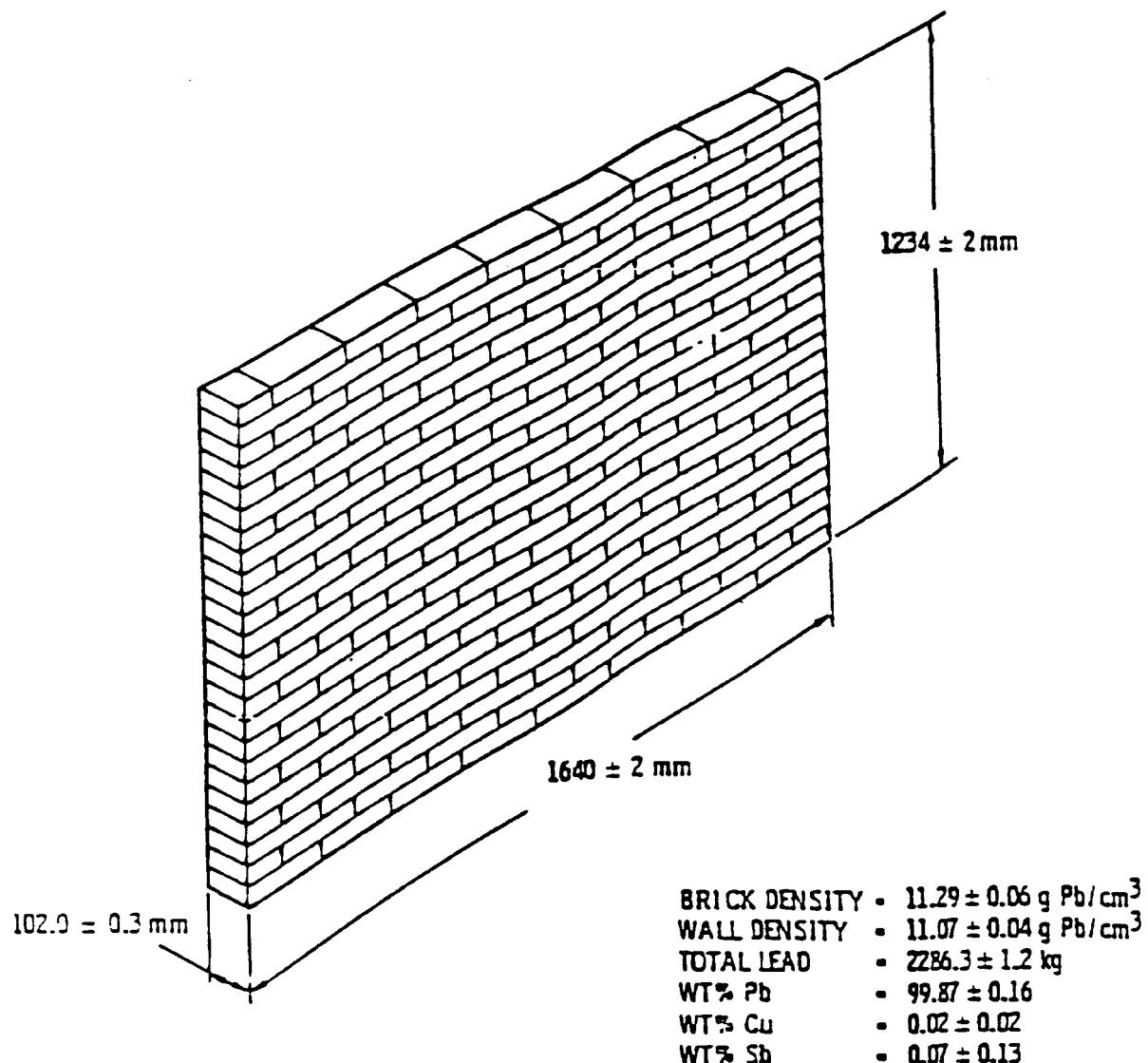


Figure 2.37 Assembled lead wall for experiments from PNL-2827. *Source:* Ref. 10 (Reprinted with permission from authors)

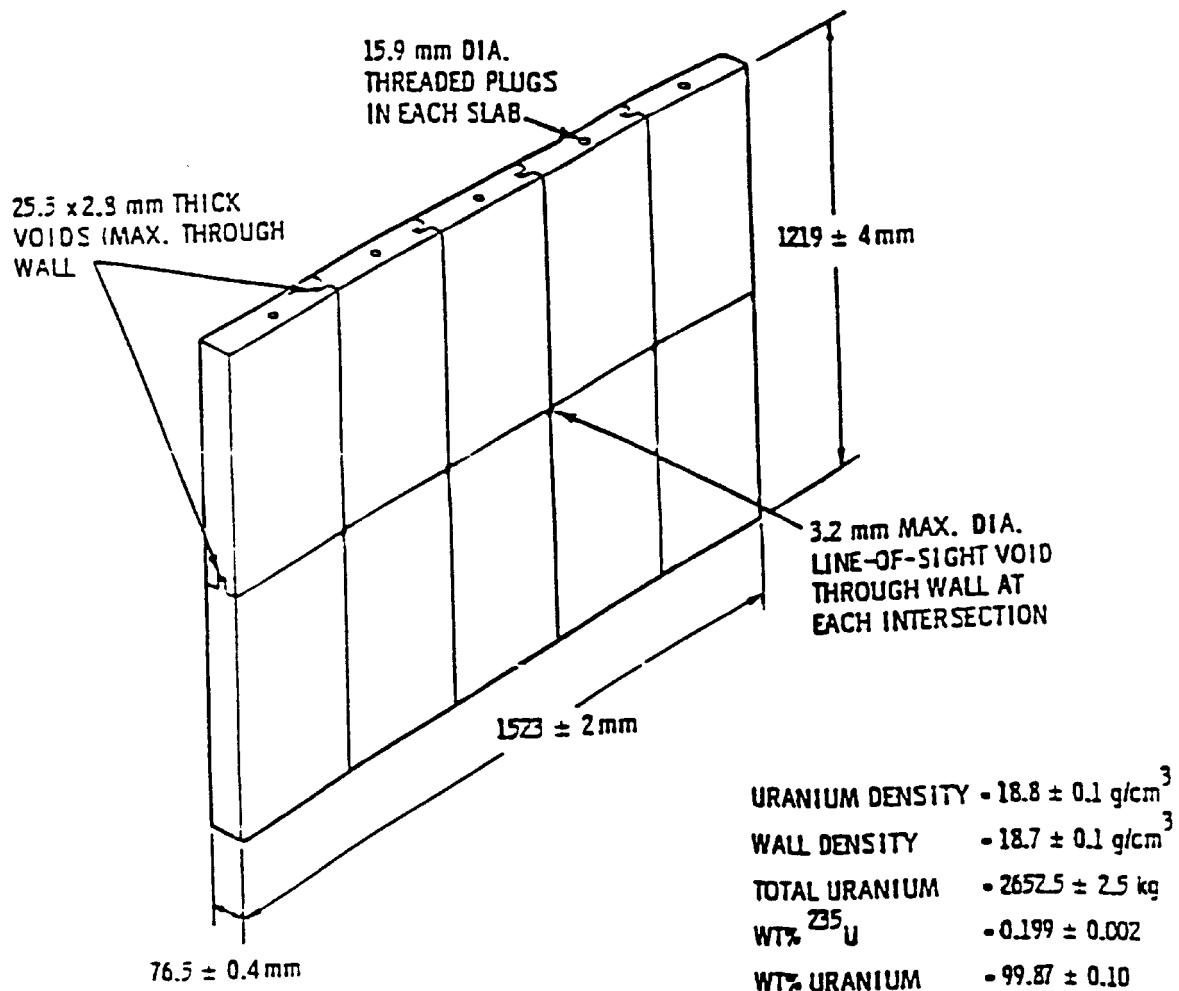


Figure 2.38 Assembled depleted uranium wall for experiments from PNL-2827. *Source:* Ref. 10
(Reprinted with permission from authors)

Physical Description

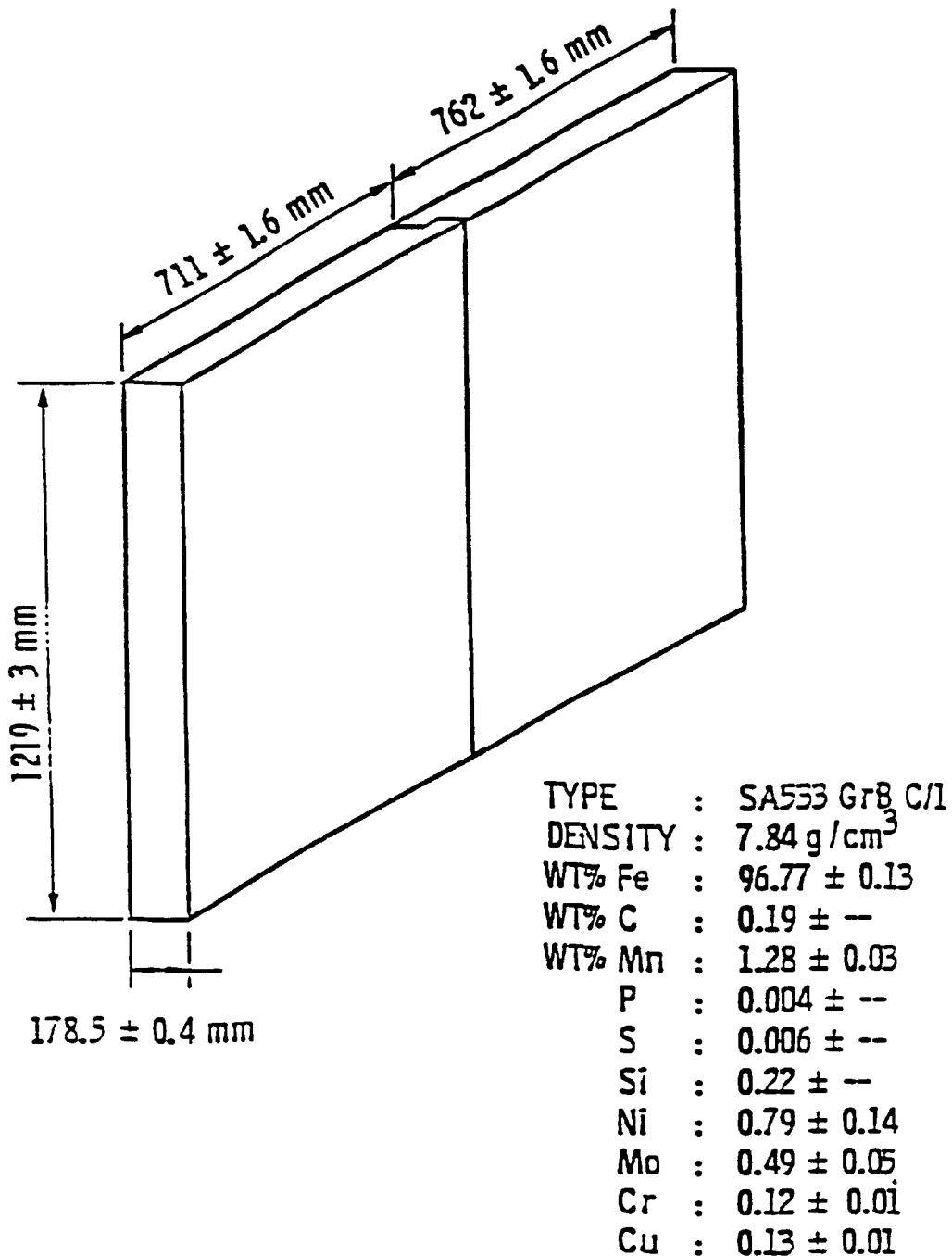


Figure 2.39 Assembled steel wall for experiments from PNL-3602. *Source:* Ref. 22 (Reprinted with permission from authors)

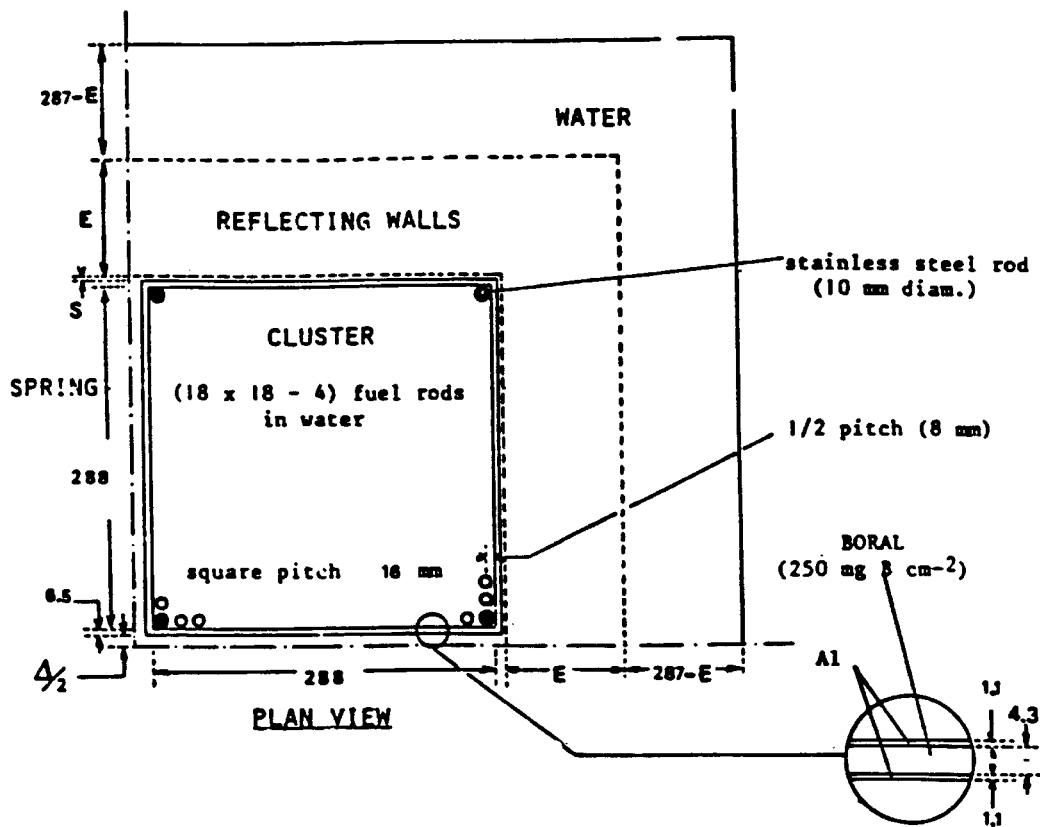


Figure 2.40 Quarter-assembly configuration for experiments from PATRAM'80. Source: Ref. 23
(Reprinted with permission by author)

Physical Description

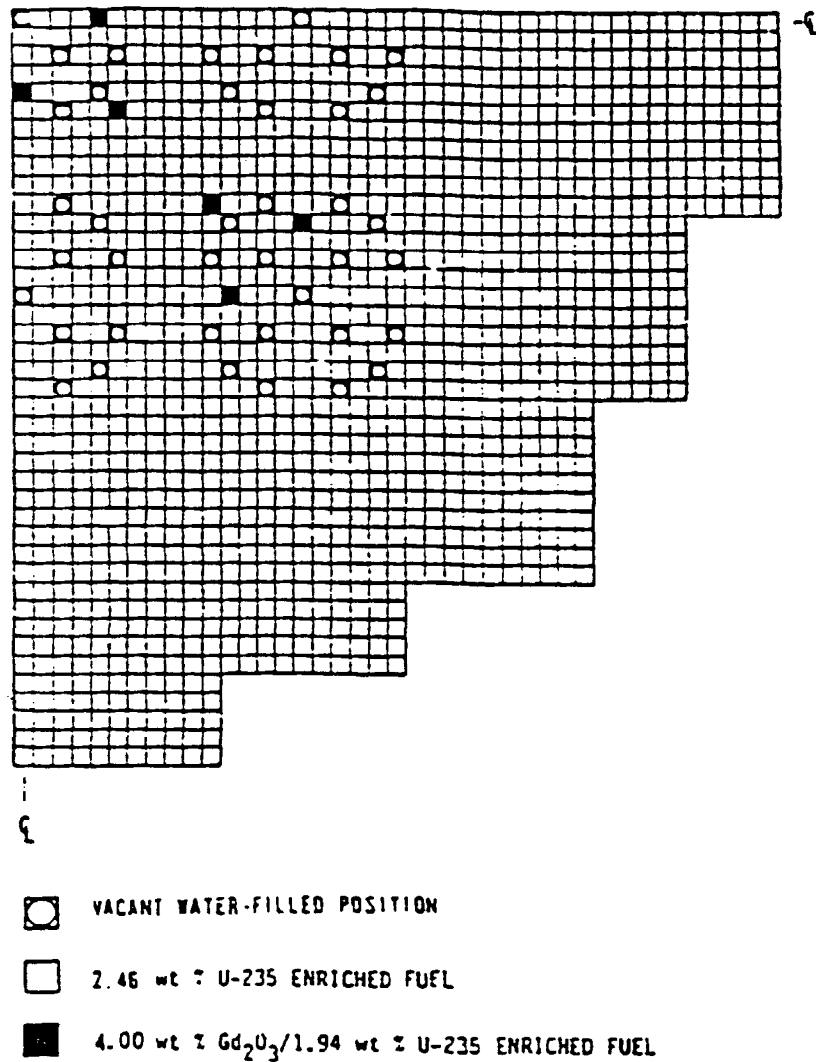


Figure 2.41 Quarter-core loading diagram for **BW1810A**. *Source:* Ref. 24

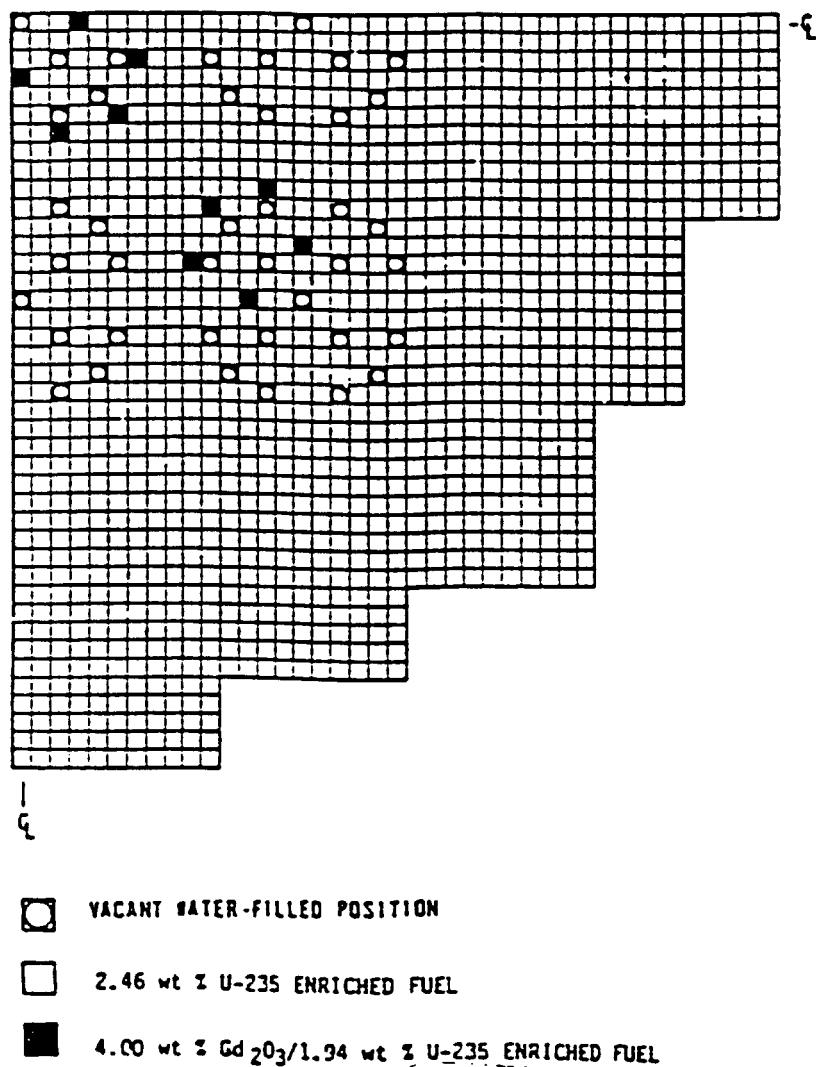


Figure 2.42 Quarter-core loading diagram for **BW1810B**. *Source:* Ref. 24

Physical Description

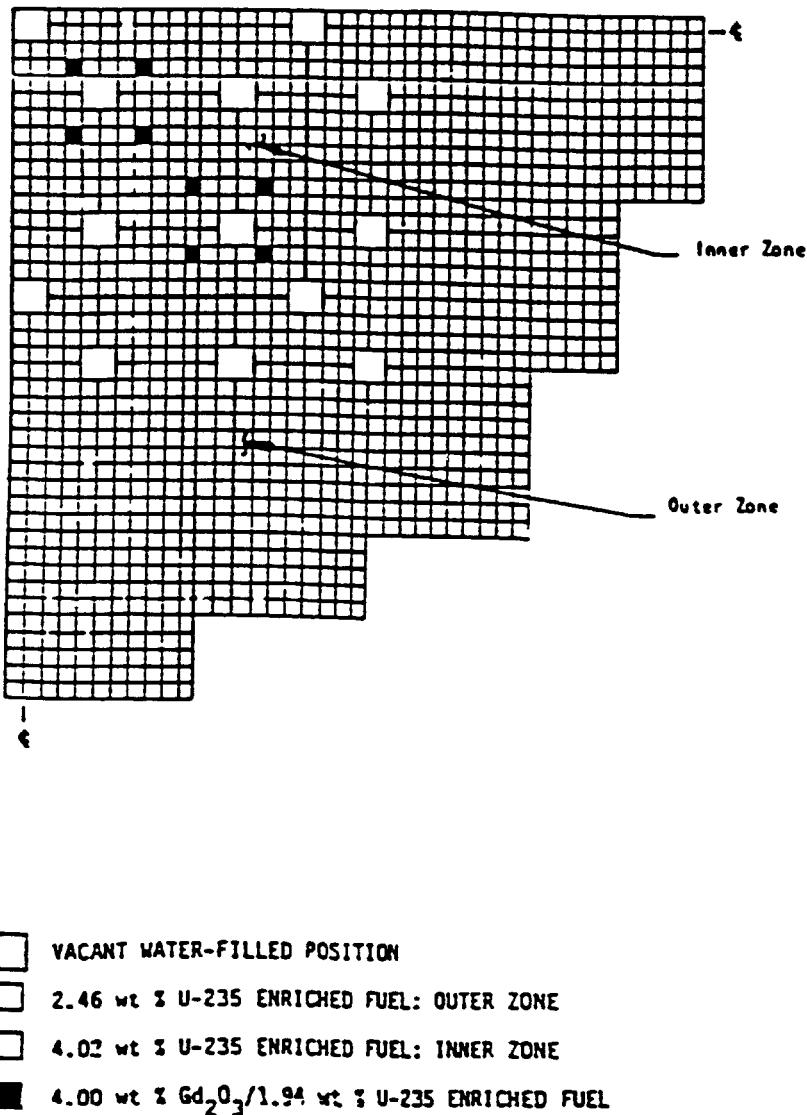


Figure 2.43 Quarter-core loading diagram for BW1810C. *Source:* Ref. 24

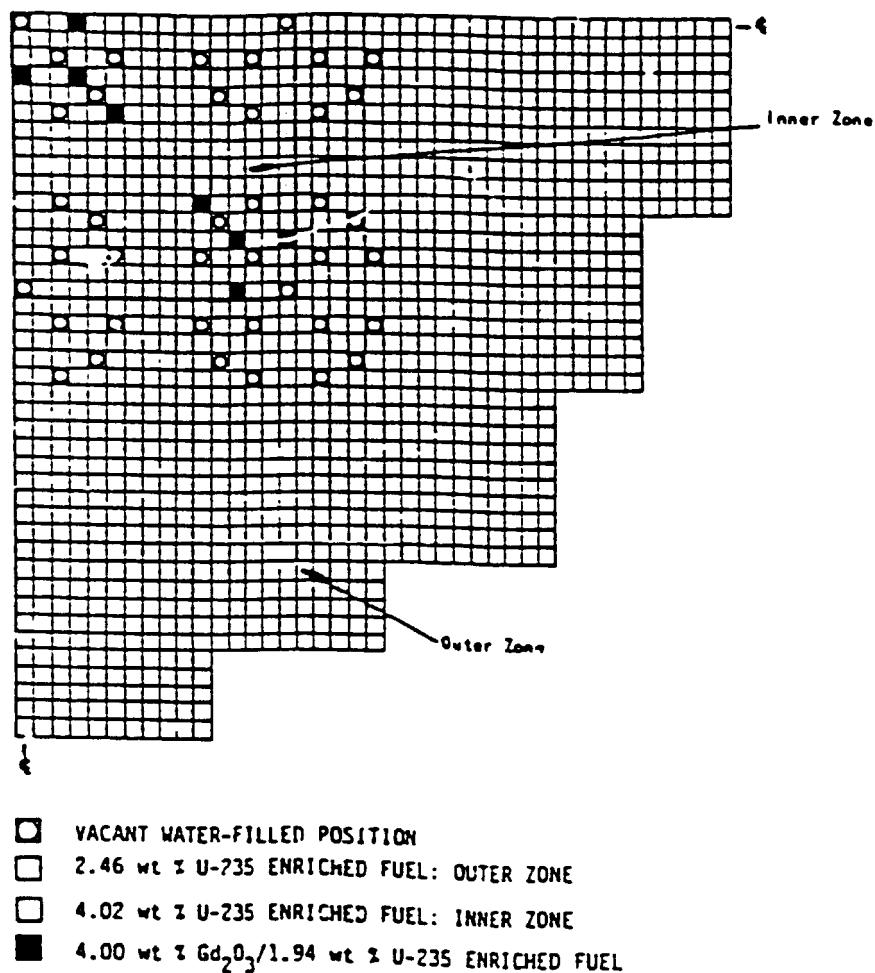


Figure 2.44 Quarter-core loading diagram for BW1810D. *Source:* Ref. 24

Physical Description

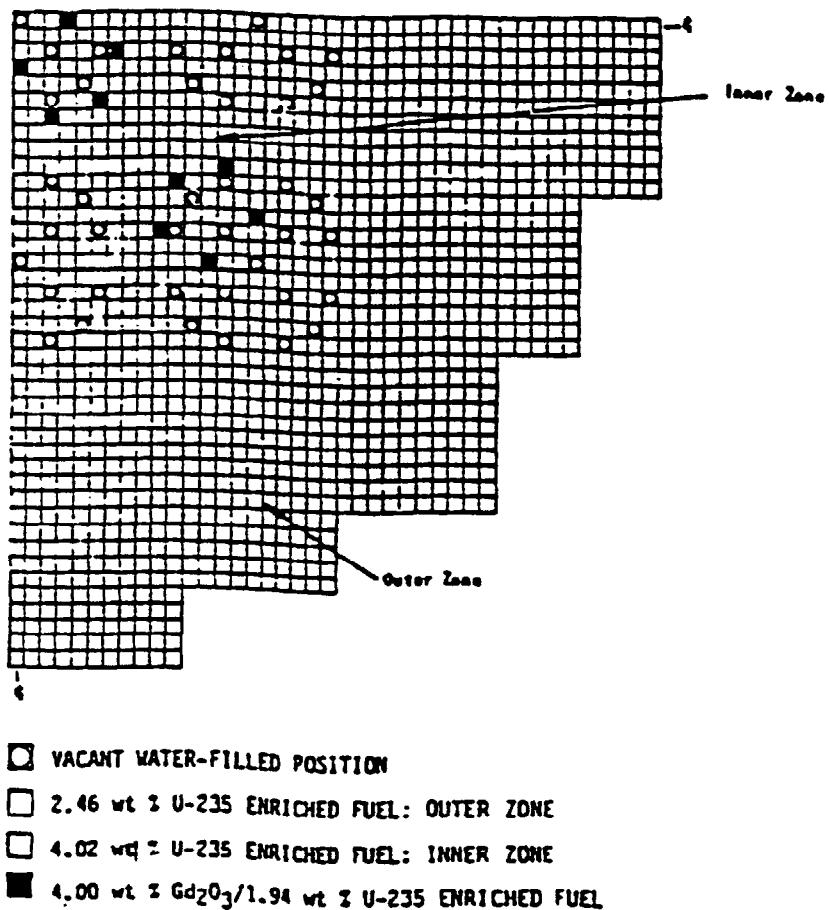
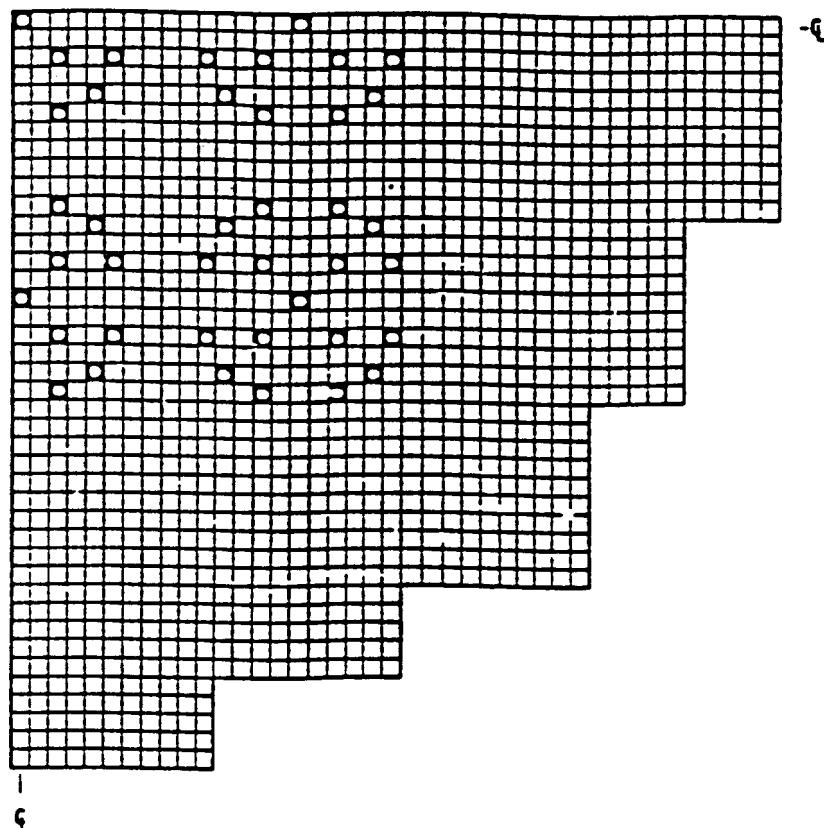


Figure 2.45 Quarter-core loading diagram for **BW1810E**. *Source:* Ref. 24



- VACANT WATER-FILLED POSITION**
- 2.46 wt U-235 ENRICHED FUEL**

Figure 2.46 Quarter-core loading diagram for **BW1810F**. *Source:* Ref. 24

Physical Description

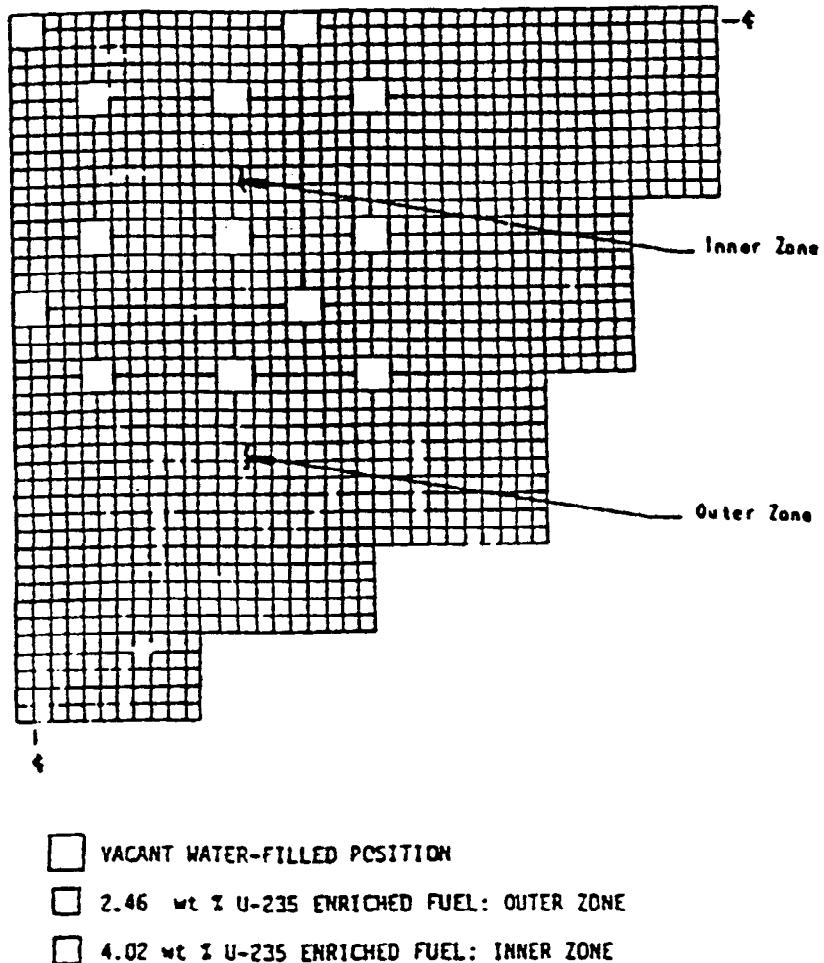


Figure 2.47 Quarter-core loading diagram for **BW1810G**. *Source:* Ref. 24

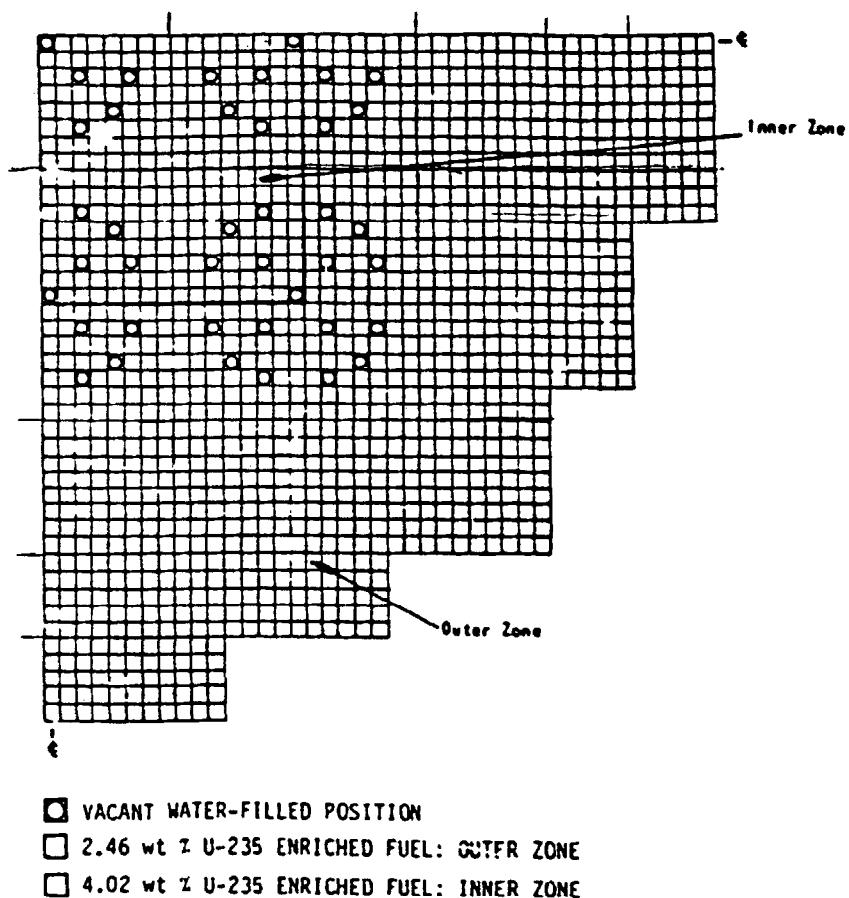
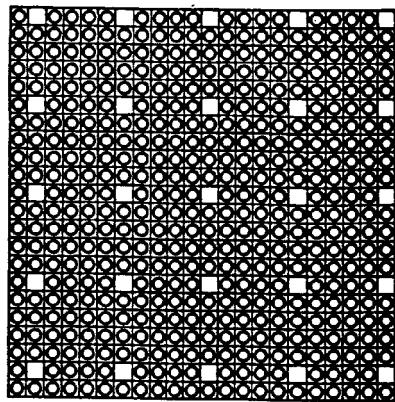
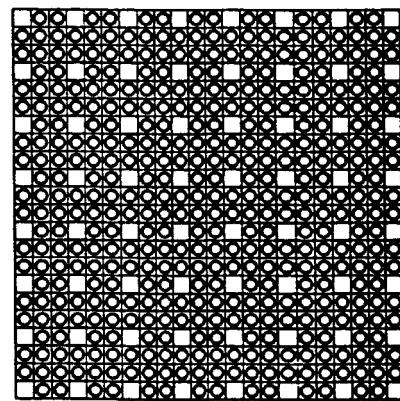


Figure 2.48 Quarter-core loading diagram for **BW1810H**. *Source:* Ref. 24

Physical Description



(a) **NSE71W1**



b) **NSE71W2**

Figure 2.49 Cross-sectional view of modeled **NSE71W1** and **NSE71W2** assemblies with water holes

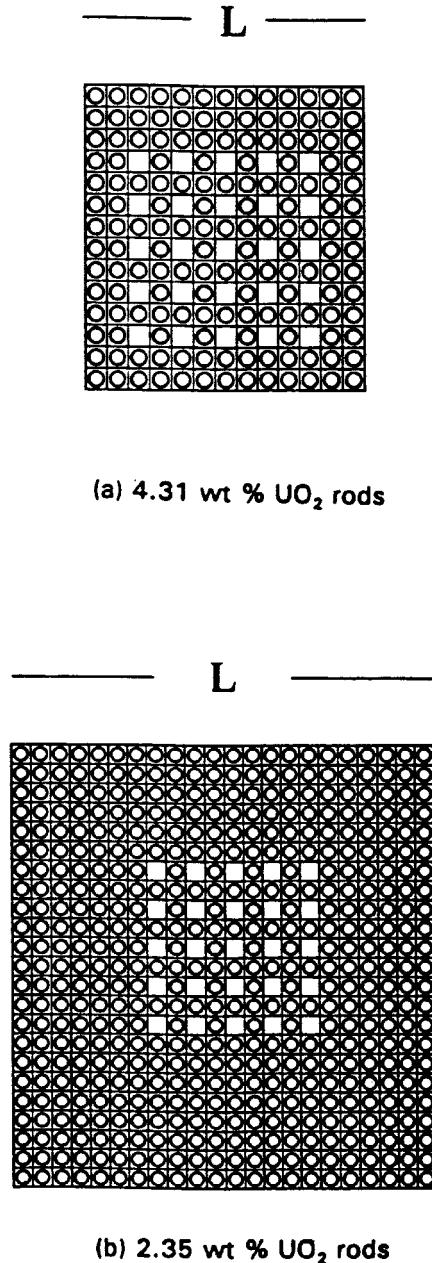
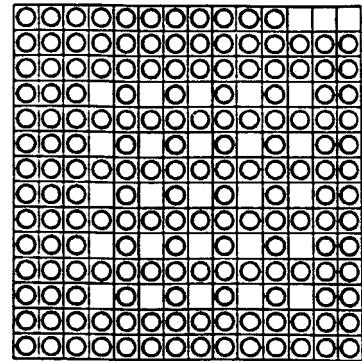
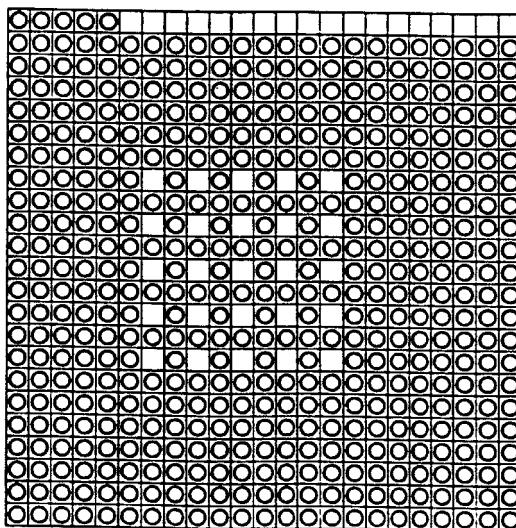


Figure 2.50 Cross-sectional view of water hole experiments from PNL-3314

Physical Description

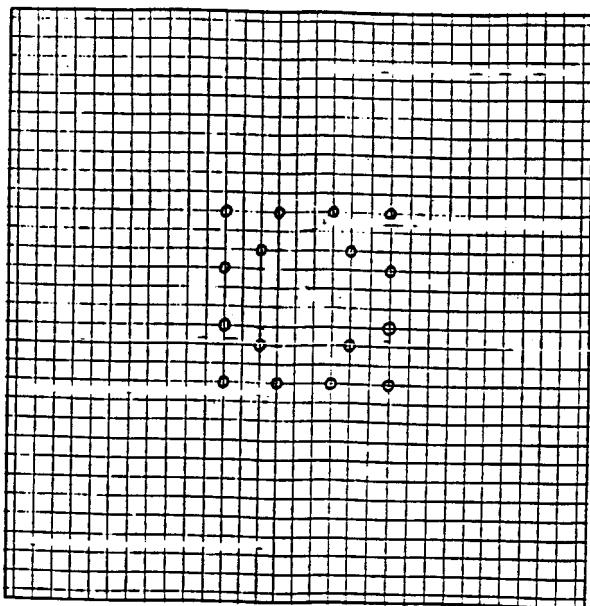


(a) **P3314W1**

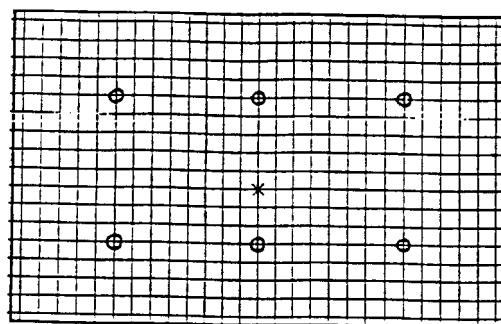


(b) **P3314W2**

Figure 2.51 Cross-sectional view of modeled **P3314W1** and **P3314W2** assemblies with water holes



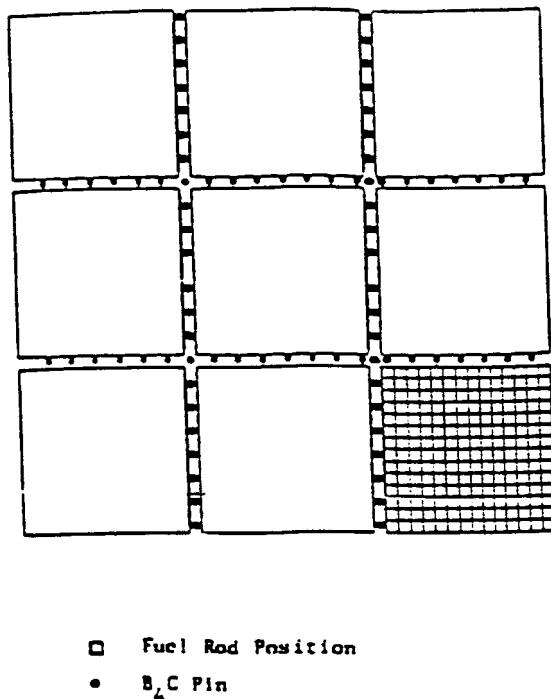
(a) W3269W1



(b) W3269W2

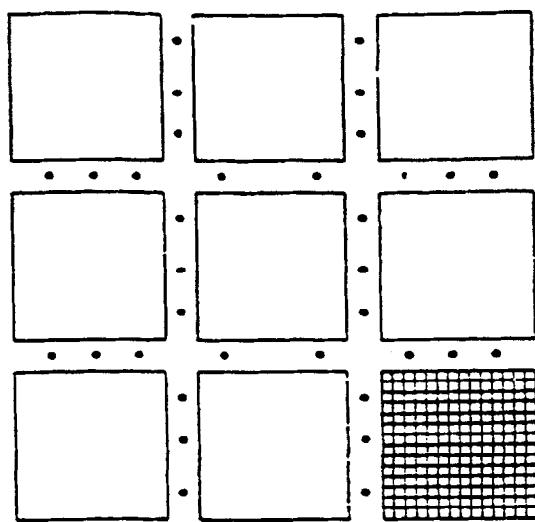
Figure 2.52 Core layouts of W3269W1 and W3269W2 with water hole locations (circles)

Physical Description



Note: The large squares represent 14×14 fuel assemblies as shown in the lower right-hand corner.

Figure 2.53 Experiment **BW1484C1** core loading diagram. Source: Ref. 6



□ Fuel Rod Position
● B₄C Pin

Note: The large squares represent 14 × 14 fuel assemblies as shown in the lower right-hand corner.

Figure 2.54 Experiment BWS1484C2 core loading diagram. *Source:* Ref. 6

Physical Description

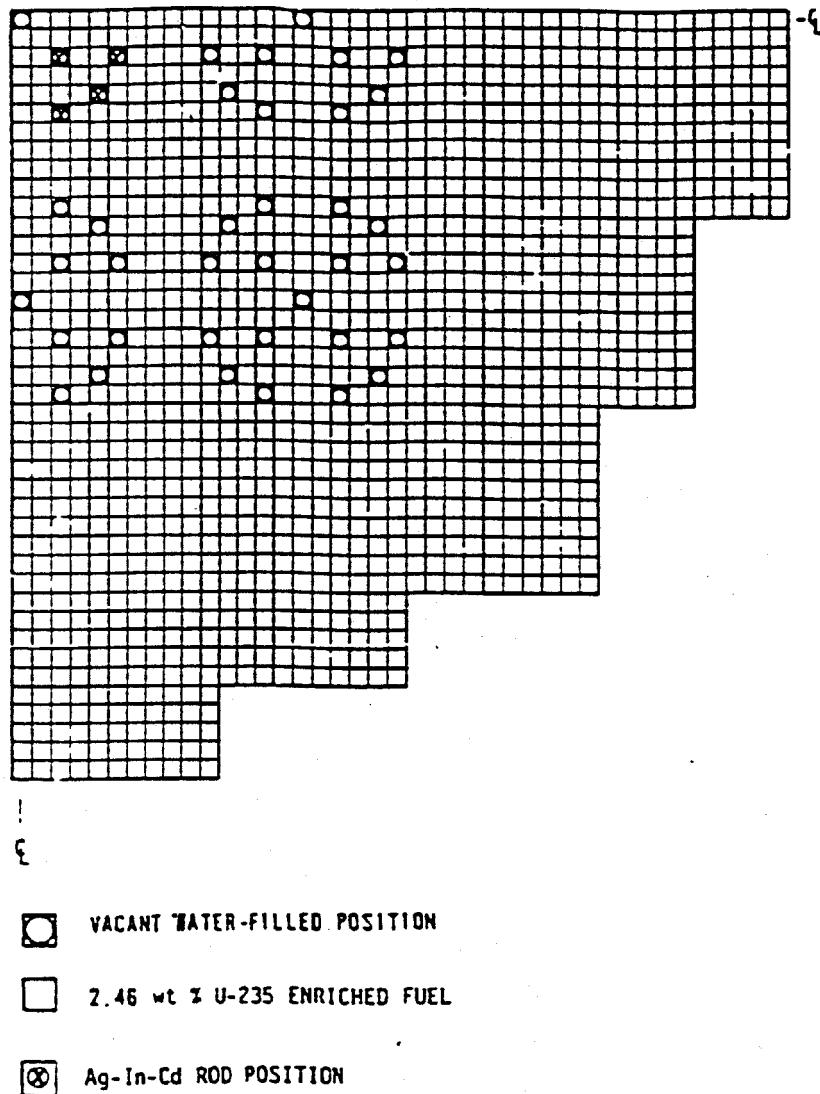
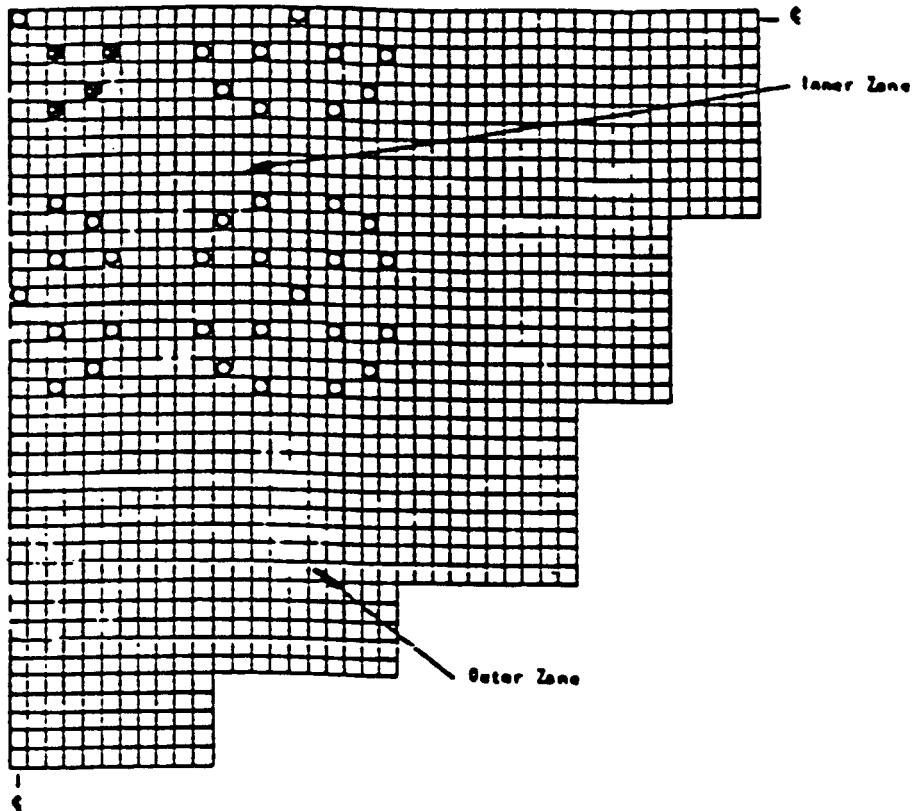


Figure 2.55 Core loading diagram for **BW1810I**. *Source:* Ref. 24



- VACANT WATER-FILLED POSITION
- 2.46 wt % U-235 ENRICHED FUEL: OUTER ZONE
- 4.02 wt % U-235 ENRICHED FUEL: INNER ZONE
- R_{4C} ROD POSITION

Figure 2.56 Core loading diagram for BW1810J. *Source:* Ref. 24

Physical Description

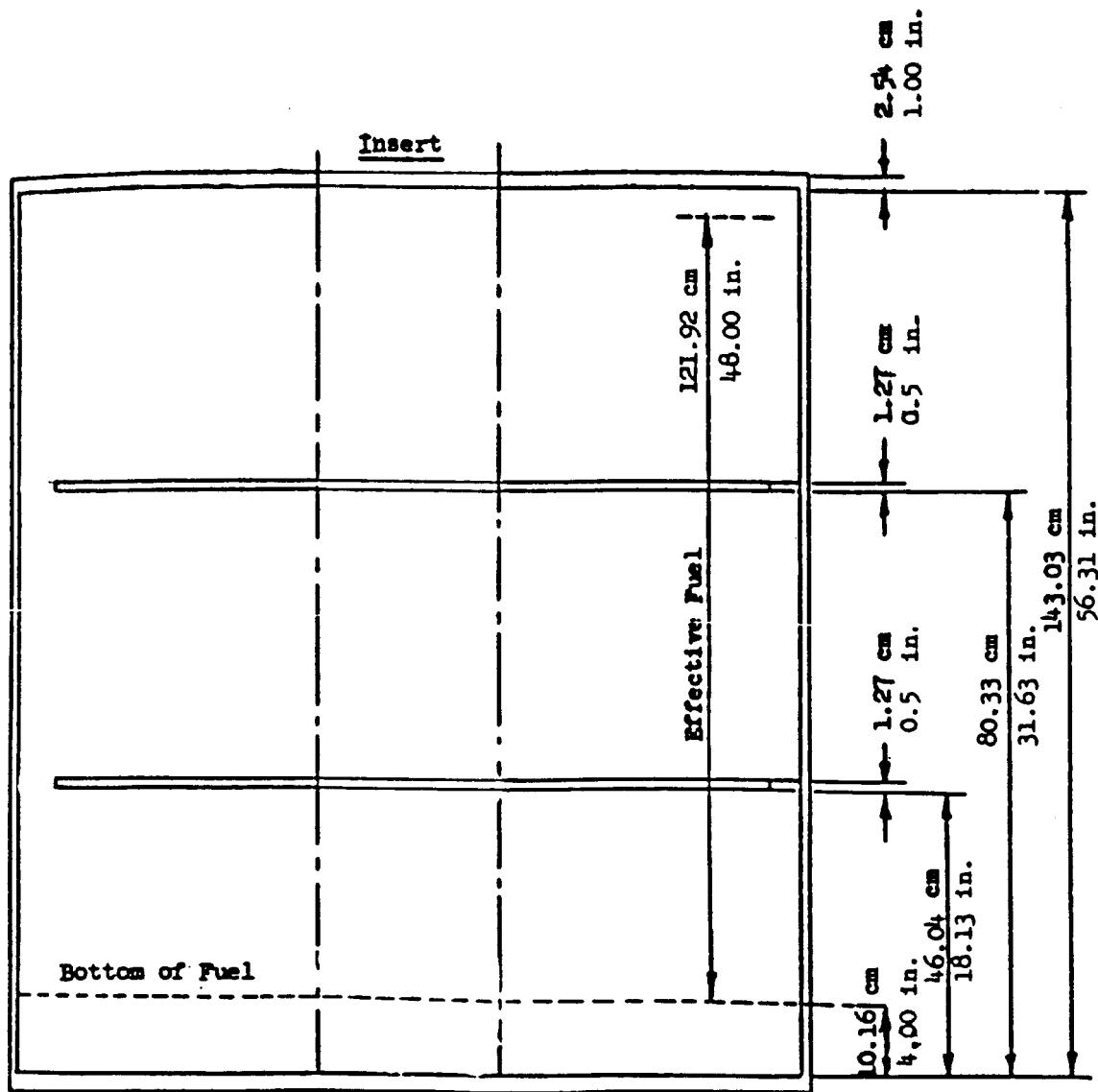


Figure 2.57 Vertical cross section of core assembly for experiments W3269B1, W3269B2, and W3269B3.
Source: Ref. 15

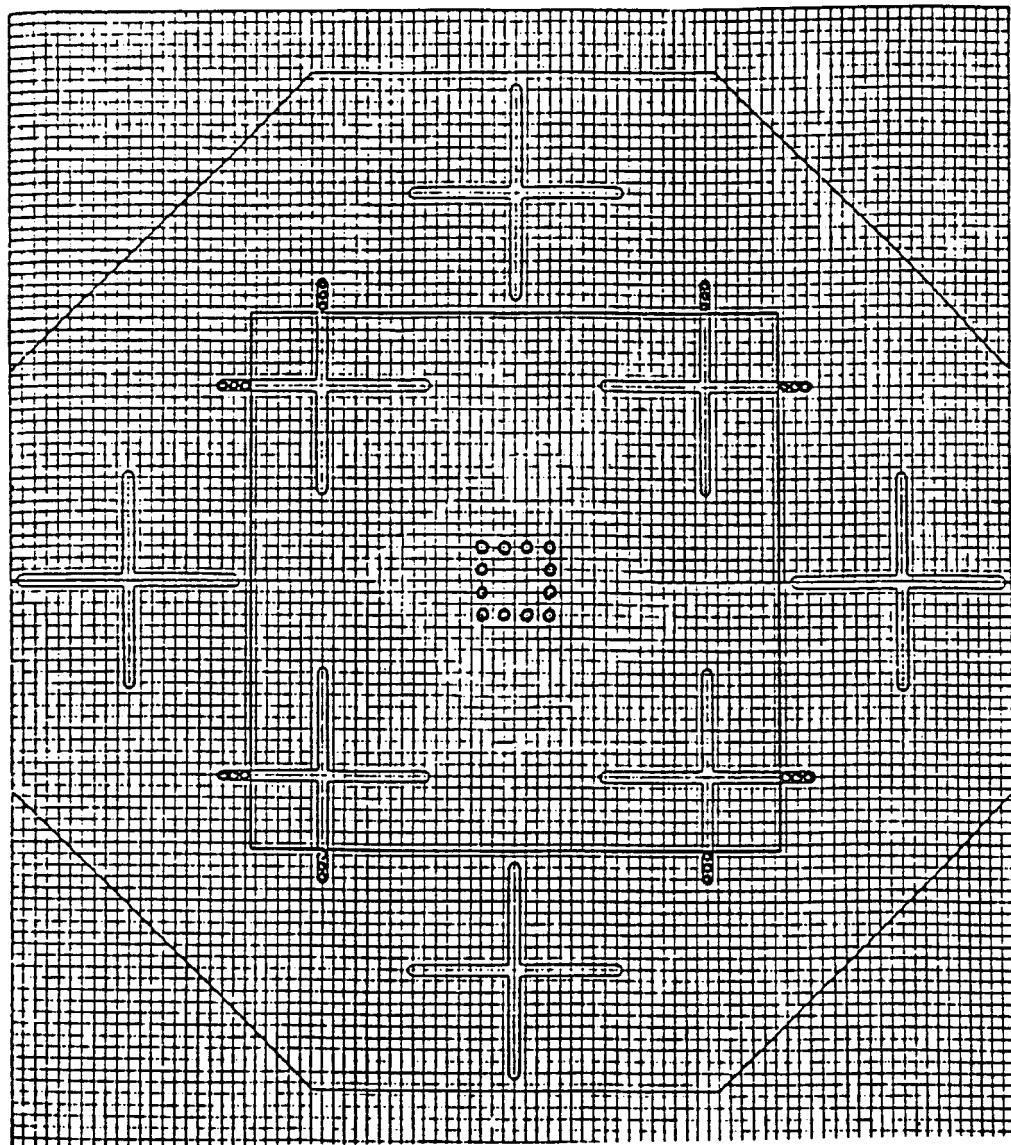


Figure 2.58 Core configuration for experiment **W3269B1**. *Source:* Ref. 15

Physical Description

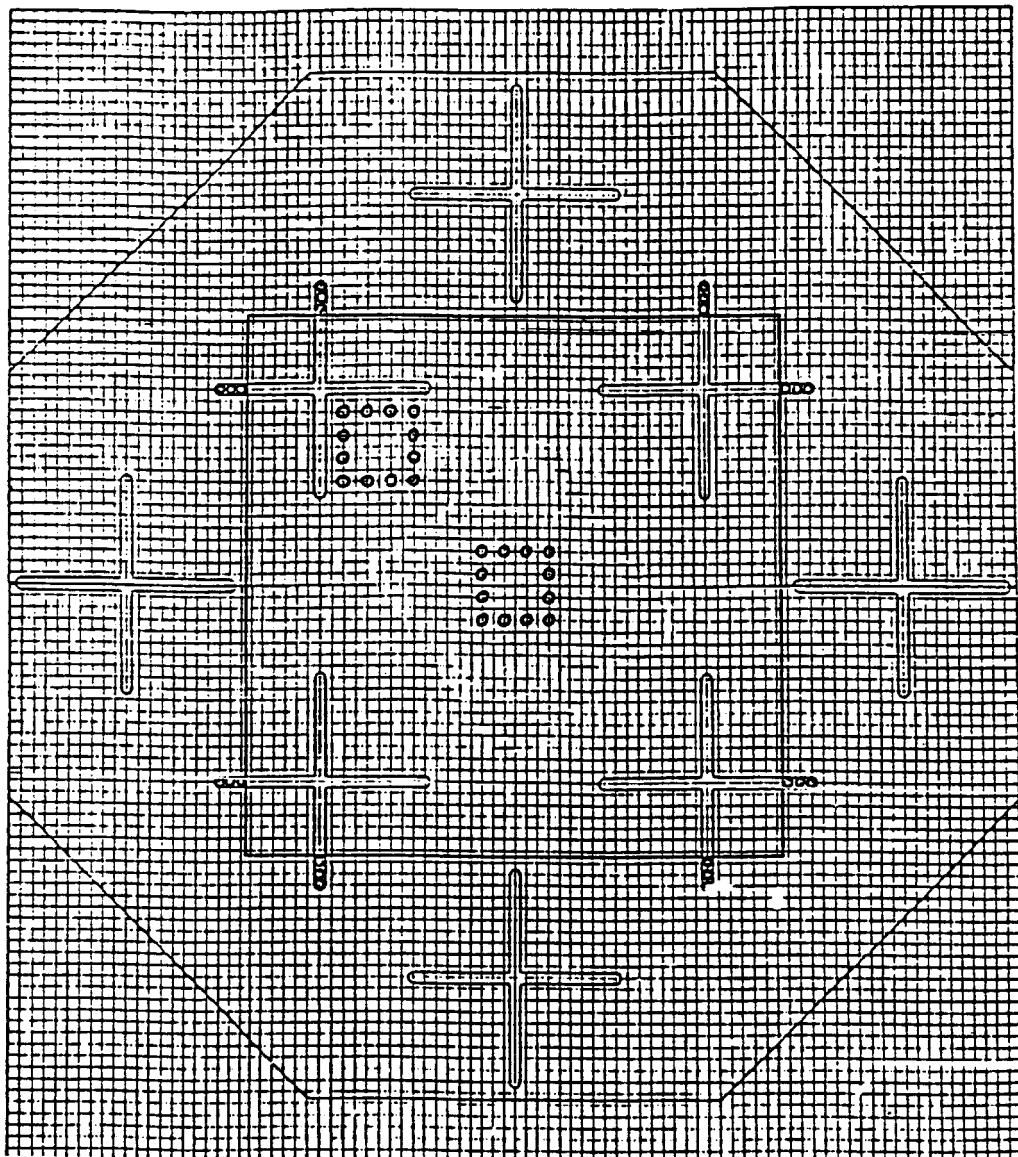


Figure 2.59 Core configuration for experiment **W3796B2**. *Source:* Ref. 15

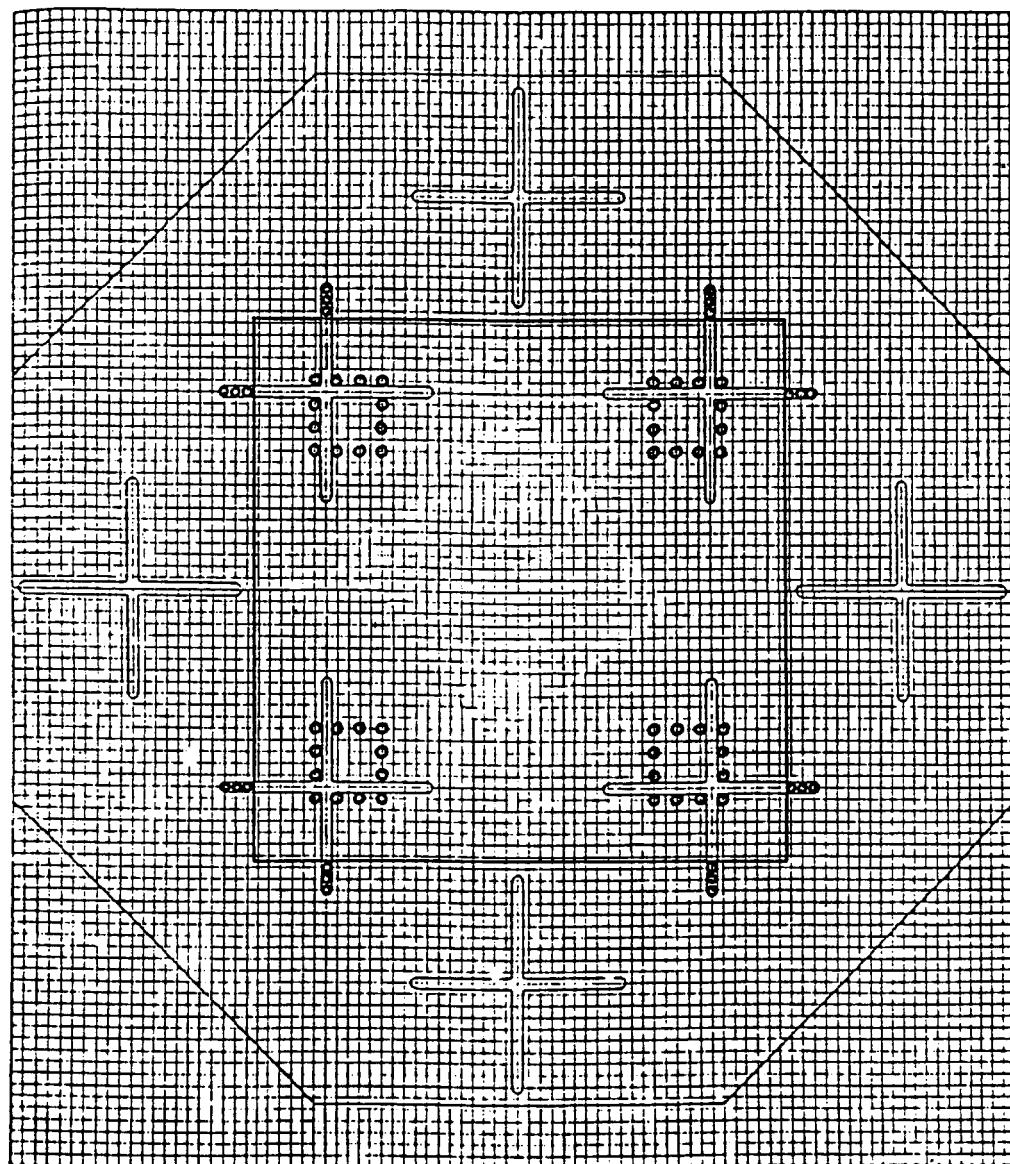
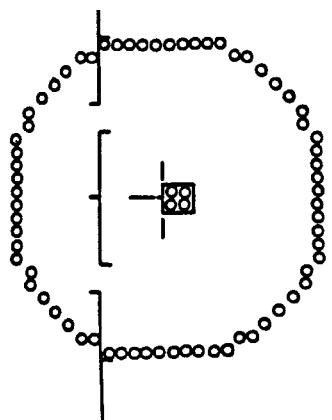
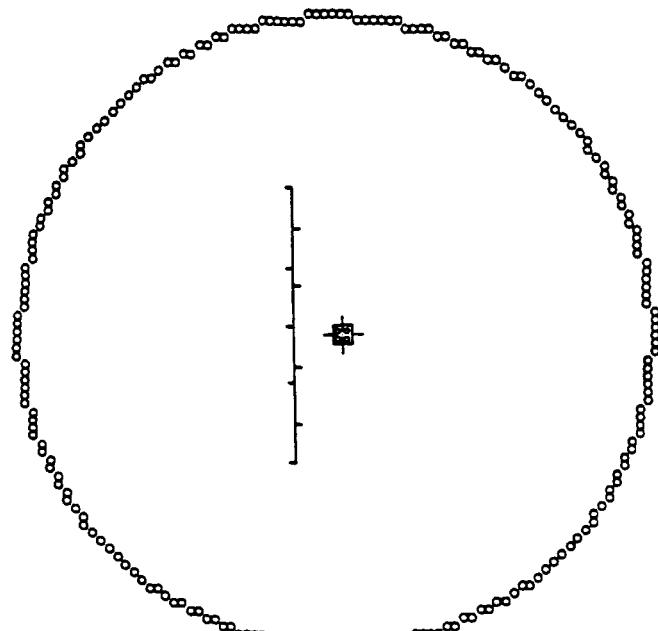


Figure 2.60 Core configuration for experiment **W3269B3**. *Source:* Ref. 15

Physical Description



(a) **BW1231B1**



(b) **BW1231B2**

Figure 2.61 Core diagrams for experiments from BAW-1231

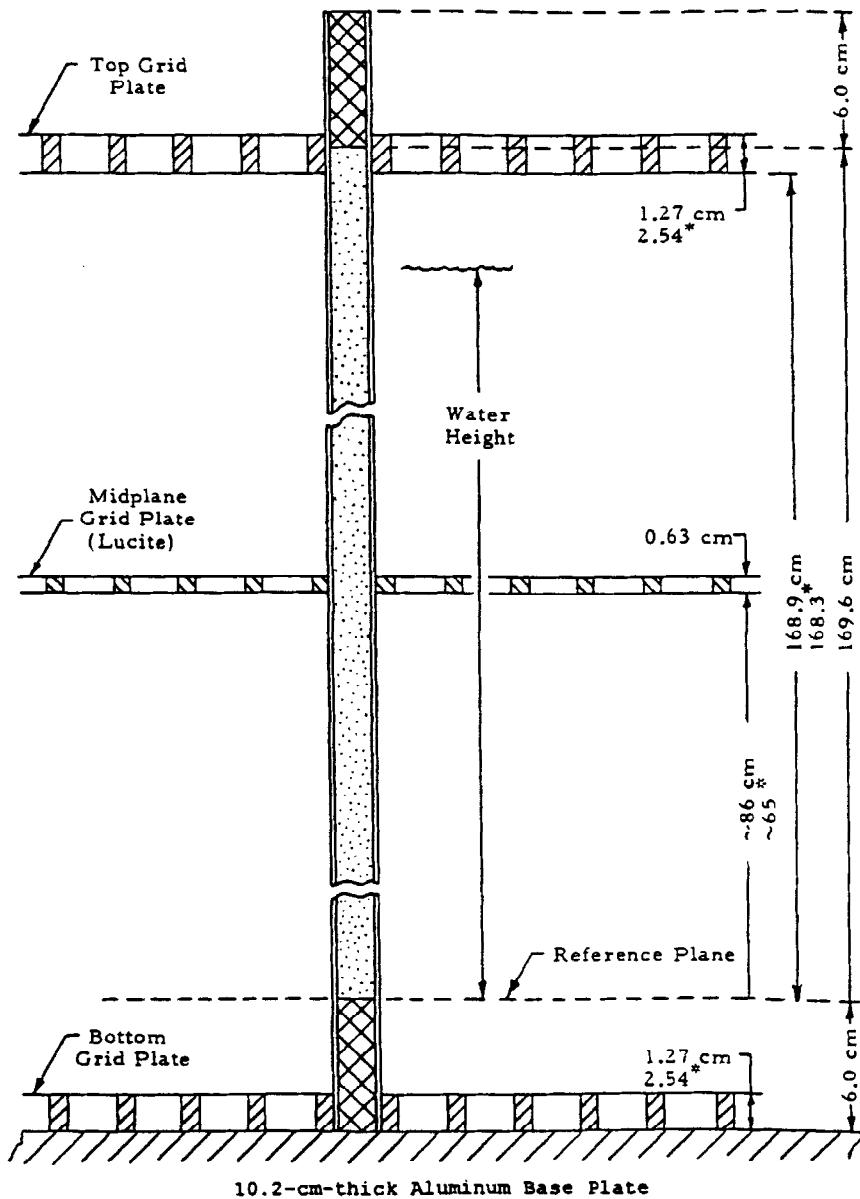


Figure 2.62 Vertical dimensions for BW1231B1 and BW1231B2

Physical Description

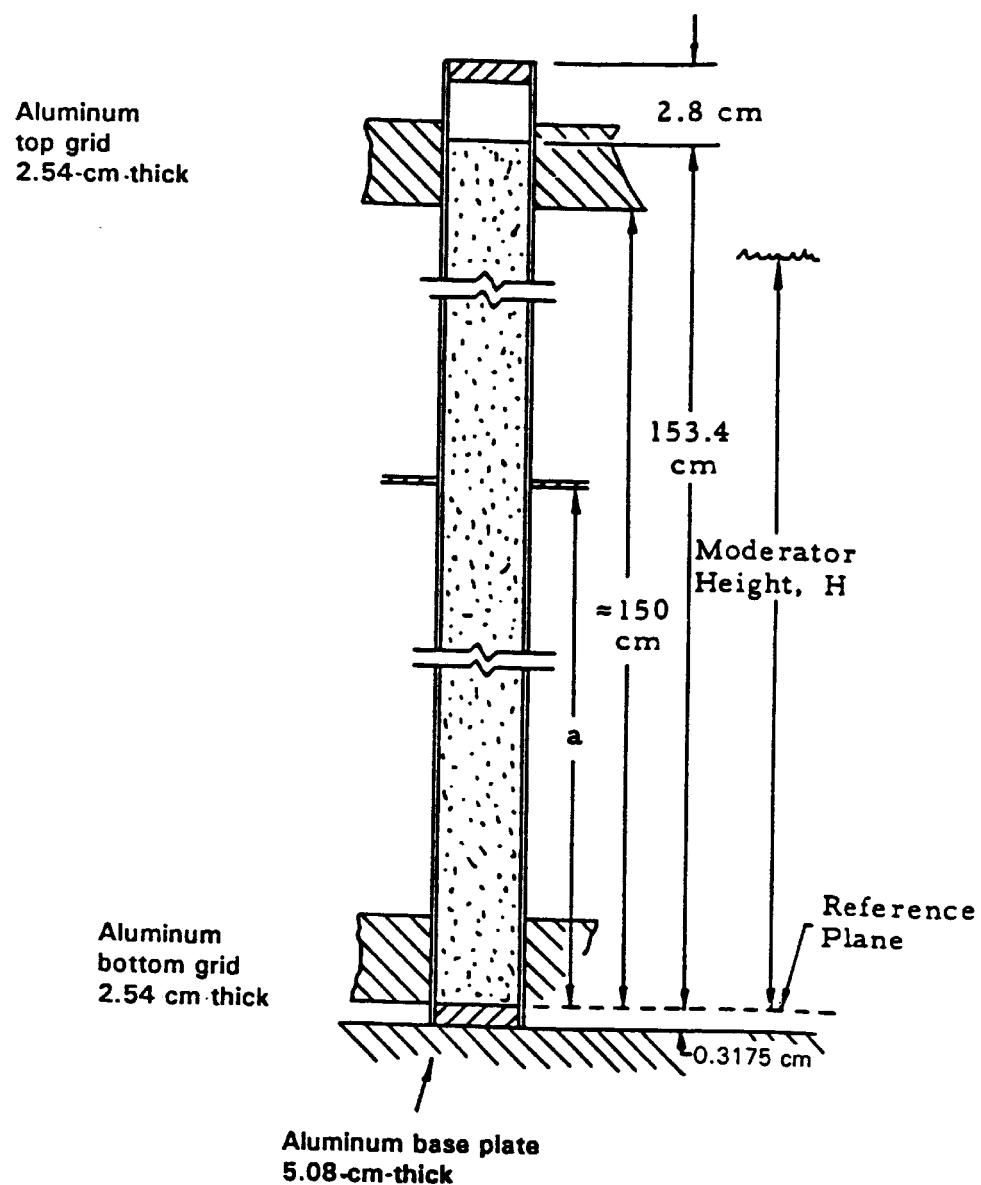


Figure 2.63 Vertical dimensions for BW1273M experiment

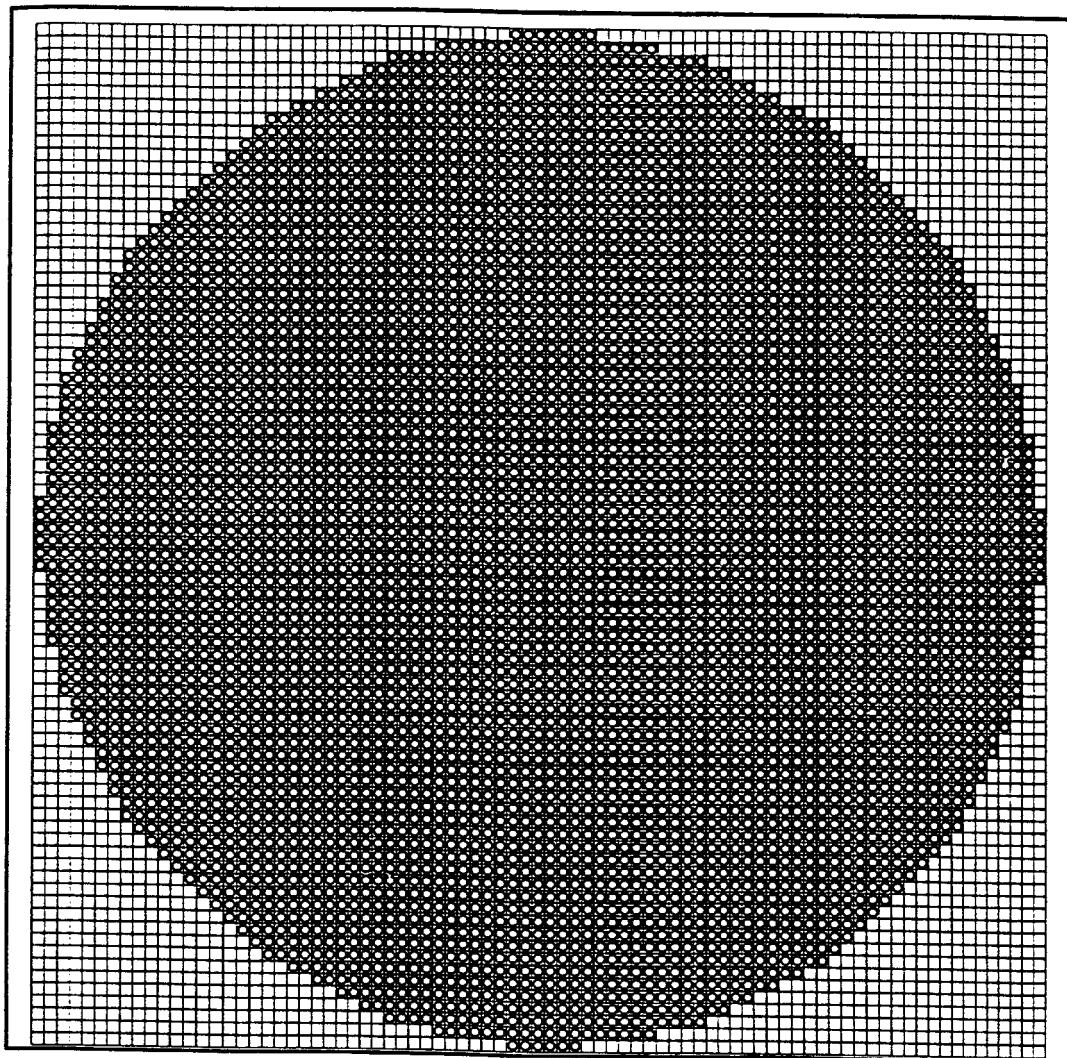


Figure 2.64 Cross-sectional view of modeled **BW1273M** core

Physical Description

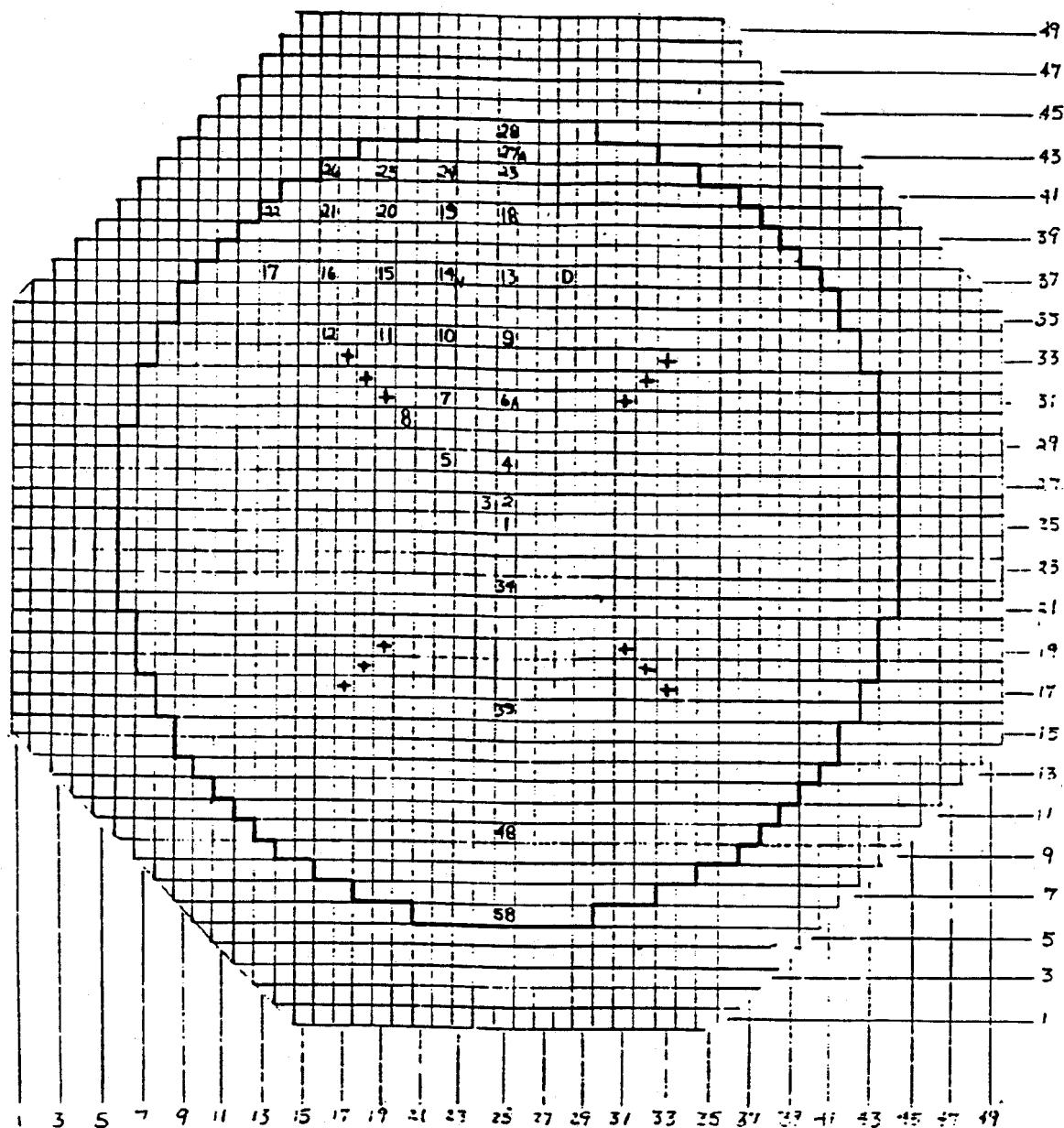


Figure 2.65 Core layout for **EPRU65B**. *Source:* Ref. 7 (Copyright © 1976. Electric Power Research Institute. EPRI NP-196. *Clean Critical Experiment Benchmarks for Plutonium Recycle in LWRs*. Reprinted with permission)

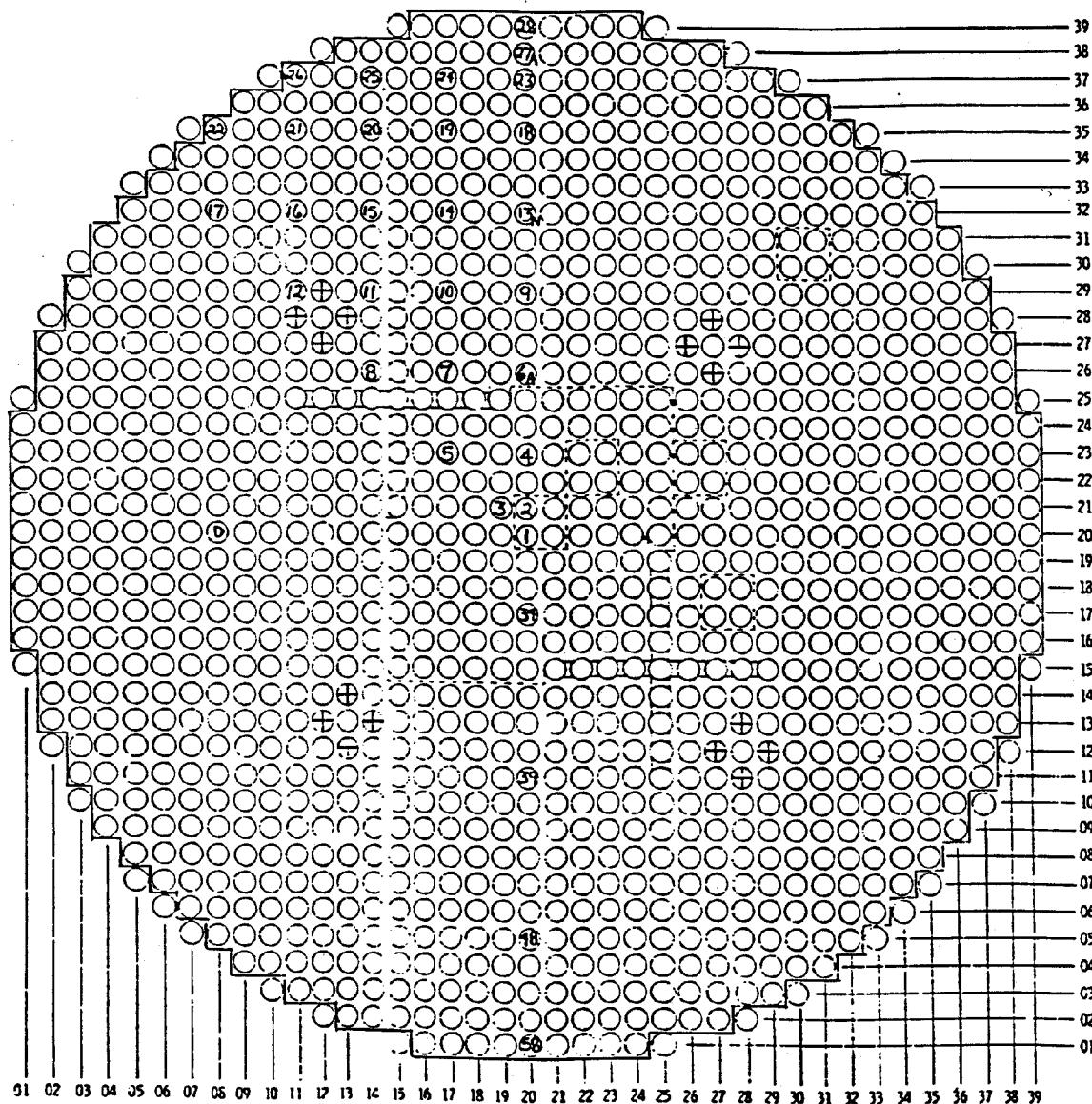


Figure 2.66 Core layout for EPRU75B. *Source:* Ref. 7 (Copyright © 1976. Electric Power Research Institute. EPRI NP-196. *Clean Critical Experiment Benchmarks for Plutonium Recycle in LWRs*. Reprinted with permission)

Physical Description

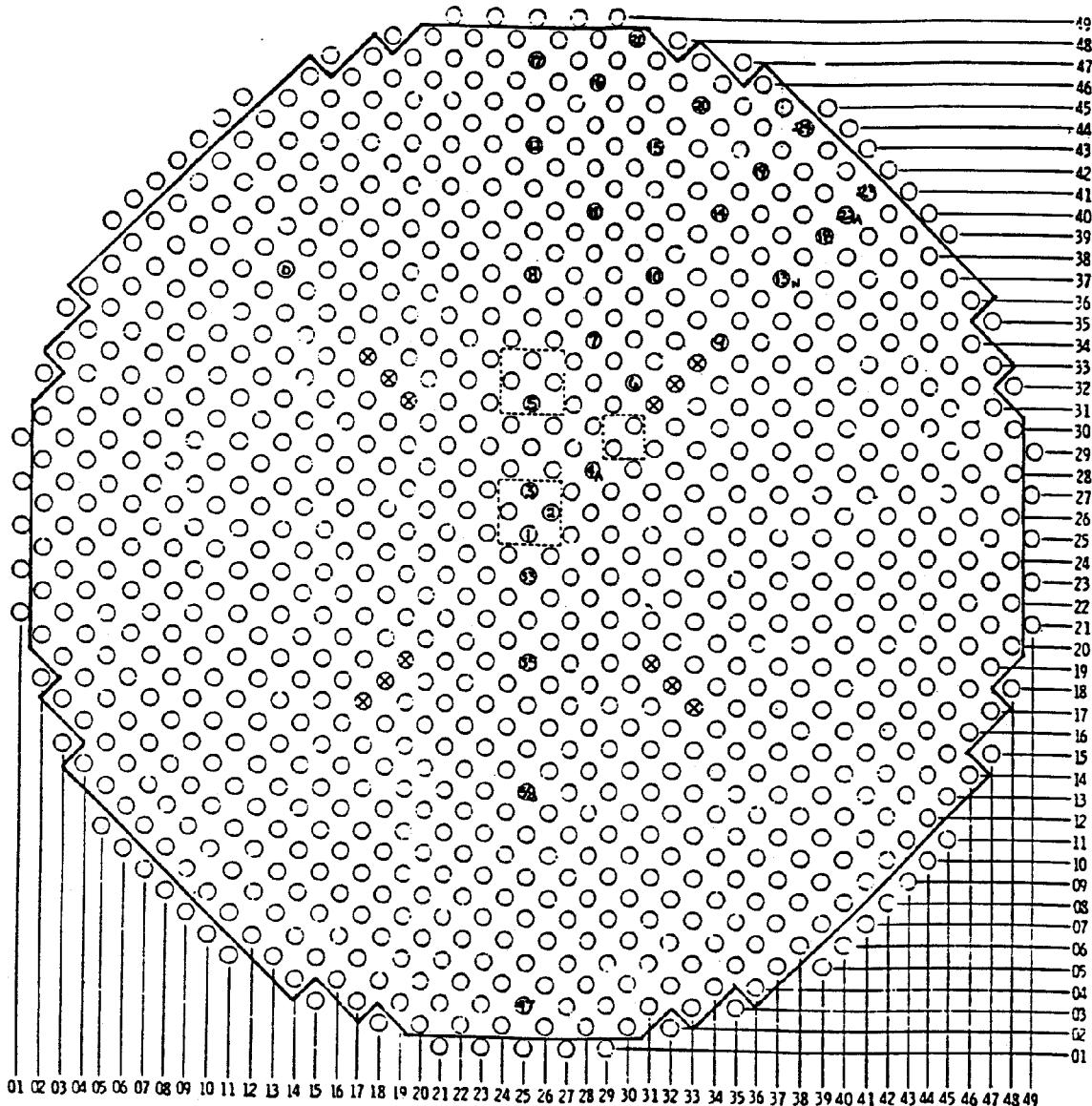


Figure 2.67 Core layout for **EPRU87B**. *Source:* Ref. 7 (Copyright © 1976. Electric Power Research Institute. EPRI NP-196. *Clean Critical Experiment Benchmarks for Plutonium Recycle in LWRs*. Reprinted with permission)

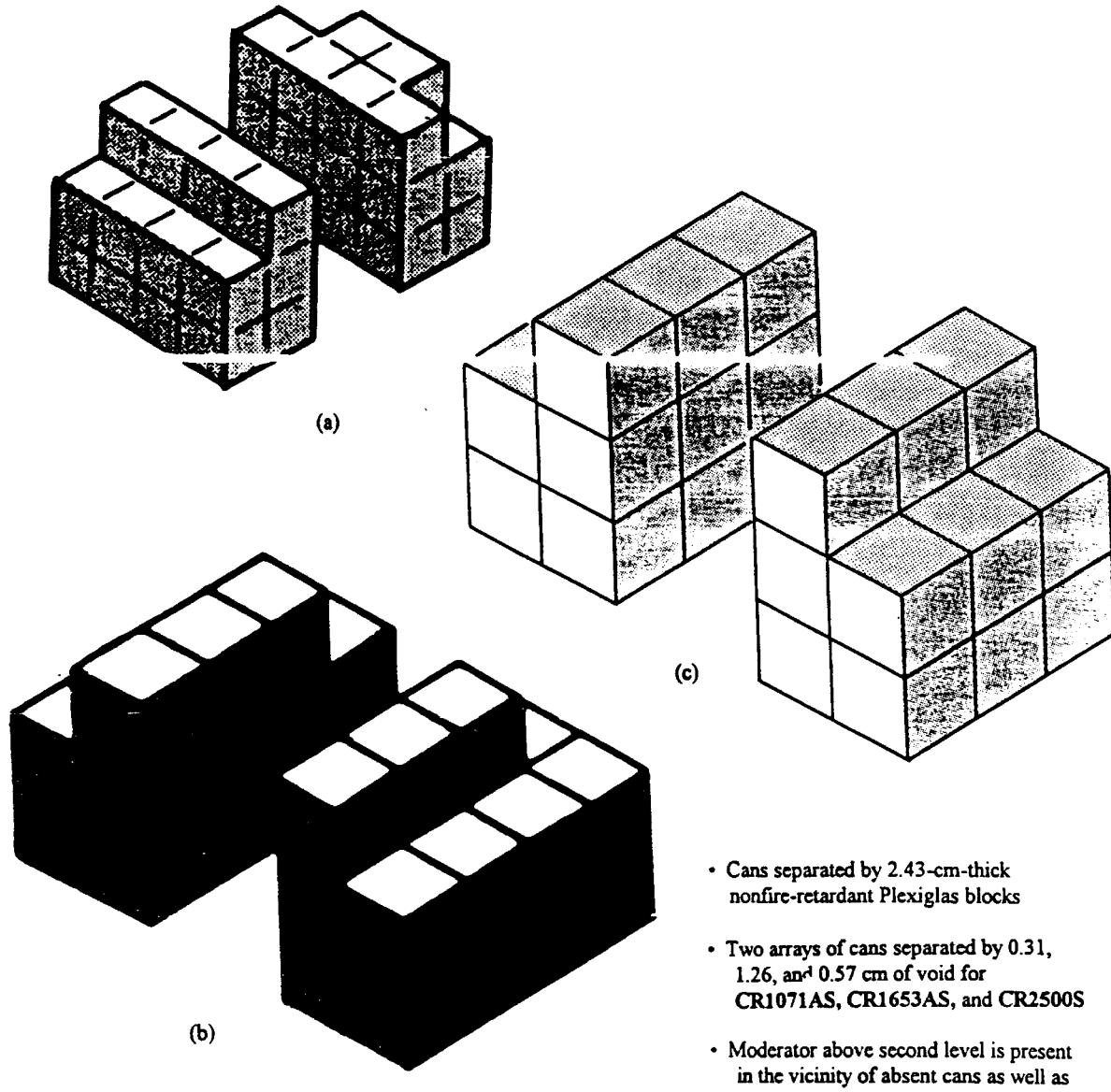


Figure 2.68 Isometric drawings of the (a) 42, (b) 38, and (c) 30 can configurations of experiment CR1071AS, CR1653AS, CR2500S. *Source:* Refs. 29–31

Physical Description

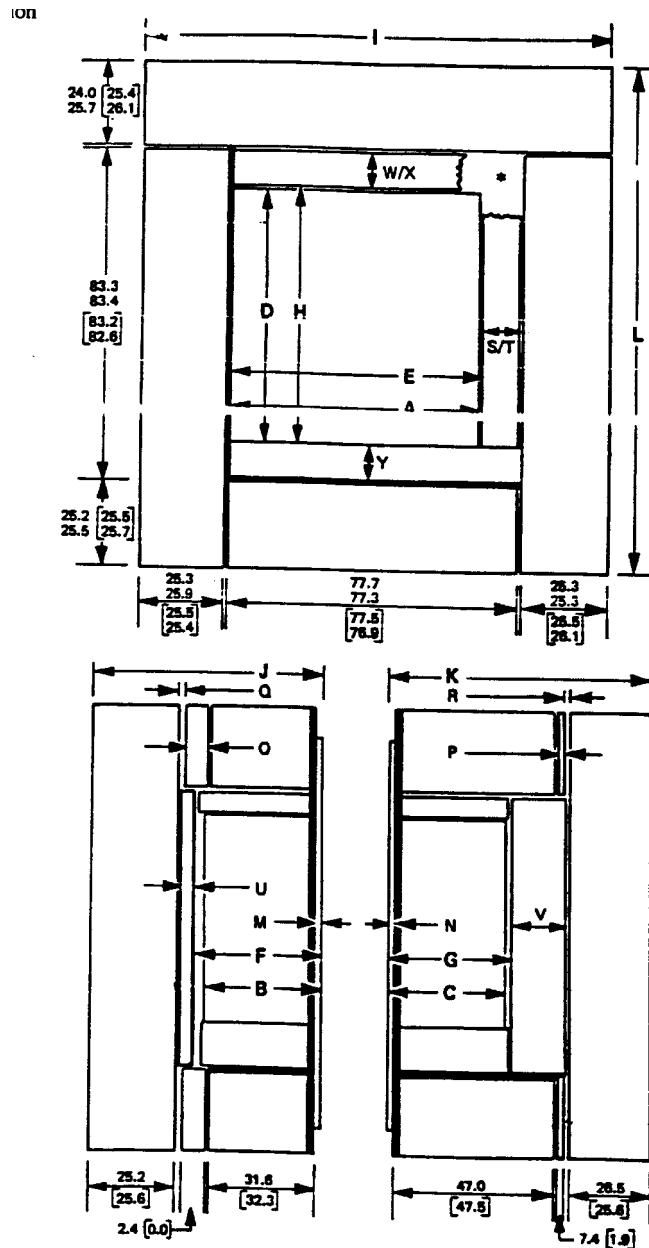


Figure 2.69 Planar and elevation view for **CR1071AS** (dimensions in cm, paired dimensions are for north and south tables). *Source:* Ref. 29

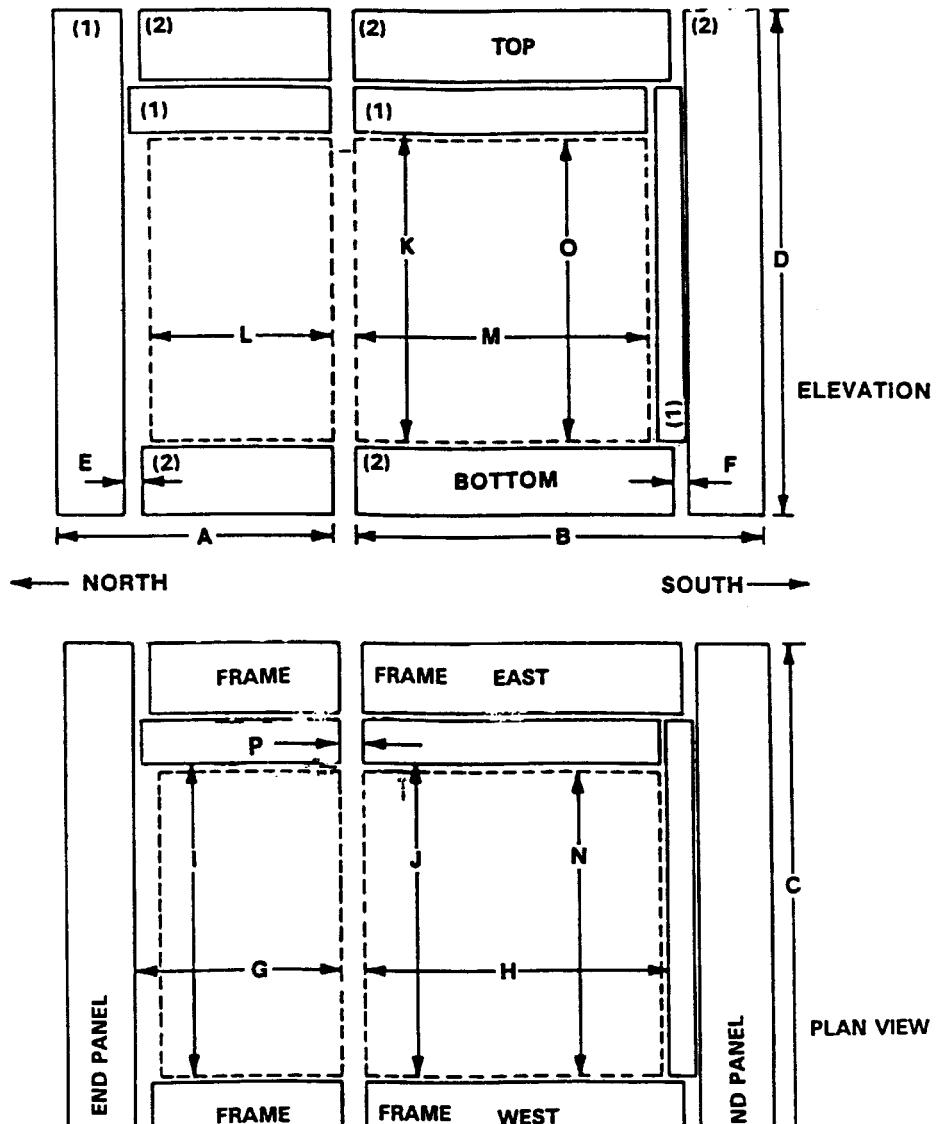


Figure 2.70 Planar and elevation view of core boundary (dashed lines) and reflector boundaries (solid lines) for CR1653AS and CR2500AS. *Source:* Ref. 30

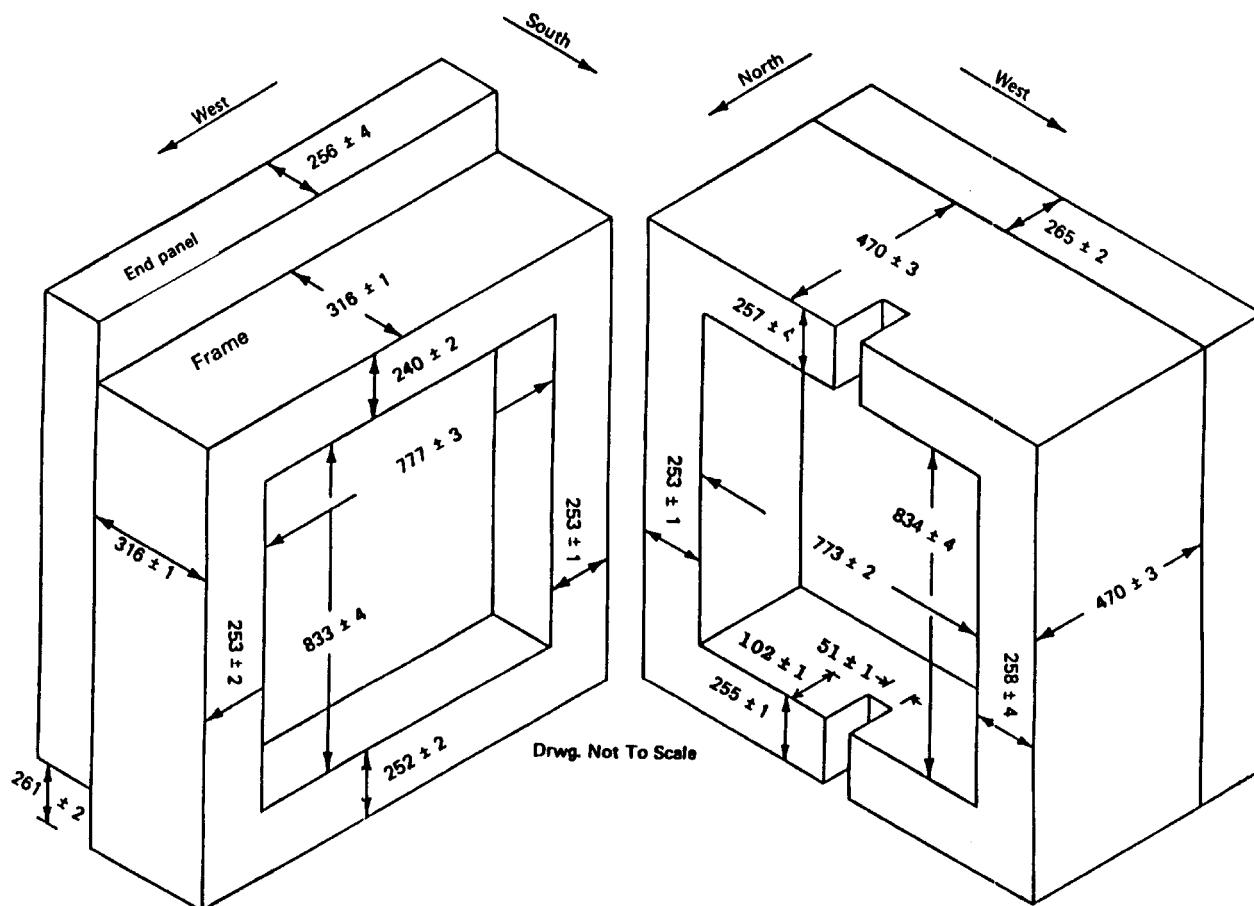


Figure 2.71 Dimension (mm) plastic reflector end panel and frame for CR1653AS. *Source:* Ref. 28

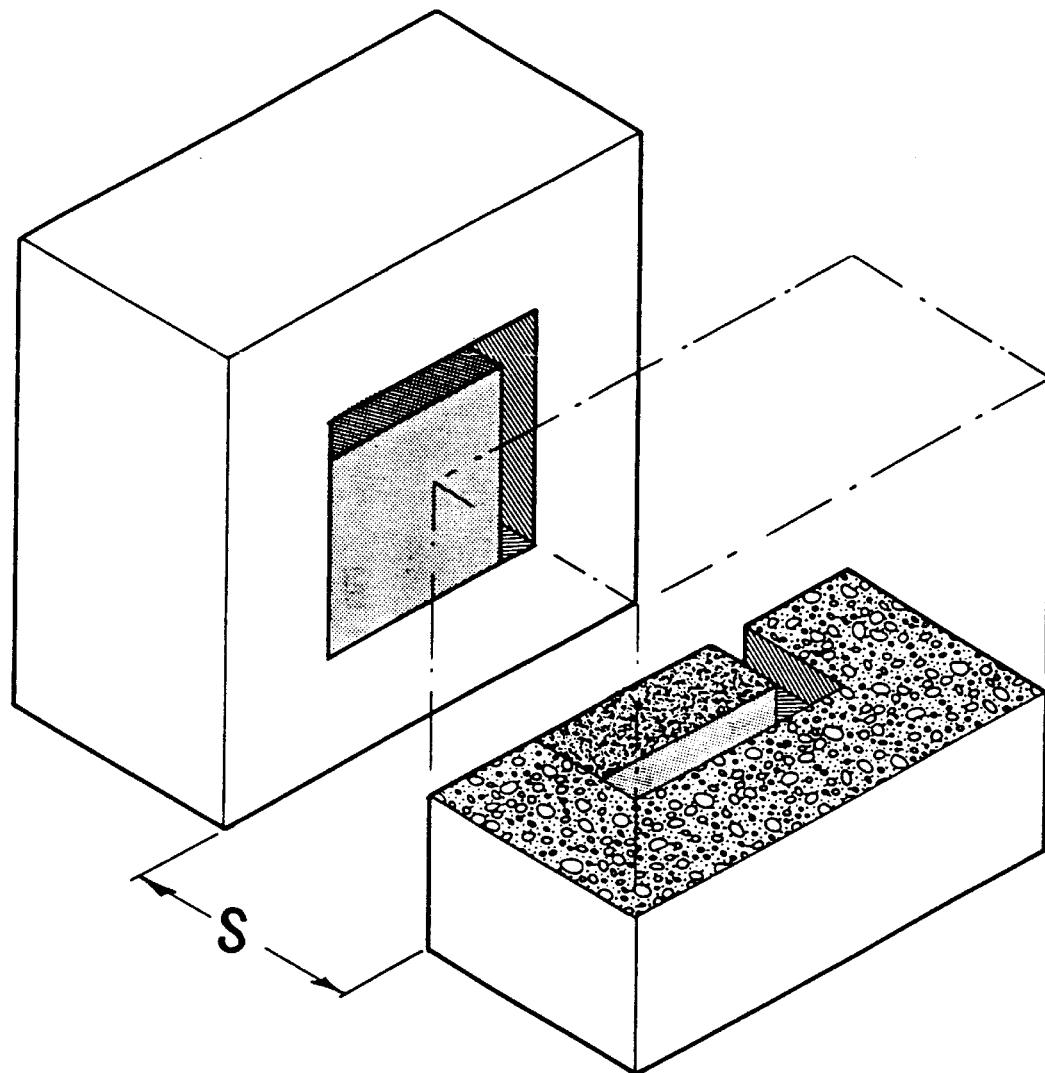


Figure 2.72 Three nested cuboids of **CR1071AS** and **CR2500S**: core, reflector interior, reflector exterior.
Source: Ref. 29

3 Validation of the SCALE 44-Group ENDF/B-V Library with the LWR Critical Experiments

In order to demonstrate the applicability of the SCALE 44-group ENDF/B-V cross-section library (created on 5/16/96) for the range of conditions spanned by the fresh fuel experiments described in the previous section, computational models have been developed based on each experimental configuration. Structural components such as control and safety rod guides, support angles and channels, and tanks were neglected because they had no significant impact on the system k_{eff} . Specific modeling assumptions were noted in detail in Sect. 2. Chemical elements that appeared in materials in trace amounts were also considered negligible in the models. For reference, the SCALE-4.3 input files for these experiments are included in Appendix A.

The following subsection describes the sequences and modules of the SCALE-4.3 system used in the analysis of these computational models. This description is followed by a discussion of the results of calculations performed with SCALE-4.3 using these models, in terms of the classes of experiments described in Sect. 2.

3.1 Description of the SCALE Code System

SCALE is a computational system consisting of a set of well-established codes and data libraries suitable for analyses of nuclear fuel facility and package designs in the areas of criticality safety, radiation shielding, source term characterization, and heat transfer. The codes are compiled in a modular fashion and called by control modules that provide automated sequences for standard system analyses in each area.

The CSAS control module contains automated sequences that perform problem-dependent cross-section processing and three-dimensional (3-D) Monte Carlo calculations of neutron multiplication. Three CSAS control sequences, CSASN, CSAS25, and CSAS2X, were used to perform resonance processing and/or calculate effective neutron multiplication factors for the critical benchmark experiments supplied in this document. All neutronic control sequences use the SCALE Material Information Processor (MIP) to calculate material number densities and prepare geometry data for resonance self-shielding and optional flux-weighting cell calculations and to create data input files for the cross-section processing codes. The BONAMI³² and NITAWL-II³³ codes are then used to perform problem-specific (resonance- and temperature-corrected) cross-section processing. BONAMI applies the Bondarenko method of resonance self-shielding for nuclides that have Bondarenko data included in the cross-section library. NITAWL-II uses the Nordheim integral treatment to perform resonance self-shielding corrections for nuclides that have resonance parameters included with their cross-section data. The CSASN sequence terminates at this point; the cross-section library produced from this calculation can be used as is or combined with other cross-section libraries and used in a subsequent criticality calculation.

The CSAS25 sequence then invokes KENO V.a,³⁴ a three-dimensional (3-D) multigroup Monte Carlo criticality code to determine the effective multiplication factor (k_{eff}) from the problem-dependent cross-section data and the user-specified geometry data. Other calculated KENO V.a quantities include average neutron lifetime and generation time, energy-dependent leakages, energy- and region-dependent absorptions, fissions, fluxes, and fission densities. The CSAS2X sequence invokes the one-dimensional (1-D) discrete-ordinates code XSDRNPM³⁵ to prepare cell-weighted cross sections prior to the execution of KENO V.a.

SCALE-4.3 includes the 238-group AMPX master-format neutron cross-section library³ which contains data for all the nuclides available in ENDF/B-V and a broad structure 44-group neutron cross-section library² collapsed from the 238-group library. The group structure specification for each library was based on knowledge gained from the definition and use of the 218-group and 27-group libraries developed for the SCALE code system using ENDF/B-IV data.

Validation

The 238-group library has Bondarenko shielding factors included for nuclides with unresolved resonances, nuclides with Adler-Adler resonance data (^{233}U and ^{241}Pu), and the nonresonance nuclides ^7Li , ^{19}F , ^{27}Al , and ^{28}Si . Bondarenko factors are used for the latter nuclides because they exhibit resonance structure in the point data. This library includes s-, p-, and d-wave resonance data in the resonance parameters that are passed to NITAWL-II. The calculational effect of including these higher-order resonance data is addressed in Appendix B.

The broad-structure 44-group derivative of the fine-structure 238-group library was collapsed using a fuel cell spectrum based on a 17×17 Westinghouse pressurized-water-reactor (PWR) fuel assembly. The broad-group structure was designed to accommodate two windows in the oxygen cross-section spectrum, a window in the iron cross-section spectrum, the Maxwellian peak in the thermal range, and the 0.3-eV resonance in ^{239}Pu (which, due to low energy and lack of resonance data, cannot be modeled by the Nordheim Integral Treatment in NITAWL-II). The 44-group library has a group structure similar to the 27-group library, as shown in Table 3.1. All boundaries in the 27-group ENDF/B-IV library correspond to those in the 44-group ENDF/B-V library except for the upper bound of group 23. Based on an analysis of a set of 93 thermal and fast critical experiments, the ENDF/B-V 44-group library demonstrated markedly improved performance over similar analyses performed with the ENDF/B-IV 27-group library.²

3.2 Modeling and Calculational Techniques

Several techniques for modeling the fuel region of particular experiments are addressed in Sect. 3.2.1. KENO V.a input parameters are discussed in Sect. 3.2.2.

3.2.1 Fuel Region Modeling

The experiments listed in Table 3.2 were explicitly modeled by considering the fuel rod regions submerged in and protruding from the moderator region. To accomplish this in CSAS, the Dancoff factors and resonance data had to be calculated for the fuel in the region void of moderator using a CSASN “PARM=CHECK” case and then explicitly specified in the CSAS25 calculation using the “MORE DATA” option. In all other experiments with fuel rods above the moderator, the contribution of the fuel in the region void of moderator was considered negligible and was not modeled.

In some instances more than one fissile mixture was present per experiment. Since only one CSAS unit cell specification is allowed per problem, the Dancoff factors and resonance data had to be calculated for the other unit cell descriptions using a CSASN “PARM=CHECK” case and then explicitly specified in the CSAS25 calculation using the “MORE DATA” option. The experiments with two or three fissile mixtures modeled using this method are listed in Table 3.3.

The experiments in Table 3.4 were modeled with CSAS2X in order to account for eccentricities of the control rod cruciform followers (the nine fuel rods of the follower veins were on a slightly different pitch than the core lattice). The followers were represented as nine core lattice positions containing mixture 500 that uses the XSDRNP cell-weighted cross sections for the fuel and moderator. For the fuel rods of the core, the Dancoff factors and resonance data had to be calculated for the regions submerged in and protruding from the moderator region using CSASN and then explicitly specified in the CSAS25 calculation as in the other experiments above.

3.2.2 KENO V.a Parameter Data

All criticality calculations were run with 405 generations and 600 neutrons per generation for a total of 245,000 histories. The first five generations were omitted when calculating the average eigenvalue of the system. Default

values were used for all other parameters including the start option of flat neutron distribution over the entire system. No albedo boundary conditions were applied; the default for each face is vacuum and is applied to the outermost region of every problem. No biasing was used to track neutrons in the water reflector region of each problem.

The calculated k_{eff} values throughout this report are estimates of the eigenvalues of systems and have associated uncertainties due to the statistical nature of the Monte Carlo codes.

3.3 Calculational Results Overview

The calculational results for the 173 LWR fuel pin lattice critical experiments described in Sect. 2.1 are presented and discussed in Sect. 3.4. The results for the seven homogeneous uranium systems described in Sect. 2.2 are presented and discussed in Sect. 3.5.

Two important calculated parameters in the presentation of results are the average energy group causing fission (AEG) and the energy of the average lethargy causing fission (AEF). AEG is a pseudo-neutron-spectra parameter calculated by KENO V.a that has been used historically as a single global parameter for correlating experiments to safety evaluation applications.³⁶ AEF has been added to the KENO V.a output in version 4.3 of SCALE and offers a single parameter in physical units (eV). Due to group structure and the techniques used to determine the average values, the energy that corresponds to AEG and the value of AEF may not be equivalent. AEG is a spectral index that is useful in validation but is not valid when comparing different cross-section libraries. On the other hand, AEF is more useful in interlibrary comparisons since it is a physically real parameter and not as dependent on the group structure of a library. For this reason, the remainder of this report will focus on AEF rather than AEG. Table 3.1 gives the group structure for the 44-group library used in this validation and is useful in locating an energy range corresponding to an AEG value. The table provides the upper energy bound of each broad group and the number of fine groups collapsed into it from the 238-group cross-section library.

In the following sections of this report, the validation results have been analyzed by grouping the experiments in terms of physical or neutronic characteristics as set forth in Sect. 2. For each group, the mean k_{eff} (\bar{k}_{eff}) and the range of calculated k_{eff} and AEF (eV) values are reported. The reported mean is the average of the nominal values of k_{eff} computed for each group of experiments. The standard deviation (σ_k) characterizes the distribution of the nominal values around this mean; this statistic does not include uncertainties associated with each individual Monte Carlo calculation.

In the discussions that follow, the term “positive bias” denotes a calculated k_{eff} value greater than the measured critical condition ($k_{\text{eff}} = 1$) and “negative bias” conversely denotes a calculated k_{eff} value less than 1. The remainder of this section presents the results of these analyses by group. A comparison of these results to those obtained with the 238-group library is provided in Appendix B.

3.4 Results for LWR Fuel Pin Lattices

This section reports the calculational results for 173 critical experiments classified as containing LWR fuel pin lattices. Table 3.5 contains nominal computed values of the effective neutron multiplication factor, k_{eff} with associated standard deviation (σ), average energy group of neutrons causing fission (AEG), and energy of the average lethargy causing fission (AEF) for the LWR critical experiments. Figures 3.1 and 3.2 are histograms showing the frequency of k_{eff} and AEF for all 173 experiments in Table 3.5. Note the clustering of calculated k_{eff} near $k_{\text{eff}} = 1$ and the narrow range of AEF values that this validation encompasses. This distribution is remarkably

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normal, indicating no systematic biases on a global level. The nominal calculated k_{eff} values range from 0.9909 to 1.0129, with an average k_{eff} value of 0.9994 ± 0.0035 and an average bias of -0.06% . Sixty-eight percent of all k_{eff} values fall within 0.0035 of 0.9994 while 95% of all k_{eff} values fall within 0.0070 of 0.9994. AEF values ranged from 3.4451 to 0.0702 eV with more than 75% of the values within the range of 0.1 to 0.562 eV.

3.4.1 Simple Lattices

Descriptive statistics of the 21 simple (i.e., no absorbers, poisons, reflecting walls, etc.) square or hexagonal lattice calculations are given in Table 3.6. As can be seen from the table, the 17 square lattice calculations exhibited an average bias of -0.20% and spanned a relatively large range of AEF values, attesting to the variety of square lattice experiments used in the validation. The limited set of four hexagonal lattice calculations has a positive bias of 0.27% . Note that the hexagonal lattice experiments tend to have harder spectra than the square lattices and span a much larger energy range.

3.4.2 Lattices and Separator Plates Only

The calculated k_{eff} results for the 45 lattice with separator plate calculations are given in Table 3.7. The results of calculations of simple lattices with separator plates and borated moderator are given in Table 3.8, while Table 3.9 gives statistics of the calculational results of experiments with separator plates and voiding materials (i.e., flux traps). From Tables 3.7, 3.8, and 3.9, one can see that calculations involving aluminum separator plates have larger standard deviations associated with the average k_{eff} values, indicating a larger variation in results for these experiments. In all three tables, the highest k_{eff} values are recorded for calculations involving aluminum separator plates.

3.4.3 Lattices and Reflecting Walls Only

The calculational results of 35 lattice experiments with reflecting walls are summarized in Table 3.10. The largest positive bias in the validation of LWR-type fuel pin lattices for a group of more than four experiments is seen in the lead reflecting wall experiment calculations. For this group of experiments, the calculational bias is $+0.37\%$. Only very small positive biases are observed for the calculations of the steel reflecting wall and the uranium reflecting wall experiments. The overall bias for all reflecting wall experiment calculations is $+0.13\%$.

3.4.4 Lattices with Separator Plates and Reflecting Walls

The calculational results of 15 lattice experiments with separator plates and reflecting walls are presented in Table 3.11. The calculated k_{eff} values were scattered over a broad range from 0.9920 to 1.0040. As a group, the average calculational bias was -0.08% , and a narrow range of AEF values was observed (0.144–0.305 eV).

3.4.5 Lattices with Urania Gadolinia Rods

Table 3.12 gives descriptive statistics of the five lattices containing interspersed fuel rods with gadolinium in the form of $\text{UO}_2\text{-Gd}_2\text{O}_3$. This set of five calculations yielded nominal k_{eff} values over a small range from 0.9971 to 1.0005 with an average k_{eff} value of 0.9986 (Table 3.12). All of these experiments contained water holes and soluble boron. These cases give very consistent results but provide a very limited validation for urania gadolinia because the set consisted of only five critical experiments from one report with a small range in AEF values.

3.4.6 Lattices with Water Holes

A negative calculational bias of 0.15% is observed in the results in Table 3.13 for the six water-hole experiments with no soluble boron. For the three water-hole calculations where soluble boron was used in the moderator, a small bias of -0.08% and an increased average AEF (i.e., harder spectrum) were observed.

3.4.7 Lattices with B₄C or Ag-In-Cd Absorber Rods

Calculations of experiments with B₄C or Ag-In-Cd rods had average biases of -0.49% and -0.30%, respectively. One experiment in each group contained soluble boron and water holes. The total bias for the set of nine absorber rod calculations was -0.37%, given in Table 3.14 with other descriptive statistics of these calculations.

3.4.8 Simple Lattices with Soluble Boron

Fourteen simple lattice experiments contained soluble boron in the moderator. This set of calculations yielded calculated k_{eff} values ranging from 0.9947 to 1.0035 with an average k_{eff} value of 0.9992 (Table 3.15). AEF values spanned from 0.92 to 1.189 eV, a significant span of thermalized systems.

3.5 Results for Homogeneous Uranium Systems

This section reports the calculational results for seven low-enriched homogeneous uranium critical experiments. These experiments are included because some transportation packages may contain low-enriched fuel in geometric configurations other than the typical LWR fuel pin lattice geometry. Individual results are tabulated in Table 3.16. Group statistics are presented in Table 3.17.

The nominal calculated k_{eff} values ranged from 1.0011 to 1.0207 with an average bias of +1.29 %. This bias is attributed to the manner in which the library was generated. The 44-group library was collapsed to encompass the key spectral aspects of a different type of system, that of a typical LWR spent fuel package. Results obtained for these cases with the 238-group library show a much smaller bias, as can be seen in Table B.3. Only a small number of homogeneous systems have been considered in this validation. These few results for homogeneous systems indicate a larger bias than demonstrated for lattice systems. If the 44-group library is to be used for low-enriched fuel in other geometric configurations, care should be taken to ensure that adequate validation is performed for the particular application.

3.5.1 Homogeneous UF₄ in Paraffin

This set of calculations consisted of four experiments. Note that the 2.00 wt % ²³⁵U cases agree well with the LWR fuel results (i.e., +0.29% bias). However, the 3.00 wt % cases exhibit a bias of approximately +1.4%. Although the reasons for this discrepancy are unknown, it is consistent with previous results for these cases.³⁷

3.5.2 Damp Oxide

This set of calculations consisted of three experiments. The average calculated k_{eff} value is 1.9% high. This bias is consistent with previous results for these cases.³⁷

Validation

Table 3.1 Broad-group structure of the 44GROUPNDF5 library

Fast groups			Thermal groups		
Group	No. fine groups	Upper energy (eV)	Group	No. fine groups	Upper energy (eV)
1	(7)	2.0000×10^{7a}	23	(14)	3.0000×10^{0b}
2	(1)	8.1873×10^6	24	(27)	1.7700×10^{0a}
3	(1)	6.4340×10^{6a}	25	(10)	1.0000×10^{0a}
4	(2)	4.8000×10^6	26	(5)	6.2500×10^{-1}
5	(1)	3.0000×10^{6a}	27	(1)	4.0000×10^{-1a}
6	(1)	2.4790×10^6	28	(1)	3.7500×10^{-1}
7	(1)	2.3540×10^6	29	(1)	3.5000×10^{-1}
8	(2)	1.8500×10^{6a}	30	(2)	3.2500×10^{-1a}
9	(8)	1.4000×10^{6a}	31	(1)	2.7500×10^{-1}
10	(14)	9.0000×10^{5a}	32	(1)	2.5000×10^{-1}
11	(6)	4.0000×10^{5a}	33	(1)	2.2500×10^{-1a}
12	(10)	1.0000×10^{5a}	34	(2)	2.0000×10^{-1}
13	(1)	2.5000×10^4	35	(2)	1.5000×10^{-1}
14	(7)	1.7000×10^{4a}	36	(3)	1.0000×10^{-1a}
15	(11)	3.0000×10^{3a}	37	(2)	7.0000×10^{-2}
16	(12)	5.5000×10^{2a}	38	(1)	5.0000×10^{-2a}
17	(30)	1.0000×10^{2a}	39	(1)	4.0000×10^{-2}
18	(16)	3.0000×10^{1a}	40	(1)	3.0000×10^{-2a}
19	(2)	1.0000×10^{1a}	41	(1)	2.5300×10^{-2}
20	(6)	8.1000×10^0	42	(1)	1.0000×10^{-2a}
21	(3)	6.0000×10^0	43	(3)	7.5000×10^{-3}
22	(6)	4.7500×10^0	44	(9)	3.0000×10^{-3}
			<i>44 Lower Energy</i>		1.0000×10^{-5}

^a 27-group boundaries.

^b Adjusted 27-group boundary.

Table 3.2 Explicit fuel rod models for fuel above the moderator

ANS33AL1	ANS33STY	NSE71H1	W3269C
ANS33AL2	BW1231B1	NSE71H2	W3269SL1
ANS33AL3	BW1231B2	NSE71H3	W3269SL2
ANS33EB1	BW1273M	PAT80L1	W3269W1
ANS33EB2	DSN399-1	PAT80L2	W3269W2
ANS33EP1	DSN399-2	PAT80SS1	W3385SL1
ANS33EP2	DSN399-3	PAT80SS2	W3385SL2
ANS33SLG	DSN399-4	W3269A	

Table 3.3 Experiments with multiple fissile mixtures

Two fissile mixtures	Three fissile mixtures
BW1810A	BW1810J
BW1810B	BW1810C
BW1810G	BW1810D
BW1810H	BW1810E

Table 3.4 Experiments modeled with CSAS2X

W3269B1
W3269B2
W3269B3

Table 3.5 Calculational results using SCALE 44-group cross-section library

Case No.	Case name	Enrich.			Pitch (cm)	H ₂ O/fuel vol.	Plate matl. ^a	concn. (wt %)	Plate thick. (cm)	Wall matl. ^b	separ. (cm)	No. of holes/pin	Boron concn. (ppm)	Sol. boron ^c	Boron clad ^d	Other ^e	Lattice ^f	Assembly separ.		Dancoff factor			
		k _{eff}	±σ	(wt %)																			
1	ANS33AL1	1.0027	0.0017	4.74	5	33.98	0.234478	1.35	2.302	138.4	AL	-	.30	-	-	-	N	-	AL	-	S	5.0	.20096
2	ANS33AL2	1.0129	0.0018	4.74	5	34.39	0.196837	1.35	2.302	138.4	AL	-	.30	-	-	-	N	-	AL	-	S	2.5	.20096
3	ANS33AL3	1.0035	0.0018	4.74	5	34.63	0.174878	1.35	2.302	138.4	AL	-	.30	-	-	-	N	-	AL	-	S	10.0	.20096
4	ANS33EB1	0.9979	0.0018	4.74	5	33.88	0.243861	1.35	2.302	138.4	AL	-	.30	-	-	-	N	-	AL	F3	S	2.5	.20096
5	ANS33EB2	1.0096	0.0017	4.74	5	34.29	0.205591	1.35	2.302	138.4	AL	-	.30	-	-	-	N	-	AL	F3	S	5.0	.20096
6	ANS33EP1	0.9964	0.0018	4.74	5	33.80	0.250214	1.35	2.302	138.4	AL	-	.30	-	-	-	N	-	AL	F3	S	2.5	.20096
7	ANS33EP2	1.0020	0.0018	4.74	5	34.09	0.221917	1.35	2.302	138.4	AL	-	.30	-	-	-	N	-	AL	F3	S	5.0	.20096
8	ANS33SLG	0.9964	0.0018	4.74	5	34.41	0.195652	1.35	2.302	138.4	-	-	-	-	-	N	-	AL	-	S	5.0	.20096	
9	ANS33STY	0.9909	0.0019	4.74	5	33.65	0.266292	1.35	2.302	138.4	AL	-	.30	-	-	-	N	-	AL	F3	S	2.5	.20096
10	B1645S01	0.9976	0.0013	2.46	17	32.82	0.401634	1.410	1.015	119.4	AL	-	-	-	-	-	Y	1068	AL	-	S	1.78	.34784
11	B1645S02	1.0007	0.0014	2.46	17	32.76	0.411180	1.410	1.015	119.4	AL	-	-	-	-	-	Y	1156	AL	-	S	1.78	.34784
12	BW1231B1	0.9969	0.0014	4.02	25	31.13	0.727147	1.511	1.139	88.6	-	-	-	-	-	Y	1152	SS	-	S	-	.25722	
13	BW1231B2	0.9985	0.0012	4.02	25	29.91	1.18903	1.511	1.139	88.6	-	-	-	-	-	Y	3389	SS	-	S	-	.25699	
14	BW1273M	0.9947	0.0014	2.46	26	32.21	0.525212	1.511	1.376	161.5	-	-	-	-	-	Y	1675	AL	-	S	-	.26414	
15	BW1484A1	0.9965	0.0015	2.46	6	34.55	0.193780	1.636	1.841	216.1	AL	1.6	.645	-	-	-	Y	15	AL	-	S	1.64	.19071
16	BW1484A2	0.9954	0.0016	2.46	6	35.16	0.152035	1.636	1.841	216.1	AL	0.1	.645	-	-	-	Y	72	AL	-	S	4.92	.19071
17	BW1484B1	0.9973	0.0014	2.46	6	33.95	0.247151	1.636	1.841	216.1	-	-	-	-	-	Y	1037	AL	-	S	-	.19062	
18	BW1484B2	0.9973	0.0012	2.46	6	34.55	0.193879	1.636	1.841	216.1	-	-	-	-	-	Y	769	AL	-	S	1.64	.19065	
19	BW1484B3	0.9992	0.0014	2.46	6	35.25	0.146615	1.636	1.841	216.1	-	-	-	-	-	Y	143	AL	-	S	4.92	.19070	
20	BW1484C1	0.9937	0.0014	2.46	6	34.64	0.188354	1.636	1.841	216.1	-	-	-	-	-	N	-	AL	B	S	1.64	.19072	
21	BW1484C2	0.9936	0.0016	2.46	6	35.23	0.148105	1.636	1.841	216.1	-	-	-	-	-	N	-	AL	B	S	1.64	.19072	
22	BW1484S1	0.9981	0.0015	2.46	6	34.52	0.194990	1.636	1.841	216.1	SS	-	-	-	-	-	Y	432	AL	-	S	1.64	.19069
23	BW1484S2	0.9989	0.0016	2.46	6	34.54	0.193171	1.636	1.841	216.1	SS	-	.462	-	-	-	Y	514	AL	-	S	1.64	.19068
24	BW1484SL	0.9966	0.0016	2.46	6	35.42	0.137530	1.636	1.841	216.1	-	-	-	-	-	N	-	AL	-	S	6.54	.19072	
25	BW1645S1	1.0010	0.0016	2.46	17	30.11	1.32817	1.209	0.383	45.0	AL	-	-	-	-	-	Y	746	AL	-	S	1.78	.61533
26	BW1645S2	1.0035	0.0014	2.46	17	29.99	1.39167	1.209	0.383	45.0	AL	-	-	-	-	-	Y	886	AL	-	S	1.78	.61532
27	BW1645T1	1.0062	0.0016	2.46	17	29.18	2.15829	1.209	0.148	17.4	AL	-	.076	-	-	-	Y	335	AL	-	H	1.78	.76438
28	BW1645T2	1.0068	0.0015	2.46	17	29.04	2.28077	1.209	0.148	17.4	AL	-	.076	-	-	-	Y	435	AL	-	H	1.78	.76437
29	BW1645T3	1.0007	0.0016	2.46	17	30.05	1.50993	1.209	0.148	17.4	AL	-	.076	-	-	-	Y	361	AL	-	H	2.54	.76438
30	BW1645T4	0.9986	0.0016	2.46	17	31.17	0.968191	1.209	0.148	17.4	AL	-	.076	-	-	-	Y	121	AL	-	H	3.81	.76439
31	BW1810A	0.9971	0.0013	2.46	24	33.96	0.244783	1.636	1.841	216.1	-	-	-	-	.032	Y	1239	AL	G	S	-	.19043	
32	BW1810B	0.9980	0.0013	2.46	24	33.98	0.243472	1.636	1.841	216.1	-	-	-	-	.032	Y	1170	AL	G	S	-	.19043	
33	BW1810C	1.0005	0.0012	2.46	24	33.14	0.331369	1.636	1.841	216.1	-	-	-	-	.039	Y	1499	AL	G	S	-	.18973	
													119.2									.18527	
34	BW1810D	0.9999	0.0012	2.46	24	33.10	0.336940	1.636	1.841	216.1	-	-	-	-	.032	Y	1654	AL	G	S	.18973	.18973	
													1.532	119.2								.18527	
35	BW1810E	0.9976	0.0015	2.46	24	33.16	0.328183	1.636	1.841	216.1	-	-	-	-	.032	Y	1579	AL	G	S	-	.18973	
													1.532	119.2								.18527	
36	BW1810F	1.0032	0.0010	2.46	24	33.96	0.244782	1.636	1.841	216.1	-	-	-	-	.032	Y	1337	AL	-	S	-	.18973	
37	BW1810G	0.9971	0.0012	2.46	24	32.91	0.360952	1.636	1.841	216.1	-	-	-	-	.039	Y	1776	AL	-	S	-	.18973	
													1.532	119.2								.18527	
38	BW1810H	0.9973	0.0013	2.46	24	32.95	0.354969	1.636	1.841	216.1	-	-	-	-	.032	Y	1899	AL	-	S	-	.18973	
													1.532	119.2								.18527	
39	BW1810I	1.0022	0.0014	2.46	24	33.96	0.245038	1.636	1.841	216.1	-	-	-	-	.028	Y	1250	AL	A	S	-	.18973	
40	BW1810J	0.9980	0.0013	2.46	24	33.13	0.332394	1.636	1.532	216.1	-	-	-	-	.028	Y	1635	AL	B	S	-	.18973	
													1.532	119.2								.18527	
41	DSN399-1	1.0056	0.0019	4.74	18	33.94	0.232338	1.35	2.302	138.2	HF	-	.105	-	-	-	N	-	AL	-	S	1.8	.20101
42	DSN399-2	1.0010	0.0015	4.74	18	34.41	0.190708	1.35	2.302	138.2	HF	-	.105	-	-	-	N	-	AL	-	S	5.8	.20101

Table 3.5 (continued)

Case No.	Case name	k_{eff}	$\pm \sigma$	Enrich.			Pitch H ₂ O/fuel			Boron Plate			Wall No. of holes/			Boron			Assembly separ.			Dancoff factor	
				(wt %)	Ref.	AEG	AEF(eV)	(cm)	vol.	H/X	matl. ^a	concn. ^b (wt %)	thick. (cm)	matl. ^b	(cm)	pin	boron ^c (ppm)	sol. concen.	Clad ^d	Other ^e	Lattice ^f		
43	DSN399-3	1.0024	0.0017	4.74	18	35.32	0.130849	1.6	3.807	228.6	HF	-	.105	-	-	N	-	AL	-	S	-	.10503	
44	DSN399-4	0.9965	0.0017	4.74	18	35.36	0.128298	1.6	3.807	228.6	HF	-	.105	-	-	N	-	AL	-	S	-	.10503	
45	EPRU65	0.9977	0.0018	2.35	7	33.90	0.258691	1.562	1.196	163.6	-	-	-	-	-	N	-	AL	-	S	-	.27720	
46	EPRU65B	0.9985	0.0018	2.35	7	33.41	0.315549	1.562	1.196	163.6	-	-	-	-	-	Y	463	AL	-	S	-	.27715	
47	EPRU75	0.9974	0.0016	2.35	7	35.86	0.113352	1.905	2.408	329.4	-	-	-	-	-	N	-	AL	-	S	-	.11669	
48	EPRU75B	1.0023	0.0011	2.35	7	35.28	0.143515	1.905	2.408	329.4	-	-	-	-	-	Y	568	AL	-	S	-	.11665	
49	EPRU87	0.9986	0.0014	2.35	7	36.61	0.082692	2.210	3.687	504.2	-	-	-	-	-	N	-	AL	-	S	-	.05727	
50	EPRU87B	0.9985	0.0014	2.35	7	36.33	0.092090	2.210	3.687	504.2	-	-	-	-	-	Y	286	AL	-	S	-	.05726	
51	NSE71H1	0.9982	0.0019	4.74	8	33.52	0.272528	1.35	1.804	108.3	-	-	-	-	-	N	-	AL	-	H	-	.25747	
52	NSE71H2	1.0009	0.0017	4.74	8	35.74	0.110404	1.72	3.811	228.8	-	-	-	-	-	N	-	AL	-	H	-	.10167	
53	NSE71H3	1.0036	0.0021	4.74	8	36.88	0.070193	2.26	7.608	456.8	-	-	-	-	-	N	-	AL	-	H	-	.02984	
54	NSE71SQ	1.0014	0.0017	4.74	8	33.79	0.243524	1.26	1.823	110.0	-	-	-	-	-	N	-	AL	-	S	-	.25719	
55	NSE71W1	0.9993	0.0020	4.74	8	33.99	0.224204	1.26	1.823	110.0	-	-	-	-	.054	N	-	AL	-	S	-	.25719	
56	NSE71W2	0.9976	0.0016	4.74	8	34.37	0.192011	1.26	1.823	110.0	-	-	-	-	.152	N	-	AL	-	S	-	.25719	
57	P2438AL	0.9951	0.0016	2.35	9	36.30	0.094226	2.032	2.918	398.7	AL	-	.625	-	-	N	-	AL	-	S	8.67	.08629	
58	P2438BA	0.9972	0.0015	2.35	9	36.22	0.097404	2.032	2.918	398.7	B	28.7	.713	-	-	N	-	AL	-	S	5.05	.08629	
59	P2438CU	0.9957	0.0015	2.35	9	36.25	0.095990	2.032	2.918	398.7	CU	-	.646	-	-	N	-	AL	-	S	6.62	.08629	
60	P2438SLG	0.9997	0.0012	2.35	9	36.29	0.094440	2.032	2.918	398.7	-	-	-	-	-	N	-	AL	-	S	8.39	.08629	
61	P2438SS	0.9978	0.0014	2.35	9	36.26	0.095690	2.032	2.918	398.7	SS	-	.485	-	-	N	-	AL	-	S	6.88	.08629	
62	P2438ZR	0.9956	0.0014	2.35	9	36.28	0.095115	2.032	2.918	398.7	ZR	-	.652	-	-	N	-	AL	-	S	8.79	.08629	
63	P2615AL	1.0004	0.0016	4.31	19	35.74	0.114069	2.540	3.883	256.1	AL	-	.625	-	-	N	-	AL	-	S	10.72	.03889	
64	P2615BA	0.9970	0.0017	4.31	19	35.72	0.115080	2.540	3.883	256.1	B	28.7	.713	-	-	N	-	AL	-	S	6.72	.03889	
65	P2615CD1	0.9985	0.0017	4.31	19	35.74	0.114253	2.540	3.883	256.1	CD	-	.201	-	-	N	-	AL	-	S	7.82	.03889	
66	P2615CD2	0.9990	0.0018	4.31	19	35.72	0.115015	2.540	3.883	256.1	CD	-	.201	-	-	N	-	AL	-	S	5.68	.03889	
67	P2615CU	1.0003	0.0016	4.31	19	35.73	0.114411	2.540	3.883	256.1	CU	-	.646	-	-	N	-	AL	-	S	8.15	.03889	
68	P2615SS	0.9998	0.0017	4.31	19	35.74	0.113821	2.540	3.883	256.1	SS	-	.485	-	-	N	-	AL	-	S	8.58	.03889	
69	P2615ZR	0.9980	0.0018	4.31	19	35.75	0.113465	2.540	3.883	256.1	ZR	-	.652	-	-	N	-	AL	-	S	10.92	.03889	
70	P2827L1	1.0023	0.0014	2.35	10	36.24	0.096202	2.032	2.918	398.7	-	-	-	L	0.66	-	N	-	AL	-	S	13.72	.08629
71	P2827L2	0.9997	0.0016	2.35	10	36.28	0.095061	2.032	2.918	398.7	-	-	-	L	2.62	-	N	-	AL	-	S	11.25	.08629
72	P2827L3	1.0081	0.0020	4.31	10	35.66	0.116654	2.540	3.883	256.1	-	-	-	L	0.66	-	N	-	AL	-	S	20.78	.03889
73	P2827L4	1.0073	0.0019	4.31	10	35.72	0.114400	2.540	3.883	256.1	-	-	-	L	1.32	-	N	-	AL	-	S	19.04	.03889
74	P2827SLG	0.9948	0.0015	2.35	10	36.29	0.094400	2.032	2.918	398.7	-	-	-	-	-	N	-	AL	-	S	8.31	.08629	
75	P2827U1	1.0004	0.0015	2.35	10	34.74	0.212926	2.032	2.918	398.7	-	-	-	U	-	-	N	-	AL	-	S	11.83	.08629
76	P2827U2	0.9998	0.0014	2.35	10	35.15	0.173574	2.032	2.918	398.7	-	-	-	U	1.96	-	N	-	AL	-	S	14.11	.08629
77	P2827U3	1.0018	0.0018	4.31	10	33.43	0.385311	2.540	3.883	256.1	-	-	-	U	-	-	N	-	AL	-	S	15.38	.03889
78	P2827U4	1.0042	0.0017	4.31	10	34.09	0.280030	2.540	3.883	256.1	-	-	-	U	1.96	-	N	-	AL	-	S	15.32	.03889
79	P3314AL	0.9973	0.0020	4.31	11	33.96	0.237442	1.892	1.60	105.4	AL	-	.625	-	-	N	-	AL	-	S	9.04 ^g	.17284	
80	P3314BA	1.0002	0.0017	4.31	11	33.17	0.324124	1.892	1.60	105.4	B	28.7	.713	-	-	N	-	AL	-	S	4.80 ^g	.17284	
81	P3314BC	1.0008	0.0019	4.31	11	33.23	0.316489	1.892	1.60	105.4	B	31.9	.231	-	-	N	-	AL	-	S	3.53 ^g	.17284	
82	P3314BF1	1.0022	0.0017	4.31	11	33.22	0.317435	1.892	1.60	105.4	BF	-	.546	-	-	N	-	AL	-	S	3.60 ^g	.17284	
83	P3314BF2	0.9981	0.0019	4.31	11	33.21	0.318470	1.892	1.60	105.4	BF	-	.772	-	-	N	-	AL	-	S	4.94 ^g	.17284	
84	P3314BS1	0.9970	0.0016	2.35	11	34.84	0.174267	1.684	1.60	218.6	SS	1.1	.298	-	-	N	-	AL	-	S	3.86	.20179	
85	P3314BS2	0.9959	0.0016	2.35	11	34.84	0.173578	1.684	1.60	218.6	SS	1.6	.298	-	-	N	-	AL	-	S	3.46	.20179	
86	P3314BS3	0.9972	0.0016	4.31	11	33.41	0.294518	1.892	1.60	105.4	SS	1.1	.298	-	-	N	-	AL	-	S	7.23	.17284	
87	P3314BS4	1.0005	0.0016	4.31	11	33.41	0.294168	1.892	1.60	105.4	SS	1.6	.298	-	-	N	-	AL	-	S	6.63	.17284	
88	P3314CD1	1.0001	0.0016	4.31	11	33.30	0.305451	1.892	1.60	105.4	CD	-	.061	-	-	N	-	AL	-	S	5.30 ^g	.17284	
89	P3314CD2	0.9929	0.0018	2.35	11	34.80	0.176886	1.684	1.60	218.6	CD	-	.061	-	-	N	-	AL	-	S	3.04	.20179	
90	P3314CU1	0.9941	0.0017	4.31	11	33.88	0.244311	1.892	1.60	105.4	CU	-	.337	-	-	N	-	AL	-	S	5.94 ^g	.17284	

Table 3.5 (continued)

Case No.	Case name	k_{eff}	$\pm\sigma$	Enrich. (wt %)	Ref.	AEG	AEF(eV)	Pitch (cm)	$H_2O/fuel$	matl. ^a	Plate H/X	Boron concen.	Plate thick.	Wall matl. ^b	No. of separ.	Boron Sol. boron ^c	Boron concen.	Assembly Clad ^d	separ.	Dancoff factor			
												(wt %)	(cm)	(cm)	(cm)	pin	(ppm)	Lattice ^e	(cm)				
91	P3314CU2	1.0005	0.0017	4.31	11	33.70	0.260474	1.892	1.60	105.4	CU	-	.646	-	-	-	N	-	AL	-	S	2.67 ^g	.17284
92	P3314CU3	0.9972	0.0016	4.31	11	33.50	0.283800	1.892	1.60	105.4	CU	-	.337	-	-	-	N	-	AL	-	S	10.36	.17284
93	P3314CU4	0.9992	0.0018	4.31	11	33.43	0.292385	1.892	1.60	105.4	UD	-	.357	-	-	-	N	-	AL	-	S	7.61	.17284
94	P3314CU5	0.9938	0.0017	2.35	11	34.98	0.164629	1.684	1.60	218.6	CU	-	.337	-	-	-	N	-	AL	-	S	5.24	.20179
95	P3314CU6	0.9958	0.0016	2.35	11	34.86	0.172536	1.684	1.60	218.6	UD	-	.357	-	-	-	N	-	AL	-	S	2.60	.20179
96	P3314SLG	0.9982	0.0017	4.31	11	33.97	0.235686	1.892	1.60	105.4	-	-	-	-	-	N	-	AL	-	S	10.86 ^g	.17284	
97	P3314SS1	0.9969	0.0015	4.31	11	33.95	0.235781	1.892	1.60	105.4	SS	-	.302	-	-	-	N	-	AL	-	S	3.38 ^g	.17284
98	P3314SS2	1.0011	0.0016	4.31	11	33.77	0.255004	1.892	1.60	105.4	SS	-	.302	-	-	-	N	-	AL	-	S	11.55 ^g	.17284
99	P3314SS3	0.9990	0.0018	4.31	11	33.88	0.243407	1.892	1.60	105.4	SS	-	.485	-	-	-	N	-	AL	-	S	4.47 ^g	.17284
100	P3314SS4	0.9957	0.0018	4.31	11	33.74	0.257511	1.892	1.60	105.4	SS	-	.485	-	-	-	N	-	AL	-	S	8.36 ^g	.17284
101	P3314SS5	0.9944	0.0018	2.35	11	34.95	0.166761	1.684	1.60	218.6	SS	-	.302	-	-	-	N	-	AL	-	S	7.80	.20179
102	P3314SS6	1.0003	0.0018	4.31	11	33.52	0.282203	1.892	1.60	105.4	SS	-	.302	-	-	-	N	-	AL	-	S	10.52	.17284
103	P3314W1	1.0015	0.0017	4.31	11	34.38	0.199212	1.892	1.60	105.4	-	-	-	-	.149	N	-	AL	-	S	-	.17284	
104	P3314W2	0.9958	0.0015	2.35	11	35.22	0.148243	1.684	1.60	218.6	-	-	-	-	.051	N	-	AL	-	S	-	.20179	
105	P3314ZR	0.9978	0.0016	4.31	11	33.97	0.235701	1.892	1.60	105.4	ZR	-	.652	-	-	-	N	-	AL	-	S	11.04 ^g	.20179
106	P3602BB	0.9988	0.0015	4.31	22	33.31	0.304578	1.892	1.60	105.4	B	30.4	.292	SS	1.96	-	N	-	AL	-	S	8.30	.17284
107	P3602BS1	1.0000	0.0017	2.35	22	34.76	0.177973	1.684	1.60	218.6	SS	1.1	.298	SS	1.32	-	N	-	AL	-	S	4.80	.20179
108	P3602BS2	1.0001	0.0018	4.31	22	33.36	0.298546	1.892	1.60	105.4	SS	1.1	.298	SS	1.96	-	N	-	AL	-	S	9.83	.17284
109	P3602CD1	0.9988	0.0016	2.35	22	34.72	0.181191	1.684	1.60	218.6	CD	-	.061	SS	1.32	-	N	-	AL	-	S	3.86	.20179
110	P3602CD2	1.0002	0.0017	4.31	22	33.33	0.301071	1.892	1.60	105.4	CD	-	.061	SS	1.96	-	N	-	AL	-	S	8.94	.17284
111	P3602CU1	0.9964	0.0014	2.35	22	34.84	0.172511	1.684	1.60	218.6	CU	-	.337	SS	1.32	-	N	-	AL	-	S	7.79	.20179
112	P3602CU2	0.9980	0.0014	2.35	22	34.78	0.176071	1.684	1.60	218.6	UD	-	.357	SS	1.32	-	N	-	AL	-	S	5.43	.20179
113	P3602CU3	1.0039	0.0016	4.31	22	33.38	0.296714	1.892	1.60	105.4	CU	-	.337	SS	1.96	-	N	-	AL	-	S	13.47	.17284
114	P3602CU4	1.0040	0.0016	4.31	22	33.37	0.297224	1.892	1.60	105.4	UD	-	.357	SS	1.96	-	N	-	AL	-	S	10.57	.17284
115	P3602N11	1.0003	0.0018	2.35	22	34.73	0.180388	1.684	1.60	218.6	-	-	-	SS	-	-	N	-	AL	-	S	8.98	.20179
116	P3602N12	0.9963	0.0017	2.35	22	34.80	0.175283	1.684	1.60	218.6	-	-	-	SS	0.66	-	N	-	AL	-	S	9.58	.20179
117	P3602N13	0.9957	0.0016	2.35	22	34.92	0.167197	1.684	1.60	218.6	-	-	-	SS	1.68	-	N	-	AL	-	S	9.66	.20179
118	P3602N14	0.9984	0.0015	2.35	22	35.03	0.160446	1.684	1.60	218.6	-	-	-	SS	3.91	-	N	-	AL	-	S	8.54	.20179
119	P3602N21	0.9995	0.0015	2.35	22	36.27	0.094794	2.032	2.918	398.7	-	-	-	SS	2.62	-	N	-	AL	-	S	10.36	.08290
120	P3602N22	0.9967	0.0015	2.35	22	36.18	0.098047	1.892	2.918	398.7	-	-	-	SS	0.66	-	N	-	AL	-	S	11.20	.08290
121	P3602N31	1.0010	0.0018	4.31	22	33.19	0.317009	1.892	1.60	105.4	-	-	-	SS	0.00	-	N	-	AL	-	S	14.87	.17284
122	P3602N32	1.0015	0.0019	4.31	22	33.29	0.304586	1.892	1.60	105.4	-	-	-	SS	0.66	-	N	-	AL	-	S	15.74	.17284
123	P3602N33	1.0045	0.0019	4.31	22	33.37	0.295430	1.892	1.60	105.4	-	-	-	SS	1.32	-	N	-	AL	-	S	15.87	.17284
124	P3602N34	1.0027	0.0016	4.31	22	33.43	0.289835	1.892	1.60	105.4	-	-	-	SS	1.96	-	N	-	AL	-	S	15.84	.17284
125	P3602N35	1.0036	0.0018	4.31	22	33.48	0.284370	1.892	1.60	105.4	-	-	-	SS	2.62	-	N	-	AL	-	S	15.45	.17284
126	P3602N36	1.0009	0.0017	4.31	22	33.58	0.275421	2.540	1.60	105.4	-	-	-	SS	5.41	-	N	-	AL	-	S	13.82	.17284
127	P3602N41	1.0002	0.0016	4.31	22	35.50	0.123377	2.540	3.883	256.1	-	-	-	SS	-	-	N	-	AL	-	S	12.89	.03885
128	P3602N42	1.0019	0.0017	4.31	22	35.63	0.117741	2.540	3.883	256.1	-	-	-	SS	1.32	-	N	-	AL	-	S	14.12	.03885
129	P3602N43	0.9994	0.0017	4.31	22	35.74	0.113378	1.684	3.883	256.1	-	-	-	SS	2.62	-	N	-	AL	-	S	12.44	.03885
130	P3602SS1	0.9978	0.0016	2.35	22	34.87	0.170525	1.892	1.60	218.6	SS	-	.302	SS	1.32	-	N	-	AL	-	S	8.28	.20179
131	P3602SS2	1.0012	0.0018	4.31	22	33.40	0.292861	1.684	1.60	105.4	SS	-	.302	SS	1.96	-	N	-	AL	-	S	13.75	.17284
132	P3926L1	0.9996	0.0014	2.35	12	34.85	0.172514	1.684	1.60	218.6	-	-	-	L	-	-	N	-	AL	-	S	10.06	.20179
133	P3926L2	1.0028	0.0016	2.35	12	34.92	0.167446	1.684	1.60	218.6	-	-	-	L	0.66	-	N	-	AL	-	S	10.11	.20179
134	P3926L3	1.0017	0.0015	2.35	12	35.06	0.158275	1.684	1.60	218.6	-	-	-	L	3.28	-	N	-	AL	-	S	8.50	.20179
135	P3926L4	1.0055	0.0019	4.31	12	33.31	0.304464	1.892	1.60	105.4	-	-	-	L	-	-	N	-	AL	-	S	17.74	.17284
136	P3926L5	1.0070	0.0017	4.31	12	33.37	0.296797	1.892	1.60	105.4	-	-	-	L	0.66	-	N	-	AL	-	S	18.18	.17284
137	P3926L6	1.0026	0.0016	4.31	12	33.51	0.281808	1.892	1.60	105.4	-	-	-	L	1.96	-	N	-	AL	-	S	17.43	.17284
138	P3926SL1	0.9942	0.0015	2.35	12	35.07	0.159108	1.684	1.60	218.6	-	-	-	W	-	-	N	-	AL	-	S	6.59	.20179

Table 3.5 (continued)

Case No.	Case name	k_{eff}	$\pm \sigma$	Enrich. (wt %)	Ref.	AEG	AEF(eV)	Pitch (cm)	H_2O/fuel	matl. ^a	Plate matl. ^a	Boron concen. (wt %)	Plate thick. (cm)	Wall matl. ^b	Wall separ. (cm)	No. of holes/pin	Boron sol. concen. (ppm)	Assembly					
																		separ.	Dancoff factor	Lattice ^d			
139	P3926SL2	0.9990	0.0019	4.31	12	33.55	.279386	1.892	1.60	105.4	-	-	-	-	-	N	-	AL	-	S	12.97	.17284	
140	P3926U1	0.9979	0.0017	2.35	12	33.28	.403558	1.684	1.60	218.6	-	-	-	U	-	-	N	-	AL	-	S	8.06	.20179
141	P3926U2	0.9980	0.0017	2.35	12	33.62	.341429	1.684	1.60	218.6	-	-	-	U	1.32	-	N	-	AL	-	S	9.50	.20179
142	P3926U3	1.0001	0.0015	2.35	12	34.15	.263699	1.684	1.60	218.6	-	-	-	U	3.91	-	N	-	AL	-	S	9.19	.20179
143	P3926U4	1.0026	0.0017	4.31	12	31.93	.655172	1.892	1.60	105.4	-	-	-	U	-	-	N	-	AL	-	S	15.33	.17284
144	P3926U5	0.9999	0.0017	4.31	12	32.45	.511391	1.892	1.60	105.4	-	-	-	U	1.96	-	N	-	AL	-	S	19.24	.17284
145	P3926U6	1.0024	0.0016	4.31	12	32.74	.444529	1.892	1.60	105.4	-	-	-	U	3.28	-	N	-	AL	-	S	18.78	.17284
146	P4267B1	0.9969	0.0015	4.31	13	31.80	.548827	1.890	1.59	105.1	-	-	-	-	-	Y	2150	AL	-	S	-	.17349	
147	P4267B2	1.0035	0.0013	4.31	13	31.54	.608525	1.890	1.59	105.1	-	-	-	-	-	Y	2550	AL	-	S	-	.17346	
148	P4267B3	1.0025	0.0015	4.31	13	30.97	.7944676	1.715	1.090	71.9	-	-	-	-	-	Y	1030	AL	-	S	-	.27021	
149	P4267B4	0.9993	0.0016	4.31	13	30.51	.955273	1.715	1.090	71.9	-	-	-	-	-	Y	1820	AL	-	S	-	.27012	
150	P4267B5	1.0031	0.0014	4.31	13	30.08	1.12803	1.715	1.090	71.9	-	-	-	-	-	Y	2550	AL	-	S	-	.27000	
151	P4267SL1	0.9974	0.0018	4.31	13	33.44	.291929	1.890	1.59	105.1	-	-	-	-	-	N	-	AL	-	S	-	.17369	
152	P4267SL2	0.9993	0.0017	4.31	13	31.95	.5433594	1.715	1.090	71.9	-	-	-	-	-	N	-	AL	-	S	-	.27032	
153	P49-194	1.0081	0.0016	4.31	14	27.62	3.44514	1.598	0.509	33.6	-	-	-	-	-	N	-	AL	-	-	-	.47372	
154	P62FT231	1.0005	0.0018	4.31	20	32.92	.359262	1.891	1.60	105.0	B	35.6	.683	-	-	-	N	-	AL	-	S	5.67	.17338
155	P71F14F3	1.0029	0.0018	4.31	21	32.81	.376130	1.891	1.60	105.0	B	29.2	.673	-	-	-	N	-	AL	F1	S	5.19	.17388
156	P71F14V3	0.9973	0.0017	4.31	21	32.88	.364695	1.891	1.60	105.0	B	29.2	.673	-	-	-	N	-	AL	F2	S	5.19	.17388
157	P71F14V5	0.9977	0.0016	4.31	21	32.86	.367506	1.891	1.60	105.0	B	29.2	.673	-	-	-	N	-	AL	F2	S	5.19	.17388
158	P71F214R	1.0010	0.0020	4.31	21	32.88	.365283	1.891	1.60	105.0	B	29.2	.673	-	-	-	N	-	AL	-	S	5.19	.17388
159	PAT80L1	1.0031	0.0018	4.74	23	35.03	.148022	1.6	3.807	228.6	B	39.3	.11	L	0.23	-	N	-	AL	-	S	2.0	.10503
160	PAT80L2	0.9920	0.0018	4.74	23	35.08	.143839	1.6	3.807	228.6	B	39.3	.11	L	2.50	-	N	-	AL	-	S	2.0	.10503
161	PAT80SS1	1.0004	0.0017	4.74	23	35.00	.149442	1.6	3.807	228.6	B	39.3	.11	SS	0.23	-	N	-	AL	-	S	2.0	.10503
162	PAT80SS2	0.9926	0.0021	4.74	23	35.09	.143903	1.6	3.807	228.6	B	39.3	.11	SS	2.50	-	N	-	AL	-	S	2.0	.10503
163	W3269A	0.9934	0.0016	5.70	15	33.11	.311261	1.422	1.932	98.3	-	-	-	-	-	N	-	SS	-	S	-	.18534	
164	W3269B1	0.9963	0.0015	3.70	15	32.36	.452602	1.105	1.447	111.0	-	-	-	-	-	N	-	SS	-	S	-	.04346	
165	W3269B2	0.9964	0.0014	3.70	15	32.39	.447071	1.105	1.447	111.0	-	-	-	-	-	N	-	SS	A	S	-	.18534	
166	W3269B3	0.9948	0.0016	3.70	15	32.26	.471281	1.105	1.447	111.0	-	-	-	-	-	N	-	SS	A	S	-	.37720	
167	W3269C	0.9986	0.0015	2.72	15	33.75	.269691	1.524	1.495	156.1	-	-	-	-	-	N	-	SS	A	S	-	.37720	
168	W3269SL1	0.9952	0.0017	2.72	15	33.35	.329668	1.524	1.495	156.1	-	-	-	-	-	N	-	SS	A	S	-	.37720	
169	W3269SL2	1.0040	0.0020	5.70	15	33.08	.319337	1.422	1.932	98.3	-	-	-	-	-	N	-	ZR	A	S	-	.23385	
170	W3269W1	0.9957	0.0018	5.70	15	33.50	.310025	1.524	1.495	156.1	-	-	-	-	-	N	-	ZR	-	S	-	.23388	
171	W3269W2	1.0009	0.0017	5.70	15	33.18	.305719	1.422	1.932	98.3	-	-	-	-	-	N	-	SS	-	S	-	.18534	
172	W3385S11	0.9964	0.0017	5.74	16	33.21	.299510	1.422	1.933	97.6	-	-	-	-	.017	N	-	ZR	-	S	-	.23388	
173	W3385S12	1.0005	0.0020	5.74	16	35.86	.104227	2.011	5.067	255.9	-	-	-	-	.013	N	-	SS	-	S	-	.18534	

^aAL - aluminum; B - boral; BF - boroflex; CD - cadmium; CU - copper; HF - hafnium; SS - stainless steel; UD - copper-cadmium; ZR - Zircaloy.^bL - lead; SS - stainless steel; U - depleted uranium.^cY - yes; N - no.^dAL - aluminum; SS - stainless steel; ZR - Zircaloy.^eA - Ag-In-Cd rods; B - B₄C rods; F1 - flux trap containing fuel rods; F2 - flux trap containing aluminum plates or rods; F3 - flux trap containing polyethylene or polystyrene; G - UO₂-Gd₂O₃ rods.^fH - hexagonal; S - square.^gOther separation distance is 2.83 cm.

Validation

Table 3.6 Descriptive statistics of simple lattice calculations

Description	No. of exp.	k_{eff} range	\bar{k}_{eff}	$\pm\sigma_k$	AEF range (eV)
Square	17	0.9942–1.0004	0.9980	0.0025	0.083–0.544
Hexagonal	4	0.9982–1.0081	1.0027	0.0042	0.070–3.445
TOTAL	21	0.9942–1.0081	0.9989	0.0033	0.070–3.445

Table 3.7 Descriptive statistics of separator plate only calculations

Description	No. of exp.	k_{eff} range	\bar{k}_{eff}	$\pm\sigma_k$	AEF range (eV)
Aluminum	6	0.9951–1.0129	1.0020	0.0062	0.094–0.237
Boral	6	0.9970–1.0010	0.9995	0.0018	0.097–0.365
Boroflex	2	0.9981–1.0022	1.0002	0.0029	0.317–0.318
Cadmium	4	0.9929–1.0001	0.9976	0.0032	0.114–0.305
Copper	6	0.9938–1.0005	0.9969	0.0029	0.096–0.283
Cu-Cd	2	0.9938–0.9992	0.9965	0.0038	0.173–0.292
Hafnium	4	0.9965–1.0056	1.0014	0.0038	0.128–0.232
Borated steel	4	0.9959–1.0005	0.9977	0.0020	0.174–0.295
Steel	8	0.9944–1.0011	0.9981	0.0023	0.097–0.282
Zircaloy	3	0.9956–0.9980	0.9971	0.0013	0.095–0.236
TOTAL	45	0.9929–1.0129	0.9989	0.0035	0.094–0.365

Table 3.8 Descriptive statistics of separator plate-soluble boron calculations

Plate lattice	No. of exp.	k_{eff} range	\bar{k}_{eff}	$\pm\sigma_k$	AEF range (eV)
Hexagonal					
Aluminum	4	0.9986–1.0068	1.0031	0.0041	0.968–2.281
Square					
Borated aluminum	2	0.9954–0.9965	0.9960	0.0008	0.152–0.194
Aluminum	4	0.9976–1.0035	1.0007	0.0024	0.402–1.392
Steel	2	0.9981–0.9989	0.9985	0.0006	0.193–0.195
TOTAL	12	0.9954–1.0068	1.0003	0.0036	0.152–2.281

Table 3.9 Descriptive statistics of separator plate-void material (flux trap) calculations

Description	No. of exp.	k_{eff} range	\bar{k}_{eff}	$\pm\sigma_k$	AEF range (eV)
Al-polyethylene	4	0.9964–1.0096	1.0015	0.0059	0.206–0.250
Al-polystyrene	1	0.9909	0.9909	0.0000	0.266
Boral-Al	2	0.9973–0.9977	0.9975	0.0003	0.365–0.368
Boral-fuel rods	1	1.0029	1.0029	0.0000	0.376
TOTAL	8	0.9909–1.0096	0.9993	0.0055	0.206–0.368

Table 3.10 Descriptive statistics of reflecting wall calculations

Description	No. of exp.	k_{eff} range	\bar{k}_{eff}	$\pm\sigma_k$	AEF range (eV)
Lead	10	0.9996–1.0081	1.0037	0.0031	0.095–0.304
Steel	15	0.9957–1.0045	1.0002	0.0026	0.095–0.317
Uranium	10	0.9979–1.0042	1.0007	0.0020	0.173–0.655
TOTAL	35	0.9957–1.0081	1.0013	0.0030	0.095–0.655

Table 3.11 Descriptive statistics of reflecting wall-separator plate calculations

Wall/plate material	No. of exp.	k_{eff} range	\bar{k}_{eff}	$\pm\sigma_k$	AEF range (eV)
Lead-Boral	2	0.9920–1.0031	0.9976	0.0078	0.144–0.148
Steel-Boral	3	0.9926–1.0004	0.9973	0.0041	0.144–0.305
Steel-Cadmium	2	0.9988–1.0002	0.9995	0.0010	0.181–0.301
Steel-Copper	2	0.9964–1.0039	1.0002	0.0053	0.173–0.297
Steel-Cu-Cd	2	0.9980–1.0040	1.0010	0.0042	0.176–0.297
Steel-Borated steel	2	1.0000–1.0001	1.0001	0.0001	0.178–0.299
Steel-Steel	2	0.9978–1.0012	0.9995	0.0024	0.171–0.293
TOTAL	15	0.9920–1.0040	0.9992	0.0035	0.144–0.305

Table 3.12 Descriptive statistics of urania gadolinia rod calculations

Description	No. of exp.	k_{eff} range	\bar{k}_{eff}	$\pm\sigma_k$	AEF range (eV)
Urania-gadolinia rods	5	0.9971–1.0005	0.9986	0.0015	0.243–0.337

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Table 3.13 Descriptive statistics of water hole calculations

Description	No. of exp.	k_{eff} range	\bar{k}_{eff}	$\pm \sigma_k$	AEF range (eV)
Water holes	6	0.9957–1.0015	0.9985	0.0025	0.148–0.310
Water holes-soluble boron	3	0.9971–1.0032	0.9992	0.0035	0.245–0.355
TOTAL	9	0.9957–1.0032	0.9987	0.0027	0.148–0.355

Table 3.14 Descriptive statistics of absorber rod calculations

Description	No. of exp.	k_{eff} range	\bar{k}_{eff}	$\pm \sigma_k$	AEF range (eV)
B ₄ C	3	0.9936–0.9980	0.9951	0.0025	0.148–0.332
Ag-In-Cd	6	0.9934–1.0022	0.9970	0.0031	0.245–0.471
TOTAL	9	0.9936–1.0022	0.9963	0.0029	0.148–0.471

Table 3.15 Descriptive statistics of soluble boron calculations

Description	No. of exp.	k_{eff} range	\bar{k}_{eff}	$\pm \sigma_k$	AEF range (eV)
Borated water	14	0.9947–1.0035	0.9992	0.0027	0.92–1.189

Table 3.16 Calculational results and experimental parameters of homogenized uranium experiments

Case No.	Case desig.	k_{eff}	$\pm \sigma$	Enrichment	Ref.	AEG	AEF	H/X	Fuel form	Moderator	Moderator thickness	Reflector
174	CR1071AS	1.0207	0.0016	4.46	28,29,31	32.45	0.45405	17.12	U_3O_8	Plexiglas	2.43	Plexiglas
175	CR1653AS	1.0169	0.0018	4.48	28,30,31	32.78	0.38852	27.33	U_3O_8	Plexiglas	2.43	Plexiglas
176	CR2500S	1.0194	0.0018	4.48	28,31	33.20	0.31665	44.27	U_3O_8	Plexiglas	2.43	Plexiglas
177	YDR14PL2	1.0011	0.0015	2.00	27	36.49	0.08319	406.3	UF_4	Paraffin	0.0	Paraffin
178	YDR14PL3	1.0115	0.0017	3.00	27	33.86	0.23625	133.4	UF_4	Paraffin	0.0	Paraffin
179	YDR14UN2	1.0047	0.0015	2.00	27	35.39	0.13273	293.9	UF_4	Paraffin	0.0	None
180	YDR14UN3	1.0163	0.0017	3.00	27	33.10	0.32152	133.4	UF_4	Paraffin	0.0	None

Validation

Table 3.17 Descriptive statistics of homogenized uranium calculations

Description	No. of exp.	k_{eff} range	\bar{k}_{eff}	$\pm\sigma_k$	AEF range (eV)
UF ₄ in paraffin	4	1.0011–1.0163	1.0084	0.0068	0.083–0.322
Damp oxide (U ₃ O ₈)	3	1.0169–1.0207	1.0190	0.0019	0.317–0.454
TOTAL	7	1.0011–1.0207	1.0129	0.0075	0.083–0.454

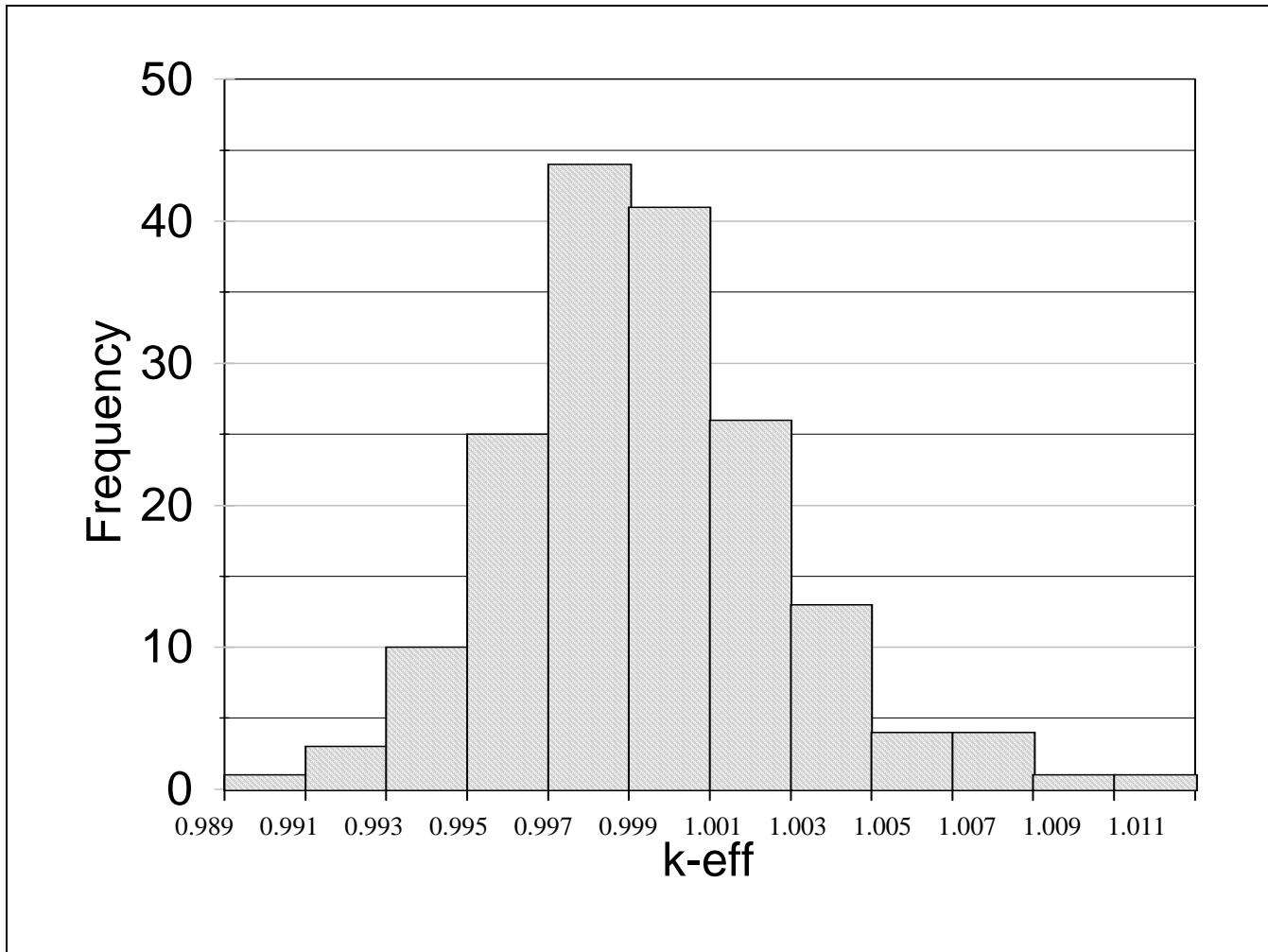


Figure 3.1 Frequency chart for calculated k_{eff} of 173 LWR fuel pin lattice experiments

Validation

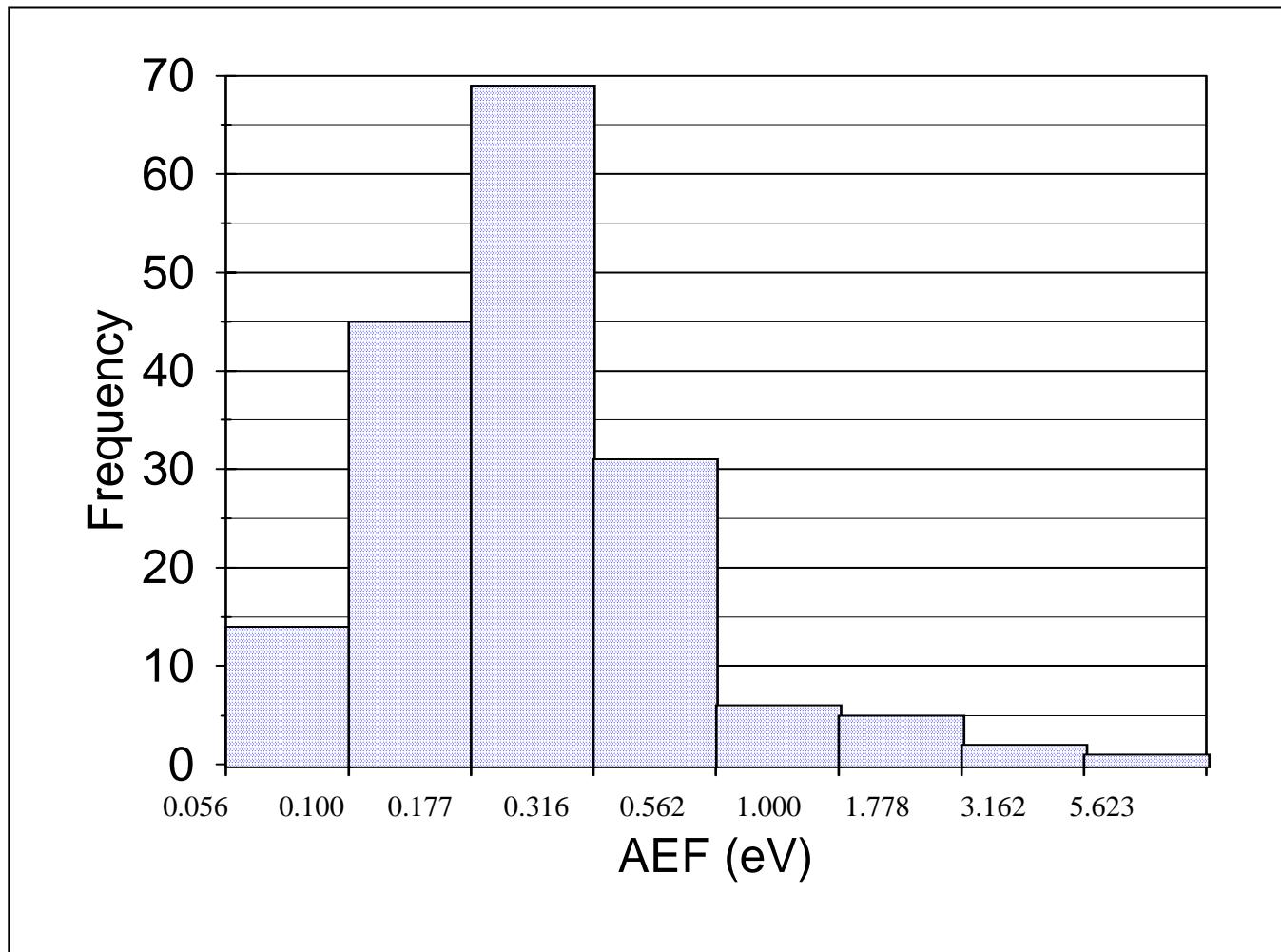


Figure 3.2 Frequency chart for calculated AEF of 173 LWR fuel pin lattice experiments

4 Determination of Bias and Subcritical Limits

Essential elements in the validation of a calculational method for criticality safety applications include the determination of calculational biases and the incorporation of these biases into subcritical limits. This section presents two methods for performing this task and then applies the methods to the validation of the SCALE 44-group library for the LWR lattice results in Sect. 3.

4.1 Establishment of an Upper Subcritical Limit

For a subcritical configuration, it is desirable to possess a confidence that the calculation of k_{eff} for a system guarantees sufficient subcriticality. This assurance of subcriticality requires the determination of an acceptable margin based on known biases and uncertainties associated with the codes and data used to calculate k_{eff} . This subsection describes two methods for the determination of an Upper Subcritical Limit (USL) from the bias and uncertainty terms associated with the calculation of criticality. These approaches are used to help define uncertainty and bias terms as they relate to criticality experiments and calculations.

The recommended approach for establishing subcriticality based on the numerical calculation of the neutron multiplication factor is prescribed in Sect. 5.1 of ANSI/ANS-8.17 (Ref. 38). The following paragraphs describe the recommended approach as set forth in the Standard.

The criteria to establish subcriticality requires that for a system to be considered subcritical the calculated multiplication factor for the system, k_s , must be less than or equal to an established maximum allowable multiplication factor based on benchmark calculations and uncertainty terms, that is,

$$k_s \leq k_c - \Delta k_s - \Delta k_c - \Delta k_m, \quad (4.1)$$

where

- k_c = mean value of k_{eff} resulting from the calculation of benchmark criticality experiments using a specific calculational method and data,
- Δk_s = uncertainty in the value of k_s ,
- Δk_c = uncertainty in the value of k_c ,
- Δk_m = additional margin to ensure subcriticality.

Often Δk_m is arbitrarily assigned an administrative limit of 0.05; however, a value for this margin can also be estimated statistically.

If the calculational bias β is defined as $\beta = k_c - 1$, then the uncertainty in the bias is identical to the uncertainty in k_c (i.e., $\Delta k_c = \Delta \beta$). According to this definition of bias, the bias is negative if $k_c < 1$ and positive if $k_c > 1$. Thus the subcriticality condition may be rewritten as

$$k_s + \Delta k_s + \Delta k_m - \beta + \Delta \beta \leq 1. \quad (4.2)$$

The value k_c and thus the bias β are not necessarily constant over the range of a parameter of interest. If trends exist which cause the benchmark values of k_{eff} to vary with one or more parameters (e.g., enrichment, AEF, etc.), then β can be determined from a best fit for the calculated k_{eff} values as a function of each of the parameters upon which it is dependent. Trends must be taken into account if extrapolation outside the range of validation is to be performed.

The set of critical experiments used as benchmarks in the computation of β should be representative of the composition, configuration, and nuclear characteristics of the system for which k_s is to be determined. However,

Determination of Limits

ANSI/ANS-8.1 (Ref. 39) allows that the range of applicability may be extended beyond the range of conditions represented by the benchmark experiments by extrapolating the trends established for the bias. When the extrapolation is large relative to the range of data (“large” is not defined by the ANSI standard), the calculational method applied should be supplemented by other methods in order to better estimate the extrapolated bias.

In addition to the bias β determined based on a given computational method, data, and a suite of benchmarks, there is an uncertainty in the bias $\Delta\beta$. This uncertainty may include uncertainties in the critical experiments, statistical and/or convergence uncertainties in the benchmark calculations, uncertainties due to extrapolation beyond the range of experimental data, and uncertainties due to limitations or weaknesses in the geometrical or nuclear modeling of the critical experiments. Similarly, for a given subcritical system, there is an uncertainty, Δk_s , associated with the calculated k_{eff} value for the system, k_s . This uncertainty may include statistical/convergence and modeling uncertainties, as well as uncertainties in the materials and fabrication.

Based on the criteria for subcriticality set forth in ANSI/ANS-8.17 and described above, a USL may be determined based on the analysis of a number of critical systems. The USL is determined such that there is a high degree of confidence that a calculated result is subcritical; a system is considered acceptably subcritical if a calculated k_{eff} plus calculational uncertainties lies at or below this limit (i.e., $k_s + \Delta k_s \leq \text{USL}$). Thus the USL is the magnitude of the sum of the biases, uncertainties, and administrative and/or statistical margins applied to a set of critical benchmarks, such that with a high degree of confidence

$$\text{USL} = 1 - \Delta k_m + \beta - \Delta\beta . \quad (4.3)$$

Based on a given set of critical experiments, USLs are determined as a function of key system parameters, such as AEF, fuel enrichment, or fuel/moderator ratio. Because both $\Delta\beta$ and β can vary with a given parameter, the USL is typically expressed as a function of the parameter, within an appropriate range of applicability derived from the parameter bounds.

In the two methods presented in the following sections, a minimum of 25 data points (i.e., calculated k_{eff} values) are required to verify normality, which is assumed in these methods. The software discussed below which implements these methods performs a crude test for whether or not the k_{eff} values as a group are normal around the mean value of k_{eff} . The test is commonly known as the “goodness of fit.” The distribution of k_{eff} values around the mean are pooled into five equally probable bins. The test may not be reliable if there are fewer than 5 observations in each bin. Thus the test will always be flagged as not being reliable for cases where there are fewer than 25 observations and may be flagged for more observations if there are fewer than 5 observations in any bin. If there is an insufficient number of observations to ensure normality with this test, other statistical methods should be employed to determine normality or additional uncertainties to account for the paucity of data should be considered. Note in the example applications in Sect. 4.1.3 that contain less than 25 points, no additional uncertainty has been applied. These examples are only for illustration of the methods presented in Sects. 4.1.1 and 4.1.2.

4.1.1 USL Method 1: Confidence Band with Administrative Margin

The first method applies a statistical calculation of the bias and its uncertainty plus an administrative margin to a linear fit of critical experiment benchmark data. This approach is illustrated in Fig. 4.1. In this figure, the upper line (solid) represents a linear regression fit to a set of calculations based on critical experiments, $k_c(x)$. As indicated in the figure, $\beta(x)$ is given as $k_c(x) - 1$. The middle line (long dashes) represents the lower confidence band for a single additional calculation. The width of this band is determined statistically based on the existing data and a specified level of confidence; the greater the standard deviation in the data or the larger the confidence desired, the larger the band width will be. This confidence band, W , accounts for uncertainties in the experiments, the calculational approach, and in calculational data (e.g., cross sections), and is therefore a statistical basis for $\Delta\beta$, the uncertainty in the value of β . W is defined for a confidence level of $(1-\gamma_1)$ using the relationship

$$W = \max \left\{ w(x) \Big|_{x_{\min}, x_{\max}} \right\}, \quad (4.4)$$

where

$$w(x) = t_{1 - \gamma_1} s_p \left[1 + \frac{1}{n} + \frac{(x - \bar{x})^2}{\sum_{i=1,n} (x_i - \bar{x})^2} \right]^{\frac{1}{2}} \quad (4.5)$$

and

- n = the number of critical calculations used in establishing $k_c(x)$,
- $t_{1 - \gamma_1}$ = the Student-t distribution statistic for $1 - \gamma_1$ and $n-2$ degrees of freedom (obtained from t tables⁴⁰)
- \bar{x} = the mean value of parameter x in the set of calculations,
- s_p = the pooled standard deviation for the set of criticality calculations.

The function $w(x)$ is a curvilinear function. For simplicity, it is desirable to obtain a constant width margin. Hence, for conservatism, the confidence band width W is defined as the maximum of ($w(x_{\min})$, $w(x_{\max})$), where x_{\min} and x_{\max} are the minimum and maximum values of the independent parameter x , respectively. Typically, W is determined at a 95% confidence level.

The pooled standard deviation is obtained from the pooled variance ($s_p^2 = \sqrt{s_p^2}$), where s_p^2 is given as

$$s_p^2 = s_{k(x)}^2 + s_w^2, \quad (4.6)$$

where $s_{k(x)}^2$ is the variance (or mean-square error) of the regression fit, and is given by:

$$s_{k(x)}^2 = \frac{1}{(n-2)} \left[\sum_{i=1,n} (k_i - \bar{k})^2 - \frac{\left\{ \sum_{i=1,n} (x_i - \bar{x})(k_i - \bar{k}) \right\}^2}{\sum_{i=1,n} (x_i - \bar{x})^2} \right], \quad (4.7)$$

and s_w^2 is the within-variance of the data:

$$s_w^2 = \frac{1}{n} \sum_{i=1,n} \sigma_i^2, \quad (4.8)$$

where σ_i is the standard deviation associated with k_i for a Monte Carlo calculation. For best results, it is recommended that the individual standard deviations for the Monte Carlo calculations be roughly uniform in value. For deterministic codes that do not have a standard deviation associated with a computed value of k , the standard deviation is zero. However, this term could be used as a mechanism to include known uncertainties in experimental data.

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The bottom line (short dashes) in Fig. 4.1 represents the USL, based on an additional margin of subcriticality. Note in Fig. 4.2 that a “positive bias adjustment” line has been added to the line $k_c(x) - W$ at the point where $k_c(x) = 1$. This adjustment has been made to prevent taking credit for a positive bias [$\beta(x) > 0$] by assuming $k_c(x) = 1$ everywhere that $k_c(x) > 1$. Likewise, the USL has been adjusted so that the margin of subcriticality is constant with respect to the positive-bias-adjusted form of $k_c(x) - W$. This additional margin provides further assurance of subcriticality, and represents the quantity Δk_m defined earlier. In USL Method 1, Δk_m is given an arbitrary administrative value; a minimum of 0.05 is recommended for application to transportation and storage packages. Using these formulations, the USL Method 1 is defined as

$$USL_1(x) = 1 - \Delta k_m - W + \beta(x). \quad (4.9)$$

In application to transportation and storage packages, the $USL(x)$ value should not be greater than 0.95.

4.1.2 USL Method 2: Single-Sided Uniform Width Closed Interval Approach

In this method, sometimes referred to as a lower tolerance band (LTB) approach, statistical techniques with a rigorous basis⁴¹⁻⁴⁴ are applied in order to determine a combined lower confidence band plus subcritical margin. In other words, in the administrative margin approach Δk_m and $\Delta \beta$ are determined independently, while in the LTB method, a combined statistical lower bound is determined. The following discussion of Method 2 is taken from Ref. 45 and is based on equations and/or definitions from Refs. 43 and 44.

The purpose of this method is to determine a uniform tolerance band over a specified closed interval for a linear least-squares model. The level of confidence in the limit being calculated is α and is typically in the range from 0.90 to 0.999.

The USL Method 2 is defined as

$$USL_2(x) = 1.0 - (C_{\alpha/P} \cdot s_p) + \beta(x), \quad (4.10)$$

where s_p is the pooled variance of k_c described earlier. The term $C_{\alpha/P} \cdot s_p$ provides a band for which there is a probability P with a confidence α that an additional calculation of k_{eff} for a critical system will lie within the band. For example, a $C_{95/99.5}$ multiplier produces a USL for which there is a 95% confidence that 995 out of 1000 future calculations of critical systems will yield a value of k_{eff} above the USL.

The analysis is over the closed interval from $x = a$ to $x = b$. $C_{\alpha/P}$ is calculated according to the following equations:

$$g = \sqrt{\frac{1}{n} + \frac{(a - \bar{x})^2}{\sum_{i=1}^n (x_i - \bar{x})^2}} \quad (4.11)$$

$$h = \sqrt{\frac{1}{n} + \frac{(b - \bar{x})^2}{\sum_{i=1}^n (x_i - \bar{x})^2}} \quad (4.12)$$

$$\rho = \frac{1}{gh} \cdot \left\{ \frac{1}{n} + \frac{(a - \bar{x})(b - \bar{x})}{\sum_{i=1}^n (x_i - \bar{x})^2} \right\} \quad (4.13)$$

$$A = \frac{g}{h} \quad (4.14)$$

It should be noted that there is an inconsistency in the notation used in Refs. 43 and 44. In Ref. 44, the notation for the summation of x^2 actually means the summation of the quantity $(x - \bar{x})^2$.

A , ρ , and $(n - 2)$ are used to determine the value of D from Table 3 in Ref. 43, which covers values of $0.5 \leq A \leq 1.5$. The procedure to follow when A is in this range is

$$C^* = D \cdot g. \quad (4.15)$$

When A is outside the above range, A is replaced by $1/A$ for the determination of D , and C^* is given by

$$C^* = D \cdot h. \quad (4.16)$$

Next,

$$C_{\alpha/p} = C^* + z_p \cdot \sqrt{\frac{n-2}{\chi^2}}, \quad (4.17)$$

where

z_p is the Student t statistic depending on n and P , and

χ^2 is the chi square distribution, a function of $n - 2$ and α .

This approach provides a more statistically based subcritical margin, Δk_m , which can be determined as the difference $(C_{\alpha/p} \cdot s_p) - W$. In criticality safety applications, such a statistically determined approach generally, but not necessarily, yields a margin of less than 0.05, which serves to illustrate the adequacy of the administrative margin. The recommended purpose of Method 2 is to apply it in tandem with Method 1 to verify that the administrative margin is conservative relative to a purely statistical basis. **This concurrent application of Method 2 is especially important when a limited number of data points are used in determination of**

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$k_c(x)$, or when the calculated values have a large standard deviation. In these cases, the statistically based subcritical margin may indicate the need for a larger administrative margin.

Appendix C documents a computer program called USLSTATS that has been developed to perform the required statistical analysis and calculate USLs based on Methods 1 and 2.

4.1.3 Application of Upper Subcritical Limit Methods

Either of these two methods is generally considered applicable over the range of a given parameter in the set of calculations used to determine the USL. However, as discussed earlier, ANSI/ANS-8.1 allows the range of applicability to be extended beyond this range by extrapolating the trends established for the bias. No precise guidelines are specified for the limits of extrapolation. Thus engineering judgment and additional uncertainty should be applied when extrapolating beyond the range of the parameter bounds. Note that $w(x)$ should be used rather than W in performing any extrapolation because $k_c(x) - W$ is a straight line based on $w(x)$ and is only assured of being conservative within the range of the parameter bounds (Fig. 4.1).

Based on the critical experiments described earlier in this report, it is possible to determine a set of USLs based on any of the various parameters studied (e.g., AEF, pitch, H/X, water-to-fuel volume ratio, etc.). The remainder of this section will demonstrate the calculation of the USL as a function of these parameters using the two methods described above. These examples will demonstrate the approach of each method and may be used for guidance in applying each of the methods for any appropriate set of benchmarks, any given criticality code or code system, or for a different cross-section library.

Of primary importance in this analysis is the determination of parameters responsible for variations in k_{eff} . To determine each parameter's effectiveness in explaining variations in calculated k_{eff} values, linear regression analyses are employed. Of the 173 LWR cases, 167 cases contain data for k_{eff} , H/X, AEF, pitch, water-to-fuel volume ratio, enrichment, and Dancoff factor. The other six cases contain multiple enrichments and were therefore excluded from this parametric analysis.

The first step is to determine the correlation coefficients for different subsets of the 173 LWR critical experiments used in the validation. These values provide a measure of the statistical correlation between each independent variable and variations in the calculated k_{eff} values. The variable with the strongest correlation to the calculated k_{eff} values is then used in a linear regression equation to describe the variation in k_{eff} , $k_c(x)$, for determination of the USL.

The subsets of LWR critical experiments analyzed are tabulated in Table 4.1 versus the classes of experiments as presented in Sect. 3. The table shows how many experiments from each class were included in each subset. Other subsets could be constructed by selecting or combining different classes from the table. The results presented here are not intended to be exhaustive, but instructive in demonstrating the application of the USL methods discussed earlier.

A statistical summary of the variables included in this analysis is given in Table 4.2. For each variable, the number of experiments where that variable is applicable is listed, together with the mean, median, minimum, and maximum values of the variable. A breakdown of the independent variables applicable to each subset of experiments analyzed is shown in Table 4.3.

The results of these analyses are displayed in Table 4.4. For each subset, several independent variables exist, as listed in Table 4.3. A linear regression analysis was performed for each independent variable and the corresponding correlation coefficient, r , was calculated. An exact correlation between the dependent variable (i.e., k_{eff}) and an independent variable would be indicated by $|r| = 1$. No correlation whatsoever would be indicated by $r = 0$. The three variables with the greatest correlation are listed for each subset, along with their corresponding

correlation coefficients. The most strongly correlated variable is used to form the regression equation for $k_c(x)$. The standard error in the last column is the average error in the estimate of k_{eff} using the regression equation for $k_c(x)$.

Tables 4.5 and 4.6 summarize intermediate calculations and the final USL equations using the correlation of k_{eff} to key parameters for each of the subsets as listed in Table 4.3. The resulting USL equations are illustrated in Figs. 4.2–4.9. The calculated k_{eff} values are plotted against the lines representing the linear regression fit [$k_c(x)$], the 95% confidence band for a single calculation [$k_c(x)-W$], the USL based on Method 1 [$USL_1=k_c(x)-W-0.05$], and the USL based on Method 2 [$USL_2=k_c(x)-C_{95/99.5} \cdot s_p$]. As can be seen from the table and the figures, the statistically based subcritical margin is less than the assumed administrative margin of 0.05 used in Method 1 for all subsets of experiments considered. The correlations of results for all LWR experiments to AEF and enrichment are very weak as can be seen by the lack of any trends in Figs. 4.2 and 4.3. The plot of k_{eff} vs AEF in Fig. 4.2 was separated into two plots because the wide range of AEF values compressed the large number of low energy data points when all data were plotted together. The limited number of enrichments in the selected experiments also makes fuel enrichment a poor choice for an independent variable. No statistically significant correlation to any independent variable was found for the water hole experiment subset. The subsets of experiments with the strongest correlation of the calculated k_{eff} values to an independent variable were the separator plates and soluble boron experiments ($r = 0.908$ vs AEF) and the borated separator plates and reflecting walls experiments ($r = -0.815$ vs reflector separation). The correlation of the linear regression fits to the actual data for these subsets can be seen in Figs. 4.8 and 4.9, respectively.

In order to apply these USL methods to an application, it is necessary for the expected parameter value (design or calculational) to lie within the range of applicability of that parameter. To achieve this, one should first determine the values of the parameters from Table 4.2 that characterize the desired application. Next, the classes of experiments in Table 4.1 should be checked to determine which class(es) share similar geometry features to the application of concern. The parameter with the strongest correlation to the k_{eff} values should be used to generate the USL. The range of values of this key parameter defines the range of applicability for the USL. The value of the key parameter for the application of concern must lie within this range in order to apply the USL.

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Table 4.1 Subsets of LWR-type fuel experiments

Table No.	Class	Number of experiments in subsets							
		All expts.	Separator plates	Reflecting walls	Soluble boron	Plates and walls	Plates and boron	Water holes	Borated plates and walls
3.6	Simple lattice	21							
3.7	Separator plate	45	45						
3.8	Plates w/soluble boron	12	12		12		12		
3.9		8	8						
3.10	Flux trap	35		35					
3.11	Reflecting wall	15	15	15		15			7
3.12	Plates w/walls	2			2			2	
3.13	Urania gadolinia ^a	7			1			7	
3.14	Water holes ^a	8			1			1	
3.15	Absorber rods ^a	14			14				
	TOTAL	167	80	50	30		12	10	7

^aOne or more experiments were not included because they consisted of two types of fuel rods with different enrichments.

Table 4.2 Statistical summary of LWR-type fuel experiments

Variable	No. of experiments	Mean	Median	Minimum	Maximum
k_{eff}	173	0.9994	0.9992	0.9909	1.0129
AEG	173	33.94	33.95	27.62	36.88
AEF	173	0.3267	0.2443	0.0702	3.4451
Pitch	173	1.771	1.684	1.105	2.540
Enrichment	167	3.62	4.31	2.35	5.74
Water/fuel	167	2.100	1.6	0.148	9.004
Dancoff factor	167	0.1916	0.1739	0.0298	0.7644
H/X	167	183.5	155.9	17.2	541.1
Assembly separation	110	8.11	7.81	1.64	20.78
Plate thickness	76	0.371	0.302	0.061	0.772
Wall separation	50	1.51	1.32	0.00	5.41
Soluble boron conc.	36	1132	1110	15	3389
Plate boron conc.	22	21.3	29.0	1.1	39.3
Water hole/fuel pin	16	0.048	0.032	0.013	0.152

Table 4.3 Independent variables by subset

Variable	All expts.	Separator plates	Reflecting walls	Soluble boron	Plates and walls	Water holes	Plates and boron	Borated plates and walls
Enrichment	X	X	X	X	X	X	X	X
AEF	X	X	X	X	X	X	X	X
Pitch	X	X	X	X	X	X	X	X
H ₂ O/fuel	X	X	X	X	X	X	X	X
H/X	X	X	X	X	X	X	X	X
Dancoff	X	X	X	X	X	X	X	X
Assembly separation distance			X		X			
Assembly-to-wall separation distance								X
Soluble boron concentration				X			X	
Plate thickness					X		X	
Plate boron concentration							X	X
Water holes/fuel pin						X		

Table 4.4 Regression analyses results for subsets of LWR-type fuel experiments

Subset	No. of observ.	Correlated key parameters	Correlation coefficients, r	Regression equation	Standard error
All experiments	167	AEF, enr, H/X	0.307, 0.289, -0.183	$k_c(x) = 0.9985 + 2.7174E-3*AEF$	0.0037
Separator plates	80	H/X, AEF, Dancoff	-0.370, 0.369, 0.295	$k_c(x) = 1.0019 - 1.6680E-5*H/X$	0.0039
Reflecting walls	50	sep, pitch, enr	0.688, 0.462, 0.372	$k_c(x) = 0.9953 + 4.6483E-4*sep$	0.0029
Soluble boron	30	AEF, Dancoff, w/f	0.632, 0.486, -0.402	$k_c(x) = 0.9976 + 3.2428E-3*AEF$	0.0028
Separator plates and reflecting walls	15	AEF, pitch, H/X	0.553, 0.545, -0.537	$k_c(x) = 0.9931 + 2.7925E-2*AEF$	0.0035
Separator plates and soluble boron	12	AEF, Dancoff, H/X	0.908, 0.737, -0.735	$k(x) = 0.9964 + 4.1672E-3*AEF$	0.0022
Water holes	10	none	N/A	N/A	N/A
Borated separator plates and reflecting walls	7	ss	-0.815	$k_c(x) = 1.0035 - 3.5202E-3*ss$	0.0032

^a enr – enrichment; sep – assembly separation; w/f – water/fuel volume; ss - reflector wall separation distance.

Table 4.5 Summary of USL calculations of Figs. 4.4-4.13

Figure	No. of exp.	$k_c(x)$	Correlation coefficient, r	Most negative bias ($\$_{min}$)	W	Δk_m (USL ₂)	Parameter bounds	Confidence band with administrative margin of 0.05, USL ₁	Single-sided uniform width closed interval, USL ₂
4.2, k_{eff} vs AEF (all experiments)	167	$0.9985 + 2.7174E-3 * AEF$	0.307	≤ 0.0091	$7.2146E-3$	0.015	0.070-3.445	0.9415-0.9428	0.9770-0.9782
4.3, k_{eff} vs enrichment (all experiments)	167	$0.9959 + 9.6691E-4 * enr$	0.289	≤ 0.0091	$6.2707E-3$	0.012	2.35-5.74	0.9419-0.9437	0.9796-0.9814
4.4, k_{eff} vs H/X (separator plates)	80	$1.0019 \pm 1.6680E-5 * H/X$	≤ 0.370	≤ 0.0091	$6.6660E-3$	0.010	17.2-398.5	0.9433-0.9386	0.9836-0.9789
4.5, k_{eff} vs assembly separation (reflecting walls)	50	$0.9953 + 4.6483E-4 * sep$	0.688	≤ 0.0080	$5.1381E-3$	0.008	2.00-20.78	0.9411-0.9449	0.9829-0.9867
4.6, k_{eff} vs AEF (soluble boron)	30	$0.9976 + 3.2428E-3 * AEF$	0.632	≤ 0.0053	$5.4354E-3$	0.009	0.092-2.281	0.9425-0.9446	0.9831-0.9851
4.7, k_{eff} vs AEF (separator plates and reflecting walls)	15	$0.9931 + 2.7925E-2 * AEF$	0.553	≤ 0.0080	$6.7130E-3$	0.014	0.144-0.305	0.9403-0.9433	0.9761-0.9791
4.8, k_{eff} vs AEF (separator plates and soluble boron)	12	$0.9964 + 4.1672E-3 * AEF$	0.908	≤ 0.0046	$4.6206E-3$	0.010	0.152-2.281	0.9425-0.9454	0.9822-0.9851
4.9, k_{eff} vs reflecting wall separation (borated separator plates and reflecting walls)	7	$1.0035 \pm 3.5202E-3 * ss$	≤ 0.815	≤ 0.0080	$7.7476E-3$	0.023	0.23-2.50	0.9423-0.9370	0.9696-0.9644

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Table 4.6 USL equations for Figs. 4.4-4.12

Figure No.	Confidence band with administrative margin of 0.05, USL_1	Single-sided uniform width closed interval, USL_2
4.2	$0.9413 + 2.7174E-3*AEF$ ($AEF < 0.535$) 0.9428 ($AEF \geq 0.535$)	$0.9768 + 2.7174E-3*AEF$ ($AEF < 0.535$) 0.9782 ($AEF \geq 0.535$)
4.3	$0.9397 + 9.6691E-4*enr$ ($enr < 4.209$) 0.9437 ($enr \geq 4.209$)	$0.9773 + 9.6691E-4*enr$ ($enr < 4.209$) 0.9814 ($enr \geq 4.209$)
4.4	0.9433 ($H/X \leq 116.8$) $0.9453 - 1.6680E-5*H/X$ ($H/X > 116.8$)	0.9836 ($H/X \leq 116.8$) $0.9856 - 1.6680E-5*H/X$ ($H/X > 116.8$)
4.5	$0.9402 + 4.6483E-4*sep$ ($sep < 10.073$) 0.9449 ($sep \geq 10.073$)	$0.9820 + 4.6483E-4*sep$ ($sep < 10.073$) 0.9867 ($sep \geq 10.073$)
4.6	$0.9422 + 3.2428E-3*AEF$ ($AEF < 0.731$) 0.9446 ($AEF \geq 0.731$)	$0.9828 + 3.2428E-3*AEF$ ($AEF < 0.731$) 0.9851 ($AEF \geq 0.731$)
4.7	$0.9364 + 2.7925E-2*AEF$ ($AEF < 0.247$) 0.9433 ($AEF \geq 0.247$)	$0.9722 + 2.7925E-2*AEF$ ($AEF < 0.247$) 0.9791 ($AEF \geq 0.247$)
4.8	$0.9418 + 4.1672E-3*AEF$ ($AEF < 0.852$) 0.9454 ($AEF \geq 0.852$)	$0.9816 + 4.1672E-3*AEF$ ($AEF < 0.852$) 0.9851 ($AEF \geq 0.852$)
4.9	0.9423 ($ss \leq 1.001$) $0.9458 - 3.5202E-3*ss$ ($ss > 1.001$)	0.9696 ($ss \leq 1.001$) $0.9732 - 3.5202E-3*ss$ ($ss > 1.001$)

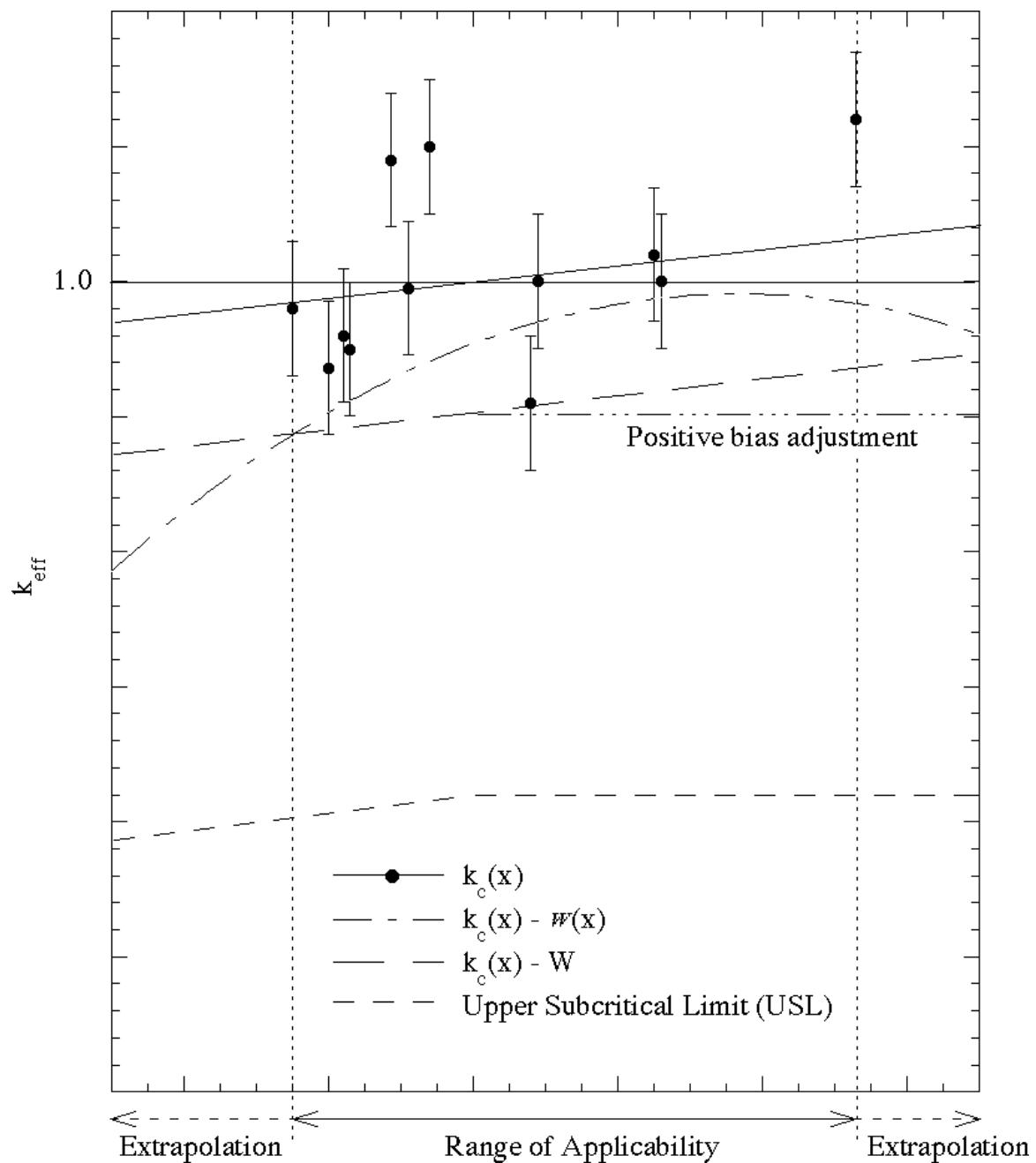


Figure 4.1 Confidence band and additional margin applied to a set of criticality calculations

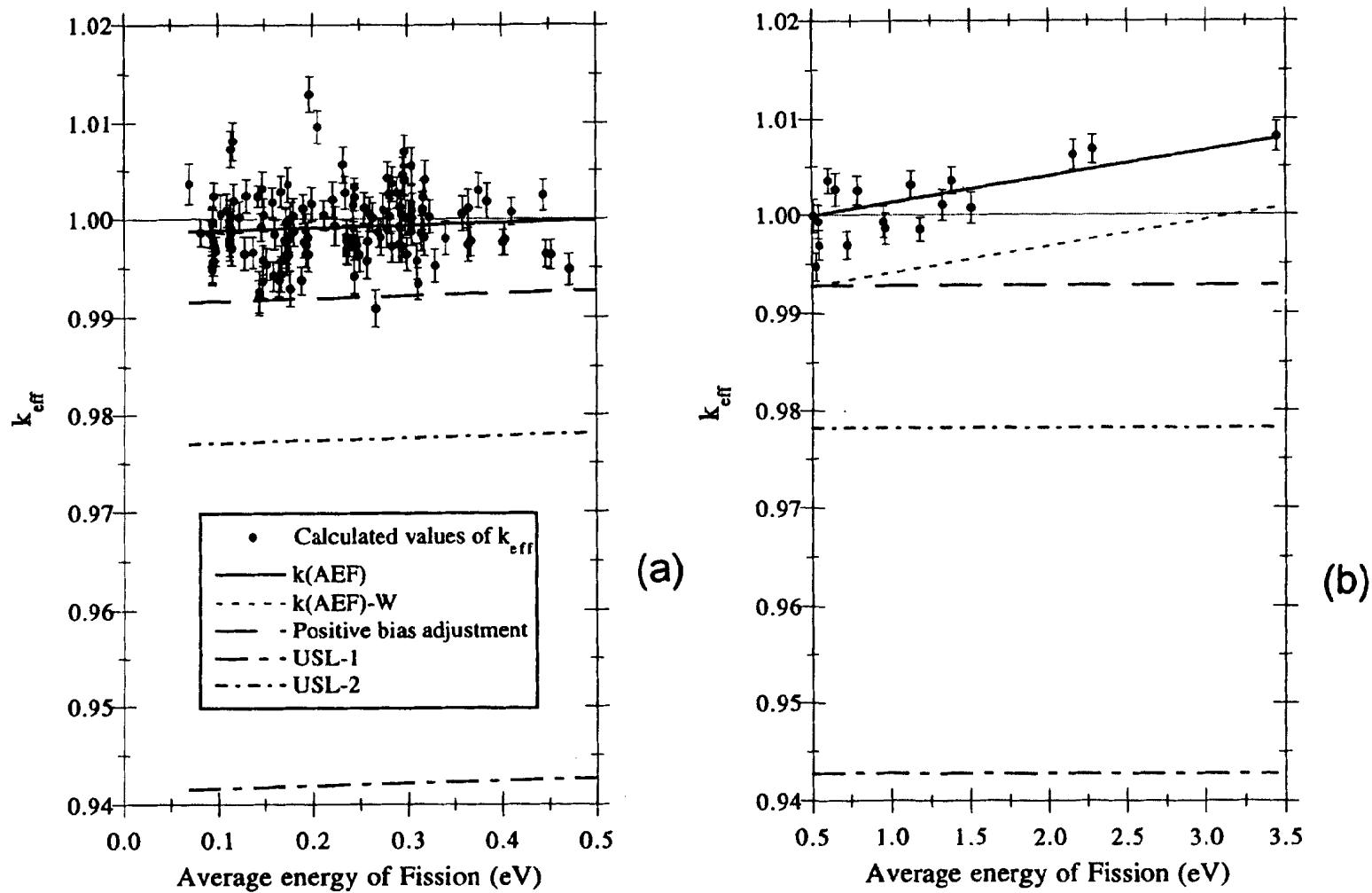


Figure 4.2 USLs for 167 LWR-type fuel critical experiments, k_{eff} vs enrichment

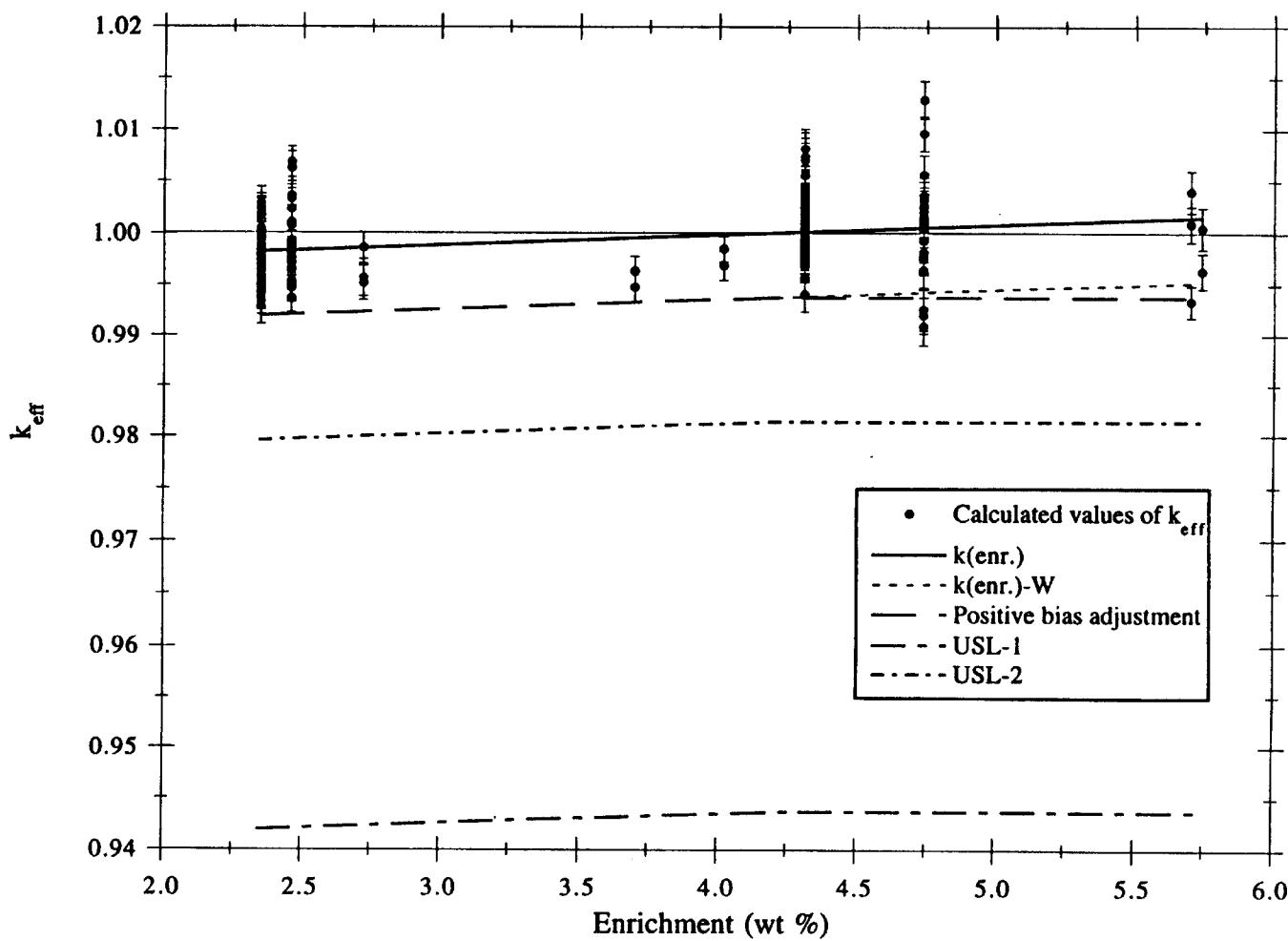
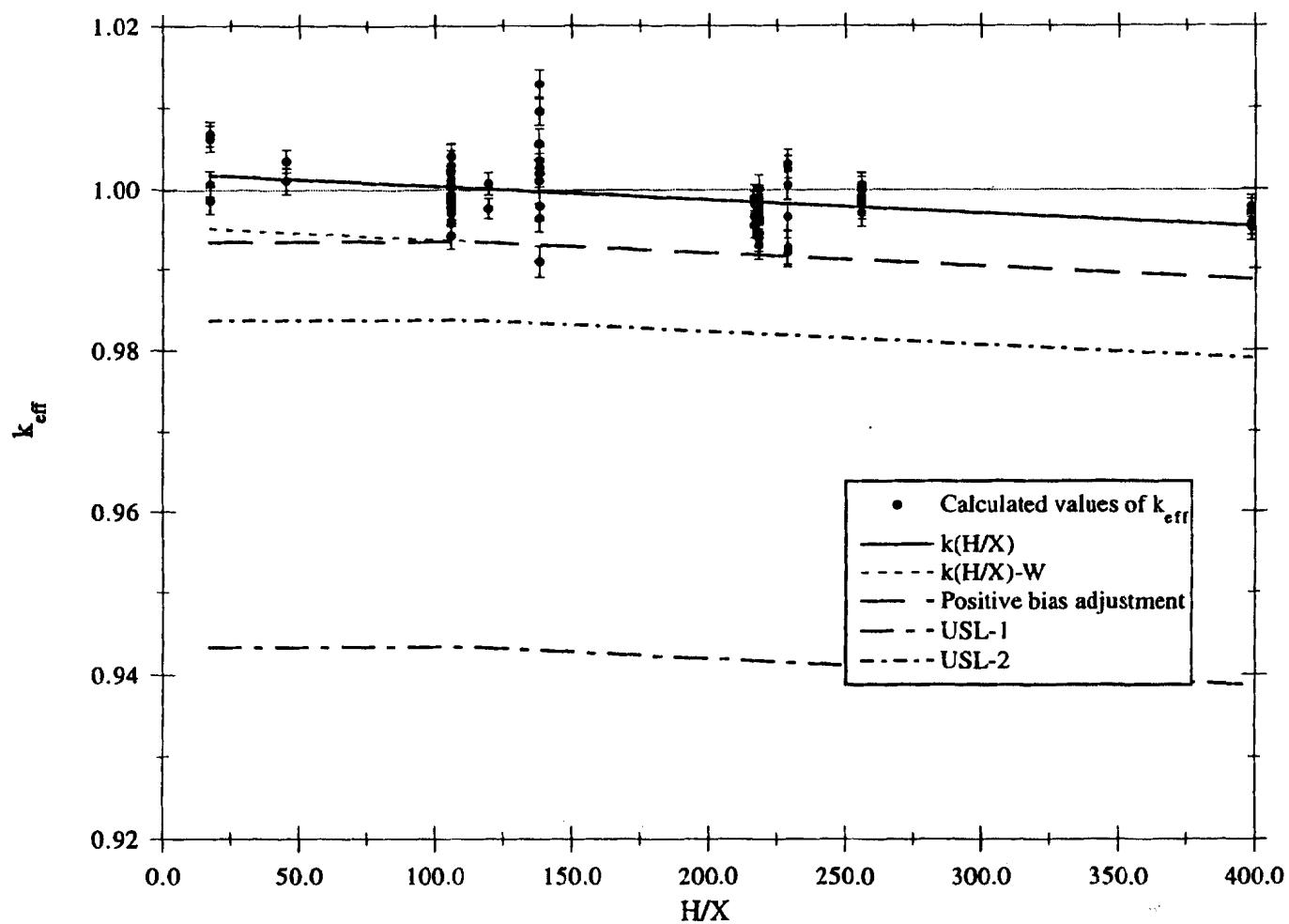
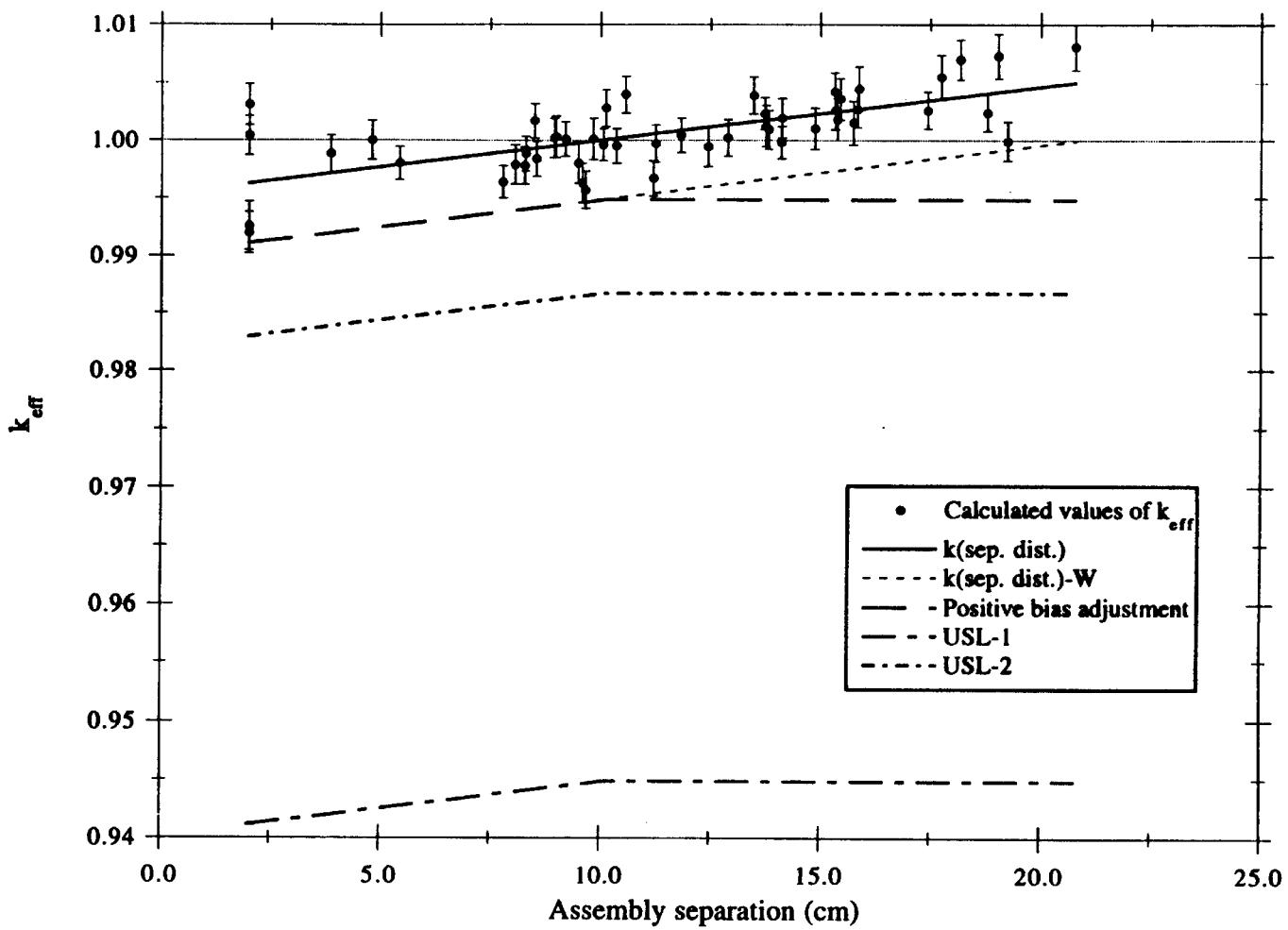
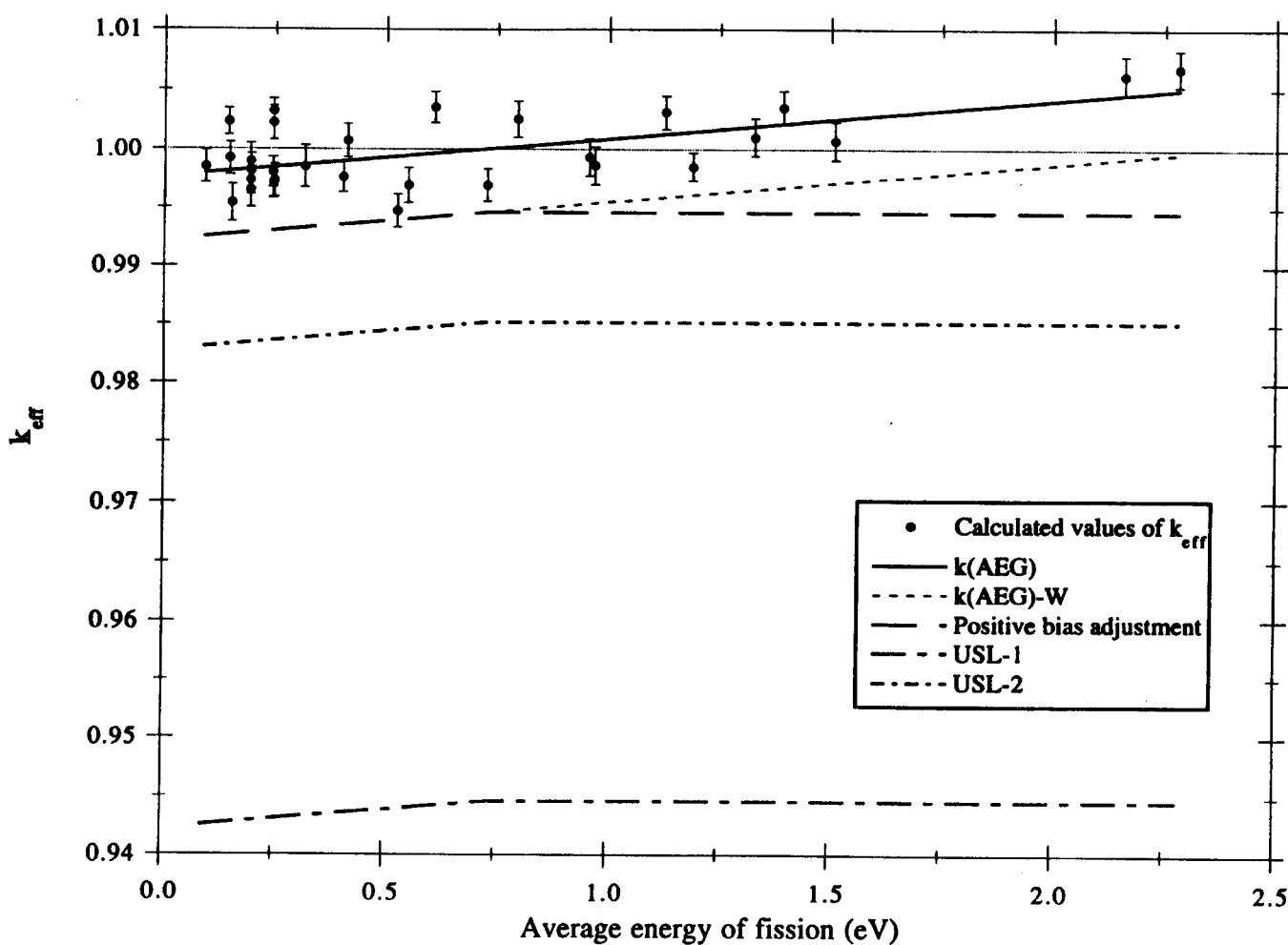


Figure 4.3 USLs for 167 LWR fuel pin lattice critical experiments, k_{eff} vs enrichment

Figure 4.4 USLs for 80 separator plate critical experiments, k_{eff} vs H/X



Figure 4.6 USLs for 30 soluble boron critical experiments, k_{eff} vs AEF

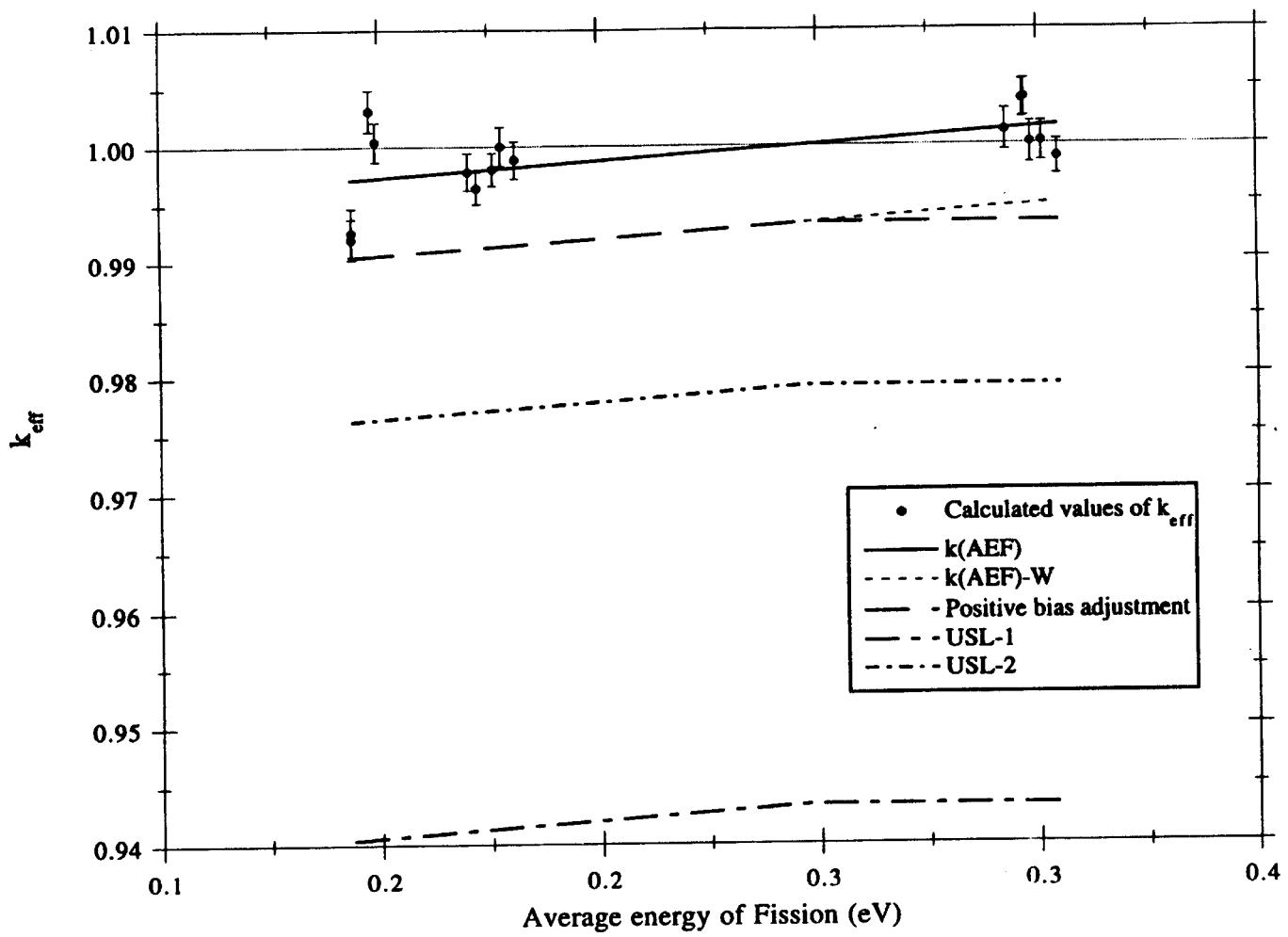
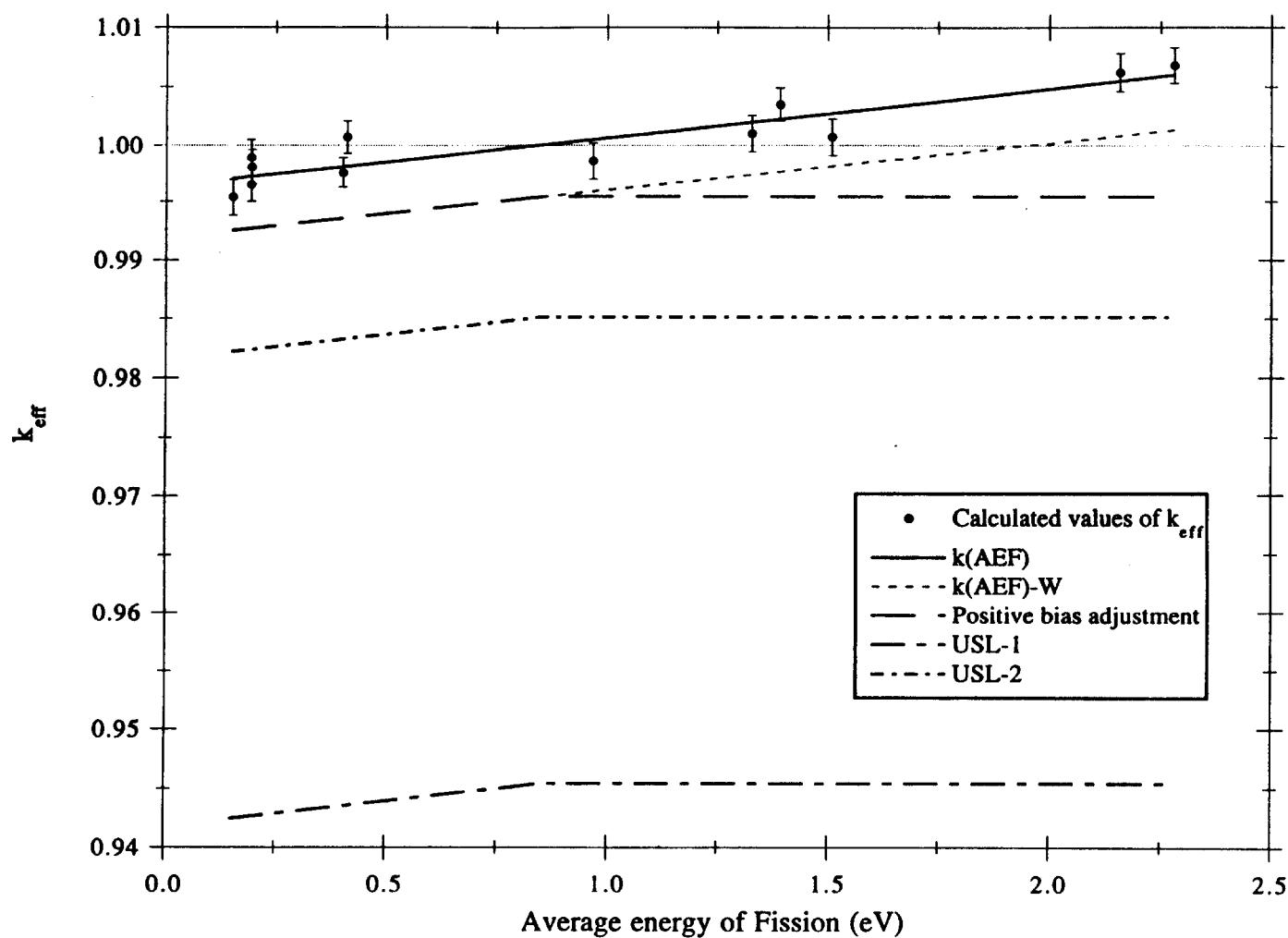


Figure 4.7 USLs for 15 separator plate and reflecting wall critical experiments, k_{eff} vs AEF

Figure 4.8 USLs for 12 separator plate, soluble boron critical experiments, k_{eff} vs AEF

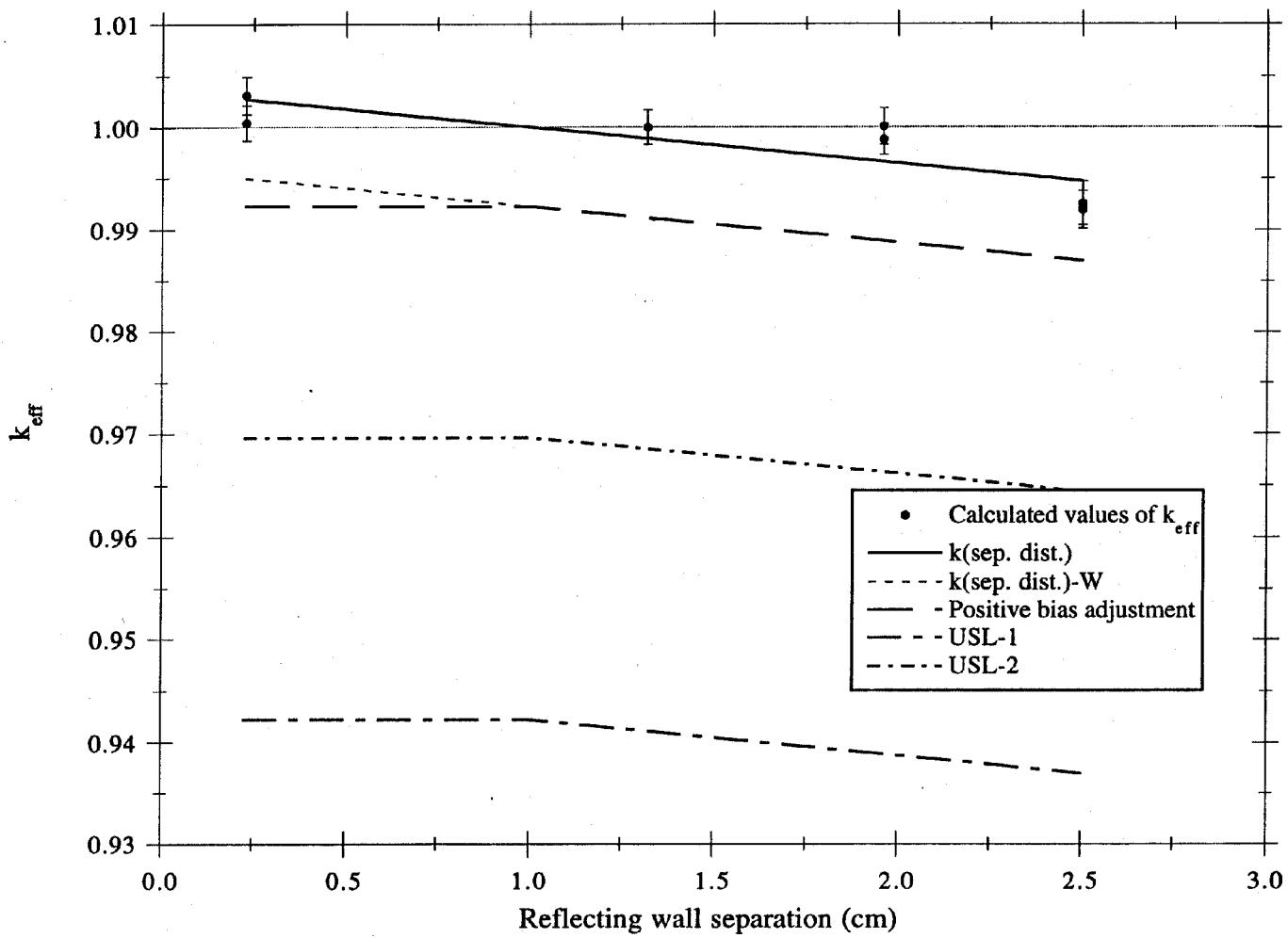


Figure 4.9 USLs for 7 borated separator plates and reflecting wall critical experiments, k_{eff} vs reflecting wall separation distance

5 Guidelines for Experiment Selection and Areas of Applicability

The calculation method used to establish the criticality safety of transportation and storage packages needs to be validated against measured data that have been shown to be applicable to the package under consideration. This section provides guidance in determining the applicable range for a validation study. Section 5.1 provides guidelines for selecting suitable experiments to use in the evaluation of transportation and storage package designs. The experiments used in the validation are parameterized in Sect. 5.2 for easy comparison to package designs under consideration.

5.1 Guidelines for Selecting Suitable Experiments

Historically, nuclear criticality experiments were performed to address specific fissionable material, reactor, fabrication/process, storage or transport design concerns. The experiments generally consisted of the same, or very nearly the same, configurations and materials requiring safety evaluation for the designs of interest. Aside from performing diagnostic measurements (e.g., flux wire traverses, threshold detector measurements, reaction rate ratios, replacement measurements, etc.), little effort was expended or needed to characterize the experiment for its intended application because the experiment itself was a "mockup" of the configuration of materials needing a safety evaluation. Many of the experiments were subsequently characterized according to elemental constituents, densities, and various parametric ratios. The use of uranium metal-to-water mass-, atom- and volume-ratios; uranium metal-to-carbon atom-ratios {e.g., $[C/(Pu + U)]$, $[H/(Pu + U)]$, C/X , H/X , where X refers to the fissile isotope}; fuel lattice pitches; solid angles; surface densities; and others came into broad usage with fair success. With the advent of more sophisticated computational techniques, parameters such as neutron leakage fraction and neutron absorption fraction became useful characterization parameters. Subsequently, a pseudo-neutron-spectra parameter, the computed average neutron energy group causing fission (AEG), was used as a single global parameter for correlating experiments to safety evaluation applications³⁶ for systems of similar fissile species, enrichments, degree of heterogeneity or homogeneity, and chemical form. Additionally, various neutron energy-weighted parameters, such as thermal neutron absorptions versus total neutron absorption, total neutron fissions versus fast neutron fissions, thermal neutron fissions versus thermal neutron absorptions, and the average neutron energy group weighted by fissions, were used for the characterization of systems and their concomitant computational biases.⁴⁶ A two-group diffusion theory parameter⁴⁷ for characterizing the neutron slowing down, resonance absorption characteristics, and thermal absorption characteristics has also been applied.

Most neutronics computer codes provide integral and energy dependent parameters that can be used for characterizing the spectra of a calculated system. Computer codes that have been historically used for nuclear criticality safety benchmarking and evaluations provide simplistic integral values such as average neutron energy group causing fission (AEG),³⁴ and more complex parametric categories⁴⁸ such as nonfuel absorption, leakage fraction, resonance absorption probability, fast fission probability, energy distribution of neutron absorption, and geometry effects as measured by the energy weighted ratios of neutron collisions in all materials divided by neutron collisions in fissile and fissionable materials.

There are three fundamental parameters that should be considered in the selection of suitable experiments⁴⁹ for use in the evaluation of transportation and storage package designs. They are the materials of construction (including fissionable material), the geometry of construction, and the inherent neutron energy spectrum affecting the fissionable material(s). There are substantial variances within each of these three categories that require further considerations.

Regarding materials of construction (including fissionable material):

Guidelines

- The fissionable species (e.g., ^{233}U , ^{235}U , ^{238}U , ^{238}Pu , ^{239}Pu , ^{240}Pu , ^{241}Pu , etc.) used in the benchmark experiments should be as similar as possible, including enrichment and relative masses and volumes, as those materials in the package design under normal and hypothetical accident conditions.
- The nonfissionable species (e.g., lead, stainless steel, boron, cadmium, phenolic foam, depleted uranium, water, etc.) used in the benchmark experiments should be as similar as possible, including relative masses and volumes, as those materials in the package design under normal and hypothetical accident conditions.
- Reflector and moderator materials in experiments should be as similar as possible to those in the package design under normal and hypothetical accident conditions.
- Physical form (e.g., metal, solution, compound) and temperature of materials should be as similar as possible.
- Ratio of nonfissionable materials to fissionable material should be similar as well.

Important items to consider regarding geometry of construction (including fissionable material):

- The relative geometric position and size of the construction materials
- Homogeneity or heterogeneity of system
- Shape of units and system
- Lattice pattern, spacing, and interstitial materials in arrays
- Reflection

Regarding the neutron energy spectrum, the neutron density versus energy should be considered by comparison of the following items from the benchmark experiments and the package design:

- Leakage
- Absorption
- Production
- Flux

The specific quantization of the above three categories of parameters is difficult at best and generally requires the use of alternative approaches by using benchmark experiments that are characterized by a limited set of physical and computed neutronic parameters that are then compared with the safety design computed neutronic parameters.

5.2 Parameterization of Validation Experiments

Several principal parameters have been identified for controlling the criticality of transportation packages:⁵⁰ (1) type, mass, and form of fissile material; (2) degree of moderation; (3) amount and distribution of absorber materials; (4) internal and external package geometry; and (5) reflector effectiveness. The fissile material, degree

of moderation, and package geometry controls the neutron flux energy and spatial distributions. The degree of moderation, absorber materials, and package geometry are used to control the neutron loss rate through capture and leakage (in conjunction with reflector effectiveness).

These five parameters were used as guidelines in grouping the critical experiments considered by classes in the validation. Table 3.5 presents a parameterization of the 173 LWR-type fuel experiments documented in this report. The experiments are listed by case names, reference numbers, and case numbers. Case numbers are alphabetically assigned. The computed effective neutron multiplication factor (k_{eff}) and associated standard deviation are given for each case. The number of experiments associated with each characterization used in Table 3.5 is tabulated in Table 5.1.

The fissile material type, ^{235}U , and chemical form of the uranium compound, UO_2 , were the same for all experiments and were therefore omitted from the table; however, the ^{235}U isotopic enrichment which affects neutron production rates was included since it varied from 2.35 wt % to 5.74 wt % across the experiments.

Fissile systems are often characterized by their degree of moderation. A direct characterization can be defined by the effective ratio of hydrogen(H)-to-fissile(X) material atom densities, or H/X of the system. Other parameters such as water-to-fuel volume ratio for a unit cell, average energy group for fission (AEG), and energy of average lethargy causing fission (AEF) can also give an indication of the degree of thermalization of a fissile system. These parameters usually correlate to the pitch and the Dancoff factor, which is a function of the pitch. Both of these parameters may be useful in the investigation of system moderation. The thermalization of lattice configurations can also be influenced by the presence of water holes. A parameter giving the ratio of the number of water holes to fuel pin positions is included in Table 3.5 for examination, along with H/X, AEG, AEF, pitch, and Dancoff factor.

Absorber materials are an effective means of criticality control for thermal systems such as those involving LWR-type fuel. Their effectiveness is dependent on the absorber material, distribution, and surface area. Three columns of Table 3.5 give this information in the form of separator plate material, boron weight percent per plate, and plate thickness. Experiments having homogeneous absorbers in the form of soluble boron in water have been singled out with their boron concentration specified. A final column labeled "Other" gives information about other absorbers in the system (e.g., Ag-In-Cd rods, B_4C rods, $\text{UO}_2\text{-Gd}_2\text{O}_3$ fuel rods). This column also specifies if the separator plates are part of a flux trap with voiding materials.

The geometry of heterogeneous fissile materials, the design and placement of absorber materials (previously discussed), and the separation between fissile materials affect the neutron flux energy and spatial distribution. The fissile material is in the form of fuel rods consisting of UO_2 pellets or powder encased in either aluminum, stainless steel, or Zircaloy cladding. Fuel rods are bundled in hexagonal or square lattices of 1.105-cm to 2.540-cm pitch. Table 3.5 lists the lattice type, pitch, cladding material, and separation distance of assemblies for each experiment.

Most experiments have water reflection of at least 15 to 20 cm (20 cm of water reflection typically ensures a maximum increase in k_{eff} due to reflection) on the x, y, and z faces of the system. Notable exceptions are those systems that had fuel rods above the moderator surface. In addition to water reflectors, several experiments contained reflectors in the form of shielding materials (e.g., lead, steel, depleted uranium) that minimize neutron leakage. Such experiments were parameterized in Table 3.5 by reflecting wall material and separation distance from fuel assemblies.

The seven homogeneous uranium experiments were also parameterized. Experimental parameters and calculational results for these experiments are compiled in Table 3.16.

Table 5.1 Characterization variables of LWR-type fuel experiments

Variable	Values	Number of experiments
Other	A: Ag-In-Cd rods B: B ₄ C rods F: Flux trap with void materials G: UO ₂ Gd ₃ rods	6 3 8 5
Total		22
Soluble boron	Y: yes N: no	36 137
Total		173
Clad	AL: aluminum SS: stainless steel ZR: zircaloy	154 10 3
Total		167
Pitch type	S: square H: hexagonal	165 8
Total		173
Plate material	Al: aluminum B: Boral BF: Boroflex CD: cadmium CU: copper HF: hafnium SS: stainless steel UD: copper-cadmium ZR: zircaloy	21 14 2 6 8 4 18 4 3
Total		76
Reflecting wall material	L: lead U: uranium SS: stainless steel	12 10 28
Total		50

6 Summary

The detailed experiment descriptions in this report provide a useful compendium of criticality benchmark data for validation of LWR fuel transportation and storage applications. Experiments are categorized by common features such as separator plates, reflecting walls, and soluble boron and parameterized by key variables such as enrichment, water-to-fuel volume ratio, H/X, AEF, and pitch. These data enable the analyst to readily identify appropriate experiments for a particular application.

Benchmark calculations have been performed for all of these cases using SCALE 4.3 and the 44-group ENDF/B-V cross-section library to provide a sample validation. In addition, the calculations were repeated with the 238-group library to determine the adequacy of the 44-group energy structure as shown in Appendix B. On average, the 238-group results were approximately 0.35% less. The 238-group results were more accurate for the homogeneous uranium critical experiments.

Two methods for statistical determination of calculational biases and USLs were presented: (1) a 95% confidence band for a single future calculation with an administrative subcritical margin and (2) a lower tolerance band (LTB) based on a 95% confidence band on 99.5% of all future calculations. The methods were demonstrated using several subsets of the 44-group validation results.

Finally, guidance was provided on the selection of appropriate criticality experiments that are applicable to validate a computational method for the system of concern. Important parameters that should be examined to demonstrate areas of applicability were discussed. The parameterization of the included experiments was described to assist the analyst in this process.

Hopefully, the large amount of experimental and calculational data compiled within this report along with the technical guidance provided will prove to be valuable assets for criticality safety analysts and reviewers of LWR fuel applications. Additional LWR-related experiments are available, however, as shown in Table 1.1. A user who may need experiment characterizations not identified in this report should investigate these experiments.

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APPENDIX A

SCALE Input File Listings

This appendix contains input files for all cases discussed in Sect. 3. These files are also available in electronic form from the SCALE home page on the World Wide Web (WWW). A pointer for the SCALE home page may be found at <http://www.cad.ornl.gov>.

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```

ans33all
#csas25
ans33all
44group latticecell
uo2      1 den=10.38 1.0 293 92235 4.742 92238 95.258      end
arbmag5  2.70 4 0 0 1 13027 98.85 12000 0.50 14000 0.43
          26000 0.22 2 1 293                                end
h2o      3 1.0
arbmstl  7.90 3 0 0 1 26000 72.0 24000 18.0 28000 10.0 4 1
al       5 den=2.651 1.0                                end
uo2      6 den=10.38 1.0 293 92235 4.742 92238 95.258      end
al       7 1.0                                end
end comp
squarepitch 1.35 0.79 1 3 0.94 2 0.82 0      end
more data res=6 cyl 0.395 dan(6)=0.989755      end
4-18x18 assemblies separated by 0.3-cm-thick aluminum plates and 1.9
cm of water, 25.66 cm water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

read geom

unit 1

cylinder 7 1 .470 0.0 -1.55
cuboid 3 1 4p.675 0.0 -1.55
reflector 4 1 5r0 0.4 1

unit 2

cylinder 7 1 .470 0.0 -0.25
cylinder 3 1 .500 0.0 -0.25
cuboid 4 1 4p.675 0.0 -0.25

unit 3

cylinder 1 1 .395 25.66 0.0
cylinder 0 1 .410 25.66 0.0
cylinder 2 1 .470 25.66 0.0
cuboid 3 1 4p.675 25.66 0.0

unit 4

array 1 3*0.0
reflector 3 1 0.0 0.3 0.0 0.3 2r0 1
reflector 5 1 0.3 0.0 0.3 0.0 2r0 1

unit 5

array 1 3*0.0
reflector 3 1 0.3 0.0 0.0 0.3 2r0 1
reflector 5 1 0.0 0.3 0.3 0.0 2r0 1

unit 6

array 1 3*0.0
reflector 3 1 0.0 0.3 0.3 0.0 2r0 1
reflector 5 1 0.3 0.0 0.0 0.3 2r0 1

unit 7

array 1 3*0.0
reflector 3 1 0.3 0.0 0.3 0.0 2r0 1
reflector 5 1 0.0 0.3 0.0 0.3 2r0 1

unit 8

cuboid 3 1 2p0.95 2p12.30 27.56 0.0
reflector 5 1 2r0.0 0 0.3 0 0.3 1

unit 9

cuboid 3 1 2p12.30 2p0.95 27.56 0.0
reflector 5 1 0 0.3 2r0.0 0 0.3 1

unit 10

cuboid 3 1 2p0.95 2p0.95 27.56 0.0
reflector 5 1 5r0.0 0.3 1

```

unit 11
cuboid 3 1 2p12.30 2p0.95 27.56 0.0
reflector 5 1 0.3 0 2r0.0 0 0.3 1
unit 12
cuboid 3 1 2p0.95 2p12.30 27.56 0.0
reflector 5 1 2r0.0 0.3 0 0 0.3 1
unit 13
cylinder 6 1 .395 90.00 25.66
cylinder 0 1 .410 96.9 25.66
cylinder 2 1 .470 98.2 25.66
cuboid 0 1 4p.675 98.2 25.66
unit 14
array 2 3*0.0
reflector 0 1 0.0 0.3 0.0 0.3 2r0 1
reflector 5 1 0.3 0.0 0.3 0.0 2r0 1
unit 15
array 2 3*0.0
reflector 0 1 0.3 0.0 0.0 0.3 2r0 1
reflector 5 1 0.0 0.3 0.0 0.0 2r0 1
unit 16
array 2 3*0.0
reflector 0 1 0.0 0.3 0.3 0.0 2r0 1
reflector 5 1 0.3 0.0 0.0 0.3 2r0 1
unit 17
array 2 3*0.0
reflector 0 1 0.3 0.0 0.3 0.0 2r0 1
reflector 5 1 0.0 0.3 0.0 0.3 2r0 1
unit 18
cuboid 0 1 2p0.95 2p12.30 98.2 25.66
reflector 5 1 2r0.0 0 0.3 2r0 1
unit 19
cuboid 0 1 2p12.30 2p0.95 98.2 25.66
reflector 5 1 0 0.3 2r0.0 2r0 1
unit 20
cuboid 0 1 2p0.95 2p0.95 98.2 25.66
reflector 5 1 4r0.0 2r0 1
unit 21
cuboid 0 1 2p12.30 2p0.95 98.2 25.66
reflector 5 1 0.3 0 2r0.0 2r0 1
unit 22
cuboid 0 1 2p0.95 2p12.30 98.2 25.66
reflector 5 1 2r0.0 0.3 0 2r0 1
unit 23
array 3 3*0.0
reflector 3 1 4r20 2r01
reflector 4 1 5r0 .8 1
reflector 3 1 5r0 20 1
unit 24
array 4 3*0.0
reflector 0 1 4r20 2r0 1
global unit 25
array 5 3*0.0
end geom

read array
ara=1 nux=18 nuy=18 nuz=3 fill 324r1 324r2 324r3      end fill
ara=2 nux=18 nuy=18 nuz=1 fill 324r13      end fill
ara=3 nux=3 nuy=3 nuz=1 fill 4 8 5 9 10 11 6 12 7      end fill
ara=4 nux=3 nuy=3 nuz=1 fill 14 18 15 19 20 21 16 22 17      end fill

```

```

ara=5 nux=1 nuy=1 nuz=2 fill 23 24
end array
end data
end

ans33a12

#csas25
ans33a12
44group latticecell
uo2    1 den=10.38 1.0 293 92235 4.742 92238 95.258    end
arbmag5   2.70 4 0 0 1 13027 98.85 12000 0.50 14000 0.43 26000
          0.22 2 1 293
h2o     3 1.0
end
arbmsl  7.90 3 0 0 1 26000 72.0 24000 18.0 28000 10.0 4 1
al      5 den=2.651 1.0
end
uo2    6 den=10.38 1.0 293 92235 4.742 92238 95.258    end
al      7 1.0
end comp
squarepitch 1.35 0.79 1 3 0.94 2 0.82 0
more data res=6 cyl 0.395 dan(6)=0.989755
4-18x18 assemblies separated by 0.3-cm-thick aluminum plates and 4.4
'cm of water, 32.78 cm water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 7 1 .470 0.0 -1.55
cuboid   3 1 4p.675 0.0 -1.55
reflector 4 1 5r0.0 0.4 1
unit 2
cylinder 7 1 .470 0.0 -0.25
cylinder 3 1 .500 0.0 -0.25
cuboid   4 1 4p.675 0.0 -0.25
unit 3
cylinder 1 1 .395 32.78 0.0
cylinder 0 1 .410 32.78 0.0
cylinder 2 1 .470 32.78 0.0
cuboid   3 1 4p.675 32.78 0.0
unit 4
array 1 3*0.0
reflector 3 1 0.0 0.3 0.0 0.3 2r0 1
reflector 5 1 0.3 0.0 0.3 0.0 2r0 1
unit 5
array 1 3*0.0
reflector 3 1 0.3 0.0 0.0 0.3 2r0 1
reflector 5 1 0.0 0.3 0.3 0.0 2r0 1
unit 6
array 1 3*0.0
reflector 3 1 0.0 0.3 0.3 0.0 2r0 1
reflector 5 1 0.3 0.0 0.0 0.3 2r0 1
unit 7
array 1 3*0.0
reflector 3 1 0.3 0.0 0.3 0.0 2r0 1
reflector 5 1 0.0 0.3 0.0 0.3 2r0 1
unit 8
cuboid   3 1 2p2.2 2p12.30 34.68 0.0
reflector 5 1 2r0.0 0 0.3 0 0.3 1
end fill

```

```

unit 9
cuboid   3 1 2p12.30 2p2.2 34.68 0.0
reflector 5 1 0 0.3 2r0.0 0 0.3 1
unit 10
cuboid   3 1 2p2.2 2p2.2 34.68 0.0
reflector 5 1 5r0.0 0.3 1
unit 11
cuboid   3 1 2p12.30 2p2.2 34.68 0.0
reflector 5 1 0.3 0 2r0.0 0 0.3 1
unit 12
cuboid   3 1 2p2.2 2p12.30 34.68 0.0
reflector 5 1 2r0.0 0.3 0 0 0.3 1
unit 13
cylinder 6 1 .395 90.00 32.78
cylinder 0 1 .410 96.9 32.78
cylinder 2 1 .470 98.2 32.78
cuboid   0 1 4p.675 98.2 32.78
unit 14
array 2 3*0.0
reflector 0 1 0.0 0.3 0.0 0.3 2r0 1
reflector 5 1 0.3 0.0 0.3 0.0 2r0 1
unit 15
array 2 3*0.0
reflector 0 1 0.3 0.0 0.0 0.3 2r0 1
reflector 5 1 0.0 0.3 0.3 0.0 2r0 1
unit 16
array 2 3*0.0
reflector 0 1 0.0 0.3 0.3 0.0 2r0 1
reflector 5 1 0.3 0.0 0.0 0.3 2r0 1
unit 17
array 2 3*0.0
reflector 0 1 0.3 0.0 0.3 0.0 2r0 1
reflector 5 1 0.0 0.3 0.0 0.3 2r0 1
unit 18
cuboid   0 1 2p2.2 2p12.30 98.2 32.78
reflector 5 1 2r0.0 0 0.3 2r0 1
unit 19
cuboid   0 1 2p12.30 2p2.2 98.2 32.78
reflector 5 1 0 0.3 2r0.0 2r0 1
unit 20
cuboid   0 1 2p2.2 2p2.2 98.2 32.78
reflector 5 1 4r0.0 2r0 1
unit 21
cuboid   0 1 2p12.30 2p2.2 98.2 32.78
reflector 5 1 0.3 0 2r0.0 2r0 1
unit 22
cuboid   0 1 2p2.2 2p12.30 98.2 32.78
reflector 5 1 2r0.0 0.3 0 2r0 1
unit 23
array 3 3*0.0
reflector 3 1 4r20 2r01
reflector 4 1 5r0 .8 1
reflector 3 1 5r0 20 1
unit 24
array 4 3*0.0
reflector 0 1 4r20 2r0 1
global unit 25
array 5 3*0.0
end geom

```

```

read array
ara=1 nux=18 nuy=18 nuz=3 fill 324r1 324r2 324r3      end fill
ara=2 nux=18 nuy=18 nuz=1 fill 324r13     end fill
ara=3 nux=3  nuy=3  nuz=1 fill 4 8 5 9 10 11 6 12 7    end fill
ara=4 nux=3  nuy=3  nuz=1 fill 14 18 15 19 20 21 16 22 17 end fill
ara=5 nux=1  nuy=1  nuz=2 fill 23 24      end fill
end array
end data
end

ans33al3

#csas25
ans33al3
44group latticecell
uc2      1 den=10.38 1.0 293 92235 4.742 92238 95.258      end
arbmag5  2.70 4 0 0 1 13027 98.85 12000 0.50 14000 0.43 26000
          0.22 2 1 293
h2o      3 1.0      end
arbmsl   7.90 3 0 0 1 26000 72.00 24000 18.00 28000 10.0 4 1 end
al       5 den=2.651 1.0      end
uo2      6 den=10.38 1.0 293 92235 4.742 92238 95.258      end
al       7 1.0      end
end comp
squarepitch 1.35 0.79 1 3 0.94 2 0.82 0      end
more data res=6 cyl 0.395 dan(6)=0.989755      end
4-18x18 assemblies separated by 0.3-cm-thick aluminum plates and 9.4
'cm of water, 64.12 cm water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

```

reflector 5 1  0.0 0.3 0.0 0.3 2r0 1
unit 8
cuboid   3 1  2p4.7 2p12.30 66.02 0.0
reflector 5 1  2r0.0 0 0.3 0 0.3 1
unit 9
cuboid   3 1  2p12.30 2p4.7 66.02 0.0
reflector 5 1  0 0.3 2r0.0 0 0.3 1
unit 10
cuboid   3 1  2p4.7 2p4.7 66.02 0.0
reflector 5 1  5r0.0      0.3 1
unit 11
cuboid   3 1  2p12.30 2p4.7 66.02 0.0
reflector 5 1  0.3 0 2r0.0 0 0.3 1
unit 12
cuboid   3 1  2p4.7 2p12.30 66.02 0.0
reflector 5 1  2r0.0 0.3 0 0 0.3 1
unit 13
cylinder 6 1  .395      90.00 64.12
cylinder 0 1  .410      96.9 64.12
cylinder 2 1  .470      98.2 64.12
cuboid   0 1  4p.675     98.2 64.12
unit 14
array 2  3*0.0
reflector 0 1  0.0 0.3 0.0 0.3 2r0 1
reflector 5 1  0.3 0.0 0.3 0.0 2r0 1
unit 15
array 2  3*0.0
reflector 0 1  0.3 0.0 0.0 0.3 2r0 1
reflector 5 1  0.0 0.3 .3 0.0 2r0 1
unit 16
array 2  3*0.0
reflector 0 1  0.0 0.3 .3 0.0 2r0 1
reflector 5 1  0.3 0.0 0.0 0.3 2r0 1
unit 17
array 2  3*0.0
reflector 0 1  0.3 0.0 0.3 0.0 2r0 1
reflector 5 1  0.0 0.3 0.0 0.3 2r0 1
unit 18
cuboid   0 1  2p4.7 2p12.30 98.2 64.12
reflector 5 1  2r0.0 0 0.3 2r0 1
unit 19
cuboid   0 1  2p12.30 2p4.7 98.2 64.12
reflector 5 1  0 0.3 2r0.0 2r0 1
unit 20
cuboid   0 1  2p4.7 2p4.7 98.2 64.12
reflector 5 1  4r0.0      2r0 1
unit 21
cuboid   0 1  2p12.30 2p4.7 98.2 64.12
reflector 5 1  0.3 0 2r0.0 2r0 1
unit 22
cuboid   0 1  2p4.7 2p12.30 98.2 64.12
reflector 5 1  2r0.0 0.3 0 2r0 1
unit 23
array 3  3*0.0
reflector 3 1  4r20 2r0 1
reflector 4 1  5r0  .8 1
reflector 3 1  5r0  20 1
unit 24
array 4  3*0.0

```

```

reflector 0 1 4r20 2r0 1
global unit 25

array 5 3*0.0
end geom

read array
ara=1 nux=18 nuy=18 nuz=3 fill 324r1 324r2 324r3      end fill
ara=2 nux=18 nuy=18 nuz=1 fill 324r13     end fill
ara=3 nux=3 nuy=3 nuz=1 fill 4 8 5 9 10 11 6 12 7    end fill
ara=4 nux=3 nuy=3 nuz=1 fill 14 18 15 19 20 21 16 22 17 end fill
ara=5 nux=1 nuy=1 nuz=2 fill 23 24      end fill
end array
end data
end

ans33eb1

#csas25
ans33eb1
44group latticecell
uo2      1 den=10.38 1.0 293 92235 4.742 92238 95.258      end
arbmag5  2.70 4 0 0 1 13027 98.85 12000 0.50 14000 0.43 26000
          0.22 2 1 293      end
h2o      3 1.0      end
arbmsl1  7.90 3 0 0 1 26000 72.0 24000 18.0 28000 10.0 4 1  end
polyethylene 5 den=0.5540 1.0      end
uo2      6 den=10.38 1.0 293 92235 4.742 92238 95.258      end
al       7 den=2.651 1.0      end
al       8 1.0      end
end comp
squarepitch 1.35 0.79 1 3 0.94 2 0.82 0      end
more data res=6 cyl 0.395 dan(6)=0.989755      end
4-18x18 assemblies separated by 0.3-cm-thick aluminum plates and 1.9
`cm of polyethylene balls, 25.54 cm water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 8 1 .470 0.0 -1.55
cuboid   3 1 4p.675 0.0 -1.55
reflector 4 1 5r0 0.4 1
unit 2
cylinder 8 1 .470 0.0 -0.25
cylinder 3 1 .500 0.0 -0.25
cuboid   4 1 4p.675 0.0 -0.25
unit 3
cylinder 1 1 .395 25.54 0.0
cylinder 0 1 .410 25.54 0.0
cylinder 2 1 .470 25.54 0.0
cuboid   3 1 4p.675 25.54 0.0
unit 4
array 1 3*0.0
reflector 3 1 0.0 0.3 0.0 0.3 2r0 1
reflector 7 1 0.3 0.0 0.3 0.0 2r0 1
unit 5
array 1 3*0.0
reflector 3 1 0.3 0.0 0.0 0.3 2r0 1
reflector 7 1 0.0 0.3 0.3 0.0 2r0 1
unit 6
array 1 3*0.0
reflector 3 1 0.0 0.3 .3 0.0 2r0 1
reflector 7 1 0.3 0.0 0.0 0.3 2r0 1
unit 7
array 1 3*0.0
reflector 3 1 0.3 0.0 0.3 0.0 2r0 1
reflector 7 1 0.0 0.3 0.0 0.3 2r0 1
unit 8
cuboid   5 1 2p0.95 2p12.30 27.44 0.0
reflector 7 1 2r0.0 0 0.3 0 0.3 1
unit 9
cuboid   5 1 2p12.30 2p0.95 27.44 0.0
reflector 7 1 0 0.3 2r0.0 0 0.3 1
unit 10
cuboid   5 1 2p0.95 2p0.95 27.44 0.0
reflector 7 1 5r0.0 0 0.3 0 0.3 1
unit 11
cuboid   5 1 2p12.30 2p0.95 27.44 0.0
reflector 7 1 0.3 0 2r0.0 0 0.3 1
unit 12
cuboid   5 1 2p0.95 2p12.30 27.44 0.0
reflector 7 1 2r0.0 0.3 0 0 0.3 1
unit 13
cylinder 6 1 .395 90.00 25.54
cylinder 0 1 .410 96.9 25.54
cylinder 2 1 .470 98.2 25.54
cuboid   0 1 4p.675 98.2 25.54
unit 14
array 2 3*0.0
reflector 0 1 0.0 0.3 0.0 0.3 2r0 1
reflector 7 1 0.3 0.0 0.3 0.0 2r0 1
unit 15
array 2 3*0.0
reflector 0 1 0.3 0.0 0.0 0.3 2r0 1
reflector 7 1 0.0 0.3 0.3 0.0 2r0 1
unit 16
array 2 3*0.0
reflector 0 1 0.0 0.3 .3 0.0 2r0 1
reflector 7 1 0.3 0.0 0.0 0.3 2r0 1
unit 17
array 2 3*0.0
reflector 0 1 0.3 0.0 0.3 0.0 2r0 1
reflector 7 1 0.0 0.3 0.0 0.3 2r0 1
unit 18
cuboid   0 1 2p0.95 2p12.30 98.2 25.54
reflector 7 1 2r0.0 0 0.3 2r0 1
unit 19
cuboid   0 1 2p12.30 2p0.95 98.2 25.54
reflector 7 1 0 0.3 2r0.0 2r0 1
unit 20
cuboid   0 1 2p0.95 2p0.95 98.2 25.54
reflector 7 1 4r0.0 0 2r0 1
unit 21
cuboid   0 1 2p12.30 2p0.95 98.2 25.54
reflector 7 1 0.3 0 2r0.0 2r0 1
unit 22
cuboid   0 1 2p0.95 2p12.30 98.2 25.54
reflector 7 1 2r0.0 0.3 0 2r0 1

```

```

unit 23
array 3 3*0.0
reflector 3 1 4r20 2r0 1
reflector 4 1 5r0 .8 1
reflector 3 1 5r0 20 1
unit 24
array 4 3*0.0
reflector 0 1 4r20 2r0 1
global unit 25
array 5 3*0.0 end geom

read array
ara1 nux=18 nuy=18 nuz=3 fill 324r1 324r2 324r3      end fill
ara2 nux=18 nuy=18 nuz=1 fill 324r13                 end fill
ara3 nux=3 nuy=3 nuz=1 fill 4 8 5 9 10 11 6 12 7      end fill
ara4 nux=3 nuy=3 nuz=1 fill 14 18 15 19 20 21 16 22 17 end fill
ara5 nux=1 nuy=1 nuz=2 fill 23 24                  end fill
end array
end data
end

ans33eb2

#csas25
ans33eb2
44group latticecell
uo2      1 den=10.38 1.0 293 92235 4.742 92238 95.258   end
arbmag5  2.70 4 0 0 1 13027 98.85 12000 0.50 14000 0.43
          26000 0.22 2 1 293
h2o      3 1.0
arbmstl  7.90 3 0 0 1 26000 72.0 24000 18.0 28000 10.0 4 1
polyethylene 5 den=0.5796 1.0
uo2      6 den=10.38 1.0 293 92235 4.742 92238 95.258   end
al       7 den=2.651 1.0
al       8 1.0
end comp
squarepitch 1.35 0.79 1 3 0.94 2 0.82 0
more data res=6 cyl 0.395 dan(6)=0.989755
4-18x18 assemblies separated by 0.3-cm-thick aluminum plates and 4.4
'cm of polyethylene balls, 30.73 cm water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 8 1 .470 0.0 -1.55
cuboid   3 1 4p.675 0.0 -1.55
reflector 4 1 5r0 0.4 1
unit 2
cylinder 8 1 .470 0.0 -0.25
cylinder 3 1 .500 0.0 -0.25
cuboid   4 1 4p.675 0.0 -0.25
unit 3
cylinder 1 1 .395 30.73 0.0
cylinder 0 1 .410 30.73 0.0
cylinder 2 1 .470 30.73 0.0
cuboid   3 1 4p.675 30.73 0.0
unit 4
array 1 3*0.0
reflector 3 1 0.0 0.3 0.0 0.3 2r0 1

```

```

reflector 7 1 0.3 0.0 0.3 0.0 2r0 1
unit 5
array 1 3*0.0
reflector 3 1 0.3 0.0 0.0 0.3 2r0 1
reflector 7 1 0.0 0.3 .3 0.0 2r0 1
unit 6
array 1 3*0.0
reflector 3 1 0.0 0.3 .3 0.0 2r0 1
reflector 7 1 0.3 0.0 0.0 0.3 2r0 1
unit 7
array 1 3*0.0
reflector 3 1 0.3 0.0 0.3 0.0 2r0 1
reflector 7 1 0.0 0.3 0.0 0.3 2r0 1
unit 8
cuboid   5 1 2p2.2 2p12.30 32.63 0.0
reflector 7 1 2r0.0 0 0.3 0 0.3 1
unit 9
cuboid   5 1 2p12.30 2p2.2 32.63 0.0
reflector 7 1 0 0.3 2r0.0 0 0.3 1
unit 10
cuboid   5 1 2p2.2 2p2.2 32.63 0.0
reflector 7 1 5r0.0 0.3 1
unit 11
cuboid   5 1 2p12.30 2p2.2 32.63 0.0
reflector 7 1 0.3 0 2r0.0 0 0.3 1
unit 12
cuboid   5 1 2p2.2 2p12.30 32.63 0.0
reflector 7 1 2r0.0 0.3 0 0 0.3 1
unit 13
cylinder 6 1 .395 90.00 30.73
cylinder 0 1 .410 96.9 30.73
cylinder 2 1 .470 98.2 30.73
cuboid   0 1 4p.675 98.2 30.73
unit 14
array 2 3*0.0
reflector 0 1 0.0 0.3 0.0 0.3 2r0 1
reflector 7 1 0.3 0.0 0.3 0.0 2r0 1
unit 15
array 2 3*0.0
reflector 0 1 0.3 0.0 0.0 0.3 2r0 1
reflector 7 1 0.0 0.3 .3 0.0 2r0 1
unit 16
array 2 3*0.0
reflector 0 1 0.0 0.3 .3 0.0 2r0 1
reflector 7 1 0.3 0.0 0.0 0.3 2r0 1
unit 17
array 2 3*0.0
reflector 0 1 0.3 0.0 0.3 0.0 2r0 1
reflector 7 1 0.0 0.3 0.0 0.3 2r0 1
unit 18
cuboid   0 1 2p2.2 2p12.30 98.2 30.73
reflector 7 1 2r0.0 0 0.3 2r0 1
unit 19
cuboid   0 1 2p12.30 2p2.2 98.2 30.73
reflector 7 1 0 0.3 2r0.0 2r0 1
unit 20
cuboid   0 1 2p2.2 2p2.2 98.2 30.73
reflector 7 1 4r0.0 2r0 1
unit 21

```

```

cuboid    0 1  2p12.30 2p2.2   98.2  30.73
reflector 7 1  0.3 0  2r0.0  2r0      1
unit 22
cuboid    0 1  2p2.2   2p12.30  98.2  30.73
reflector 7 1  2r0.0  0.3 0  2r0      1
unit 23
array 3 3*0.0
reflector 3 1 4r20  2r0 1
reflector 4 1 5r0   .8 1
reflector 3 1 5r0   20 1
unit 24
array 4 3*0.0
reflector 0 1 4r20  2r0 1
global unit 25
array 5 3*0.0
end geom

read array
ara=1 nux=18 nuy=18 nuz=3 fill 324rl 324r2 324r3      end fill
ara=2 nux=18 nuy=18 nuz=1 fill 324rl3                 end fill
ara=3 nux=3 nuy=3 nuz=1 fill 4 8 5 9 10 11 6 12 7      end fill
ara=4 nux=3 nuy=3 nuz=1 fill 14 18 15 19 20 21 16 22 17 end fill
ara=5 nux=1 nuy=1 nuz=2 fill 23 24                  end fill
end array
end data
end

```

ans33ep1

```

#csas25
ans33ep1
44group latticecell
u02      1 den=10.38 1.0 293 92235 4.742 92238 95.258      end
arbmag5  2.70 4 0 0 1 13027 98.85 12000 0.50 14000 0.43 26000
          0.22 2 1 293
h2o       3 1.0
poly(h2o) 4 den=.2879 1.0
arbmagstl 7.90 3 0 0 1 26000 72.0 24000 18.0 28000 10.0 5 1
al        6 den=2.651 1.0
u02      7 den=10.38 1.0 293 92235 4.742 92238 95.258      end
al        8 1.0
end comp
squarepitch 1.35 0.79 1 3 0.94 2 0.82 0      end
more data res=7 cyl 0.395 dan(7)=0.989755      end
4-18x18 assemblies separated by 0.3-cm-thick aluminum plates and 1.9
`cm of polyethylene powder, 26.98 cm water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

```

read geom
unit 1
cylinder 8 1  .470     0.0   -0.75
cuboid   3 1  4p.675   0.0   -1.55
reflector 4 1 5r0.0   0.4     1
unit 2
cylinder 8 1  .470     0.0   -0.25
cylinder 3 1  .500     0.0   -0.25
cuboid   5 1  4p.675   0.0   -0.25
unit 3
cylinder 1 1  .395     26.98  0.0

```

```

cylinder 0 1  .410     26.98  0.0
cylinder 2 1  .470     26.98  0.0
cuboid   3 1  4p.675   26.98  0.0
unit 4
array 1 3*0.0
reflector 3 1  0.0 0.3 0.0 0.3 2r0 1
reflector 6 1  0.3 0.0 0.3 0.0 2r0 1
unit 5
array 1 3*0.0
reflector 3 1  0.3 0.0 0.0 0.3 2r0 1
reflector 6 1  0.0 0.3 .3 0.0 2r0 1
unit 6
array 1 3*0.0
reflector 3 1  0.0 0.3 .3 0.0 2r0 1
reflector 6 1  0.3 0.0 0.0 0.3 2r0 1
unit 7
array 1 3*0.0
reflector 3 1  0.3 0.0 0.3 0.0 2r0 1
reflector 6 1  0.0 0.3 0.0 0.3 2r0 1
unit 8
cuboid   4 1  2p.95   2p12.30 28.88  0.0
reflector 6 1  2r0.0  0 0.3 0 0.3   1
unit 9
cuboid   4 1  2p12.30 2p.95   28.88  0.0
reflector 6 1  0 0.3 2r0.0  0 0.3   1
unit 10
cuboid   4 1  2p.95  2p.95   28.88  0.0
reflector 6 1  5r0.0   0.3     1
unit 11
cuboid   4 1  2p12.30 2p.95   28.88  0.0
reflector 6 1  0.3 0  2r0.0  0 0.3   1
unit 12
cuboid   4 1  2p.95  2p12.30 28.88  0.0
reflector 6 1  2r0.0  0.3 0  0 0.3   1
unit 13
cylinder 7 1  .395     90.00  26.98
cylinder 0 1  .410     96.9   26.98
cylinder 2 1  .470     98.2   26.98
cuboid   0 1  4p.675   98.2   26.98
unit 14
array 2 3*0.0
reflector 0 1  0.0 0.3 0.0 0.3 2r0 1
reflector 6 1  0.3 0.0 0.3 0.0 2r0 1
unit 15
array 2 3*0.0
reflector 0 1  0.3 0.0 0.0 0.3 2r0 1
reflector 6 1  0.0 0.3 .3 0.0 2r0 1
unit 16
array 2 3*0.0
reflector 0 1  0.0 0.3 .3 0.0 2r0 1
reflector 6 1  0.3 0.0 0.0 0.3 2r0 1
unit 17
array 2 3*0.0
reflector 0 1  0.3 0.0 0.3 0.0 2r0 1
reflector 6 1  0.0 0.3 0.0 0.3 2r0 1
unit 18
cuboid   0 1  2p.95  2p12.30 98.2   26.98
reflector 6 1  2r0.0  0 0.3 2r0   1

```

```

unit 19
cuboid 0 1 2p12.30 2p.95 98.2 26.98
reflector 6 1 0 0.3 2r0.0 2r0 1
unit 20
cuboid 0 1 2p.95 2p.95 98.2 26.98
reflector 6 1 4r0.0 2r0 1
unit 21
cuboid 0 1 2p12.30 2p.95 98.2 26.98
reflector 6 1 0.3 0 2r0.0 2r0 1
unit 22
cuboid 0 1 2p.95 2p12.30 98.2 26.98
reflector 6 1 2r0.0 0.3 0 2r0 1
unit 23
array 3 3*0.0
reflector 3 1 4r20 2r0 1
reflector 5 1 5r0 .8 1
reflector 3 1 5r 20 1
unit 24
array 4 3*0.0
reflector 0 1 4r20 2r0 1
global unit 25
array 5 3*0.0
end geom

read array
ara1 nux=18 nuy=18 nuz=3 fill 324r1 324r2 324r3      end fill
ara2 nux=18 nuy=18 nuz=1 fill 324r13     end fill
ara3 nux=3 nuy=3 nuz=1 fill 4 8 5 9 10 11 6 12 7      end fill
ara4 nux=3 nuy=3 nuz=1 fill 14 18 15 19 20 21 16 22 17 end fill
ara5 nux=1 nuy=1 nuz=2 fill 23 24      end fill
end array
end data
end

ans33ep2

#csas25
ans33ep2
44group latticecell
uo2      1 den=10.38 1.0 293 92235 4.742 92238 95.258    end
arbmag5  2.70 4 0 0 1 13027 98.85 12000 0.50 14000 0.43 26000
          0.22 2 1 293      end
h2o      3 1.0      end
poly(h2o) 4 den=.3335 1.0      end
arbmsl   7.90 3 0 0 1 26000 72.0 24000 18.0 28000 10.0 5 1    end
al       6 den=2.651 1.0      end
uo2      7 den=10.38 1.0 293 92235 4.742 92238 95.258    end
al       8 1.0      end
end comp
squarepitch 1.35 0.79 1 3 0.94 2 0.82 0      end
more data res=7 cyl 0.395 dan(7)=0.989755      end
4-18x18 assemblies separated by 0.3-cm-thick aluminum plates and 4.4
'cm of polyethylene powder, 30.16 cm water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 8 1 .470 0.0 -0.75
cuboid   3 1 4p.675 0.0 -1.55

```

```

reflector 4 1 5r0.0 0.4 1
unit 2
cylinder 8 1 .470 0.0 -0.25
cylinder 3 1 .500 0.0 -0.25
cuboid   5 1 4p.675 0.0 -0.25
unit 3
cylinder 1 1 .395 30.16 0.0
cylinder 0 1 .410 30.16 0.0
cylinder 2 1 .470 30.16 0.0
cuboid   3 1 4p.675 30.16 0.0
unit 4
array 1 3*0.0
reflector 3 1 0.0 0.3 0.0 0.3 2r0 1
reflector 6 1 0.3 0.0 0.3 0.0 2r0 1
unit 5
array 1 3*0.0
reflector 3 1 0.3 0.0 0.0 0.3 2r0 1
reflector 6 1 0.0 0.3 .3 0.0 2r0 1
unit 6
array 1 3*0.0
reflector 3 1 0.0 0.3 .3 0.0 2r0 1
reflector 6 1 0.3 0.0 0.0 0.3 2r0 1
unit 7
array 1 3*0.0
reflector 3 1 0.3 0.0 0.3 0.0 2r0 1
reflector 6 1 0.0 0.3 0.0 0.3 2r0 1
unit 8
cuboid   4 1 2p2.2 2p12.30 32.06 0.0
reflector 6 1 2r0.0 0 0.3 0 0.3 1
unit 9
cuboid   4 1 2p12.30 2p2.2 32.06 0.0
reflector 6 1 0 0.3 2r0.0 0 0.3 1
unit 10
cuboid   4 1 2p2.2 2p2.2 32.06 0.0
reflector 6 1 5r0.0 0.3 0 0.3 1
unit 11
cuboid   4 1 2p12.30 2p2.2 32.06 0.0
reflector 6 1 0.3 0 2r0.0 0 0.3 1
unit 12
cuboid   4 1 2p2.2 2p12.30 32.06 0.0
reflector 6 1 2r0.0 0.3 0 0 0.3 1
unit 13
cylinder 7 1 .395 90.00 30.16
cylinder 0 1 .410 96.9 30.16
cylinder 2 1 .470 98.2 30.16
cuboid   0 1 4p.675 98.2 30.16
unit 14
array 2 3*0.0
reflector 0 1 0.0 0.3 0.0 0.3 2r0 1
reflector 6 1 0.3 0.0 0.3 0.0 2r0 1
unit 15
array 2 3*0.0
reflector 0 1 0.3 0.0 0.0 0.3 2r0 1
reflector 6 1 0.0 0.3 .3 0.0 2r0 1
unit 16
array 2 3*0.0
reflector 0 1 0.0 0.3 .3 0.0 2r0 1
reflector 6 1 0.3 0.0 0.0 0.3 2r0 1

```

```

unit 17
array 2 3*0.0
reflector 0 1 0.3 0.0 0.3 0.0 2r0 1
reflector 6 1 0.0 0.3 0.0 0.3 2r0 1
unit 18
cuboid 0 1 2p2.2 2p12.30 98.2 30.16
reflector 6 1 2r0.0 0 0.3 2r0 1
unit 19
cuboid 0 1 2p12.30 2p2.2 98.2 30.16
reflector 6 1 0 0.3 2r0.0 2r0 1
unit 20
cuboid 0 1 2p2.2 2p2.2 98.2 30.16
reflector 6 1 4r0.0 2r0 1
unit 21
cuboid 0 1 2p12.30 2p2.2 98.2 30.16
reflector 6 1 0.3 0 2r0.0 2r0 1
unit 22
cuboid 0 1 2p2.2 2p12.30 98.2 30.16
reflector 6 1 2r0.0 0.3 0 2r0 1
unit 23
array 3 3*0.0
reflector 3 1 4r20 2r0 1
reflector 5 1 5r0 .8 1
reflector 3 1 5r0 20 1
unit 24
array 4 3*0.0
reflector 0 1 4r20 2r0 1
global unit 25
array 5 3*0.0
end geom

read array
ara=1 nux=18 nuy=18 nuz=3 fill 324r1 324r2 324r3      end fill
ara=2 nux=18 nuy=18 nuz=1 fill 324r13      end fill
ara=3 nux=3 nuy=3 nuz=1 fill 4 8 5 9 10 11 6 12 7      end fill
ara=4 nux=3 nuy=3 nuz=1 fill 14 18 15 19 20 21 16 22 17      end fill
ara=5 nux=1 nuy=1 nuz=2 fill 23 24      end fill
end array

end data
end

ans33slg

#csas25
ans33slg
44group latticecell
uo2 1 den=10.38 1.0 293 92235 4.742 92238 95.258      end
arbmag5 2.70 4 0 0 1 13027 98.85 12000 0.50 14000 0.43 26000
0.22 2 1 293      end
h2o 3 1.0      end
arbmsl 7.90 3 0 0 1 26000 72.00 24000 18.00 28000 10.0 4 1 end
uo2 5 den=10.38 1.0 293 92235 4.742 92238 95.258      end
al 6 den=2.651 1.0      end
al 7 1.0      end
end comp
squarepitch 1.35 0.79 1 3 0.94 2 0.82 0      end
more data res=5 cyl 0.395 dan(5)=0.989755      end
4-18x18 assemblies separated by 5.0 cm of water, 28.61 cm water height

```

```

read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 7 1 .470 0.0 -0.75
cuboid 3 1 4p.675 0.0 -1.55
reflector 4 1 5r0.0 0.4 1
unit 2
cylinder 7 1 .470 0.0 -0.25
cylinder 3 1 .500 0.0 -0.25
cuboid 4 1 4p.675 0.0 -0.25
unit 3
cylinder 1 1 .395 31.47 0.0
cylinder 0 1 .410 31.47 0.0
cylinder 2 1 .470 31.47 0.0
cuboid 3 1 4p.675 31.47 0.0
unit 4
array 1 3*0.0
reflector 3 1 4r.3 2r0 1
unit 5
array 1 3*0.0
reflector 3 1 4r.3 2r0 1
unit 6
array 1 3*0.0
reflector 3 1 4r.3 2r0 1
unit 7
array 1 3*0.0
reflector 3 1 4r.3 2r0 1
unit 8
cuboid 3 1 2p2.2 2p12.30 33.37 0.0
reflector 3 1 2r0.0 0 0.3 0 0.3 1
unit 9
cuboid 3 1 2p12.30 2p2.2 33.37 0.0
reflector 3 1 0 0.3 2r0.0 0 0.3 1
unit 10
cuboid 3 1 2p2.2 2p2.2 33.37 0.0
reflector 3 1 5r0.0 0.3 1
unit 11
cuboid 3 1 2p12.30 2p2.2 33.37 0.0
reflector 3 1 0.3 0 2r0.0 0 0.3 1
unit 12
cuboid 3 1 2p2.2 2p12.30 33.37 0.0
reflector 3 1 2r0.0 0.3 0 0 0.3 1
unit 13
cylinder 5 1 .395 90.00 31.47
cylinder 0 1 .410 96.9 31.47
cylinder 2 1 .470 98.2 31.47
cuboid 0 1 4p.675 98.2 31.47
unit 14
array 2 3*0.0
reflector 0 1 4r.3 2r0 1
unit 15
array 2 3*0.0
reflector 0 1 4r.3 2r0 1
unit 16
array 2 3*0.0
reflector 0 1 4r.3 2r0 1
unit 17

```

```

array 2 3*0.0
reflector 0 1 4r.3      2r0 1
unit 18
cuboid 0 1 2p2.2 2p12.30 98.2 31.47
reflector 0 1 2r0.0 0 0.3 2r0 1
unit 19
cuboid 0 1 2p12.30 2p2.2 98.2 31.47
reflector 0 1 0 0.3 2r0.0 2r0 1
unit 20
cuboid 0 1 2p2.2 2p2.2 98.2 31.47
unit 21
cuboid 0 1 2p12.30 2p2.2 98.2 31.47
reflector 0 1 0.3 0 2r0.0 2r0 1
unit 22
cuboid 0 1 2p2.2 2p12.30 98.2 31.47
reflector 0 1 2r0.0 0.3 0 2r0 1
unit 23
array 3 3*0.0
reflector 3 1 4r20 2r0 1
reflector 4 1 5r0 .8 1
reflector 3 1 5r0 20 1
unit 24
array 4 3*0.0
reflector 0 1 4r20 2r0 1
global unit 25
array 5 3*0.0
end geom

read array
ara=1 nux=18 nuy=18 nuz=3 fill 324r1 324r2 324r3      end fill
ara=2 nux=18 nuy=18 nuz=1 fill 324r13      end fill
ara=3 nux=3 nuy=3 nuz=1 fill 4 8 5 9 10 11 6 12 7      end fill
ara=4 nux=3 nuy=3 nuz=1 fill 14 18 15 19 20 21 16 22 17      end fill
ara=5 nux=1 nuy=1 nuz=2 fill 23 24      end fill
end array
end data
end

ans33sty

#csas25
ans33sty
44group latticecell
uo2 1 den=10.38 1.0 293 92235 4.742 92238 95.258      end
arbmag5 2.70 4 0 0 1 13027 98.85 12000 0.50 14000 0.43 26000
0.22 2 1 293      end
h2o 3 1.0      end
arbmpoly 0.0323 2 0 1 0 6312 8 1901 8 4 1      end
arbmsl 7.90 3 0 0 1 26000 72.0 24000 18.0 28000 10.0 5 1      end
al 6 den=2.651 1.0      end
uo2 7 den=10.38 1.0 293 92235 4.742 92238 95.258      end
al 8 1.0      end
end comp
squarepitch 1.35 0.79 1 3 0.94 2 0.82 0      end
more data res=7 cyl 0.395 dan(7)=0.989755      end
4-18x18 assemblies separated by 0.3-cm-thick aluminum plates and 1.9
'cm of expanded polystyrene, 28.61 cm water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

```

read geom
unit 1
cylinder 8 1 .470 0.0 -.75
cuboid 3 1 4p.675 0.0 -1.55
reflector 5 1 5r0.0 0.4 1
unit 2
cylinder 8 1 .470 0.0 -0.25
cylinder 3 1 .500 0.0 -0.25
cuboid 5 1 4p.675 0.0 -0.25
unit 3
cylinder 1 1 .395 28.61 0.0
cylinder 0 1 .410 28.61 0.0
cylinder 2 1 .470 28.61 0.0
cuboid 3 1 4p.675 28.61 0.0
unit 4
array 1 3*0.0
reflector 3 1 0.0 0.3 0.0 0.3 2r0 1
reflector 6 1 0.3 0.0 0.3 0.0 2r0 1
unit 5
array 1 3*0.0
reflector 3 1 0.3 0.0 0.0 0.3 2r0 1
reflector 6 1 0.0 0.3 .3 0.0 2r0 1
unit 6
array 1 3*0.0
reflector 3 1 0.0 0.3 .3 0.0 2r0 1
reflector 6 1 0.3 0.0 0.0 0.3 2r0 1
unit 7
array 1 3*0.0
reflector 3 1 0.3 0.0 0.3 0.0 2r0 1
reflector 6 1 0.0 0.3 0.0 0.3 2r0 1
unit 8
cuboid 4 1 2p.95 2p12.30 30.51 0.0
reflector 6 1 2r0.0 0 0.3 0 0.3 1
unit 9
cuboid 4 1 2p12.30 2p.95 30.51 0.0
reflector 6 1 0 0.3 2r0.0 0 0.3 1
unit 10
cuboid 4 1 2p.95 2p.95 30.51 0.0
reflector 6 1 5r0.0 0.3 1
unit 11
cuboid 4 1 2p12.30 2p.95 30.51 0.0
reflector 6 1 0.3 0 2r0.0 0 0.3 1
unit 12
cuboid 4 1 2p.95 2p12.30 30.51 0.0
reflector 6 1 2r0.0 0.3 0 0 0.3 1
unit 13
cylinder 7 1 .395 90.00 28.61
cylinder 0 1 .410 96.9 28.61
cylinder 2 1 .470 98.2 28.61
cuboid 0 1 4p.675 98.2 28.61
unit 14
array 2 3*0.0
reflector 0 1 0.0 0.3 0.0 0.3 2r0 1
reflector 6 1 0.3 0.0 0.3 0.0 2r0 1
unit 15
array 2 3*0.0
reflector 0 1 0.3 0.0 0.0 0.3 2r0 1
reflector 6 1 0.0 0.3 .3 0.0 2r0 1

```

```

unit 16
array 2 3*0.0
reflector 0 1 0.0 0.3 .3 0.0 2r0 1
reflector 6 1 0.3 0.0 0.0 0.3 2r0 1
unit 17
array 2 3*0.0
reflector 0 1 0.3 0.0 0.3 0.0 2r0 1
reflector 6 1 0.0 0.3 0.0 0.3 2r0 1
unit 18
cuboid 0 1 2p.95 2p12.30 98.2 28.61
reflector 6 1 2r0.0 0 0.3 2r0 1
unit 19
cuboid 0 1 2p12.30 2p.95 98.2 28.61
reflector 6 1 0 0.3 2r0.0 2r0 1
unit 20
cuboid 0 1 2p.95 2p.95 98.2 28.61
reflector 6 1 4r0.0 2r0 1
unit 21
cuboid 0 1 2p12.30 2p.95 98.2 28.61
reflector 6 1 0.3 0 2r0.0 2r0 1
unit 22
cuboid 0 1 2p.95 2p12.30 98.2 28.61
reflector 6 1 2r0.0 0.3 0 2r0 1
unit 23
array 3 3*0.0
reflector 3 1 4r20 2r0 1
reflector 5 1 5r0 .8 1
reflector 3 1 5r0 20 1
unit 24
array 4 3*0.0
reflector 0 1 4r20 2r0 1
global unit 25
array 5 3*0.0
end geom

read array
ara=1 nux=18 nuy=18 nuz=3 fill 324rl 324r2 324r3      end fill
ara=2 nux=18 nuy=18 nuz=1 fill 324rl3                 end fill
ara=3 nux=3 nuy=3 nuz=1 fill 4 8 5 9 10 11 6 12 7    end fill
ara=4 nux=3 nuy=3 nuz=1 fill 14 18 15 19 20 21 16 22 17 end fill
ara=5 nux=1 nuy=1 nuz=2 fill 23 24                  end fill
end array
end data
end

b1645sol

#csas25
b1645sol
44group      latticecell
uo2          1 0.9325 293 92235 2.459 92238 97.541 end
al           2 1.0 293                                end
h2o          3 1.0 293                                end
boron        3 den=1068.0-6                         end
carbonsteel  4 1.0 293                                end
end comp
squarepitch 1.4097 1.0300 1 3 1.2060 2 1.0440 0   end
9-15x15 assemblies separated by 0.0762-cm-thick aluminum plates and
'1.6396 cm of water, 144.85 cm water height with 1156 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 1
cylinder 2 1 .6030          101.81 -.318
cuboid   3 1 4p0.70485      101.81 -.318
unit 2
cylinder 1 1 .5150          101.81  0.0
cylinder 0 1 .5220          101.81  0.0
cylinder 2 1 .6030          101.81 -.318
cuboid   3 1 4p0.70485      101.81 -.318
unit 3
array    1 -9.1631 -9.1631 -0.318
cuboid   3 1 2p9.95725 2p9.1631 101.81 -.318
unit 4
cuboid   3 1 2p9.95725 2p0.79415 101.81 -.318
unit 5
cuboid   3 1 2p7.62          2p0.71795 101.81 -.318
cuboid   2 1 2p7.62          2p0.79415 101.81 -.318
cuboid   3 1 2p9.95725 2p0.79415 101.81 -.318
global unit 6
array    2 -49.78625 -48.9921      -.318
reflector 2 1 5r0            2.882       1
reflector 3 1 10 10 10 10 0 0 1
reflector 2 1 4r0            0 8.9       1
reflector 3 1 4r0            0 2.86      1
reflector 4 1 4r0            0 1.0       1
reflector 3 1 4r20           0 0         1
end geom

read array
ara=1 nux=13 nuy=13 nuz=1 fill 1 11r2 1 13r2 10q13 1 11r2 1 end fill
ara=2 nux=5 nuy=9 nuz=1 fill 5r3 4 3r5 4 3q10 5r3      end fill
end array
end data
end

b1645so2

#csas25
b1645so2
44group      latticecell
uo2          1 0.9325 293 92235 2.459 92238 97.541 end
al           2 1.0 293                                end
h2o          3 1.0 293                                end
boron        3 den=1156.0-6                         end
carbonsteel  4 1.0 293                                end
end comp
squarepitch 1.4097 1.0300 1 3 1.2060 2 1.0440 0   end
9-15x15 assemblies separated by 0.0762-cm-thick aluminum plates and
'1.6396 cm of water, 144.85 cm water height with 1156 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 1
cylinder 2 1 .6030          144.85 -.318
cuboid   3 1 4p0.70485      144.85 -.318

```

```

unit 2
cylinder 1 1 .5150          144.85 0.0
cylinder 0 1 .5220          144.85 0.0
cylinder 2 1 .6030          144.85 -.318
cuboid   3 1 4p0.70485      144.85 -.318
unit 3
array    1 -9.1631 -9.1631 -0.318
cuboid   3 1 2p9.95725 2p9.1631 144.85 -.318
unit 4
cuboid   3 1 2p9.95725 2p0.79415 144.85 -.318
unit 5
cuboid   3 1 2p7.62          2p0.71795 144.85 -.318
cuboid   2 1 2p7.62          2p0.79415 144.85 -.318
cuboid   3 1 2p9.95725 2p0.79415 144.85 -.318
global unit 6
array    2 -49.78625 -48.9921      -.318
reflector 2 1 5r0            2.882     1
reflector 3 1 10 10 10 0 0    1
reflector 2 1 4r0            0 8.9     1
reflector 3 1 4r0            0 2.86    1
reflector 4 1 4r0            0 1.0     1
reflector 3 1 4r20           0 0       1
end geom

read array
ara=1 nux=13 nuy=13 nuz=1 fill 1 11r2 1 13r2 10q13 1 11r2 1 end fill
ara=2 nux=5 nuy=9 nuz=1 fill 5r3 4 3r5 4 3q10 5r3      end fill
end array
end data
end

bwl231b1

=csas25
bwl231b1
44group   latticecell
uo2        1 0.863 285 92235 4.02 92238 95.98 end
ss304      2 1.0 285 end
h2o        3 1.0 285 end
boron      3 den=.001152 1.0 285 end
al          4 1.0 285 end
plexiglas   5 1.0 285 end
uo2        6 0.863 285 92235 4.02 92238 95.98 end
end comp
squarepitch 1.511 1.128 1 3 1.208 2 end
more data res=6 cyl 0.564 dan(6)=0.901122 end
Core of 936 fuel rods, 167.5 cm water height with 1152 ppm boron
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 4 1 .564 2.365 0
cylinder 2 1 .604 2.365 0
cuboid   3 1 4p.7555 2.365 0
unit 2
cuboid   3 1 4p.7555 2.365 0
unit 10
cylinder 1 1 .564 86.0 0
cylinder 2 1 .604 86.0 0
cuboid   3 1 4p.7555 86.0 0
unit 11
cuboid   3 1 4p.7555 86.0 0
unit 20
cylinder 1 1 .564 0.63 0
cylinder 2 1 .604 0.63 0
cuboid   5 1 4p.7555 0.63 0
unit 21
cuboid   5 1 4p.7555 0.63 0
unit 30
cylinder 1 1 .564 80.87 0
cylinder 2 1 .604 80.87 0
cuboid   3 1 4p.7555 80.87 0
unit 31
cuboid   3 1 4p.7555 80.87 0
unit 40
cylinder 6 1 .564 1.4 0
cylinder 2 1 .604 1.4 0
cuboid   0 1 4p.7555 1.4 0
unit 41
cuboid   0 1 4p.7555 1.4 0
unit 50
cylinder 1 1 .564 0.7 0
cylinder 2 1 .604 0.7 0
cuboid   4 1 4p.7555 0.7 0
unit 51
cuboid   4 1 4p.7555 0.7 0
unit 60
array 1 3*0.0
reflector 3 1 4r30 2r0 1
reflector 4 1 5r0 11.47 1
unit 70
array 2 3*0.0
reflector 0 1 4r30 2r0 1
unit 80
array 3 3*0.0
reflector 4 1 4r30 6.57 0 1
global
unit 90
array 4 3*0.0
end geom

read array
ara=1 nux=34 nuy=34 nuz=4
fill
12r2 5r1 n17 9r2 8r1 n17 8r2 9r1 n17
6r2 11r1 n17 5r2 12r1 n17 4r2 13r1 n17
3r2 14r1 n17 3r2 14r1 n17 2r2 15r1 n17 1r2 16r1 n17
1r2 16r1 n17 1r2 16r1 n17 170r1
n578
12r11 5r10 n17 9r11 8r10 n17 8r11 9r10 n17
6r11 11r10 n17 5r11 12r10 n17 4r11 13r10 n17
3r11 14r10 n17 3r11 14r10 n17 2r11 15r10 n17 1r11 16r10 n17
1r11 16r10 n17 1r11 16r10 n17 170r10
n578
12r21 5r20 n17 9r21 8r20 n17 8r21 9r20 n17
6r21 11r20 n17 5r21 12r20 n17 4r21 13r20 n17
3r21 14r20 n17 3r21 14r20 n17 2r21 15r20 n17 1r21 16r20 n17
1r21 16r20 n17 1r21 16r20 n17 170r20

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n578
12r31 5r30 n17 9r31 8r30 n17 8r31 9r30 n17
6r31 11r30 n17 5r31 12r30 n17 4r31 13r30 n17
3r31 14r30 n17 3r31 14r30 n17 2r31 15r30 n17 1r31 16r30 n17
1r31 16r30 n17 1r31 16r30 n17 170r30
n578 end fill
ara=2 nux=34 nuy=34 nuz=1
fill
12r41 5r40 n17 9r41 8r40 n17 8r41 9r40 n17
6r41 11r40 n17 5r41 12r40 n17 4r41 13r40 n17
3r41 14r40 n17 3r41 14r40 n17 2r41 15r40 n17 1r41 16r40 n17
1r41 16r40 n17 1r41 16r40 n17 170r40
n578 end fill
ara=3 nux=34 nuy=34 nuz=1
fill
12r51 5r50 n17 9r51 8r50 n17 8r51 9r50 n17
6r51 11r50 n17 5r51 12r50 n17 4r51 13r50 n17
3r51 14r50 n17 3r51 14r50 n17 2r51 15r50 n17 1r51 16r50 n17
1r51 16r50 n17 1r51 16r50 n17 170r50
n578 end fill
ara=4 nux=1 nuy=1 nuz=3 fill 60 70 80 end fill
end array
end data
end

bw1231b2

=csas25
bw1231b2
44group latticecell
uo2    1  0.863  287  92235  4.02  92238  95.98  end
ss304   2  1.0   287
h2o     3  1.0   287
boron   3  den=.003389  1.0   287
al      4  1.0   287
plexiglas 5  1.0   287
uo2    6  0.863  287  92235  4.02  92238  95.98  end
end comp
squarepitch 1.511 1.128 1  3  1.208  2
more data res=6 cyl 0.564 dan(6)=0.901122
Core of 4904 fuel rods, 146.65 cm water height with 3389 ppm boron
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 4 1 .564  3.46  0
cylinder 2 1 .604  3.46  0
cuboid   3 1 4p.7555  3.46  0
unit 2
cuboid   3 1 4p.7555  3.46  0
unit 10
cylinder 1 1 .564  65.0  0
cylinder 2 1 .604  65.0  0
cuboid   3 1 4p.7555  65.0  0
unit 11
cuboid   3 1 4p.7555  65.0. 0
unit 20
cylinder 1 1 .564  0.63  0
cylinder 2 1 .604  0.63  0

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cuboid   5 1 4p.7555  0.63  0
unit 21
cuboid   5 1 4p.7555  0.63  0
unit 30
cylinder 1 1 .564  81.02  0
cylinder 2 1 .604  81.02  0
cuboid   3 1 4p.7555  81.02  0
unit 31
cuboid   3 1 4p.7555  81.02  0
unit 40
cylinder 6 1 .564  21.65  0
cylinder 2 1 .604  21.65  0
cuboid   0 1 4p.7555  21.65  0
unit 41
cuboid   0 1 4p.7555  21.65  0
unit 50
cylinder 1 1 .564  1.3   0
cylinder 2 1 .604  1.3   0
cuboid   4 1 4p.7555  1.3   0
unit 51
cuboid   4 1 4p.7555  1.3   0
unit 60
array 1 3*0.0
reflector 3 1 4r30.0  2r0 1
reflector 4 1 5r0   12.74 1
unit 70
array 2 3*0.0
reflector 0 1 4r30   2r0 1
unit 80
array 3 3*0.0
reflector 4 1 4r30  7.24  0 1
global
unit 90
array 4 3*0.0
end geom

read array
ara=1  nux=80 nuy=80 nuz=4
fill
37r2 3rl n40  31r2 9rl n40  27r2 13rl n40
25r2 15rl n40 23r2 17rl n40  21r2 19rl n40
19r2 21rl n40 18r2 22rl n40  16r2 24rl n40
15r2 25rl n40 14r2 26rl n40  13r2 27rl n40
12r2 28rl n40 11r2 29rl n40  10r2 30rl n40
9r2 31rl n40 8r2 32rl n40  8r2 32rl n40
7r2 33rl n40 6r2 34rl n40  6r2 34rl n40
5r2 35rl n40 5r2 35rl n40  4r2 36rl n40
4r2 36rl n40 3r2 37rl n40  3r2 37rl n40
2r2 38rl n40 2r2 38rl n40  2r2 38rl n40
2r2 38rl n40 1r2 39rl n40  1r2 39rl n40
1r2 39rl n40 1r2 39rl n40  1r2 39rl n40
1r2 39rl n40 40rl n40  40rl n40 40rl n40
n3200
37r11 3rl n40  31r11 9rl n40  27r11 13rl n40
25r11 15rl n40 23r11 17rl n40  21r11 19rl n40
19r11 21rl n40 18r11 22rl n40  16r11 24rl n40
15r11 25rl n40 14r11 26rl n40  13r11 27rl n40
12r11 28rl n40 11r11 29rl n40  10r11 30rl n40
9rl1 31rl n40 8rl1 32rl n40  8rl1 32rl n40

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7r11 33r10 n40 6r11 34r10 n40 6r11 34r10 n40
5r11 35r10 n40 5r11 35r10 n40 4r11 36r10 n40
4r11 36r10 n40 3r11 37r10 n40 3r11 37r10 n40
2r11 38r10 n40 2r11 38r10 n40 2r11 38r10 n40
2r11 38r10 n40 1r11 39r10 n40 1r11 39r10 n40
1r11 39r10 n40 1r11 39r10 n40 1r11 39r10 n40
1r11 39r10 n40 40r10 n40 40r10 n40 40r10 n40
n3200
37r21 3r20 n40 31r21 9r20 n40 27r21 13r20 n40
25r21 15r20 n40 23r21 17r20 n40 21r21 19r20 n40
19r21 21r20 n40 18r21 22r20 n40 16r21 24r20 n40
15r21 25r20 n40 14r21 26r20 n40 13r21 27r20 n40
12r21 28r20 n40 11r21 29r20 n40 10r21 30r20 n40
9r21 31r20 n40 8r21 32r20 n40 8r21 32r20 n40
7r21 33r20 n40 6r21 34r20 n40 6r21 34r20 n40
5r21 35r20 n40 5r21 35r20 n40 4r21 36r20 n40
4r21 36r20 n40 3r21 37r20 n40 3r21 37r20 n40
2r21 38r20 n40 2r21 38r20 n40 2r21 38r20 n40
2r21 38r20 n40 1r21 39r20 n40 1r21 39r20 n40
1r21 39r20 n40 1r21 39r20 n40 1r21 39r20 n40
1r21 39r20 n40 40r20 n40 40r20 n40 40r20 n40
n3200
37r31 3r30 n40 31r31 9r30 n40 27r31 13r30 n40
25r31 15r30 n40 23r31 17r30 n40 21r31 19r30 n40
19r31 21r30 n40 18r31 22r30 n40 16r31 24r30 n40
15r31 25r30 n40 14r31 26r30 n40 13r31 27r30 n40
12r31 28r30 n40 11r31 29r30 n40 10r31 30r30 n40
9r31 31r30 n40 8r31 32r30 n40 8r31 32r30 n40
7r31 33r30 n40 6r31 34r30 n40 6r31 34r30 n40
5r31 35r30 n40 5r31 35r30 n40 4r31 36r30 n40
4r31 36r30 n40 3r31 37r30 n40 3r31 37r30 n40
2r31 38r30 n40 2r31 38r30 n40 2r31 38r30 n40
2r31 38r30 n40 1r31 39r30 n40 1r31 39r30 n40
1r31 39r30 n40 1r31 39r30 n40 1r31 39r30 n40
1r31 39r30 n40 40r30 n40 40r30 n40 40r30 n40
n3200
end fill
ara=2 nux=80 nuy=80 nuz=1
fill
37r41 3r40 n40 31r41 9r40 n40 27r41 13r40 n40
25r41 15r40 n40 23r41 17r40 n40 21r41 19r40 n40
19r41 21r40 n40 18r41 22r40 n40 16r41 24r40 n40
15r41 25r40 n40 14r41 26r40 n40 13r41 27r40 n40
12r41 28r40 n40 11r41 29r40 n40 10r41 30r40 n40
9r41 31r40 n40 8r41 32r40 n40 8r41 32r40 n40
7r41 33r40 n40 6r41 34r40 n40 6r41 34r40 n40
5r41 35r40 n40 5r41 35r40 n40 4r41 36r40 n40
4r41 36r40 n40 3r41 37r40 n40 3r41 37r40 n40
2r41 38r40 n40 2r41 38r40 n40 2r41 38r40 n40
2r41 38r40 n40 1r41 39r40 n40 1r41 39r40 n40
1r41 39r40 n40 1r41 39r40 n40 1r41 39r40 n40
1r41 39r40 n40 40r40 n40 40r40 n40 40r40 n40
n3200
end fill
ara=3 nux=80 nuy=80 nuz=1
fill
37r51 3r50 n40 31r51 9r50 n40 27r51 13r50 n40
25r51 15r50 n40 23r51 17r50 n40 21r51 19r50 n40
19r51 21r50 n40 18r51 22r50 n40 16r51 24r50 n40

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15r51 25r50 n40 14r51 26r50 n40 13r51 27r50 n40
12r51 28r50 n40 11r51 29r50 n40 10r51 30r50 n40
9r51 31r50 n40 8r51 32r50 n40 8r51 32r50 n40
7r51 33r50 n40 6r51 34r50 n40 6r51 34r50 n40
5r51 35r50 n40 5r51 35r50 n40 4r51 36r50 n40
4r51 36r50 n40 3r51 37r50 n40 3r51 37r50 n40
2r51 38r50 n40 2r51 38r50 n40 2r51 38r50 n40
2r51 38r50 n40 1r51 39r50 n40 1r51 39r50 n40
1r51 39r50 n40 1r51 39r50 n40 1r51 39r50 n40
1r51 39r50 n40 40r50 n40 40r50 n40 40r50 n40
n3200
end fill
ara=4 nux=1 nuy=1 nuz=3 fill 60 70 80 end fill
end array
end data
end

bw1273m

#csas25
bw1273m
44group latticecell
uo2 1 den=10.24 1.0 293 92235 2.459 92238 97.541 end
al 2 1.0 end
h2o 3 1.0 end
boron 3 den=1.675e-3 end
uo2 4 den=10.24 1.0 293 92235 2.459 92238 97.541 end
plexiglas 5 1.0 end
end comp
squarepitch 1.511 1.030 1 3 1.206 2 1.044 0 end
more data res=4 cyl 0.515 dan(4)=0.982883 end
Core of 5137 fuel rods, 93.2 cm water height with 1675 ppm boron
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 2 1 .603 .3175 0.0
cuboid 3 1 4p.7555 .3175 0.0
unit 2
cylinder 1 1 .515 2.54 0.0
cylinder 0 1 .522 2.54 0.0
cylinder 2 1 .603 2.54 0.0
cuboid 3 1 4p.615 2.54 0.0
cuboid 2 1 4p.7555 2.54 0.0
unit 3
cylinder 1 1 .515 46.46 0.0
cylinder 0 1 .522 46.46 0.0
cylinder 2 1 .603 46.46 0.0
cuboid 3 1 4p.7555 46.46 0.0
unit 4
cylinder 1 1 .515 .1588 0.0
cylinder 0 1 .522 .1588 0.0
cylinder 2 1 .603 .1588 0.0
cuboid 3 1 4p.615 .1588 0.0
cuboid 5 1 4p.7555 .1588 0.0
unit 5
cylinder 1 1 .515 32.8412 0.0
cylinder 0 1 .522 32.8412 0.0
cylinder 2 1 .603 32.8412 0.0

```

```

cuboid    3 1  4p.7555 32.8412 0.0
unit 6
cylinder 1 1   .515     .1588 0.0
cylinder 0 1   .522     .1588 0.0
cylinder 2 1   .603     .1588 0.0
cuboid    3 1  4p.615    .1588 0.0
cuboid    5 1  4p.7555    .1588 0.0
unit 7
cylinder 1 1   .515    11.0412 0.0
cylinder 0 1   .522    11.0412 0.0
cylinder 2 1   .603    11.0412 0.0
cuboid    3 1  4p.7555 11.0412 0.0
unit 8
cylinder 4 1   .515     60.2 0.0
cylinder 0 1   .522     60.2 0.0
cylinder 2 1   .603     60.2 0.0
cuboid    0 1  4p.7555    60.2 0.0
unit 10
cylinder 2 1   .603     .3175 0.0
cuboid    3 1  4p.7555    .3175 0.0
unit 11
cuboid    3 1  4p.615    2.54 0.0
cuboid    2 1  4p.7555    2.54 0.0
unit 12
cuboid    3 1  4p.7555   46.46 0.0
unit 13
cuboid    3 1  4p.615    .1588 0.0
cuboid    5 1  4p.7555    .1588 0.0
unit 14
cuboid    3 1  4p.7555 32.8412 0.0
unit 15
cuboid    3 1  4p.615    .1588 0.0
cuboid    5 1  4p.7555    .1588 0.0
unit 16
cuboid    3 1  4p.7555 11.0412 0.0
unit 17
cuboid    0 1  4p.7555   60.2 0.0
unit 20
array 1   3*0.0
unit 21
array 2   3*0.0
global unit 22
array 3   3*0.0
reflector 2 1  5r0    5.08 1
reflector 3 1  4r30   2r0 1
end geom

read array
ara=1 nux=1 nuy=1 nuz=8 fill 1 2 3 4 5 6 7 8      end fill
ara=2 nux=1 nuy=1 nuz=8 fill 10 11 12 13 14 15 16 17  end fill
ara=3 nux=82 nuy=82 nuz=1 fill
38r21  6r20 38r21 32r21 18r20 32r21 28r21 26r20 28r21 26r21 30r20 26r21
24r21 34r20 24r21 22r21 38r20 22r21 20r21 42r20 20r21 18r21 46r20 18r21
17r21 48r20 17r21 16r21 50r20 16r21 15r21 52r20 15r21 14r21 54r20 14r21
13r21 56r20 13r21 12r21 58r20 12r21 11r21 60r20 11r21 10r21 62r20 10r21
9r21 64r20 9r21 8r21 66r20 8r21 7r21 68r20 7r21 q82
6r21 70r20 6r21 q82      5r21 72r20 5r21 q82
4r21 74r20 4r21 q82
3r21 76r20 3r21 q82      2r21 78r20 2r21 3q82
                                         1r21 80r20 1r21 5q82      82r20      2q82
                                         n3280
                                         38r21 7r20 37r21 end fill
end array
end data
end

bw1484a1

#csas25
bw1484a1
44group latticecell
uo2  1 den=10.22 1.0 293 92235 2.459 92238 97.541 end
al  2 1.0      end
h2o 3 1.0      end
boron 3 den=15e-6      end
al  4 den=2.7 .98386      end
boron 4 den=2.7 .01614      end
end comp
squarepitch 1.636 1.030 1 3 1.206 2 1.044 0      end
9-14x14 assemblies separated by 0.645-cm-thick borated aluminum plates
'and 0.991 cm of water, plates-to-center assembly distance of 0.3725
'cm, 150.27 cm water height with 15 ppm boron
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1   0.515     0.635    0.0
cylinder 0 1   0.522     0.635    0.0
cuboid   2 1 4p0.818    0.635    0.0

unit 2
cylinder 1 1   0.515    147.4125 0.0
cylinder 0 1   0.522    147.4125 0.0
cylinder 2 1   0.603    147.4125 0.0
cuboid   3 1 4p0.818    147.4125 0.0

unit 3
cuboid   2 1 4p0.818    0.635    0.0
unit 4
cylinder 2 1   0.635    147.4125 0.0
cuboid   3 1 4p0.818    147.4125 0.0
unit 5
array 1 3*0.0
unit 6
array 2 3*0.0
unit 7
array 3 2r-22.904 0.0
reflector 3 1   .6185 9.808 .6185 9.808 2r0 1
reflector 4 1   .3225 0.0   .3225      3r0 1
unit 8
array 3 2r-22.904 0.0
reflector 3 1   2r.3725 .6185 9.808      2r0 1
reflector 4 1   3r.3225      3r0 1
unit 9
array 3 2r-22.904 0.0
reflector 3 1   9.808 .6185 .6185 9.808 2r0 1
reflector 4 1   0.0   2r.3225      3r0 1
unit 10
array 3 2r-22.904 0.0

```

```

reflector 3 1 .6185 9.808 2r.3725      2r0  1
reflector 4 1 .3225 0.0    2r.3225      2r0  1
unit 11
array 3 2r-22.904 0.0
reflector 3 1 4r.3725      2r0  1
reflector 4 1 4r.3225      2r0  1
unit 12
array 3 2r-22.904 0.0
reflector 3 1 9.808 .6185 2r.3725      2r0  1
reflector 4 1 0.0   3r.3225      2r0  1
unit 13
array 3 2r-22.904 0.0
reflector 3 1 .6185 9.808 9.808 .6185 2r0  1
reflector 4 1 .3225 2r0 .3225      2r0  1
unit 14
array 3 2r-22.904 0.0
reflector 3 1 2r.3725 9.808 .6185      2r0  1
reflector 4 1 2r.3225 0   .3225      2r0  1
unit 15
array 3 2r-22.904 0.0
reflector 3 1 9.808 .6185 9.808 .6185 2r0  1
reflector 4 1 0   .3225 0 .3225      2r0  1
global unit 16
array 4 2*-45.808 0.0
reflector 2 1 5r0.0 1.905 1
reflector 2 1 5r0 2.54 1
reflector 3 1 5r0 0.3175 1
reflector 2 1 5r0 5.08 1
reflector 3 1 4r20 2r0 1
end geom

read array
ara=1 nux=1 nuy=1 nuz=2 fill 1 2 end fill
ara=2 nux=1 nuy=1 nuz=2 fill 3 4 end fill
ara=3 nux=14 nuy=14 nuz=1 fill 6 12r5 6 14r5 11q14 6 12r5 6 end fill
ara=4 nux=3 nuy=3 nuz=1 fill 7 8 9 10 11 12 13 14 15      end fill
end array
end data
end

bwl484a2

#csas25
bwl484a2
44group latticecell
uo2 1 den=10.22 1.0 293 92235 2.459 92238 97.541 end
al 2 1.0          end
h2o 3 1.0          end
boron 3 den=72e-6 end
al 4 den=2.7 .99899 end
boron 4 den=2.7 .00101 end
end comp
squarepitch 1.636 1.030 1 3 1.206 2 1.044 0      end
9-14x14 assemblies separated by 0.645-cm-thick borated aluminum plates
'and 4.263 cm of water, plates-to-center assembly distance of 0.3725
'cm, 151.69 cm water height with 72 ppm boron
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom

```

```

unit 1
cylinder 1 1 0.515 0.635 0.0
cylinder 0 1 0.522 0.635 0.0
cuboid 2 1 4p0.818 0.635 0.0
unit 2
cylinder 1 1 0.515 148.8325 0.0
cylinder 0 1 0.522 148.8325 0.0
cylinder 2 1 0.603 148.8325 0.0
cuboid 3 1 4p0.818 148.8325 0.0
unit 3
cuboid 2 1 4p0.818 0.635 0.0
unit 4
cylinder 2 1 0.635 148.8325 0.0
cuboid 3 1 4p0.818 148.8325 0.0
unit 5
array 1 3*0.0
unit 6
array 2 3*0.0
unit 7
array 3 2r-22.904 0.0
reflector 3 1 3.8905 6.536 3.8905 6.536 2r0 1
reflector 4 1 .3225 0.0   .3225      3r0  1
unit 8
array 3 2r-22.904 0.0
reflector 3 1 2r.3725 3.8905 6.536      2r0  1
reflector 4 1 3r.3225           3r0  1
unit 9
array 3 2r-22.904 0.0
reflector 3 1 6.536 3.8905 3.8905 6.536 2r0 1
reflector 4 1 0.0   2r.3225      3r0  1
unit 10
array 3 2r-22.904 0.0
reflector 3 1 3.8905 6.536 2r.3725      2r0  1
reflector 4 1 .3225 0.0   2r.3225      2r0  1
unit 11
array 3 2r-22.904 0.0
reflector 3 1 4r.3725           2r0  1
reflector 4 1 4r.3225           2r0  1
unit 12
array 3 2r-22.904 0.0
reflector 3 1 6.536 3.8905 2r.3725      2r0  1
reflector 4 1 0.0   3r.3225      2r0  1
unit 13
array 3 2r-22.904 0.0
reflector 3 1 3.8905 6.536 6.536 3.8905 2r0  1
reflector 4 1 .3225 2r0   .3225      2r0  1
unit 14
array 3 2r-22.904 0.0
reflector 3 1 2r.3725 6.536 3.8905 2r0  1
reflector 4 1 2r.3225 0   .3225      2r0  1
unit 15
array 3 2r-22.904 0.0
reflector 3 1 6.536 3.8905 6.536 3.8905 2r0  1
reflector 4 1 0.0   .3225 0.0   .3225      2r0  1
global unit 16
array 4 2*-45.808 0.0
reflector 2 1 5r0 1.905 1
reflector 2 1 5r0 2.54 1
reflector 3 1 5r0 0.3175 1

```

```

reflector 2 1      5r0 5.08    1
reflector 3 1      4r20 2r0    1
end geom

read array
ara=1 nux=1  nuy=1  nuz=2 fill 1 2 end fill
ara=2 nux=1  nuy=1  nuz=2 fill 3 4 end fill
ara=3 nux=14 nuy=14 nuz=1 fill 6 12r5 6 14r5 11q14 6 12r5 6 end fill
ara=4 nux=3  nuy=3  nuz=1 fill 7 8 9 10 11 12 13 14 15      end fill
end array
end data
end

bwl484b1

#csas25
bwl484b1
44group latticecell
uo2  1 den=10.22 1.0 293 92235 2.459 92238 97.541
al   2 1.0
h2o  3 1.0
boron 3 den=1037e-6
end comp
squarepitch 1.636 1.030 1 3 1.206 2 1.044 0
9-14x14 assemblies separated by 0.0 cm of water, 144.29 cm water
'height with 1037 ppm boron
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 2 1 0.603 .3175 0.0
cuboid   3 1 4p.818 .3175 0.0
unit 2
cylinder 1 1 0.515 2.54 0.0
cylinder 0 1 0.522 2.54 0.0
cylinder 2 1 0.603 2.54 0.0
cuboid   3 1 4p.615 2.54 0.0
cuboid   2 1 4p.818 2.54 0.0
unit 3
cylinder 1 1 0.515 141.4325 0.0
cylinder 0 1 0.522 141.4325 0.0
cylinder 2 1 0.603 141.4325 0.0
cuboid   3 1 4p.818 141.4325 0.0
unit 4
array 1 3*0.0
global unit 5
array 2 3*0.0
reflector 2 1 5r0.0 5.08 1
reflector 3 1 5r0.0 2.54 1
reflector 2 1 5r0.0 1.27 1
reflector 3 1 4r24 2r0 1
end geom

read array
ara=1 nux=14 nuy=14 nuz=3 fill 196r1 196r2 196r3 end fill
ara=2 nux=3  nuy=3  nuz=1 fill f4 end fill
end array
end data
end

```

bwl484b2

```

#csas25
bwl484b2
44group latticecell
uo2  1 den=10.22 1.0 293 92235 2.459 92238 97.541
al   2 1.0
h2o  3 1.0
boron 3 den=702e-6
end comp
squarepitch 1.636 1.030 1 3 1.206 2 1.044 0
9-14x14 assemblies separated by 1.636 cm of water, 100.32 cm water
'height with 702 ppm boron
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 2 1 0.603 .3175 0.0
cuboid   3 1 4p.818 .3175 0.0
unit 2
cylinder 1 1 0.515 2.54 0.0
cylinder 0 1 0.522 2.54 0.0
cylinder 2 1 0.603 2.54 0.0
cuboid   3 1 4p.615 2.54 0.0
cuboid   2 1 4p.818 2.54 0.0
unit 3
cylinder 1 1 0.515 97.4625 0.0
cylinder 0 1 0.522 97.4625 0.0
cylinder 2 1 0.603 97.4625 0.0
cuboid   3 1 4p.818 97.4625 0.0
unit 4
array 1 3*0.0
reflector 3 1 4r.818 2r0 1
global unit 5
array 2 3*0.0
reflector 2 1 5r0.0 5.08 1
reflector 3 1 5r0.0 2.54 1
reflector 2 1 5r0.0 1.27 1
reflector 3 1 4r24 2r0 1
end geom

read array
ara=1 nux=14 nuy=14 nuz=3 fill 196r1 196r2 196r3 end fill
ara=2 nux=3  nuy=3  nuz=1 fill f4 end fill
end array
end data
end

bwl484b3

#csas25
bwl484b3
44group latticecell
uo2  1 den=10.22 1.0 293 92235 2.459 92238 97.541
al   2 1.0
h2o  3 1.0
boron 3 den=143e-6
end comp
squarepitch 1.636 1.030 1 3 1.206 2 1.044 0

```

9-14x14 assemblies separated by 4.908 cm of water, 149.12 cm water
 'height with 143 ppm boron
 read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
 unit 1
 cylinder 1 1 0.515 0.635 0.0
 cylinder 0 1 0.522 0.635 0.0
 cuboid 2 1 4p0.818 0.635 0.0
 unit 2
 cylinder 1 1 0.515 148.8325 0.0
 cylinder 0 1 0.522 148.8325 0.0
 cylinder 2 1 0.603 148.8325 0.0
 cuboid 3 1 4p0.818 148.8325 0.0
 unit 3
 cuboid 2 1 4p0.818 0.635 0.0
 unit 4
 cylinder 2 1 0.635 148.8325 0.0
 cuboid 3 1 4p0.818 148.8325 0.0
 unit 5
 array 1 3*0.0
 unit 6
 array 2 3*0.0
 unit 7
 array 3 2r-22.904 0.0
 reflector 3 1 2.454 9.808 2.454 9.808 2r0 1
 unit 8
 array 3 2r-22.904 0.0
 reflector 3 1 2r2.454 2.454 9.808 2r0 1
 unit 9
 array 3 2r-22.904 0.0
 reflector 3 1 9.808 2.454 2.454 9.808 2r0 1
 unit 10
 array 3 2r-22.904 0.0
 reflector 3 1 2.454 9.808 2r2.454 2r0 1
 unit 11
 array 3 2r-22.904 0.0
 reflector 3 1 4r2.454 2r0 1
 unit 12
 array 3 2r-22.904 0.0
 reflector 3 1 9.808 2.454 2r2.454 2r0 1
 unit 13
 array 3 2r-22.904 0.0
 reflector 3 1 2.454 9.808 9.808 2.454 2r0 1
 unit 14
 array 3 2r-22.904 0.0
 reflector 3 1 2r2.454 9.808 2.454 2r0 1
 unit 15
 array 3 2r-22.904 0.0
 reflector 3 1 9.808 2.454 9.808 2.454 2r0 1
 global unit 16
 array 4 2*-45.808 0.0
 reflector 2 1 5r0 1.905 1
 reflector 2 1 5r0 2.54 1
 reflector 3 1 5r0 0.3175 1
 reflector 2 1 5r0 5.08 1
 reflector 3 1 4r20 2r0 1
 end geom

read array
 ara=1 nux=1 nuy=1 nuz=2 fill 1 2 end fill
 ara=2 nux=1 nuy=1 nuz=2 fill 3 4 end fill
 ara=3 nux=14 nuy=14 nuz=1 fill 6 12r5 6 14r5 11q14 6 12r5 6 end fill
 ara=4 nux=3 nuy=3 nuz=1 fill 7 8 9 10 11 12 13 14 15 end fill
 end array
 end data
 end

bw1484c1

=csas25
bw1484c1
 44group latticecell
 uo2 1 den=10.22 1.0 293 92235 2.459 92238 97.541 end
 al 2 1.0 end
 h2o 3 1.0 end
 b4c 4 den=1.28 0.986 end
 arbmb2o3 1.28 2 1 1 0 5000 2 8016 3 4 0.001 end
 end comp
 squarepitch 1.636 1.030 1 3 1.206 2 1.044 0 end
 9-14x14 assemblies separated by 1.636 cm of water containing 84 B₄C
 'rods, 145.68 cm water height
 read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
 unit 1
 cylinder 2 1 0.603 .3175 0.0
 cuboid 3 1 4p0.818 .3175 0.0
 unit 2
 cylinder 2 1 0.5565 .3175 0.0
 cuboid 3 1 4p0.818 .3175 0.0
 unit 3
 cuboid 3 1 4p0.818 .3175 0.0
 unit 4
 cylinder 1 1 0.515 2.54 0.0
 cylinder 0 1 0.522 2.54 0.0
 cylinder 2 1 0.603 2.54 0.0
 cuboid 3 1 4p0.615 2.54 0.0
 cuboid 2 1 4p0.818 2.54 0.0
 unit 5
 cylinder 2 1 0.4675 0.6345 0.0
 cylinder 4 1 0.4675 2.54 0.0
 cylinder 2 1 0.5565 2.54 0.0
 cuboid 3 1 4p0.615 2.54 0.0
 cuboid 2 1 4p0.818 2.54 0.0
 unit 6
 cuboid 3 1 4p0.615 2.54 0.0
 cuboid 2 1 4p0.818 2.54 0.0
 unit 7
 cylinder 1 1 0.515 142.8225 0.0
 cylinder 0 1 0.522 142.8225 0.0
 cylinder 2 1 0.603 142.8225 0.0
 cuboid 3 1 4p0.818 142.8225 0.0
 unit 8
 cylinder 4 1 0.4675 142.8225 0.0
 cylinder 2 1 0.5565 142.8225 0.0
 cuboid 3 1 4p0.818 142.8225 0.0

```

unit 9
cuboid 3 1 4p0.818      142.8225 0.0
unit 11
array 1 3*0.0
unit 12
array 2 3*0.0
unit 13
array 3 3*0.0
unit 14
array 4 3*0.0
unit 15
array 5 3*0.0
unit 16
array 6 3*0.0
unit 17
array 7 3*0.0
unit 18
array 8 3*0.0
unit 19
array 9 3*0.0
unit 20
array 10 3*0.0
unit 21
array 11 3*0.0
global unit 22
array 12 3*0.0
cuboid 2 1 71.984 0.0 71.984 0.0 145.68 -5.08
cuboid 3 1 71.984 0.0 71.984 0.0 145.68 -7.62
cuboid 2 1 71.984 0.0 71.984 0.0 145.68 -8.89
reflector 3 1 4r3 2r0 8
end geom

read array
ara=1 nux=1 nuy=1 nuz=3 fill 1 4 7    end fill
ara=2 nux=1 nuy=1 nuz=3 fill 2 5 8    end fill
ara=3 nux=1 nuy=1 nuz=3 fill 3 6 9    end fill
ara=4 nux=14 nuy=14 nuz=1 fill f11    end fill
ara=5 nux=1 nuy=14 nuz=1 fill 12 13 6q2 end fill
ara=6 nux=1 nuy=14 nuz=1
fill 13 12 2q2 13 13 12 13 2q2    end fill
ara=7 nux=1 nuy=14 nuz=1 fill 13 12 6q2 end fill
ara=8 nux=5 nuy=1 nuz=1
fill 14 15 14 15 14    end fill
ara=9 nux=5 nuy=1 nuz=1
fill 14 16 14 16 14    end fill
ara=10 nux=5 nuy=1 nuz=1
fill 14 17 14 17 14    end fill
ara=11 nux=44 nuy=1 nuz=1
fill 13 13 12 13q2 12 12 13 6q2 end fill
ara=12 nux=1 nuy=5 nuz=1
fill 18 21 19 21 20    end fill
end array
end data
end

bwl484c2
=csas25
bwl484c2

        44group latticecell
        uo2 1 den=10.22 1.0 293 92235 2.459 92238 97.541
        al 2 1.0
        h2o 3 1.0
        b4c 4 den=1.28 0.986
        arbmb2o3 1.28 2 1 1 0 5000 2 8016 3 4 0.001
        end comp
        squarepitch 1.636 1.030 1 3 1.206 2 1.044 0
        9-14x14 assemblies separated by 4.908 cm of water containing 34 B4C
        'rods, 111.49 cm water height
        read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

        read geom
        unit 1
        cylinder 2 1 0.603 .3175 0.0
        cuboid 3 1 4p0.818 .3175 0.0
        unit 2
        cylinder 2 1 0.5565 .3175 0.0
        cuboid 3 1 2p2.454 2p.818 0.3175 0.0
        unit 3
        cuboid 3 1 2p2.454 2p.818 0.3175 0.0
        unit 4
        cylinder 1 1 0.515 2.54 0.0
        cylinder 0 1 0.522 2.54 0.0
        cylinder 2 1 0.603 2.54 0.0
        cuboid 3 1 4p0.615 2.54 0.0
        cuboid 2 1 4p0.818 2.54 0.0
        unit 5
        cylinder 2 1 0.4675 0.6345 0.0
        cylinder 4 1 0.4675 2.54 0.0
        cylinder 2 1 0.5565 2.54 0.0
        cuboid 3 1 4p0.615 2.54 0.0
        cuboid 2 1 2p2.454 2p.818 2.54 0.0
        unit 6
        cuboid 3 1 4p0.615 2.54 0.0
        cuboid 2 1 2p2.454 2p.818 2.54 0.0
        unit 7
        cylinder 1 1 0.515 108.6325 0.0
        cylinder 0 1 0.522 108.6325 0.0
        cylinder 2 1 0.603 108.6325 0.0
        cuboid 3 1 4p0.818 108.6325 0.0
        unit 8
        cylinder 4 1 0.4675 108.6325 0.0
        cylinder 2 1 0.5565 108.6325 0.0
        cuboid 3 1 2p2.454 2p.818 108.6325 0.0
        unit 9
        cuboid 3 1 2p2.454 2p.818 108.6325 0.0
        unit 10
        cylinder 2 1 0.5565 .3175 0.0
        cuboid 3 1 2p0.818 2p2.454 0.3175 0.0
        unit 11
        cylinder 2 1 0.4675 0.6345 0.0
        cylinder 4 1 0.4675 2.54 0.0
        cylinder 2 1 0.5565 2.54 0.0
        cuboid 3 1 4p0.615 2.54 0.0
        cuboid 2 1 2p0.818 2p2.454 2.54 0.0
        unit 12
        cylinder 4 1 0.4675 108.6325 0.0
        cylinder 2 1 0.5565 108.6325 0.0

```

```

cuboid    3 1 2p0.818  2p2.454 108.6325 0.0
unit 13
cuboid    3 1 2p0.818  2p2.454   0.3175 0.0
unit 14
cuboid    3 1 4p0.615    2.54      0.0
cuboid    2 1 2p0.818  2p2.454    2.54 0.0
unit 15
cuboid    3 1 2p0.818  2p2.454 108.6325 0.0
unit 16
array 1   3*0.0
unit 17
array 2   3*0.0
unit 18
array 3   3*0.0
unit 19
array 4   3*0.0
unit 20
array 5   3*0.0
unit 21
array 6   3*0.0
unit 22
array 7   3*0.0
unit 23
array 8   3*0.0
unit 24
array 9   3*0.0
unit 25
array 10  3*0.0
unit 26
array 11  3*0.0
global unit 27
array 12  3*0.0
cuboid 2 1 78.528 0.0 78.528 0.0 111.49 -5.08
cuboid 3 1 78.528 0.0 78.528 0.0 111.49 -7.62
cuboid 2 1 78.528 0.0 78.528 0.0 111.49 -8.89
reflector 3 1 4r3 2r0 8
end geom

read array
ara=1 nux=1 nuy=1 nuz=3 fill 1 4 7    end fill
ara=2 nux=1 nuy=1 nuz=3 fill 2 5 8    end fill
ara=3 nux=1 nuy=1 nuz=3 fill 3 6 9    end fill
ara=4 nux=1 nuy=1 nuz=3 fill 10 11 12 end fill
ara=5 nux=1 nuy=1 nuz=3 fill 13 14 15 end fill
ara=6 nux=14 nuy=14 nuz=1 fill f16    end fill
ara=7 nux=1 nuy=14 nuz=1
fill 2r18 17 4r18 17 3r18 17 2r18    end fill
ara=8 nux=5 nuy=1 nuz=1
fill 21 22 21 22 21    end fill
ara=9 nux=14 nuy=1 nuz=1
fill 2r20 19 3r20 19 3r20 19 3r20    end fill
ara=10 nux=20 nuy=1 nuz=1
fill 5r20 19 8r20 19 5r20    end fill
ara=11 nux=3 nuy=1 nuz=1 fill 24 25 24 end fill
ara=12 nux=1 nuy=5 nuz=1
fill 23 26 23 26 23    end fill
end array
end data
end

```

bw1484s1

```

#csas25
bw1484s1
44group latticecell
uo2 1 den=10.22 1.0 293 92235 2.459 92238 97.541
al 2 1.0
h2o 3 1.0
boron 3 den=514e-6
c 4 0 2.012-4
mn 4 0 1.470-3
si 4 0 1.004-3
cr 4 0 1.677-2
ni 4 0 6.600-3
fe 4 0 6.184-2
end comp
squarepitch 1.636 1.030 1 3 1.206 2 1.044 0
9-14x14 assemblies separated by 0.645-cm-thick 304-L stainless steel
'plates and 0.991 cm of water, plates-to-center assembly distance of
'0.4525 cm, 149.90 cm water height with 514 ppm boron
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.515 0.635 0.0
cylinder 0 1 0.522 0.635 0.0
cuboid 2 1 4p0.818 0.635 0.0
unit 2
cylinder 1 1 0.515 147.0425 0.0
cylinder 0 1 0.522 147.0425 0.0
cylinder 2 1 0.603 147.0425 0.0
cuboid 3 1 4p0.818 147.0425 0.0
unit 3
cuboid 2 1 4p0.818 0.635 0.0
unit 4
cylinder 2 1 0.635 147.0425 0.0
cuboid 3 1 4p0.818 147.0425 0.0
unit 5
array 1 3*0.0
unit 6
array 2 3*0.0
unit 7
array 3 2r-22.904 0.0
reflector 3 1 0.7215 9.808 .7215 9.808 2r0 1
reflector 4 1 0.231 0. 0.231 3r0 1
unit 8
array 3 2r-22.904 0.0
reflector 3 1 2r0.4525 0.7215 9.808 2r0 1
reflector 4 1 3r0.231 3r0 1
unit 9
array 3 2r-22.904 0.0
reflector 3 1 9.808 0.7215 0.7215 9.808 2r0 1
reflector 4 1 0. 2r0.231 3r0 1
unit 10
array 3 2r-22.904 0.0
reflector 3 1 0.7215 9.808 2r0.4525 2r0 1
reflector 4 1 0.231 0. 2r0.231 2r0 1
unit 11
array 3 2r-22.904 0.0

```

```

reflector 3 1 4r0.4525          2r0  1
reflector 4 1 4r0.231           2r0  1
unit 12
array 3 2r-22.904 0.0
reflector 3 1 9.808 0.7215 2r0.4525    2r0  1
reflector 4 1 0. 3r0.231         2r0  1
unit 13
array 3 2r-22.904 0.0
reflector 3 1 0.7215 9.808 9.808 0.7215   2r0  1
reflector 4 1 0.231 2r0. 0.231        2r0  1
unit 14
array 3 2r-22.904 0.0
reflector 3 1 2r0.4525 9.808 0.7215    2r0  1
reflector 4 1 2r0.231 0. 0.231         2r0  1
unit 15
array 3 2r-22.904 0.0
reflector 3 1 9.808 0.7215 9.808 0.7215   2r0  1
reflector 4 1 0. 0.231 0. 0.231         2r0  1
global unit 16
array 4 2*-45.808 0.0
reflector 2 1 5r0 1.905 1
reflector 2 1 5r0 2.54 1
reflector 3 1 5r0 0.3175 1
reflector 2 1 5r0 5.08 1
reflector 3 1 4r20 2r0 1
end geom

read array
ara1 nux=1 nuy=1 nuz=2 fill 1 2           end fill
ara2 nux=1 nuy=1 nuz=2 fill 3 4           end fill
ara3 nux=14 nuy=14 nuz=1 fill 6 12r5 6 14r5 11q14 6 12r5 6 end fill
ara4 nux=3 nuy=3 nuz=1 fill 7 8 9 10 11 12 13 14 15 end fill
end array
end data
end

bwl484s2

#csas25
bwl484s2
44group latticecell
uo2 1 den=10.22 1.0 293 92235 2.459 92238 97.541      end
al 2 1.0           end
h2o 3 1.0           end
boron 3 den=432e-6       end
c 4 0 2.012-4       end
mn 4 0 1.470-3       end
si 4 0 1.004-3       end
cr 4 0 1.677-2       end
ni 4 0 6.600-3       end
fe 4 0 6.184-2       end
end comp
squarepitch 1.636 1.030 1 3 1.206 2 1.044 0       end
9-14x14 assemblies separated by 0.645-cm-thick 304-L stainless steel
'plates and 0.991 cm of water, plates-to-center assembly distance of
'0.4525 cm, 100.89 cm water height with 432 ppm boron
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.515 0.635 0.0
cylinder 0 1 0.522 0.635 0.0
cuboid 2 1 4p0.818 0.635 0.0
unit 2
cylinder 1 1 0.515 98.0325 0.0
cylinder 0 1 0.522 98.0325 0.0
cylinder 2 1 0.603 98.0325 0.0
cuboid 3 1 4p0.818 98.0325 0.0
unit 3
cuboid 2 1 4p0.818 0.635 0.0
unit 4
cylinder 2 1 0.635 98.0325 0.0
cuboid 3 1 4p0.818 98.0325 0.0
unit 5
array 1 3*0.0
unit 6
array 2 3*0.0
unit 7
array 3 2r-22.904 0.0
reflector 3 1 0.7215 9.808 0.7215 9.808 2r0 1
reflector 4 1 0.231 0. 0.231            3r0  1
unit 8
array 3 2r-22.904 0.0
reflector 3 1 2r0.4525 0.7215 9.808 2r0 1
reflector 4 1 3r0.231                3r0  1
unit 9
array 3 2r-22.904 0.0
reflector 3 1 9.808 0.7215 0.7215 9.808 2r0 1
reflector 4 1 0. 2r0.231              3r0  1
unit 10
array 3 2r-22.904 0.0
reflector 3 1 0.7215 9.808 2r0.4525 2r0 1
reflector 4 1 0.231 0. 2r0.231        2r0  1
unit 11
array 3 2r-22.904 0.0
reflector 3 1 4r0.4525               2r0  1
reflector 4 1 4r0.231                2r0  1
unit 12
array 3 2r-22.904 0.0
reflector 3 1 9.808 0.7215 2r0.4525 2r0 1
reflector 4 1 0. 3r0.231              2r0  1
unit 13
array 3 2r-22.904 0.0
reflector 3 1 0.7215 9.808 9.808 0.7215 2r0 1
reflector 4 1 0.231 2r0. 0.231        2r0  1
unit 14
array 3 2r-22.904 0.0
reflector 3 1 2r0.4525 9.808 0.7215 2r0 1
reflector 4 1 2r0.231 0. 0.231        2r0  1
unit 15
array 3 2r-22.904 0.0
reflector 3 1 9.808 0.7215 9.808 0.7215 2r0 1
reflector 4 1 0. 0.231 0. 0.231        2r0  1
global unit 16
array 4 2*-45.808 0.0
reflector 2 1 5r0 1.905 1
reflector 2 1 5r0 2.54 1
reflector 3 1 5r0 0.3175 1

```

```

reflector 2 1 5r0 5.08 1
reflector 3 1 4r20 2r0 1
end geom

read array
ara=1 nux=1 nuy=1 nuz=2 fill 1 2
ara=2 nux=1 nuy=1 nuz=2 fill 3 4
ara=3 nux=14 nuy=14 nuz=1 fill 6 12r5 6 14r5 11q14 6 12r5 6
ara=4 nux=3 nuy=3 nuz=1 fill 7 8 9 10 11 12 13 14 15
end array
end data
end

bwl484s1

#csas25
bwl484s1
44group latticecell
uo2 1 den=10.22 1.0 293 92235 2.459 92238 97.541
al 2 1.0
h2o 3 1.0
end comp
squarepitch 1.636 1.030 1 3 1.206 2 1.044 0
9-14x14 assemblies separated by 6.544 cm of water, 129.65 cm water
'height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 2 1 0.603 .3175 0.0
cuboid 3 1 4p0.818 .3175 0.0
unit 2
cylinder 1 1 0.515 2.54 0.0
cylinder 0 1 0.522 2.54 0.0
cylinder 2 1 0.603 2.54 0.0
cuboid 3 1 4p0.615 2.54 0.0
cuboid 2 1 4p0.818 2.54 0.0
unit 3
cylinder 1 1 0.515 126.7925 0.0
cylinder 0 1 0.522 126.7925 0.0
cylinder 2 1 0.603 126.7925 0.0
cuboid 3 1 4p0.818 126.7925 0.0
unit 4
array 1 3*0.0
reflector 3 1 4r3.272 2r0 1
global unit 5
array 2 3*0.0
reflector 2 1 5r0.0 5.08 1
reflector 3 1 5r0.0 2.54 1
reflector 2 1 5r0.0 1.27 1
reflector 3 1 4r24. 2r0. 1
end geom

read array
ara=1 nux=14 nuy=14 nuz=3 fill 196r1 196r2 196r3 end fill
ara=2 nux=3 nuy=3 nuz=1 fill f4 end fill
end array
end data
end

```

bwl645s1

```

#csas25
bw1645s1
44group latticecell
uo2 1 0.9325 293 92235 2.459 92238 97.541
al 2 1.0 293
h2o 3 1.0 293
boron 3 den=746.0-6
al 4 .25 293
h2o 4 .75 293
boron 4 den=746.0-6 .75
carbonsteel 5 1.0 293
end comp
squarepitch 1.2090 1.0300 1 3 1.2060 2 1.0440 0
9-15x15 assemblies separated by 0.0762-cm-thick aluminum plates and
'1.6256 cm of water, 100.24 cm water height with 746 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 1
cylinder 2 1 0.6030 100.24 -.318
cuboid 3 1 4p.6045 100.24 -.318
unit 2
cylinder 1 1 0.5150 100.24 0.0
cylinder 0 1 0.5220 100.24 0.0
cylinder 2 1 0.6030 100.24 -.318
cuboid 3 1 4p.6045 100.24 -.318
unit 3
array 1 -9.0675 -9.0675 -0.318
cuboid 3 1 2p9.955 2p9.0675 100.24 -.318
unit 4
cuboid 3 1 2p9.955 2p0.8875 100.24 -.318
unit 5
cuboid 3 1 2p7.62 2p0.8113 100.24 -.318
cuboid 2 1 2p7.62 2p0.8875 100.24 -.318
cuboid 3 1 2p9.955 2p0.8875 100.24 -.318
global unit 6
array 2 -49.775 -48.8875 -.318
reflector 4 1 5r0 1.067 1
reflector 2 1 5r0 1.815 1
reflector 3 1 10 10 10 10 0 0 1
reflector 2 1 4r0 0 8.9 1
reflector 3 1 4r0 0 2.86 1
reflector 5 1 4r0 0 1.0 1
reflector 3 1 4r20 0 0 1
end geom

read array
ara=1 nux=15 nuy=15 nuz=1
fill 1 13r2 1 15r2 12q15 1 13r2 1
ara=2 nux=5 nuy=9 nuz=1 fill 5r3 4 3r5 4 3q10 5r3 end fill
end array
end data
end

```

bw1645s2

```
#csas25
bw1645s2
44group          latticecell
uo2      1  0.9325 293 92235 2.459 92238 97.541    end
al       2  1.0 293                                end
h2o      3  1.0 293                                end
boron   3  den=886.0-6                            end
al       4  .25 293                                end
h2o      4  .75 293                                end
boron   4  den=886.0-6 .75                          end
carbonsteel 5  1.0 293                                end
end comp
squarepitch 1.2090 1.0300 1  3  1.2060 2  1.0440 0    end
9-15x15 assemblies separated by 0.0762-cm-thick aluminum plates and
'1.6256 cm of water, 145.00 cm water height with 886 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes
end parm
```

```
read geom
unit 1
cylinder 2 1 0.6030          145.0  -.318
cuboid   3 1 4p.6045          145.0  -.318
unit 2
cylinder 1 1 0.5150          145.0   0.0
cylinder 0 1 0.5220          145.0   0.0
cylinder 2 1 0.6030          145.0  -.318
cuboid   3 1 4p.6045          145.0  -.318
unit 3
array    1 -9.0675 -9.0675 -0.318
cuboid   3 1 2p9.955 2p9.0675 145.0  -.318
unit 4
cuboid   3 1 2p9.955 2p0.8875 145.0  -.318
unit 5
cuboid   3 1 2p7.62 2p0.8113 145.0  -.318
cuboid   2 1 2p7.62 2p0.8875 145.0  -.318
cuboid   3 1 2p9.955 2p0.8875 145.0  -.318
global unit 6
array    2 -49.775  -48.8875  -.318
reflector 4 1 5r0           1.067  1
reflector 2 1 5r0           1.815  1
reflector 3 1 10 10 10 10 0  0  1
reflector 2 1 4r0           0     8.9  1
reflector 3 1 4r0           0     2.86 1
reflector 5 1 4r0           0     1.0  1
reflector 3 1 4r20          0     0  1
end geom
```

```
read array
ara=1 nux=15 nuy=15 nuz=1
fill 1 13r2 1 15r2 12q15 1 13r2 1 end fill
ara=2 nux=5  nuy=9  nuz=1
fill 5r3 4 3r5 4 3q10 5r3      end fill
end array
end data
end
```

bw1645t1

```
#csas25
bw1645t1
44group          latticecell
uo2      1  den=10.22 1.0 293 92235 2.459 92238 97.541
end
al       2  1.0 293                                end
h2o      3  1.0 293                                end
boron   3  den=335.0-6                            end
al       4  .25 293                                end
h2o      4  .75 293                                end
boron   4  den=335.0-6 .75                          end
carbonsteel 5  1.0 293                                end
end comp
triangpitch 1.2093 1.030 1  3  1.206 2  1.044 0    end
5x5 array of hexagonal lattice assemblies separated by 0.0762-cm-thick
'aluminum plates and 1.6256- and 1.7926-cm of water, 104.82 cm water
'height with 335 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm
```

```
read geom
unit 1
zhemicyl-y 1 1  0.515          104.82  0.0
zhemicyl-y 0 1  0.522          104.82  0.0
zhemicyl-y 2 1  0.603          104.82 -0.318
unit 2
zhemicyl+y 1 1  0.515          104.82  0.0
zhemicyl+y 0 1  0.522          104.82  0.0
zhemicyl+y 2 1  0.603          104.82 -0.318
unit 3
zhemicyl-x 1 1  0.515          104.82  0.0
zhemicyl-x 0 1  0.522          104.82  0.0
zhemicyl-x 2 1  0.603          104.82 -0.318
unit 4
zhemicyl+x 1 1  0.515          104.82  0.0
zhemicyl+x 0 1  0.522          104.82  0.0
zhemicyl+x 2 1  0.603          104.82 -0.318
unit 5
zhemicyl-y 2 1  0.603          104.82 -0.318
unit 6
zhemicyl+y 2 1  0.603          104.82 -0.318
unit 11
zhemicyl-y 1 1  0.515          104.82  0.0
zhemicyl-y 0 1  0.522          104.82  0.0
zhemicyl-y 2 1  0.603          104.82 -0.318
cuboid   3 1 2p0.6047 0 -2.0946 104.82 -0.318
hole     2 0   -2.0946 0
hole     3 +0.6047 -1.0473 0
hole     4 -0.6047 -1.0473 0
unit 12
zhemicyl-y 1 1  0.515          104.82  0.0
zhemicyl-y 0 1  0.522          104.82  0.0
zhemicyl-y 2 1  0.603          104.82 -0.318
cuboid   3 1 2p0.6047 0 -2.0946 104.82 -0.318
hole     2 0   -2.0946 0
hole     3 +0.6047 -1.0473 0
unit 13
zhemicyl-y 1 1  0.515          104.82  0.0
```

```

zhemicyl-y 0 1    0.522          104.82   0.0
zhemicyl-y 2 1    0.603          104.82  -0.318
cuboid   3 1 2p0.6047 0 -2.0946  104.82  -0.318
hole     2 0      -2.0946  0
hole     4  -0.6047 -1.0473  0
unit 14
zhemicyl-y 1 1    0.515          104.82   0.0
zhemicyl-y 0 1    0.522          104.82   0.0
zhemicyl-y 2 1    0.603          104.82  -0.318
cuboid   3 1 2p0.6047 0 -2.0946  104.82  -0.318
hole     6 0      -2.0946  0
hole     3  +0.6047 -1.0473  0
unit 15
zhemicyl-y 1 1    0.515          104.82   0.0
zhemicyl-y 0 1    0.522          104.82   0.0
zhemicyl-y 2 1    0.603          104.82  -0.318
cuboid   3 1 2p0.6047 0 -2.0946  104.82  -0.318
hole     6 0      -2.0946  0
hole     4  -0.6047 -1.0473  0
unit 16
zhemicyl-y 2 1    0.603          104.82  -0.318
cuboid   3 1 2p0.6047 0 -2.0946  104.82  -0.318
hole     2 0      -2.0946  0
hole     3  +0.6047 -1.0473  0
unit 17
zhemicyl-y 2 1    0.603          104.82  -0.318
cuboid   3 1 2p0.6047 0 -2.0946  104.82  -0.318
hole     2 0      -2.0946  0
hole     4  -0.6047 -1.0473  0
unit 18
zhemicyl-y 1 1    0.515          104.82   0.0
zhemicyl-y 0 1    0.522          104.82   0.0
zhemicyl-y 2 1    0.603          104.82  -0.318
cuboid   3 1 2p0.6047 0 -.6047   104.82  -0.318
unit 19
zhemicyl+y 1 1   0.515          104.82   0.0
zhemicyl+y 0 1   0.522          104.82   0.0
zhemicyl+y 2 1   0.603          104.82  -0.318
cuboid   3 1 2p0.6047 .6047  0  104.82  -0.318
unit 20
zhemicyl-y 2 1   0.603          104.82  -0.318
cuboid   3 1 2p0.6047 0 -.6047   104.82  -0.318
unit 21
zhemicyl+y 2 1   0.603          104.82  -0.318
cuboid   3 1 2p0.6047 .6047  0  104.82  -0.318
unit 31
array    1 -9.0705 -8.9831      -0.318
cuboid   3 1 2p9.9578 2p8.9831  104.82  -0.318
unit 32
cuboid   3 1 2p9.9578 2p0.9708  104.82  -0.318
unit 33
cuboid   3 1 2p7.62 2p0.8946   104.82  -0.318
cuboid   2 1 2p7.62 2p0.9708   104.82  -0.318
cuboid   3 1 2p9.9578 2p0.9708  104.82  -0.318
global unit 34
array    2 -49.789 -48.7987     -0.318
reflector 4 1 5r0                 1.067  1
reflector 2 1 5r0                 1.815  1
reflector 3 1 2r11.2025 2r12.5285 2r0  1
reflector 2 1 4r0                 0       8.9   1
reflector 3 1 4r0                 0       2.86  1
reflector 5 1 4r0                 0       1.0   1
reflector 3 1 2r18.7975 2r17.4715 2r0  1
end geom
read array
ara=1 nux=15 nuy=10 nuz=1 fill 20 13r18 20 14 13r11 15 12 13r11 13
5q15 16 13r11 17 21 13r19 21
end fill
ara=2 nux=5 nuy=9 nuz=1 fill 5r31 32 3r33 32 3q10 5r31
end fill
end array
end data
end
bw1645t2
#csas25
bw1645t2
44group           latticecell
uo2   1  den=10.22 1.0 293 92235 2.459 92238 97.541
al    2  1.0 293
h2o   3  1.0 293
boron 3  den=435.0-6
al    4  .25 293
h2o   4  .75 293
boron 4  den=435.0-6 .75
carbonsteel 5  1.0 293
end comp
triangpitch 1.2093 1.030 1 3 1.206 2 1.044 0
5x5 array of hexagonal lattice assemblies separated by 0.0762-cm-thick
'aluminum plates and 1.6256- and 1.7926-cm of water, 143.96 cm water
'height with 435 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm
read geom
unit 1
zhemicyl-y 1 1 .515          143.96   0.0
zhemicyl-y 0 1 .522          143.96   0.0
zhemicyl-y 2 1 .603          143.96  -0.318
unit 2
zhemicyl+y 1 1 .515          143.96   0.0
zhemicyl+y 0 1 .522          143.96   0.0
zhemicyl+y 2 1 .603          143.96  -0.318
unit 3
zhemicyl-x 1 1 .515          143.96   0.0
zhemicyl-x 0 1 .522          143.96   0.0
zhemicyl-x 2 1 .603          143.96  -0.318
unit 4
zhemicyl+x 1 1 .515          143.96   0.0
zhemicyl+x 0 1 .522          143.96   0.0
zhemicyl+x 2 1 .603          143.96  -0.318
unit 5
zhemicyl-y 2 1 .603          143.96  -0.318
unit 6
zhemicyl+y 2 1 .603          143.96  -0.318
unit 11
zhemicyl-y 1 1 .515          143.96   0.0
zhemicyl-y 0 1 .522          143.96   0.0
zhemicyl-y 2 1 .603          143.96  -0.318

```

```

cuboid    3 1 2p.6047  0 -2.0946 143.96 -0.318
hole      2 0          -2.0946        0.0
hole      3 +0.6047   -1.0473        0.0
hole      4 -0.6047   -1.0473        0.0
unit 12
zhemicyl-y 1 1 .515           143.96  0.0
zhemicyl-y 0 1 .522           143.96  0.0
zhemicyl-y 2 1 .603           143.96 -0.318
cuboid    3 1 2p.6047  0 -2.0946 143.96 -0.318
hole      2 0          -2.0946        0.0
hole      3 +0.6047   -1.0473        0.0
unit 13
zhemicyl-y 1 1 .515           143.96  0.0
zhemicyl-y 0 1 .522           143.96  0.0
zhemicyl-y 2 1 .603           143.96 -0.318
cuboid    3 1 2p.6047  0 -2.0946 143.96 -0.318
hole      2 0          -2.0946        0.0
hole      4 -0.6047   -1.0473        0.0
unit 14
zhemicyl-y 1 1 .515           143.96  0.0
zhemicyl-y 0 1 .522           143.96  0.0
zhemicyl-y 2 1 .603           143.96 -0.318
cuboid    3 1 2p.6047  0 -2.0946 143.96 -0.318
hole      6 0          -2.0946        0.0
hole      3 +0.6047   -1.0473        0.0
unit 15
zhemicyl-y 1 1 .515           143.96  0.0
zhemicyl-y 0 1 .522           143.96  0.0
zhemicyl-y 2 1 .603           143.96 -0.318
cuboid    3 1 2p.6047  0 -2.0946 143.96 -0.318
hole      6 0          -2.0946        0.0
hole      4 -0.6047   -1.0473        0.0
unit 16
zhemicyl-y 2 1 .603           143.96 -0.318
cuboid    3 1 2p.6047  0 -2.0946 143.96 -0.318
hole      2 0          -2.0946        0.0
hole      3 +0.6047   -1.0473        0.0
unit 17
zhemicyl-y 2 1 .603           143.96 -0.318
cuboid    3 1 2p.6047  0 -2.0946 143.96 -0.318
hole      2 0          -2.0946        0.0
hole      4 -0.6047   -1.0473        0.0
unit 18
zhemicyl-y 1 1 .515           143.96  0.0
zhemicyl-y 0 1 .522           143.96  0.0
zhemicyl-y 2 1 .603           143.96 -0.318
cuboid    3 1 2p.6047  0 -.6047 143.96 -0.318
unit 19
zhemicyl+y 1 1 .515          143.96  0.0
zhemicyl+y 0 1 .522          143.96  0.0
zhemicyl+y 2 1 .603          143.96 -0.318
cuboid    3 1 2p.6047 .6047  0 143.96 -0.318
unit 20
zhemicyl-y 2 1 .603           143.96 -0.318
cuboid    3 1 2p.6047  0 -.6047 143.96 -0.318
unit 21
zhemicyl+y 2 1 .603          143.96 -0.318
cuboid    3 1 2p.6047 .6047  0 143.96 -0.318
unit 31
array     1   -9.0705 -8.9831        -0.318
cuboid    3 1 2p9.9578 2p8.9831 143.96 -0.318
unit 32
cuboid    3 1 2p9.9578 2p0.9708 143.96 -0.318
unit 33
cuboid    3 1 2p7.62 2p0.8946 143.96 -0.318
cuboid    2 1 2p7.62 2p0.9708 143.96 -0.318
cuboid    3 1 2p9.9578 2p0.9708 143.96 -0.318
global unit 34
array     2   -49.789 -48.7987        -0.318
reflector 4 1 5r0       1.067      1
reflector 2 1 5r0       1.815      1
reflector 3 1 2r11.2025 2r12.5285 2r0 1
reflector 2 1 4r0       0 8.9       1
reflector 3 1 4r0       0 2.86      1
reflector 5 1 4r0       0 1.0       1
reflector 3 1 2r18.7975 2r17.4715 2r0 1
end geom

read array
ara=1 nux=15 nuy=10 nuz=1 fill 20 13r18 20 14 13r11 15 12 13r11 13
5q15 16 13r11 17 21 13r19 21
end fill
ara=2 nux=5 nuy=9 nuz=1 fill 5r31 32 3r33 32 3q10 5r31
end fill
end array
end data
end

bw1645t3

#csas25
bw1645t3
44group latticecell
uo2      1 den=10.22 1.0 293 92235 2.459 92238 97.541 end
al       2 1.0 293
end
h2o      3 1.0 293
end
boron   3 den=361.0-6
end
al       4 .25 293
end
h2o      4 .75 293
end
boron   4 den=361.0-6 .75
end
carbonsteel 5 1.0 293
end
end comp
triangpitch 1.2093 1.030 1 3 1.206 2 1.044 0
5x5 array of hexagonal lattice assemblies separated by
0.0762-cm-thick
'aluminum plates and 2.3866- and 2.5566-cm of water, 142.54 cm
water
height with 361 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 1
zhemicyl-y 1 1 .515          142.54  0.0
zhemicyl-y 0 1 .522          142.54  0.0
zhemicyl-y 2 1 .603          142.54 -0.318
unit 2
zhemicyl+y 1 1 .515          142.54  0.0
zhemicyl+y 0 1 .522          142.54  0.0
zhemicyl+y 2 1 .603          142.54 -0.318

```

```

unit 3
zhemicyl-x 1 1 .515          142.54  0.0
zhemicyl-x 0 1 .522          142.54  0.0
zhemicyl-x 2 1 .603          142.54 -0.318
unit 4
zhemicyl+x 1 1 .515          142.54  0.0
zhemicyl+x 0 1 .522          142.54  0.0
zhemicyl+x 2 1 .603          142.54 -0.318
unit 5
zhemicyl-y 2 1 .603          142.54 -0.318
unit 6
zhemicyl+y 2 1 .603          142.54 -0.318
unit 11
zhemicyl-y 1 1 .515          142.54  0.0
zhemicyl-y 0 1 .522          142.54  0.0
zhemicyl-y 2 1 .603          142.54 -0.318
cuboid 3 1 2p.6047 0 -2.0946 142.54 -0.318
hole 2 0 -2.0946 -0.0
hole 3 +0.6047 -1.0473 -0.0
hole 4 -0.6047 -1.0473 -0.0
unit 12
zhemicyl-y 1 1 .515          142.54  0.0
zhemicyl-y 0 1 .522          142.54  0.0
zhemicyl-y 2 1 .603          142.54 -0.318
cuboid 3 1 2p.6047 0 -2.0946 142.54 -0.318
hole 2 0 -2.0946 -0.0
hole 3 +0.6047 -1.0473 -0.0
unit 13
zhemicyl-y 1 1 .515          142.54  0.0
zhemicyl-y 0 1 .522          142.54  0.0
zhemicyl-y 2 1 .603          142.54 -0.318
cuboid 3 1 2p.6047 0 -2.0946 142.54 -0.318
hole 2 0 -2.0946 -0.0
hole 4 -0.6047 -1.0473 -0.0
unit 14
zhemicyl-y 1 1 .515          142.54  0.0
zhemicyl-y 0 1 .522          142.54  0.0
zhemicyl-y 2 1 .603          142.54 -0.318
cuboid 3 1 2p.6047 0 -2.0946 142.54 -0.318
hole 6 0 -2.0946 -0.0
hole 3 +0.6047 -1.0473 -0.0
unit 15
zhemicyl-y 1 1 .515          142.54  0.0
zhemicyl-y 0 1 .522          142.54  0.0
zhemicyl-y 2 1 .603          142.54 -0.318
cuboid 3 1 2p.6047 0 -2.0946 142.54 -0.318
hole 6 0 -2.0946 -0.0
hole 4 -0.6047 -1.0473 -0.0
unit 16
zhemicyl-y 2 1 .603          142.54 -0.318
cuboid 3 1 2p.6047 0 -2.0946 142.54 -0.318
hole 2 0 -2.0946 -0.0
hole 3 +0.6047 -1.0473 -0.0
unit 17
zhemicyl-y 2 1 .603          142.54 -0.318
cuboid 3 1 2p.6047 0 -2.0946 142.54 -0.318
hole 2 0 -2.0946 -0.0
hole 4 -0.6047 -1.0473 -0.0

```

```

unit 18
zhemicyl-y 1 1 .515          142.54  0.0
zhemicyl-y 0 1 .522          142.54  0.0
zhemicyl-y 2 1 .603          142.54 -0.318
cuboid 3 1 2p.6047 0 -.6047 142.54 -0.318
unit 19
zhemicyl+y 1 1 .515          142.54  0.0
zhemicyl+y 0 1 .522          142.54  0.0
zhemicyl+y 2 1 .603          142.54 -0.318
cuboid 3 1 2p.6047 .6047 0 142.54 -0.318
unit 20
zhemicyl-y 2 1 .603          142.54 -0.318
cuboid 3 1 2p.6047 0 -.6047 142.54 -0.318
unit 21
zhemicyl+y 2 1 .603          142.54 -0.318
cuboid 3 1 2p.6047 .6047 0 142.54 -0.318
unit 31
array 1 -9.0705 -8.9831 -0.318
cuboid 3 1 2p10.4233 2p8.9831 142.54 -0.318
unit 32
cuboid 3 1 2p10.4233 2p1.3528 142.54 -0.318
unit 33
cuboid 3 1 2p7.62 2p1.2766 142.54 -0.318
cuboid 2 1 2p7.62 2p1.3528 142.54 -0.318
cuboid 3 1 2p10.4233 2p1.3528 142.54 -0.318
global unit 34
array 2 -52.1165 -50.267 -0.318
reflector 4 1 5r0 1.067 1
reflector 2 1 5r0 1.815 1
reflector 3 1 2r9.3 2r11.0065 2r0 1
reflector 2 1 4r0 0 8.9 1
reflector 3 1 4r0 0 2.86 1
reflector 5 1 4r0 0 1.0 1
reflector 3 1 2r20.7 2r18.9935 2r0 1
end geom

read array
ara=1 nux=15 nuy=10 nuz=1 fill 20 13r18 20 14 13r11 15 12 13r11 13
5q15 16 13r11 17 21 13r19 21 end fill
ara=2 nux=5 nuy=9 nuz=1 fill 5r31 32 3r33 32 3q10 5r31 end fill
end array
end data
end

bw1645t4

#csas25
bw1645t4
44group latticecell
u02      1 den=10.22 1.0 293 92235 2.459 92238 97.541 end
al       2 1.0 293 end
h2o      3 1.0 293 end
boron   3 den=121.0-6 end
al       4 .25 293 end
h2o      4 .75 293 end
boron   4 den=121.0-6 .75 end
carbonsteel 5 1.0 293 end
end comp
triangpitch 1.2093 1.030 1 3 1.206 2 1.044 0 end

```

```

5x5 array of hexagonal lattice assemblies separated by
  0.0762-cm-thick
'aluminum plates and 3.6546- and 3.8236-cm of water, 145.64 cm water
'height with 121 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 1
zhemicyl-y 1 1 .515          145.64  0.0
zhemicyl-y 0 1 .522          145.64  0.0
zhemicyl-y 2 1 .603          145.64 -0.318
unit 2
zhemicyl+y 1 1 .515          145.64  0.0
zhemicyl+y 0 1 .522          145.64  0.0
zhemicyl+y 2 1 .603          145.64 -0.318
unit 3
zhemicyl-x 1 1 .515          145.64  0.0
zhemicyl-x 0 1 .522          145.64  0.0
zhemicyl-x 2 1 .603          145.64 -0.318
unit 4
zhemicyl+x 1 1 .515          145.64  0.0
zhemicyl+x 0 1 .522          145.64  0.0
zhemicyl+x 2 1 .603          145.64 -0.318
unit 5
zhemicyl-y 2 1 .603          145.64 -0.318
unit 6
zhemicyl+y 2 1 .603          145.64 -0.318
unit 11
zhemicyl-y 1 1 .515          145.64  0.0
zhemicyl-y 0 1 .522          145.64  0.0
zhemicyl-y 2 1 .603          145.64 -0.318
cuboid 3 1 2p.6047 0 -2.0946 145.64 -0.318
hole   2 0 -2.0946 -0.0
hole   3 +0.6047 -1.0473 -0.0
hole   4 -0.6047 -1.0473 -0.0
unit 12
zhemicyl-y 1 1 .515          145.64  0.0
zhemicyl-y 0 1 .522          145.64  0.0
zhemicyl-y 2 1 .603          145.64 -0.318
cuboid 3 1 2p.6047 0 -2.0946 145.64 -0.318
hole   2 0 -2.0946 -0.0
hole   3 +0.6047 -1.0473 -0.0
unit 13
zhemicyl-y 1 1 .515          145.64  0.0
zhemicyl-y 0 1 .522          145.64  0.0
zhemicyl-y 2 1 .603          145.64 -0.318
cuboid 3 1 2p.6047 0 -2.0946 145.64 -0.318
hole   2 0 -2.0946 -0.0
hole   4 -0.6047 -1.0473 -0.0
unit 14
zhemicyl-y 1 1 .515          145.64  0.0
zhemicyl-y 0 1 .522          145.64  0.0
zhemicyl-y 2 1 .603          145.64 -0.318
cuboid 3 1 2p.6047 0 -2.0946 145.64 -0.318
hole   6 0 -2.0946 -0.0
hole   3 +0.6047 -1.0473 -0.0
unit 15
zhemicyl-y 1 1 .515          145.64  0.0
zhemicyl-y 0 1 .522          145.64  0.0

```

```

zhemicyl-y 2 1 .603          145.64 -0.318
cuboid 3 1 2p.6047 0 -2.0946 145.64 -0.318
hole   6 0 -2.0946 -0.0
hole   4 -0.6047 -1.0473 -0.0
unit 16
zhemicyl-y 2 1 .603          145.64 -0.318
cuboid 3 1 2p.6047 0 -2.0946 145.64 -0.318
hole   2 0 -2.0946 -0.0
hole   3 +0.6047 -1.0473 -0.0
unit 17
zhemicyl-y 2 1 .603          145.64 -0.318
cuboid 3 1 2p.6047 0 -2.0946 145.64 -0.318
hole   2 0 -2.0946 -0.0
hole   4 -0.6047 -1.0473 -0.0
unit 18
zhemicyl-y 1 1 .515          145.64  0.0
zhemicyl-y 0 1 .522          145.64  0.0
zhemicyl-y 2 1 .603          145.64 -0.318
cuboid 3 1 2p.6047 0 -.6047 145.64 -0.318
unit 19
zhemicyl+y 1 1 .515          145.64  0.0
zhemicyl+y 0 1 .522          145.64  0.0
zhemicyl+y 2 1 .603          145.64 -0.318
cuboid 3 1 2p.6047 .6047 0 145.64 -0.318
unit 20
zhemicyl-y 2 1 .603          145.64 -0.318
cuboid 3 1 2p.6047 0 -.6047 145.64 -0.318
unit 21
zhemicyl+y 2 1 .603          145.64 -0.318
cuboid 3 1 2p.6047 .6047 0 145.64 -0.318
unit 31
array 1 -9.0705 -8.9831 -0.318
cuboid 3 1 2p11.0568 2p8.9831 145.64  0.318
unit 32
cuboid 3 1 2p11.0568 2p1.963 145.64 -0.318
unit 33
cuboid 3 1 2p7.62  2p1.9101 145.64 -0.318
cuboid 2 1 2p7.62  2p1.963 145.64 -0.318
cuboid 3 1 2p11.0568 2p1.963 145.64 -0.318
global unit 34
array 2 -55.284 -52.8607 -0.318
reflector 4 1 5r0 1.067 1
reflector 2 1 5r0 1.815 1
reflector 3 1 2r6.125 2r8.4705 2r0 1
reflector 2 1 4r0 0 8.9 1
reflector 3 1 4r0 0 2.86 1
reflector 5 1 4r0 0 1.0 1
reflector 3 1 2r23.875 2r21.5295 2r0 1
end geom

read array
ara=1 nux=15 nuy=10 nuz=1 fill 20 13r18 20 14 13r11 15 12 13r11 13
5q15 16 13r11 17 21 13r19 21 end fill
ara=2 nux=5 nuy=9 nuz=1 fill 5r31 32 3r33 32 3q10 5r31 end fill
end array
end data
end

```

```

bw1810a
=csas25
bw1810a
44group          latticecell
uo2   1 den=10.24  1.0  293 92235 2.459 92238 97.541
h2o   2 den=1.0    0.998761
boron 2 den=1.0    0.001239
al    3           1.0
uo2   4 den=10.24  0.96 293 92235 1.944 92238 98.056
gd-152 4 den=0.3555 0.002
gd-154 4 den=0.3555 0.0218
gd-155 4 den=0.3555 0.148
gd-156 4 den=0.3555 0.2047
gd-157 4 den=0.3555 0.1565
gd-158 4 den=0.3555 0.2484
gd-160 4 den=0.3555 0.2186
o     4 den=0.0541 1
end comp
squarepitch 1.636 1.0297 1 2 1.2060 3 1.0434 0
more data res=4 cylinder .51499 dan(4)=.189958 end more data
Core of 4788 2.459 wt% 235U fuel rods, 20 UO2-Gd2O3 fuel rods, 153
'water holes, 145.0 cm water height with 1239.3 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 2
cylinder 1 1 .5149 145 .3175
cylinder 0 1 .522 145 .3175
cylinder 3 1 .603 145 0
cuboid 2 1 .818 -.818 .818 -.818 145 0
unit 3
cuboid 2 1 .818 -.818 .818 -.818 145 0
unit 4
array 2 -49.898 -6.544 0
unit 5
array 3 -33.538 -8.180 0
unit 6
array 4 -33.538 -8.180 0
global unit 7
array 1 -66.258 -36.81 0
cylinder 2 1 76.2 145 0.0
hole 4 0 -43.3542 0
hole 4 0 43.3542 0
hole 5 0 -58.0784 0
hole 6 0 58.0784 0
cylinder 3 1 76.2 145 -5.08
cylinder 2 1 76.2 145 -7.62
cylinder 3 1 77.47 145 -8.890
cuboid 0 1 4p77.47 145 -8.890
unit 8
cylinder 4 1 .51499 145 0.3175
cylinder 0 1 .52197 145 0.3175
cylinder 3 1 .60325 145 0
cuboid 2 1 .818 -.818 .818 -.818 145 0
end geom

read array
ara=1 nux=81 nuy=45 fill

```

```

10r3 61r2 10r3
1q81
5r3 15r2 3r2 3 1q4 10r2 3 3r2 3b39
5r3 16r2 3 7r2 3 6r2 3 7r2 7b37
5r3 71r2 5r3
5r3 15r2 3 2r2 3 3r2 3 2r2 3 4r2 3 2r2 3 3r2 3b39
5r3 71r2 5r3
5r3 20r2 3 3r2 8 10r2 3 1b40
5r3 71r2 5r3
5r3 15r2 3 2r2 3 3r2 3 2r2 3 4r2 3 2r2 3 3r2 3b39
5r3 71r2 5r3
5r3 16r2 3 3r2 8 3r2 3 6r2 3 7r2 7b37
23r2 3 3r2 3 2r2 8 7r2 3 3r2 3b39
324r2
20r2 3r2 3 1q4 7r2 8 2r2 3 3r2 3b39
21r2 3 7r2 3 6r2 3 3r2 8 1b40
81r2
20r2 3 2r2 3 3r2 3 2r2 3 4r2 3 2r2 3 3r2 3b39
81r2
25r2 3 10r2 8 3r2 3 1b40
81b1782
ara=2 nux=61 nuy=8 fill f2
ara=3 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1 1
3 1 10 1 1 5 1 1 1 1
3 32 41 1 1 5 1 1 1 1 1
end loop
ara=4 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1
3 1 10 1 6 10 1 1 1 1
3 32 41 1 6 10 1 1 1 1
end loop
end array
end data
end

bw1810b
=csas25
bw1810b
44group          latticecell
uo2   1 den=10.24  1.0  293 92235 2.459 92238 97.541
h2o   2 den=1.0    0.998829
boron 2 den=1.0    0.001171
al    3           1.0
uo2   4 den=10.24  0.96 293 92235 1.944 92238 98.056
gd-152 4 den=0.3555 0.002
gd-154 4 den=0.3555 0.0218
gd-155 4 den=0.3555 0.148
gd-156 4 den=0.3555 0.2047
gd-157 4 den=0.3555 0.1565
gd-158 4 den=0.3555 0.2484
gd-160 4 den=0.3555 0.2186
o     4 den=0.0541 1
end comp
squarepitch 1.636 1.0297 1 2 1.2060 3 1.0434 0
more data res=4 cylinder .51499 dan(4)=.189958 end more data
Core of 4772 2.459 wt% 235U fuel rods, 36 UO2-Gd2O3 fuel rods, 153
'water holes, 145.0 cm water height with 1170.7 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

```

```

read geom
unit 2
cylinder 1 1 .5149          145  0.3175
cylinder 0 1 .522           145  0.3175
cylinder 3 1 .603           145  0
cuboid   2 1 .818 -.818 .818 145  0
unit 3
cuboid   2 1 .818 -.818 .818 145  0
unit 4
array 2 -49.898 -6.544 0
unit 5
array 3 -33.538 -8.180 0
unit 6
array 4 -33.538 -8.180 0
global unit 7
array 1 -66.258 -36.81 0
cylinder 2 1 76.2          145  0.0
hole    4 0 -43.3542 0
hole    4 0 43.3542 0
hole   5 0 -58.0784 0
hole   6 0 58.0784 0
cylinder 3 1 76.2          145 -5.08
cylinder 2 1 76.2          145 -7.62
cylinder 3 1 77.47         145 -8.890
cuboid   0 1 4p77.47        145 -8.890
unit 8
cylinder 4 1 .51499         145  0.3175
cylinder 0 1 .52197         145  0.3175
cylinder 3 1 .60325         145  0
cuboid   2 1 .818 -.818 .818 145  0
end geom

read array
ara=1 nux=81 nuy=45 fill
10r3 61r2 10r3
1q81
5r3 15r2 3r2 3 1q4 10r2 3 3r2 3b39
5r3 16r2 3 7r2 3 6r2 3 7r2 7b37
5r3 71r2 5r3
5r3 15r2 3 2r2 3 3r2 3 2r2 3 4r2 3 2r2 3 3r2 3b39
5r3 71r2 5r3
5r3 20r2 3 3r2 8 10r2 3 1b40
5r3 71r2 5r3
5r3 15r2 3 2r2 3 3r2 3 2r2 3 8 3r2 3 2r2 3 3r2 3b39
5r3 20r2 8 29r2 8 20r2 5r3
5r3 16r2 3 7r2 3 6r2 3 7r2 7b37
23r2 3 3r2 3 2r2 8 7r2 3 3r2 3b39
27r2 8 25r2 8 27r2
162r2
38r2 8 3r2 8 38r2
20r2 3r2 3 1q4 7r2 8 2r2 3 3r2 3b39
21r2 3 7r2 3 6r2 3 7r2 7b37
40r2 8 40r2
20r2 3 2r2 3 3r2 3 2r2 3 3r2 8 3 2r2 3 3r2 3b39
81r2
25r2 3 10r2 8 3r2 3 1b40
81b1782
end fill
ara=2 nux=61 nuy=8 fill f2 end fill

```

```

ara=3 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1 1
3 1 10 1 1 5 1 1 1 1 1
3 32 41 1 1 5 1 1 1 1 1
end loop
ara=4 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1 1
3 1 10 1 6 10 1 1 1 1 1
3 32 41 1 6 10 1 1 1 1 1
end loop
end array
end data
end

bw1810c

=csas25
bw1810c
44group latticecell
uo2 1 den=9.46 1.0 293 92235 4.02 92238 95.98
ss304 2 1.0
h2o 3 den=1.0 0.998501
boron 3 den=1.0 0.001499
uo2 4 den=10.24 1.0 293 92235 2.459 92238 97.541
al 5 1.0
uo2 6 den=10.24 0.96 293 92235 1.944 92238 98.056
gd-152 6 den=0.3555 0.002
gd-154 6 den=0.3555 0.0218
gd-155 6 den=0.3555 0.148
gd-156 6 den=0.3555 0.2047
gd-157 6 den=0.3555 0.1565
gd-158 6 den=0.3555 0.2484
gd-160 6 den=0.3555 0.2186
o 6 den=0.0541 1
end comp
squarepitch 1.636 1.128 1 3 1.208 2
more data res=4 cylinder .51486 dan(4)=.189732
res=6 cylinder .51499 dan(6)=.189958 end more data
Core of 3676 2.459 wt% UO2 fuel rods, 912 4.020 wt% UO2 fuel rods, 32
'UO2-Gd2O3 fuel rods, 180 water holes, 145.0 cm water height with
'1499.0 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 1
cylinder 1 1 .5639 145 5.969
cylinder 2 1 .6039 145 0
cuboid   3 1 .818 -.818 .818 -.818 145 0
unit 2
cylinder 4 1 .5149 145 .3175
cylinder 0 1 .5217 145 .3175
cylinder 5 1 .603 145 0
cuboid   3 1 .818 -.818 .818 -.818 145 0
unit 3
cuboid   3 1 .818 -.818 .818 -.818 145 0
unit 4
array 2 -49.898 -6.544 0
unit 5
array 3 -33.538 -8.180 0
unit 6
array 4 -33.538 -8.180 0

```

global unit 7
array 1 -66.258 -36.81 0
cylinder 3 1 76.2 145 0.0
hole 4 0 -43.3542 0
hole 4 0 43.3542 0
hole 5 0 -58.0784 0
hole 6 0 58.0784 0
cylinder 5 1 76.2 145 -5.08
cylinder 3 1 76.2 145 -7.62
cylinder 5 1 77.47 145 -8.890
cuboid 0 1 4p77.47 145 -8.890
unit 8
cylinder 6 1 .51499 145 .3175
cylinder 0 1 .52197 145 .3175
cylinder 5 1 .60325 145 0
cuboid 3 1 .818 -.818 .818 -.818 145 0
end geom
read array
ara=1 nux=81 nuy=45 fill
10r3 61r2 10r3
10r3 3r2 6r2 2r3 2q8 7r2 7b37
5r3 5x2 3r2 6r2 2r3 2q8 7r2 7b37
5r3 7l1r2 5r3
1q81
5r3 18r2 2r3 14r2 3r3 3b39
5r3 18r2 2r3 14r1 3r3 3b39
5r3 19r2 33r1 19r2 5r3
5r3 19r2 2r1 8 3r1 8 19r1 19b31
5r3 14r2 2r3 3r2 3r1 2r3 6r1 2r3 7r1 7b37
1q81
5r3 19r2 33r1 19r2 5r3
24r2 2r1 8 3r1 8 19r1 19b31
24r2 33r1 24r2
1q81
24r2 9r1 8 3r1 8 5r1 5b38
24r2 33r1 24r2
19r2 2r3 3r2 3r1 2r3 6r1 2r3 7r1 7b37
1q81
24r2 9r1 8 3r1 8 5r1 5b38
24r2 33r1 24r2
23r2 2r3 14r1 3r3 3b39
1q81
81b1782
end fill
ara=2 nux=61 nuy=8 fill f2 end fill
ara=3 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1 1
3 1 10 1 1 5 1 1 1 1 1
3 32 41 1 1 5 1 1 1 1 1 end loop
ara=4 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1 1
3 1 10 1 6 10 1 1 1 1 1
3 32 41 1 6 10 1 1 1 1 1 end loop
end array
end data
end

bw1810d
=csas25
bw1810d
44group latticecell
uo2 1 den=9.46 1.0 293 92235 4.02 92238 95.98 end
ss304 2 1.0 end
h2o 3 den=1.0 0.998346 end
boron 3 den=1.0 0.001654 end
uo2 4 den=10.24 1.0 293 92235 2.459 92238 97.541 end
al 5 1.0 end
uo2 6 den=10.24 0.96 293 92235 1.944 92238 98.056 end
gd-152 6 den=0.3555 0.002 end
gd-154 6 den=0.3555 0.0218 end
gd-155 6 den=0.3555 0.148 end
gd-156 6 den=0.3555 0.2047 end
gd-157 6 den=0.3555 0.1565 end
gd-158 6 den=0.3555 0.2484 end
gd-160 6 den=0.3555 0.2186 end
o 6 den=0.0541 1 end
end comp
squarepitch 1.636 1.128 1 3 1.208 2 end
more data res=4 cylinder .51486 dan(4)=.189732
res=6 cylinder .51499 dan(6)=.189958 end more data
Core of 3920 2.459 wt% ^{235}U UO₂ fuel rods, 860 4.020 wt% ^{235}U UO₂ fuel rods, 28 UO₂-Gd₂O₃ fuel rods, 153 water holes, 145.0 cm water height with 1653.8 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm
read geom
unit 1
cylinder 1 1 .5639 145 5.969
cylinder 2 1 .6039 145 0
cuboid 3 1 .818 -.818 .818 -.818 145 0
unit 2
cylinder 4 1 .5149 145 .3175
cylinder 0 1 .5217 145 .3175
cylinder 5 1 .603 145 0
cuboid 3 1 .818 -.818 .818 -.818 145 0
unit 3
cuboid 3 1 .818 -.818 .818 -.818 145 0
unit 4
array 2 -49.898 -6.544 0
unit 5
array 3 -33.538 -8.180 0
unit 6
array 4 -33.538 -8.180 0
global unit 7
array 1 -66.258 -36.81 0
cylinder 3 1 76.2 145 0.0
hole 4 0 -43.3542 0
hole 4 0 43.3542 0
hole 5 0 -58.0784 0
hole 6 0 58.0784 0
cylinder 5 1 76.2 145 -5.08
cylinder 3 1 76.2 145 -7.62
cylinder 5 1 77.47 145 -8.890
cuboid 0 1 4p77.47 145 -8.890

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unit 8
cylinder 6 1 .51499 145 0.3175
cylinder 0 1 .52197 145 0.3175
cylinder 5 1 .60325 145 0
cuboid 3 1 .818 -.818 .818 -.818 145 0
end geom

read array
ara=1 nux=81 nuy=45 loop
2 1 81 1 1 45 1 1 1 1
1 26 56 1 8 38 1 1 1 1
3 24 54 15 3 33 15 1 1 1
3 28 58 15 3 33 15 1 1 1
3 24 54 15 13 43 15 1 1 1
3 28 58 15 13 43 15 1 1 1
3 22 52 15 4 34 15 1 1 1
3 30 60 15 4 34 15 1 1 1
3 22 52 15 12 42 15 1 1 1
3 30 60 15 12 42 15 1 1 1
3 21 51 15 6 36 15 1 1 1
3 24 54 15 6 36 15 1 1 1
3 28 58 15 6 36 15 1 1 1
3 31 61 15 6 36 15 1 1 1
3 21 51 15 10 40 15 1 1 1
3 24 54 15 10 40 15 1 1 1
3 28 58 15 10 40 15 1 1 1
3 31 61 15 10 40 15 1 1 1
3 26 56 15 8 38 15 1 1 1
3 1 10 1 1 2 1 1 1 1
3 72 81 1 1 2 1 1 1 1
3 1 5 1 3 12 1 1 1 1
3 77 81 1 3 12 1 1 1 1
3 1 10 1 44 45 1 1 1 1
3 72 81 1 44 45 1 1 1 1
3 1 5 1 34 43 1 1 1 1
3 77 81 1 34 43 1 1 1 1
8 29 53 24 8 38 30 1 1 1
8 26 56 30 11 35 24 1 1 1
8 29 53 24 11 35 24 1 1 1
8 31 51 20 13 33 20 1 1 1
8 36 46 10 18 28 10 1 1 1
8 38 44 6 20 26 6 1 1 1
8 38 44 6 23 23 1 1 1 1
8 41 41 1 20 26 6 1 1 1
end loop
ara=2 nux=61 nuy=8 fill f2 end fill
ara=3 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1
3 1 10 1 1 5 1 1 1 1
3 32 41 1 1 5 1 1 1 1 end loop
ara=4 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1
3 1 10 1 6 10 1 1 1 1
3 32 41 1 6 10 1 1 1 1 end loop
end array
end data
end

```

bw1810e

```

=csas25
bw1810e
44group latticecell
uo2 1 den=9.46 1.0 293 92235 4.02 92238 95.98 end
ss304 2 1.0 end
h2o 3 den=1.0 0.998421 end
boron 3 den=1.0 0.001579 end
uo2 4 den=10.24 1.0 293 92235 2.459 92238 97.541 end
al 5 1.0 end
uo2 6 den=10.24 0.96 293 92235 1.944 92238 98.056 end
gd-152 6 den=0.3555 0.002 end
gd-154 6 den=0.3555 0.0218 end
gd-155 6 den=0.3555 0.148 end
gd-156 6 den=0.3555 0.2047 end
gd-157 6 den=0.3555 0.1565 end
gd-158 6 den=0.3555 0.2484 end
gd-160 6 den=0.3555 0.2186 end
o 6 den=0.0541 1 end
end comp
squarepitch 1.636 1.128 1 3 1.208 2 end
more data res=4 cylinder .51486 dan(4)=.189732
res=6 cylinder .51499 dan(6)=.189958 end more data
Core of 3676 2.459 wt%  $^{235}\text{U}$  UO2 fuel rods, 852 4.020 wt%  $^{235}\text{U}$  UO2 fuel
'rods, 36 UO2-Gd2O3 fuel rods, 153 water holes, 145.0 cm water height
'with 1579.4 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 1
cylinder 1 1 .5639 145 5.969
cylinder 2 1 .6039 145 0
cuboid 3 1 .818 -.818 .818 -.818 145 0
unit 2
cylinder 4 1 .5149 145 .3175
cylinder 0 1 .5217 145 .3175
cylinder 5 1 .603 145 0
cuboid 3 1 .818 -.818 .818 -.818 145 0
unit 3
cuboid 3 1 .818 -.818 .818 -.818 145 0
unit 4
array 2 -49.898 -6.544 0
unit 5
array 3 -33.538 -8.180 0
unit 6
array 4 -33.538 -8.180 0
global unit 7
array 1 -66.258 -36.81 0
cylinder 3 1 76.2 145 0.0
hole 4 0 -43.3542 0
hole 4 0 43.3542 0
hole 5 0 -58.0784 0
hole 6 0 58.0784 0
cylinder 5 1 76.2 145 -5.08
cylinder 3 1 76.2 145 -7.62
cylinder 5 1 77.47 145 -8.890
cuboid 0 1 4p77.47 145 -8.890

```

```

unit 8
cylinder 6 1 .51499 145 0.3175
cylinder 0 1 .52197 145 0.3175
cylinder 5 1 .60325 145 0
cuboid 3 1 .818 -.818 .818 -.818 145 0

read array
ara=1 nux=81 nuy=45 loop
2 1 81 1 1 45 1 1 1 1
1 26 56 1 8 38 1 1 1 1
3 24 54 15 3 33 15 1 1 1
3 28 58 15 3 33 15 1 1 1
3 24 54 15 13 43 15 1 1 1
3 28 58 15 13 43 15 1 1 1
3 22 52 15 4 34 15 1 1 1
3 30 60 15 4 34 15 1 1 1
3 22 52 15 12 42 15 1 1 1
3 30 60 15 12 42 15 1 1 1
3 21 51 15 6 36 15 1 1 1
3 24 54 15 6 36 15 1 1 1
3 28 58 15 6 36 15 1 1 1
3 31 61 15 6 36 15 1 1 1
3 21 51 15 10 40 15 1 1 1
3 24 54 15 10 40 15 1 1 1
3 28 58 15 10 40 15 1 1 1
3 31 61 15 10 40 15 1 1 1
3 26 56 15 8 38 15 1 1 1
3 1 10 1 1 2 1 1 1 1
3 72 81 1 1 2 1 1 1 1
3 1 5 1 3 12 1 1 1 1
3 77 81 1 3 12 1 1 1 1
3 1 10 1 44 45 1 1 1 1
3 72 81 1 44 45 1 1 1 1
3 1 5 1 34 43 1 1 1 1
3 77 81 1 34 43 1 1 1 1
8 29 53 24 8 38 30 1 1 1
8 26 56 30 11 35 24 1 1 1
8 28 54 26 14 32 18 1 1 1
8 32 50 18 10 36 26 1 1 1
8 31 51 20 13 33 20 1 1 1
8 36 46 10 18 28 10 1 1 1
8 35 47 12 21 25 4 1 1 1
8 39 43 4 17 29 12 1 1 1
8 38 44 6 23 23 1 1 1 1
8 41 41 1 20 26 6 1 1 1
end loop
ara=2 nux=61 nuy=8 fill f2 end fill
ara=3 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1 1
3 1 10 1 1 5 1 1 1 1
3 32 41 1 1 5 1 1 1 1 1
end loop
ara=4 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1 1
3 1 10 1 6 10 1 1 1 1
3 32 41 1 6 10 1 1 1 1
end loop
end array
end data
end

```

bw1810f

```

=csas25
bw1810f
44group latticecell
uo2 1 den=10.24 1.0 293 92235 2.459 92238 97.541
al 2 1.0
h2o 3 den=1.0 0.998663
boron 3 den=1.0 0.001337
end comp
squarepitch 1.636 1.125 1 3 1.206 2
Core of 4808 2.459 wt% 235U UO2 fuel rods, 153 water holes, 145.0 cm
'water height with 1337.9 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 2
cylinder 1 1 .5149 145 .3175
cylinder 0 1 .5217 145 .3175
cylinder 2 1 .603 145 0
cuboid 3 1 .818 -.818 .818 -.818 145 0
unit 3
cuboid 3 1 .818 -.818 .818 -.818 145 0
unit 4
array 2 -49.898 -6.544 0
unit 5
array 3 -33.538 -8.180 0
unit 6
array 4 -33.538 -8.180 0
global unit 7
array 1 -66.258 -36.81 0
cylinder 3 1 76.2 145 0.0
hole 4 0 -43.3542 0
hole 4 0 43.3542 0
hole 5 0 -58.0784 0
hole 6 0 58.0784 0
cylinder 2 1 76.2 145 -5.08
cylinder 3 1 76.2 145 -7.62
cylinder 2 1 77.47 145 -8.890
cuboid 0 1 4p77.47 145 -8.890
end geom

read array
ara=1 nux=81 nuy=45 fill
10r3 61r2 10r3
1q81
5r3 15r2 3r2 3 1q4 10r2 3 3r2 3b39
5r3 16r2 3 7r2 3 6r2 3 7r2 7b37
5r3 71r2 5r3
5r3 15r2 3 2r2 3 3r2 3 2r2 3 4r2 3 2r2 3 3r2 3b39
5r3 71r2 5r3
5r3 20r2 3 3r2 2 10r2 3 1b40
5r3 71r2 5r3
5r3 15r2 3 2r2 3 3r2 3 2r2 3 4r2 3 2r2 3 3r2 3b39
5r3 71r2 5r3
5r3 16r2 3 3r2 2 3r2 3 6r2 3 7r2 7b37
23r2 3 3r2 3 2r2 2 7r2 3 3r2 3b39
324r2
20r2 3r2 3 1q4 7r2 2 2r2 3 3r2 3b39

```

```

2lr2 3 7r2 3 6r2 3 3r2 2 1b40
8lr2
20r2 3 2r2 3 3r2 3 2r2 3 4r2 3 2r2 3 3r2 3b39
8lr2
25r2 3 10r2 2 3r2 3 1b40
81b1782
end fill
ara=2 nux=61 nuy=8 fill f2 end fill
ara=3 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1 1
3 1 10 1 1 5 1 1 1 1
3 32 41 1 1 5 1 1 1 1 1 end loop
ara=4 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1
3 1 10 1 6 10 1 1 1 1
3 32 41 1 6 10 1 1 1 1 1 end loop
end array
end data
end

bw1810g

=csas25
bw1810g
44group          latticecell
uo2   1 den=9.46  1.0 293 92235 4.02  92238 95.98
ss304 2          1.0
end
h2o   3 den=1.0  0.998224
boron 3 den=1.0  0.001776
uo2   4 den=10.24 1.0 293 92235 2.459 92238 97.541
al    5          1.0
end comp
squarepitch 1.636 1.128 1 3 1.208 2
more data res=4 cylinder .51486 dan(4)=.189732 end more data
Core of 3676 2.459 wt% 235U UO2 fuel rods, 944 4.020 235U wt% UO2 fuel 'rods, 180
water holes, 145.0 cm water height with 1776.8 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 1
cylinder 1 1 .5639 145 5.969
cylinder 2 1 .6039 145 0
cuboid   3 1   .818 -.818 .818 -.818 145 0
unit 2
cylinder 4 1 .5149 145 .3175
cylinder 0 1 .5217 145 .3175
cylinder 5 1 .603 145 0
cuboid   3 1   .818 -.818 .818 -.818 145 0
unit 3
cuboid   3 1   .818 -.818 .818 -.818 145 0
unit 4
array 2 -49.898 -6.544 0
unit 5
array 3 -33.538 -8.180 0
unit 6
array 4 -33.538 -8.180 0
global unit 7
array 1 -66.258 -36.81 0
cylinder 3 1 76.2 145 0.0

```

```

hole 4 0   -43.3542 0
hole 4 0   43.3542 0
hole 5 0   -58.0784 0
hole 6 0   58.0784 0
cylinder 5 1 76.2 145 -5.08
cylinder 3 1 76.2 145 -7.62
cylinder 5 1 77.47 145 -8.890
cuboid   0 1 4p77.47 145 -8.890
end geom

read array
ara=1 nux=81 nuy=45 fill
10r3 6lr2 10r3
10r3 3r2 6r2 2r3 2q8 7r2 7b37
5r3 5r2 3r2 6r2 2r3 2q8 7r2 7b37
5r3 71r2 5r3
1q81
5r3 18r2 2r3 14r2 3r3 3b39
5r3 18r2 2r3 14r1 3r3 3b39
5r3 19r2 33r1 19r2 5r3
1q81
5r3 14r2 2r3 3r2 3r1 2r3 6r1 2r3 7r1 7b37
1q81
24r2 33r1 24r2
5q81
19r2 2r3 3r2 3r1 2r3 6r1 2r3 7r1 7b37
1q81
24r2 33r1 24r2
1q81
23r2 2r3 14r1 3r3 3b39
1q81
81b1782
end fill
ara=2 nux=61 nuy=8 fill f2 end fill
ara=3 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1 1
3 1 10 1 1 5 1 1 1 1
3 32 41 1 1 5 1 1 1 1 1 end loop
ara=4 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1
3 1 10 1 6 10 1 1 1 1
3 32 41 1 6 10 1 1 1 1 1 end loop
end array
end data
end

bw1810h

=csas25
bw1810h
44group          latticecell
uo2   1 den=9.46 1.0 293 92235 4.02  92238 95.98
ss304 2          1.0 293
end
h2o   3 den=1.0  0.998101
boron 3 den=1.0  0.001899
uo2   4 den=10.24 1.0 293 92235 2.459 92238 97.541
al    5 1.0 293
end comp
squarepitch 1.636 1.128 1 3 1.208 2

```

```

more data res=4 cylinder .51486 dan(4)=.189732 end more data
Core of 3920 2.459 wt% 235U UO2 fuel rods, 888 4.020 wt% 235U UO2 fuel
'rods, 153 water holes, 145.0 cm water height with 1899.3 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 1
cylinder 1 1 .5639 145 5.969
cylinder 2 1 .6039 145 0
cuboid 3 1 .818 -.818 .818 -.818 145 0
unit 2
cylinder 4 1 .5149 145 .3175
cylinder 0 1 .5217 145 .3175
cylinder 5 1 .603 145 0
cuboid 3 1 .818 -.818 .818 -.818 145 0
unit 3
cuboid 3 1 .818 -.818 .818 -.818 145 0
unit 4
array 2 -49.898 -6.544 0
unit 5
array 3 -33.538 -8.180 0
unit 6
array 4 -33.538 -8.180 0
global unit 7
array 1 -66.258 -36.81 0
cylinder 3 1 76.2 145 0.0
hole 4 0 -43.3542 0
hole 4 0 43.3542 0
hole 5 0 -58.0784 0
hole 6 0 58.0784 0
cylinder 5 1 76.2 145 -5.08
cylinder 3 1 76.2 145 -7.62
cylinder 5 1 77.47 145 -8.890
cuboid 0 1 4p77.47 145 -8.890
end geom

read array
ara=1 nux=81 nuy=45 loop
2 1 81 1 1 45 1 1 1 1
1 26 56 1 8 38 1 1 1 1
3 24 54 15 3 33 15 1 1 1
3 28 58 15 3 33 15 1 1 1
3 24 54 15 13 43 15 1 1 1
3 28 58 15 13 43 15 1 1 1
3 22 52 15 4 34 15 1 1 1
3 30 60 15 4 34 15 1 1 1
3 22 52 15 12 42 15 1 1 1
3 30 60 15 12 42 15 1 1 1
3 21 51 15 6 36 15 1 1 1
3 24 54 15 6 36 15 1 1 1
3 28 58 15 6 36 15 1 1 1
3 31 61 15 6 36 15 1 1 1
3 21 51 15 10 40 15 1 1 1
3 24 54 15 10 40 15 1 1 1
3 28 58 15 10 40 15 1 1 1
3 31 61 15 10 40 15 1 1 1
3 26 56 15 8 38 15 1 1 1
3 1 10 1 1 2 1 1 1 1
3 72 81 1 1 2 1 1 1 1

3 1 5 1 3 12 1 1 1 1
3 77 81 1 3 12 1 1 1 1
3 1 10 1 44 45 1 1 1 1
3 72 81 1 44 45 1 1 1 1
3 1 5 1 34 43 1 1 1 1
3 77 81 1 34 43 1 1 1 1
end loop
ara=2 nux=61 nuy=8 fill f2 end fill
ara=3 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1
3 1 10 1 1 5 1 1 1 1
3 32 41 1 1 5 1 1 1 1 end loop
ara=4 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1
3 1 10 1 6 10 1 1 1 1
3 32 41 1 6 10 1 1 1 1 end loop
end array
end data
end

bw1810i

=csas25
bw1810i
44group latticecell
uo2 1 den=10.24 1.0 293 92235 2.459 92238 97.541
al 2 1.0
end
h2o 3 den=1.0 0.99875
endboron 3 den=1.0 0.00125
end
ag 4 den=10.15 0.797
end
in 4 den=10.15 0.151
end
cd 4 den=10.15 0.052
end comp
squarepitch 1.636 1.125 1 3 1.206 2
end
Core of 4808 2.459 wt% 235U UO2 fuel rods, 16 Ag-In-Cd rods, 137 water
'holes, 145.0 cm water height with 1250.0 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 1
cylinder 4 1 .508 145 .3175
cylinder 0 1 .5219 145 .3175
cylinder 2 1 .6033 145 0
cuboid 3 1 .818 -.818 .818 -.818 145 0
unit 2
cylinder 1 1 .5149 145 .3175
cylinder 0 1 .5217 145 .3175
cylinder 2 1 .603 145 0
cuboid 3 1 .818 -.818 .818 -.818 145 0
unit 3
cuboid 3 1 .818 -.818 .818 -.818 145 0
unit 4
array 2 -49.898 -6.544 0
unit 5
array 3 -33.538 -8.180 0
unit 6
array 4 -33.538 -8.180 0
global unit 7
array 1 -66.258 -36.81 0

```

```

cylinder 3 1 76.2    145  0.0
hole   4 0 -43.3542  0
hole   4 0  43.3542  0
hole   5 0 -58.0784  0
hole   6 0  58.0784  0
cylinder 2 1 76.2    145 -5.08
cylinder 3 1 76.2    145 -7.62
cylinder 2 1 77.47   145 -8.890
cuboid   0 1 4p77.47 145 -8.890
end geom

read array
ara=1 nux=81 nuy=45 fill
10r3 61r2 10r3
1q81
5r3 15r2 3r2 3 1q4 10r2 3 3r2 3b39
5r3 16r2 3 7r2 3 6r2 3 7r2 7b37
5r3 71r2 5r3
5r3 15r2 3 2r2 3 3r2 3 2r2 3 4r2 3 2r2 3 3r2 3b39
5r3 71r2 5r3
5r3 20r2 3 3r2 2 10r2 3 1b40
5r3 71r2 5r3
5r3 15r2 3 2r2 3 3r2 3 2r2 3 4r2 3 2r2 3 3r2 3b39
5r3 71r2 5r3
5r3 16r2 3 3r2 2 3r2 3 6r2 3 7r2 7b37
23r2 3 3r2 3 2r2 2 7r2 3 3r2 3b39
324r2
20r2 3r2 3 1q4 7r2 2 2r2 1 3r2 3b39
21r2 3 7r2 3 6r2 1 3r2 2 1b40
81r2
20r2 3 2r2 3 3r2 3 2r2 3 4r2 1 2r2 1 3r2 3b39
81r2
25r2 3 10r2 2 3r2 3 1b40
81b1782
end fill
ara=2 nux=61 nuy=8 fill f2 end fill
ara=3 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1
3 1 10 1 1 5 1 1 1 1
3 32 41 1 1 5 1 1 1 1 end loop
ara=4 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1
3 1 10 1 1 6 10 1 1 1 1
3 32 41 1 1 6 10 1 1 1 1 end loop
end array
end data
end

```

bw1810j

```

=csas25
bw1810j
44group          latticecell
uo2  1 den=9.46  1.0 293 92235 4.02  92238 95.98
ss304 2 1.0 293
h2o  3 den=1.0  0.998365
boron 3 den=1.0  0.001635
uo2  4 den=10.24 1.0 293 92235 2.459 92238 97.541
al   5 1.0 293

```

```

b4c   6 den=1.28 0.986
end comp
squarepitch 1.636 1.128 1 3 1.208 2
more data res=4 cylinder .51486 dan(4)=.189732 end more data
Core of 3920 2.459 wt% 235U UO2 fuel rods, 888 4.020 wt% 235U UO2 fuel
'rods, 16 B4C rods, 137 water holes, 145.0 cm water height with 1635.4
'ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 1
cylinder 1 1 .5639 145 5.969
cylinder 2 1 .6039 145 0
cuboid   3 1 .818 -.818 .818 -.818 145 0
unit 2
cylinder 4 1 .5149 145 .3175
cylinder 0 1 .5217 145 .3175
cylinder 5 1 .603 145 0
cuboid   3 1 .818 -.818 .818 -.818 145 0
unit 3
cuboid   3 1 .818 -.818 .818 -.818 145 0
unit 4
array 2 -49.898 -6.544 0
unit 5
array 3 -33.538 -8.180 0
unit 6
array 4 -33.538 -8.180 0
global unit 7
array 1 -66.258 -36.81 0
cylinder 3 1 76.2 145 0.0
hole   4 0 -43.3542 0
hole   4 0  43.3542 0
hole   5 0 -58.0784 0
hole   6 0  58.0784 0
cylinder 5 1 76.2 145 -5.08
cylinder 3 1 76.2 145 -7.62
cylinder 5 1 77.47 145 -8.890
cuboid   0 1 4p77.47 145 -8.890
unit 8
cylinder 6 1 .46736 145 0.3175
cylinder 5 1 .55626 145 0.0
cuboid   3 1 4p.818 145 0.0
end geom

read array
ara=1 nux=81 nuy=45 fill
10r3 61r2 10r3
1q81
5r3 15r2 3r2 3 1q4 10r2 3 3r2 3b39
5r3 16r2 3 7r2 3 6r2 3 7r2 7b37
5r3 71r2 5r3
5r3 15r2 3 2r2 3 3r2 3 2r2 3 4r2 3 2r2 3 3r2 3b39
5r3 71r2 5r3
5r3 20r2 3 14r1 3 1b40
5r3 20r2 3lrl 20r2 5r3
5r3 15r2 3 2r2 3 2 2rl 3 1q3 4rl 3 2rl 3 3rl 3b39
5r3 20r2 3lrl 20r2 5r3
5r3 16r2 3 3r2 4rl 3 6rl 3 7rl 7b37
23r2 3 2 2rl 3 10rl 3 3rl 3b39

```

```

25r2 3lrl 25r2
3g81
23r2 3 2 2r1 3 10rl 8 3rl 3b39
21r2 3 3r2 4rl 3 6rl 8 7rl 7b37
25r2 3lrl 25r2
20r2 3 2r2 3 2 2rl 3 1q3 4rl 8 2rl 8 3rl 3b39
25r2 3lrl 25r2
25r2 3 14rl 3 1b40
8lb1782
end fill
ara=2 nux=61 nuy=8 fill f2 end fill
ara=3 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1 1
3 1 10 1 1 5 1 1 1 1
3 32 41 1 1 5 1 1 1 1 1 1 1 1 1 1 1 1
end loop
ara=4 nux=41 nuy=10 loop
2 1 41 1 1 10 1 1 1 1 1
3 1 10 1 6 10 1 1 1 1
3 32 41 1 6 10 1 1 1 1 1 1 1 1 1 1 1 1 1
end loop
end array
end data
end

cr1071as

=csas25
cr1071as
44group      latticecell
u308      1 den=4.54 1 293.0 92234 0.03 92235 4.48 92236
0.09 92238 95.4
h2o      1 den=.09316
arbm-baggie 1.596-2 3 0 0 6012 84.9 1001 14.01 8016 1.20 1
arbm-all100 2.713 4 0 0 1 13027 99.33 26000 0.42 29000 0.12
14000 0.1 2
arbm-tape(vinyl) 1.374-2 7 0 0 0 6012 45.91 1001 5.92 8016 10.82
17000 25.73 20000 6.9 22000 1.6 82000 1.1 2
arbm-tape(mylar) 1.832-2 3 0 0 0 6012 65.50 1001 6.83 8016 27.02 2
end
arbm-moderator 1.185 3 0 0 0 6012 59.49 1001 7.83 8016 32.48 3
end
arbm-plex(reg) 1.185 3 0 0 0 6012 59.59 1001 7.84 8016 32.23 4
9935
end
arbm-plex(paper) 0.766 3 0 0 0 6012 42.17 1001 6.48 8016 49.5 4
.0049
arbm-plex(glue) 0.728 3 0 0 0 6012 86.29 1001 11.67 8016 1.20 4
.0016
arbm-plex(tris) 1.284 8 0 0 1 6012 52.03 1001 7.16 7014 0 .16
8016 29.82 15031 1.02 17000 1.81 35079 3.55 35081 3.55 5 .9935
end
arbm-plex(paper) 0.766 3 0 0 0 6012 42.17 1001 6.48 8016 49.5
5 .0049
arbm-plex(glue) 0.728 3 0 0 0 6012 86.29 1001 11.67 8016 1.20
5 .0016
arbm-filler 1.185 3 0 0 0 6012 59.49 1001 7.83 8016 32.48
6 1.0
end comp
symmslabcell 17.67 14.92 1 3 15.24 2
38 cans of damp uranium oxide,U3O8, separated by 2.43 cm of Plexiglas,
'Plexiglas reflected
parm run=yes npg=600 gen=405 nsk=5 nub=yes end parm
read

```

```

read geom
unit 51
com='fuel box with moderator +x,+y,+z'
cuboid 1 1 6p7.46
cuboid 2 1 6p7.62
reflector 3 1 1.215 0.0 1.215 0.0 1.215 0.0 1
unit 52
com='fuel box with moderator -x,+y,+z'
cuboid 1 1 6p7.46
cuboid 2 1 6p7.62
reflector 3 1 0.0 1.215 1.215 0.0 1.215 0.0 1
unit 53
com='fuel box with moderator +x,+y,-y,+z'
cuboid 1 1 6p7.46
cuboid 2 1 6p7.62
reflector 3 1 1.215 0.0 2r1.215 1.215 0.0 1
unit 54
com='fuel box with moderator -x,+y,-y,+z'
cuboid 1 1 6p7.46
cuboid 2 1 6p7.62
reflector 3 1 0.0 1.215 2r1.215 1.215 0.0 1
unit 55
com='fuel box with moderator +x,-y,+z'
cuboid 1 1 6p7.46
cuboid 2 1 6p7.62
reflector 3 1 1.215 0.0 0.0 1.215 1.215 0.0 1
unit 56
com='fuel box with moderator -x,-y,+z'
cuboid 1 1 6p7.46
cuboid 2 1 6p7.62
reflector 3 1 0.0 1.215 0.0 1.215 1.215 0.0 1
unit 57
com='fuel box with moderator +x,+y,+z,-z'
cuboid 1 1 6p7.46
cuboid 2 1 6p7.62
reflector 3 1 1.215 0.0 1.215 0.0 2r1.215 1
unit 58
com='fuel box with moderator -x,+y,+z,-z'
cuboid 1 1 6p7.46
cuboid 2 1 6p7.62
reflector 3 1 0.0 1.215 1.215 0.0 2r1.215 1
unit 59
com='fuel box with moderator +x,+y,-y,+z,-z'
cuboid 1 1 6p7.46
cuboid 2 1 6p7.62
reflector 3 1 1.215 0.0 4r1.215 1
unit 60
com='fuel box with moderator -x,+y,-y,+z,-z'
cuboid 1 1 6p7.46
cuboid 2 1 6p7.62
reflector 3 1 0.0 5r1.215 1
unit 61
com='fuel box with moderator +x,-y,+z,-z'
cuboid 1 1 6p7.46
cuboid 2 1 6p7.62
reflector 3 1 1.215 0.0 0.0 1.215 2r1.215 1
unit 62
com='fuel box with moderator -x,-y,+z,-z'
cuboid 1 1 6p7.46

```

```

cuboid 2 1 6p7.62
reflector 3 1 0.0 1.215 0.0 1.215 2r1.215 1
unit 63
com='fuel box with moderator -x,+y,-z'
cuboid 1 1 6p7.46
cuboid 2 1 6p7.62
reflector 3 1 0.0 1.215 1.215 0.0 0.0 1.215 1
unit 64
com='fuel box with moderator +x,+y,-y,-z'
cuboid 1 1 6p7.46
cuboid 2 1 6p7.62
reflector 3 1 1.215 0.0 2r1.215 0.0 1.215 1
unit 65
com='fuel box with moderator -x,+y,-y,-z'
cuboid 1 1 6p7.46
cuboid 2 1 6p7.62
reflector 3 1 0.0 1.215 2r1.215 0.0 1.215 1
unit 66
com='fuel box with moderator -x,-y,-z'
cuboid 1 1 6p7.46
cuboid 2 1 6p7.62
reflector 3 1 0.0 1.215 0.0 1.215 0.0 1.215 1
unit 67
com='fuel box with moderator +x,+y,-z'
cuboid 1 1 6p7.46
cuboid 2 1 6p7.62
reflector 3 1 1.215 0.0 1.215 0.0 0.0 1.215 1
unit 68
com='fuel box with moderator +x,-y,-z'
cuboid 1 1 6p7.46
cuboid 2 1 6p7.62
reflector 3 1 1.215 0.0 0.0 0.0 1.215 0.0 1.215 1
unit 69
com='empty fuel location edge'
cuboid 0 1 6p8.2275
unit 70
com='empty fuel location middle'
cuboid 0 1 2p8.2275 2p8.835 2p8.2275
unit 11
com='north split table core'
array 1 3*0.0
cuboid 0 1 32.91 -.59 68.25 0.0 50.58 0.0
reflector 6 1 0 4.9 8.5 0.0 7.3 26.1 1
reflector 0 1 0 0.6 .75 3*0 1
unit 12
com='south split table core'
array 2 3*0.0
cuboid 0 1 33.5 0.0 68.25 0.0 50.58 0.0
reflector 6 1 12.2 0 8.5 0.0 7.3 26.1 1
reflector 0 1 1.3 0 .75 3*0 1
unit 21
com='north bottom reflector '
cuboid 3 1 7.4 0.0 2p64.05 2p12.60
cuboid 5 1 39.0 0.0 2p64.05 2p12.60
unit 22
com='north top reflector '
cuboid 3 1 7.4 0.0 2p64.05 2p12.00
cuboid 5 1 39.0 0.0 2p64.05 2p12.00

```

```

unit 23
com='north side reflector '
cuboid 3 1 7.4 0.0 2p12.65 57.88 -26.1
cuboid 5 1 39.0 0.0 2p12.65 57.88 -26.1
unit 24
com='south bottom reflector with tris'
cuboid 0 1 10.2 0.0 2p2.55 2p12.60
cuboid 5 1 47.0 0.0 2p64.05 2p12.60
unit 25
com='south top reflector with tris'
cuboid 0 1 10.2 0.0 2p2.55 2p12.00
cuboid 5 1 47.0 0.0 2p64.05 2p12.00
unit 26
com='south side reflector with tris'
cuboid 5 1 47.0 0.0 2p12.65 57.88 -26.1
unit 31
com='north array core+side'
array 3 3*0.0
unit 32
com='south array core+side'
array 4 3*0.0
unit 33
com='north array'
array 5 3*0.0
reflector 4 1 0 25.2 4r0.0 1
reflector 3 1 1.23 0 4r0.0 1
unit 34
com='south array'
array 6 3*0.0
reflector 5 1 26.5 5r0.0 1
reflector 3 1 0 1.23 4r0.0 1
reflector 0 1 0 .31 4r0.0 1
global
unit 35
com='total'
array 7 3*0.0
end geometry

read array
ara=1 nux=2 nuy=4 nuz=3
com='north split table core'
fill 51 52 53 54 1q2 55 56 57 58 59 60 1q2 61 62 69 63 64
65 1q2 69 66
ara=2 nux=2 nuy=4 nuz=3
com='south split table core'
fill 51 52 53 54 1q2 55 56 57 58 59 60 1q2 61 62 67 69 64
70 1q2 68 69
ara=3 nux=1 nuy=3 nuz=1
com='north core with side wall'
fill 23 11 23
ara=4 nux=1 nuy=3 nuz=1
com='south core with side wall'
fill 26 12 26
ara=5 nux=1 nuy=1 nuz=3
com='north assembly'
fill 21 31 22
ara=6 nux=1 nuy=1 nuz=3
com='south assembly'
fill 24 32 25
end fill

```

```

ara=7 nux=2 nuy=1 nuz=1
com='total'
fill 33 34
end array
end data
end

cr1653as

=csas25
cr1653as
44group latticeccell
u3o8    1 den=4.54 1 293.0 92234 0.03 92235 4.48 92236
        0.09 92238 95.4
h2o    1 den=.16060
end
arbm-baggie 1.596-2 3 0 0 0 6012 84.9 1001 14.01 8016 1.20 1
arbm-all100 2.713 4 0 0 1 13027 99.33 26000 0.42 29000 0.12
        14000 0.1 2
arbm-tape(vinyl) 1.374-2 7 0 0 0 6012 45.91 1001 5.92 8016 10.82
        17000 25.73 20000 6.9 22000 1.6 82000 1.1 2
arbm-tape(mylar) 1.832-2 3 0 0 0 6012 65.50 1001 6.83 8016 27.02 2
arbm-moderator 1.185 3 0 0 0 6012 59.49 1001 7.83 8016 32.48 3
arbm-plex(reg) 1.185 3 0 0 0 6012 59.59 1001 7.84 8016
        32.23 4 .9935
arbm-plex(paper) 0.766 3 0 0 0 6012 42.17 1001 6.48 8016
        49.5 4 .0049
arbm-plex(glue) 0.728 3 0 0 0 6012 86.29 1001 11.67 8016
        1.20 4 .0016
arbm-plex(tris) 1.284 8 0 0 1 6012 52.03 1001 7.16 7014 0.16 8016
        29.82 15031 1.02 17000 1.81 35079 3.55 35081
        3.55 5 .9935
arbm-plex(paper) 0.766 3 0 0 0 6012 42.17 1001 6.48 8016 49.5
        5 .0049
arbm-plex(glue) 0.728 3 0 0 0 6012 86.29 1001 11.67 8016 1.20
        5 .0016
arbm-filler 1.185 3 0 0 0 6012 59.49 1001 7.83 8016 32.48
        6 1.0
end comp
symmslabcell 17.67 14.92 1 3 15.24 2
38 cans of damp uranium oxide,U3O8, separated by 2.43 cm of Plexiglas,
'Plexiglas reflected
read parm run=yes npg=600 gen=405 nsk=5 nub=yes end parm

read geom
unit 1
com='fuel box 15.24 cm on a side with .16 cm walls '
cuboid 1 1 6p7.46
cuboid 2 1 6p7.62
unit 2
com='x-face interstitial moderator'
cuboid 3 1 2p1.215 4p7.62
unit 3
com='y-face interstitial moderator'
cuboid 3 1 2p7.62 2p1.215 2p7.62
unit 4
com='z-face interstitial moderator'
cuboid 3 1 4p7.62 2p1.215
end fill

```

```

unit 5
com='more x-face moderator'
cuboid 3 1 4p1.215 2p7.62
unit 6
com='more y-face moderator'
cuboid 3 1 2p7.62 4p1.215
unit 7
com='more z-face moderator'
cuboid 3 1 2p1.215 2p7.62 2p1.215
unit 8
com='last of interstitial moderator'
cuboid 3 1 6p1.215
unit 51
com='empty fuel location'
cuboid 0 1 6p7.620
unit 52
com='x-face moderator void'
cuboid 0 1 2p1.215 4p7.62
unit 53
com='y-face moderator void'
cuboid 0 1 2p7.62 2p1.215 2p7.62
unit 11
com='north split table core'
array 1 3*0.0
cuboid 0 1 32.91 -.59 69.0 0.0 50.58 0.0
reflector 6 1 0 4.9 8.5 0.0 7.3 26.1 1
reflector 0 1 0 0.6 4*0 1
unit 12
com='south split table core'
array 2 3*0.0
cuboid 0 1 33.6 0.0 69.0 0.0 50.58 0.0
reflector 6 1 12.2 0 8.5 0.0 7.3 26.1 1
reflector 0 1 1.3 0 4*0 1
unit 21
com='north bottom reflector '
cuboid 3 1 7.4 0.0 2p64.05 2p12.60
cuboid 5 1 39.0 0.0 2p64.05 2p12.60
unit 22
com='north top reflector '
cuboid 3 1 7.4 0.0 2p64.05 2p12.00
cuboid 5 1 39.0 0.0 2p64.05 2p12.00
unit 23
com='north side reflector '
cuboid 3 1 7.4 0.0 2p12.65 57.88 -26.1
cuboid 5 1 39.0 0.0 2p12.65 57.88 -26.1
unit 24
com='south bottom reflector with tris'
cuboid 0 1 10.2 0.0 2p2.55 2p12.60
cuboid 5 1 47.1 0.0 2p64.05 2p12.60
unit 25
com='south top reflector with tris'
cuboid 0 1 10.2 0.0 2p2.55 2p12.00
cuboid 5 1 47.1 0.0 2p64.05 2p12.00
unit 26
com='south side reflector with tris'
cuboid 5 1 47.1 0.0 2p12.65 57.88 -26.1
unit 31
com='north array core+side'
array 3 3*0.0

```

```

unit 32
com='south array core+side'
array 4 3*0.0
unit 33
com='north array'
array 5 3*0.0
reflector 4 1 0 25.2 4r0.0 1
reflector 3 1 1.23 0 4r0.0 1
unit 34
com='south array'
array 6 3*0.0
reflector 0 1 0.5 5r0.0 1
reflector 5 1 26.5 5r0.0 1
reflector 3 1 0 1.23 4r0.0 1
reflector 0 1 0 1.26 4r0.0 1
global
unit 35
com='total'
array 7 3*0.0
end geometry

read array
ara=1 nux=3 nuy=7 nuz=5
com='north split table core'
fill 1 2 1 3 5 3 2q6 1 2 1
4 7 4 6 8 6 2q6 4 7 4
1q42
51 2 1 53 5 3 2q6 51 52 51 end fill
ara=2 nux=3 nuy=7 nuz=5
com='south split table core'
fill 1 2 1 3 5 3 2q6 1 2 1
4 7 4 6 8 6 2q6 4 7 4
1q42
1 2 51 3 5 53 2q6 51 52 51 end fill
ara=3 nux=1 nuy=3 nuz=1
com='north core with side wall'
fill 23 11 23 end fill
ara=4 nux=1 nuy=3 nuz=1
com='south core with side wall'
fill 26 12 26 end fill
ara=5 nux=1 nuy=1 nuz=3
com='north assembly'
fill 21 31 22 end fill
ara=6 nux=1 nuy=1 nuz=3
com='south assembly'
fill 24 32 25 end fill
ara=7 nux=2 nuy=1 nuz=1
com='total'
fill 33 34 end fill
end array
end data
end

cr2500s

=csas25
cr2500s
44group
u3o8      latticecell
          1 den=4.54 1 293.0 92234 0.03 92235 4.48 92236

```

```

          0.09 92238 95.4
          end
h2o      1 den=.27248
          end
arbm-baggie 1.596-2 3 0 0 0 6012 84.9 1001 14.01 8016 1.20 1 end
arbm-all100 2.713 4 0 0 1 13027 99.33 26000 0.42 29000 0.12
          14000 0.1 2
          end
arbm-tape(vinyl) 1.374-2 7 0 0 0 6012 45.91 1001 5.92 8016 10.82
          17000 25.73 20000 6.9 22000 1.6 82000 1.1 2
          end
arbm-tape(mylar) 2.748-2 3 0 0 0 6012 65.50 1001 6.83 8016 27.02
          2
          end
arbm-moderator 1.185 3 0 0 0 6012 59.49 1001 7.83 8016 32.48 3 end
arbm-plex(reg) 1.185 3 0 0 0 6012 59.59 1001 7.84 8016 32.23 4
          .9935
          end
arbm-plex(paper) 0.766 3 0 0 0 6012 42.17 1001 6.48 8016 49.5 4
          .0049
          end
arbm-plex(glue) 0.728 3 0 0 0 6012 86.29 1001 11.67 8016 1.20 4
          .0016
          end
arbm-plex(tris) 1.284 8 0 0 1 6012 52.03 1001 7.16 7014 0.16
          8016 29.82 15031 1.02 17000 1.81 35079 3.55 35081
          3.55 5 .9935
          end
arbm-plex(paper) 0.766 3 0 0 0 6012 42.17 1001 6.48 8016 49.5
          5 .0049
          end
arbm-plex(glue) 0.728 3 0 0 0 6012 86.29 1001 11.67 8016 1.20 5
          .0016
          end
arbm-filler 1.185 3 0 0 0 6012 59.49 1001 7.83 8016 32.48 6
          1.0
          end
end comp
symmslabcell 17.67 14.92 1 3 15.24 2
          end
          30 cans of damp uranium oxide,U3O8, separated by 2.43 cm
of Plexiglas, 'Plexiglas reflected'
read parm run=yes npg=600 gen=405 nsk=5 nub=yes end parm

read geom
unit 1
com='fuel box 15.24 cm on a side with .16 cm walls '
cuboid 1 1 6p7.46
cuboid 2 1 6p7.62
unit 2
com='x-face interstitial moderator'
cuboid 3 1 2p1.215 4p7.62
unit 3
com='y-face interstitial moderator'
cuboid 3 1 2p7.62 2p1.215 2p7.62
unit 4
com='z-face interstitial moderator'
cuboid 3 1 4p7.62 2p1.215
unit 5
com='more x-face moderator'
cuboid 3 1 4p1.215 2p7.62
unit 6
com='more y-face moderator'
cuboid 3 1 2p7.62 4p1.215
unit 7
com='more z-face moderator'
cuboid 3 1 2p1.215 2p7.62 2p1.215
unit 8
com='last of interstitial moderator'
cuboid 3 1 6p1.215
unit 51
com='empty fuel location'

```

```

cuboid 0 1 6p7.620
unit 53
com='y-face moderator void'
cuboid 0 1 2p7.62 2p1.215 2p7.62
unit 11
com='north split table core'
array 1 3*0.0
cuboid 0 1 32.91 - .59 77.50 0.0 50.58 0.0
reflector 6 1 4*0 2.42 30.0 1
reflector 0 1 0 0 0 0.3 0 1
unit 12
com='south split table core'
array 2 3*0.0
cuboid 0 1 33.5 0.0 77.50 0.0 50.58 0.0
reflector 6 1 13.5 3*0 2.42 30.0 1
reflector 0 1 0 0 0 0.3 0 1
unit 21
com='north bottom reflector '
cuboid 3 1 1.90 0.0 2p64.05 2p12.60
cuboid 5 1 33.50 0.0 2p64.05 2p12.60
unit 22
com='north top reflector '
cuboid 3 1 1.90 0.0 2p64.05 2p12.00
cuboid 5 1 33.50 0.0 2p64.05 2p12.00
unit 23
com='north side reflector '
cuboid 3 1 1.90 0.0 2p12.65 53.3 -30.0
cuboid 5 1 33.50 0.0 2p12.65 53.3 -30.0
unit 24
com='south bottom reflector with tris'
cuboid 0 1 10.2 0.0 2p2.55 2p12.60
cuboid 5 1 47.0 0.0 2p64.05 2p12.60
unit 25
com='south top reflector with tris'
cuboid 0 1 10.2 0.0 2p2.55 2p12.00
cuboid 5 1 47.0 0.0 2p64.05 2p12.00
unit 26
com='south side reflector with tris'
cuboid 5 1 47.0 0.0 2p12.65 53.3 -30.0
unit 31
com='north array core+side'
array 3 3*0.0
unit 32
com='south array core+side'
array 4 3*0.0
unit 33
com='north array'
array 5 3*0.0
reflector 4 1 0 25.2 4r0.0 1
reflector 3 1 1.23 0 4r0.0 1
unit 34
com='south array'
array 6 3*0.0
reflector 5 1 26.5 5r0.0 1
reflector 3 1 0 1.23 4r0.0 1
reflector 0 1 0 .57 4r0.0 1
global
unit 35
com='total'

```

```

array 7 3*0.0
end geometry

read array
ara=1 nux=3 nuy=5 nuz=5
com='north split table core'
fill 1 2 1 3 5 3 1q6 1 2 1
4 7 4 6 8 6 1q6 4 7 4
1q30
51 2 1 53 5 3 1q6 51 2 1 end fill
ara=2 nux=3 nuy=5 nuz=5
com='south split table core'
fill 1 2 1 3 5 3 1q6 1 2 1
4 7 4 6 8 6 1q6 4 7 4
1q30
1 2 51 3 5 53 1q6 1 2 51 end fill
ara=3 nux=1 nuy=3 nuz=1
com='north core with side wall'
fill 23 11 23 end fill
ara=4 nux=1 nuy=3 nuz=1
com='south core with side wall'
fill 26 12 26 end fill
ara=5 nux=1 nuy=1 nuz=3
com='north assembly'
fill 21 31 22 end fill
ara=6 nux=1 nuy=1 nuz=3
com='south assembly'
fill 24 32 25 end fill
ara=7 nux=2 nuy=1 nuz=1
com='total'
fill 33 34 end fill
end array
end data
end

dsn399-1

=csas25
dsn399-1
44group latticecell
u02 1 0.947 293 92235 4.742 92238 95.258
al 2 1.0
end
h2o 3 1.0
end
arbmss 7.90 3 0 0 1 24304 19.17 26304 71.40 28304 9.37 4
end
hf 5 den=13.29
end
u02 6 0.947 293 92235 4.742 92238 95.258
end
comp
squarepitch 1.35 0.79 1 3 0.94 2 0.82 0
end
more data res=6 cylinder .395 dan(6)=.989923 end more
4-18x18 assemblies separated by 0.1046-cm-thick hafnium plates and
'1.6954 cm of water, plate-to-assembly distance of 0.9 cm, 37.66 cm
'water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0 .395 37.66 0.0
cylinder 0 1 0 .410 37.66 0.0
cylinder 2 1 0 .470 37.66 0.0

```

```

cuboid 3 1 4p0.675      37.66 0.0
unit 2
cylinder 2 1 0.470      0.25 0.0
cylinder 3 1 0.500      0.25 0.0
cuboid 4 1 4p0.675      0.25 0.0
unit 3
cylinder 2 1 0.470      2.75 1.75
cuboid 3 1 4p0.675      2.75 1.2
cuboid 4 1 4p0.675      2.75 0.0
unit 4
array 1 3*0.0
reflector 3 1 0 24.8 4r0 1
unit 5
cuboid 5 1 2p.0523     24.3 0   40.66 0.8
cuboid 3 1 2p.9        24.3 0   40.66 0.8
cuboid 4 1 2p.9        24.3 0   40.66 0.0
unit 6
array 1 3*0.0
reflector 3 1 24.8 0 4r0 1
unit 7
array 2 3*0.0
unit 8
cuboid 3 1 49.9477 0 24.8 0   40.66 0.8
cuboid 5 1 50.0523 0 24.8 0   40.66 0.8
cuboid 3 1 100. 0 24.8 0   40.66 0.8
cuboid 4 1 100. 0 24.8 0   40.66 0.0
unit 9
cuboid 3 1 49.9477 0 0.8477 0 40.66 0.8
cuboid 5 1 50.0523 0 0.8477 0 40.66 0.8
cuboid 3 1 100. 0 0.8477 0 40.66 0.8
cuboid 5 1 100. 0 0.9523 0 40.66 0.8
cuboid 4 1 100. 0 0.9523 0 40.66 0.0
unit 10
cuboid 3 1 49.9477 0 0.8477 0 40.66 0.8
cuboid 5 1 50.0523 0 0.8477 0 40.66 0.8
cuboid 3 1 100. 0 0.8477 0 40.66 0.8
cuboid 4 1 100. 0 0.8477 0 40.66 0.0
unit 11
array 3 3*0.0
reflector 3 1 4r20.0 0.0 20.0 1
unit 12
cylinder 6 1 0.395      90.00 37.66
cylinder 0 1 0.410      90.00 37.66
cylinder 2 1 0.470      90.00 37.66
cuboid 0 1 4p0.675      90.00 37.66
unit 13
array 4 3*0.0
reflector 0 1 0 24.8 2r0 7.8 0.0 1
unit 14
cuboid 5 1 2p.0523 24.3 0 97.80 37.66
cuboid 0 1 2p.9        24.3 0 97.80 37.66
unit 15
array 4 3*0.0
reflector 0 1 24.8 0 2r0 7.8 0.0 1
unit 16
array 5 3*0.0
unit 17
cuboid 0 1 49.9477 0 24.8 0 97.80 37.66
cuboid 5 1 50.0523 0 24.8 0 97.80 37.66

```

```

cuboid 0 1 100      0 24.8      0 97.80 37.66
unit 18
cuboid 0 1 49.9477 0 0.8477 0 97.80 37.66
cuboid 5 1 50.0523 0 0.8477 0 97.80 37.66
cuboid 0 1 100      0 0.8477 0 97.80 37.66
cuboid 5 1 100      0 0.9523 0 97.80 37.66
unit 19
cuboid 0 1 49.9477 0 0.8477 0 97.80 37.66
cuboid 5 1 50.0523 0 0.8477 0 97.80 37.66
cuboid 0 1 100      0 0.8477 0 97.80 37.66
unit 20
array 6 3*0.0
reflector 0 1 4r20.0 2r0.0 1
global
unit 21
array 7 3*0.0
end geom

read array
ara=1 nux=18 nuy=18 nuz=3 fill 324r3 324r2 324rl end fill
ara=2 nux=3 nuy=1 nuz=1 fill 4 5 6 end fill
ara=3 nux=1 nuy=6 nuz=1 fill 8 7 9 10 7 8 end fill
ara=4 nux=18 nuy=18 nuz=1 fill 324rl2 end fill
ara=5 nux=3 nuy=1 nuz=1 fill 13 14 15 end fill
ara=6 nux=1 nuy=6 nuz=1 fill 17 16 18 19 16 17 end fill
ara=7 nux=1 nuy=1 nuz=2 fill 11 20 end fill
end array
end data
end

dsn399-2

=csas25
dsn399-2
44group latticecell
u02 1 0.947 293 92235 4.742 92238 95.258
al 2 1.0
h2o 3 1.0
arbmss 7.90 3 0 0 1 24304 19.17 26304 71.40 28304 9.37 4
hf 5 den=13.29
u02 6 0.947 293 92235 4.742 92238 95.258
end comp
squarepitch 1.35 0.79 1 3 0.94 2 0.82 0
more data res=6 cylinder .395 dan(6)=.989923 end more
4-18x18 assemblies separated by 0.1046-cm-thick hafnium plates and
'5.6954 cm of water, plate-to-assembly distance of 2.9 cm, 53.40 cm
'water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.395      53.40 0.0
cylinder 0 1 0.410      53.40 0.0
cylinder 2 1 0.470      53.40 0.0
cuboid 3 1 4p0.675      53.40 0.0
unit 2
cylinder 2 1 0.470      0.25 0.0
cylinder 3 1 0.500      0.25 0.0
cuboid 4 1 4p0.675      0.25 0.0

```

```

unit 3
cylinder 2 1 0.470      2.75  1.75
cuboid   3 1 4p0.675    2.75  1.2
cuboid   4 1 4p0.675    2.75  0.0
unit 4
array 1 3*0.0
reflector 3 1 0 22.8 4r0 1
unit 5
cuboid   5 1 2p.0523   24.3   0 56.40 0.8
cuboid   3 1 2p2.9     24.3   0 56.40 0.8
cuboid   4 1 2p2.9     24.3   0 56.40 0.0
unit 6
array 1 3*0.0
reflector 3 1 22.8 0 4r0 1
unit 7
array 2 3*0.0
unit 8
cuboid   3 1 49.9477 0 22.8   0 56.40 0.8
cuboid   5 1 50.0523 0 22.8   0 56.40 0.8
cuboid   3 1 100.     0 22.8   0 56.40 0.8
cuboid   4 1 100.     0 22.8   0 56.40 0.0
unit 9
cuboid   3 1 49.9477 0 2.8477 0 56.40 .8
cuboid   5 1 50.0523 0 2.8477 0 56.40 .8
cuboid   3 1 100.     0 2.8477 0 56.40 .8
cuboid   5 1 100.     0 2.9523 0 56.40 .8
cuboid   4 1 100.     0 2.9523 0 56.40 .0
unit 10
cuboid   3 1 49.9477 0 2.8477 0 56.40 .8
cuboid   5 1 50.0523 0 2.8477 0 56.40 .8
cuboid   3 1 100.     0 2.8477 0 56.40 .8
cuboid   4 1 100.     0 2.8477 0 56.40 .0
unit 11
array 3 3*0.0
reflector 3 1 4r20.0 0.0 20.0 1
unit 12
cylinder 6 1 0.395      90.00 53.40
cylinder 0 1 0.410      90.00 53.40
cylinder 2 1 0.470      90.00 53.40
cuboid   0 1 4p0.675    90.00 53.40
unit 13
array 4 3*0.0
reflector 0 1 0 22.8 2r0 7.8 0.0 1
unit 14
cuboid   5 1 2p.0523   24.3   0 97.80 53.40
cuboid   0 1 2p2.9     24.3   0 97.80 53.40
unit 15
array 4 3*0.0
reflector 0 1 22.8 0 2r0 7.8 0.0 1
unit 16
array 5 3*0.0
unit 17
cuboid   0 1 49.9477 0 22.8   0 97.80 53.40
cuboid   5 1 50.0523 0 22.8   0 97.80 53.40
cuboid   0 1 100.     0 22.8   0 97.80 53.40
unit 18
cuboid   0 1 49.9477 0 2.8477 0 97.80 53.40
cuboid   5 1 50.0523 0 2.8477 0 97.80 53.40
cuboid   0 1 100.     0 2.8477 0 97.80 53.40

```

```

cuboid   5 1 100.     0 2.9523 0 97.80 53.40
unit 19
cuboid   0 1 49.9477 0 2.8477 0 97.80 53.40
cuboid   5 1 50.0523 0 2.8477 0 97.80 53.40
cuboid   0 1 100.     0 2.8477 0 97.80 53.40
unit 20
array 6 3*0.0
reflector 0 1 4r20.0 2r0.0 1
global
unit 21
array 7 3*0.0
end geom

read array
ara=1 nux=18 nuz=3 fill 324r3 324r2 324rl end fill
ara=2 nux=3 nuz=1 fill 4 5 6 end fill
ara=3 nux=1 nuy=6 nuz=1 fill 8 7 9 10 7 8 end fill
ara=4 nux=18 nuz=18 nuy=1 fill 324rl2 end fill
ara=5 nux=3 nuz=1 fill 13 14 15 end fill
ara=6 nux=1 nuy=6 nuz=1 fill 17 16 18 19 16 17 end fill
ara=7 nux=1 nuy=1 nuz=2 fill 11 20 end fill
end array
end data
end

dsn399-3

=csas25
dsn399-3
44group latticecell
u02   1 0.947 293 92235 4.742 92238 95.258
al    2 1.0
h2o   3 1.0
arbmss 7.90 3 0 0 1 24304 19.17 26304 71.40 28304 9.37 4
hf    5 den=13.29
u02   6 0.947 293 92235 4.742 92238 95.258
end comp
squarepitch 1.60 0.79 1 3 0.94 2 0.82 0
more data res=6 cylinder .395 dan(6)=.991569 end more
1-21x21 assembly surrounded by 0.1046-cm-thick hafnium plates and 0.8
`cm of water, plate-to-assembly distance of 0.8 cm, 49.99 cm water
`height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.395      49.99 0.0
cylinder 0 1 0.410      49.99 0.0
cylinder 2 1 0.470      49.99 0.0
cuboid   3 1 4p0.8      49.99 0.0
unit 2
cylinder 2 1 0.470      0.25  0.0
cylinder 3 1 0.500      0.25  0.0
cuboid   4 1 4p0.8      0.25  0.0
unit 3
cylinder 2 1 0.470      2.35  1.35
cuboid   3 1 4p0.8      2.35  0.8
cuboid   4 1 4p0.8      2.35  0.0

```

```

unit 4
cuboid 3 1 16.2954 0 16.2954 0      52.59 0.8
cuboid 5 1 16.4      0 16.2954 0      52.59 0.8
cuboid 3 1 66.4     0 16.2954 0      52.59 0.8
cuboid 4 1 66.4     0 16.2954 0      52.59 0.0
unit 5
cuboid 5 1 16.2954 0 0.0      -0.1046 52.59 0.8
cuboid 3 1 16.2954 0 33.7046 -0.1046 52.59 0.8
cuboid 4 1 16.2954 0 33.7046 -0.1046 52.59 0.0
unit 6
array 1 3*0.0
reflector 5 1 4r0.1046 2r0.0 1
unit 7
cuboid 3 1 16.2954 0 33.7046 0.0      52.59 0.8
cuboid 5 1 16.2954 0 33.7046 -.1046 52.59 0.8
cuboid 4 1 16.2954 0 33.7046 -.1046 52.59 0.0
unit 8
array 2 3*0.0
unit 9
cuboid 3 1 50.      0 16.2954 0      52.59 0.8
cuboid 5 1 50.1046 0 16.2954 0      52.59 0.8
cuboid 3 1 66.4     0 16.2954 0      52.59 0.8
cuboid 4 1 66.4     0 16.2954 0      52.59 0.0
unit 10
array 3 3*0.0
reflector 3 1 4r20.0 0.0 20.0 1
unit 11
cylinder 6 1 0.395          90.00 49.99
cylinder 0 1 0.410          90.00 49.99
cylinder 2 1 0.470          90.00 49.99
cuboid 0 1 4p0.8           90.00 49.99
unit 12
cuboid 0 1 16.2954 0 16.2954 0      98.20 49.99
cuboid 5 1 16.4      0 16.2954 0      98.20 49.99
cuboid 0 1 66.4     0 16.2954 0      98.20 49.99
unit 13
cuboid 5 1 16.2954 0 0.0      -0.1046 98.20 49.99
cuboid 0 1 16.2954 0 33.7046 -0.1046 98.20 49.99
unit 14
array 4 3*0.0
reflector 5 1 4r0.1046 2r0.0 1
reflector 0 1 4r0.0      8.2 0 1
unit 15
cuboid 0 1 16.2954 0 33.7046 0.0      98.20 49.99
cuboid 5 1 16.2954 0 33.7046 -.1046 98.20 49.99
unit 16
array 5 3*0.0
unit 17
cuboid 0 1 50.      0 16.2954 0      98.20 49.99
cuboid 5 1 50.1046 0 16.2954 0      98.20 49.99
cuboid 0 1 66.4     0 16.2954 0      98.20 49.99
unit 18
array 6 3*0.0
reflector 0 1 4r20.0 2r0.0 1
global
unit 19
array 7 3*0.0
end geom

```

```

read array
ara=1 nux=21 nuy=21 nuz=3 fill 441r3 441r2 441rl1 end fill
ara=2 nux=3 nuy=1 nuz=1 fill 5 6 7 end fill
ara=3 nux=1 nuy=3 nuz=1 fill 9 8 4 end fill
ara=4 nux=21 nuy=21 nuz=1 fill 441r11 end fill
ara=5 nux=3 nuy=1 nuz=1 fill 13 14 15 end fill
ara=6 nux=1 nuy=3 nuz=1 fill 17 16 12 end fill
ara=7 nux=1 nuy=1 nuz=2 fill 10 18 end fill
end array
end data
end

dsn399-4

=csas25
dsn399-4
44group latticecell
uo2   1 0.947 293 92235 4.742 92238 95.258
al    2 1.0
h2o   3 1.0
arbmass 7.90 3 0 0 1 24304 19.17 26304 71.40 28304 9.37 4
hf    5 den=13.29
uo2   6 0.947 293 92235 4.742 92238 95.258
end comp
squarepitch 1.60 0.79 1 3 0.94 2 0.82 0
more data res=6 cylinder .395 dan(6)=.991569 end more
1-20x20 assembly surrounded by 0.1046-cm-thick hafnium plates and 2.4
`cm of water, plate-to-assembly distance of 2.4 cm, 52.83 cm water
`height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.395          52.83 0.0
cylinder 0 1 0.410          52.83 0.0
cylinder 2 1 0.470          52.83 0.0
cuboid 3 1 4p0.8           52.83 0.0
unit 2
cylinder 2 1 0.470          0.25 0.0
cylinder 3 1 0.500          0.25 0.0
cuboid 4 1 4p0.8           0.25 0.0
unit 3
cylinder 2 1 0.470          2.35 1.35
cuboid 3 1 4p0.8           2.35 0.8
unit 4
cuboid 3 1 16.2954 0 16.2954 0 55.43 0.8
cuboid 5 1 16.4      0 16.2954 0 55.43 0.8
cuboid 3 1 66.4     0 16.2954 0 55.43 0.8
unit 5
cuboid 5 1 16.2954 0 0.1046 0 55.43 0.8
cuboid 3 1 16.2954 0 33.8092 0 55.43 0.8
unit 6
array 1 3*0.0
reflector 3 1 1.6 0 1.6 0 2r0.0 1
reflector 5 1 4r0.1046 2r0.0 1
unit 7
cuboid 3 1 16.2954 0 33.7046 0 55.43 0.8
cuboid 5 1 16.2954 0 33.8092 0 55.43 0.8

```

```

unit 8
array 2 3*0.0
unit 9
cuboid 3 1 50. 0 16.2954 0 55.43 0.8
cuboid 5 1 50.1046 0 16.2954 0 55.43 0.8
cuboid 3 1 66.4 0 16.2954 0 55.43 0.8
unit 10
array 3 3*0.0
reflector 4 1 5r0.0 0.8 1
reflector 3 1 4r20.0 0.0 20.0 1
unit 11
cylinder 6 1 0.395 90.00 52.83
cylinder 0 1 0.410 90.00 52.83
cylinder 2 1 0.470 90.00 52.83
cuboid 0 1 4p0.8 90.00 52.83
unit 12
cuboid 0 1 16.2954 0 16.2954 0 98.20 52.83
cuboid 5 1 16.4 0 16.2954 0 98.20 52.83
cuboid 0 1 66.4 0 16.2954 0 98.20 52.83
unit 13
cuboid 5 1 16.2954 0 0.1046 0 98.20 52.83
cuboid 0 1 16.2954 0 33.8092 0 98.20 52.83
unit 14
array 4 3*0.0
reflector 0 1 1.6 0 1.6 0 8.2 0 1
reflector 5 1 4r0.1046 2r0.0 1
unit 15
cuboid 0 1 16.2954 0 33.7046 0 98.20 52.83
cuboid 5 1 16.2954 0 33.8092 0 98.20 52.83
unit 16
array 5 3*0.0
unit 17
cuboid 0 1 50. 0 16.2954 0 98.20 52.83
cuboid 5 1 50.1046 0 16.2954 0 98.20 52.83
cuboid 0 1 66.4 0 16.2954 0 98.20 52.83
unit 18
array 6 3*0.0
reflector 0 1 4r20.0 2r0.0 1
global
unit 19
array 7 3*0.0
end geom

read array
ara=1 nux=20 nuy=20 nuz=3 fill 400r3 400r2 400r1 end fill
ara=2 nux=3 nuy=1 nuz=1 fill 5 6 7 end fill
ara=3 nux=1 nuy=3 nuz=1 fill 9 8 4 end fill
ara=4 nux=20 nuy=20 nuz=1 fill 400r11 end fill
ara=5 nux=3 nuy=1 nuz=1 fill 13 14 15 end fill
ara=6 nux=1 nuy=3 nuz=1 fill 17 16 12 end fill
ara=7 nux=1 nuy=1 nuz=2 fill 10 18 end fill
end array
end data
end

```

epru65

```

#csas25
epru65

```

```

44group latticecell
uo2 1 den=9.20 1.0 293 92234 0.0137 92235 2.35 92236
0.0171 92238 97.62
al 3 1.0 293
h2o 4 1.0 293
pb 5 1.0 293
end comp
squarepitch 1.5621 1.1176 1 4 1.2700 3
Core of 708 fuel rods, 111.76 cm water height with 0.9 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 1
cylinder 3 1 .635 2.540 2.2225
cuboid 4 1 .78105 -.78105 .78105 -.78105 2.540 2.2225
cuboid 3 1 .78105 -.78105 .78105 -.78105 2.540 0
unit 2
cylinder 3 1 .635 5.080 2.540
cuboid 4 1 .66675 -.66675 .66675 -.66675 5.080 2.540
cuboid 3 1 .78105 -.78105 .78105 -.78105 5.080 2.540
unit 3
cylinder 3 1 .5588 7.3025 5.080
cylinder 1 1 .5588 95.885 5.080
cylinder 3 1 .635 95.885 5.080
cuboid 4 1 .78105 -.78105 .78105 -.78105 95.885 5.080
unit 4
cylinder 1 1 .5588 98.4250 95.885
cylinder 3 1 .635 98.4250 95.885
cuboid 4 1 .74041 -.74041 .74041 -.74041 98.4250 95.885
cuboid 3 1 .78105 -.78105 .78105 -.78105 98.4250 95.885
unit 5
cylinder 1 1 .5588 98.7425 98.4250
cylinder 3 1 .635 100.0125 98.4250
cuboid 4 1 .78105 -.78105 .78105 -.78105 100.0125 98.4250
cuboid 5 1 .78105 -.78105 .78105 -.78105 100.965 98.4250
unit 6
cuboid 4 1 .78105 -.78105 .78105 -.78105 2.540 2.2225
cuboid 3 1 .78105 -.78105 .78105 -.78105 2.540 0
unit 7
cuboid 4 1 .66675 -.66675 .66675 -.66675 5.080 2.540
cuboid 3 1 .78105 -.78105 .78105 -.78105 5.080 2.540
unit 8
cuboid 4 1 .78105 -.78105 .78105 -.78105 95.885 5.080
unit 9
cuboid 4 1 .74041 -.74041 .74041 -.74041 98.4250 95.885
cuboid 3 1 .78105 -.78105 .78105 -.78105 98.4250 95.885
unit 10
cuboid 4 1 .78105 -.78105 .78105 -.78105 100.0125 98.4250
cuboid 5 1 .78105 -.78105 .78105 -.78105 100.965 98.4250
global unit 11
array 1 0 0 0
reflector 4 1 30 30 30 30 15.24 30 1
end geom

read array
ara=1 nux=31 nuy=31 nuz=5
fill
13r6 5r1 23r6 11r1 18r6 15r1 15r6 17r1 13r6 19r1 11r6 21r1 9r6
23r1 7r6 25r1 5r6 27r1 2r6 1q31 1r6 29r1 1r6 2q31

```

```

154rl 1r6 155b403
13r7 5r2 23r7 11r2 18r7 15r2 15r7 17r2 13r7 19r2 11r7 21r2 9r7
    23r2 7r7 25r2 5r7 27r2 2r7 1q31 1r7 29r2 1r7 2q31
154r2 1r7 155b403
13r8 5r3 23r8 11r3 18r8 15r3 15r8 17r3 13r8 19r3 11r8 21r3 9r8
    23r3 7r8 25r3 5r8 27r3 2r8 1q31 1r8 29r3 1r8 2q31
154r3 1r8 155b403
13r9 5r4 23r9 11r4 18r9 15r4 15r9 17r4 13r9 19r4 11r9 21r4 9r9
    23r4 7r9 25r4 5r9 27r4 2r9 1q31 1r9 29r4 1r9 2q31
154r4 1r9 155b403
13r10 5r5 23r10 11r5 18r10 15r5 15r10 17r5 13r10 19r5 11r10 21r5 9r10
    23r5 7r10 25r5 5r10 27r5 2r10 1q31 1r10 29r5 1r10 2q31
154r5 1r10 155b403
end fill
end array
end data
end

epru65b

=csas25
epru65
44group          latticecell
uo2  1  den=9.20 1.0 293 92234 0.0137 92235 2.35 92236
    0.0171 92238 97.62
al   3  1.0 293
h2o  4  1.0 293
boron 4  den=463.8-6
end comp
squarepitch 1.5621 1.1176 1 4 1.2700 3
Core of 1201 fuel rods, 111.76 cm water height with 463.8 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 1
cylinder 3 1 .635 2.540 2.2225
cuboid   4 1   .78105 -.78105 .78105 -.78105 2.540      2.2225
cuboid   3 1   .78105 -.78105 .78105 -.78105 2.540 0
unit 2
cylinder 3 1 .635 5.080 2.540
cuboid   4 1   .66675 -.66675 .66675 -.66675 5.080 2.540
cuboid   3 1   .78105 -.78105 .78105 -.78105 5.080 2.540
unit 3
cylinder 3 1 .5588 7.3025 5.080
cylinder 1 1 .5588 95.885 5.080
cylinder 3 1 .635 95.885 5.080
cuboid   4 1   .78105 -.78105 .78105 -.78105 95.885      5.080
unit 4
cylinder 1 1 .5588 98.4250 95.885
cylinder 3 1 .635 98.4250 95.885
cuboid   4 1   .74041 -.74041 .74041 -.74041 98.4250 95.885
cuboid   3 1   .78105 -.78105 .78105 -.78105 98.4250 95.885
unit 5
cylinder 1 1 .5588 98.7425 98.4250
cylinder 3 1 .635 100.0125 98.4250
cuboid   4 1   .78105 -.78105 .78105 -.78105 100.0125 98.4250
unit 6
cuboid   4 1   .78105 -.78105 .78105 -.78105 2.540      2.2225
cuboid   3 1   .78105 -.78105 .78105 -.78105 2.540 0

```

```

unit 7
cuboid   4 1   .66675 -.66675 .66675 -.66675 5.080      2.540
cuboid   3 1   .78105 -.78105 .78105 -.78105 5.080      2.540
unit 8
cuboid   4 1   .78105 -.78105 .78105 -.78105 95.885     5.080
unit 9
cuboid   4 1   .74041 -.74041 .74041 -.74041 98.4250 95.885
cuboid   3 1   .78105 -.78105 .78105 -.78105 98.4250 95.885
unit 10
cuboid  4 1   .78105 -.78105 .78105 -.78105 100.0125 98.4250
global unit 11
array   1  0 0 0
reflector 4 1 30 30 30 30 15.24 30  1
end geom

read array
ara=1 nux=39 nuy=39 nuz=5
fill
15r6 9r1 27r6 15r1 22r6 19r1 18r6 23r1 15r6 25r1 13r6
27r1 11r6
29r1 9r6 31r1 7r6 33r1 3r6 1q39 2r6 35r1 2r6 1q39
1r6 37r1 1r6 2q39 35l1r1 35lb585
15r7 9r2 27r7 15r2 22r7 19r2 18r7 23r2 15r7 25r2 13r7
27r2 11r7
29r2 9r7 31r2 7r7 33r2 3r7 1q39 2r7 35r2 2r7 1q39
1r7 37r2 1r7 2q39 35l2r2 35lb585
15r8 9r3 27r8 15r3 22r8 19r3 18r8 23r3 15r8 25r3 13r8 27r3 11r8
29r3 9r8 31r3 7r8 33r3 3r8 1q39 2r8 35r3 2r8 1q39
1r8 37r3 1r8 2q39 35l1r3 35lb585
15r9 9r4 27r9 15r4 22r9 19r4 18r9 23r4 15r9 25r4 13r9 27r4 11r9
29r4 9r9 31r4 7r9 33r4 3r9 1q39 2r9 35r4 2r9 1q39
1r9 37r4 1r9 2q39 35l1r4 35lb585
15r10 9r5 27r10 15r5 22r10 19r5 18r10 23r5 15r10 25r5 13r10 27r5 1r10
29r5 9r10 31r5 7r10 33r5 3r10 1q39 2r10 35r5 2r10 1q39
1r10 37r5 1r10 2q39 35l1r5 35lb585
end fill
end array
end data
end

epru75

#csas25
epru75
44group          latticecell
uo2  1  den=9.20 1.0 293 92234 0.0137 92235 2.35 92236
    0.0171 92238 97.62
al   3  1.0 293
h2o  4  1.0 293
end comp
squarepitch 1.905 1.1176 1 4 1.2700 3
Core of 383 fuel rods, 112.08 cm water height with 0.5 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 1
cylinder 3 1 .635 5.080 3.175
cuboid   4 1   0.9525 -0.9525 0.9525 -0.9525 5.080 3.175
cuboid   3 1   0.9525 -0.9525 0.9525 -0.9525 5.080 0

```

```

unit 2
cylinder 3 1 .635 6.985 5.080
cylinder 4 1 .74422 6.985 5.080
cuboid 3 1 0.9525 -0.9525 0.9525 -0.9525 6.985 5.080
unit 3
cylinder 1 1 .5588 93.98 6.985
cylinder 3 1 .635 93.98 6.985
cuboid 4 1 0.9525 -0.9525 0.9525 -0.9525 93.98 6.985
unit 4
cylinder 1 1 .5588 95.8850 93.98
cylinder 3 1 .635 95.8850 93.98
cylinder 4 1 .74422 95.8850 93.98
cuboid 3 1 0.9525 -0.9525 0.9525 -0.9525 95.8850 93.98
unit 5
cylinder 1 1 .5588 98.425 95.8850
cylinder 3 1 .635 99.695 95.8850
cuboid 4 1 0.9525 -0.9525 0.9525 -0.9525 99.695 95.8850
unit 6
cuboid 4 1 0.9525 -0.9525 0.9525 -0.9525 5.080 3.175
cuboid 3 1 0.9525 -0.9525 0.9525 -0.9525 5.080 0
unit 7
cylinder 4 1 .74422 6.985 5.080
cuboid 3 1 0.9525 -0.9525 0.9525 -0.9525 6.985 5.080
unit 8
cuboid 4 1 0.9525 -0.9525 0.9525 -0.9525 93.98 6.985
unit 9
cylinder 4 1 .74422 95.8850 93.98
cuboid 3 1 0.9525 -0.9525 0.9525 -0.9525 95.8850 93.98
unit 10
cuboid 4 1 0.9525 -0.9525 0.9525 -0.9525 99.695 95.8850
global unit 11
array 1 0 0 0
reflector 4 1 30 30 30 30 15.24 30 1
end geom

read array
ara=1 nux=21 nuy=21 nuz=5
fill
 8r6 5r1 9r6 19r1 1r6 5q21 1r6 145r1 1r6 147b147
 8r7 5r2 9r7 19r2 1r7 5q21 1r7 145r2 1r7 147b147
 8r8 5r3 9r8 19r3 1r8 5q21 1r8 145r3 1r8 147b147
 8r9 5r4 9r9 19r4 1r9 5q21 1r9 145r4 1r9 147b147
 8r10 5r5 9r10 19r5 1r10 5q21 1r10 145r5 1r10 147b147
end fill
end array
end data
end

epru75b

#csas25
epru75b
44groupndf5          latticecell
uo2 1 den=9.20 1.0 293 92234 0.0137 92235 2.35 92236
  0.0171 92238 97.62
al 3 1.0 293
h2o 4 1.0 293
boron 4 den=568.1-6
end comp

```

```

squarepitch 1.905 1.1176 1 4 1.2700 3
Core of 1201 fuel rods, 112.08 cm water height with 568 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 1
cylinder 3 1 .635 5.080 3.175
cuboid 4 1 0.9525 -0.9525 0.9525 -0.9525 5.080 3.175
cuboid 3 1 0.9525 -0.9525 0.9525 -0.9525 5.080 0
unit 2
cylinder 3 1 .635 6.985 5.080
cylinder 4 1 .74422 6.985 5.080
cuboid 3 1 0.9525 -0.9525 0.9525 -0.9525 6.985 5.080
unit 3
cylinder 1 1 .5588 93.98 6.985
cylinder 3 1 .635 93.98 6.985
cuboid 4 1 0.9525 -0.9525 0.9525 -0.9525 93.98 6.985
unit 4
cylinder 1 1 .5588 95.8850 93.98
cylinder 3 1 .635 95.8850 93.98
cylinder 4 1 .74422 95.8850 93.98
cuboid 3 1 0.9525 -0.9525 0.9525 -0.9525 95.8850 93.98
unit 5
cylinder 1 1 .5588 98.425 95.8850
cylinder 3 1 .635 99.695 95.8850
cuboid 4 1 0.9525 -0.9525 0.9525 -0.9525 99.695 95.8850
unit 6
cuboid 4 1 0.9525 -0.9525 0.9525 -0.9525 5.080 3.175
cuboid 3 1 0.9525 -0.9525 0.9525 -0.9525 5.080 0
unit 7
cylinder 4 1 .74422 6.985 5.080
cuboid 3 1 0.9525 -0.9525 0.9525 -0.9525 6.985 5.080
unit 8
cuboid 4 1 0.9525 -0.9525 0.9525 -0.9525 93.98 6.985
unit 9
cylinder 4 1 .74422 95.8850 93.98
cuboid 3 1 0.9525 -0.9525 0.9525 -0.9525 95.8850 93.98
unit 10
cuboid 4 1 0.9525 -0.9525 0.9525 -0.9525 99.695 95.8850
global unit 11
array 1 0 0 0
reflector 4 1 30 30 30 30 15.24 30 1
end geom

read array
ara=1 nux=39 nuy=39 nuz=5
fill
 15r6 9r1 27r6 15r1 22r6 19r1 18r6 23r1 15r6 25r1 13r6 27r1 11r6
  29r1 9r6 31r1 7r6 33r1 3r6 1q39 2r6 35r1 2r6 1q39
  1r6 37r1 1r6 2q39 351r1 351b585
  15r7 9r2 27r7 15r2 22r7 19r2 18r7 23r2 15r7 25r2 13r7 27r2 11r7
  29r2 9r7 31r2 7r7 33r2 3r7 1q39 2r7 35r2 2r7 1q39
  1r7 37r2 1r7 2q39 351r2 351b585
  15r8 9r3 27r8 15r3 22r8 19r3 18r8 23r3 15r8 25r3 13r8 27r3 11r8
  29r3 9r8 31r3 7r8 33r3 3r8 1q39 2r8 35r3 2r8 1q39
  1r8 37r3 1r8 2q39 351r3 351b585
  15r9 9r4 27r9 15r4 22r9 19r4 18r9 23r4 15r9 25r4 13r9 27r4 11r9
  29r4 9r9 31r4 7r9 33r4 3r9 1q39 2r9 35r4 2r9 1q39
  1r9 37r4 1r9 2q39 351r4 351b585

```

```

15r10 9r5 27r10 15r5 22r10 19r5 18r10 23r5 15r10 25r5 13r10 27r5 1r10
29r5 9r10 31r5 7r10 33r5 3x10 1q39 2r10 35r5 2r10 1q39
1r10 37r5 1r10 2q39 35l1r5 35lb585

```

```

end fill
end array
end data
end

```

epru87

```

#csas25
epru87
44group          latticecell
uo2  1  den=9.20 1.0 293 92234 0.0137  92235 2.35  92236
               0.0171 92238 97.62
al   3  1.0 293
h2o  4  1.0 293
pb   5  1.0 293
end comp
squarepitch 2.2098 1.1176 1.4  1.2700 3
Core of 342 fuel rods, 111.76 cm water height with 0.9 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 1
cylinder 3 1 .635 2.540 2.225
cuboid   4 1    .78105 -.78105 .78105 -.78105 2.540 2.225
cuboid   3 1    .78105 -.78105 .78105 -.78105 2.540 0
unit 2
cylinder 3 1 .635 5.080 2.540
cuboid   4 1    .66675 -.66675 .66675 -.66675 5.080 2.540
cuboid   3 1    .78105 -.78105 .78105 -.78105 5.080 2.540
unit 3
cylinder 3 1 .5588 7.3025 5.080
cylinder 1 1 .5588 95.885 5.080
cylinder 3 1 .635 95.885 5.080
cuboid   4 1    .78105 -.78105 .78105 -.78105 95.885 5.080
unit 4
cylinder 1 1 .5588 98.4250 95.885
cylinder 3 1 .635 98.4250 95.885
cuboid   4 1    .74041 -.74041 .74041 -.74041 98.4250 95.885
cuboid   3 1    .78105 -.78105 .78105 -.78105 98.4250 95.885
unit 5
cylinder 1 1 .5588 98.7425 98.4250
cylinder 3 1 .635 100.0125 98.4250
cuboid   4 1    .78105 -.78105 .78105 -.78105 100.0125 98.4250
cuboid   5 1    .78105 -.78105 .78105 -.78105 100.965 98.4250
unit 6
cuboid   4 1    .78105 -.78105 .78105 -.78105 2.540 2.225
cuboid   3 1    .78105 -.78105 .78105 -.78105 2.540 0
unit 7
cuboid   4 1    .66675 -.66675 .66675 -.66675 5.080 2.540
cuboid   3 1    .78105 -.78105 .78105 -.78105 5.080 2.540
unit 8
cuboid   4 1    .78105 -.78105 .78105 -.78105 95.885 5.080
unit 9
cuboid   4 1    .74041 -.74041 .74041 -.74041 98.4250 95.885
cuboid   3 1    .78105 -.78105 .78105 -.78105 98.4250 95.885

```

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```

unit 10
cuboid   4 1    .78105 -.78105 .78105 -.78105 100.0125 98.4250
cuboid   5 1    .78105 -.78105 .78105 -.78105 100.965 98.4250
global unit 11
array    1  0 0 0
reflector 4 1 30 30 30 30 15.24 30  1
end geom

read array
ara=1 nux=29 tuy=29 nuz=5
fill
10r6 1 6 4q2 9r6 9r6 1 6 6q2 6r6 6r6 1 6 8q2 5r6 5r6 1 6 9q2 4r6
4r6 1 6 10q2 3r6 3r6 1 6 11q2 2r6 2r6 1 6 12q2 6 1q58
6 1 13q2 6 1 6 13q2 1 4q58 261b232
9r6 1 6 5q2 8r6 10r6 1 6 4q2 9r6
10r7 2 7 4q2 9r7 9r7 2 7 6q2 6r7 6r7 2 7 8q2 5r7 5r7 2 7 9q2 4r7
4r7 2 7 10q2 3r7 3r7 2 7 11q2 2r7 2r7 2 7 12q2 7 1q58
7 2 13q2 7 2 7 13q2 2 4q58 261b232
9r7 2 7 5q2 8r7 10r7 2 7 4q2 9r7
10r8 3 8 4q2 9r8 9r8 3 8 6q2 6r8 6r8 3 8 8q2 5r8 5r8 3 8 9q2 4r8
4r8 3 8 10q2 3r8 3r8 3 8 11q2 2r8 2r8 3 8 12q2 8 1q58
8 3 13q2 8 3 8 13q2 3 4q58 261b232
9r8 3 8 5q2 8r8 10r8 3 8 4q2 9r8
10r9 4 9 4q2 9r9 9r9 4 9 6q2 6r9 6r9 4 9 8q2 5r9 5r9 4 9 9q2 4r9
4r9 4 9 10q2 3r9 3r9 4 9 11q2 2r9 2r9 4 9 12q2 9 1q58
9 4 13q2 9 4 9 13q2 4 4q58 261b232
9r9 4 9 5q2 8r9 10r9 4 9 4q2 9r9
10r10 5 10 4q2 9r10 9r10 5 10 6q2 6r10 6r10 5 10 8q2 5r10 5r10 5 10
9q2 4r10
4r10 5 10 10q2 3r10 3r10 5 10 11q2 2r10 2r10 5 10 12q2 10 1q58
10 5 13q2 10 5 10 13q2 5 4q58 261b232
9r10 5 10 5q2 8r10 10r10 5 10 4q2 9r10
end fill
end array
end data
end

```

epru87b

```

#csas25
epru87b
44group          latticecell
uo2  1  den=9.20 1.0 293 92234 0.0137  92235 2.35  92236 0.0171
               92238 97.62
al   3  1.0 293
h2o  4  1.0 293
boron 4 den=285.8-6
end comp
squarepitch 2.2098 1.1176 1.4  1.2700 3
Core of 885 fuel rods, 111.76 cm water height with 285.8 ppm boron
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 1
cylinder 3 1 .635 2.540 2.225
cuboid   4 1    1.1049 -.1.1049 1.1049 -1.1049 2.540 2.225
cuboid   3 1    1.1049 -.1.1049 1.1049 -1.1049 2.540 0
unit 2
cylinder 3 1 .635 5.080 2.540

```

Appendix A

```

cuboid    4 1    .99060 -.99060 .99060 -.99060 5.080 2.540
cuboid    3 1    1.1049 -1.1049 1.1049 -1.1049 5.080 2.540
unit 3
cylinder 3 1 .5588 7.3025 5.080
cylinder 1 1 .5588 95.885 5.080
cylinder 3 1 .635 95.885 5.080
cuboid    4 1    1.1049 -1.1049 1.1049 -1.1049 95.885 5.080
unit 4
cylinder 1 1 .5588 98.4250 95.885
cylinder 3 1 .635 98.4250 95.885
cuboid    4 1    1.06426 -1.06426 1.06426 -1.06426 98.4250 95.885
cuboid    3 1    1.1049 -1.1049 1.1049 -1.1049 98.4250 95.885
unit 5
cylinder 1 1 .5588 98.7425 98.4250
cylinder 3 1 .635 100.0125 98.4250
cuboid    4 1    1.1049 -1.1049 1.1049 -1.1049 100.0125 98.4250
unit 6
cuboid    4 1    1.1049 -1.1049 1.1049 -1.1049 2.540 2.2225
cuboid    3 1    1.1049 -1.1049 1.1049 -1.1049 2.540 0
unit 7
cuboid    4 1    .99060 -.99060 .99060 -.99060 5.080 2.540
cuboid    3 1    1.1049 -1.1049 1.1049 -1.1049 5.080 2.540
unit 8
cuboid    4 1    1.1049 -1.1049 1.1049 -1.1049 95.885 5.080
unit 9
cuboid    4 1    1.06426 -1.06426 1.06426 -1.06426 98.4250 95.885
cuboid    3 1    1.1049 -1.1049 1.1049 -1.1049 98.4250 95.885
unit 10
cuboid   4 1    1.1049 -1.1049 1.1049 -1.1049 100.0125 98.4250
global unit 11
array     1 0 0 0
reflector 4 1 30 30 30 30 15.24 30 1
end geom

read array
ara=1 nux=33 nuy=33 nuz=5
fill
 11r6 11r1 20r6 15r1 16r6 19r1 13r6 21r1 11r6 23r1 9r6 25r1 7r6
 27r1 5r6 29r1 2r6 1q33 1r6 31r1 1r6 1q33 363r1 363b363
 11r7 11r2 20r7 15r2 16r7 19r2 13r7 21r2 11r7 23r2 9r7 25r2 7r7
 27r2 5r7 29r2 2r7 1q33 1r7 31r2 1r7 1q33 363r2 363b363
 11r8 11r3 20r8 15r3 16r8 19r3 13r8 21r3 11r8 23r3 9r8 25r3 7r8
 27r3 5r8 29r3 2r8 1q33 1r8 31r3 1r8 1q33 363r3 363b363
 11r9 11r4 20r9 15r4 16r9 19r4 13r9 21r4 11r9 23r4 9r9 25r4 7r9
 27r4 5r9 29r4 2r9 1q33 1r9 31r4 1r9 1q33 363r4 363b363
 11r10 11r5 20r10 15r5 16r10 19r5 13r10 21r5 11r10 23r5 9r10 25r5 7r10
 27r5 5r10 29r5 2r10 1q33 1r10 31r5 1r10 1q33 363r5 363b363
end fill
end array
end data
end

nse71h1

#csas25
nse71h1
44group latticecell
uo2    1 den=10.38 1.0 293 92235 4.742 92238 95.258      end
arbmag5 2.70 4 0 0 1 13027 98.85 12000 0.47 14000 0.43

```

```

26000 0.22 2 1 293
3 1.0
end
arbmsl 7.90 3 0 0 1 26304 71.40 24304 19.16 28304 9.44 4 1
end
al      5 0.437
end
arbmsl 7.90 3 0 0 1 26304 71.40 24304 19.16 28304 9.44 5 .505 end
h2o      5 0.058
end
al      6 0.62
end
h2o      6 0.038
end
uo2      7 0.946 293 92235 4.742 92238 95.258
end
end comp
triangpitch 1.35 0.79 1 3 0.94 2 0.82 0
end
more data res=7 cyl 0.395 dan(7)=.98636
end
Core of 547 fuel rods in a hexagonal lattice, 60.93 cm water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 2
zhemicyl+y 1 1 .395          60.93 0.0
zhemicyl+y 0 1 .410          60.93 0.0
zhemicyl+y 2 1 .470          60.93 0.0
unit 3
zhemicyl-x 1 1 .395          60.93 0.0
zhemicyl-x 0 1 .410          60.93 0.0
zhemicyl-x 2 1 .470          60.93 0.0
unit 4
zhemicyl+x 1 1 .395          60.93 0.0
zhemicyl+x 0 1 .410          60.93 0.0
zhemicyl+x 2 1 .470          60.93 0.0
unit 5
zhemicyl-y 1 1 .395          60.93 0.0
zhemicyl-y 0 1 .410          60.93 0.0
zhemicyl-y 2 1 .470          60.93 0.0
cuboid   3 1 2p1.1692 0 -1.35 60.93 0.0
hole     2 0                 -1.35 0.0
hole     3 +1.1692           -0.675 0.0
hole     4 -1.1692           -0.675 0.0
unit 6
zhemicyl+y 1 1 .395          60.93 0.0
zhemicyl+y 0 1 .410          60.93 0.0
zhemicyl+y 2 1 .470          60.93 0.0
cuboid   3 1 2p1.1692 1.35 0 60.93 0.0
hole     3 +1.1692           +0.675 0.0
unit 7
zhemicyl+y 1 1 .395          60.93 0.0
zhemicyl+y 0 1 .410          60.93 0.0
zhemicyl+y 2 1 .470          60.93 0.0
cuboid   3 1 2p1.1692 1.35 0 60.93 0.0
hole     4 -1.1692           +0.675 0.0
unit 8
zhemicyl-y 1 1 .395          60.93 0.0
zhemicyl-y 0 1 .410          60.93 0.0

```

```

zhemicyl-y 2 1 .470      60.93  0.0
cuboid    3 1 2p1.1692  0 -1.35  60.93  0.0
hole      3   +1.1692   -0.675   0.0
unit     9
zhemicyl-y 1 1 .395      60.93  0.0
zhemicyl-y 0 1 .410      60.93  0.0
zhemicyl-y 2 1 .470      60.93  0.0
cuboid    3 1 2p1.1692  0 -1.35  60.93  0.0
hole      4   -1.1692   -0.675   0.0
unit    10
zhemicyl-y 1 1 .395      60.93  0.0
zhemicyl-y 0 1 .410      60.93  0.0
zhemicyl-y 2 1 .470      60.93  0.0
cuboid    3 1 2p1.1692  0 -1.35  60.93  0.0
unit    11
zhemicyl+y 1 1 .395      60.93  0.0
zhemicyl+y 0 1 .410      60.93  0.0
zhemicyl+y 2 1 .470      60.93  0.0
cuboid    3 1 2p1.1692  1.35   0   60.93  0.0
unit    12
cuboid    3 1 2p1.1692  1.35   0   60.93  0.0
hole      3   +1.1692   +0.675   0.0
unit    13
cuboid    3 1 2p1.1692  1.35   0   60.93  0.0
hole      4   -1.1692   +0.675   0.0
unit    14
cuboid    3 1 2p1.1692  1.35   0   60.93  0.0
unit    15
zhemicyl+y 7 1 .395      29.07  0.0
zhemicyl+y 0 1 .410      29.07  0.0
zhemicyl+y 2 1 .470      29.07  0.0
unit    16
zhemicyl-x 7 1 .395      29.07  0.0
zhemicyl-x 0 1 .410      29.07  0.0
zhemicyl-x 2 1 .470      29.07  0.0
unit    17
zhemicyl+x 7 1 .395      29.07  0.0
zhemicyl+x 0 1 .410      29.07  0.0
zhemicyl+x 2 1 .470      29.07  0.0
unit    18
zhemicyl-y 7 1 .395      29.07  0.0
zhemicyl-y 0 1 .410      29.07  0.0
zhemicyl-y 2 1 .470      29.07  0.0
cuboid    0 1 2p1.1692  0 -1.35  29.07  0.0
hole      15   0       -1.35   0.0
hole      16   +1.1692  -0.675   0.0
hole      17   -1.1692  -0.675   0.0
unit    19
zhemicyl+y 7 1 .395      29.07  0.0
zhemicyl+y 0 1 .410      29.07  0.0
zhemicyl+y 2 1 .470      29.07  0.0
cuboid    0 1 2p1.1692  1.35   0   29.07  0.0
hole      16   +1.1692   +0.675   0.0
unit    20
zhemicyl+y 7 1 .395      29.07  0.0
zhemicyl+y 0 1 .410      29.07  0.0
zhemicyl+y 2 1 .470      29.07  0.0
cuboid    0 1 2p1.1692  1.35   0   29.07  0.0
hole      17   -1.1692   +0.675   0.0

```

```

unit    21
zhemicyl-y 7 1 .395      29.07  0.0
zhemicyl-y 0 1 .410      29.07  0.0
zhemicyl-y 2 1 .470      29.07  0.0
cuboid    0 1 2p1.1692  0 -1.35  29.07  0.0
hole      16   +1.1692   -0.675   0.0
unit    22
zhemicyl-y 7 1 .395      29.07  0.0
zhemicyl-y 0 1 .410      29.07  0.0
zhemicyl-y 2 1 .470      29.07  0.0
cuboid    0 1 2p1.1692  0 -1.35  29.07  0.0
hole      17   -1.1692   -0.675   0.0
unit    23
zhemicyl+y 7 1 .395      29.07  0.0
zhemicyl+y 0 1 .410      29.07  0.0
zhemicyl+y 2 1 .470      29.07  0.0
cuboid    0 1 2p1.1692  0 -1.35  29.07  0.0
unit    24
zhemicyl+y 7 1 .395      29.07  0.0
zhemicyl+y 0 1 .410      29.07  0.0
zhemicyl+y 2 1 .470      29.07  0.0
cuboid    0 1 2p1.1692  1.35   0   29.07  0.0
unit    25
cuboid    0 1 2p1.1692  1.35   0   29.07  0.0
hole      16   +1.1692   +0.675   0.0
unit    26
cuboid    0 1 2p1.1692  1.35   0   29.07  0.0
hole      17   -1.1692   +0.675   0.0
unit    27
cuboid    0 1 2p1.1692  1.35   0   29.07  0.0
unit    28
array 1 3*0.0
reflector 5 1 5r0   0.25  1
reflector 6 1 5r0   1.55  1
reflector 3 1 4r20  2r0   1
reflector 4 1 5r0   .8   1
reflector 3 1 5r0   20   1
unit    29
array 2 3*0.0
reflector 0 1 4r20  2r0   1
global unit 30
array 3 3*0.0
end geom

read array
ara=1 nux=15 nuy=28 nuz=1
fill 7r14 10 7r14 6r14 8 5 9 6r14 5r14 8 3r5 9 5r14
      4r14 8 5r5 9 4r14 3r14 8 7r5 9 3r14 2r14 8 9r5 9 2r14
      14 8 11r5 9 14 12 13r5 13 13q15
      14 6 11r5 7 14 2r14 6 9r5 7 2r14 3r14 6 7r5 7 3r14
      4r14 6 5r5 7 4r14 5r14 6 3r5 7 5r14 6r14 6 5 7 6r14
      7r14 11 7r14                                end fill
ara=2 nux=15 nuy=28 nuz=1
fill 7r27 23 7r27 6r27 21 18 22 6r27 5r27 21 3r18 22 5r27
      4r27 21 5r18 22 4r27 3r27 21 7r18 22 3r27 2r27 21 9r18 22 2r27
      27 21 11r18 22 27 25 13r18 26 13q15
      27 19 11r18 20 27 2r27 19 9r18 20 2r27 3r27 19 7r18 20 3r27
      4r27 19 5r18 20 4r27 5r27 19 3r18 20 5r27 6r27 19 18 20 6r27
      7r27 24 7r27                                end fill

```

```

ara=3 nux=1 nuy=1 nuz=2 fill 28 29 end fill
end array
end data
end

nse71h2

#csas25
nse71h2
44group latticecell
uo2    1 den=10.38 1.0 293 92235 4.742 92238 95.258
arbmag5 2.70 4 0 0 1 13027 98.85 12000 0.47 14000 0.43
26000 0.22 2 1 293
h2o    3 1.0
arbmastl 7.90 3 0 0 1 26304 71.40 24304 19.16 28304 9.44 4 1
al      5 0.437
arbmastl 7.90 3 0 0 1 26304 71.40 24304 19.16 28304 9.44 5 .505
h2o    5 0.058
al      6 0.62
h2o    6 0.038
uo2    7 0.946 293 92235 4.742 92238 95.258
end comp
triangpitch 1.72 0.79 1 3 0.94 2 0.82 0
more data res=7 cyl 0.395 dan(7)=.98899
Core of 271 fuel rods in a hexagonal lattice, 68.06 cm water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 2
zhemicyl+y 1 1 .395          68.06 0.0
zhemicyl+y 0 1 .410          68.06 0.0
zhemicyl+y 2 1 .470          68.06 0.0
unit 3
zhemicyl-x 1 1 .395          68.06 0.0
zhemicyl-x 0 1 .410          68.06 0.0
zhemicyl-x 2 1 .470          68.06 0.0
unit 4
zhemicyl+x 1 1 .395          68.06 0.0
zhemicyl+x 0 1 .410          68.06 0.0
zhemicyl+x 2 1 .470          68.06 0.0
unit 5
zhemicyl-y 1 1 .395          68.06 0.0
zhemicyl-y 0 1 .410          68.06 0.0
zhemicyl-y 2 1 .470          68.06 0.0
cuboid   3 1 2p1.4896 0 -1.72 68.06 0.0
hole     2 0 -1.72 0.0
hole     3 +1.4896 -0.860 0.0
hole     4 -1.4896 -0.860 0.0
unit 6
zhemicyl+y 1 1 .395          68.06 0.0
zhemicyl+y 0 1 .410          68.06 0.0
zhemicyl+y 2 1 .470          68.06 0.0
cuboid   3 1 2p1.4896 1.72 0 68.06 0.0
hole     3 +1.4896 +0.860 0.0
unit 7
zhemicyl+y 1 1 .395          68.06 0.0
zhemicyl+y 0 1 .410          68.06 0.0
zhemicyl+y 2 1 .470          68.06 0.0
cuboid   3 1 2p1.4896 1.72 0 68.06 0.0

```

```

hole     4 -1.4896 +0.860 0.0
unit 8
zhemicyl-y 1 1 .395          68.06 0.0
zhemicyl-y 0 1 .410          68.06 0.0
zhemicyl-y 2 1 .470          68.06 0.0
cuboid   3 1 2p1.4896 0 -1.72 68.06 0.0
hole     3 +1.4896 -0.860 0.0
unit 9
zhemicyl-y 1 1 .395          68.06 0.0
zhemicyl-y 0 1 .410          68.06 0.0
zhemicyl-y 2 1 .470          68.06 0.0
cuboid   3 1 2p1.4896 0 -1.72 68.06 0.0
hole     4 -1.4896 -0.860 0.0
unit 10
zhemicyl-y 1 1 .395          68.06 0.0
zhemicyl-y 0 1 .410          68.06 0.0
zhemicyl-y 2 1 .470          68.06 0.0
cuboid   3 1 2p1.4896 0 -1.72 68.06 0.0
unit 11
zhemicyl+y 1 1 .395          68.06 0.0
zhemicyl+y 0 1 .410          68.06 0.0
zhemicyl+y 2 1 .470          68.06 0.0
cuboid   3 1 2p1.4896 1.72 0 68.06 0.0
unit 12
cuboid   3 1 2p1.4896 1.72 0 68.06 0.0
hole     3 +1.4896 +0.860 0.0
unit 13
cuboid   3 1 2p1.4896 1.72 0 68.06 0.0
hole     4 -1.4896 +0.860 0.0
unit 14
cuboid   3 1 2p1.4896 1.72 0 68.06 0.0
unit 15
zhemicyl+y 7 1 .395          90.00 68.06
zhemicyl+y 0 1 .410          90.00 68.06
zhemicyl+y 2 1 .470          90.00 68.06
unit 16
zhemicyl-x 7 1 .395          90.00 68.06
zhemicyl-x 0 1 .410          90.00 68.06
zhemicyl-x 2 1 .470          90.00 68.06
unit 17
zhemicyl+x 7 1 .395          90.00 68.06
zhemicyl+x 0 1 .410          90.00 68.06
zhemicyl+x 2 1 .470          90.00 68.06
unit 18
zhemicyl-y 7 1 .395          90.00 68.06
zhemicyl-y 0 1 .410          90.00 68.06
zhemicyl-y 2 1 .470          90.00 68.06
cuboid   0 1 2p1.4896 0 -1.72 90.00 68.06
hole     15 0 -1.72 0.0
hole     16 +1.4896 -0.860 0.0
hole     17 -1.4896 -0.860 0.0
unit 19
zhemicyl+y 7 1 .395          90.00 68.06
zhemicyl+y 0 1 .410          90.00 68.06
zhemicyl+y 2 1 .470          90.00 68.06
cuboid   0 1 2p1.4896 1.72 0 90.00 68.06
hole     16 +1.4896 +0.860 0.0
unit 20
zhemicyl+y 7 1 .395          90.00 68.06

```

```

zhemicyl+y 0 1 .410          90.00 68.06
zhemicyl+y 2 1 .470          90.00 68.06
cuboid    0 1 2p1.4896 1.72 0 90.00 68.06
hole      17 -1.4896 +0.860   0.0
unit     21
zhemicyl-y 7 1 .395          90.00 68.06
zhemicyl-y 0 1 .410          90.00 68.06
zhemicyl-y 2 1 .470          90.00 68.06
cuboid    0 1 2p1.4896 0 -1.72 90.00 68.06
hole      16 +1.4896 -0.860   0.0
unit     22
zhemicyl-y 7 1 .395          90.00 68.06
zhemicyl-y 0 1 .410          90.00 68.06
zhemicyl-y 2 1 .470          90.00 68.06
cuboid    0 1 2p1.4896 0 -1.72 90.00 68.06
hole      17 -1.4896 -0.860   0.0
unit     23
zhemicyl-y 7 1 .395          90.00 68.06
zhemicyl-y 0 1 .410          90.00 68.06
zhemicyl-y 2 1 .470          90.00 68.06
cuboid    0 1 2p1.4896 0 -1.72 90.00 68.06
unit     24
zhemicyl+y 7 1 .395          90.00 68.06
zhemicyl+y 0 1 .410          90.00 68.06
zhemicyl+y 2 1 .470          90.00 68.06
cuboid    0 1 2p1.4896 0 -1.72 90.00 68.06
unit     25
cuboid    0 1 2p1.4896 1.72 0 90.00 68.06
hole      16 +1.4896 +0.860   0.0
unit     26
cuboid    0 1 2p1.4896 1.72 0 90.00 68.06
hole      17 -1.4896 +0.860   0.0
unit     27
cuboid    0 1 2p1.4896 1.72 0 90.00 68.06
unit     28
array 1 3*0.0
reflector 5 1 5r0 0.25 1
reflector 6 1 5r0 1.55 1
reflector 3 1 4r20 2r0 1
reflector 4 1 5r0 .8 1
reflector 3 1 5r0 20 1
unit     29
array 2 3*0.0
reflector 0 1 4r20 2r0 1
global unit 30
array 3 3*0.0
end geom

read array
ara=1 nux=11 nuy=20 nuz=1
fill 5r14 10 5r14 4r14 8 5 9 4r14 3r14 8 3r5 9 3r14
2r14 8 5r5 9 2r14 14 8 7r5 9 14 12 9r5 13
9q11
14 6 7r5 7 14 2r14 6 5r5 7 2r14 3r14 6 3r5 7 3r14
4r14 6 5 7 4r14 5r14 11 5r14 end fill
ara=2 nux=11 nuy=20 nuz=1
fill 5r27 23 5r27 4r27 21 18 22 4r27 3r27 21 3r18 22 3r27
2r27 21 5r18 22 2r27 27 21 7r18 22 27 25 9r18 26
9q11

27 19 7r18 20 27 2r27 19 5r18 20 2r27 3r27 19 3r18 20 3r27
4r27 19 18 20 4r27 5r27 24 5r27 end fill
ara=3 nux=1 nuy=1 nuz=2 fill 28 29 end fill
end array
end data
end

nse71h3

#csas25
nse71h3
44group latticecell
uo2 1 den=10.38 1.0 293 92235 4.742 92238 95.258
arbmag5 2.70 4 0 0 1 13027 98.85 12000 0.47 14000 0.43
26000 0.22 2 1 293
h2o 3 1.0
arbmsrl 7.90 3 0 0 1 26304 71.40 24304 19.16 28304 9.44 4 1
end
al 5 0.437
arbmsrl 7.90 3 0 0 1 26304 71.40 24304 19.16 28304 9.44 5 .505 end
h2o 5 0.058
end
al 6 0.62
h2o 6 0.038
end
uo2 7 0.946 293 92235 4.742 92238 95.258
end
end comp
triangpitch 2.26 0.79 1 3 0.94 2 0.82 0
end
more data res=7 cyl 0.395 dan(7)=.991675
end
Core of 217 fuel rods in a hexagonal lattice, 79.50 cm water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 2
zhemicyl+y 1 1 .395          79.50 0.0
zhemicyl+y 0 1 .410          79.50 0.0
zhemicyl+y 2 1 .470          79.50 0.0
unit 3
zhemicyl-x 1 1 .395          79.50 0.0
zhemicyl-x 0 1 .410          79.50 0.0
zhemicyl-x 2 1 .470          79.50 0.0
unit 4
zhemicyl+x 1 1 .395          79.50 0.0
zhemicyl+x 0 1 .410          79.50 0.0
zhemicyl+x 2 1 .470          79.50 0.0
unit 5
zhemicyl-y 1 1 .395          79.50 0.0
zhemicyl-y 0 1 .410          79.50 0.0
zhemicyl-y 2 1 .470          79.50 0.0
cuboid 3 1 2p1.9572 0 -2.26 79.50 0.0
hole 2 0 -2.26 0.0
hole 3 +1.9572 -1.130 0.0
hole 4 -1.9572 -1.130 0.0
unit 6
zhemicyl+y 1 1 .395          79.50 0.0
zhemicyl+y 0 1 .410          79.50 0.0

```

zhemicyl+y 2 1 .470 79.50 0.0
 cuboid 3 1 2p1.9572 2.26 0 79.50 0.0
 hole 3 +1.9572 +1.130 0.0
 unit 7
 zhemicyl+y 1 1 .395 79.50 0.0
 zhemicyl+y 0 1 .410 79.50 0.0
 zhemicyl+y 2 1 .470 79.50 0.0
 cuboid 3 1 2p1.9572 2.26 0 79.50 0.0
 hole 4 -1.9572 +1.130 0.0
 unit 8
 zhemicyl-y 1 1 .395 79.50 0.0
 zhemicyl-y 0 1 .410 79.50 0.0
 zhemicyl-y 2 1 .470 79.50 0.0
 cuboid 3 1 2p1.9572 0 -2.26 79.50 0.0
 hole 3 +1.9572 -1.130 0.0
 unit 9
 zhemicyl-y 1 1 .395 79.50 0.0
 zhemicyl-y 0 1 .410 79.50 0.0
 zhemicyl-y 2 1 .470 79.50 0.0
 cuboid 3 1 2p1.9572 0 -2.26 79.50 0.0
 hole 4 -1.9572 -1.130 0.0
 unit 10
 zhemicyl-y 1 1 .395 79.50 0.0
 zhemicyl-y 0 1 .410 79.50 0.0
 zhemicyl-y 2 1 .470 79.50 0.0
 cuboid 3 1 2p1.9572 0 -2.26 79.50 0.0
 unit 11
 zhemicyl+y 1 1 .395 79.50 0.0
 zhemicyl+y 0 1 .410 79.50 0.0
 zhemicyl+y 2 1 .470 79.50 0.0
 cuboid 3 1 2p1.9572 2.26 0 79.50 0.0
 unit 12
 zhemicyl-y 1 1 .395 79.50 0.0
 zhemicyl-y 0 1 .410 79.50 0.0
 zhemicyl-y 2 1 .470 79.50 0.0
 cuboid 3 1 2p1.9572 0 -2.26 79.50 0.0
 hole 2 0 -2.26 0.0
 hole 3 +1.9572 -1.130 0.0
 unit 13
 zhemicyl-y 1 1 .395 79.50 0.0
 zhemicyl-y 0 1 .410 79.50 0.0
 zhemicyl-y 2 1 .470 79.50 0.0
 cuboid 3 1 2p1.9572 0 -2.26 79.50 0.0
 hole 2 0 -2.26 0.0
 hole 4 -1.9572 -1.130 0.0
 unit 14
 cuboid 3 1 2p1.9572 2.26 0 79.50 0.0
 unit 15
 zhemicyl+y 7 1 .395 90.00 79.50
 zhemicyl+y 0 1 .410 90.00 79.50
 zhemicyl+y 2 1 .470 90.00 79.50
 unit 16
 zhemicyl-x 7 1 .395 90.00 79.50
 zhemicyl-x 0 1 .410 90.00 79.50
 zhemicyl-x 2 1 .470 90.00 79.50
 unit 17
 zhemicyl+x 7 1 .395 90.00 79.50
 zhemicyl+x 0 1 .410 90.00 79.50
 zhemicyl+x 2 1 .470 90.00 79.50

unit 18
 zhemicyl-y 7 1 .395 90.00 79.50
 zhemicyl-y 0 1 .410 90.00 79.50
 zhemicyl-y 2 1 .470 90.00 79.50
 cuboid 0 1 2p1.9572 0 -2.26 90.00 79.50
 hole 15 0 -2.26 0.0
 hole 16 +1.9572 -1.130 0.0
 hole 17 -1.9572 -1.130 0.0
 unit 19
 zhemicyl+y 7 1 .395 90.00 79.50
 zhemicyl+y 0 1 .410 90.00 79.50
 zhemicyl+y 2 1 .470 90.00 79.50
 cuboid 0 1 2p1.9572 2.26 0 90.00 79.50
 hole 16 +1.9572 +1.130 0.0
 unit 20
 zhemicyl+y 7 1 .395 90.00 79.50
 zhemicyl+y 0 1 .410 90.00 79.50
 zhemicyl+y 2 1 .470 90.00 79.50
 cuboid 0 1 2p1.9572 2.26 0 90.00 79.50
 hole 17 -1.9572 +1.130 0.0
 unit 21
 zhemicyl-y 7 1 .395 90.00 79.50
 zhemicyl-y 0 1 .410 90.00 79.50
 zhemicyl-y 2 1 .470 90.00 79.50
 cuboid 0 1 2p1.9572 0 -2.26 90.00 79.50
 hole 16 +1.9572 -1.130 0.0
 unit 22
 zhemicyl-y 7 1 .395 90.00 79.50
 zhemicyl-y 0 1 .410 90.00 79.50
 zhemicyl-y 2 1 .470 90.00 79.50
 cuboid 0 1 2p1.9572 0 -2.26 90.00 79.50
 hole 17 -1.9572 -1.130 0.0
 unit 23
 zhemicyl-y 7 1 .395 90.00 79.50
 zhemicyl-y 0 1 .410 90.00 79.50
 zhemicyl-y 2 1 .470 90.00 79.50
 cuboid 0 1 2p1.9572 0 -2.26 90.00 79.50
 unit 24
 zhemicyl+y 7 1 .395 90.00 79.50
 zhemicyl+y 0 1 .410 90.00 79.50
 zhemicyl+y 2 1 .470 90.00 79.50
 cuboid 0 1 2p1.9572 2.26 0 90.00 79.50
 unit 25
 zhemicyl-y 7 1 .395 90.00 79.50
 zhemicyl-y 0 1 .410 90.00 79.50
 zhemicyl-y 2 1 .470 90.00 79.50
 cuboid 0 1 2p1.9572 0 -2.26 90.00 79.50
 hole 15 0 -2.26 0.0
 hole 16 +1.9572 -1.130 0.0
 unit 26
 zhemicyl-y 7 1 .395 90.00 79.50
 zhemicyl-y 0 1 .410 90.00 79.50
 zhemicyl-y 2 1 .470 90.00 79.50
 cuboid 0 1 2p1.9572 0 -2.26 90.00 79.50
 hole 15 0 -2.26 0.0
 hole 17 -1.9572 -1.130 0.0
 unit 27
 cuboid 0 1 2p1.9572 2.26 0 90.00 79.50

```

unit 28
array 1 3*0.0
reflector 5 1 5r0    0.25 1
reflector 6 1 5r0    1.55 1
reflector 3 1 4r20  2r0    1
reflector 4 1 5r0    .8   1
reflector 3 1 5r0    20   1
unit 29
array 2 3*0.0
reflector 0 1 4r20  2r0    1
global unit 30

array 3 3*0.0
end geom

read array
ara=1 nux=9 nuy=18 nuz=1
fill 4r14 10 4r14  3r14 8 5 9 3r14  2r14 8 3r5 9 2r14
14 8 5r5 9 14 8 7r5 9 12 7r5 13
7q9
6 7r5 7 14 6 5r5 7 14 2r14 6 3r5 7 2r14
3r14 6 5 7 3r14 4r14 11 4r14 end fill
ara=2 nux=9 nuy=18 nuz=1
fill 4r27 23 4r27 3r27 21 18 22 3r27 2r27 21 3r18 22 2r27
27 21 5r18 22 27 21 7r18 22 25 7r18 26
7q9
19 7r18 20 27 19 5r18 20 27 2r27 19 3r18 20 2r27
3r27 19 18 20 3r27 4r27 24 4r27 end fill
ara=3 nux=1 nuy=1 nuz=2 fill 28 29 end fill
end array
end data
end

nse71sq

=csas25
nse71sq
44group latticecell
uo2    1 0.947 293 92235 4.742 92238 95.258
arbmag5 2.70 4 0 0 1 13027 98.85 12000 0.47 14000 0.43
26000 0.22 2 1 293
h2o    3 1.0
arbmass 7.90 3 0 0 1 24304 19.17 26304 71.40 28304 9.37 4
al     5 1.0
end comp
squarepitch 1.26 0.79 1 3 0.94 2 0.82 0
Core of 22x22 fuel rods, 90.69 cm water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.395      90.00 0.0
cylinder 0 1 0.410      90.00 0.0
cylinder 2 1 0.470      90.00 0.0
cuboid  3 1 4p0.63      90.69 0.0
unit 2
cylinder 5 1 0.470      0.25 0.0
cylinder 3 1 0.500      0.25 0.0
cuboid  4 1 4p0.63      0.25 0.0

unit 3
cylinder 5 1 0.470      2.35  0.8
cuboid  3 1 4p0.63      2.35  0.8
cuboid  4 1 4p0.63      2.35  0.0
unit 4
array 1 3*0.0
unit 5
cylinder 3 1 0.500      0.00 -0.25
cuboid  4 1 4p0.63      0.00 -0.25
cuboid  3 1 4p0.63      0.00 -1.80
cuboid  4 1 4p0.63      0.00 -2.60
cuboid  3 1 4p0.63      81.36 -2.60
global

```

```

unit 6
array 2 3*0.0
reflector 3 1 4r20.0 0.0 20.0 1
end geom

read array
ara=1 nux=1 nuy=1 nuz=3 fill 3 2 1 end fill
ara=2 nux=22 nuy=22 nuz=1 fill 5 4r4 3q5 5 4 88r4 3q110 5 4r4
      3q5 5 4 22r4 end fill
end array
end data
end

nse71w2

=csas25
nse71w2
44group latticecell
uo2   1 0.947 293 92235 4.742 92238 95.258 end
arbmag5 2.70 4 0 0 1 13027 98.85 12000 0.47 14000 0.43
      26000 0.22 2 1 293 end
h2o    3 1.0 end
arbmass 7.90 3 0 0 1 24000 19.17 26000 71.40 28000 9.37 4 end
al     5 1.0 end
end comp
squarepitch 1.26 0.79 1 3 0.94 2 0.82 0 end
Core of 22x22 positions: 420 fuel rods, 64 water holes, 73.05 cm water 'height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.395      73.05 0.0
cylinder 0 1 0.410      73.05 0.0
cylinder 2 1 0.470      73.05 0.0
cuboid   3 1 4p0.63      73.05 0.0
unit 2
cylinder 5 1 0.470      0.25 0.0
cylinder 3 1 0.500      0.25 0.0
cuboid   4 1 4p0.63      0.25 0.0
unit 3
cylinder 5 1 0.470      2.35 0.8
cuboid   3 1 4p0.63      2.35 0.8
cuboid   4 1 4p0.63      2.35 0.0
unit 4
array 1 3*0.0
unit 5
cylinder 3 1 0.500      0.00 -0.25
cuboid   4 1 4p0.63      0.00 -0.25
cuboid   3 1 4p0.63      0.00 -1.80
cuboid   4 1 4p0.63      0.00 -2.60
cuboid   3 1 4p0.63      73.05 -2.60
global
unit 6
array 2 3*0.0
reflector 3 1 4r20.0 0.0 20.0 1
end geom

read array
ara=1 nux=1 nuy=1 nuz=3 fill 3 2 1 end fill

```

```

ara=2 nux=22 nuy=22 nuz=1 fill 5 2r4 6q3 5 44r4 6q66 5 2r4
      6q3 5 end fill
end array
end data
end

p49-194

=csas25          parm=size=300000
p49-194
44group
uo2   1 den=10.40 1.0 293 92234 .022 92235 4.306 92236
      .022 92238 95.65 end
al     2 1.0 293 end
h     3 den=1.321 .065 293 end
c     3 den=1.321 .58 293 end
o     3 den=1.321 .221 293 end
s     3 den=1.321 .017 293 end
ca    3 den=1.321 .114 293 end
si    3 den=1.321 .003 293 end
h2o   4 1.0 293 end
h     5 den=1.185 .08 293 end
c     5 den=1.185 .60 293 end
o     5 den=1.185 .32 293 end
poly(h2o) 6 den=0.905 1.0 293 end
end comp
triangpitch 1.598 1.265 1 4 1.415 2 1.283 0 end
Core of 1185 fuel rods in a hexagonal lattice
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
com!=! 0.0 to 2.54 cm 01 !
zhemicyl+x 3 1 .6415 2.54 0.0
zhemicyl+x 2 1 .7075 2.54 0.0
zhemicyl+x 4 1 .714 2.54 0.0
unit 2
com!=! 0.0 to 2.54 cm 01 !
zhemicyl-y 3 1 .6415 2.54 0.0
zhemicyl-y 2 1 .7075 2.54 0.0
zhemicyl-y 4 1 .714 2.54 0.0
unit 3
com!=! 0.0 to 2.54 cm 01 !
zhemicyl-x 3 1 .6415 2.54 0.0
zhemicyl-x 2 1 .7075 2.54 0.0
zhemicyl-x 4 1 .714 2.54 0.0
unit 4
com!=! 0.0 to 2.54 cm 01 !
zhemicyl+y 3 1 .6415 2.54 0.0
zhemicyl+y 2 1 .7075 2.54 0.0
zhemicyl+y 4 1 .714 2.54 0.0
unit 5
com!=! 0.0 to 35.48 cm 02 !
zhemicyl+x 1 1 .6325 35.48 0.0
zhemicyl+x 0 1 .6415 35.48 0.0
zhemicyl+x 2 1 .7075 35.48 0.0
unit 6
com!=! 0.0 to 35.48 cm 02 !
zhemicyl-y 1 1 .6325 35.48 0.0

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zhemicyl-y 0 1 .6415 35.48 0.0
zhemicyl-y 2 1 .7075 35.48 0.0
unit 7
com!= 0.0 to 35.48 cm 02 !
zhemicyl-x 1 1 .6325 35.48 0.0
zhemicyl-x 0 1 .6415 35.48 0.0
zhemicyl-x 2 1 .7075 35.48 0.0
unit 8
com!= 0.0 to 35.48 cm 02 !
zhemicyl+y 1 1 .6325 35.48 0.0
zhemicyl+y 0 1 .6415 35.48 0.0
zhemicyl+y 2 1 .7075 35.48 0.0
unit 9
com!= 0.0 to 1.35 cm 03 !
zhemicyl+x 1 1 .6325 1.35 0.0
zhemicyl+x 0 1 .6415 1.35 0.0
zhemicyl+x 2 1 .7075 1.35 0.0
zhemicyl+x 4 1 .714 1.35 0.0
unit 10
com!= 0.0 to 1.35 cm 03 !
zhemicyl-y 1 1 .6325 1.35 0.0
zhemicyl-y 0 1 .6415 1.35 0.0
zhemicyl-y 2 1 .7075 1.35 0.0
zhemicyl-y 4 1 .714 1.35 0.0
unit 11
com!= 0.0 to 1.35 cm 03 !
zhemicyl-x 1 1 .6325 1.35 0.0
zhemicyl-x 0 1 .6415 1.35 0.0
zhemicyl-x 2 1 .7075 1.35 0.0
zhemicyl-x 4 1 .714 1.35 0.0
unit 12
com!= 0.0 to 1.35 cm 03 !
zhemicyl+y 1 1 .6325 1.35 0.0
zhemicyl+y 0 1 .6415 1.35 0.0
zhemicyl+y 2 1 .7075 1.35 0.0
zhemicyl+y 4 1 .714 1.35 0.0
unit 13
com!= 0.0 to 47.291 cm 04 !
zhemicyl+x 1 1 .6325 47.291 0.0
zhemicyl+x 0 1 .6415 47.291 0.0
zhemicyl+x 2 1 .7075 47.291 0.0
unit 14
com!= 0.0 to 47.291 cm 04 !
zhemicyl-y 1 1 .6325 47.291 0.0
zhemicyl-y 0 1 .6415 47.291 0.0
zhemicyl-y 2 1 .7075 47.291 0.0
unit 15
com!= 0.0 to 47.291 cm 04 !
zhemicyl-x 1 1 .6325 47.291 0.0
zhemicyl-x 0 1 .6415 47.291 0.0
zhemicyl-x 2 1 .7075 47.291 0.0
unit 16
com!= 0.0 to 47.291 cm 04 !
zhemicyl+y 1 1 .6325 47.291 0.0
zhemicyl+y 0 1 .6415 47.291 0.0
zhemicyl+y 2 1 .7075 47.291 0.0
unit 17
com!= 0.0 to 5.969 cm 06 !
zhemicyl+x 1 1 .6325 5.969 0.0
zhemicyl+y 0 1 .6415 5.969 0.0
zhemicyl+y 2 1 .7075 5.969 0.0
unit 18
com!= 0.0 to 5.969 cm 06 !
zhemicyl-x 1 1 .6325 5.969 0.0
zhemicyl-x 0 1 .6415 5.969 0.0
zhemicyl-x 2 1 .7075 5.969 0.0
unit 19
com!= 0.0 to 5.969 cm 06 !
zhemicyl+y 1 1 .6325 5.969 0.0
zhemicyl+y 0 1 .6415 5.969 0.0
zhemicyl+y 2 1 .7075 5.969 0.0
unit 20
com!= 0.0 to 5.969 cm 06 !
zhemicyl+x 1 1 .6325 5.969 0.0
zhemicyl+x 0 1 .6415 5.969 0.0
zhemicyl+x 2 1 .7075 5.969 0.0
unit 21
com!= 0.0 to .809 cm 01 !
zhemicyl+x 3 1 .6415 .809 0.0
zhemicyl+x 2 1 .7075 .809 0.0
unit 22
com!= 0.0 to .809 cm 01 !
zhemicyl-y 3 1 .6415 .809 0.0
zhemicyl-y 2 1 .7075 .809 0.0
unit 23
com!= 0.0 to .809 cm 01 !
zhemicyl-x 3 1 .6415 .809 0.0
zhemicyl-x 2 1 .7075 .809 0.0
unit 24
com!= 0.0 to .809 cm 01 !
zhemicyl+y 3 1 .6415 .809 0.0
zhemicyl+y 2 1 .7075 .809 0.0
unit 25
com!= 0.0 to 1.35 cm 01 !
zhemicyl+x 3 1 .6415 1.35 0.0
zhemicyl+x 2 1 .7075 1.35 0.0
zhemicyl+x 4 1 .714 1.35 0.0
unit 26
com!= 0.0 to 1.35 cm 01 !
zhemicyl-y 3 1 .6415 1.35 0.0
zhemicyl-y 2 1 .7075 1.35 0.0
zhemicyl-y 4 1 .714 1.35 0.0
unit 27
com!= 0.0 to 1.35 cm 01 !
zhemicyl-x 3 1 .6415 1.35 0.0
zhemicyl-x 2 1 .7075 1.35 0.0
zhemicyl-x 4 1 .714 1.35 0.0
unit 28
com!= 0.0 to 1.35 cm 01 !
zhemicyl+y 3 1 .6415 1.35 0.0
zhemicyl+y 2 1 .7075 1.35 0.0
zhemicyl+y 4 1 .714 1.35 0.0
unit 31
com!= 0.0 to 0.381 cm 01 !
zhemicyl+x 3 1 .6415 0.381 0.0
zhemicyl+x 2 1 .7075 0.381 0.0
zhemicyl+x 4 1 .714 0.381 0.0
unit 32

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com=! 0.0 to 0.381 cm 01 !
zhemicyl-y 3 1 .6415 0.381 0.0
zhemicyl-y 2 1 .7075 0.381 0.0
zhemicyl-y 4 1 .714 0.381 0.0
unit 33
com=! 0.0 to 0.381 cm 01 !
zhemicyl-x 3 1 .6415 0.381 0.0
zhemicyl-x 2 1 .7075 0.381 0.0
zhemicyl-x 4 1 .714 0.381 0.0
unit 34
com=! 0.0 to 0.381 cm 01 !
zhemicyl+y 3 1 .6415 0.381 0.0
zhemicyl+y 2 1 .7075 0.381 0.0
zhemicyl+y 4 1 .714 0.381 0.0
unit 101
com=! 0.0 to 1.35 cm 01 !
zhemicyl+x 3 1 .6415 1.35 0.0
zhemicyl+x 2 1 .7075 1.35 0.0
zhemicyl+x 4 1 .7140 1.35 0.0
cuboid 6 1 1.598 0 2p1.384 1.35 0.0
hole 26 .799 1.384 0.0
hole 27 1.598 0 0.0
hole 28 .799 -1.384 0.0
unit 102
com=! 0.0 to 1.35 cm 02 !
zhemicyl+x 3 1 .6415 1.35 0.0
zhemicyl+x 2 1 .7075 1.35 0.0
zhemicyl+x 4 1 .7140 1.35 0.0
cuboid 6 1 1.598 0 2p1.384 1.35 0.0
hole 26 .799 1.384 0.0
hole 27 1.598 0 0.0
unit 103
com=! 0.0 to 1.35 cm 03 !
zhemicyl+x 3 1 .6415 1.35 0.0
zhemicyl+x 2 1 .7075 1.35 0.0
zhemicyl+x 4 1 .7140 1.35 0.0
cuboid 6 1 1.598 0 2p1.384 1.35 0.0
hole 26 .799 1.384 0.0
hole 28 .799 -1.384 0.0
unit 104
com=! 0.0 to 1.35 cm 04 !
zhemicyl+x 3 1 .6415 1.35 0
zhemicyl+x 2 1 .7075 1.35 0
zhemicyl+x 4 1 .7140 1.35 0
cuboid 6 1 1.598 0.0 2p1.384 1.35 0.0
hole 27 1.598 0.0 0
hole 28 .799 -1.384 0
unit 105
com=! 0.0 to 1.35 cm 05 !
zhemicyl+x 3 1 .6415 1.35 0
zhemicyl+x 2 1 .7075 1.35 0
zhemicyl+x 4 1 .7140 1.35 0
cuboid 6 1 1.598 0.0 2p1.384 1.35 0.0
hole 26 .799 1.384 0
unit 106
com=! 0.0 to 1.35 cm 06 !
zhemicyl+x 3 1 .6415 1.35 0
zhemicyl+x 2 1 .7075 1.35 0
zhemicyl+x 4 1 .7140 1.35 0
cuboid 6 1 1.598 0.0 2p1.384 1.35 0.0
hole 27 1.598 1.384 0
unit 107
com=! 0.0 to 1.35 cm 07 !
zhemicyl+x 3 1 .6415 1.35 0
zhemicyl+x 2 1 .7075 1.35 0
zhemicyl+x 4 1 .7140 1.35 0
cuboid 6 1 1.598 0.0 2p1.384 1.35 0.0
hole 28 .799 -1.384 0
unit 108
com=! 0.0 to 1.35 cm 08 !
zhemicyl+x 3 1 .6415 1.35 0
zhemicyl+x 2 1 .7075 1.35 0
zhemicyl+x 4 1 .7140 1.35 0
cuboid 6 1 1.598 0.0 2p1.384 1.35 0.0
unit 109
com=! 0.0 to 1.35 cm 09 !
zhemicyl-y 3 1 .6415 1.35 0
zhemicyl-y 2 1 .7075 1.35 0
zhemicyl-y 4 1 .7140 1.35 0
cuboid 6 1 2p0.799 0.0 -2.768 1.35 0.0
hole 27 0.799 -1.384 0
hole 28 0.0 -2.768 0
unit 110
com=! 0.0 to 1.35 cm 10 !
zhemicyl-y 3 1 .6415 1.35 0
zhemicyl-y 2 1 .7075 1.35 0
zhemicyl-y 4 1 .7140 1.35 0
cuboid 6 1 2p0.799 0.0 -2.768 1.35 0.0
hole 27 0.799 -1.384 0
unit 111
com=! 0.0 to 1.35 cm 11 !
zhemicyl-y 3 1 .6415 1.35 0
zhemicyl-y 2 1 .7075 1.35 0
zhemicyl-y 4 1 .7140 1.35 0
cuboid 6 1 2p0.799 0.0 -2.768 1.35 0.0
hole 28 0.0 -2.768 0
unit 112
com=! 0.0 to 1.35 cm 12 !
zhemicyl-y 3 1 .6415 1.35 0
zhemicyl-y 2 1 .7075 1.35 0
zhemicyl-y 4 1 .7140 1.35 0
cuboid 6 1 2p0.799 0 -2.768 1.35 0.0
unit 113
com=! 0.0 to 1.35 cm 13 !
zhemicyl-x 3 1 .6415 1.35 0
zhemicyl-x 2 1 .7075 1.35 0
zhemicyl-x 4 1 .7140 1.35 0
cuboid 6 1 0 -1.598 2p1.384 1.35 0.0
hole 28 -0.799 -1.384 0
unit 114
com=! 0.0 to 1.35 cm 14 !
zhemicyl-x 3 1 .6415 1.35 0
zhemicyl-x 2 1 .7075 1.35 0
zhemicyl-x 4 1 .7140 1.35 0
cuboid 6 1 0 -1.598 2p1.384 1.35 0.0
unit 115
com=! 0.0 to 1.35 cm 15 !
zhemicyl+y 3 1 .6415 1.35 0

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zhemicyl+y 2 1 .7075   1.35   0
zhemicyl+y 4 1 .7140   1.35   0
cuboid 6 1 2p0.799  2.768    0   1.35   0.0
unit 116
com!= 0.0 to 1.35 cm 16 !
cuboid 6 1 2p0.799  2p1.384   1.35   0.0
unit 201
com!= 0.0 to 35.48 cm 01 !
zhemicyl+x 1 1 .6325   35.48  0.0
zhemicyl+x 0 1 .6415   35.48  0.0
zhemicyl+x 2 1 .7075   35.48  0.0
cuboid 4 1 1.598    0   2p1.384   35.48  0.0
hole   6   .799    1.384   0.0
hole   7   1.598    0   0.0
hole   8   .799   -1.384   0.0
unit 202
com!= 0.0 to 35.48 cm 02 !
zhemicyl+x 1 1 .6325   35.48  0.0
zhemicyl+x 0 1 .6415   35.48  0.0
zhemicyl+x 2 1 .7075   35.48  0.0
cuboid 4 1 1.598    0   2p1.384   35.48  0.0
hole   6   .799    1.384   0.0
hole   7   1.598    0   0.0
unit 203
com!= 0.0 to 35.48 cm 03 !
zhemicyl+x 1 1 .6325   35.48  0.0
zhemicyl+x 0 1 .6415   35.48  0.0
zhemicyl+x 2 1 .7075   35.48  0.0
cuboid 4 1 1.598    0   2p1.384   35.48  0.0
hole   6   .799    1.384   0.0
hole   8   .799   -1.384   0.0
unit 204
com!= 0.0 to 35.48 cm 04 !
zhemicyl+x 1 1 .6325   35.48  0
zhemicyl+x 0 1 .6415   35.48  0
zhemicyl+x 2 1 .7075   35.48  0
cuboid 4 1 1.598    0.0  2p1.384   35.48  0.0
hole   7   1.598    0.0   0
hole   8   .799   -1.384   0
unit 205
com!= 0.0 to 35.48 cm 05 !
zhemicyl+x 1 1 .6325   35.48  0
zhemicyl+x 0 1 .6415   35.48  0
zhemicyl+x 2 1 .7075   35.48  0
cuboid 4 1 1.598    0.0  2p1.384   35.48  0.0
hole   6   .799    1.384   0
unit 206
com!= 0.0 to 35.48 cm 06 !
zhemicyl+x 1 1 .6325   35.48  0
zhemicyl+x 0 1 .6415   35.48  0
zhemicyl+x 2 1 .7075   35.48  0
cuboid 4 1 1.598    0.0  2p1.384   35.48  0.0
hole   7   1.598    0.0   0
unit 207
com!= 0.0 to 35.48 cm 07 !
zhemicyl+x 1 1 .6325   35.48  0
zhemicyl+x 0 1 .6415   35.48  0
zhemicyl+x 2 1 .7075   35.48  0
cuboid 4 1 1.598    0.0  2p1.384   35.48  0.0
hole   8   .799   -1.384   0
unit 208
hole   8   .799   -1.384   0
unit 209
com!= 0.0 to 35.48 cm 08 !
zhemicyl+x 1 1 .6325   35.48  0
zhemicyl+x 0 1 .6415   35.48  0
zhemicyl+x 2 1 .7075   35.48  0
cuboid 4 1 1.598    0.0  2p1.384   35.48  0.0
unit 209
com!= 0.0 to 35.48 cm 09 !
zhemicyl-y 1 1 .6325   35.48  0
zhemicyl-y 0 1 .6415   35.48  0
zhemicyl-y 2 1 .7075   35.48  0
cuboid 4 1 2p0.799   0.0 -2.768   35.48  0.0
hole   7   0.799   -1.384   0
hole   8   0.0   -2.768   0
unit 210
com!= 0.0 to 35.48 cm 10 !
zhemicyl-y 1 1 .6325   35.48  0
zhemicyl-y 0 1 .6415   35.48  0
zhemicyl-y 2 1 .7075   35.48  0
cuboid 4 1 2p0.799   0.0 -2.768   35.48  0.0
hole   7   0.799   -1.384   0
unit 211
com!= 0.0 to 35.48 cm 11 !
zhemicyl-y 1 1 .6325   35.48  0
zhemicyl-y 0 1 .6415   35.48  0
zhemicyl-y 2 1 .7075   35.48  0
cuboid 4 1 2p0.799   0.0 -2.768   35.48  0.0
hole   8   0.0   -2.768   0
unit 212
com!= 0.0 to 35.48 cm 12 !
zhemicyl-y 1 1 .6325   35.48  0
zhemicyl-y 0 1 .6415   35.48  0
zhemicyl-y 2 1 .7075   35.48  0
cuboid 4 1 2p0.799   0.0 -2.768   35.48  0.0
unit 213
com!= 0.0 to 35.48 cm 13 !
zhemicyl-x 1 1 .6325   35.48  0
zhemicyl-x 0 1 .6415   35.48  0
zhemicyl-x 2 1 .7075   35.48  0
cuboid 4 1 0   -1.598  2p1.384   35.48  0.0
hole   8   -0.799   -1.384   0
unit 214
com!= 0.0 to 35.48 cm 14 !
zhemicyl-x 1 1 .6325   35.48  0
zhemicyl-x 0 1 .6415   35.48  0
zhemicyl-x 2 1 .7075   35.48  0
cuboid 4 1 0   -1.598  2p1.384   35.48  0.0
unit 215
com!= 0.0 to 35.48 cm 15 !
zhemicyl+y 1 1 .6325   35.48  0
zhemicyl+y 0 1 .6415   35.48  0
zhemicyl+y 2 1 .7075   35.48  0
cuboid 4 1 2p0.799   2.768   0.   35.48  0.0
unit 216
com!= 0.0 to 35.48 cm 16 !
cuboid 4 1 2p0.799   2p1.384   35.48  0.0
unit 301
com!= 0.0 to 1.35 cm 01 !

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zhemicyl+x 1 1 .6325 1.35 0.0
zhemicyl+x 0 1 .6415 1.35 0.0
zhemicyl+x 2 1 .7075 1.35 0.0
zhemicyl+x 4 1 .7140 1.35 0.0
cuboid 6 1 1.598 0 2p1.384 1.35 0.0
hole 10 .799 1.384 0.0
hole 11 1.598 0 0.0
hole 12 .799 -1.384 0.0
unit 302
com!= 0.0 to 1.35 cm 02 !
zhemicyl+x 1 1 .6325 1.35 0.0
zhemicyl+x 0 1 .6415 1.35 0.0
zhemicyl+x 2 1 .7075 1.35 0.0
zhemicyl+x 4 1 .7140 1.35 0.0
cuboid 6 1 1.598 0 2p1.384 1.35 0.0
hole 10 .799 1.384 0.0
hole 11 1.598 0 0.0
unit 303
com!= 0.0 to 1.35 cm 03 !
zhemicyl+x 1 1 .6325 1.35 0.0
zhemicyl+x 0 1 .6415 1.35 0.0
zhemicyl+x 2 1 .7075 1.35 0.0
zhemicyl+x 4 1 .7140 1.35 0.0
cuboid 6 1 1.598 0 2p1.384 1.35 0.0
hole 10 .799 1.384 0.0
hole 12 .799 -1.384 0.0
unit 304
com!= 0.0 to 1.35 cm 04 !
zhemicyl+x 1 1 .6325 1.35 0
zhemicyl+x 0 1 .6415 1.35 0
zhemicyl+x 2 1 .7075 1.35 0
zhemicyl+x 4 1 .7140 1.35 0
cuboid 6 1 1.598 0.0 2p1.384 1.35 0.0
hole 11 1.598 0.0 0
hole 12 .799 -1.384 0
unit 305
com!= 0.0 to 1.35 cm 05 !
zhemicyl+x 1 1 .6325 1.35 0
zhemicyl+x 0 1 .6415 1.35 0
zhemicyl+x 2 1 .7075 1.35 0
zhemicyl+x 4 1 .7140 1.35 0
cuboid 6 1 1.598 0.0 2p1.384 1.35 0.0
hole 10 .799 1.384 0
unit 306
com!= 0.0 to 1.35 cm 06 !
zhemicyl+x 1 1 .6325 1.35 0
zhemicyl+x 0 1 .6415 1.35 0
zhemicyl+x 2 1 .7075 1.35 0
zhemicyl+x 4 1 .7140 1.35 0
cuboid 6 1 1.598 0.0 2p1.384 1.35 0.0
hole 11 1.598 0.0 0
unit 307
com!= 0.0 to 1.35 cm 07 !
zhemicyl+x 1 1 .6325 1.35 0
zhemicyl+x 0 1 .6415 1.35 0
zhemicyl+x 2 1 .7075 1.35 0
zhemicyl+x 4 1 .7140 1.35 0
cuboid 6 1 1.598 0.0 2p1.384 1.35 0.0
hole 12 .799 -1.384 0

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unit 308
com!= 0.0 to 1.35 cm 08 !
zhemicyl+x 1 1 .6325 1.35 0
zhemicyl+x 0 1 .6415 1.35 0
zhemicyl+x 2 1 .7075 1.35 0
zhemicyl+x 4 1 .7140 1.35 0
cuboid 6 1 1.598 0.0 2p1.384 1.35 0.0
unit 309
com!= 0.0 to 1.35 cm 09 !
zhemicyl-y 3 1 .6415 1.35 0
zhemicyl-y 2 1 .7075 1.35 0
zhemicyl-y 4 1 .7140 1.35 0
cuboid 6 1 2p0.799 0.0 -2.768 1.35 0.0
hole 11 .799 -1.384 0
hole 12 0.0 -2.768 0
unit 310
com!= 0.0 to 1.35 cm 10 !
zhemicyl-y 1 1 .6325 1.35 0
zhemicyl-y 0 1 .6415 1.35 0
zhemicyl-y 2 1 .7075 1.35 0
zhemicyl-y 4 1 .7140 1.35 0
cuboid 6 1 2p0.799 0.0 -2.768 1.35 0.0
hole 11 .799 -1.384 0
unit 311
com!= 0.0 to 1.35 cm 11 !
zhemicyl-y 1 1 .6325 1.35 0
zhemicyl-y 0 1 .6415 1.35 0
zhemicyl-y 2 1 .7075 1.35 0
zhemicyl-y 4 1 .7140 1.35 0
cuboid 6 1 2p0.799 0.0 -2.768 1.35 0.0
hole 12 0.0 -2.768 0
unit 312
com!= 0.0 to 1.35 cm 12 !
zhemicyl-y 1 1 .6325 1.35 0
zhemicyl-y 0 1 .6415 1.35 0
zhemicyl-y 2 1 .7075 1.35 0
zhemicyl-y 4 1 .7140 1.35 0
cuboid 6 1 2p0.799 0.0 -2.768 1.35 0.0
unit 313
com!= 0.0 to 1.35 cm 13 !
zhemicyl-x 1 1 .6325 1.35 0
zhemicyl-x 0 1 .6415 1.35 0
zhemicyl-x 2 1 .7075 1.35 0
zhemicyl-x 4 1 .7140 1.35 0
cuboid 6 1 0 -1.598 2p1.384 1.35 0.0
hole 12 -0.799 -1.384 0
unit 314
com!= 0.0 to 1.35 cm 14 !
zhemicyl-x 1 1 .6325 1.35 0
zhemicyl-x 0 1 .6415 1.35 0
zhemicyl-x 2 1 .7075 1.35 0
zhemicyl-x 4 1 .7140 1.35 0
cuboid 6 1 0 -1.598 2p1.384 1.35 0.0
unit 315
com!= 0.0 to 1.35 cm 15 !
zhemicyl+y 1 1 .6325 1.35 0
zhemicyl+y 0 1 .6415 1.35 0
zhemicyl+y 2 1 .7075 1.35 0
zhemicyl+y 4 1 .7140 1.35 0

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cuboid 6 1 2p0.799  2.768     0   1.35  0.0
unit 316
com=! 0.0 to 1.35 cm 16 !
cuboid 6 1 2p0.799  2p1.384      1.35  0.0
unit 401
com=! 0.0 to 47.291 cm 01 !
zhemicyl+x 1 1 .6325  47.291 0.0
zhemicyl+x 0 1 .6415  47.291 0.0
zhemicyl+x 2 1 .7075  47.291 0.0
cuboid 4 1 1.598  0    2p1.384  47.291 0.0
hole   14   .799    1.384  0.0
hole   15   1.598   0    0.0
hole   16   .799   -1.384 0.0
unit 402
com=! 0.0 to 47.291 cm 02 !
zhemicyl+x 1 1 .6325  47.291 0.0
zhemicyl+x 0 1 .6415  47.291 0.0
zhemicyl+x 2 1 .7075  47.291 0.0
cuboid 4 1 1.598  0    2p1.384  47.291 0.0
hole   14   .799    1.384  0.0
hole   15   1.598   0    0.0
unit 403
com=! 0.0 to 47.291 cm 03 !
zhemicyl+x 1 1 .6325  47.291 0.0
zhemicyl+x 0 1 .6415  47.291 0.0
zhemicyl+x 2 1 .7075  47.291 0.0
cuboid 4 1 1.598  0    2p1.384  47.291 0.0
hole   14   .799    1.384  0.0
hole   16   .799   -1.384 0.0
unit 404
com=! 0.0 to 47.291 cm 04 !
zhemicyl+x 1 1 .6325  47.291 0
zhemicyl+x 0 1 .6415  47.291 0
zhemicyl+x 2 1 .7075  47.291 0
cuboid 4 1 1.598  0.0   2p1.384  47.291 0.0
hole   15   1.598   0.0   0
hole   16   .799   -1.384 0
unit 405
com=! 0.0 to 47.291 cm 05 !
zhemicyl+x 1 1 .6325  47.291 0
zhemicyl+x 0 1 .6415  47.291 0
zhemicyl+x 2 1 .7075  47.291 0
cuboid 4 1 1.598  0.0   2p1.384  47.291 0.0
hole   14   .799    1.384  0
unit 406
com=! 0.0 to 47.291 cm 06 !
zhemicyl+x 1 1 .6325  47.291 0
zhemicyl+x 0 1 .6415  47.291 0
zhemicyl+x 2 1 .7075  47.291 0
cuboid 4 1 1.598  0.0   2p1.384  47.291 0.0
hole   15   1.598   0.0   0
unit 407
com=! 0.0 to 47.291 cm 07 !
zhemicyl+x 1 1 .6325  47.291 0
zhemicyl+x 0 1 .6415  47.291 0
zhemicyl+x 2 1 .7075  47.291 0
cuboid 4 1 1.598  0.0   2p1.384  47.291 0.0
hole   16   .799   -1.384 0
unit 408
com=! 0.0 to 47.291 cm 08 !
zhemicyl+x 1 1 .6325  47.291 0
zhemicyl+x 0 1 .6415  47.291 0
zhemicyl+x 2 1 .7075  47.291 0
cuboid 4 1 1.598  0.0   2p1.384  47.291 0.0
unit 409
com=! 0.0 to 47.291 cm 09 !
zhemicyl-y 1 1 .6325  47.291 0
zhemicyl-y 0 1 .6415  47.291 0
zhemicyl-y 2 1 .7075  47.291 0
cuboid 4 1 2p0.799  0.0  -2.768   47.291 0.0
hole   15   0.799   -1.384 0
hole   16   0.0    -2.768 0
unit 410
com=! 0.0 to 47.291 cm 10 !
zhemicyl-y 1 1 .6325  47.291 0
zhemicyl-y 0 1 .6415  47.291 0
zhemicyl-y 2 1 .7075  47.291 0
cuboid 4 1 2p0.799  0.0  -2.768   47.291 0.0
hole   15   0.799   -1.384 0
unit 411
com=! 0.0 to 47.291 cm 11 !
zhemicyl-y 1 1 .6325  47.291 0
zhemicyl-y 0 1 .6415  47.291 0
zhemicyl-y 2 1 .7075  47.291 0
cuboid 4 1 2p0.799  0.0  -2.768   47.291 0.0
hole   16   0.0    -2.768 0
unit 412
com=! 0.0 to 47.291 cm 12 !
zhemicyl-y 1 1 .6325  47.291 0
zhemicyl-y 0 1 .6415  47.291 0
zhemicyl-y 2 1 .7075  47.291 0
cuboid 4 1 2p0.799  0.0  -2.768   47.291 0.0
unit 413
com=! 0.0 to 47.291 cm 13 !
zhemicyl-x 1 1 .6325  47.291 0
zhemicyl-x 0 1 .6415  47.291 0
zhemicyl-x 2 1 .7075  47.291 0
cuboid 4 1 0   -1.598   2p1.384  47.291 0.0
hole   16   -0.799   -1.384 0
unit 414
com=! 0.0 to 47.291 cm 14 !
zhemicyl-x 1 1 .6325  47.291 0
zhemicyl-x 0 1 .6415  47.291 0
zhemicyl-x 2 1 .7075  47.291 0
cuboid 4 1 0   -1.598   2p1.384  47.291 0.0
unit 415
com=! 0.0 to 47.291 cm 15 !
zhemicyl+y 1 1 .6325  47.291 0
zhemicyl+y 0 1 .6415  47.291 0
zhemicyl+y 2 1 .7075  47.291 0
cuboid 4 1 2p0.799  2.768   0    47.291 0.0
unit 416
com=! 0.0 to 47.291 cm 16 !
cuboid 4 1 2p0.799  2p1.384      47.291 0.0
unit 501
com=! 0.0 to 5.969 cm 01 !
zhemicyl+x 1 1 .6325  5.969 0.0

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zhemicyl+x 0 1 .6415 5.969 0.0
zhemicyl+x 2 1 .7075 5.969 0.0
cuboid 4 1 1.598 0 2p1.384 5.969 0.0
hole 18 .799 1.384 0.0
hole 19 1.598 0 0.0
hole 20 .799 -1.384 0.0
unit 502
com=! 0.0 to 5.969 cm 02 !
zhemicyl+x 1 1 .6325 5.969 0.0
zhemicyl+x 0 1 .6415 5.969 0.0
zhemicyl+x 2 1 .7075 5.969 0.0
cuboid 4 1 1.598 0 2p1.384 5.969 0.0
hole 18 .799 1.384 0.0
hole 19 1.598 0 0.0
unit 503
com=! 0.0 to 5.969 cm 03 !
zhemicyl+x 1 1 .6325 5.969 0.0
zhemicyl+x 0 1 .6415 5.969 0.0
zhemicyl+x 2 1 .7075 5.969 0.0
cuboid 4 1 1.598 0 2p1.384 5.969 0.0
hole 18 .799 1.384 0.0
hole 20 .799 -1.384 0.0
unit 504
com=! 0.0 to 5.969 cm 04 !
zhemicyl+x 1 1 .6325 5.969 0
zhemicyl+x 0 1 .6415 5.969 0
zhemicyl+x 2 1 .7075 5.969 0
cuboid 4 1 1.598 0.0 2p1.384 5.969 0.0
hole 19 1.598 0.0 0
hole 20 .799 -1.384 0
unit 505
com=! 0.0 to 5.969 cm 05 !
zhemicyl+x 1 1 .6325 5.969 0
zhemicyl+x 0 1 .6415 5.969 0
zhemicyl+x 2 1 .7075 5.969 0
cuboid 4 1 1.598 0.0 2p1.384 5.969 0.0
hole 18 .799 1.384 0
unit 506
com=! 0.0 to 5.969 cm 06 !
zhemicyl+x 1 1 .6325 5.969 0
zhemicyl+x 0 1 .6415 5.969 0
zhemicyl+x 2 1 .7075 5.969 0
cuboid 4 1 1.598 0.0 2p1.384 5.969 0.0
hole 19 1.598 0.0 0
unit 507
com=! 0.0 to 5.969 cm 07 !
zhemicyl+x 1 1 .6325 5.969 0
zhemicyl+x 0 1 .6415 5.969 0
zhemicyl+x 2 1 .7075 5.969 0
cuboid 4 1 1.598 0.0 2p1.384 5.969 0.0
hole 20 .799 -1.384 0
unit 508
com=! 0.0 to 5.969 cm 08 !
zhemicyl+x 1 1 .6325 5.969 0
zhemicyl+x 0 1 .6415 5.969 0
zhemicyl+x 2 1 .7075 5.969 0
cuboid 4 1 1.598 0.0 2p1.384 5.969 0.0
unit 509
com=! 0.0 to 5.969 cm 09 !
zhemicyl-y 1 1 .6325 5.969 0
zhemicyl-y 0 1 .6415 5.969 0
zhemicyl-y 2 1 .7075 5.969 0
cuboid 4 1 2p0.799 0.0 -2.768 5.969 0.0
hole 19 0.799 -1.384 0
hole 20 0.0 -2.768 0
unit 510
com=! 0.0 to 5.969 cm 10 !
zhemicyl-y 1 1 .6325 5.969 0
zhemicyl-y 0 1 .6415 5.969 0
zhemicyl-y 2 1 .7075 5.969 0
cuboid 4 1 2p0.799 0.0 -2.768 5.969 0.0
hole 19 0.799 -1.384 0
unit 511
com=! 0.0 to 5.969 cm 11 !
zhemicyl-y 1 1 .6325 5.969 0
zhemicyl-y 0 1 .6415 5.969 0
zhemicyl-y 2 1 .7075 5.969 0
cuboid 4 1 2p0.799 0.0 -2.768 5.969 0.0
hole 20 0.0 -2.768 0
unit 512
com=! 0.0 to 5.969 cm 12 !
zhemicyl-y 1 1 .6325 5.969 0
zhemicyl-y 0 1 .6415 5.969 0
zhemicyl-y 2 1 .7075 5.969 0
cuboid 4 1 2p0.799 0.0 -2.768 5.969 0.0
unit 513
com=! 0.0 to 5.969 cm 13 !
zhemicyl-x 1 1 .6325 5.969 0
zhemicyl-x 0 1 .6415 5.969 0
zhemicyl-x 2 1 .7075 5.969 0
cuboid 4 1 0 -1.598 2p1.384 5.969 0.0
hole 20 -0.799 -1.384 0
unit 514
com=! 0.0 to 5.969 cm 14 !
zhemicyl-x 1 1 .6325 5.969 0
zhemicyl-x 0 1 .6415 5.969 0
zhemicyl-x 2 1 .7075 5.969 0
cuboid 4 1 0 -1.598 2p1.384 5.969 0.0
unit 515
com=! 0.0 to 5.969 cm 15 !
zhemicyl+y 1 1 .6325 5.969 0
zhemicyl+y 0 1 .6415 5.969 0
zhemicyl+y 2 1 .7075 5.969 0
cuboid 4 1 2p0.799 2.768 0 5.969 0.0
unit 516
com=! 0.0 to 5.969 cm 16 !
cuboid 4 1 2p0.799 2p1.384 5.969 0.0
unit 601
com=! 0.0 to 2.54 cm 01 !
zhemicyl+x 3 1 .6415 2.54 0.0
zhemicyl+x 2 1 .7075 2.54 0.0
cuboid 4 1 1.598 0 2p1.384 2.54 0.0
hole 2 .799 1.384 0.0
hole 3 1.598 0 0.0
hole 4 .799 -1.384 0.0
unit 602
com=! 0.0 to 2.54 cm 02 !
zhemicyl+x 3 1 .6415 2.54 0.0

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zhemicyl+x 2 1 .7075    2.54  0.0
cuboid 4 1 1.598   0      2p1.384  2.54  0.0
hole    2    .799     1.384  0.0
hole    3    1.598   0      0.0
unit 603
com!=! 0.0 to 2.54 cm 03 !
zhemicyl+x 3 1 .6415    2.54  0.0
zhemicyl+x 2 1 .7075    2.54  0.0
cuboid 4 1 1.598   0      2p1.384  2.54  0.0
hole    2    .799     1.384  0.0
hole    4    .799    -1.384  0.0
unit 604
com!=! 0.0 to 2.54 cm 04 !
zhemicyl+x 3 1 .6415    2.54  0
zhemicyl+x 2 1 .7075    2.54  0
cuboid 4 1 1.598   0.0    2p1.384  2.54  0.0
hole    3    1.598   0.0    0.0
hole    4    .799    -1.384  0
unit 605
com!=! 0.0 to 2.54 cm 05 !
zhemicyl+x 3 1 .6415    2.54  0
zhemicyl+x 2 1 .7075    2.54  0
cuboid 4 1 1.598   0.0    2p1.384  2.54  0.0
hole    2    .799     1.384  0
unit 606
com!=! 0.0 to 2.54 cm 06 !
zhemicyl+x 3 1 .6415    2.54  0
zhemicyl+x 2 1 .7075    2.54  0
cuboid 4 1 1.598   0.0    2p1.384  2.54  0.0
hole    3    1.598   0.0    0.0
unit 607
com!=! 0.0 to 2.54 cm 07 !
zhemicyl+x 3 1 .6415    2.54  0
zhemicyl+x 2 1 .7075    2.54  0
cuboid 4 1 1.598   0.0    2p1.384  2.54  0.0
hole    4    .799    -1.384  0
unit 608
com!=! 0.0 to 2.54 cm 08 !
zhemicyl+x 3 1 .6415    2.54  0
zhemicyl+x 2 1 .7075    2.54  0
cuboid 4 1 1.598   0.0    2p1.384  2.54  0.0
unit 609
com!=! 0.0 to 2.54 cm 09 !
zhemicyl-y 3 1 .6415    2.54  0
zhemicyl-y 2 1 .7075    2.54  0
cuboid 4 1 2p0.799  0.0  -2.768   2.54  0.0
hole    3    0.799   -1.384  0
hole    4    0.0     -2.768   0
unit 610
com!=! 0.0 to 2.54 cm 10 !
zhemicyl-y 3 1 .6415    2.54  0
zhemicyl-y 2 1 .7075    2.54  0
cuboid 4 1 2p0.799  0.0  -2.768   2.54  0.0
hole    3    0.799   -1.384  0
unit 611
com!=! 0.0 to 2.54 cm 11 !
zhemicyl-y 3 1 .6415    2.54  0
zhemicyl-y 2 1 .7075    2.54  0
cuboid 4 1 2p0.799  0.0  -2.768   2.54  0.0

```

```

hole    4    0.0     -2.768   0
unit 612
com!=! 0.0 to 2.54 cm 12 !
zhemicyl-y 3 1 .6415    2.54  0
zhemicyl-y 2 1 .7075    2.54  0
cuboid 4 1 2p0.799  0.0  -2.768   2.54  0.0
unit 613
com!=! 0.0 to 2.54 cm 13 !
zhemicyl-x 3 1 .6415    2.54  0
zhemicyl-x 2 1 .7075    2.54  0
cuboid 4 1 0      -1.598   2p1.384  2.54  0.0
hole    4    -0.799   -1.384  0
unit 614
com!=! 0.0 to 2.54 cm 14 !
zhemicyl-x 3 1 .6415    2.54  0
zhemicyl-x 2 1 .7075    2.54  0
cuboid 4 1 0      -1.598   2p1.384  2.54  0.0
unit 615
com!=! 0.0 to 2.54 cm 15 !
zhemicyl+y 3 1 .6415    2.54  0
zhemicyl+y 2 1 .7075    2.54  0
cuboid 4 1 2p0.799  2.768   0      2.54  0.0
unit 616
com!=! 0.0 to 2.54 cm 16 !
cuboid 4 1 2p0.799  2p1.384        2.54  0.0
unit 701
com!=! 0.0 to 0.809 cm 01 !
zhemicyl+x 3 1 .6415    0.809  0.0
zhemicyl+x 2 1 .7075    0.809  0.0
cuboid 4 1 1.598   0      2p1.384  0.809  0.0
hole    22   .799     1.384  0.0
hole    23   1.598   0      0.0
hole    24   .799    -1.384  0.0
unit 702
com!=! 0.0 to 0.809 cm 02 !
zhemicyl+x 3 1 .6415    0.809  0.0
zhemicyl+x 2 1 .7075    0.809  0.0
cuboid 4 1 1.598   0      2p1.384  0.809  0.0
hole    22   .799     1.384  0.0
hole    23   1.598   0      0.0
unit 703
com!=! 0.0 to 0.809 cm 03 !
zhemicyl+x 3 1 .6415    0.809  0.0
zhemicyl+x 2 1 .7075    0.809  0.0
cuboid 4 1 1.598   0      2p1.384  0.809  0.0
hole    22   .799     1.384  0.0
hole    24   .799    -1.384  0.0
unit 704
com!=! 0.0 to 0.809 cm 04 !
zhemicyl+x 3 1 .6415    0.809  0
zhemicyl+x 2 1 .7075    0.809  0
cuboid 4 1 1.598   0.0    2p1.384  0.809  0.0
hole    23   1.598   0.0    0.0
hole    24   .799    -1.384  0
unit 705
com!=! 0.0 to 0.809 cm 05 !
zhemicyl+x 3 1 .6415    0.809  0
zhemicyl+x 2 1 .7075    0.809  0
cuboid 4 1 1.598   0.0    2p1.384  0.809  0.0

```

```

hole    22    .799    1.384  0
unit 706
com!= 0.0 to 0.809 cm 06 !
zhemicyl+x 3 1 .6415  0.809  0
zhemicyl+x 2 1 .7075  0.809  0
cuboid 4 1 1.598   0.0  2p1.384  0.809  0.0
hole   23    1.598   0.0  0
unit 707
com!= 0.0 to 0.809 cm 07 !
zhemicyl+x 3 1 .6415  0.809  0
zhemicyl+x 2 1 .7075  0.809  0
cuboid 4 1 1.598   0.0  2p1.384  0.809  0.0
hole   24    .799   -1.384  0
unit 708
com!= 0.0 to 0.809 cm 08 !
zhemicyl+x 3 1 .6415  0.809  0
zhemicyl+x 2 1 .7075  0.809  0
cuboid 4 1 1.598   0.0  2p1.384  0.809  0.0
unit 709
com!= 0.0 to 0.809 cm 09 !
zhemicyl-y 3 1 .6415  0.809  0
zhemicyl-y 2 1 .7075  0.809  0
cuboid 4 1 2p0.799  0.0 -2.768   0.809  0.0
hole   23    0.799   -1.384  0
hole   24    0.0   -2.768   0
unit 710
com!= 0.0 to 0.809 cm 10 !
zhemicyl-y 3 1 .6415  0.809  0
zhemicyl-y 2 1 .7075  0.809  0
cuboid 4 1 2p0.799  0.0 -2.768   0.809  0.0
hole   23    0.799   -1.384  0
unit 711
com!= 0.0 to 0.809 cm 11 !
zhemicyl-y 3 1 .6415  0.809  0
zhemicyl-y 2 1 .7075  0.809  0
cuboid 4 1 2p0.799  0.0 -2.768   0.809  0.0
hole   24    0.0   -2.768   0
unit 712
com!= 0.0 to 0.809 cm 12 !
zhemicyl-y 3 1 .6415  0.809  0
zhemicyl-y 2 1 .7075  0.809  0
cuboid 4 1 2p0.799  0.0 -2.768   0.809  0.0
unit 713
com!= 0.0 to 0.809 cm 13 !
zhemicyl-x 3 1 .6415  0.809  0
zhemicyl-x 2 1 .7075  0.809  0
cuboid 4 1 0   -1.598  2p1.384  0.809  0.0
hole   24   -0.799   -1.384  0
unit 714
com!= 0.0 to 0.809 cm 14 !
zhemicyl-x 3 1 .6415  0.809  0
zhemicyl-x 2 1 .7075  0.809  0
cuboid 4 1 0   -1.598  2p1.384  0.809  0.0
unit 715
com!= 0.0 to 0.809 cm 15 !
zhemicyl+y 3 1 .6415  0.809  0
zhemicyl+y 2 1 .7075  0.809  0
cuboid 4 1 2p0.799  2.768   0   0.809  0.0

```

```

unit 716
com!= 0.0 to 0.809 cm 16 !
cuboid 4 1 2p0.799  2p1.384   0.809  0.0
unit 801
com!= 0.0 to 0.381 cm 01 !
zhemicyl+x 3 1 .6415  0.381  0.0
zhemicyl+x 2 1 .7075  0.381  0.0
cuboid 4 1 1.598   0   2p1.384  0.381  0.0
hole   32    .799    1.384  0.0
hole   33    1.598   0   0.0
hole   34    .799   -1.384  0.0
unit 802
com!= 0.0 to 0.381 cm 02 !
zhemicyl+x 3 1 .6415  0.381  0.0
zhemicyl+x 2 1 .7075  0.381  0.0
cuboid 4 1 1.598   0   2p1.384  0.381  0.0
hole   32    .799    1.384  0.0
hole   33    1.598   0   0.0
unit 803
com!= 0.0 to 0.381 cm 03 !
zhemicyl+x 3 1 .6415  0.381  0.0
zhemicyl+x 2 1 .7075  0.381  0.0
cuboid 4 1 1.598   0   2p1.384  0.381  0.0
hole   32    .799    1.384  0.0
hole   34    .799   -1.384  0.0
unit 804
com!= 0.0 to 0.381 cm 04 !
zhemicyl+x 3 1 .6415  0.381  0
zhemicyl+x 2 1 .7075  0.381  0
cuboid 4 1 1.598   0.0  2p1.384  0.381  0.0
hole   33    1.598   0.0  0
hole   34    .799   -1.384  0
unit 805
com!= 0.0 to 0.381 cm 05 !
zhemicyl+x 3 1 .6415  0.381  0
zhemicyl+x 2 1 .7075  0.381  0
cuboid 4 1 1.598   0.0  2p1.384  0.381  0.0
hole   32    .799    1.384  0
unit 806
com!= 0.0 to 0.381 cm 06 !
zhemicyl+x 3 1 .6415  0.381  0
zhemicyl+x 2 1 .7075  0.381  0
cuboid 4 1 1.598   0.0  2p1.384  0.381  0.0
hole   33    1.598   0.0  0
unit 807
com!= 0.0 to 0.381 cm 07 !
zhemicyl+x 3 1 .6415  0.381  0
zhemicyl+x 2 1 .7075  0.381  0
cuboid 4 1 1.598   0.0  2p1.384  0.381  0.0
hole   34    .799   -1.384  0
unit 808
com!= 0.0 to 0.381 cm 08 !
zhemicyl+x 3 1 .6415  0.381  0
zhemicyl+x 2 1 .7075  0.381  0
cuboid 4 1 1.598   0.0  2p1.384  0.381  0.0
unit 809
com!= 0.0 to 0.381 cm 09 !
zhemicyl-y 3 1 .6415  0.381  0
zhemicyl-y 2 1 .7075  0.381  0

```


Appendix A

```

216 213      34r201 208 216
2r216 213    32r201 207 2r216
2r216 214    204   30r201 203 3r216
4r216 213    28r201 207 215 3r216
5r216 213    204   25r201 207 5r216
7r216 213    204   22r201 207 215 6r216
8r216 215    213   204   16r201 204 207 215 8r216
11r216 2r215 213   9r204 207 3r215 11r216
11r316 3r312 310   9r302 305 2r312 11r316
8r316 312    310   302   16r301 302 305 312 8r316
6r316 312    310   22r301 305 7r316
5r316 310    304   25r301 302 305 5r316
4r316 310    304   28r301 305 4r316
3r316 310    304   30r301 305 3r316
2r316 310    304   32r301 305 2r316
316 314     34r301 305 316
316 310     34r301 303 316
314 314     36r301 308 2q38
316 309     34r301 307 316
316 313     34r301 308 316
2r316 313    304   32r301 307 2r316
2r316 314    304   30r301 303 3r316
4r316 313    304   28r301 307 3r316
5r316 313    304   25r301 307 5r316
7r316 313    304   22r301 307 315 6r316
8r316 315    313   304   16r301 304 305 315 8r316
11r316 2r315 313   9r304 307 3r315 11r316
11r416 3r412 410   9r402 405 2r412 11r416
8r416 412    410   402   16r401 402 405 412 8r416
6r416 412    410   22r401 405 7r416
5r416 410    410   25r401 402 405 5r416
4r416 410    410   28r401 405 4r416
3r416 410    410   30r401 405 3r416
2r416 410    410   32r401 405 2r416
416 414     34r401 405 416
416 410     410   34r401 403 416
414 414     410   36r401 408 2q38
416 409     410   34r401 407 416
416 413     413   34r401 408 416
2r416 413    404   32r401 407 2r416
2r416 414    404   30r401 403 3r416
4r416 413    404   28r401 407 415 3r416
5r416 413    404   25r401 407 5r416
7r416 413    404   22r401 407 415 6r416
8r416 415    413   404   16r401 404 407 415 8r416
11r416 2r415 413   9r404 407 3r415 11r416
11r316 3r312 310   9r302 305 2r312 11r316
8r316 312    310   302   16r301 302 305 312 8r316
6r316 312    310   22r301 305 7r316
5r316 310    310   25r301 302 305 5r316
4r316 310    310   28r301 305 4r316
3r316 310    310   30r301 305 3r316
2r316 310    310   32r301 305 2r316
316 314     34r301 305 316
316 310     34r301 303 316
314 314     36r301 308 2q38
316 309     34r301 307 316
316 313     34r301 308 316
2r316 313    313   32r301 307 2r316
2r316 314    313   30r301 307 3r316
4r316 314    313   28r301 307 4r316
3r316 314    313   30r301 307 3r316
2r316 314    313   22r301 307 315 6r316
11r316 2r316 313   9r304 307 3r315 11r316
11r416 3r416 604   9r402 603 3r416
8r416 415    604   25r401 604 25r416
6r416 415    604   22r401 607 615 6r416
5r416 415    604   16r401 604 607 615 8r416
11r616 2r615 613   9r604 607 3r615 11r616
end fill
end array
end data
end

p2438al
=csas25
p2438al
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
arbmal   2.692 8 0 0 1 13027 97.15 24000 .21 29000 .12
end
end
end
end

```

```

26000 .82 25055 .21 14000 .82 16000 .06 22000
       .61 5                                     end
end comp
squarepitch 2.032 1.1176 1 3 1.27 2           end
3-20x16 assemblies separated by 0.625-cm-thick aluminum plates and '8.045 cm
of water, plate-to-assembly distance of 0.645 cm
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588                         91.44  0.0
cylinder 2 1 0.635                           96.52 -1.27
cuboid   3 1 4p1.016                          96.52 -1.27
unit 2
array 1 3*0.0
reflector 3 1 2r0.0 2r1.544 2r0.0 1
unit 3
cuboid   5 1 4.303 3.794 36.5    0.0  91.5  0.0
cuboid   2 1 4.405 3.692 36.5    0.0  91.5  0.0
cuboid   3 1 5.05  0.0   36.5    0.0  96.52 -1.27
unit 4
cuboid   5 1 1.256 0.747 36.5    0.0  91.5  0.0
cuboid   2 1 1.358 0.645 36.5    0.0  91.5  0.0
cuboid   3 1 5.05  0.0   36.5    0.0  96.52 -1.27
unit 5
array 2 3*0.0
reflector 3 1 2r0.0 2r1.994 2r0.0 1
global
unit 6
array 3 3*0.0
reflector 4 1 5r0  2.54   1
reflector 3 1 2r30.5 2r26.51 2r15.3 1
end geometry

read array
ara=1 nux=20 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5  nuy=1 nuz=1 fill 2 3 2 4 2 end fill
end array
end data
end



p2438ba


=csas25
p2438ba
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65
al       2 1.0
h2o     3 1.0
plexiglas 4 1.0
arbmboral 2.49 5 1 0 1 5000 28.7 13027 62.8
          6012 7.97 26000 .33 14000 .2 5 1 293
end comp
squarepitch 2.032 1.1176 1 3 1.27 2           end
2-22x16 and 1-20x16 (center) assemblies separated by 0.713-cm-thick 'Boral-A
plates and 4.337 cm of water, plate-to-assembly distance of '0.645 cm
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588                         91.44  0.0
cylinder 2 1 0.635                           96.52 -1.27
cuboid   3 1 4p1.016                          96.52 -1.27

```

```

unit 2
array 1 3*0.0
reflector 3 1 2r0.0 2r1.994 2r0.0 1
unit 3
cuboid   5 1 4.303 3.794 36.5    0.0  91.5  0.0
cuboid   2 1 4.405 3.692 36.5    0.0  91.5  0.0
cuboid   3 1 5.05  0.0   36.5    0.0  96.52 -1.27
unit 4
cuboid   5 1 1.256 0.747 36.5    0.0  91.5  0.0
cuboid   2 1 1.358 0.645 36.5    0.0  91.5  0.0
cuboid   3 1 5.05  0.0   36.5    0.0  96.52 -1.27
unit 5
array 2 3*0.0
reflector 3 1 2r0.0 2r1.994 2r0.0 1
global
unit 6
array 3 3*0.0
reflector 4 1 5r0  2.54   1
reflector 3 1 2r30.5 2r26.51 2r15.3 1
end geometry

read array
ara=1 nux=22 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=20 nuy=16 nuz=1 fill f1      end fill
ara=3 nux=5  nuy=1 nuz=1 fill 2 3 5 4 2 end fill
end array
end data
end



p2438cu


=csas25
p2438cu
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65
al       2 1.0
h2o     3 1.0
plexiglas 4 1.0
cu       5  den=8.913
end comp
squarepitch 2.032 1.1176 1 3 1.27 2           end
3-20x16 assemblies separated by 0.646-cm-thick copper plates and
'5.974 cm of water, plate-to-assembly distance of 0.645 cm
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588                         91.44  0.0
cylinder 2 1 0.635                           96.52 -1.27
cuboid   3 1 4p1.016                          96.52 -1.27
unit 2
array 1 3*0.0
reflector 3 1 2r0.0 2r1.544 2r0.0 1
unit 3
cuboid   3 1 5.329 0.0   35.6    0.0  91.5  0.0
cuboid   5 1 5.975 0.0   35.6    0.0  91.5  0.0
cuboid   3 1 6.62  0.0   35.6    0.0  97.79 0.0
unit 4
cuboid   3 1 0.645 0.0   35.6    0.0  91.5  0.0

```

```

cuboid    5 1 1.291  0.0  35.6   0.0   91.5   0.0
cuboid    3 1 6.62   0.0  35.6   0.0   97.79   0.0
global unit 5
array 2 3*0.0
reflector 4 1 5r0 2.54      1
reflector 3 1 2r30.5 2r28.96 2r15.3 1
end geometry

```

```

read array
ara=1 nux=20 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5  nuy=1  nuz=1 fill 2 3 2 4 2 end fill
end array
end data
end

```

p2438slg

```

=csas25
p2438slg
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65
al       2 1.0
h2o     3 1.0
plexiglas 4 1.0
end comp
squarepitch 2.032 1.1176 1 3 1.27 2
3-20x16 assemblies separated by 8.39 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

```

read geom
unit 1
cylinder 1 1 0.5588          91.44   0.0
cylinder 2 1 0.635           96.52  -1.27
cuboid   3 1 4p1.016          96.52  -1.27
unit 2
array 1 3*0.0
unit 3
cuboid   3 1 8.39   0.0  32.512  0.0   96.52  -1.27
global unit 4
array 2 3*0.0
reflector 4 1 5r0 2.54      1
reflector 3 1 4r30.5 2r15.3 1
end geometry

```

```

read array
ara=1 nux=20 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5  nuy=1  nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end

```

p2438ss

```

=csas25
p2438ss
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65
al       2 1.0
h2o     3 1.0

```

```

plexiglas 4 1.0
arbmass   7.93 6 0 0 1 24304 18.56 29000 0.27 26304
          68.24 25000 1.58 42000 0.26 28304 11.09 5
end
end comp
squarepitch 2.032 1.1176 1 3 1.27 2
3-20x16 assemblies separated by 0.485-cm-thick 304L stainless steel
'plates and 6.395 cm of water, plate-to-assembly distance of 0.645 cm
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

```

read geom
unit 1
cylinder 1 1 0.5588          92.72   1.27
cylinder 2 1 0.635           97.79   0.00
cuboid   3 1 4p1.016          97.79   0.00
unit 2
array 1 3*0.0
cuboid   3 1 40.64   0.0  34.056 -1.544 97.79   0.0
unit 3
cuboid   3 1 5.750   0.0  35.6    0.0   91.5   0.0
cuboid   5 1 6.235   0.0  35.6    0.0   91.5   0.0
cuboid   3 1 6.88    0.0  35.6    0.0   97.79   0.0
unit 4
cuboid   3 1 0.645   0.0  35.6    0.0   91.5   0.0
cuboid   5 1 1.130   0.0  35.6    0.0   91.5   0.0
cuboid   3 1 6.88    0.0  35.6    0.0   97.79   0.0
global unit 5
array 2 3*0.0
reflector 4 1 5r0          2.54 1
reflector 3 1 4r30.5 15.2 15.3 1
end geometry

```

```

read array
ara=1 nux=20 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5  nuy=1  nuz=1 fill 2 3 2 4 2 end fill
end array
end data
end

```

p2438zr

```

=csas25
p2438zr
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65
al       2 1.0
h2o     3 1.0
plexiglas 4 1.0
arbmrz4  6.32 4 0 0 1 40000 98.16 50000 1.5
          24000 .13 26000 .21 5
end comp
squarepitch 2.032 1.1176 1 3 1.27 2
3-20x16 assemblies separated by 0.652-cm-thick Zircaloy-4 plates and
'8.138 cm of water, plate-to-assembly distance of 0.645 cm
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

```

read geom
unit 1
cylinder 1 1 0.5588          91.44   0.0
cylinder 2 1 0.635           96.52  -1.27

```

```

cuboid    3 1 4p1.016          96.52  -1.27
unit 2
array 1 3*0.0
reflector 3 1 2r0.0  2r1.544 2r0.0 1
unit 3
cuboid    3 1 7.493  0.0  35.6   0.0   91.5   0.0
cuboid    5 1 8.145  0.0  35.6   0.0   91.5   0.0
cuboid    3 1 8.79   0.0  35.6   0.0   97.79  0.0
unit 4
cuboid    3 1 0.645  0.0  35.6   0.0   91.5   0.0
cuboid    5 1 1.297  0.0  35.6   0.0   91.5   0.0
cuboid    3 1 8.79   0.0  35.6   0.0   97.79  0.0
global unit 5
array 2 3*0.0
reflector 4 1 5r0 2.54     1
reflector 3 1 2r30.5 2r28.96 2r15.3 1
end geometry

read array
ara=1 nux=20 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5  nuy=1 nuz=1 fill 2 3 2 4 2 end fill
end array
end data
end



p2615al


=csas25
p2615al
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
arbmal   2.692 8 0 0 1 13027 97.15 24000 .21 29000 .12
         26000 .82 25055 .21 14000 .82 16000 .06 22000
         .61 5
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
         16000 1.7 8016 22.1 14000 0.3 6
end comp
squarepitch 2.540 1.2649 1 3 1.4147 2 1.2827 0
3-15x8 assemblies separated by 0.713-cm-thick Boral-A plates and
'6.007 cm of water, plate-to-assembly distance of 3.277 cm
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245          91.44  0.0
cylinder 0 1 0.64135          91.44  0.0
cylinder 6 1 0.64135          93.98  -2.54
cylinder 2 1 0.70735          93.98  -2.54
cuboid   3 1 4p1.270          93.98  -2.54
unit 2
array 1 3*0.0
reflector 3 1 2r0  2r7.64 2r0  1
unit 3
cuboid   5 1 0.0  -0.625 2p17.8     88.96  -2.54
cuboid   3 1 .105 -10.615 2p17.8     93.98  -2.54

```

```

unit 4
cuboid   5 1 0.625  0.0  2p17.8     88.96  -2.54
cuboid   3 1 10.615 -.105 2p17.8     93.98  -2.54
global unit 5
array 2 -67.87   -17.8   0.
reflector 4 1 5r0.0  2.54 1
reflector 3 1 2r30.5 2r22.86 2r15.3 1
end geometry

read array
ara=1 nux=15 nuy=8 nuz=1 fill f1      end fill
ara=2 nux=5  nuy=1 nuz=1 fill 2 3 2 4 2 end fill
end array
end data
end



p2615ba


=csas25
p2615ba
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
arbmboral 2.49 4 1 0 1 5000 28.7 13027 63.0
         6012 7.97 26000 0.33 5 1 293
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
         16000 1.7 8016 22.1 14000 0.3 6
end comp
squarepitch 2.540 1.2649 1 3 1.4147 2 1.2827 0
3-15x8 assemblies separated by 0.713-cm-thick Boral-A plates and
'6.007 cm of water, plate-to-assembly distance of 3.277 cm
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245          91.44  0.0
cylinder 0 1 0.64135          91.44  0.0
cylinder 6 1 0.64135          93.98  -2.54
cylinder 2 1 0.70735          93.98  -2.54
cuboid   3 1 4p1.270          93.98  -2.54
unit 2
array 1 3*0.0
reflector 3 1 2r0  2r8.09 2r0  1
unit 3
cuboid   5 1 -0.102 -0.611 2p18.25     88.96  -2.54
cuboid   2 1 0.0  -0.713 2p18.25     88.96  -2.54
cuboid   3 1 3.277 -3.443 2p18.25     93.98  -2.54
unit 4
cuboid   5 1 0.611 0.102 2p18.25     88.96  -2.54
cuboid   2 1 0.713 0.0  2p18.25     88.96  -2.54
cuboid   3 1 3.443 -3.277 2p18.25     93.98  -2.54
global unit 5
array 2 -63.87   -18.25  0.
reflector 4 1 5r0.0  2.54 1
reflector 3 1 2r30.5 2r22.41 2r15.3 1
end geometry

```

```

read array
ara=1 nux=15 nuy=8 nuz=1 fill f1      end fill
ara=2 nux=5  nuy=1 nuz=1 fill 2 3 2 4 2 end fill
end array
end data
end



p2615cd1


=csas25
p2615cd1
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
cd       5 0.997
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
          16000 1.7 8016 22.1 14000 0.3 6
end comp
squarepitch 2.540 1.2649 1 3 1.4147 2 1.2827 0
3-15x8 assemblies separated by 0.2006-cm-thick cadmium plates and
of water, plate-to-assembly distance of 3.277 cm
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245           91.44  0.0
cylinder 0 1 0.64135           91.44  0.0
cylinder 6 1 0.64135           93.98 -2.54
cylinder 2 1 0.70735           93.98 -2.54
cuboid   3 1 4p1.270           93.98 -2.54
unit 2
array 1 3*0.0
reflector 3 1 2r0  2r7.64 2r0  1
unit 3
cuboid   5 1 0.0 -0.2006 2p17.8    88.96 -2.54
cuboid   3 1 3.277 -4.003 2p17.8    93.98 -2.54
unit 4
cuboid   5 1 0.2006 0.0 2p17.8    88.96 -2.54
cuboid   3 1 4.003 -3.277 2p17.8    93.98 -2.54
global unit 5
array 2 -64.43   -17.8   0.
reflector 4 1 5r0.0  2.54 1
reflector 3 1 2r30.5 2r22.86 2r15.3 1
end geometry
read array
ara=1 nux=15 nuy=8 nuz=1 fill f1      end fill
ara=2 nux=5  nuy=1 nuz=1 fill 2 3 2 4 2 end fill
end array
end data
end



p2615cd2


=csas25
p2615cd2
44group latticecell

```

```

uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
cu       5 den=8.913
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
          16000 1.7 8016 22.1 14000 0.3 6
end comp
squarepitch 2.540 1.2649 1 3 1.4147 2 1.2827 0
3-15x8 assemblies separated by 0.2006-cm-thick cadmium plates and
of water, plate-to-assembly distance of 3.277 cm
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245           91.44  0.0
cylinder 0 1 0.64135           91.44  0.0
cylinder 6 1 0.64135           93.98 -2.54
cylinder 2 1 0.70735           93.98 -2.54
cuboid   3 1 4p1.270           93.98 -2.54
unit 2
array 1 3*0.0
reflector 3 1 2r0  2r7.64 2r0  1
unit 3
cuboid   5 1 0.0 -0.2006 2p17.8    88.96 -2.54
cuboid   3 1 5.151 -0.529 2p17.8    93.98 -2.54
global unit 5
array 2 -62.83   -17.8   0.
reflector 4 1 5r0.0  2.54 1
reflector 3 1 2r30.5 2r22.86 2r15.3 1
end geometry

read array
ara=1 nux=15 nuy=8 nuz=1 fill f1      end fill
ara=2 nux=5  nuy=1 nuz=1 fill 2 3 2 4 2 end fill
end array
end data
end



p2615cu


=csas25
p2615cu
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
cu       5 den=8.913
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
          16000 1.7 8016 22.1 14000 0.3 6
end comp
squarepitch 2.540 1.2649 1 3 1.4147 2 1.2827 0
3-15x8 assemblies separated by 0.646-cm-thick copper plates and 7.504
cm of water, plate-to-assembly distance of 0.084 cm

```

```

read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245      91.44  0.0
cylinder 0 1 0.64135      91.44  0.0
cylinder 6 1 0.64135      93.98 -2.54
cylinder 2 1 0.70735      93.98 -2.54
cuboid   3 1 4p1.270       93.98 -2.54
unit 2
array 1 3*0.0
reflector 3 1 2r0  2r7.64 2r0  1
unit 3
cuboid   5 1  0.0 -0.646 2p17.8     88.96 -2.54
cuboid   3 1  0.084 -8.066 2p17.8    93.98 -2.54
unit 4
cuboid   5 1  0.646  0.0 2p17.8     88.96 -2.54
cuboid   3 1  8.066 -0.084 2p17.8    93.98 -2.54
global unit 5
array 2 -65.73 -17.8  0.
reflector 4 1 5r0.0  2.54 1
reflector 3 1 2r30.5 2r22.86 2r15.3 1
end geometry

read array
ara=1 nux=15 nuy=8 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 4 2 end fill
end array
end data
end



p2615ss


=csas25
p2615ss
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
ss304    5 1.0
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 6
end comp
squarepitch 2.540 1.2649 1 3 1.4147 2 1.2827 0
3-15x8 assemblies separated by 0.485-cm-thick 304L stainless steel
'plates and 0.095 cm of water, plate-to-assembly distance of 0.245 cm
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245      91.44  0.0
cylinder 0 1 0.64135      91.44  0.0
cylinder 6 1 0.64135      93.98 -2.54
cylinder 2 1 0.70735      93.98 -2.54
cuboid   3 1 4p1.270       93.98 -2.54
unit 2
array 1 3*0.0
reflector 3 1 2r0  2r7.64 2r0  1
unit 3

```

```

cuboid   5 1  0.0 -0.485 2p17.8     88.96 -2.54
cuboid   3 1  0.245 -8.335 2p17.8    93.98 -2.54
unit 4
cuboid   5 1  0.485  0.0 2p17.8     88.96 -2.54
cuboid   3 1  8.335 -0.245 2p17.8    93.98 -2.54
global unit 5
array 2 -65.73 -17.8  0.
reflector 4 1 5r0.0  2.54 1
reflector 3 1 2r30.5 2r22.86 2r15.3 1
end geometry

read array
ara=1 nux=15 nuy=8 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 4 2 end fill
end array
end data
end



p2615zr


=csas25
p2615zr
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
arbmrzr4 6.32 4 0 0 1 40000 .9816 50000 .015
24000 .0013 26000 .0021 5
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 6
end comp
squarepitch 2.540 1.2649 1 3 1.4147 2 1.2827 0
3-15x8 assemblies separated by 0.652-cm-thick Zircaloy-4 plates and
'10.268 cm of water, plate-to-assembly distance of 0.078 cm
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245      91.44  0.0
cylinder 0 1 0.64135      91.44  0.0
cylinder 6 1 0.64135      93.98 -2.54
cylinder 2 1 0.70735      93.98 -2.54
cuboid   3 1 4p1.270       93.98 -2.54
unit 2
array 1 3*0.0
reflector 3 1 2r0  2r7.64 2r0  1
unit 3
cuboid   5 1  0.0 -0.652 2p17.8     88.96 -2.54
cuboid   3 1  0.078 -10.842 2p17.8    93.98 -2.54
unit 4
cuboid   5 1  0.652  0.0 2p17.8     88.96 -2.54
cuboid   3 1  10.842 -0.078 2p17.8    93.98 -2.54
global unit 5
array 2 -68.07 -17.8  0.
reflector 4 1 5r0.0  2.54 1
reflector 3 1 2r30.5 2r22.86 2r15.3 1
end
```

```

end geometry
read array
ara=1 nux=15 nuy=8 nuz=1 fill f1      end fill
ara=2 nux=5  nuy=1 nuz=1 fill 2 3 2 4 2 end fill
end array
end data
end



p282711


=csas25
p282711
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
h2o      5 1.0
pb       6 .9758
end comp
squarepitch 2.032 1.1176 1 3 1.27 2
3-19x16 assemblies separated by 11.25 cm of water, assemblies
'separated from lead reflecting walls by 2.616 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

```

read geom
unit 1
cylinder 1 1 0.5588          91.44  0.0
cylinder 2 1 0.635           96.52 -1.27
cuboid   3 1 4p1.016         96.52 -1.27
unit 2
array 1 3*0.0
unit 3
cuboid   5 1 12.958 0.0    32.512  0.0   96.52 -1.27
global unit 4
array 2 -70.87 -16.256 0.
reflector 4 1 5r0.0 2.54          1
cuboid   5 1 2p82.0 2p16.916 104.29 -19.11
reflector 6 1 2r0.0 2r10.2 2r0.0  1
reflector 5 1 2r30.5 2r19.64 7.43  0
end geometry

```

```

read array
ara=1 nux=19 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5  nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end

```

p282712

```

h2o      5 1.0
pb       6 .9758
end comp
squarepitch 2.032 1.1176 1 3 1.27 2
3-19x16 assemblies separated by 11.25 cm of water, assemblies
'separated from lead reflecting walls by 2.616 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

```

read geom
unit 1
cylinder 1 1 0.5588          91.44  0.0
cylinder 2 1 0.635           96.52 -1.27
cuboid   3 1 4p1.016         96.52 -1.27
unit 2
array 1 3*0.0
unit 3
cuboid   5 1 10.488 0.0    32.512  0.0   96.52 -1.27
global unit 4
array 2 -68.4 -16.256 0.
reflector 4 1 5r0.0 2.54          1
cuboid   5 1 2p82.0 2p18.872 104.29 -19.11
reflector 6 1 2r0.0 2r10.2 2r0.0  1
reflector 5 1 2r30.5 2r17.684 7.43  0
end geometry

```

```

read array
ara=1 nux=19 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5  nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end

```

p282713

```

read geom
unit 1
cylinder 1 1 0.63245          91.44  0.0
cylinder 0 1 0.64135          91.44  0.0
cylinder 7 1 0.64135          93.98 -2.54
cylinder 2 1 0.70735          93.98 -2.54
cuboid   3 1 4p1.270          93.98 -2.54
unit 2
array 1 3*0.0

```

```

unit 3
cuboid 3 1 19.6547 0.0 20.32 0.0 93.98 -2.54
global unit 4
array 2 -69.1847 -10.16 0.
reflector 4 1 5r0.0 2.54 1
cuboid 3 1 2p82.0 2p10.82 103.02 -20.38
reflector 5 1 2r0.0 2r10.2 2r0.0 1
reflector 3 1 2r30.5 2r19.64 6.16 0 1
end geometry

read array
ara=1 nux=13 nuy=8 nuz=1 fill f1 end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end



p282714


=csas25
p282714
44group latticecell
uo2 1 0.949 293 92235 4.31 92238 95.69
al 2 1.0
h2o 3 1.0
plexiglas 4 1.0
h2o 5 1.0
pb 6 .9758
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 7
end comp
squarepitch 2.540 1.2649 1 3 1.4147 2 1.2827 0
3-13x8 assemblies separated by 19.04 cm of water, assemblies separated 'from
lead reflecting walls by 1.321 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245 91.44 0.0
cylinder 0 1 0.64135 91.44 0.0
cylinder 7 1 0.64135 93.98 -2.54
cylinder 2 1 0.70735 93.98 -2.54
cuboid 3 1 4p1.270 93.98 -2.54
unit 2
array 1 3*0.0
unit 3
cuboid 5 1 17.9147 0.0 20.32 0.0 93.98 -2.54
global unit 4
array 2 -67.4447 -10.16 0.
reflector 4 1 5r0.0 2.54 1
cuboid 5 1 2p82.0 2p11.481 103.02 -20.38
reflector 6 1 2r0.0 2r10.2 2r0.0 1
reflector 5 1 2r30.5 2r18.979 2r6.16 1
end geometry

read array
ara=1 nux=13 nuy=8 nuz=1 fill f1 end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array

end data
end



p2827slg


=csas25
p2827slg
44group latticecell
uo2 1 0.84 293 92235 2.35 92238 97.65
al 2 1.0
h2o 3 1.0
plexiglas 4 1.0
h2o 5 1.0
end comp
squarepitch 2.032 1.1176 1 3 1.27 2
3-19x16 assemblies separated by 8.31 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588 91.44 0.0
cylinder 2 1 0.635 96.52 -1.27
cuboid 3 1 4p1.016 96.52 -1.27
unit 2
array 1 3*0.0
unit 3
cuboid 5 1 7.548 0.0 32.512 0.0 96.52 -1.27
global unit 4
array 2 -65.460 -16.256 0.
reflector 4 1 5r0.0 2.54 1
reflector 5 1 4r30.5 15.2 15.3 1
end geometry

read array
ara=1 nux=19 nuy=16 nuz=1 fill f1 end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end



p2827u1


=csas25
p2827u1
44group latticecell
uo2 1 0.84 293 92235 2.35 92238 97.65
al 2 1.0
h2o 3 1.0
plexiglas 4 1.0
h2o 5 1.0
uranium 6 .98163 293 92235 .199 92238 99.801
end comp
squarepitch 2.032 1.1176 1 3 1.27 2
3-19x16 assemblies separated by 11.83 cm of water, assemblies
separated from depleted uranium reflecting walls by 0.0 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1

```

```

cylinder 1 1 0.5588          91.44   0.0
cylinder 2 1 0.635           96.52  -1.27
cuboid    3 1 4p1.016         96.52  -1.27
unit 2
array 1 3*0.0
unit 3
cuboid    5 1 11.068 0.0   32.512  0.0   96.52  -1.27
global unit 4
array 2 -68.98  -16.256  0.
reflector 4 1 5r0.0  2.54           1
cuboid    5 1 2p76.15 2p16.256 102.79  -19.11
reflector 6 1 2r0.0  2r7.65  2r0.0       1
reflector 5 1 2r30.5 2r22.85  8.93 0       1
end geometry

read array
ara=1 nux=19 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5  nuy=1  nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end



p2827u2



```

=csas25
p2827u2
44group latticecell
uo2 1 0.84 293 92235 2.35 92238 97.65 end
al 2 1.0 end
h2o 3 1.0 end
plexiglas 4 1.0 end
h2o 5 1.0 end
uranium 6 .98163 293 92235 .199 92238 99.801 end
end comp
squarepitch 2.032 1.1176 1 3 1.27 2 end
3-19x16 assemblies separated by 14.11 cm of water, assemblies 'separated from
depleted uranium reflecting walls by 1.956 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245 91.44 0.0
cylinder 0 1 0.64135 91.44 0.0
cylinder 7 1 0.64135 93.98 -2.54
cylinder 2 1 0.70735 93.98 -2.54
cuboid 3 1 4p1.270 93.98 -2.54
unit 2
array 1 3*0.0
unit 3
cuboid 5 1 14.2547 0.0 20.32 0.0 93.98 -2.54
global unit 4
array 2 -63.7847 -10.16 0.
reflector 4 1 5r0.0 2.54 1
cuboid 5 1 2p76.15 2p10.16 101.52 -20.38
reflector 6 1 2r0.0 2r7.65 2r0.0 1
reflector 5 1 2r30.5 2r22.85 7.66 0 1
end geometry

read array
ara=1 nux=13 nuy=8 nuz=1 fill f1 end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end

```


```

```

end array
end data
end



p2827u3



```

=csas25
p2827u3
44group latticecell
uo2 1 0.949 293 92235 4.31 92238 95.69 end
al 2 1.0 end
h2o 3 1.0 end
plexiglas 4 1.0 end
h2o 5 1.0 end
uranium 6 .98163 293 92235 .199 92238 99.801 end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 7 end
end comp
squarepitch 2.540 1.2649 1 3 1.4147 2 1.2827 0 end
3-13x8 assemblies separated by 15.38 cm of water, assemblies separated
'from depleted uranium reflecting walls by 0.0 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245 91.44 0.0
cylinder 0 1 0.64135 91.44 0.0
cylinder 7 1 0.64135 93.98 -2.54
cylinder 2 1 0.70735 93.98 -2.54
cuboid 3 1 4p1.270 93.98 -2.54
unit 2
array 1 3*0.0
unit 3
cuboid 5 1 14.2547 0.0 20.32 0.0 93.98 -2.54
global unit 4
array 2 -63.7847 -10.16 0.
reflector 4 1 5r0.0 2.54 1
cuboid 5 1 2p76.15 2p10.16 101.52 -20.38
reflector 6 1 2r0.0 2r7.65 2r0.0 1
reflector 5 1 2r30.5 2r22.85 7.66 0 1
end geometry

read array
ara=1 nux=13 nuy=8 nuz=1 fill f1 end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end

p2827u4


```

=csas25
p2827u4
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69      end
al       2 1.0          end
h2o     3 1.0          end
plexiglas 4 1.0        end
h2o     5 1.0          end

```


```


```

```

uranium   6 .98163 293 92235 .199 92238 99.801      end
arbmrubber 1.321 6 0 0 6012 58. 1001 6.5 20000 11.4
          16000 1.7 8016 22.1 14000 0.3 7      end
end comp
squarepitch 2.540 1.2649 1 3 1.4147 2 1.2827 0      end
3-19x16 assemblies separated by 15.32 cm of water, assemblies 'separated from
depleted uranium reflecting walls by 1.956 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245           91.44 0.0
cylinder 0 1 0.64135           91.44 0.0
cylinder 7 1 0.64135           93.98 -2.54
cylinder 2 1 0.70735           93.98 -2.54
cuboid   3 1 4p1.270           93.98 -2.54
unit 2
array   1 3*0.0
unit 3
cuboid   5 1 14.1947 0.0 20.32 0.0 93.98 -2.54
global unit 4
array 2 -59.9147 -10.16 0.
reflector 4 1 5r0.0 2.54           1
cuboid   5 1 2p76.15 2p12.116 101.52 -20.38
reflector 6 1 2r0.0 2r7.65 2r0.0 1
reflector 5 1 2r30.5 2r20.894 7.66 0 1
end geometry

read array
ara=1 nux=12 nuy=8 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end



p3314al


=csas25
p3314al
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69      end
al       2 1.0      end
h2o      3 1.0      end
plexiglas 4 1.0      end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
          16000 1.7 8016 22.1 14000 0.3 5      end
al      6 den=2.692 .9715      end
cr      6 den=2.692 .0021      end
cu      6 den=2.692 .0012      end
fe      6 den=2.692 .0082      end
mn      6 den=2.692 .0021      end
si      6 den=2.692 .0082      end
s       6 den=2.692 .0006      end
ti      6 den=2.692 .0061      end
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0      end
2-9x12 and 2-9x1 assemblies separated by 0.625-cm-thick aluminum 'plates and
2.205- and 8.415-cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

```

read geom
unit 1
cylinder 1 1 0.63245           91.44 0.0
cylinder 0 1 0.64135           91.44 0.0
cylinder 5 1 0.64135           93.98 -2.54
cylinder 2 1 0.70735           93.98 -2.54
cuboid   3 1 4p.9460            93.98 -2.54
unit 2
cuboid   3 1 17.157 0.0 22.704 0.0 93.98 -2.54
unit 3
array   1 3*0.0
unit 4
cuboid   6 1 2.83 2.205 22.704 0.0 88.96 -2.54
cuboid   3 1 2.83 0.0 22.704 0.0 93.98 -2.54
unit 5
cuboid   6 1 71.2 0.0 0.625 0.0 88.96 -2.54
cuboid   3 1 71.2 0.0 0.625 0.0 93.98 -2.54
unit 6
cuboid   3 1 36.39 0.0 8.415 0.0 88.96 -2.54
cuboid   6 1 37.015 0.0 8.415 0.0 88.96 -2.54
cuboid   3 1 71.2 0.0 8.415 0.0 93.98 -2.54
unit 7
cuboid   3 1 17.157 0.0 1.892 0.0 93.98 -2.54
unit 8
cuboid   6 1 2.83 2.205 1.892 0.0 88.96 -2.54
cuboid   3 1 2.83 0.0 1.892 0.0 93.98 -2.54
unit 9
array   2 3*0.0
unit 10
cuboid  3 1 36.39 0.0 37.564 0.0 88.96 -2.54
cuboid  6 1 37.015 0.0 37.564 0.0 88.96 -2.54
cuboid  3 1 71.2 0.0 37.564 0.0 93.98 -2.54
unit 11
array   3 3*0.0
unit 12
array   4 3*0.0
global unit 13
array   5 3*0.0
reflector 4 1 5r0.0 2.54 1
reflector 3 1 4r30.0 2r15.0 1
end geometry

read array
ara=1 nux=9 nuy=12 nuz=1 fill f1      end fill
ara=2 nux=9 nuy=1 nuz=1 fill f1      end fill
ara=3 nux=5 nuy=1 nuz=1 fill 2 3 4 3 2      end fill
ara=4 nux=5 nuy=1 nuz=1 fill 7 9 8 9 7      end fill
ara=5 nux=1 nuy=5 nuz=1 fill 11 5 6 12 10 end fill
end array
end data
end



p3314ba


=csas25
p3314ba
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0      end

```

end

```

h2o      3 1.0
plexiglas 4 1.0
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 5
b       6 den=2.49 .287
c       6 den=2.49 .0797
al      6 den=2.49 .6249
cr      6 den=2.49 .0005
cu      6 den=2.49 .0009
fe      6 den=2.49 .0033
mg      6 den=2.49 .0005
mn      6 den=2.49 .0005
na      6 den=2.49 .0002
ni      6 den=2.49 .0002
si      6 den=2.49 .0020
s       6 den=2.49 .0003
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0
2-11x14 and 2-11x16 assemblies separated by 0.713-cm-thick Boral-A 'plates
and 2.117- and 4.087-cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245          91.44  0.0
cylinder 0 1 0.64135          91.44  0.0
cylinder 5 1 0.64135          93.98 -2.54
cylinder 2 1 0.70735          93.98 -2.54
cuboid   3 1 4p.9460           93.98 -2.54
unit 2
cuboid   3 1 13.373 0.0 26.488 0.0  93.98 -2.54
unit 3
array 1 3*0.0
unit 4
cuboid   6 1 2.728 2.219 26.488 0.0  88.96 -2.54
cuboid   2 1 2.83 2.117 26.488 0.0  88.96 -2.54
cuboid   3 1 2.83 0.0 26.488 0.0  93.98 -2.54
unit 5
cuboid   2 1 71.2 0.0 0.102 0.0  88.96 -2.54
cuboid   6 1 71.2 0.0 0.611 0.0  88.96 -2.54
cuboid   2 1 71.2 0.0 0.713 0.0  88.96 -2.54
cuboid   3 1 71.2 0.0 0.713 0.0  93.98 -2.54
unit 6
cuboid   3 1 36.302 0.0 4.087 0.0  88.96 -2.54
cuboid   2 1 36.404 0.0 4.087 0.0  88.96 -2.54
cuboid   6 1 36.913 0.0 4.087 0.0  88.96 -2.54
cuboid   2 1 37.015 0.0 4.087 0.0  88.96 -2.54
cuboid   3 1 71.2 0.0 4.087 0.0  93.98 -2.54
unit 7
cuboid   3 1 13.373 0.0 30.272 0.0  93.98 -2.54
unit 8
cuboid   6 1 2.728 2.219 30.272 0.0  88.96 -2.54
cuboid   2 1 2.83 2.117 30.272 0.0  88.96 -2.54
cuboid   3 1 2.83 0.0 30.272 0.0  93.98 -2.54
unit 9
array 2 3*0.0
unit 10
cuboid  3 1 36.302 0.0  9.64  0.0  88.96 -2.54
cuboid  2 1 36.404 0.0  9.64  0.0  88.96 -2.54

```

```

end
end
cuboid  6 1 36.913 0.0  9.64  0.0  88.96 -2.54
cuboid  2 1 37.015 0.0  9.64  0.0  88.96 -2.54
cuboid  3 1 71.2 0.0  9.64  0.0  93.98 -2.54
unit 11
array 3 3*0.0
unit 12
array 4 3*0.0
global unit 13
array 5 3*0.0
reflector 4 1 5r0.0 2.54 1
reflector 3 1 4r30.0 2r15.0 1
end geometry

read array
ara=1 nux=11 nuy=14 nuz=1 fill f1
ara=2 nux=11 nuy=16 nuz=1 fill f1
ara=3 nux=5 nuy=1 nuz=1 fill 2 3 4 3 2
ara=4 nux=5 nuy=1 nuz=1 fill 7 9 8 9 7
ara=5 nux=1 nuy=5 nuz=1 fill 11 5 6 12 10
end array
end data
end

p3314bc

=csas25
p3314bc
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 5
b       6 den=2.47 .3188
c       6 den=2.47 .0886
al      6 den=2.47 .5926
fe      6 den=2.47 .0005
mg      6 den=2.47 .0001
na      6 den=2.47 .0002
si      6 den=2.47 .0006
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0
2-11x14 and 2-11x14 assemblies separated by 0.231-cm-thick Boral-C
'plates and 2.599- and 3.299-cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245          91.44  0.0
cylinder 0 1 0.64135          91.44  0.0
cylinder 5 1 0.64135          93.98 -2.54
cylinder 2 1 0.70735          93.98 -2.54
cuboid   3 1 4p.9460           93.98 -2.54
unit 2
cuboid   3 1 13.373 0.0 26.488 0.0  93.98 -2.54
unit 3
array 1 3*0.0

```

```

unit 4
cuboid 6 1 2.805 2.624 26.488 0.0 88.96 -2.54
cuboid 2 1 2.83 2.599 26.488 0.0 88.96 -2.54
cuboid 3 1 2.83 0.0 26.488 0.0 93.98 -2.54
unit 5
cuboid 6 1 71.2 0.0 0.206 0.025 88.96 -2.54
cuboid 2 1 71.2 0.0 0.231 0.0 88.96 -2.54
cuboid 3 1 71.2 0.0 0.231 0.0 93.98 -2.54
unit 6
cuboid 3 1 36.784 0.0 3.299 0.0 88.96 -2.54
cuboid 2 1 36.809 0.0 3.299 0.0 88.96 -2.54
cuboid 6 1 36.99 0.0 3.299 0.0 88.96 -2.54
cuboid 2 1 37.015 0.0 3.299 0.0 88.96 -2.54
cuboid 3 1 71.2 0.0 3.299 0.0 93.98 -2.54
unit 7
array 2 3*0.0
unit 8
cuboid 3 1 36.784 0.0 14.694 0.0 88.96 -2.54
cuboid 2 1 36.809 0.0 14.694 0.0 88.96 -2.54
cuboid 6 1 36.99 0.0 14.694 0.0 88.96 -2.54
cuboid 2 1 37.015 0.0 14.694 0.0 88.96 -2.54
cuboid 3 1 71.2 0.0 14.694 0.0 93.98 -2.54
global unit 9
array 3 3*0.0
reflector 4 1 5r0.0 2.54 1
reflector 3 1 4r30.0 2r15.0 1
end geometry

read array
ara=1 nux=11 nuy=14 nuz=1 fill f1      end fill
ara=2 nux=5  nuy=1  nuz=1 fill 2 3 4 3 2 end fill
ara=3 nux=1  nuy=5  nuz=1 fill 7 5 6 7 8 end fill
end array
end data
end



p3314bf1


=csas25
p3314bf1
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 5
boron    6 den=1.731 .3274
c        6 den=1.731 .2113
h        6 den=1.731 .0265
cr       6 den=1.731 .0003
fe       6 den=1.731 .0005
o        6 den=1.731 .2101
si       6 den=1.731 .2239
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0
2-11x14 and 2-11x14 assemblies separated by 0.546-cm-thick Boroflex 'plates
and 2.284- and 3.054-cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245
cylinder 0 1 0.64135
cylinder 5 1 0.64135
cylinder 2 1 0.70735
cuboid 3 1 4p.9460
unit 2
array 1 3*0.0
unit 3
cuboid 3 1 26.488 0.0 13.373 0.0 93.98 -2.54
unit 4
cuboid 6 1 26.488 0.0 2.67 2.444 88.96 -2.54
cuboid 4 1 26.488 0.0 2.83 2.284 88.96 -2.54
cuboid 3 1 26.488 0.0 2.83 0.0 93.98 -2.54
unit 5
cuboid 6 1 0.386 0.16 2p35.6 88.96 -2.54
cuboid 4 1 0.546 0.0 2p35.6 88.96 -2.54
cuboid 3 1 0.546 0.0 2p35.6 93.98 -2.54
unit 6
cuboid 6 1 3.054 0.0 0.386 0.16 88.96 -2.54
cuboid 4 1 3.054 0.0 0.546 0.0 88.96 -2.54
cuboid 3 1 3.054 0.0 34.731 -36.469 93.98 -2.54
unit 7
cuboid 6 1 14.624 0.0 0.386 0.16 88.96 -2.54
cuboid 4 1 14.624 0.0 0.546 0.0 88.96 -2.54
cuboid 3 1 14.624 0.0 34.731 -36.469 93.98 -2.54
unit 8
array 2 3*0.0
global unit 9
array 3 3*0.0
reflector 4 1 5r0.0 2.54 1
reflector 3 1 4r30.0 2r15.0 1
end geometry

read array
ara=1 nux=14 nuy=11 nuz=1 fill f1      end fill
ara=2 nux=1  nuy=5  nuz=1 fill 3 2 4 2 3 end fill
ara=3 nux=5  nuy=1  nuz=1 fill 8 5 6 8 7 end fill
end array
end data
end



p3314bf2


=csas25
p3314bf2
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 5
boron    6 den=1.731 .3274
c        6 den=1.731 .2113
h        6 den=1.731 .0265
cr       6 den=1.731 .0003
fe       6 den=1.731 .0005

```

```

o      6 den=1.731 .2101          end
si      6 den=1.731 .2239          end
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0          end
2-11x14 and 2-11x16 assemblies separated by 0.772-cm-thick Boroflex 'plates
and 2.058- and 4.168-cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245           91.44  0.0
cylinder 0 1 0.64135           91.44  0.0
cylinder 5 1 0.64135           93.98 -2.54
cylinder 2 1 0.70735           93.98 -2.54
cuboid   3 1 4p.9460            93.98 -2.54
unit 2
array  1 3*0.0
unit 3
cuboid   3 1 26.488  0.0 13.373  0.0  93.98 -2.54
unit 4
cuboid   6 1 26.488  0.0  2.67  2.218  88.96 -2.54
cuboid   4 1 26.488  0.0  2.83  2.058  88.96 -2.54
cuboid   3 1 26.488  0.0  2.83  0.0   93.98 -2.54
unit 5
array  2 3*0.0
unit 6
cuboid   3 1 30.272  0.0 13.373  0.0  93.98 -2.54
unit 7
cuboid   6 1 30.272  0.0  2.67  2.218  88.96 -2.54
cuboid   4 1 30.272  0.0  2.83  2.058  88.96 -2.54
cuboid   3 1 30.272  0.0  2.83  0.0   93.98 -2.54
unit 8
cuboid   6 1 0.612   0.16  2p35.6   88.96 -2.54
cuboid   4 1 0.772   0.0   2p35.6   88.96 -2.54
cuboid   3 1 0.772   0.0   2p35.6   93.98 -2.54
unit 9
cuboid   6 1 4.168   0.0   0.612   0.16  88.96 -2.54
cuboid   4 1 4.168   0.0   0.772   0.0   88.96 -2.54
cuboid   3 1 4.168   0.0  34.957 -36.243 93.98 -2.54
unit 10
cuboid   6 1 9.500   0.0   0.612   0.16  88.96 -2.54
cuboid   4 1 9.500   0.0   0.772   0.0   88.96 -2.54
cuboid   3 1 9.500   0.0  34.957 -36.243 93.98 -2.54
unit 11
array  3 3*0.0
unit 12
array  4 3*0.0
global unit 13
array  5 3*0.0
reflector 4 1 5r0.0  2.54  1
reflector 3 1 4r30.0 2r15.0 1
end geometry

read array
ara=1 nux=14 nuy=11 nuz=1 fill f1          end fill
ara=2 nux=16 nuy=11 nuz=1 fill f1          end fill
ara=3 nux=1 nuy=5 nuz=1 fill 3 2 4 2 3    end fill
ara=4 nux=1 nuy=5 nuz=1 fill 6 5 7 5 6    end fill
ara=5 nux=5 nuy=1 nuz=1 fill 11 8 9 12 10 end fill
end array
end data
end

p3314bs1
=csas25
p3314bs1
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
cr       5 den=7.90 .1903
b        5 den=7.90 .0105
fe       5 den=7.90 .6804
ni       5 den=7.90 .0953
mn       5 den=7.90 .0158
cu       5 den=7.90 .0028
mo       5 den=7.90 .0049
end comp
squarepitch 1.684 1.1176 1 3 1.27 2 end geometry
2-17x20 and 1-25x20 (center) assemblies separated by 0.298-cm-thick
'1.1 wt% B stainless steel plates and 3.562 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

p3314bs2

```
=csas25
p3314bs2
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
cr       5 den=7.77 .1960
b        5 den=7.77 .0162
fe       5 den=7.77 .6640
ni       5 den=7.77 .1012
mn       5 den=7.77 .0169
cu       5 den=7.77 .0026
mo       5 den=7.77 .0031
end comp
squarepitch 1.684 1.1176 1 3 1.27 2 end geometry
2-17x20 and 1-25x20 (center) assemblies separated by 0.298-cm-thick
'1.1 wt% B stainless steel plates and 3.162 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588          91.44  0.0
cylinder 2 1 0.635           96.52 -1.27
cuboid   3 1 4p0.842          96.52 -1.27
unit 2
array    1 3*0.0
reflector 3 1 2r0  1.92 0.0 2r0  1
unit 3
array    2 3*0.0
reflector 3 1 2r0  1.92 0.0 2r0  1
unit 4
cuboid   5 1 0.0  -0.298  35.6 0.0  90.23 -1.27
cuboid   3 1 0.0  -3.46   35.6 0.0  96.52 -1.27
unit 5
cuboid   5 1 0.298  0.0   35.6 0.0  90.23 -1.27
cuboid   3 1 3.46  0.0   35.6 0.0  96.52 -1.27
global unit 9
array    3 -53.138 -17.8   0.
reflector 4 1 5r0.0  2.54   1
reflector 3 1 4r30.0 2r15.0 1
end geometry
read array
ara=1 nux=25 nuy=20 nuz=1 fill f1      end fill
ara=2 nux=17 nuy=20 nuz=1 fill f1      end fill
ara=3 nux=5 nuy=1 nuz=1 fill 3 4 2 5 3 end fill
end array
end data
end
```

p3314bs3

```
=csas25
p3314bs3
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
end
```

```
h2o      3 1.0
plexiglas 4 1.0
cr       5 den=7.90 .1903
b        5 den=7.90 .0105
fe       5 den=7.90 .6804
ni       5 den=7.90 .0953
mn       5 den=7.90 .0158
cu       5 den=7.90 .0028
mo       5 den=7.90 .0049
arbmrubber 1.321 6 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 6
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0
3-12x16 assemblies separated by 0.298-cm-thick 1.1 wt% B stainless
'steel plates and 6.932 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm
```

```
read geom
unit 1
cylinder 1 1 0.63245          91.44  0.0
cylinder 0 1 0.64135          91.44  0.0
cylinder 6 1 0.64135          93.98 -2.54
cylinder 2 1 0.70735          93.98 -2.54
cuboid   3 1 4p0.946          93.98 -2.54
unit 2
array    1 3*0.0
reflector 3 1 2r0  2r2.664 2r0  1
unit 3
cuboid   5 1 0.0  -0.298  2p17.8   88.96 -2.54
cuboid   3 1 0.0  -07.23  2p17.8   93.98 -2.54
unit 4
cuboid   5 1 0.298  0.0   2p17.8   88.96 -2.54
cuboid   3 1 07.23  0.0   2p17.8   93.98 -2.54
global unit 5
array    2 -41.286 -17.8   0.
reflector 4 1 5r0.0  2.54   1
reflector 3 1 4r30.0 2r15.0 1
end geometry
```

```
read array
ara=1 nux=12 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 4 2 end fill
end array
end data
end
```

p3314bs4

```
=csas25
p3314bs4
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
cr       5 den=7.77 .1960
b        5 den=7.77 .0162
fe       5 den=7.77 .6640
end
```

```

ni      5 den=7.77 .1012          end
mn      5 den=7.77 .0169          end
cu      5 den=7.77 .0026          end
mo      5 den=7.77 .0031          end
arbmrubber 1.321 6 0 0 6012 58. 1001 6.5 20000 11.4
           16000 1.7 8016 22.1 14000 0.3 6          end
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0          end
3-12x16 assemblies separated by 0.298-cm-thick 1.6 wt% B stainless 'steel
plates and 6.332 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245          91.44  0.0
cylinder 0 1 0.64135          91.44  0.0
cylinder 6 1 0.64135          93.98 -2.54
cylinder 2 1 0.70735          93.98 -2.54
cuboid   3 1 4p.9460           93.98 -2.54
unit 2
array 1 3*0.0
reflector 3 1 2r0 2r2.664 2r0 1
unit 3
cuboid   5 1 0.0 -0.298 2p17.8    88.96 -2.54
cuboid   3 1 0.0 -06.63 2p17.8    93.98 -2.54
unit 4
cuboid   5 1 0.298 0.0 2p17.8    88.96 -2.54
cuboid   3 1 06.63 0.0 2p17.8    93.98 -2.54
global unit 5
array 2 -40.686 -17.8 0.
reflector 4 1 5r0.0 2.54 1
reflector 3 1 4r30.0 2r15.0 1
end geometry

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 4 2 end fill
end array
end data
end



p3314cd1


=csas25
p3314cd1
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69          end
al       2 1.0          end
h2o      3 1.0          end
plexiglas 4 1.0          end
arbmrubber 1.321 6 0 0 6012 58. 1001 6.5 20000 11.4
           16000 1.7 8016 22.1 14000 0.3 5          end
cd       6 den=8.65         end
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0          end
2-11x14 and 2-11x13 assemblies separated by 0.061546-cm-thick cadmium
'plates and 2.769- and 5.239-cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

```

read geom
unit 1
cylinder 1 1 0.63245          91.44  0.0
cylinder 0 1 0.64135          91.44  0.0
cylinder 5 1 0.64135          93.98 -2.54
cylinder 2 1 0.70735          93.98 -2.54
cuboid   3 1 4p.9460           93.98 -2.54
unit 2
cuboid   3 1 13.373 0.0 26.488 0.0 93.98 -2.54
unit 3
array 1 3*0.0
unit 4
cuboid   6 1 2.83 2.769 26.488 0.0 88.96 -2.54
cuboid   3 1 2.83 0.0 26.488 0.0 93.98 -2.54
unit 5
cuboid   6 1 71.2 0.0 0.061 0.0 88.96 -2.54
cuboid   3 1 71.2 0.0 0.061 0.0 93.98 -2.54
unit 6
cuboid   3 1 36.954 0.0 5.2939 0.0 88.96 -2.54
cuboid   6 1 37.105 0.0 5.2939 0.0 88.96 -2.54
cuboid   3 1 71.2 0.0 5.2939 0.0 93.98 -2.54
unit 7
cuboid   3 1 13.373 0.0 24.596 0.0 93.98 -2.54
unit 8
cuboid   6 1 2.83 2.769 24.596 0.0 88.96 -2.54
cuboid   3 1 2.83 0.0 24.596 0.0 93.98 -2.54
unit 9
array 2 3*0.0
unit 10
cuboid   3 1 36.954 0.0 14.843 0.0 88.96 -2.54
cuboid   6 1 37.015 0.0 14.843 0.0 88.96 -2.54
cuboid   3 1 71.2 0.0 14.843 0.0 93.98 -2.54
unit 11
array 3 3*0.0
unit 12
array 4 3*0.0
global unit 13
array 5 3*0.0
reflector 4 1 5r0.0 2.54 1
reflector 3 1 4r30.0 2r15.0 1
end geometry

```

```

read array
ara=1 nux=11 nuy=14 nuz=1 fill f1      end fill
ara=2 nux=11 nuy=13 nuz=1 fill f1      end fill
ara=3 nux=5 nuy=1 nuz=1 fill 2 3 4 3 2      end fill
ara=4 nux=5 nuy=1 nuz=1 fill 7 9 8 9 7      end fill
ara=5 nux=1 nuy=5 nuz=1 fill 11 5 6 12 10 end fill
end array
end data
end

```

p3314cd2

```

=csas25
p3314cd2
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65          end
al       2 1.0          end

```

```

h2o      3 1.0
plexiglas 4 1.0
cd      5 den=8.65
end comp
squarepitch 1.684 1.1176 1 3 1.27 2 end geometry
2-17x20 and 1-25x20 (center) assemblies separated by 0.061-cm-thick 'cadmium
plates and 2.979 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588          91.44  0.0
cylinder 2 1 0.635           96.52 -1.27
cuboid   3 1 4p0.842          96.52 -1.27
unit 2
array 1 3*0.0
reflector 3 1 2r0 1.92 0.0 2r0 1
unit 3
array 2 3*0.0
reflector 3 1 2r0 1.92 0.0 2r0 1
unit 4
cuboid   5 1 0.0 -0.061 35.6 0.0  90.23 -1.27
cuboid   3 1 0.0 -3.04 35.6 0.0  96.52 -1.27
unit 5
cuboid   5 1 0.061 0.0 35.6 0.0  90.23 -1.27
cuboid   3 1 3.04 0.0 35.6 0.0  96.52 -1.27
global unit 9
array 3 -52.718 -17.8 0.
reflector 4 1 5r0.0 2.54 1
reflector 3 1 4r30.0 2r15.0 1
end geometry

read array
ara=1 nux=25 nuy=20 nuz=1 fill f1      end fill
ara=2 nux=17 nuy=20 nuz=1 fill f1      end fill
ara=3 nux=5 nuy=1 nuz=1 fill 3 4 2 5 3 end fill
end array
end data
end



p3314cu1


=csas25
p3314cul
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al      2 1.0
h2o      3 1.0
plexiglas 4 1.0
arbmrubber 1.321 6 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 5
cu      6 den=8.913
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0
2-9x12 and 2-9x7 assemblies separated by 0.337-cm-thick copper 'plates and
2.493- and 5.603-cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom

```

```

unit 1
cylinder 1 1 0.63245          91.44  0.0
cylinder 0 1 0.64135          91.44  0.0
cylinder 5 1 0.64135          93.98 -2.54
cylinder 2 1 0.70735          93.98 -2.54
cuboid   3 1 4p.9460           93.98 -2.54
unit 2
cuboid   3 1 12.157 0.0 22.704 0.0  93.98 -2.54
unit 3
array 1 3*0.0
unit 4
cuboid   6 1 2.83 2.493 22.704 0.0  88.96 -2.54
cuboid   3 1 2.83 0.0 22.704 0.0  93.98 -2.54
unit 5
cuboid   6 1 61.2 0.0 0.337 0.0  88.96 -2.54
cuboid   3 1 61.2 0.0 0.337 0.0  93.98 -2.54
unit 6
cuboid   3 1 31.678 0.0 5.603 0.0  88.96 -2.54
cuboid   6 1 32.015 0.0 5.603 0.0  88.96 -2.54
cuboid   3 1 61.2 0.0 5.603 0.0  93.98 -2.54
unit 7
cuboid   3 1 12.157 0.0 13.244 0.0  93.98 -2.54
unit 8
cuboid   6 1 2.83 2.493 13.244 0.0  88.96 -2.54
cuboid   3 1 2.83 0.0 13.244 0.0  93.98 -2.54
unit 9
array 2 3*0.0
unit 10
cuboid   3 1 31.678 0.0 19.312 0.0  88.96 -2.54
cuboid   6 1 32.015 0.0 19.312 0.0  88.96 -2.54
cuboid   3 1 61.2 0.0 19.312 0.0  93.98 -2.54
unit 11
array 3 3*0.0
unit 12
array 4 3*0.0
global unit 13
array 5 3*0.0
reflector 4 1 5r0.0 2.54 1
reflector 3 1 4r30.0 2r15.0 1
end geometry

read array
ara=1 nux=9 nuy=12 nuz=1 fill f1      end fill
ara=2 nux=9 nuy=7 nuz=1 fill f1      end fill
ara=3 nux=5 nuy=1 nuz=1 fill 2 3 4 3 2  end fill
ara=4 nux=5 nuy=1 nuz=1 fill 7 9 8 9 7  end fill
ara=5 nux=1 nuy=5 nuz=1 fill 11 5 6 12 10 end fill
end array
end data
end



p3314cu2


=csas25
p3314cu2
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al      2 1.0
h2o      3 1.0

```

```

plexiglas 4 1.0
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
          16000 1.7 8016 22.1 14000 0.3 5
cu       6 den=8.913
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0
2-9x12 and 2-9x5 assemblies separated by 0.646-cm-thick copper    'plates and
2.184- and 2.024-cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245           91.44  0.0
cylinder 0 1 0.64135           91.44  0.0
cylinder 5 1 0.64135           93.98 -2.54
cylinder 2 1 0.70735           93.98 -2.54
cuboid   3 1 4p.9460            93.98 -2.54
unit 2
cuboid   3 1 17.157 0.0 22.704 0.0  93.98 -2.54
unit 3
array 1 3*0.0
unit 4
cuboid   6 1 2.83  2.184 22.704 0.0  88.96 -2.54
cuboid   3 1 2.83  0.0   22.704 0.0  93.98 -2.54
unit 5
cuboid   6 1 71.2  0.0   0.646 0.0   88.96 -2.54
cuboid   3 1 71.2  0.0   0.646 0.0   93.98 -2.54
unit 6
cuboid   3 1 36.369 0.0  2.024 0.0   88.96 -2.54
cuboid   6 1 37.015 0.0  2.024 0.0   88.96 -2.54
cuboid   3 1 71.2  0.0  2.024 0.0   93.98 -2.54
unit 7
cuboid   3 1 17.157 0.0  9.46  0.0   93.98 -2.54
unit 8
cuboid   6 1 2.83  2.184 9.46  0.0   88.96 -2.54
cuboid   3 1 2.83  0.0   9.46  0.0   93.98 -2.54
unit 9
array 2 3*0.0
unit 10
cuboid   3 1 36.369 0.0  36.366 0.0  88.96 -2.54
cuboid   6 1 37.015 0.0  36.366 0.0  88.96 -2.54
cuboid   3 1 71.2  0.0  36.366 0.0  93.98 -2.54
unit 11
array 3 3*0.0
unit 12
array 4 3*0.0
global unit 13
array 5 3*0.0
reflector 4 1 5r0.0  2.54  1
reflector 3 1 4r30.0 2r15.0 1
end geometry

read array
ara=1 nux=9  nuy=12 nuz=1 fill f1      end fill
ara=2 nux=9  nuy=5  nuz=1 fill f1      end fill
ara=3 nux=5  nuy=1  nuz=1 fill 2 3 4 3 2  end fill
ara=4 nux=5  nuy=1  nuz=1 fill 7 9 8 9 7  end fill
ara=5 nux=1  nuy=5  nuz=1 fill 11 5 6 12 10 end fill
end array

end data
end
p3314cu3

=csas25
p3314cu3
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o     3 1.0
plexiglas 4 1.0
cu       5 den=8.913
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
          16000 1.7 8016 22.1 14000 0.3 6
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0
3-12x16 assemblies separated by 0.337-cm-thick copper plates and
'10.023 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm
read geom
unit 1
cylinder 1 1 0.63245           91.44  0.0
cylinder 0 1 0.64135           91.44  0.0
cylinder 6 1 0.64135           93.98 -2.54
cylinder 2 1 0.70735           93.98 -2.54
cuboid   3 1 4p.946             93.98 -2.54
unit 2
array 1 3*0.0
reflector 3 1 2r0  2r0.164 2r0  1
unit 3
cuboid   5 1 0.0  -0.337 2p15.3   88.96 -2.54
cuboid   3 1 0.0  -10.36 2p15.3   93.98 -2.54
unit 4
cuboid   5 1 0.337 0.0  2p15.3   88.96 -2.54
cuboid   3 1 10.36 0.0  2p15.3   93.98 -2.54
global unit 5
array 2 -44.416 -15.3  0.
reflector 4 1 5r0.0  2.54  1
reflector 3 1 4r30.0 2r15.0 1
end geometry

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5  nuy=1  nuz=1 fill 2 3 2 4 2 end fill
end array
end data
end

p3314cu4

=csas25
p3314cu4
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o     3 1.0
plexiglas 4 1.0
end
end
end
end

```

```

cu      5 den=8.913 .99          end
cd      5 den=8.913 .01          end
arbmrubber 1.321 6 0 0 6012 58. 1001 6.5 20000 11.4
       16000 1.7 8016 22.1 14000 0.3 6          end
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0          end
3-12x16 assemblies separated by 0.357-cm-thick copper plates and
'7.253 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245           91.44  0.0
cylinder 0 1 0.64135           91.44  0.0
cylinder 6 1 0.64135           93.98 -2.54
cylinder 2 1 0.70735           93.98 -2.54
cuboid   3 1 4p0.946           93.98 -2.54
unit 2
array   1 3*0.0
reflector 3 1 2r0  2r2.664 2r0  1
unit 3
cuboid   5 1 0.0 -0.357 2p17.8    88.96 -2.54
cuboid   3 1 0.0 -07.61 2p17.8    93.98 -2.54
unit 4
cuboid   5 1 0.357 0.0 2p17.8    88.96 -2.54
cuboid   3 1 07.61 0.0 2p17.8    93.98 -2.54
global unit 5
array   2 -41.666 -17.8  0.
reflector 4 1 5r0.0  2.54  1
reflector 3 1 4r30.0 2r15.0 1
end geometry

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 4 2 end fill
end array
end data
end



p3314cu5


=csas25
p3314cu5
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
cu       5 den=8.91 .99
cd       5 den=8.91 .01
end comp
squarepitch 1.684 1.1176 1 3 1.27 2 end geometry
2-20x18 and 1-25x18 (center) assemblies separated by 0.357-cm-thick
'1 wt% cadmium copper plates and 2.243 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588           91.44  0.0
cylinder 2 1 0.635            96.52 -1.27
cuboid   3 1 4p0.842           96.52 -1.27
unit 2
array   1 3*0.0
reflector 3 1 2r0  5.288 0.0 2r0  1
unit 3
array   2 3*0.0
reflector 3 1 2r0  5.288 0.0 2r0  1
unit 4
cuboid   5 1 0.0 -0.357 35.6 0.0    90.23 -1.27
cuboid   3 1 0.0 -2.60 35.6 0.0    96.52 -1.27
unit 5
cuboid   5 1 0.357 0.0 35.6 0.0    90.23 -1.27

```

```

cuboid 3 1 2.60 0.0 35.6 0.0 96.52 -1.27
global unit 9
array 3 -57.33 -17.8 0.
reflector 4 1 5r0.0 2.54 1
reflector 3 1 4r30.0 2r15.0 1
end geometry

read array
ara=1 nux=25 nuy=18 nuz=1 fill f1      end fill
ara=2 nux=20 nuy=18 nuz=1 fill f1      end fill
ara=3 nux=5 nuy=1 nuz=1 fill 3 4 2 5 3 end fill
end array
end data
end

p3314slg

=csas25
p3314slg
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69      end
al       2 1.0      end
h2o      3 1.0      end
plexiglas 4 1.0     end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
          16000 1.7 8016 22.1 14000 0.3 5      end
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0      end
2-9x12 and 2-9x1 assemblies separated by 2.83- and 10.86-cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245      91.44 0.0
cylinder 0 1 0.64135      91.44 0.0
cylinder 5 1 0.64135      93.98 -2.54
cylinder 2 1 0.70735      93.98 -2.54
cuboid   3 1 4p.9460       93.98 -2.54
unit 2
cuboid   3 1 17.157 0.0 22.704 0.0 93.98 -2.54
unit 3
array 1 3*0.0
unit 4
cuboid   3 1 2.83 0.0 22.704 0.0 93.98 -2.54
unit 5
cuboid   3 1 71.2 0.0 10.86 0.0 93.98 -2.54
unit 6
cuboid   3 1 17.157 0.0 1.892 0.0 93.98 -2.54
unit 7
cuboid   3 1 2.83 0.0 1.892 0.0 93.98 -2.54
unit 8
array 2 3*0.0
unit 9
cuboid   3 1 71.2 0.0 35.744 0.0 93.98 -2.54
unit 10
array 3 3*0.0
unit 11
array 4 3*0.0
global unit 12

```

```

array 5 3*0.0
reflector 4 1 5r0.0 2.54 1
reflector 3 1 4r30.0 2r15.0 1
end geometry

read array
ara=1 nux=9 nuy=12 nuz=1 fill f1      end fill
ara=2 nux=9 nuy=1 nuz=1 fill f1      end fill
ara=3 nux=5 nuy=1 nuz=1 fill 2 3 4 3 2 end fill
ara=4 nux=5 nuy=1 nuz=1 fill 6 8 7 8 6 end fill
ara=5 nux=1 nuy=4 nuz=1 fill 10 5 11 9 end fill
end array
end data
end

p3314ssl

=csas25
p3314ssl
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69      end
al       2 1.0      end
h2o      3 1.0      end
plexiglas 4 1.0     end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
          16000 1.7 8016 22.1 14000 0.3 5      end
cr       6 den=7.93 .1856      end
cu       6 den=7.93 .0027      end
fe       6 den=7.93 .6824      end
mn       6 den=7.93 .0158      end
mo       6 den=7.93 .0026      end
ni       6 den=7.93 .1109      end
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0      end
2-9x12 and 2-9x2 assemblies separated by 0.302-cm-thick 0.0 wt% B
'stainless steel plates and 2.528- and 3.078-cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245      91.44 0.0
cylinder 0 1 0.64135      91.44 0.0
cylinder 5 1 0.64135      93.98 -2.54
cylinder 2 1 0.70735      93.98 -2.54
cuboid   3 1 4p.9460       93.98 -2.54
unit 2
cuboid   3 1 17.157 0.0 22.704 0.0 93.98 -2.54
unit 3
array 1 3*0.0
unit 4
cuboid   6 1 2.83 2.528 22.704 0.0 88.96 -2.54
cuboid   3 1 2.83 0.0 22.704 0.0 93.98 -2.54
unit 5
cuboid   6 1 71.2 0.0 0.302 0.0 88.96 -2.54
cuboid   3 1 71.2 0.0 0.302 0.0 93.98 -2.54
unit 6
cuboid   3 1 36.713 0.0 3.078 0.0 88.96 -2.54
cuboid   6 1 37.015 0.0 3.078 0.0 88.96 -2.54
cuboid   3 1 71.2 0.0 3.078 0.0 93.98 -2.54

```

```

unit 7
cuboid 3 1 17.157 0.0 3.784 0.0 93.98 -2.54
unit 8
cuboid 6 1 2.83 2.528 3.784 0.0 88.96 -2.54
cuboid 3 1 2.83 0.0 3.784 0.0 93.98 -2.54
unit 9
array 2 3*0.0
unit 10
cuboid 3 1 36.713 0.0 41.332 0.0 88.96 -2.54
cuboid 6 1 37.015 0.0 41.332 0.0 88.96 -2.54
cuboid 3 1 71.2 0.0 41.332 0.0 93.98 -2.54
unit 11
array 3 3*0.0
unit 12
array 4 3*0.0
global unit 13
array 5 3*0.0
reflector 4 1 5r0.0 2.54 1
reflector 3 1 4r30.0 2r15.0 1
end geometry

read array
ara=1 nux=9 nuy=12 nuz=1 fill f1 end fill
ara=2 nux=9 nuy=2 nuz=1 fill f1 end fill
ara=3 nux=5 nuy=1 nuz=1 fill 2 3 4 3 2 end fill
ara=4 nux=5 nuy=1 nuz=1 fill 7 9 8 9 7 end fill
ara=5 nux=1 nuy=5 nuz=1 fill 11 5 6 12 10 end fill
end array
end data
end



p3314ss2


=csas25
p3314ss2
44group latticecell
uo2 1 0.949 293 92235 4.31 92238 95.69
al 2 1.0
end
h2o 3 1.0
end
plexiglas 4 1.0
end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 5
end
cr 6 den=7.93 .1856
cu 6 den=7.93 .0027
fe 6 den=7.93 .6824
mn 6 den=7.93 .0158
mo 6 den=7.93 .0026
ni 6 den=7.93 .1109
end
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0
end
2-9x12 and 2-9x13 assemblies separated by 0.302-cm-thick 0.0 wt% B 'stainless
steel plates and 2.528- and 11.248-cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245 91.44 0.0
cylinder 0 1 0.64135 91.44 0.0
cylinder 5 1 0.64135 93.98 -2.54
cylinder 2 1 0.70735 93.98 -2.54
cuboid 3 1 4p.9460 93.98 -2.54
unit 2
cuboid 3 1 17.157 0.0 22.704 0.0 93.98 -2.54
unit 3
array 1 3*0.0
unit 4
cuboid 6 1 2.83 2.528 22.704 0.0 88.96 -2.54
cuboid 3 1 2.83 0.0 22.704 0.0 93.98 -2.54
unit 5
cuboid 6 1 71.2 0.0 0.302 0.0 88.96 -2.54
cuboid 3 1 71.2 0.0 0.302 0.0 93.98 -2.54
unit 6
cuboid 3 1 36.713 0.0 11.248 0.0 88.96 -2.54
cuboid 6 1 37.015 0.0 11.248 0.0 88.96 -2.54
cuboid 3 1 71.2 0.0 11.248 0.0 93.98 -2.54
unit 7
cuboid 3 1 17.157 0.0 24.596 0.0 93.98 -2.54
unit 8
cuboid 6 1 2.83 2.528 24.596 0.0 88.96 -2.54
cuboid 3 1 2.83 0.0 24.596 0.0 93.98 -2.54
unit 9
array 2 3*0.0
unit 10
cuboid 3 1 36.713 0.0 12.35 0.0 88.96 -2.54
cuboid 6 1 37.015 0.0 12.35 0.0 88.96 -2.54
cuboid 3 1 71.2 0.0 12.35 0.0 93.98 -2.54
unit 11
array 3 3*0.0
unit 12
array 4 3*0.0
global unit 13
array 5 3*0.0
reflector 4 1 5r0.0 2.54 1
reflector 3 1 4r30.0 2r15.0 1
end geometry

read array
ara=1 nux=9 nuy=12 nuz=1 fill f1 end fill
ara=2 nux=9 nuy=13 nuz=1 fill f1 end fill
ara=3 nux=5 nuy=1 nuz=1 fill 2 3 4 3 2 end fill
ara=4 nux=5 nuy=1 nuz=1 fill 7 9 8 9 7 end fill
ara=5 nux=1 nuy=5 nuz=1 fill 11 5 6 12 10 end fill
end array
end data
end



p3314ss3


=csas25
p3314ss3
44group latticecell
uo2 1 0.949 293 92235 4.31 92238 95.69
al 2 1.0
end
h2o 3 1.0
end
plexiglas 4 1.0
end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 5
end
cr 6 den=7.93 .1856
end

```

```

cu      6 den=7.93 .0027          end
fe      6 den=7.93 .6824          end
mn      6 den=7.93 .0158          end
mo      6 den=7.93 .0026          end
ni      6 den=7.93 .1109          end
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0          end
2-9x12 and 2-9x5 assemblies separated by 0.485-cm-thick 0.0 wt% B 'stainless
steel plates and 2.83- and 4.47-cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245           91.44  0.0
cylinder 0 1 0.64135           91.44  0.0
cylinder 5 1 0.64135           93.98 -2.54
cylinder 2 1 0.70735           93.98 -2.54
cuboid   3 1 4p.9460            93.98 -2.54
unit 2
cuboid   3 1 17.157 0.0 22.704 0.0  93.98 -2.54
unit 3
array 1 3*0.0
unit 4
cuboid   6 1 2.83  2.345 22.704 0.0  88.96 -2.54
cuboid   3 1 2.83  0.0   22.704 0.0  93.98 -2.54
unit 5
cuboid   6 1 71.2  0.0   0.485 0.0   88.96 -2.54
cuboid   3 1 71.2  0.0   0.485 0.0   93.98 -2.54
unit 6
cuboid   3 1 36.53  0.0   3.985 0.0   88.96 -2.54
cuboid   6 1 37.015 0.0   3.985 0.0   88.96 -2.54
cuboid   3 1 71.2  0.0   3.985 0.0   93.98 -2.54
unit 7
cuboid   3 1 17.157 0.0  9.46 0.0    93.98 -2.54
unit 8
cuboid   6 1 2.83  2.528 9.46 0.0    88.96 -2.54
cuboid   3 1 2.83  0.0   9.46 0.0    93.98 -2.54
unit 9
array 2 3*0.0
unit 10
cuboid   3 1 36.53  0.0   34.566 0.0   88.96 -2.54
cuboid   6 1 37.015 0.0   34.566 0.0   88.96 -2.54
cuboid   3 1 71.2  0.0   34.566 0.0   93.98 -2.54
unit 11
array 3 3*0.0
unit 12
array 4 3*0.0
global unit 13
array 5 3*0.0
reflector 4 1 5r0.0  2.54  1
reflector 3 1 4r30.0 2r15.0 1
end geometry

read array
ara=1 nux=9 nuy=12 nuz=1 fill f1          end fill
ara=2 nux=9 nuy=5 nuz=1 fill f1          end fill
ara=3 nux=5 nuy=1 nuz=1 fill 2 3 4 3 2    end fill
ara=4 nux=5 nuy=1 nuz=1 fill 7 9 8 9 7    end fill
ara=5 nux=1 nuy=5 nuz=1 fill 11 5 6 12 10  end fill
end array
end data
end

p3314ss4

=csas25
p3314ss4
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 5
cr       6 den=7.93 .1856
cu       6 den=7.93 .0027
fe       6 den=7.93 .6824
mn       6 den=7.93 .0158
mo       6 den=7.93 .0026
ni       6 den=7.93 .1109
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0          end
2-9x12 and 2-9x12 assemblies separated by 0.485-cm-thick 0.0 wt% B
'stainless steel plates and 2.83- and 8.36-cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245           91.44  0.0
cylinder 0 1 0.64135           91.44  0.0
cylinder 5 1 0.64135           93.98 -2.54
cylinder 2 1 0.70735           93.98 -2.54
cuboid   3 1 4p.9460            93.98 -2.54
unit 2
cuboid   3 1 17.157 0.0 22.704 0.0  93.98 -2.54
unit 3
array 1 3*0.0
unit 4
cuboid   6 1 2.83  2.345 22.704 0.0  88.96 -2.54
cuboid   3 1 2.83  0.0   22.704 0.0  93.98 -2.54
unit 5
cuboid   6 1 71.2  0.0   0.485 0.0   88.96 -2.54
cuboid   3 1 71.2  0.0   0.485 0.0   93.98 -2.54
unit 6
cuboid   3 1 36.53  0.0   7.875 0.0   88.96 -2.54
cuboid   6 1 37.015 0.0   7.875 0.0   88.96 -2.54
cuboid   3 1 71.2  0.0   7.875 0.0   93.98 -2.54
unit 7
cuboid   3 1 17.157 0.0  22.704 0.0  93.98 -2.54
unit 8
cuboid   6 1 2.83  2.345 22.704 0.0  88.96 -2.54
cuboid   3 1 2.83  0.0   22.704 0.0  93.98 -2.54
unit 9
array 2 3*0.0
unit 10
cuboid   3 1 36.53  0.0   17.432 0.0   88.96 -2.54
cuboid   6 1 37.015 0.0   17.432 0.0   88.96 -2.54
cuboid   3 1 71.2  0.0   17.432 0.0   93.98 -2.54

```

```

unit 11
array 3 3*0.0
unit 12
array 4 3*0.0
global unit 13
array 5 3*0.0
reflector 4 1 5r0.0 2.54 1
reflector 3 1 4r30.0 2r15.0 1
end geometry

read array
ara=1 nux=9 nuy=12 nuz=1 fill f1      end fill
ara=2 nux=9 nuy=12 nuz=1 fill f1      end fill
ara=3 nux=5 nuy=1 nuz=1 fill 2 3 4 3 2    end fill
ara=4 nux=5 nuy=1 nuz=1 fill 7 9 8 9 7    end fill
ara=5 nux=5 nuy=1 nuz=1 fill 11 5 6 12 10   end fill
end array
end data
end



p3314ss5


=csas25
p3314ss5
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
cr       5 den=7.93 .1856
cu       5 den=7.93 .0027
fe       5 den=7.93 .6824
mn       5 den=7.93 .0158
mo       5 den=7.93 .0026
ni       5 den=7.93 .1109
end comp
squarepitch 1.684 1.1176 1 3 1.27 2 end geometry
2-17x10 and 1-25x20 (center) assemblies separated by 0.302-cm-thick
'0.0 wt % B stainless steel plates and 7.80 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588          91.44  0.0
cylinder 2 1 0.635           96.52 -1.27
cuboid   3 1 4p0.842          96.52 -1.27
unit 2
array 1 3*0.0
reflector 3 1 2r0 1.92 0.0 2r0 1
unit 3
array 2 3*0.0
reflector 3 1 2r0 1.92 0.0 2r0 1
unit 4
cuboid   5 1 0.0 -0.302 35.6 0.0   90.23 -1.27
cuboid   3 1 0.0 -7.80 35.6 0.0   96.52 -1.27
unit 5
cuboid   5 1 0.302 0.0 35.6 0.0   90.23 -1.27
cuboid   3 1 7.80 0.0 35.6 0.0   96.52 -1.27
global unit 9

```

```

array 3 -57.478 -17.8  0.
reflector 4 1 5r0.0 2.54 1
reflector 3 1 4r30.0 2r15.0 1
end geometry

read array
ara=1 nux=25 nuy=20 nuz=1 fill f1      end fill
ara=2 nux=17 nuy=20 nuz=1 fill f1      end fill
ara=3 nux=5 nuy=1 nuz=1 fill 3 4 2 5 3   end fill
end array
end data
end



p3314ss6


=csas25
p3314ss6
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
cr       5 den=7.93 .1856
cu       5 den=7.93 .0027
fe       5 den=7.93 .6824
mn       5 den=7.93 .0158
mo       5 den=7.93 .0026
ni       5 den=7.93 .1109
arbmrubber 1.321 6 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 6
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0
3-12x16 assemblies separated by 0.302-cm-thick 0.0 wt% B stainless
'steel plates and 10.218 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245          91.44  0.0
cylinder 0 1 0.64135          91.44  0.0
cylinder 6 1 0.64135          93.98 -2.54
cylinder 2 1 0.70735          93.98 -2.54
cuboid   3 1 4p0.946          93.98 -2.54
unit 2
array 1 3*0.0
reflector 3 1 2r0 2r2.664 2r0 1
unit 3
cuboid   5 1 0.0 -0.302 2p17.8   88.96 -2.54
cuboid   3 1 0.0 -10.52 2p17.8   93.98 -2.54
unit 4
cuboid   5 1 0.302 0.0 2p17.8   88.96 -2.54
cuboid   3 1 10.52 0.0 2p17.8   93.98 -2.54
global unit 5
array 2 -44.576 -17.8  0.
reflector 4 1 5r0.0 2.54 1
reflector 3 1 4r30.0 2r15.0 1
end geometry

read array

```

```

ara=1 nux=12 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5  nuy=1 nuz=1 fill 2 3 2 4 2 end fill
end array
end data
end



p3314wl


=csas25
p3314wl
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
           16000 1.7 8016 22.1 14000 0.3 5
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0 end geometry
Core of 14x14 positions: 168 fuel rods and 25 water holes
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245          91.44  0.0
cylinder 0 1 0.64135          91.44  0.0
cylinder 5 1 0.64135          93.98 -2.54
cylinder 2 1 0.70735          93.98 -2.54
cuboid   3 1 4p.9460          93.98 -2.54
unit 2
cuboid   3 1 4p.9460          93.98 -2.54
unit 3
array 1 3*0.0
unit 4
array 2 3*0.0
unit 5
array 3 3*0.0
global unit 6
array 4 3*0.0
reflector 4 1 5r0.0          2.54 1
reflector 3 1 4r30. 15.2 15.3 1
end geometry

read array
ara=1 nux=14 nuy=1 nuz=1 fill f1      end fill
ara=2 nux=14 nuy=1 nuz=1 fill 2r1 1 2 4q2 2r1 end fill
ara=3 nux=14 nuy=1 nuz=1 fill llr1 3r2      end fill
ara=4 nux=1 nuy=14 nuz=1 fill 2r3 4 3 4q2 3 5 end fill
end array
end data
end



p3314w2


=csas25
p3314w2
44group latticecell
uo2      1 0.840 293 92235 2.35 92238 97.65
al       2 1.0
end

```

```

h2o      3 1.0
plexiglas 4 1.0
end comp
squarepitch 1.684 1.1176 1 3 1.27 2 end geometry
Core of 23x23 positions: 486 fuel rods and 25 water holes
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588          91.44  0.0
cylinder 2 1 0.635           96.52 -1.27
cuboid   3 1 4p.0.842         96.52 -1.27
unit 2
cuboid   3 1 4p.842           96.52 -1.27
unit 3
array 1 3*0.0
unit 4
array 2 3*0.0
unit 5
array 3 3*0.0
global unit 6
array 4 3*0.0
reflector 4 1 5r0.0          2.54 1
reflector 3 1 4r30. 15.2 15.3 1
end geometry

read array
ara=1 nux=23 nuy=1 nuz=1 fill f1      end fill
ara=2 nux=23 nuy=1 nuz=1 fill 5rl 1 2 4q2 8rl  end fill
ara=3 nux=23 nuy=1 nuz=1 fill 5rl 18r2      end fill
ara=4 nux=1 nuy=23 nuz=1 fill 7r3 4 3 4q2 5r3 5 end fill
end array
end data
end



p3314zr


=csas25
p3314zr
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
h2o      5
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
           16000 1.7 8016 22.1 14000 0.3 6
arbmrzr4 6.32 4 0 0 1 40000 .9816 50000 .015
           24000 .0013 26000 .0021 7
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0
2-9x12 and 2-9x1 assemblies separated by 0.652-cm-thick Zircaloy-4
'plates and 2.178- and 10.388-cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245          91.44  0.0
cylinder 0 1 0.64135          91.44  0.0

```

```

cylinder 6 1 0.64135          93.98 -2.54
cylinder 2 1 0.70735          93.98 -2.54
cuboid   3 1 4p.9460           93.98 -2.54
unit 2
cuboid   5 1 17.157 0.0 22.704 0.0  93.98 -2.54
unit 3
array 1 3*0.0
unit 4
cuboid   7 1 2.83 2.178 22.704 0.0  88.96 -2.54
cuboid   5 1 2.83 0.0 22.704 0.0   93.98 -2.54
unit 5
cuboid   7 1 71.2 0.0 0.652 0.0   93.98 -2.54
unit 6
cuboid   5 1 36.363 0.0 10.388 0.0  88.96 -2.54
cuboid   7 1 37.015 0.0 10.388 0.0   88.96 -2.54
cuboid   5 1 71.2 0.0 10.388 0.0   93.98 -2.54
unit 7
cuboid   5 1 17.157 0.0 3.784 0.0   93.98 -2.54
unit 8
cuboid   7 1 2.83 2.178 3.784 0.0   88.96 -2.54
cuboid   5 1 2.83 0.0 3.784 0.0   93.98 -2.54
unit 9
array 2 3*0.0
unit 10
cuboid   5 1 36.363 0.0 33.672 0.0   88.96 -2.54
cuboid   7 1 37.015 0.0 33.672 0.0   88.96 -2.54
cuboid   5 1 71.2 0.0 33.672 0.0   93.98 -2.54
unit 11
array 3 3*0.0
unit 12
array 4 3*0.0
global unit 13
array 5 3*0.0
reflector 4 1 5r0.0 2.54 1
reflector 5 1 4r30.0 2rl1.0 1
end geometry

read array
ara=1 nux=9 nuy=12 nuz=1 fill f1      end fill
ara=2 nux=9 nuy=2 nuz=1 fill f1      end fill
ara=3 nux=5 nuy=1 nuz=1 fill 2 3 4 3 2  end fill
ara=4 nux=5 nuy=1 nuz=1 fill 7 9 8 9 7  end fill
ara=5 nux=1 nuy=5 nuz=1 fill 11 5 6 12 10 end fill
end array
end data
end



p3602bb


=csas25
p3602bb
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69      end
al       2 1.0      end
h2o      3 1.0      end
plexiglas 4 1.0      end
arbmssteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055 1.28
               14000 .22 28304 .79 42000 .49 24304 .12 29000 .13 5      end
boron    6 den=7.9 .0105      end
crss     6 den=7.9 .1903      end
cu       6 den=7.9 .0028      end
fess     6 den=7.9 .6804      end
mn       6 den=7.9 .0158      end
mo       6 den=7.9 .0049      end
niiss    6 den=7.9 .0953      end

```

```

end comp
squarepitch 1.684 1.1176 1 3 1.27 2 end
2-18x20 and 1-25x18 (center) assemblies separated by 0.298-cm-thick '1.1 wt% B
304L stainless steel plates and 4.502 cm of water, 'assemblies separated from
stainless steel reflecting walls by 1.321 'cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

```

read geom
unit 1
cylinder 1 1 0.5588 91.44 0.0
cylinder 2 1 0.635 96.52 -1.27
cuboid 3 1 4p0.842 96.52 -1.27
unit 2
array 1 3*0.0
unit 3
cuboid 3 1 4.088 0.0 30.312 0.0 96.52 -1.27
unit 4
cuboid 6 1 0.298 0.0 2p15.1 90.23 -1.27
cuboid 3 1 0.298 0.0 2p15.156 96.52 -1.27
unit 5
array 2 3*0.0
global unit 6
array 3 -59.116 -15.156 0.
reflector 4 1 5r0.0 2.54 1
cuboid 3 1 2p73.65 2p16.477 102.79 -19.11
reflector 5 1 2r0.0 2r17.85 2r0.0 1
reflector 3 1 2r30.5 2r11.329 8.93 0 1
end geometry

```

```

read array
ara=1 nux=20 nuy=18 nuz=1 fill f1 end fill
ara=2 nux=25 nuy=18 nuz=1 fill f1 end fill
ara=3 nux=7 nuy=1 nuz=1 fill 2 3 4 5 4 3 2 end fill
end array
end data
end

```

p3602bs2

```

=csas25
p3602bs2
44group latticecell
uo2 1 0.949 293 92235 4.31 92238 95.69 end
al 2 1.0 end
h2o 3 1.0 end
plexiglas 4 1.0 end
armsteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055 1.28
14000 .22 28304 .79 42000 .49 24304 .12 29000 .13 5 end
armrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4 end
16000 1.7 8016 22.1 14000 0.3 6 end
boron 7 den=7.9 .0105 end
crss 7 den=7.9 .1903 end
cu 7 den=7.9 .0028 end
fess 7 den=7.9 .6804 end
mn 7 den=7.9 .0158 end
mo 7 den=7.9 .0049 end
niss 7 den=7.9 .0953 end
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0 end

```

```

2-20x18 and 1-25x18 (center) assemblies separated by 0.061-cm-thick
'cadmium plates and 3.799 cm of water, assemblies separated from
'stainless steel reflecting walls by 1.321 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

```

read geom
unit 1
cylinder 1 1 0.63245 91.44 0.0
cylinder 0 1 0.64135 91.44 0.0
cylinder 6 1 0.64135 93.98 -2.54
cylinder 2 1 0.70735 93.98 -2.54
cuboid 3 1 4p.9460 93.98 -2.54
unit 2
array 1 3*0.0
unit 3
cuboid 3 1 9.0547 0.0 30.272 0.0 93.98 -2.54
unit 4
cuboid 7 1 0.298 0.0 2p15.1 88.96 -2.54
cuboid 3 1 0.298 0.0 2p15.136 93.98 -2.54
global unit 5
array 2 -43.4087 -15.136 0.
reflector 4 1 5r0.0 2.54 1
cuboid 3 1 2p73.65 2p17.092 101.52 -20.38
reflector 5 1 2r0.0 2r17.85 2r0.0 1
reflector 3 1 2r30.5 2r10.694 7.54 0 1
end geometry

```

```

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1 end fill
ara=2 nux=7 nuy=1 nuz=1 fill 2 3 4 2 4 3 2 end fill
end array
end data
end

```

p3602cd1

```

=csas25
p3602cd1
44group latticecell
uo2 1 0.84 293 92235 2.35 92238 97.65 end
al 2 1.0 end
h2o 3 1.0 end
plexiglas 4 1.0
armsteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055 1.28
14000 .22 28304 .79 42000 .49 24304 .12 29000 .13 5 end
cd 6 den=8.65 end
end comp
squarepitch 1.684 1.1176 1 3 1.27 2 end
2-20x18 and 1-25x18(center)assemblies separated by 0.061-cm-thick
'cadmium plates and 3.799 cm of water, assemblies separated from
'stainless steel reflecting walls by 1.321 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588 91.44 0.0
cylinder 2 1 0.635 96.52 -1.27
cuboid 3 1 4p0.842 96.52 -1.27
unit 2

```

```

array 1 3*0.0
unit 3
cuboid 3 1 3.385 0.0 30.312 0.0 96.52 -1.27
unit 4
cuboid 6 1 0.061 0.0 2p15.1 90.23 -1.27
cuboid 3 1 0.061 0.0 2p15.156 96.52 -1.27
unit 5
array 2 3*0.0
global unit 6
array 3 -58.115 -15.156 0.
reflector 4 1 5r0.0 2.54 1
cuboid 3 1 2p73.65 2p16.477 102.79 -19.11
reflector 5 1 2r0.0 2r17.85 2r0.0 1
reflector 3 1 2r30.5 2r11.329 8.93 0 1
end geometry

read array
ara=1 nux=20 nuy=18 nuz=1 fill f1 end fill
ara=2 nux=25 nuy=18 nuz=1 fill f1 end fill
ara=3 nux=7 nuy=1 nuz=1 fill 2 3 4 5 4 3 2 end fill
end array
end data
end

p3602cd2

=csas25
p3602cd2
44group latticecell
uo2 1 0.949 293 92235 4.31 92238 95.69 end
al 2 1.0 end
h2o 3 1.0 end
plexiglas 4 1.0 end
arbmsteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055
1.28 14000 .22 28304 .79 42000 .49 24304 .12
29000 .13 5 end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 6 end
cd 7 den=8.65 end
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0 end
3-12X16 assemblies separated by 0.061-cm-thick cadmium plates and '8.799 cm of
water, assemblies separated from stainless steel 'reflecting walls by 1.956 cm
of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245 91.44 0.0
cylinder 0 1 0.64135 91.44 0.0
cylinder 6 1 0.64135 93.98 -2.54
cylinder 2 1 0.70735 93.98 -2.54
cuboid 3 1 4p.9460 93.98 -2.54
unit 2
array 1 3*0.0
unit 3
cuboid 3 1 8.4017 0.0 30.272 0.0 93.98 -2.54
unit 4
cuboid 7 1 0.061 0.0 2p15.1 88.96 -2.54

```

```

cuboid 3 1 0.061 0.0 2p15.136 93.98 -2.54
global unit 5
array 2 -42.5187 -15.136 0.
reflector 4 1 5r0.0 2.54 1
cuboid 3 1 2p73.65 2p17.092 101.52 -20.38
reflector 5 1 2r0.0 2r17.85 2r0.0 1
reflector 3 1 2r30.5 2r10.694 7.54 0 1
end geometry

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1 end fill
ara=2 nux=7 nuy=1 nuz=1 fill 2 3 4 2 4 3 2 end fill
end array
end data
end

p3602cul

=csas25
p3602cul
44group latticecell
uo2 1 0.84 293 92235 2.35 92238 97.65 end
al 2 1.0 end
h2o 3 1.0 end
plexiglas 4 1.0 end
arbmsteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055 1.28
14000 .22 28304 .79 42000 .49 24304 .12 29000 .13 5 end
cu 6 den=8.913 end
end comp
squarepitch 1.684 1.1176 1 3 1.27 2 end
2-20x18 and 1-25x18 (center) assemblies separated by 0.337-cm-thick
'copper plates and 7.453 cm of water, assemblies separated from
'stainless steel reflecting walls by 1.321 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588 91.44 0.0
cylinder 2 1 0.635 96.52 -1.27
cuboid 3 1 4p0.842 96.52 -1.27
unit 2
array 1 3*0.0
unit 3
cuboid 3 1 7.039 0.0 30.312 0.0 96.52 -1.27
unit 4
cuboid 6 1 0.337 0.0 2p15.1 90.23 -1.27
cuboid 3 1 0.337 0.0 2p15.156 96.52 -1.27
unit 5
array 2 3*0.0
global unit 6
array 3 -62.106 -15.156 0.
reflector 4 1 5r0.0 2.54 1
cuboid 3 1 2p73.65 2p16.477 102.79 -19.11
reflector 5 1 2r0.0 2r17.85 2r0.0 1
reflector 3 1 2r30.5 2r11.329 8.93 0 1
end geometry

read array
ara=1 nux=20 nuy=18 nuz=1 fill f1 end fill

```

```

ara=2 nux=25 nuy=18 nuz=1 fill f1      end fill
ara=3 nux=7  nuy=1  nuz=1 fill 2 3 4 5 4 3 2 end fill
end array
end data
end



p3602cu2


=csas25
p3602cu2
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
arbmsteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055 1.28
          14000 .22 28304 .79 42000 .49 24304 .12 29000 .13 5
cu       6 den=8.910 .99
cd       6 den=8.910 .01
end comp
squarepitch 1.684 1.1176 1 3 1.27 2
end
2-20x18 and 1-25x18 (center) assemblies separated by 0.357-cm-thick 1 'wt%
cadmium copper plates and 5.073 cm of water, assemblies separated 'from
stainless steel reflecting walls by 1.321 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588      91.44  0.0
cylinder 2 1 0.635       96.52 -1.27
cuboid   3 1 4p0.842      96.52 -1.27
unit 2
array   1 3*0.0
unit 3
cuboid   3 1 4.659 0.0 30.312 0.0     96.52 -1.27
unit 4
cuboid   6 1 0.357 0.0 2p15.1      90.23 -1.27
cuboid   3 1 0.357 0.0 2p15.156    96.52 -1.27
unit 5
array   2 3*0.0
global unit 6
array   3 -59.746 -15.156 0.
reflector 4 1 5r0.0        2.54   1
cuboid   3 1 2p73.65 2p16.477 102.79 -19.11
reflector 5 1 2r0.0        2r17.85 2r0.0 1
reflector 3 1 2r30.5      2r11.329 8.93 0 1
end geometry

read array
ara=1 nux=20 nuy=18 nuz=1 fill f1      end fill
ara=2 nux=25 nuy=18 nuz=1 fill f1      end fill
ara=3 nux=7  nuy=1  nuz=1 fill 2 3 4 5 4 3 2 end fill
end array
end data
end

```

p3602cu3

```

arbmsteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055 1.28
          14000 .22 28304 .79 42000 .49 24304 .12 29000 .13 5 end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
          16000 1.7 8016 22.1 14000 0.3 6 end
cu          7 den=8.910 .99 end
cd          7 den=8.910 .01 end
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0 end
3-12x16 assemblies separated by 0.357-cm-thick 1 wt% cadmium copper 'plates
and 10.213 cm of water, assemblies separated from stainless 'steel reflecting
walls by 1.956 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245          91.44 0.0
cylinder 0 1 0.64135          91.44 0.0
cylinder 6 1 0.64135          93.98 -2.54
cylinder 2 1 0.70735          93.98 -2.54
cuboid   3 1 4p.9460           93.98 -2.54
unit 2
array   1 3*0.0
unit 3
cuboid   3 1 9.7357 0.0 30.272 0.0 93.98 -2.54
unit 4
cuboid   7 1 0.357 0.0 2p15.1     88.96 -2.54
cuboid   3 1 0.357 0.0 2p15.136   93.98 -2.54
global unit 5
array   2 -44.1487 -15.136 0.
reflector 4 1 5r0.0          2.54 1
cuboid   3 1 2p73.65 2p17.092 101.52 -20.38
reflector 5 1 2r0.0          2r17.85 2r0.0 1
reflector 3 1 2r30.5         2r10.694 7.54 0 1
end geometry

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=7 nuy=1 nuz=1 fill 2 3 4 2 4 3 2 end fill
end array
end data
end



p3602n11


=csas25
p3602n11
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
h2o      5 1.0
end

arbmsteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055 1.28
          14000 .22 28304 .79 42000 .49 24304 .12 29000 .13 6 end
end comp
squarepitch 1.684 1.1176 1 3 1.27 2 end
2-20x18 and 1-25x18 (center) assemblies separated by 9.58 cm of water,
'assemblies separated from stainless steel reflecting walls by 0.66 cm
'of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588          91.44 0.0
cylinder 2 1 0.635           96.52 -1.27
cuboid   3 1 4p.842           96.52 -1.27
unit 2
array   1 3*0.0

```

```

water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

```

read geom
unit 1
cylinder 1 1 0.5588          91.44 0.0
cylinder 2 1 0.635           96.52 -1.27
cuboid   3 1 4p.842           96.52 -1.27
unit 2
array   1 3*0.0
unit 3
array   2 3*0.0
unit 4
cuboid   5 1 8.566 0.0 30.312 0.0 96.52 -1.27
global unit 5
array 3 -63.296 -15.156 0.
reflector 4 1 5r0.0          2.54
cuboid   5 1 2p73.65 2p15.156 102.79 -19.11
reflector 6 1 2r0.0          2r17.85 2r0.0 1
reflector 5 1 5r9.0          0
reflector 5 1 2r21.0         4r0
end geometry

```

```

read array
ara=1 nux=25 nuy=18 nuz=1 fill f1      end fill
ara=2 nux=20 nuy=18 nuz=1 fill f1      end fill
ara=3 nux=5 nuy=1 nuz=1 fill 3 4 2 4 3 end fill
end array
end data
end

```

p3602n12

```

=csas25
p3602n12
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
h2o      5 1.0
arbmsteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055 1.28
          14000 .22 28304 .79 42000 .49 24304 .12 29000 .13 6 end
end comp

```

```

squarepitch 1.684 1.1176 1 3 1.27 2 end
2-20x18 and 1-25x18 (center) assemblies separated by 9.58 cm of water,
'assemblies separated from stainless steel reflecting walls by 0.66 cm
'of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

```

read geom
unit 1
cylinder 1 1 0.5588          91.44 0.0
cylinder 2 1 0.635           96.52 -1.27
cuboid   3 1 4p.842           96.52 -1.27
unit 2
array   1 3*0.0

```

```

unit 3
array 2 3*0.0
unit 4
cuboid 5 1 9.166 0.0 30.312 0.0 96.52 -1.27
global unit 5
array 3 -63.896 -15.156 0.
reflector 4 1 5r0.0 2.54 1
cuboid 5 1 2p73.65 2p15.816 102.79 -19.11
reflector 6 1 2r0.0 2r17.85 2r0.0 1
reflector 5 1 5r9.0 0 1
reflector 5 1 2r21.0 4r0 1
end geometry

read array
ara=1 nux=25 nuy=18 nuz=1 fill f1      end fill
ara=2 nux=20 nuy=18 nuz=1 fill f1      end fill
ara=3 nux=5 nuy=1 nuz=1 fill 3 4 2 4 3 end fill
end array
end data
end



p3602n13



=csas25
p3602n13
44group latticecell
uo2 1 0.84 293 92235 2.35 92238 97.65
al 2 1.0
end
h2o 3 1.0
end
plexiglas 4 1.0
end
h2o 5 1.0
end
arbmssteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055 1.28
14000 .22 28304 .79 42000 .49 24304 .12 29000 .13 6 end
end comp
squarepitch 1.684 1.1176 1 3 1.27 2
2-20x18 and 1-25x18 (center) assemblies separated by 8.54 cm of water,
'assemblies separated from stainless steel reflecting walls by 3.912
'cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588 91.44 0.0
cylinder 2 1 0.635 96.52 -1.27
cuboid 3 1 4p.842 96.52 -1.27
unit 2
array 1 3*0.0
unit 3
array 2 3*0.0
unit 4
cuboid 5 1 8.126 0.0 30.312 0.0 96.52 -1.27
global unit 5
array 3 -62.856 -15.156 0.
reflector 4 1 5r0.0 2.54 1
cuboid 5 1 2p73.65 2p19.068 102.79 -19.11
reflector 6 1 2r0.0 2r17.85 2r0.0 1
reflector 5 1 5r9.0 0 1
reflector 5 1 2r21.0 4r0 1
end geometry

```

```

read array
ara=1 nux=25 nuy=18 nuz=1 fill f1      end fill
ara=2 nux=20 nuy=18 nuz=1 fill f1      end fill
ara=3 nux=5 nuy=1 nuz=1 fill 3 4 2 4 3 end fill
end array
end data
end



p3602n14



=csas25
p3602n14
44group latticecell
uo2 1 0.84 293 92235 2.35 92238 97.65
al 2 1.0
end
h2o 3 1.0
end
plexiglas 4 1.0
end
h2o 5 1.0
end
arbmssteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055 1.28
14000 .22 28304 .79 42000 .49 24304 .12 29000 .13 6 end
end comp
squarepitch 1.684 1.1176 1 3 1.27 2
2-20x18 and 1-25x18 (center) assemblies separated by 8.54 cm of water,
'assemblies separated from stainless steel reflecting walls by 3.912
'cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588 91.44 0.0
cylinder 2 1 0.635 96.52 -1.27
cuboid 3 1 4p.842 96.52 -1.27
unit 2
array 1 3*0.0
unit 3
array 2 3*0.0
unit 4
cuboid 5 1 8.126 0.0 30.312 0.0 96.52 -1.27
global unit 5
array 3 -62.856 -15.156 0.
reflector 4 1 5r0.0 2.54 1
cuboid 5 1 2p73.65 2p19.068 102.79 -19.11
reflector 6 1 2r0.0 2r17.85 2r0.0 1
reflector 5 1 5r9.0 0 1
reflector 5 1 2r21.0 4r0 1
end geometry

read array
ara=1 nux=25 nuy=18 nuz=1 fill f1      end fill
ara=2 nux=20 nuy=18 nuz=1 fill f1      end fill
ara=3 nux=5 nuy=1 nuz=1 fill 3 4 2 4 3 end fill
end array
end data
end

```

p3602n21

```
=csas25
p3602n21
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65      end
al       2 1.0      end
h2o      3 1.0      end
plexiglas 4 1.0      end
h2o      5 1.0      end
armsteel 7.84  8 0 0 1 26304 96.78  6012 0.19  25055 1.28
          14000 .22 28304 .79 42000 .49  24304 .12 29000 .13 6 end
end comp
squarepitch 2.032 1.1176 1 3 1.27 2      end
3-19x16 assemblies separated by 11.20 cm of water, assemblies
'separated from stainless steel reflecting walls by 0.66 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588      91.44  0.0
cylinder 2 1 0.635      96.52 -1.27
cuboid   3 1 4p1.016      96.52 -1.27
unit 2
array   1 3*0.0
unit 3
cuboid   5 1 10.438 0.0  32.512 0.0      96.52 -1.27
global unit 4
array   2 -68.35 -16.256 0.
reflector 4 1 5r0.0 2.54      1
cuboid   5 1 2p73.65 2p18.872 102.79 -19.11
reflector 6 1 2r0.0 2r17.85 2r0.0      1
reflector 5 1 5r9.0 0      1
reflector 5 1 2r21.0 4r0      1
end geometry

read array
ara=1 nux=19 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end
```

p3602n22

```
=csas25
p3602n22
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65      end
al       2 1.0      end
h2o      3 1.0      end
plexiglas 4 1.0      end
h2o      5 1.0      end
armsteel 7.84  8 0 0 1 26304 96.78  6012 0.19  25055 1.28
          14000 .22 28304 .79 42000 .49  24304 .12 29000 .13 6 end
end comp
squarepitch 2.032 1.1176 1 3 1.27 2      end
3-19x16 assemblies separated by 10.36 cm of water, assemblies 'separated from
stainless steel reflecting walls by 2.616 cm of water
```

```
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm
```

```
read geom
unit 1
cylinder 1 1 0.5588      91.44  0.0
cylinder 2 1 0.635      96.52 -1.27
cuboid   3 1 4p1.016      96.52 -1.27
unit 2
array   1 3*0.0
unit 3
cuboid   5 1 10.438 0.0  32.512 0.0      96.52 -1.27
global unit 4
array   2 -68.35 -16.256 0.
reflector 4 1 5r0.0 2.54      1
cuboid   5 1 2p73.65 2p16.916 102.79 -19.11
reflector 6 1 2r0.0 2r17.85 2r0.0      1
reflector 5 1 5r9.0 0      1
reflector 5 1 2r21.0 4r0      1
end geometry
```

```
read array
ara=1 nux=19 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end
```

p3602n31

```
=csas25
p3602n31
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69      end
al       2 1.0      end
h2o      3 1.0      end
plexiglas 4 1.0      end
h2o      5 1.0      end
armsteel 7.84  8 0 0 1 26304 96.78  6012 0.19  25055 1.28
          14000 .22 28304 .79 42000 .49  24304 .12 29000 .13 6 end
armrubber 1.321 6 0 0 6012 58. 1001 6.5 20000 11.4
          16000 1.7 8016 22.1 14000 0.3 7      end
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0      end
3-12x16 assemblies separated by 14.87 cm of water, assemblies
'separated from stainless steel reflecting walls by 0.0 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm
```

```
read geom
unit 1
cylinder 1 1 0.63245      91.44  0.0
cylinder 0 1 0.64135      91.44  0.0
cylinder 7 1 0.64135      93.98 -2.54
cylinder 2 1 0.70735      93.98 -2.54
cuboid   3 1 4p.9460      93.98 -2.54
unit 2
array   1 3*0.0
unit 3
cuboid   5 1 14.3927 0.0  30.272 0.0      93.98 -2.54
global unit 5
```

```

array 2 -48.4487 -15.136 0.
reflector 4 1 5r0.0 2.54 1
cuboid 5 1 2p73.65 2p15.136 101.52 -20.38
reflector 6 1 2r0.0 2r17.85 2r0.0 1
reflector 5 1 5r8.0 0 1
reflector 5 1 4r3.0 2r0 1
reflector 5 1 2r20.0 4r0 1
end geometry

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end



p3602n32


=csas25
p3602n32
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
h2o      5 1.0
arbmsteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055 1.28
        14000 .22 28304 .79 42000 .49 24304 .12 29000 .13 6
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
        16000 1.7 8016 22.1 14000 0.3 7
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0
3-12x16 assemblies separated by 15.74 cm of water, assemblies
'separated from stainless steel reflecting walls by 0.66 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245          91.44 0.0
cylinder 0 1 0.64135          91.44 0.0
cylinder 7 1 0.64135          93.98 -2.54
cylinder 2 1 0.70735          93.98 -2.54
cuboid   3 1 4p.9460           93.98 -2.54
unit 2
array 1 3*0.0
unit 3
cuboid   5 1 15.2627 0.0 30.272 0.0 93.98 -2.54
global unit 5
array 2 -49.3187 -15.136 0.
reflector 4 1 5r0.0 2.54 1
cuboid   5 1 2p73.45 2p15.796 101.52 -20.38
reflector 6 1 2r0.0 2r17.85 2r0.0 1
reflector 5 1 5r8.0 0 1
reflector 5 1 4r3.0 2r0 1
reflector 5 1 2r20.0 4r0 1
end geometry

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1      end fill

```

```

ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end

```

p3602n33**p3602n34**

```

h2o      3 1.0
plexiglas 4 1.0
h2o      5 1.0
arbmssteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055 1.28
          14000 .22 28304 .79 42000 .49 24304 .12 29000 .13 6 end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
          16000 1.7 8016 22.1 14000 0.3 7 end

end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0 end
3-12x16 assemblies separated by 15.84 cm of water, assemblies 'separated from
stainless steel reflecting walls by 1.956 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245           91.44 0.0
cylinder 0 1 0.64135           91.44 0.0
cylinder 7 1 0.64135           93.98 -2.54
cylinder 2 1 0.70735           93.98 -2.54
cuboid   3 1 4p.9460            93.98 -2.54
unit 2
array   1 3*0.0
unit 3
cuboid   5 1 15.3627 0.0 30.272 0.0 93.98 -2.54
global unit 5
array 2 -49.4187 -15.136 0.
reflector 4 1 5r0.0 2.54 1
cuboid   5 1 2p73.65 2p17.092 101.52 -20.38
reflector 6 1 2r0.0 2r17.85 2r0.0 1
reflector 5 1 5r8.0 0 1
reflector 5 1 4r3.0 2r0 1
reflector 5 1 2r20.0 4r0 1
end geometry

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end



p3602n35


=csas25
p3602n35
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69 end
al       2 1.0 end
h2o      3 1.0 end
plexiglas 4 1.0 end
h2o      5 1.0 end
arbmssteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055 1.28
          14000 .22 28304 .79 42000 .49 24304 .12 29000 .13 6 end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
          16000 1.7 8016 22.1 14000 0.3 7 end

end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0 end
3-12x16 assemblies separated by 15.45 cm of water, assemblies 'separated from

```

```

stainless steel reflecting walls by 2.616 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

```

read geom
unit 1
cylinder 1 1 0.63245           91.44 0.0
cylinder 0 1 0.64135           91.44 0.0
cylinder 7 1 0.64135           93.98 -2.54
cylinder 2 1 0.70735           93.98 -2.54
cuboid   3 1 4p.9460            93.98 -2.54
unit 2
array   1 3*0.0
unit 3
cuboid   5 1 14.9727 0.0 30.272 0.0 93.98 -2.54
global unit 5
array 2 -49.0287 -15.136 0.
reflector 4 1 5r0.0 2.54 1
cuboid   5 1 2p73.65 2p17.752 101.52 -20.38
reflector 6 1 2r0.0 2r17.85 2r0.0 1
reflector 5 1 5r8.0 0 1
reflector 5 1 4r3.0 2r0 1
reflector 5 1 2r20.0 4r0 1
end geometry

```

```

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end

```

p3602n36

```

=csas25
p3602n36
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69 end
al       2 1.0 end
h2o      3 1.0 end
plexiglas 4 1.0 end
h2o      5 1.0 end
arbmssteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055 1.28
          14000 .22 28304 .79 42000 .49 24304 .12 29000 .13 6 end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
          16000 1.7 8016 22.1 14000 0.3 7 end

end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0 end
3-12x16 assemblies separated by 13.82 cm of water, assemblies
'separated from stainless steel reflecting walls by 5.405 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245           91.44 0.0
cylinder 0 1 0.64135           91.44 0.0
cylinder 7 1 0.64135           93.98 -2.54
cylinder 2 1 0.70735           93.98 -2.54
cuboid   3 1 4p.9460            93.98 -2.54

```

```

unit 2
array 1 3*0.0
unit 3
cuboid 5 1 13.3427 0.0 30.272 0.0 93.98 -2.54
global unit 5
array 2 -47.3987 -15.136 0.
reflector 4 1 5r0.0 2.54 1
cuboid 5 1 2p73.65 2p20.541 101.52 -20.38
reflector 6 1 2r0.0 2r17.85 2r0.0 1
reflector 5 1 5r8.0 0 1
reflector 5 1 4r3.0 2r0 1
reflector 5 1 2r20.0 4r0 1
end geometry

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end



p3602n41



=csas25
p3602n41
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o     3 1.0
plexiglas 4 1.0
h2o     5 1.0
arbmsteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055 1.28
        14000 .22 28304 .79 42000 .49 24304 .12 29000 .13 6 end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
        16000 1.7 8016 22.1 14000 0.3 7 end
end comp
squarepitch 2.540 1.2649 1 3 1.4147 2 1.2827 0
3-13x8 assemblies separated by 12.89 cm of water, assemblies 'separated from
stainless steel reflecting walls by 0.0 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245          91.44 0.0
cylinder 0 1 0.64135          91.44 0.0
cylinder 7 1 0.64135          93.98 -2.54
cylinder 2 1 0.70735          93.98 -2.54
cuboid   3 1 4p1.270          93.98 -2.54
unit 2
array 1 3*0.0
unit 3
cuboid 5 1 11.7647 0.0 20.32 0.0 93.98 -2.54
global unit 5
array 2 -61.2947 -10.16 0.
reflector 4 1 5r0.0 2.54 1
cuboid 5 1 2p73.65 2p10.16 101.52 -20.38
reflector 6 1 2r0.0 2r17.85 2r0.0 1
reflector 5 1 5r8.0 0 1
reflector 5 1 4r3.0 2r0 1
reflector 5 1 2r20.0 4r0 1
end geometry

```

```

reflector 5 1 2r20.0 4r0 1
end geometry

read array
ara=1 nux=13 nuy=8 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end



p3602n42



=csas25
p3602n42
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o     3 1.0
plexiglas 4 1.0
h2o     5 1.0
arbmsteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055 1.28 14000
        .22 28304 .79 42000 .49 24304 .12 29000 .13 6 end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
        16000 1.7 8016 22.1 14000 0.3 7 end
end comp
squarepitch 2.540 1.2649 1 3 1.4147 2 1.2827 0
3-13x8 assemblies separated by 14.12 cm of water, assemblies
'separated from stainless steel reflecting walls by 1.321 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245          91.44 0.0
cylinder 0 1 0.64135          91.44 0.0
cylinder 7 1 0.64135          93.98 -2.54
cylinder 2 1 0.70735          93.98 -2.54
cuboid   3 1 4p1.270          93.98 -2.54
unit 2
array 1 3*0.0
unit 3
cuboid 5 1 12.9947 0.0 20.32 0.0 93.98 -2.54
global unit 5
array 2 -62.5247 -10.16 0.
reflector 4 1 5r0.0 2.54 1
cuboid 5 1 2p73.65 2p11.481 101.52 -20.38
reflector 6 1 2r0.0 2r17.85 2r0.0 1
reflector 5 1 5r8.0 0 1
reflector 5 1 4r3.0 2r0 1
reflector 5 1 2r20.0 4r0 1
end geometry

read array
ara=1 nux=13 nuy=8 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end

```

```


p3602n43


=csas25
p3602n43
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
h2o      5 1.0
arbmssteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055 1.28
          14000 .22 28304 .79 42000 .49 24304 .12 29000 .13 6
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
          16000 1.7 8016 22.1 14000 0.3 7
end comp
squarepitch 2.540 1.2649 1 3 1.4147 2 1.2827 0
3-13x8 assemblies separated by 12.44 cm of water, assemblies 'separated from
stainless steel reflecting walls by 2.616 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245           91.44 0.0
cylinder 0 1 0.64135           91.44 0.0
cylinder 7 1 0.64135           93.98 -2.54
cylinder 2 1 0.70735           93.98 -2.54
cuboid   3 1 4p1.270           93.98 -2.54
unit 2
array   1 3*0.0
unit 3
cuboid   5 1 11.3147 0.0 20.32 0.0 93.98 -2.54
global unit 5
array   2 -60.8447 -10.16 0.
reflector 4 1 5r0.0 2.54 1
cuboid   5 1 2p73.65 2p12.776 101.52 -20.38
reflector 6 1 2r0.0 2r17.85 2r0.0 1
reflector 5 1 5r8.0 0 1
reflector 5 1 4r3.0 2r0 1
reflector 5 1 2r20.0 4r0 1
end geometry

read array
ara=1 nux=13 nuy=8 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end
```

p3602ss1

```

=csas25
p3602ss1
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
arbmssteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055 1.28
          14000 .22 28304 .79 42000 .49 24304 .12 29000 .13 5
end
```

```

crss      6 den=7.93 .1856
cu       6 den=7.93 .0027
fess      6 den=7.93 .6824
mn       6 den=7.93 .0158
mo       6 den=7.93 .0026
niss     6 den=7.93 .1109
end comp
squarepitch 1.684 1.1176 1 3 1.27 2
2-20x18 and 1-25x18 (center) assemblies separated by 0.302-cm-thick
'304L stainless steel plates and 7.978 cm of water, assemblies
'separated from stainless steel reflecting walls by 1.321 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588           91.44 0.0
cylinder 2 1 0.635            96.52 -1.27
cuboid   3 1 0.842 -0.842 0.842 -0.842 96.52 -1.27
unit 2
array   1 3*0.0
unit 3
cuboid   3 1 7.564 0.0 30.312 0.0 96.52 -1.27
unit 4
cuboid   6 1 0.302 0.0 2p15.1 90.23 -1.27
cuboid   3 1 0.302 0.0 2p15.156 96.52 -1.27
unit 5
array   2 3*0.0
global unit 6
array   3 -62.596 -15.156 0.
reflector 4 1 5r0.0           2.54 1
cuboid   3 1 2p73.65 2p16.477 102.79 -19.11
reflector 5 1 2r0.0 2r17.85 2r0.0 1
reflector 3 1 2r30.5 2r11.329 8.93 0 1
end geometry

read array
ara=1 nux=20 nuy=18 nuz=1 fill f1      end fill
ara=2 nux=25 nuy=18 nuz=1 fill f1      end fill
ara=3 nux=7 nuy=1 nuz=1 fill 2 3 4 5 4 3 2 end fill
end array
end data
end
```

p3602ss2

=csas25
p3602ss2
44group latticecell
uo2 1 0.949 293 92235 4.31 92238 95.69
al 2 1.0
h2o 3 1.0
plexiglas 4 1.0
arbmssteel 7.84 8 0 0 1 26304 96.78 6012 0.19 25055 1.28
 14000 .22 28304 .79 42000 .49 24304 .12 29000 .13 5
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
 16000 1.7 8016 22.1 14000 0.3 6
crss 7 den=7.93 .1856
cu 7 den=7.93 .0027
fess 7 den=7.93 .6824
end

```

mn      7 den=7.93 .0158
mo      7 den=7.93 .0026
niss    7 den=7.93 .1109
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0
3-12x16 assemblies separated by 0.302-cm-thick 304L stainless steel 'plates
and 13.448 cm of water, assemblies separated from stainless 'steel reflecting
walls by 1.956 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245          91.44  0.0
cylinder 0 1 0.64135          91.44  0.0
cylinder 6 1 0.64135          93.98 -2.54
cylinder 2 1 0.70735          93.98 -2.54
cuboid   3 1 4p.9460           93.98 -2.54
unit 2
array   1 3*0.0
unit 3
cuboid   3 1 12.9707 0.0 30.272 0.0  93.98 -2.54
unit 4
cuboid   7 1 0.302 0.0 2p15.1     88.96 -2.54
cuboid   3 1 0.302 0.0 2p15.136   93.98 -2.54
global unit 5
array   2 -47.3287 -15.136 0.
reflector 4 1 5r0.0          2.54   1
cuboid   3 1 2p73.65 2p17.092 101.52 -20.38
reflector 5 1 2r0.0          2r17.85 2r0.0  1
reflector 3 1 2r30.5         2r10.694 7.54  0 1
end geometry

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1
ara=2 nux=7 nuy=1 nuz=1 fill 2 3 4 2 4 3 2
end array
end data
end



p392611


=csas25
p392611
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
h2o      5 1.0
pb       6 .9758
end comp
squarepitch 1.684 1.1176 1 3 1.27 2
2-20x18 and 1-23x18 (center) assemblies separated by 10.11 cm of 'water,
assemblies separated from lead reflecting walls by 0.66 cm of 'water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588          91.44  0.0
cylinder 2 1 0.635           96.52 -1.27
cuboid   3 1 4p0.842          96.52 -1.27
unit 2
array   1 3*0.0
unit 3
cuboid   5 1 9.696 0.0 30.312 0.0  96.52 -1.27
unit 4
array   2 3*0.0
global unit 5
array   3 -62.692 -15.156 0.
reflector 4 1 5r0.0          2.54   1
cuboid   5 1 2p82.0 2p15.816 104.29 -19.11
reflector 6 1 2r0.0          2r10.2  2r0.0  1
reflector 5 1 2r30.5         2r19.64 7.43  0 1
end geometry

read array
ara=1 nux=23 nuy=18 nuz=1 fill f1
ara=2 nux=20 nuy=18 nuz=1 fill f1
ara=3 nux=5 nuy=1 nuz=1 fill 4 3 2 3 4
end array
end data
end

```

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```

p392613

=csas25
p392613
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65      end
al       2 1.0          end
h2o      3 1.0          end
plexiglas 4 1.0          end
h2o       5 1.0          end
pb        6 .9758         end
end comp
squarepitch 1.684 1.1176 1 3 1.27 2           end
2-20x18 and 1-23x18 (center) assemblies separated by 8.50 cm of 'water,
assemblies separated from lead reflecting walls by 3.276 cm of 'water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588      91.44  0.0
cylinder 2 1 0.635       96.52 -1.27
cuboid   3 1 4p0.842      96.52 -1.27
unit 2
array   1 3*0.0
unit 3
cuboid   5 1 8.086  0.0 30.312  0.0   96.52 -1.27
unit 4
array   2 3*0.0
global unit 5
array 3 -61.132 -15.156 0.
reflector 4 1 5r0.0 2.54          1
cuboid   5 1 2p82.0 2p18.432 104.29 -19.11
reflector 6 1 2r0.0 2r10.2 2r0.0          1
reflector 5 1 2r30.5 2r17.024 7.43 0          1
end geometry

read array
ara=1 nux=23 nuy=18 nuz=1 fill f1      end fill
ara=2 nux=20 nuy=18 nuz=1 fill f1      end fill
ara=3 nux=5 nuy=1 nuz=1 fill 4 3 2 3 4 end fill
end array
end data
end

p392614

=csas25
p392614
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69      end
al       2 1.0          end
h2o      3 1.0          end
plexiglas 4 1.0          end
h2o       5 1.0          end
pb        6 .9758         end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 7           end
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0 end
3-12x16 assemblies separated by 17.74 cm of water, assemblies 'separated from
lead reflecting walls by 0.0 cm of water

```

```

read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245      91.44  0.0
cylinder 0 1 0.64135      91.44  0.0
cylinder 7 1 0.64135      93.98 -2.54
cylinder 2 1 0.70735      93.98 -2.54
cuboid   3 1 4p0.946      93.98 -2.54
unit 2
array   1 3*0.0
unit 3
cuboid   5 1 17.2627 0.0 30.272 0.0 93.98 -2.54
global unit 4
array 2 -51.3187 -15.136 0.
reflector 4 1 5r0.0 2.54          1
cuboid   5 1 2p82.0 2p15.136 103.02 -20.38
reflector 6 1 2r0.0 2r10.2 2r0.0 1
reflector 5 1 2r30.5 2r20.3 6.16 0 1
end geometry

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end

p392615

=csas25
p392615
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69      end
al       2 1.0          end
h2o      3 1.0          end
plexiglas 4 1.0          end
h2o       5 1.0          end
pb        6 .9758         end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 7           end
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0 end
3-12x16 assemblies separated by 18.18 cm of water, assemblies
'separated from lead reflecting walls by 0.66 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

```

read geom
unit 1
cylinder 1 1 0.63245      91.44  0.0
cylinder 0 1 0.64135      91.44  0.0
cylinder 7 1 0.64135      93.98 -2.54
cylinder 2 1 0.70735      93.98 -2.54
cuboid   3 1 4p0.946      93.98 -2.54
unit 2
array   1 3*0.0
unit 3
cuboid   5 1 17.7027 0.0 30.272 0.0 93.98 -2.54
global unit 4
array 2 -51.7587 -15.136 0.
reflector 4 1 5r0.0 2.54          1
cuboid   5 1 2p82.0 2p15.796 103.02 -20.38

```

```

reflector 6 1 2r0.0 2r10.2 2r0.0 1
reflector 5 1 2r30.5 2r19.64 6.16 0 1
end geometry

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5  nuy=1  nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end



p392616


=csas25
p392616
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
h2o      5 1.0
pb       6 .9758
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
          16000 1.7 8016 22.1 14000 0.3 7
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0
            3-12x16 assemblies separated by 17.43 cm of water, assemblies 'separated from
lead reflecting walls by 1.956 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245      91.44 0.0
cylinder 0 1 0.64135      91.44 0.0
cylinder 7 1 0.64135      93.98 -2.54
cylinder 2 1 0.70735      93.98 -2.54
cuboid   3 1 4p0.946      93.98 -2.54
unit 2
array 1 3*0.0
unit 3
cuboid   5 1 16.9527 0.0 30.272 0.0 93.98 -2.54
global unit 4
array 2 -51.0087 -15.136 0.
reflector 4 1 5r0.0 2.54      1
cuboid   5 1 2p82.0 2p17.092 103.02 -20.38
reflector 6 1 2r0.0 2r10.2 2r0.0 1
reflector 5 1 2r30.5 2r18.344 6.16 0 1
end geometry

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5  nuy=1  nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end



p3926s11


=csas25
p3926s11
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65
end

```

```

al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
h2o      5 1.0
end comp
squarepitch 1.684 1.1176 1 3 1.27 2
            2-20x18 and 1-23x18 (center) assemblies separated by 6.59 of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588      91.44 0.0
cylinder 2 1 0.635       96.52 -1.27
cuboid   3 1 4p0.842      96.52 -1.27
unit 2
array 1 3*0.0
unit 3
cuboid   5 1 6.176 0.0 30.312 0.0 96.52 -1.27
unit 4
array 2 3*0.0
global unit 5
array 3 -59.222 -15.156 0.
reflector 4 1 5r0          2.54 1
reflector 5 1 4r30.5 15.2 15.3 1
end geometry

read array
ara=1 nux=23 nuy=18 nuz=1 fill f1      end fill
ara=2 nux=20 nuy=18 nuz=1 fill f1      end fill
ara=3 nux=5  nuy=1  nuz=1 fill 4 3 2 3 4 end fill
end array
end data
end



p3926s12


=csas25
p3926s12
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
h2o      5 1.0
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
          16000 1.7 8016 22.1 14000 0.3 6
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0
            3-12x16 assemblies separated by 12.79 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245      91.44 0.0
cylinder 0 1 0.64135      91.44 0.0
cylinder 6 1 0.64135      93.98 -2.54
cylinder 2 1 0.70735      93.98 -2.54
cuboid   3 1 4p.9460      93.98 -2.54
unit 2
array 1 3*0.0
unit 3
cuboid   5 1 12.4927 0.0 30.272 0.0 93.98 -2.54

```

```

global unit 5
array 2 -46.5487 -15.136 0.
reflector 4 1 5r0.0 2.54 1
reflector 5 1 4r30.4 15.2 15.3 1
end geometry

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5  nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end



p3926u1


=csas25
p3926u1
44group latticecell
uo2      1 0.84 293 92235 2.35 92238 97.65
al       2 1.0
h2o      3 1.0
plexiglas 4 1.0
h2o      5 1.0
uranium 6 .98163 293 92235 .199 92238 99.801
end comp
squarepitch 1.684 1.1176 1 3 1.27 2
2-20x18 and 1-23x18 (center) assemblies separated by 9.50 cm of water,
'assemblies separated from depleted uranium reflecting walls by 1.321
'cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588          91.44  0.0
cylinder 2 1 0.635           96.52 -1.27
cuboid   3 1 4p0.842          96.52 -1.27
unit 2
array 1 3*0.0
unit 3
cuboid   5 1 7.646  0.0 30.312  0.0 96.52 -1.27
unit 4
array 2 3*0.0
global unit 5
array 3 -60.692 -15.156 0.
reflector 4 1 5r0.0 2.54          1
cuboid   5 1 2p76.15 2p15.156 102.79 -19.11
reflector 6 1 2r0.0 2r7.65 2r0.0          1
reflector 5 1 2r30.5 2r22.85 8.93 0     1
end geometry

read array
ara=1 nux=23 nuy=18 nuz=1 fill f1      end fill
ara=2 nux=20 nuy=18 nuz=1 fill f1      end fill
ara=3 nux=5  nuy=1 nuz=1 fill 4 3 2 3 4 end fill
end array
end data
end

```

p3926u2

=csas25
p3926u2
44group latticecell
uo2 1 0.84 293 92235 2.35 92238 97.65
al 2 1.0
h2o 3 1.0
plexiglas 4 1.0
h2o 5 1.0
uranium 6 .98163 293 92235 .199 92238 99.801
end comp
squarepitch 1.684 1.1176 1 3 1.27 2
2-20x18 and 1-23x18 (center) assemblies separated by 9.50 cm of water,
'assemblies separated from depleted uranium reflecting walls by 1.321
'cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.5588 91.44 0.0
cylinder 2 1 0.635 96.52 -1.27
cuboid 3 1 4p0.842 96.52 -1.27
unit 2
array 1 3*0.0
unit 3
cuboid 5 1 9.086 0.0 30.312 0.0 96.52 -1.27
unit 4
array 2 3*0.0
global unit 5
array 3 -62.132 -15.156 0.
reflector 4 1 5r0.0 2.54 1
cuboid 5 1 2p76.15 2p16.477 102.79 -19.11
reflector 6 1 2r0.0 2r7.65 2r0.0 1
reflector 5 1 2r30.5 2r21.529 8.93 0 1
end geometry

read array
ara=1 nux=23 nuy=18 nuz=1 fill f1 end fill
ara=2 nux=20 nuy=18 nuz=1 fill f1 end fill
ara=3 nux=5 nuy=1 nuz=1 fill 4 3 2 3 4 end fill
end array
end data
end

p3926u3

=csas25
p3926u3
44group latticecell
uo2 1 0.84 293 92235 2.35 92238 97.65
al 2 1.0
h2o 3 1.0
plexiglas 4 1.0
h2o 5 1.0
uranium 6 .98163 293 92235 .199 92238 99.801
end comp
squarepitch 1.684 1.1176 1 3 1.27 2
2-20x18 and 1-23x18 (center) assemblies separated by 9.19 cm of water,
'assemblies separated from depleted uranium reflecting walls by 3.912
'cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

read geom
unit 1
cylinder 1 1 0.5588          91.44  0.0
cylinder 2 1 0.635           96.52 -1.27
cuboid   3 1 4p0.842          96.52 -1.27
unit 2
array 1 3*0.0
unit 3
cuboid   5 1 8.776  0.0  30.312  0.0   96.52 -1.27
unit 4
array 2 3*0.0
global unit 5
array 3 -61.822 -15.156  0.
reflector 4 1 5r0.0  2.54          1
cuboid   5 1 2p76.15  2p19.068 102.79 -19.11
reflector 6 1 2r0.0  2r7.65  2r0.0          1
reflector 5 1 2r30.5  2r18.938 8.93  0       1
end geometry

read array
ara=1 nux=23 nuy=18 nuz=1 fill f1      end fill
ara=2 nux=20 nuy=18 nuz=1 fill f1      end fill
ara=3 nux=5 nuy=1 nuz=1 fill 4 3 2 3 4 end fill
end array
end data
end



p3926u4


=csas25
p3926u4
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o     3 1.0
plexiglas 4 1.0
h2o     5 1.0
uranium 6 .98163 293 92235 .199 92238 99.801
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 7
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0
3-12x16 assemblies separated by 15.33 cm of water, assemblies 'separated from
depleted uranium reflecting walls by 0.0 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245          91.44  0.0
cylinder 0 1 0.64135          91.44  0.0
cylinder 7 1 0.64135          93.98 -2.54
cylinder 2 1 0.70735          93.98 -2.54
cuboid   3 1 4p0.946          93.98 -2.54
unit 2
array 1 3*0.0
unit 3
cuboid   5 1 18.7627 0.0 30.272 0.0   93.98 -2.54
global unit 4
array 2 -52.8187 -15.136 0.
reflector 4 1 5r0.0  2.54          1
cuboid   5 1 2p76.15  2p17.092 101.57 -20.38
reflector 6 1 2r0.0  2r7.65  2r0.0          1
reflector 5 1 2r30.5  2r20.894 7.66  0 1
end geometry

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end
```

```

reflector 5 1 2r30.5 2r22.85 7.66 0 1
end geometry

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end



p3926u5


=csas25
p3926u5
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
h2o     3 1.0
plexiglas 4 1.0
h2o     5 1.0
uranium 6 .98163 293 92235 .199 92238 99.801
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 7
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0
3-12x16 assemblies separated by 19.24 cm of water, assemblies
'separated from depleted uranium reflecting walls by 1.956 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm
```

```

read geom
unit 1
cylinder 1 1 0.63245          91.44  0.0
cylinder 0 1 0.64135          91.44  0.0
cylinder 7 1 0.64135          93.98 -2.54
cylinder 2 1 0.70735          93.98 -2.54
cuboid   3 1 4p0.946          93.98 -2.54
unit 2
array 1 3*0.0
unit 3
cuboid   5 1 18.7627 0.0 30.272 0.0   93.98 -2.54
global unit 4
array 2 -52.8187 -15.136 0.
reflector 4 1 5r0.0  2.54          1
cuboid   5 1 2p76.15  2p17.092 101.57 -20.38
reflector 6 1 2r0.0  2r7.65  2r0.0          1
reflector 5 1 2r30.5  2r20.894 7.66  0 1
end geometry

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end



p3926u6


=csas25
p3926u6
44group latticecell
uo2      1 0.949 293 92235 4.31 92238 95.69
al       2 1.0
end
```

```

h2o      3 1.0
plexiglas 4 1.0
h2o      5 1.0
uranium   6 .98163 293 92235 .199 92238 99.801
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 7
end comp
squarepitch 1.892 1.2649 1 3 1.4147 2 1.2827 0
3-12x16 assemblies separated by 18.78 cm of water, assemblies 'separated from
depleted uranium reflecting walls by 3.276 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.63245          91.44  0.0
cylinder 0 1 0.64135          91.44  0.0
cylinder 7 1 0.64135          93.98 -2.54
cylinder 2 1 0.70735          93.98 -2.54
cuboid   3 1 4p0.945          93.98 -2.54
unit 2
array   1 3*0.0
unit 3
cuboid   5 1 18.3027 0.0 30.272 0.0    93.98 -2.54
global unit 4
array 2 -52.3587 -15.136 0.
reflector 4 1 5r0.0 2.54           1
cuboid   5 1 2p76.15 2p18.412 101.57 -20.38
reflector 6 1 2r0.0 2r7.65 2r0.0 1
reflector 5 1 2r30.5 2r19.574 7.66 0 1
end geometry

read array
ara=1 nux=12 nuy=16 nuz=1 fill f1      end fill
ara=2 nux=5 nuy=1 nuz=1 fill 2 3 2 3 2 end fill
end array
end data
end



p4267b1


=csas25
p4267b1
44group latticecell
uo2      1 den=10.40 1.0 293 92234 .022 92235 4.306 92236
        .022 92238 95.65
al       2 1.0
end
boron   3 den=.00215 1.0
end
h2o     3      1.0
end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 4
end comp
squarepitch 1.890 1.2649 1 3 1.4147 2 1.2827 0
Core of 923 fuel rods, 111.7 water height with 2150 ppm boron
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 4 1 0.63880          2.54   0.0
cylinder 2 1 0.70735          2.54   0.0
end
cuboid   5 1 4p0.945          2.54   0.0
unit 2
cylinder 1 1 0.63245          67.31  0.0
cylinder 0 1 0.64135          67.31  0.0
cylinder 2 1 0.70735          67.31  0.0
cuboid   3 1 4p0.945          67.31  0.0
unit 3
cylinder 1 1 0.63245          1.27   0.0
cylinder 0 1 0.64135          1.27   0.0
cylinder 2 1 0.70735          1.27   0.0
cuboid   5 1 4p0.945          1.27   0.0
unit 4
cylinder 1 1 0.63245          22.86  0.0
cylinder 0 1 0.64135          22.86  0.0
cylinder 2 1 0.70735          22.86  0.0
cuboid   3 1 4p0.945          22.86  0.0
unit 5
cylinder 4 1 0.63880          2.54   0.0
cylinder 2 1 0.70735          2.54   0.0
cuboid   3 1 4p0.945          2.54   0.0
unit 6
array   1 3*0.0
unit 7
cuboid   6 1 4p0.945          2.54   0.0
cuboid   3 1 4p0.945          69.85  0.0
cuboid   6 1 4p0.945          71.12  0.0
cuboid   3 1 4p0.945          96.52  0.0
global
unit 8
array 2 -22.68 -37.80 0.0
cuboid   3 1 22.68 -56.92 2p37.8 111.7 0.0
cuboid   6 1 24.585 -58.825 2p39.705 111.7 -17.105
reflector 7 1 4r30 2r0 1
end geometry

read array
ara=1 nux=1 nuy=1 nuz=5 fill 1 2 3 4 5      end fill
ara=2 nux=24 nuy=40 nuz=1 fill 72r6 7 23r6 36q24 end fill
end array
end data
end



p4267b2


=csas25
p4267b2
44group latticecell
uo2      1 den=10.40 1.0 293 92234 .022 92235 4.306 92236
        .022 92238 95.65
al       2 1.0
end
boron   3 den=.00255 1.0
end
h2o     3      1.0
end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 4
arbmrubber 0.904 2 0 1 0 6312 6 1901 3 5 1
plexiglas 6 1.0
h2o     7 1.0
end comp
squarepitch 1.890 1.2649 1 3 1.4147 2 1.2827 0
Core of 1237 fuel rods, 111.7 water height with 2550 ppm boron
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm
end

```

```

read geom
unit 1
cylinder 4 1 0.63880      2.54  0.0
cylinder 2 1 0.70735      2.54  0.0
cuboid   5 1 4p0.945      2.54  0.0
unit 2
cylinder 1 1 0.63245      67.31 0.0
cylinder 0 1 0.64135      67.31 0.0
cylinder 2 1 0.70735      67.31 0.0
cuboid   3 1 4p0.945      67.31 0.0
unit 3
cylinder 1 1 0.63245      1.27  0.0
cylinder 0 1 0.64135      1.27  0.0
cylinder 2 1 0.70735      1.27  0.0
cuboid   5 1 4p0.945      1.27  0.0
unit 4
cylinder 1 1 0.63245      22.86 0.0
cylinder 0 1 0.64135      22.86 0.0
cylinder 2 1 0.70735      22.86 0.0
cuboid   3 1 4p0.945      22.86 0.0
unit 5
cylinder 4 1 0.63880      2.54  0.0
cylinder 2 1 0.70735      2.54  0.0
cuboid   3 1 4p0.945      2.54  0.0
unit 6
array   1 3*0.0
unit 7
cuboid   6 1 4p0.945      2.54  0.0
cuboid   3 1 4p0.945      69.85 0.0
cuboid   6 1 4p0.945      71.12 0.0
cuboid   3 1 4p0.945      96.52 0.0
global
unit 8
array   2 -29.295 -37.80 0.0
cuboid   3 1 29.295 -50.305 2p37.8   111.7 0.0
cuboid   6 1 31.2   -52.21  2p39.705  111.7 -17.105
reflector 7 1 4r30 2r0 1
end geometry

```

```

read array
ara=1 nux=1 nuy=1 nuz=5 fill 1 2 3 4 5      end fill
ara=2 nux=31 nuy=40 nuz=1 fill 1147r6 7 30r6 2q31 end fill
end array
end data
end

```

p4267b3

```

=csas25
p4267b3
44group latticecell
uo2    1 den=10.40 1.0 293 92234 .022 92235 4.306 92236
      .022 92238 95.65
al     2 1.0
end
boron 3 den=.00103 1.0
end
h2o    3      1.0
end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
      16000 1.7 8016 22.1 14000 0.3 4
end
arbmprop 0.904 2 0 1 0 6312 6 1901 3 5 1
end
plexiglas 6 1.0
end
h2o    7 1.0
end
end comp

```

```

squarepitch 1.715 1.2649 1 3 1.4147 2 1.2827 0
Core of 737 fuel rods, 111.7 water height with 1030 ppm boron
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm
end
read geom
unit 1
cylinder 4 1 0.63880      2.54  0.0
cylinder 2 1 0.70735      2.54  0.0
cuboid   5 1 4p0.8575      2.54  0.0
unit 2
cylinder 1 1 0.63245      67.31 0.0
cylinder 0 1 0.64135      67.31 0.0
cylinder 2 1 0.70735      67.31 0.0
cuboid   3 1 4p0.8575      67.31 0.0
unit 3
cylinder 1 1 0.63245      1.27  0.0
cylinder 0 1 0.64135      1.27  0.0
cylinder 2 1 0.70735      1.27  0.0
cuboid   5 1 4p0.8575      1.27  0.0
unit 4
cylinder 1 1 0.63245      22.86 0.0
cylinder 0 1 0.64135      22.86 0.0
cylinder 2 1 0.70735      22.86 0.0
cuboid   5 1 4p0.8575      22.86 0.0
unit 5
cylinder 4 1 0.63880      2.54  0.0
cylinder 2 1 0.70735      2.54  0.0
cuboid   3 1 4p0.8575      2.54  0.0
unit 6
array   1 3*0.0
unit 7
cuboid   6 1 4p0.8575      2.54  0.0
cuboid   3 1 4p0.8575      69.85 0.0
cuboid   6 1 4p0.8575      71.12 0.0
cuboid   3 1 4p0.8575      96.52 0.0
global
unit 8
array   2 -14.5775 -37.73 0.0
cuboid   3 1 14.5775 -65.0225 2p37.73   111.7 0.0
cuboid   6 1 16.4825 -66.9275 2p39.635  111.7 -17.105
reflector 7 1 4r30 2r0 1
end geometry

```

```

read array
ara=1 nux=1 nuy=1 nuz=5 fill 1 2 3 4 5      end fill
ara=2 nux=17 nuy=44 nuz=1 fill 561r6 7 16r6 10q17 end fill
end array
end data
end

```

p4267b4

```

=csas25
p4267b4
44group latticecell
uo2    1 den=10.40 1.0 293 92234 .022 92235 4.306 92236
      .022 92238 95.65
al     2 1.0
end
boron 3 den=.00182 1.0
end
h2o    3      1.0
end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
      16000 1.7 8016 22.1 14000 0.3 4
end

```

```

arbmprop 0.904 2 0 1 0 6312 6 1901 3 5 1
plexiglas 6 1.0
h2o 7 1.0
end comp
squarepitch 1.715 1.2649 1 3 1.4147 2 1.2827 0
Core of 917 fuel rods, 111.7 water height with 1820 ppm boron
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 4 1 0.63880 2.54 0.0
cylinder 2 1 0.70735 2.54 0.0
cuboid 5 1 4p0.8575 2.54 0.0
unit 2
cylinder 1 1 0.63245 67.31 0.0
cylinder 0 1 0.64135 67.31 0.0
cylinder 2 1 0.70735 67.31 0.0
cuboid 3 1 4p0.8575 67.31 0.0
unit 3
cylinder 1 1 0.63245 1.27 0.0
cylinder 0 1 0.64135 1.27 0.0
cylinder 2 1 0.70735 1.27 0.0
cuboid 5 1 4p0.8575 1.27 0.0
unit 4
cylinder 1 1 0.63245 22.86 0.0
cylinder 0 1 0.64135 22.86 0.0
cylinder 2 1 0.70735 22.86 0.0
cuboid 3 1 4p0.8575 22.86 0.0
unit 5
cylinder 4 1 0.63880 2.54 0.0
cylinder 2 1 0.70735 2.54 0.0
cuboid 3 1 4p0.8575 2.54 0.0
unit 6
array 1 3*0.0
unit 7
cuboid 6 1 4p0.8575 2.54 0.0
cuboid 3 1 4p0.8575 69.85 0.0
cuboid 6 1 4p0.8575 71.12 0.0
cuboid 3 1 4p0.8575 96.52 0.0
global
unit 8
array 2 -18.0075 -37.73 0.0
cuboid 3 1 18.0075 -61.5925 2p37.73 111.7 0.0
cuboid 6 1 19.9125 -63.4975 2p39.635 111.7 -17.105
reflector 7 1 4r30 2r0 1
end geometry

read array
ara=1 nux=1 nuy=1 nuz=5 fill 1 2 3 4 5 end fill
ara=2 nux=21 nuy=44 nuz=1 fill 777r6 7 20r6 6q21 end fill
end array
end data
end



p4267b5


=csas25
p4267b5
44group latticecell
uo2 1 den=10.40 1.0 293 92234 .022 92235 4.306 92236
     .022 92238 95.65
al 2 1.0
end
end

boron 3 den=.00255 1.0
h2o 3 1.0
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 4
arbmprop 0.904 2 0 1 0 6312 6 1901 3 5 1
plexiglas 6 1.0
h2o 7 1.0
end comp
squarepitch 1.715 1.2649 1 3 1.4147 2 1.2827 0
Core of 1192 fuel rods, 111.7 water height with 2550 ppm boron
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 4 1 0.63880 2.54 0.0
cylinder 2 1 0.70735 2.54 0.0
cuboid 5 1 4p0.8575 2.54 0.0
unit 2
cylinder 1 1 0.63245 67.31 0.0
cylinder 0 1 0.64135 67.31 0.0
cylinder 2 1 0.70735 67.31 0.0
cuboid 3 1 4p0.8575 67.31 0.0
unit 3
cylinder 1 1 0.63245 1.27 0.0
cylinder 0 1 0.64135 1.27 0.0
cylinder 2 1 0.70735 1.27 0.0
cuboid 5 1 4p0.8575 1.27 0.0
unit 4
cylinder 1 1 0.63245 22.86 0.0
cylinder 0 1 0.64135 22.86 0.0
cylinder 2 1 0.70735 22.86 0.0
cuboid 5 1 4p0.8575 22.86 0.0
unit 5
cylinder 4 1 0.63880 2.54 0.0
cylinder 2 1 0.70735 2.54 0.0
cuboid 3 1 4p0.8575 2.54 0.0
unit 6
array 1 3*0.0
unit 7
cuboid 6 1 4p0.8575 2.54 0.0
cuboid 3 1 4p0.8575 69.85 0.0
cuboid 6 1 4p0.8575 71.12 0.0
cuboid 3 1 4p0.8575 96.52 0.0
global
unit 8
array 2 -24.01 -37.73 0.0
cuboid 3 1 24.01 -55.59 2p37.73 111.7 0.0
cuboid 6 1 25.915 -57.495 2p39.635 111.7 -17.105
reflector 7 1 4r30 2r0 1
end geometry

read array
ara=1 nux=1 nuy=1 nuz=5 fill 1 2 3 4 5 end fill
ara=2 nux=28 nuy=44 nuz=1 fill 112r6 7 27r6 39q28 end fill
end array
end data
end



p4267s11


=csas25
p4267s11

```

```

44group latticecell
uo2      1 den=10.40 1.0 293 92234 .022 92235 4.306 92236
          .022 92238 95.65
end
al      2 1.0
end
h2o      3 1.0
end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
          16000 1.7 8016 22.1 14000 0.3 4
end
arbmprop 0.904 2 0 1 0 6312 6 1901 3 5 1
end
plexiglas 6 1.0
end comp
squarepitch 1.890 1.2649 1 3 1.4147 2 1.2827 0
Core of 357 fuel rods, 111.7 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 4 1 0.63880           2.54  0.0
cylinder 2 1 0.70735           2.54  0.0
cuboid   5 1 4p0.945           2.54  0.0
unit 2
cylinder 1 1 0.63245           67.31 0.0
cylinder 0 1 0.64135           67.31 0.0
cylinder 2 1 0.70735           67.31 0.0
cuboid   3 1 4p0.945           67.31 0.0
unit 3
cylinder 1 1 0.63245           1.27  0.0
cylinder 0 1 0.64135           1.27  0.0
cylinder 2 1 0.70735           1.27  0.0
cuboid   5 1 4p0.945           1.27  0.0
unit 4
cylinder 1 1 0.63245           22.86 0.0
cylinder 0 1 0.64135           22.86 0.0
cylinder 2 1 0.70735           22.86 0.0
cuboid   3 1 4p0.945           22.86 0.0
unit 5
cylinder 4 1 0.63880           2.54  0.0
cylinder 2 1 0.70735           2.54  0.0
cuboid   3 1 4p0.945           2.54  0.0
unit 6
array   1 3*0.0
unit 7
cuboid   6 1 4p0.945           2.54  0.0
cuboid   3 1 4p0.945           69.85 0.0
cuboid   6 1 4p0.945           71.12 0.0
cuboid   3 1 4p0.945           96.52 0.0
global
unit 8
array   2 -8.505 -37.80 0.0
cuboid   3 1 8.505 -71.095 2p37.8   111.7 0.0
cuboid   6 1 10.41 -73.000 2p39.705 111.7 -17.105
reflector 3 1 4r30 2r0 1
end geometry

read array
ara=1 nux=1 nuy=1 nuz=5 fill 1 2 3 4 5      end fill
ara=2 nux=9 nuy=40 nuz=1 fill 333r6 7 8r6 2q9 end fill
end array
end data
end

```

p4267s12

```

=csas25
p4267s12
44group latticecell
uo2      1 den=10.40 1.0 293 92234 .022 92235 4.306 92236
          .022 92238 95.65
end
al      2 1.0
end
h2o      3 1.0
end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
          16000 1.7 8016 22.1 14000 0.3 4
end
arbmprop 0.904 2 0 1 0 6312 6 1901 3 5 1
end
plexiglas 6 1.0
end comp
squarepitch 1.715 1.2649 1 3 1.4147 2 1.2827 0
Core of 509 fuel rods, 111.7 cm water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 4 1 0.63880           2.54  0.0
cylinder 2 1 0.70735           2.54  0.0
cuboid   5 1 4p0.8575          2.54  0.0
unit 2
cylinder 1 1 0.63245           67.31 0.0
cylinder 0 1 0.64135           67.31 0.0
cylinder 2 1 0.70735           67.31 0.0
cuboid   3 1 4p0.8575          67.31 0.0
unit 3
cylinder 1 1 0.63245           1.27  0.0
cylinder 0 1 0.64135           1.27  0.0
cylinder 2 1 0.70735           1.27  0.0
cuboid   5 1 4p0.8575          1.27  0.0
unit 4
cylinder 1 1 0.63245           22.86 0.0
cylinder 0 1 0.64135           22.86 0.0
cylinder 2 1 0.70735           22.86 0.0
cuboid   3 1 4p0.8575          22.86 0.0
unit 5
cylinder 4 1 0.63880           2.54  0.0
cylinder 2 1 0.70735           2.54  0.0
cylinder 0 1 0.64135           2.54  0.0
cuboid   3 1 4p0.8575          2.54  0.0
unit 6
array   1 3*0.0
unit 7
cuboid   6 1 4p0.8575          2.54  0.0
cuboid   3 1 4p0.8575          69.85 0.0
cuboid   6 1 4p0.8575          71.12 0.0
cuboid   3 1 4p0.8575          96.52 0.0
global
unit 8
array   2 -10.29 -37.73 0.0
cuboid   3 1 10.29 -69.31 2p37.73   111.7 0.0
cuboid   6 1 12.195 -71.215 2p39.635 111.7 -17.105
reflector 3 1 4r30 2r0 1
end geometry

read array
ara=1 nux=1 nuy=1 nuz=5 fill 1 2 3 4 5      end fill
ara=2 nux=12 nuy=44 nuz=1 fill 300r6 7 11r6 18q12 end fill
end array
end data

```

```

end



p62ft231


=csas25
p62ft231
44group latticecell
uo2      1 0.9489 293 92234 0.022 92235 4.306 92236 0.022
         92238 95.65
al       2 1.0
h2o      3 1.0
arbmboral   2.64 5 1 0 1 5000 35.63 6012 9.95 13027 54.33
            8016 0.07 26000 0.02 4
arbmrubber  1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
            16000 1.7 8016 22.1 14000 0.3 5
plexiglas   6 1.0
end comp
squarepitch 1.891 1.265 1 3 1.415 2 1.283 0
3-15x16 and 1-12x16 plus 3x17 assemblies separated by 0.683-cm-thick 'Boral
plates and 3.824 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geometry
unit 1
cylinder 1 1 .6325
cylinder 0 1 .6415
cylinder 5 1 .6415
cylinder 2 1 .7075
cuboid   3 1 4p.9455
unit 2
array 2 3*0.0
cuboid   3 1 32.4220 -11.8750 44.0220 -0.2950 96.00 0.0
cuboid   2 1 32.5435 -11.8750 44.0220 -0.3965 96.00 0.0
cuboid   4 1 33.0235 -11.8750 44.0220 -0.8765 96.00 0.0
cuboid   2 1 33.1250 -11.8750 44.0220 -0.9780 96.00 0.0
unit 3
array 1 3*0.0
cuboid   3 1 44.0220 -0.2950 44.0220 -0.2950 96.00 0.0
cuboid   2 1 44.0220 -0.3965 44.0220 -0.3965 96.00 0.0
cuboid   4 1 44.0220 -0.8765 44.0220 -0.8765 96.00 0.0
cuboid   2 1 44.0220 -0.9780 44.0220 -0.9780 96.00 0.0
unit 4
array 2 3*0.0
cuboid   3 1 32.4220 -11.8750 28.6600 -15.6570 96.00 0.0
cuboid   2 1 32.5435 -11.8750 28.7615 -15.6570 96.00 0.0
cuboid   4 1 33.0235 -11.8750 29.2415 -15.6570 96.00 0.0
cuboid   2 1 33.1250 -11.8750 29.3430 -15.6570 96.00 0.0
unit 5
array 3 3*0.0
cuboid   3 1 44.0220 -0.2955 28.6600 -15.657 96.00 0.0
cuboid   2 1 44.0220 -0.3965 28.7615 -15.657 96.00 0.0
cuboid   4 1 44.0220 -0.8765 29.2415 -15.657 96.00 0.0
cuboid   2 1 44.0220 -0.9780 29.3430 -15.657 96.00 0.0
unit 6
cuboid   3 1 3.71 0.0 45.0 0.0 96.00 0.0
unit 7
cuboid   3 1 45.0 0.0 3.71 0.0 96.00 0.0
unit 8
cuboid   3 1 3.71 0.0 3.71 0.0 96.00 0.0
unit 9
cuboid   3 1 4p.9455
                           96.00 0.0

```

```

global unit 10
array 4 3*0.0
reflector 6 1 5r0      5.08 1
reflector 3 1 4r15 15. 15.88 1
end geom

read array
ara=1 nux=17 nuy=15 fill 16r1 9 14q17      end fill
ara=2 nux=17 nuy=15 fill 9 16r1 14q17      end fill
ara=3 nux=17 nuy=15 fill 51r1 16r1 9 11q17 end fill
ara=4 nux=3  nuy=3  fill 4 6 5 7 8 7 2 6 3 end fill
end array
end data
end



p71f14f3


=csas25
p71f14f3
44group latticecell
uo2      1 0.9489 293 92234 0.022 92235 4.306 92236 0.022
         92238 95.65
al       2 1.0
h2o      3 1.0
arbmboral   2.64 5 1 0 1 5000 29.22 6012 8.16 13027 62.54
            8016 0.06 26000 0.02 4
arbmrubber  1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
            16000 1.7 8016 22.1 14000 0.3 5
plexiglas   6 1.0
end comp
squarepitch 1.891 1.265 1 3 1.415 2 1.283 0
end
2-15x14 and 1-15x15 and 1-12x14 plus 3x15 assemblies separated by
'0.673-cm thick Boral plates, 14 fuel rods, and 3.844 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geometry
unit 1
cylinder 1 1 .6325
cylinder 0 1 .6415
cylinder 5 1 .6415
cylinder 2 1 .7075
cuboid   3 1 4p.9455
unit 2
array 1 3*0.0
cuboid   3 1 28.4220 -15.9050 44.2700 -.0570 96.00 0.0
cuboid   2 1 28.5235 -15.9050 44.2700 -.1585 96.00 0.0
cuboid   4 1 28.9935 -15.9050 44.2700 -.6285 96.00 0.0
cuboid   2 1 29.0950 -15.9050 44.2700 -.7300 96.00 0.0
unit 3
array 3 3*0.0
cuboid   3 1 44.2700 -.00570 44.2700 -.00570 96.00 0.0
cuboid   2 1 44.2700 -.1585 44.2700 -.1585 96.00 0.0
cuboid   4 1 44.2700 -.6285 44.2700 -.6285 96.00 0.0
cuboid   2 1 44.2700 -.7300 44.2700 -.7300 96.00 0.0

```

```

unit 4
array 2 3*0.0
cuboid 3 1 28.4220 -15.9050 28.4220 -15.9050 96.00 0.0
cuboid 2 1 28.5235 -15.9050 28.5235 -15.9050 96.00 0.0
cuboid 4 1 28.9935 -15.9050 28.9935 -15.9050 96.00 0.0
cuboid 2 1 29.0950 -15.9050 29.0950 -15.9050 96.00 0.0
unit 5
array 3 3*0.0
cuboid 3 1 44.2700 -0.0570 28.4220 -15.9050 96.00 0.0
cuboid 2 1 44.2700 -0.1585 28.5235 -15.9050 96.00 0.0
cuboid 4 1 44.2700 -0.6285 28.9935 -15.9050 96.00 0.0
cuboid 2 1 44.2700 -0.7300 29.0950 -15.9050 96.00 0.0
unit 6
array 4 -.9455 .968 0.0
cuboid 3 1 1.865 -1.865 45.00 0.0 96.00 0.0
unit 7
array 5 .968 -.9455 0.0
cuboid 3 1 45.00 0.0 1.865 -1.865 96.00 0.0
unit 8
cuboid 3 1 4p1.865 96.00 0.0
unit 9
cuboid 3 1 4p.9455 96.00 0.0
unit 10
array 6 -.9455 15.9050 0.0
cuboid 3 1 1.865 -1.865 45.00 0.0 96.00 0.0
unit 11
array 7 15.9050 -.9455 0.0
cuboid 3 1 45.00 0.0 1.865 -1.865 96.00 0.0
global unit 12
array 8 3*0.0
reflector 6 1 5r0 5.08 1
reflector 3 1 5r15. 15.88 1
end geom

read array
ara=1 nux=15 nuy=15 fill 45rl 9 14rl 11ql5 end fill
ara=2 nux=15 nuy=15 fill f1 end fill
ara=3 nux=15 nuy=15 fill 14rl 9 14q15 end fill
ara=4 nux=15 nuy=15 fill 14rl 9 end fill
ara=5 nux=15 nuy=1 fill 14rl 9 end fill
ara=6 nux=1 nuy=15 fill 9 14rl end fill
ara=7 nux=15 nuy=1 fill 9 14rl end fill
ara=8 nux=3 nuy=3 fill 4 10 5 11 8 7 2 6 3 end fill
end array
end data
end



p71f14v3


=csas25
p71f14v3
44group latticecell
uo2 1 0.9489 293 92234 0.022 92235 4.306 92236 0.022
92238 95.650
al 2 1.0
h2o 3 1.0
arbmboral 2.64 5 1 0 1 5000 29.22 6012 8.16 13027 62.54
8016 0.06 26000 0.02 4
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
16000 1.7 8016 22.1 14000 0.3 5
plexiglas 6 1.0
end comp

```

```

squarepitch 1.891 1.265 1 3 1.415 2 1.283 0
end
2-15x14 and 1-15x15 and 1-8x14 plus 7x15 assemblies separated by
'0.673-cm thick Boral plates, 0.62-cm-thick aluminum plates, and 3.844
'cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geometry
unit 1
cylinder 1 1 .6325 93.98 2.54
cylinder 0 1 .6415 93.98 2.54
cylinder 5 1 .6415 96.00 0.0
cylinder 2 1 .7075 96.00 0.0
cuboid 3 1 4p.9455 96.00 0.0
unit 2
array 1 3*0.0
cuboid 3 1 26.5310 -17.7960 44.2700 -.0570 96.00 0.0
cuboid 2 1 26.6325 -17.7960 44.2700 -.1585 96.00 0.0
cuboid 4 1 27.1025 -17.7960 44.2700 -.6285 96.00 0.0
cuboid 2 1 27.2040 -17.7960 44.2700 -.7300 96.00 0.0
unit 3
array 2 3*0.0
cuboid 3 1 44.2700 -0.0570 44.2700 -.0570 96.00 0.0
cuboid 2 1 44.2700 -0.1585 44.2700 -.1585 96.00 0.0
cuboid 4 1 44.2700 -0.6285 44.2700 -.6285 96.00 0.0
cuboid 2 1 44.2700 -0.7300 44.2700 -.7300 96.00 0.0
unit 4
array 1 3*0.0
cuboid 3 1 26.5310 -17.7960 28.4220 -15.9050 96.00 0.0
cuboid 2 1 26.6325 -17.7960 28.5235 -15.9050 96.00 0.0
cuboid 4 1 27.1025 -17.7960 28.9935 -15.9050 96.00 0.0
cuboid 2 1 27.2040 -17.7960 29.0950 -15.9050 96.00 0.0
unit 5
array 3 3*0.0
cuboid 3 1 44.2700 -0.0570 28.4220 -15.9050 96.00 0.0
cuboid 2 1 44.2700 -0.1585 28.5235 -15.9050 96.00 0.0
cuboid 4 1 44.2700 -0.6285 28.9935 -15.9050 96.00 0.0
cuboid 2 1 44.2700 -0.7300 29.0950 -15.9050 96.00 0.0
unit 6
cuboid 3 1 0.46 0.0 45.0 0.0 96.00 0.0
cuboid 2 1 1.09 0.0 45.0 0.0 96.00 0.0
cuboid 3 1 1.55 0.0 45.0 0.0 96.00 0.0
cuboid 2 1 2.18 0.0 45.0 0.0 96.00 0.0
cuboid 3 1 2.64 0.0 45.0 0.0 96.00 0.0
cuboid 2 1 3.27 0.0 45.0 0.0 96.00 0.0
cuboid 3 1 3.73 0.0 45.0 0.0 96.00 0.0
unit 7
cuboid 3 1 45.0 0.0 0.46 0.0 96.00 0.0
cuboid 2 1 45.0 0.0 1.09 0.0 96.00 0.0
cuboid 3 1 45.0 0.0 1.55 0.0 96.00 0.0
cuboid 2 1 45.0 0.0 2.18 0.0 96.00 0.0
cuboid 3 1 45.0 0.0 2.64 0.0 96.00 0.0
cuboid 2 1 45.0 0.0 3.27 0.0 96.00 0.0
cuboid 3 1 45.0 0.0 3.73 0.0 96.00 0.0
unit 8
cuboid 3 1 4p1.865 96.00 0.0
unit 9
cuboid 3 1 4p.9455 96.00 0.0
global
unit 10
array 4 3*0.0
reflector 6 1 5r0 5.08 1

```

```

reflector 3 1 5r15. 15.88 1
end geom

read array
ara=1 nux=14 nuy=15 fill f1          end fill
ara=2 nux=15 nuy=15 fill f1          end fill
ara=3 nux=15 nuy=15 fill 105r1 14r1 9 7q15 end fill
ara=4 nux=3  nuy=3  fill 4 6 5 7 8 7 2 6 3 end fill
end array
end data
end



p71f14v5


=csas25
p71f14v5
44group latticecell
uo2      1 0.9489 293 92234 0.022 92235 4.306 92236 0.022
         92238 95.650
al       2 1.0
end
h2o      3 1.0
end
arbmboral 2.64 5 1 0 1 5000 29.22 6012 8.16 13027 62.54
           8016 0.06 26000 0.02 4
end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
           16000 1.7 8016 22.1 14000 0.3 5
end
plexiglas 6 1.0
end
end comp
squarepitch 1.891 1.265 1 3 1.415 2 1.283 0
end
2-15x15 and 1-16x15 and 1-15x15 plus 1x10 assemblies separated by '0.673-cm
thick Boral plates, 14 aluminum rods, and 3.844 cm of water
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geometry
unit 1
cylinder 1 1 .6325                  93.98  2.54
cylinder 0 1 .6415                  93.98  2.54
cylinder 5 1 .6415                  96.00  0.0
cylinder 2 1 .7075                  96.00  0.0
cuboid   3 1 4p.9455                96.00  0.0
unit 2
array   3 3*0.0
cuboid   3 1 28.4220 -15.9050    44.2700 -.0570  96.00  0.0
cuboid   2 1 28.5235 -15.9050    44.2700 -.1585  96.00  0.0
cuboid   4 1 28.9935 -15.9050    44.2700 -.6285  96.00  0.0
cuboid   2 1 29.0950 -15.9050    44.2700 -.7300  96.00  0.0
unit 3
array   2 3*0.0
cuboid   3 1 44.2700 -.0570     44.2700 -.0570  96.00  0.0
cuboid   2 1 44.2700 -.1585     44.2700 -.1585  96.00  0.0
cuboid   4 1 44.2700 -.6285     44.2700 -.6285  96.00  0.0
cuboid   2 1 44.2700 -.7300     44.2700 -.7300  96.00  0.0
unit 4
array   1 3*0.0
cuboid   3 1 28.4220 -15.9050   28.4220 -15.9050 96.00  0.0
cuboid   2 1 28.5235 -15.9050   28.5235 -15.9050 96.00  0.0
cuboid   4 1 28.9935 -15.9050   28.9935 -15.9050 96.00  0.0
cuboid   2 1 29.0950 -15.9050   29.0950 -15.9050 96.00  0.0
unit 5
array   1 3*0.0
cuboid   3 1 44.2700 -.0570     28.4220 -15.9050 96.00  0.0
cuboid   2 1 44.2700 -.1585     28.5235 -15.9050 96.00  0.0
cuboid   4 1 44.2700 -.6285     28.9935 -15.9050 96.00  0.0

```

```

cuboid   2 1 44.2700 -.7300      29.0950 -15.9050 96.00  0.0
unit 6
array   4 -0.9455 2r0.0
cuboid   3 1 1.865 -1.865      44.2700 -0.7300 96.00  0.0
unit 7
array   5 0.0 -0.9455 0.0
cuboid   3 1 44.27 -0.73        1.865 -1.865 96.00  0.0
unit 8
cuboid   3 1 4p1.865
unit 9
cuboid   3 1 4p.9455
unit 10
array  6 -0.9455 2r0.0
cuboid   3 1 1.865 -1.865      29.0950 -15.9050 96.00  0.0
unit 11
array  7 0.0 -0.9455 0.0
cuboid   3 1 29.0950 -15.9050  1.865 -1.865 96.00  0.0
unit 12
cylinder 2 1 .635
cuboid   3 1 4p.9455
global unit 13
array  8 3*0.0
reflector 6 1 5r0   5.08 1
reflector 3 1 5r15. 15.88 1
end geom

read array
ara=1 nux=15 nuy=15 fill f1          end fill
ara=2 nux=15 nuy=16 fill f1          end fill
ara=3 nux=15 nuy=16 fill 225r1 5r9 10r1 end fill
ara=4 nux=1 nuy=16 fill 14r12 2r9    end fill
ara=5 nux=15 nuy=1 fill 14r12 9     end fill
ara=6 nux=1 nuy=15 fill 9 14r12     end fill
ara=7 nux=15 nuy=1 fill 9 14r12     end fill
ara=8 nux=3 nuy=3 fill 4 10 5 11 8 7 2 6 3 end fill
end array
end data
end



p71f214r


=csas25
p71f214r
44group latticecell
uo2      1 0.9489 293 92234 0.022 92235 4.306 92236 0.022
         92238 95.650
end
al       2 1.0
end
h2o      3 1.0
end
arbmboral 2.64 5 1 0 1 5000 29.22 6012 8.16 13027 62.54
           8016 0.06 26000 0.02 4
end
arbmrubber 1.321 6 0 0 0 6012 58. 1001 6.5 20000 11.4
           16000 1.7 8016 22.1 14000 0.3 5
end
plexiglas 6 1.0
end
end comp
squarepitch 1.891 1.265 1 3 1.415 2 1.283 0
end

```

3-15x16 and 1-8x15 and plus 7x16 assemblies separated by 0.673-cm 'thick Boral plates and 3.844 cm of water
 read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geometry
 unit 1
 cylinder 1 1 .6325 93.98 2.54
 cylinder 0 1 .6415 93.98 2.54
 cylinder 5 1 .6415 96.00 0.0
 cylinder 2 1 .7075 96.00 0.0
 cuboid 3 1 4p.9455 96.00 0.0
 unit 2
 array 1 3*0.0
 cuboid 3 1 30.313 -14.0140 44.270 -.0570 96.00 0.0
 cuboid 2 1 30.4145 -14.0140 44.270 -.1585 96.00 0.0
 cuboid 4 1 30.8845 -14.0140 44.270 -.6285 96.00 0.0
 cuboid 2 1 30.9860 -14.0140 44.270 -.7300 96.00 0.0
 unit 3
 array 1 3*0.0
 cuboid 3 1 44.270 -.0570 44.270 -.0570 96.00 0.0
 cuboid 2 1 44.270 -.1585 44.270 -.1585 96.00 0.0
 cuboid 4 1 44.270 -.6285 44.270 -.6285 96.00 0.0
 cuboid 2 1 44.270 -.7300 44.270 -.7300 96.00 0.0
 unit 4
 array 1 3*0.0
 cuboid 3 1 30.3130 -14.0140 28.4220 -15.9050 96.00 0.0
 cuboid 2 1 30.4145 -14.0140 28.5235 -15.9050 96.00 0.0
 cuboid 4 1 30.8845 -14.0140 28.9935 -15.9050 96.00 0.0
 cuboid 2 1 30.9860 -14.0140 29.0950 -15.9050 96.00 0.0
 unit 5
 array 2 3*0.0
 cuboid 3 1 44.270 -.0570 28.4220 -15.9050 96.00 0.0
 cuboid 2 1 44.270 -.1585 28.5235 -15.9050 96.00 0.0
 cuboid 4 1 44.270 -.6285 28.9935 -15.9050 96.00 0.0
 cuboid 2 1 44.270 -.7300 29.0950 -15.9050 96.00 0.0
 unit 6
 cuboid 3 1 2p1.865 45.0 0.0 96.00 0.0
 unit 7
 cuboid 3 1 45.0 0.0 2p1.865 96.00 0.0
 unit 8
 cuboid 3 1 4p1.865 96.00 0.0
 unit 9
 cuboid 3 1 4p.9455 96.00 0.0
 global unit 10
 array 3 3*0.0
 reflector 6 1 5r0. 5.08 1
 reflector 3 1 5r15. 15.88 1
 end geom

read array
 ara=1 nux=16 nuy=15 fill f1 end fill
 ara=2 nux=16 nuy=15 fill 15r1 9 7q16 112r1 end fill
 ara=3 nux=3 nuy=3 fill 4 6 5 7 8 7 2 6 3 end fill
 end array
 end data
 end

pat8011

=csas25
 pat8011
 44group latticecell

uo2 1 den=10.38 1.0 293 92235 4.742 92238 95.258 end
 arbmag5 2.70 4 0 0 1 13027 98.85 12000 0.47 14000 0.43 26000
 0.22 2 1 293 end
 h2o 3 1.0 end
 pb 4 den=11.34 end
 arbms 7.90 3 0 0 1 26000 72.00 24000 18.00 28000 10.0 5 end
 arbmboral 2.6189 3 1 0 0 5000 22.20 13027 71.64 6012 6.17 6 end
 uo2 7 den=10.38 1.0 293 92235 4.742 92238 95.258 end
 al 8 den=2.651 end
 al 9 1.0 end
 end comp
 squarepitch 1.6 0.79 1 3 0.94 2 0.82 0 end
 more data res=7 cylinder 0.395 dan(7)=0.991436 end more
 4-18x18 assemblies separated by 0.65-cm-thick Boral plates and 3.6 cm
 'of water, plate-to-assembly distance of 0.8 cm, assemblies separated
 'from lead reflecting walls by 1.68 cm of water, 53.98 cm water height
 read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
 unit 1
 cylinder 7 1 0.395 36.02 0.0
 cylinder 0 1 0.410 36.02 0.0
 cylinder 2 1 0.470 36.02 0.0
 cuboid 0 1 4p0.800 36.02 0.0
 unit 2
 cylinder 1 1 0.395 53.98 0.0
 cylinder 0 1 0.410 53.98 0.0
 cylinder 2 1 0.470 53.98 0.0
 cuboid 3 1 4p0.800 53.98 0.0
 unit 3
 cylinder 9 1 0.470 0.25 0.0
 cylinder 3 1 0.500 0.25 0.0
 cuboid 5 1 4p0.800 0.25 0.0
 unit 4
 cylinder 9 1 0.470 1.95 0.4
 cuboid 3 1 4p0.800 1.95 0.4
 cuboid 5 1 4p0.800 1.95 0.0
 unit 5
 array 1 3*0.0
 unit 6
 cylinder 5 1 0.500 56.18 0.4
 cuboid 3 1 4p0.800 56.18 0.4
 cuboid 5 1 4p0.800 56.18 0.0
 unit 7
 array 2 3*0.0
 reflector 8 1 4r0.11 2r0 1
 reflector 6 1 4r0.43 2r0 1
 reflector 8 1 4r0.11 2r0 1
 unit 8
 cuboid 3 1 2.0 0.0 30.1 0.0 56.18 0.4
 cuboid 5 1 2.0 0.0 30.1 0.0 56.18 0.0
 unit 9
 array 3 3*0.0
 unit 10
 cuboid 3 1 62.2 0.0 2.0 0.0 56.18 0.4
 cuboid 5 1 62.2 0.0 2.0 0.0 56.18 0.0
 unit 11
 array 4 3*0.0
 reflector 3 1 4r0.23 2r0.0 1
 reflector 4 1 4r10.0 2r0.0 1
 reflector 3 1 4r18.7 2r0.0 1
 reflector 5 1 5r0.0 0.8 1

```

reflector 3 1 5r0.0 20.0      1
unit 12
cylinder 5 1 0.500          36.02 0.0
cuboid   0 1 4p0.800         36.02 0.0
unit 13
array 5 3*0.0
reflector 8 1 4r0.11 2r0 1
reflector 6 1 4r0.43 2r0 1
reflector 8 1 4r0.11 2r0 1
unit 14
cuboid   0 1 2.0 0.0 30.1 0.0 36.02 0.0
unit 15
array 6 3*0.0
unit 16
cuboid   0 1 62.2 0.0 2.0 0.0 36.02 0.0
unit 17
array 7 3*0.0
reflector 0 1 4r0.23 2r0.0    1
reflector 4 1 4r10.0 2r0.0    1
reflector 0 1 4r18.7 2r0.0    1
global unit 18
array 8 3*0.0
end geom

read array
ara=1 nux=1 nuy=1 nuz=3 fill 4 3 2                                end fill
ara=2 nux=18 nuy=18 nuz=1 fill 6 16r5 6 18r5 15q18 6 16r5 6       end fill
ara=3 nux=3 nuy=1 nuz=1 fill 7 8 7                                end fill
ara=4 nux=1 nuy=3 nuz=1 fill 9 10 9                                end fill
ara=5 nux=18 nuy=18 nuz=1 fill 12 16r1 12 18r1 15q18 12 16r1 12   end fill
ara=6 nux=3 nuy=1 nuz=1 fill 13 14 13                               end fill
ara=7 nux=1 nuy=3 nuz=1 fill 15 16 15                               end fill
ara=8 nux=1 nuy=1 nuz=2 fill 11 17                                end fill
end array
end data
end

pat8012

=csas25
pat8012
44group latticecell
uo2     1 den=10.38 1.0 293 92235 4.742 92238 95.258      end
arbmag5 2.70 4 0 0 1 13027 98.85 12000 0.47 14000 0.43 26000
          0.22 2 1 293                                         end
h2o     3 1.0                                         end
pb      4 den=11.34                                     end
arbmass 7.90 3 0 0 1 26000 72.00 24000 18.00 28000 10.0 5 end
arbmboral 2.6189 3 1 0 0 5000 22.20 13027 71.64 6012 6.17 6 end
uo2     7 den=10.38 1.0 293 92235 4.742 92238 95.258      end
al      8 den=2.651                                     end
al      9 1.0                                         end
end comp
squarepitch 1.6 0.79 1 3 0.94 2 0.82 0 end
more data res=7 cylinder 0.395 dan(7)=0.991436 end more
4-18x18 assemblies separated by 0.65-cm-thick Boral plates and 3.6 cm
'of water, plate-to-assembly distance of 0.8 cm, assemblies separated
'from lead reflecting walls by 3.95 cm of water, 63.85 cm water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm
read geom
unit 1
cylinder 7 1 0.395          26.15 0.0
cylinder 0 1 0.410          26.15 0.0
cylinder 2 1 0.470          26.15 0.0
cuboid   0 1 4p0.800         26.15 0.0
unit 2
cylinder 1 1 0.395          63.85 0.0
cylinder 0 1 0.410          63.85 0.0
cylinder 2 1 0.470          63.85 0.0
cuboid   3 1 4p0.800         63.85 0.0
unit 3
cylinder 9 1 0.470          0.25  0.0
cylinder 3 1 0.500          0.25  0.0
cuboid   5 1 4p0.800         0.25  0.0
unit 4
cylinder 9 1 0.470          1.95  0.4
cuboid   3 1 4p0.800         1.95  0.4
cuboid   5 1 4p0.800         1.95  0.0
unit 5
array 1 3*0.0
unit 6
cylinder 5 1 0.500          66.05 0.4
cuboid   3 1 4p0.800         66.05 0.4
cuboid   5 1 4p0.800         66.05 0.0
unit 7
array 2 3*0.0
reflector 8 1 4r0.11 2r0 1
reflector 6 1 4r0.43 2r0 1
reflector 8 1 4r0.11 2r0 1
unit 8
cuboid   3 1 2.0 0.0 30.1 0.0 66.05 0.4
cuboid   5 1 2.0 0.0 30.1 0.0 66.05 0.0
unit 9
array 3 3*0.0
unit 10
cuboid   3 1 62.2 0.0 2.0 0.0 66.05 0.4
cuboid   5 1 62.2 0.0 2.0 0.0 66.05 0.0
unit 11
array 4 3*0.0
reflector 3 1 4r2.50 2r0.0    1
reflector 4 1 4r10.0 2r0.0    1
reflector 3 1 4r18.7 2r0.0    1
reflector 5 1 5r0.0 0.8       1
reflector 3 1 5r0.0 20.0      1
unit 12
cylinder 5 1 0.500          26.15 0.0
cuboid   0 1 4p0.800         26.15 0.0
unit 13
array 5 3*0.0
reflector 8 1 4r0.11 2r0 1
reflector 6 1 4r0.43 2r0 1
reflector 8 1 4r0.11 2r0 1
unit 14
cuboid   0 1 2.0 0.0 30.1 0.0 26.15 0.0
unit 15
array 6 3*0.0
unit 16
cuboid   0 1 62.2 0.0 2.0 0.0 26.15 0.0
unit 17
array 7 3*0.0
reflector 0 1 4r2.50 2r0.0    1
reflector 4 1 4r10.0 2r0.0    1
reflector 0 1 4r18.7 2r0.0    1
global unit 18

```

```

array 8 3*0.0
end geom

read array
ara=1 nux=1 nuy=1 nuz=3 fill 4 3 2 end fill
ara=2 nux=18 nuy=18 nuz=1 fill 6 16r5 6 18r5 15q18 6 16r5 6 end fill
ara=3 nux=3 nuy=1 nuz=1 fill 7 8 7 end fill
ara=4 nux=1 nuy=3 nuz=1 fill 9 10 9 end fill
ara=5 nux=18 nuy=18 nuz=1 fill 12 16r1 12 18r1 15q18 12 16r1 12 end fill
ara=6 nux=3 nuy=1 nuz=1 fill 13 14 13 end fill
ara=7 nux=1 nuy=3 nuz=1 fill 15 16 15 end fill
ara=8 nux=1 nuy=1 nuz=2 fill 11 17 end fill
end array
end data
end

pat80ss1

=csas25
pat80ss1
44group latticecell
uo2      1 den=10.38 1.0 293 92235 4.742 92238 95.258      end
arbmag5   2.70 4 0 0 1 13027 98.85 12000 0.47 14000 0.43 26000
          0.22 2 1 293      end
h2o      3 1.0      end
arbmast   7.80 3 0 0 1 26000 99.66 6012 0.14 14000 .20 4      end
arbmsmss  7.90 3 0 0 1 26000 72.00 24000 18.00 28000 10.0 5      end
arbmboral 2.6189 3 1 0 0 5000 22.20 13027 71.64 6012 6.17 6      end
uo2      7 den=10.38 1.0 293 92235 4.742 92238 95.258      end
al       8 den=2.651      end
al       9 1.0      end
end comp
squarepitch 1.6 0.79 1 3 0.94 2 0.82 0      end
more data res=7 cylinder 0.395 dan(7)=0.991436 end more
4-18x18 assemblies separated by 0.65-cm-thick Boral plates and 3.6 cm
'of water, plate-to-assembly distance of 0.8 cm, assemblies separated
'from stainless steel reflecting walls by 1.68 cm of water, 51.55 cm
'water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 7 1 0.395      38.45 0.0
cylinder 0 1 0.410      38.45 0.0
cylinder 2 1 0.470      38.45 0.0
cuboid   0 1 4p0.800      38.45 0.0
unit 2
cylinder 1 1 0.395      51.55 0.0
cylinder 0 1 0.410      51.55 0.0
cylinder 2 1 0.470      51.55 0.0
cuboid   3 1 4p0.800      51.55 0.0
unit 3
cylinder 9 1 0.470      0.25 0.0
cylinder 3 1 0.500      0.25 0.0
cuboid   5 1 4p0.800      0.25 0.0
unit 4
cylinder 9 1 0.470      1.95 0.4
cuboid   3 1 4p0.800      1.95 0.4
cuboid   5 1 4p0.800      1.95 0.0
unit 5
array 1 3*0.0
unit 6
cylinder 5 1 0.500      53.75 0.4
cuboid   3 1 4p0.800      53.75 0.4
cuboid   5 1 4p0.800      53.75 0.0
unit 7
array 2 3*0.0
reflector 8 1 4r0.11 2r0 1
reflector 6 1 4r0.43 2r0 1
reflector 8 1 4r0.11 2r0 1
unit 8
cuboid   3 1 2.0 0.0 30.1 0.0 53.75 0.4
cuboid   5 1 2.0 0.0 30.1 0.0 53.75 0.0
unit 9
array 3 3*0.0
unit 10
cuboid   3 1 62.2 0.0 2.0 0.0 53.75 0.4
cuboid   5 1 62.2 0.0 2.0 0.0 53.75 0.0
unit 11
array 4 3*0.0
reflector 3 1 4r0.23 2r0.0 1
reflector 4 1 4r15.0 2r0.0 1
reflector 3 1 4r13.7 2r0.0 1
reflector 5 1 5r0.0 0.8 1
reflector 3 1 5r0.0 20.0 1
unit 12
cylinder 5 1 0.500      38.45 0.0
cuboid   0 1 4p0.800      38.45 0.0
unit 13
array 5 3*0.0
reflector 8 1 4r0.11 2r0 1
reflector 6 1 4r0.43 2r0 1
reflector 8 1 4r0.11 2r0 1
unit 14
cuboid   0 1 2.0 0.0 30.1 0.0 38.45 0.0
unit 15
array 6 3*0.0
unit 16
cuboid   0 1 62.2 0.0 2.0 0.0 38.45 0.0
unit 17
array 7 3*0.0
reflector 0 1 4r0.23 2r0.0 1
reflector 4 1 4r15.0 2r0.0 1
reflector 0 1 4r13.7 2r0.0 1
global unit 18
array 8 3*0.0
end geom

read array
ara=1 nux=1 nuy=1 nuz=3 fill 4 3 2      end
fill
ara=2 nux=18 nuy=18 nuz=1 fill 6 16r5 6 18r5 15q18 6 16r5 6      end
fill
ara=3 nux=3 nuy=1 nuz=1 fill 7 8 7      end
fill
ara=4 nux=1 nuy=3 nuz=1 fill 9 10 9      end
fill
ara=5 nux=18 nuy=18 nuz=1 fill 12 16r1 12 18r1 15q18 12 16r1 12      end
fill
ara=6 nux=3 nuy=1 nuz=1 fill 13 14 13      end
fill
ara=7 nux=1 nuy=3 nuz=1 fill 15 16 15      end
fill

```

```

ara=8 nux=1 nuy=1 nuz=2 fill 11 17
end array
end data
end



pat80ss2


=csas25
pat80ss2
44group latticecell
uo2      1 den=10.38 1.0 293 92235 4.742 92238 95.258
arbmag5  2.70 4 0 0 1 13027 98.85 12000 0.47 14000 0.43 26000
          0.22 2 1 293
h2o      3 1.0
arbmsr   7.80 3 0 0 1 26000 99.66 6012 0.14 14000 .20 4
arbmsr   7.90 3 0 0 1 26000 72.00 24000 18.00 28000 10.0 5
arbmboral 2.6189 3 1 0 0 5000 22.20 13027 71.64 6012 6.17 6
uo2      7 den=10.38 1.0 293 92235 4.742 92238 95.258
al       8 den=2.651
al       9 1.0
end comp
squarepitch 1.6 0.79 1 3 0.94 2 0.82 0
more data res=7 cylinder 0.395 dan(7)=0.991436 end more
4-18x18 assemblies separated by 0.65-cm-thick Boral plates and 3.6 cm
'of water, plate-to-assembly distance of 0.8 cm, assemblies separated
'from stainless steel reflecting walls by 3.95 cm of water, 61.84 cm
'water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

```

read geom

unit 1

cylinder 7 1 0.395	28.16 0.0
cylinder 0 1 0.410	28.16 0.0
cylinder 2 1 0.470	28.16 0.0
cuboid 0 1 4p0.800	28.16 0.0

unit 2

cylinder 1 1 0.395	61.84 0.0
cylinder 0 1 0.410	61.84 0.0
cylinder 2 1 0.470	61.84 0.0
cuboid 3 1 4p0.800	61.84 0.0

unit 3

cylinder 9 1 0.470	0.25 0.0
cylinder 3 1 0.500	0.25 0.0
cuboid 5 1 4p0.800	0.25 0.0

unit 4

cylinder 9 1 0.470	1.95 0.4
cuboid 3 1 4p0.800	1.95 0.4
cuboid 5 1 4p0.800	1.95 0.0

unit 5

array 1 3*0.0

unit 6

cylinder 5 1 0.500	64.04 0.4
cuboid 3 1 4p0.800	64.04 0.4
cuboid 5 1 4p0.800	64.04 0.0

unit 7

array 2 3*0.0

reflector 8 1 4r0.11 2r0 1
reflector 6 1 4r0.43 2r0 1
reflector 8 1 4r0.11 2r0 1

unit 8

cuboid 3 1 2.0 0.0 30.1 0.0 64.04 0.4

```

end fill
cuboid    5 1 2.0 0.0 30.1 0.0 64.04 0.0
unit 9
array 3 3*0.0
unit 10
cuboid   3 1 62.2 0.0 2.0 0.0 64.04 0.4
cuboid   5 1 62.2 0.0 2.0 0.0 64.04 0.0
unit 11
array 4 3*0.0
reflector 3 1 4r2.50 2r0.0    1
reflector 4 1 4r15.0 2r0.0    1
reflector 3 1 4r13.7 2r0.0    1
reflector 5 1 5r0.0 0.8      1
reflector 3 1 5r0.0 20.0     1
unit 12
cylinder 5 1 0.500           28.16 0.0
cuboid   0 1 4p0.800          28.16 0.0
unit 13
array 5 3*0.0
reflector 8 1 4r0.11 2r0 1
reflector 6 1 4r0.43 2r0 1
reflector 8 1 4r0.11 2r0 1
unit 14
cuboid   0 1 2.0 0.0 30.1 0.0 28.16 0.0
unit 15
array 6 3*0.0
unit 16
cuboid   0 1 62.2 0.0 2.0 0.0 28.16 0.0
unit 17
array 7 3*0.0
reflector 0 1 4r2.50 2r0.0    1
reflector 4 1 4r15.0 2r0.0    1
reflector 0 1 4r13.7 2r0.0    1
global unit 18
array 8 3*0.0
end geom

read array
ara=1 nux=1 nuy=1 nuz=3 fill 4 3 2
fill
ara=2 nux=18 nuy=18 nuz=1 fill 6 16r5 6 18r5 15q18 6 16r5 6
fill
ara=3 nux=3 nuy=1 nuz=1 fill 7 8 7
fill
ara=4 nux=1 nuy=3 nuz=1 fill 9 10 9
fill
ara=5 nux=18 nuy=18 nuz=1 fill 12 16r1 12 18r1 15q18 12 16r1 12
fill
ara=6 nux=3 nuy=1 nuz=1 fill 13 14 13
fill
ara=7 nux=1 nuy=3 nuz=1 fill 15 16 15
fill
ara=8 nux=1 nuy=1 nuz=2 fill 11 17
fill
end array
end data
end



w3269a


=csas25
w3269a
44group latticecell

```

```

uo2    1  0.930 293 92235 5.70 92238 94.30
ss304  2  1.0
h2o    3  1.0
al     4  1.0
uo2    5  0.930 293 92235 5.70 92238 94.30
arbmaginced 9.91 3 0 0 1 47000 79.60 49000 15.17 48000 5.08 6
end comp
squarepitch 1.4224 0.9068 1 3 0.9931 2 0.9169 0
more data dan(5)=.927954 res=5 cyl .4534 end more
Core of 453 fuel rods, 6-1.024-cm-diam Ag-In-Cd rods, 88.27 cm water 'height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 .4534      45.72  0.0
cylinder 0 1 .4585      45.72  0.0
cylinder 2 1 .4966      45.72 -1.27
cuboid   3 1 4p.7112     45.72 -1.27
unit 2
cylinder 1 1 .4534      0.635  0.0
cylinder 0 1 .4585      0.635  0.0
cylinder 2 1 .4966      0.635  0.0
cuboid   4 1 4p.7112     0.635  0.0
unit 3
cylinder 1 1 .4534      36.34  0.0
cylinder 0 1 .4585      36.34  0.0
cylinder 2 1 .4966      36.34  0.0
cuboid   3 1 4p.7112     36.34  0.0
unit 4
cylinder 5 1 .4534      92.964 88.27
cylinder 0 1 .4585      92.964 88.27
cylinder 2 1 .4966      93.979 88.27
cuboid   0 1 4p.7112     93.979 88.27
unit 5
cylinder 6 1 .5118      45.72 -1.27
cuboid   3 1 4p.7112     45.72 -1.27
unit 6
cylinder 6 1 .5118      0.635  0.0
cuboid   4 1 4p.7112     0.635  0.0
unit 7
cylinder 6 1 .5118      36.34  0.0
cuboid   3 1 4p.7112     36.34  0.0
unit 8
cylinder 6 1 .5118      93.979 88.27
cuboid   0 1 4p.7112     93.979 88.27
unit 9
array 1 3*0.0
reflector 3 1 2r11.2776 2r18.3896 2r0 1
reflector 4 1 5r0 3.175   1
reflector 3 1 2r3.7224 3r0 6.35   1
reflector 4 1 5r0 5.08   1
unit 10
array 2 3*0.0
reflector 4 1 2r11.2776 2r18.3896 2r0 1
reflector 3 1 2r3.7224   4r0 1
unit 11
array 3 3*0.0
reflector 3 1 2r15. 2r18.3896 2r0 1
unit 12
array 4 3*0.0
reflector 0 1 2r15. 2r18.3896 2r0 1
reflector 4 1 4r0 1.27 0  1
end
global
unit 13
array 5 3*0.0
end geom

read array
ara=1 nux=27 nuy=17 nuz=1 fill
113r1 5 7r1 5 7r1 5 199r1 5 7r1 5 7r1 5 113r1 end fill
ara=2 nux=27 nuy=17 nuz=1 fill
113r2 6 7r2 6 7r2 6 199r2 6 7r2 6 7r2 6 113r2 end fill
ara=3 nux=27 nuy=17 nuz=1 fill
113r3 7 7r3 7 7r3 7 199r3 7 7r3 7 7r3 7 113r3 end fill
ara=4 nux=27 nuy=17 nuz=1 fill
113r4 8 7r4 8 7r4 8 199r4 8 7r4 8 7r4 8 113r4 end fill
ara=5 nux=1 nuy=1 nuz=4
fill 9 10 11 12
end fill
end array
end data
end

w3269b1

=csas2x
w3269b1
44group latticecell
uo2      1 0.950 293 92235 3.70 92238 96.30
end
ss304    2 1.0
end
h2o      3 1.0
end
arbmaginced 9.91 3 0 0 1 47000 79.60 49000 15.17 48000 5.08 4
end
al       5
end
h2o      6
end
uo2      7 0.950 293 92235 3.70 92238 96.30
end
ss304    8 1.0
end
uo2      9 0.950 293 92235 3.70 92238 96.30
end
end comp
squarepitch 1.1049 0.754 1 3 0.8555 2 0.7788 0
end
more data dan(7)=.301909 res=7 cyl .3772
dan(9)=.924574 res=10 cyl .3772 end more
Core of 2221 fuel rods, 12-0.838-cm-diam Ag-In-Cd rods, 55.41 cm water
'height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 7 1 0.3772          35.88  0.00
cylinder 0 1 0.3894          35.88  0.00
cylinder 8 1 0.4300          35.88  0.00
cuboid   6 1 4p.5525          35.88  0.00
unit 2
cuboid   500 1 4p.5525        35.88  0.00
unit 3
cylinder 4 1 0.4191          35.88  0.00

```

```

cuboid 6 1 4p.5525          35.88  0.00
unit 4
cuboid 6 1 4p.5525          35.88  0.00
unit 5
cylinder 7 1 0.3772         1.27   0.00
cylinder 0 1 0.3894         1.27   0.00
cylinder 8 1 0.4300         1.27   0.00
cuboid 5 1 4p.5525          1.27   0.00
unit 6
cuboid 500 1 4p.5525        1.27   0.00
unit 7
cylinder 4 1 0.4191         1.27   0.00
cuboid 5 1 4p.5525          1.27   0.00
unit 8
cuboid 5 1 4p.5525          1.27   0.00
unit 9
cylinder 7 1 0.3772         18.26  0.00
cylinder 0 1 0.3894         18.26  0.00
cylinder 8 1 0.4300         18.26  0.00
cuboid 6 1 4p.5525          18.26  0.00
unit 10
cuboid 500 1 4p.5525        18.26  0.00
unit 11
cylinder 4 1 0.4191         18.26  0.00
cuboid 6 1 4p.5525          18.26  0.00
unit 12
cuboid 6 1 4p.5525          18.26  0.00
unit 13
cylinder 9 1 0.377           121.92 55.41
cylinder 0 1 0.389           121.92 55.41
cylinder 8 1 0.430           121.92 55.41
cuboid 0 1 4p.5525          121.92 55.41
unit 14
cuboid 500 1 4p.5525        121.92 55.41
unit 15
cylinder 4 1 0.4191         121.92 55.41
cuboid 0 1 4p.5525          121.92 55.41
unit 16
cuboid 0 1 4p.5525          121.92 55.41
unit 17
array 1 3*0.0
reflector 6 1 2r19.8882 2r26.5176 0 10.16 1
reflector 5 1 5r0.0           2.54   1
unit 18
array 2 3*0.0
reflector 5 1 4r2.1303      2r0.0   1
reflector 6 1 2r17.7579 2r24.3873 2r0.0   1
unit 19
array 3 3*0.0
reflector 6 1 2r19.8882 2r26.5176 2r0.0   1
unit 20
array 4 3*0.0
reflector 0 1 2r19.8882 2r26.5176 10.16 0 1
reflector 5 1 4r0.             2.54  0.0 1
global unit 21
array 5 3*0.0
end geometry

read array
ara=1 nux=53 nuy=53 nuz=1 fill
9r4 2 33r4 2 9r4 2q53
3r4 6r1 2 33r1 2 6r1 3r4 5q53
19r2 15r1 19r2
3r4 6r1 2 33r1 2 6r1 3r4 8q53
3r4 47r1 3r4 3q53
3r4 20r1 3 1 3q2 19r1 3r4
3r4 47r1 3r4 20r1 3 20r1 3r4
3r4 47r1 3r4 53b1378 end fill
ara=2 nux=53 nuy=53 nuz=1 fill
9r8 6 33r8 6 9r8 2q53
3r8 6r5 6 33r5 6 6r5 3r8 5q53
19r6 15r5 19r6
3r8 6r5 6 33r5 6 6r5 3r8 8q53
3r8 47r5 3r8 3q53
3r8 20r5 7 5 3q2 19r5 3r8
3r8 47r5 3r8 20r5 7 5r5 7 20r5 3r8
53b1378 end fill
ara=3 nux=53 nuy=53 nuz=1 fill
9r12 10 33r12 10 9r10 2q53
3r12 6r9 10 33r9 10 6r9 3r12 5q53
19r10 15r9 19r10
3r12 6r9 10 33r9 10 6r9 3r12 8q53
3r12 47r9 3r12 3q53
3r12 20r9 11 9 3q2 19r9 3r12
3r12 47r9 3r12 20r9 11 5r9 11 20r9 3r12
3r12 47r9 3r12 53b1378 end fill
ara=4 nux=53 nuy=53 nuz=1 fill
9r16 14 33r16 14 9r14 2q53
3r16 6r13 14 33r13 14 6r13 3r16 5q53
19r14 15r13 19r14
3r16 6r13 14 33r13 14 6r13 3r16 8q53
3r16 47r13 3r16 3q53
3r16 20r13 15 13 3q2 19r13 3r16
3r16 47r13 3r16 20r13 15 5r13 15 20r13 3r16
3r16 47r13 3r16 53b1378 end fill
ara=5 nux=1 nuy=1 nuz=4
fill 17 18 19 20 end fill
end array
end data
end

w3269b2
=csas2x
w3269b2
44group latticecell
uo2 1 0.950 293 92235 3.70 92238 96.30
end
ss304 2 1.0
end
h2o 3 1.0
end
arbmagincd 9.91 3 0 0 1 47000 79.60 49000 15.17 48000 5.08 4
end
al 5 1.0
end

```

```

h2o      6 1.0
uo2      7 0.950 293 92235 3.70 92238 96.30
ss304    8 1.0
uo2      9 0.950 293 92235 3.70 92238 96.30
end comp
squarepitch 1.1049 0.754 1 3 0.8555 2 0.7788 0
more data dan(7)=.301909 res=7 cyl .3772
dan(9)=.924574 res=10 cyl .3772 end more
Core of 2209 fuel rods, 24-0.838-cm-diam Ag-In-Cd rods, 64.56 cm water 'height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 7 1 0.3772          35.88 0.00
cylinder 0 1 0.3894          35.88 0.00
cylinder 8 1 0.4300          35.88 0.00
cuboid   6 1 4p.5525          35.88 0.00
unit 2
cuboid   500 1 4p.5525        35.88 0.00
unit 3
cylinder 4 1 0.4191          35.88 0.00
cuboid   6 1 4p.5525          35.88 0.00
unit 4
cuboid   6 1 4p.5525          35.88 0.00
unit 5
cylinder 7 1 0.3772          1.27 0.00
cylinder 0 1 0.3894          1.27 0.00
cylinder 8 1 0.4300          1.27 0.00
cuboid   5 1 4p.5525          1.27 0.00
unit 6
cuboid   500 1 4p.5525        1.27 0.00
unit 7
cylinder 4 1 0.4191          1.27 0.00
cuboid   5 1 4p.5525          1.27 0.00
unit 8
cuboid   5 1 4p.5525          1.27 0.00
unit 9
cylinder 7 1 0.3772          27.41 0.00
cylinder 0 1 0.3894          27.41 0.00
cylinder 8 1 0.4300          27.41 0.00
cuboid   6 1 4p.5525          27.41 0.00
unit 10
cuboid   500 1 4p.5525        27.41 0.00
unit 11
cylinder 4 1 0.4191          27.41 0.00
cuboid   6 1 4p.5525          27.41 0.00
unit 12
cuboid   6 1 4p.5525          27.41 0.00
unit 13
cylinder 9 1 0.377           121.92 64.56
cylinder 0 1 0.389           121.92 64.56
cylinder 8 1 0.430           121.92 64.56
cuboid   0 1 4p.5525          121.92 64.56
unit 14
cuboid   500 1 4p.5525        121.92 64.56
unit 15
cylinder 4 1 0.4191          121.92 64.56
cuboid   0 1 4p.5525          121.92 64.56
unit 16
cuboid   0 1 4p.5525          121.92 64.56
unit 17
array 1 3*0.0

end
reflector 6 1 2r19.8882 2r26.5176 0 10.16 1
reflector 5 1 5r0.0          2.54 1
unit 18
array 2 3*0.0
reflector 5 1 4r2.1303       2r0.0 1
reflector 6 1 2r17.7579 2r24.3873 2r0.0 1
unit 19
array 3 3*0.0
reflector 6 1 2r19.8882 2r26.5176 2r0.0 1
unit 20
array 4 3*0.0
reflector 0 1 2r19.8882 2r26.5176 10.16 0 1
reflector 5 1 4r0.          2.54 0.0 1
global unit 21
array 5 3*0.0
end geometry

read array
ara=1 nux=53 nuy=53 nuz=1 fill
9r4   2 33r4   2 9r4   2q53
3r4   6r1   2 33rl   2 6rl 3r4 5q53
19r2  15rl 19r2
3r4   6r1   2 33rl   2 6rl 3r4 8q53
3r4   47rl 3r4 3q53
3r4   20rl 3 1 3q2 19rl 3r4
3r4   47rl 3r4
3r4   20rl 3 5rl   3 20rl 3r4
3r4   47rl 3r4
3r4   6rl 2 1 3 1 3q2 24rl 2 6rl 3r4
3r4   6rl 2 33rl 2 6rl 3r4
3r4   6rl 2 1 3 5rl 3 25rl 2 6rl 3r4
3r4   6rl 2 33rl 2 6rl 3r4
3r4   6rl 2 33rl 2 6rl 3r4
19r2  15rl 19r2
3r4   6rl 2 33rl 2 6rl 3r4 5q53
9r4   2 33r4   2 9r4   2q53
end fill
ara=2 nux=53 nuy=53 nuz=1 fill
9r8   6 33r8   6 9r8   2q53
3r8   6r5 6 33r5   6 6r5 3r8 5q53
19r6  15r5 19r6
3r8   6r5 6 33r5   6 6r5 3r8 8q53
3r8   47r5 3r8 3q53
3r8   20r5 7 5 3q2 19r5 3r8
3r8   47r5 3r8
3r8   20r5 7 5r5   7 20r5 3r8
3r8   47r5 3r8
3r8   6r5 6 5 7 5 3q2 24r5 6 6r5 3r8
3r8   6r5 6 33r5 6 6r5 3r8
3r8   6r5 6 5 7 5r5 7 25r5 6 6r5 3r8
3r8   6r5 6 33r5 6 6r5 3r8
3r8   6r5 6 5 7 5r5 7 25r5 6 6r5 3r8
3r8   6r5 6 33r5 6 6r5 3r8
19r6  15r5 19r6
3r8   6r5 6 33r5 6 6r5 3r8 5q53
9r8   6 33r8   6 9r8   2q53
end fill

```

```

ara=3 nux=53 nuy=53 nuz=1 fill
 9r12    10 33r12   10 9r12   2q53
 3r12    6r9     10 33r9    10 6r9   3r12 5q53
19r10   15r9   19r10
 3r12    6r9     10 33r9    10 6r9   3r12 8q53
 3r12   47r9   3r12 3q53
 3r12   20r9    11   9   3q2   19r9   3r12
 3r12   47r9   3r12
 3r12   20r9    11   5r9   11 20r9   3r12
 3r12   47r9   3r12                               53b424
 3r12   6r9     10   9    11   9   3q2   24r9   10 6r9   3r12
 3r12   6r9     10 33r9    10 6r9   3r12
 3r12   6r9     10   9    11   5r9   11 25r9   10 6r9   3r12
 3r12   6r9     10 33r9    10 6r9   3r12
 3r12   6r9     10   9    11   5r9   11 25r9   10 6r9   3r12
 3r12   6r9     10 33r9    10 6r9   3r12
 3r12   6r9     10 33r9    10 6r9   3r12
19r10   15r9   19r10
 3r12   6r9     10 33r9    10 6r9   3r12 5q53
 9r12    10 33r12   10 9r12   2q53
end fill
ara=4 nux=53 nuy=53 nuz=1 fill
 9r16    14 33r16   14 9r16   2q53
 3r16   6r13   14 33r13   14 6r13   3r16 5q53
19r14   15r13   19r14
 3r16   6r13   14 33r13   14 6r13   3r16 8q53
 3r16   47r13   3r16 3q53
 3r16   20r13   15   13   3q2   19r13   3r16
 3r16   47r13   3r16
 3r16   20r13   15   5r13   15 20r13   3r16
 3r16   47r13   3r16                               53b424
 3r16   6r13   14   13   15   13   3q2   24r13   14 6r13   3r16
 3r16   6r13   14 33r13   14 6r13   3r16
 3r16   6r13   14   13   15   5r13   15 25r13   14 6r13   3r16
 3r16   6r13   14 33r13   14 6r13   3r16
 3r16   6r13   14   13   15   5r13   15 25r13   14 6r13   3r16
 3r16   6r13   14 33r13   14 6r13   3r16
 3r16   6r13   14   13   15   13   3q2   24r13   14 6r13   3r16
 3r16   6r13   14 33r13   14 6r13   3r16
19r14   15r13   19r14
 3r16   6r13   14 33r13   14 6r13   3r16 5q53
 9r16    14 33r16   14 9r16   2q53
end fill
ara=5 nux=1 nuy=1 nuz=4 fill 17 18 19 20 end fill
end array
end data
end

```

w3269b3

```

=csas2x
w3269b3
44group      latticecell
uo2      1 0.950 293 92235 3.70 92238 96.30
ss304    2 1.0
h2o      3 1.0
arbmaginbcd 9.91 3 0 0 1 47000 79.60 49000 15.17 48000 5.08 4
al       5 1.0
h2o      6 1.0
uo2      7 0.950 293 92235 3.70 92238 96.30
ss304    8 1.0

```

```

uo2      9 0.950 293 92235 3.70 92238 96.30
end
end comp
squarepitch 1.1049 0.754 1 3 0.8555 2 0.7788 0
more data dan(7)=.301909 res=7 cyl .3772
dan(9)=.924574 res=10 cyl .3772
end more
Core of 2185 fuel rods, 48-0.838-cm-diam Ag-In-Cd rods, 57.00 cm water
'height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm
read geom
unit 1
cylinder 7 1 0.3772          35.88 0.00
cylinder 0 1 0.3894          35.88 0.00
cylinder 8 1 0.4300          35.88 0.00
cuboid   6 1 4p.5525          35.88 0.00
unit 2
cuboid   500 1 4p.5525        35.88 0.00
unit 3
cylinder 4 1 0.4191          35.88 0.00
cuboid   6 1 4p.5525          35.88 0.00
unit 4
cuboid   6 1 4p.5525          35.88 0.00
unit 5
cylinder 7 1 0.3772          1.27 0.00
cylinder 0 1 0.3894          1.27 0.00
cylinder 8 1 0.4300          1.27 0.00
cuboid   5 1 4p.5525          1.27 0.00
unit 6
cuboid   500 1 4p.5525        1.27 0.00
unit 7
cylinder 4 1 0.4191          1.27 0.00
cuboid   5 1 4p.5525          1.27 0.00
unit 8
cuboid   5 1 4p.5525          1.27 0.00
unit 9
cylinder 7 1 0.3772          19.85 0.00
cylinder 0 1 0.3894          19.85 0.00
cylinder 8 1 0.4300          19.85 0.00
cuboid   6 1 4p.5525          19.85 0.00
unit 10
cuboid   500 1 4p.5525        19.85 0.00
unit 11
cylinder 4 1 0.4191          19.85 0.00
cuboid   6 1 4p.5525          19.85 0.00
unit 12
cuboid   6 1 4p.5525          19.85 0.00
unit 13
cylinder 9 1 0.377           121.92 57.00
cylinder 0 1 0.389           121.92 57.00
cylinder 8 1 0.430           121.92 57.00
cuboid   0 1 4p.5525          121.92 57.00
unit 14
cuboid   500 1 4p.5525        121.92 57.00
unit 15
cylinder 4 1 0.4191          121.92 57.00
cuboid   0 1 4p.5525          121.92 57.00
unit 16
cuboid   0 1 4p.5525          121.92 57.00
unit 17
array 1 3*0.0

```

```

reflector 6 1 2r19.8882 2r26.5176 0 10.16 1
reflector 5 1 5r0.0 2.54 1
unit 18
array 2 3*0.0
reflector 5 1 4r2.1303 2r0.0 1
reflector 6 1 2r17.7579 2r24.3873 2r0.0 1
unit 19
array 3 3*0.0
reflector 6 1 2r19.8882 2r26.5176 2r0.0 1
unit 20
array 4 3*0.0
reflector 0 1 2r19.8882 2r26.5176 10.16 0 1
reflector 5 1 4r0. 2.54 0.0 1
global unit 21
array 5 3*0.0
end geometry

read array
ara=1 nux=53 nuy=53 nuz=1 fill
 9r4 2 33r4 2 9r4 2q53
 3r4 6rl 2 33rl 2 6rl 3r4 4q53
 3r4 5rl 3 2 3 1 2q2 2lrl 1 3 2q2 2 3 5rl 3r4
19r2 15rl 19r2
 3r4 5rl 3 2 4rl 3 23rl 3 4rl 2 3 5rl 3r4
 3r4 6rl 2 33rl 2 6rl 3r4 1q106
 3r4 5rl 3 2 3 1 2q2 2lrl 1 3 2q2 2 3 5rl 3r4
 3r4 6rl 2 33rl 2 6rl 3r4 3q53
 3r4 47rl 3r4 14q53
 3r4 6rl 2 33rl 2 6rl 3r4 3q53
 3r4 5rl 3 2 3 1 2q2 2lrl 1 3 2q2 2 3 5rl 3r4
 3r4 6rl 2 33rl 2 6rl 3r4
 3r4 5rl 3 2 4rl 3 23rl 3 4rl 2 3 5rl 3r4 1q106
19r2 15rl 19r2
 3r4 5rl 3 2 3 1 2q2 2lrl 1 3 2q2 2 3 5rl 3r4
 3r4 6rl 2 33rl 2 6rl 3r4 4q53
 9r4 2 33r4 2 9r4 2q53 end fill
ara=2 nux=53 nuy=53 nuz=1 fill
 9r8 6 33r8 6 9r8 2q53
 3r8 6r5 6 33r5 6 6r5 3r8 4q53
 3r8 5r5 7 6 7 5 2q2 2lrl 5 7 2q2 6 7 5r5 3r8
19r6 15r5 19r6
 3r8 5r5 7 6 4r5 7 23r5 7 4r5 6 7 5r5 3r8
 3r8 6r5 6 33r5 6 6r5 3r8 1q106
 3r8 5r5 7 6 7 5 2q2 2lrl 5 7 2q2 6 7 5r5 3r8
 3r8 6r5 6 33r5 6 6r5 3r8 3q53
 3r8 47r5 3r8 14q53
 3r8 6r5 6 33r5 6 6r5 3r8 3q53
 3r8 5r5 7 6 7 5 2q2 2lrl 5 7 2q2 6 7 5r5 3r8
 3r8 6r5 6 33r5 6 6r5 3r8
 3r8 5r5 7 6 4r5 7 23r5 7 4r5 6 7 5r5 3r8 1q106
19r6 15r5 19r6
 3r8 5r5 7 6 7 5 2q2 2lrl 5 7 2q2 6 7 5r5 3r8
 3r8 6r5 6 33r5 6 6r5 3r8 4q53
 9r8 6 33r8 6 9r8 2q53 end fill
ara=3 nux=53 nuy=53 nuz=1 fill
 9r12 10 33rl 10 9rl 2q53
 3r12 6r9 10 33r9 10 6rl 3r12 4q53
 3r12 5r9 11 10 11 9 2q2 2lrl 9 11 2q2 10 11 5r9 3r12
19r10 15r9 19r10
 3r12 5r9 11 10 4rl 11 23r9 11 4rl 10 11 5r9 3r12
 3r12 6r9 10 33r9 10 6rl 3r12 1q106
 3r12 5r9 11 10 11 9 2q2 2lrl 9 11 2q2 10 11 5r9 3r12
 3r12 6r9 10 33r9 10 6rl 3r12 1q106
 3r12 5r9 11 10 4rl 11 23r9 11 4rl 10 11 5r9 3r12
 3r12 6r9 10 33r9 10 6rl 3r12 3q53
 3r12 47rl 3r12 14q53
 3r12 6r9 10 33r9 10 6rl 3r12 3q53
 3r12 5r9 11 10 11 9 2q2 2lrl 9 11 2q2 10 11 5r9 3r12
 3r12 6r9 10 33r9 10 6rl 3r12
 3r12 5r9 11 10 4rl 11 23r9 11 4rl 10 11 5r9 3r12 1q106
 19r10 15r9 19r10
 3r12 5r9 11 10 11 9 2q2 2lrl 9 11 2q2 10 11 5r9 3r12
 3r12 6r9 10 33r9 10 6rl 3r12 4q53
 9r12 10 33rl 10 9rl 2q53 end fill
ara=4 nux=53 nuy=53 nuz=1 fill
 9r16 14 33r16 14 9rl 2q53
 3r16 6rl 13 14 33rl 13 14 6rl 13 3r16 4q53
 3r16 5rl 13 15 14 15 13 2q2 2lrl 13 13 15 2q2 14 15 5rl 13 3r16
 19r14 15rl 13 19rl 14
 3r16 5rl 13 15 14 4rl 13 15 23rl 13 15 4rl 13 14 15 5rl 13 3r16
 3r16 6rl 13 14 33rl 13 14 6rl 13 3r16 1q106
 3r16 5rl 13 15 14 15 13 2q2 2lrl 13 13 15 2q2 14 15 5rl 13 3r16
 3r16 6rl 13 14 33rl 13 14 6rl 13 3r16 3q53
 3r16 47rl 13 3r16 14q53
 3r16 6rl 13 14 33rl 13 14 6rl 13 3r16 3q53
 3r16 5rl 13 15 14 15 13 2q2 2lrl 13 13 15 2q2 14 15 5rl 13 3r16
 3r16 6rl 13 14 33rl 13 14 6rl 13 3r16
 3r16 5rl 13 15 14 4rl 13 15 23rl 13 15 4rl 13 14 15 5rl 13 3r16 1q106
 19r14 15rl 13 19rl 14
 3r16 5rl 13 15 14 15 13 2q2 2lrl 13 13 15 2q2 14 15 5rl 13 3r16
 3r16 6rl 13 14 33rl 13 14 6rl 13 3r16 4q53
 9r16 14 33r16 14 9rl 16 2q53 end fill
ara=5 nux=1 nuy=1 nuz=4
fill 17 18 19 20 end fill
end array
end data
end

w3269c

=csas25
w3269c
44group latticecell
uo2 1 0.950 293 92235 2.72 92238 97.28
end
arbmzir2 6.50 4 0 0 1 40000 98.20 26000 0.21 50000 1.4 24000
 0.10 2
end
h2o 3 1.0
end
arbmagincd 9.91 3 0 0 1 47000 79.60 49000 15.17 48000 5.08 4
end
al 5 1.0
end
uo2 6 0.950 293 92235 2.72 92238 97.28
end
end comp
squarepitch 1.524 1.016 1 3 1.189 2 1.0297 0
end
more data res=6 cyl .508 dan(6)=.948580 end more
Core of 945 fuel rods, 16-1.024-cm-diam Ag-In-Cd rods, 89.75 cm water
'height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm
read geom
unit 1

```

```

cylinder 1 1 0.5080      72.93  0.00
cylinder 0 1 0.5149      72.93  0.00
cylinder 2 1 0.5947      72.93 -2.07
cuboid   3 1 4p.762       72.93 -2.07
unit 2
cylinder 1 1 0.5080      0.63   0.00
cylinder 0 1 0.5149      0.63   0.00
cylinder 2 1 0.5947      0.63   0.00
cuboid   5 1 4p.762       0.63   0.00
unit 3
cylinder 1 1 0.5080      16.19  0.00
cylinder 0 1 0.5149      16.19  0.00
cylinder 2 1 0.5947      16.19  0.00
cuboid   3 1 4p.762       16.19  0.00
unit 4
cylinder 6 1 0.5080      32.17  0.00
cylinder 0 1 0.5149      32.17  0.00
cylinder 2 1 0.5947      47.17  0.00
cuboid   0 1 4p.762       47.17  0.00
unit 5
cylinder 4 1 0.5118      72.93 -2.07
cuboid   3 1 4p.762       72.93 -2.07
unit 6
cylinder 4 1 0.5118      0.63   0.00
cuboid   5 1 4p.762       0.63   0.00
unit 7
cylinder 4 1 0.5118      16.19  0.00
cuboid   3 1 4p.762       16.19  0.00
unit 8
cylinder 4 1 0.5118      32.17  0.00
cuboid   0 1 4p.762       47.17  0.00
unit 9
array 1 3*0.0
reflector 3 1 4r6.858    2r0 1
reflector 5 1 5r0          1.27 1
reflector 3 1 4r8.142    0 .48 1
reflector 5 1 5r0          5.08 1
unit 10
array 2 3*0.0
reflector 5 1 4r6.858    2r0 1
reflector 3 1 4r8.142    2r0 1
unit 11
array 3 3*0.0
reflector 3 1 4r15.0     2r0 1
unit 12
array 4 3*0.0
reflector 0 1 4r15.0     2r0 1
global
unit 13
array 5 3*0.0
end geom

read array
ara=1 nux=31 nuy=31 nuz=1 fill
31rl 9q31 10r1 5 2rl 3q3 9rl 31rl 12rl 5 4rl 5 13rl 10rl 5 8rl 5 11rl
31rl 1b464 32rl end fill
ara=2 nux=31 nuy=31 nuz=1 fill
31r2 9q31 10r2 6 2rl 3q3 9r2 31r2 12r2 6 4rl 6 13rl 10r2 6 8rl 6 11rl
31r2 1b464 32rl end fill
ara=3 nux=31 nuy=31 nuz=1 fill
31r3 9q31 10r3 7 2rl 3q3 9r3 31r3 12r3 7 4rl 7 13rl 10r3 7 8rl 7 11rl
31r3 1b464 32rl end fill

ara=4 nux=31 nuy=31 nuz=1 fill
31rl 9q31 10r4 8 2rl 3q3 9rl 31rl 12rl 8 4rl 8 13rl 10r4 8 8rl 8
11rl
31rl 1b464 32rl end fill
ara=5 nux=1 nuy=1 nuz=4
fill 9 10 11 12 end fill
end array
end data
end

w3269s11

=csas25
w3269s11
44group latticecell
uo2   1 0.950 293 92235 2.72 92238 97.28
end
arbmzir2 6.50 4 0 0 1 40000 98.20 26000 0.21 50000 1.4 24000
0.10 2
end
h2o   3 1.0
end
al    4 1.0
end
uo2   5 0.950 293 92235 2.72 92238 97.28
end
end comp
squarepitch 1.524 1.016 1 3 1.189 2 1.030 0
end more data res=5 cyl .508 dan(5)=.948684 end more
Core of 31x31 fuel rods, 38.58 cm water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.508          38.58  0.00
cylinder 0 1 0.515          38.58  0.00
cylinder 2 1 0.5945         38.58 -2.07
cuboid   3 1 4p.762          38.58 -2.07
unit 2
cylinder 5 1 0.508          121.92 38.58
cylinder 0 1 0.515          121.92 38.58
cylinder 2 1 0.5945         121.92 38.58
cuboid   0 1 4p.762          121.92 38.58
unit 3
array 1 3*0.0
unit 4
array 2 3*0.0
global unit 5
array 3 3*0.0
reflector 3 1 4r13.72 2r0 1
reflector 4 1 5r0.0 1.27 1
reflector 3 1 4r15 0 0.48 1
reflector 4 1 5r0.0 5.08 1
end geometry

read array
ara=1 nux=31 nuy=31 nuz=1 fill 31rl 30q31 end fill
ara=2 nux=31 nuy=31 nuz=1 fill 31r2 30q31 end fill
ara=3 nux=1 nuy=1 nuz=2 fill 3 4           end fill
end array
end data
end

```

```

w3269s12

=csas25
w3269s12
44group    latticecell
uo2      1 0.930 293 92235 5.70 92238 94.30
ss304    2 1.0
h2o      3 1.0
al       4 1.0
uo2      5 0.930 293 92235 5.70 92238 94.30
end comp
squarepitch 1.4224 0.9068 1 3 0.9931 2 0.9169 0
more data dan(5)=.927954 res=5 cyl .4534 end more
Core of 27x17 fuel rods, 52.97 cm water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 .4534      45.72   0.0
cylinder 0 1 .4585      45.72   0.0
cylinder 2 1 .4966      45.72  -1.27
cuboid   3 1 4p.7112     45.72  -1.27
unit 2
array 1 3*0.0
reflector 3 1 4r15.0 2r0. 1
reflector 4 1 5r0.0 3.175 1
reflector 3 1 5r0.0 6.350 1
reflector 4 1 5r0.0 5.080 1
unit 3
cylinder 1 1 .4534      0.653   0.0
cylinder 0 1 .4585      0.653   0.0
cylinder 2 1 .4966      0.653   0.0
cuboid   4 1 4p.7112     0.653   0.0
unit 4
array 2 3*0.0
reflector 4 1 4r15.0 2r0. 1
unit 5
cylinder 1 1 .4534      6.597   0.0
cuboid   3 1 4p.7112     6.597   0.0
unit 6
array 3 3*0.0
reflector 3 1 4r15.0 2r0. 1
unit 7
cylinder 5 1 .4534      39.994  0.0
cylinder 0 1 .4585      39.994  0.0
cylinder 2 1 .4966      41.009  0.0
cuboid   0 1 4p.7112     41.009  0.0
unit 8
array 4 3*0.0
reflector 0 1 4r15.0 2r0. 1
reflector 4 1 4r0  1.27 0 1
global
unit 9
array 5 3*0.0
end geom

read array
ara=1 nux=27 nuy=17 nuz=1 fill 459rl end fill
ara=2 nux=27 nuy=17 nuz=1 fill 459r3 end fill
ara=3 nux=27 nuy=17 nuz=1 fill 459r5 end fill
ara=4 nux=27 nuy=17 nuz=1 fill 459r7 end fill
ara=5 nux=1 nuy=1 nuz=4 fill 2 4 6 8 end fill

end array
end data
end

w3269w1

=csas25
w3269w1
44group    latticecell
uo2      1 0.950 293 92235 2.72 92238 97.28
end
arbomzir2 6.50 4 0 0 1 40000 98.20 26000 0.21 50000 1.4 24000
0.10 2
end
h2o      3 1.0
end
al       4 1.0
end
uo2      5 0.950 293 92235 2.72 92238 97.28
end
end comp
squarepitch 1.524 1.016 1 3 1.189 2 1.030 0
more data res=5 cyl .508 dan(5)=.948684 end more
Core of 945 fuel rods, 16 water holes, 37.21 cm water height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 0.508          37.21   0.00
cylinder 0 1 0.515          37.21   0.00
cylinder 2 1 0.5945         37.21  -2.07
cuboid   3 1 4p.762          37.21  -2.07
unit 2
cylinder 5 1 0.508          121.92  37.21
cylinder 0 1 0.515          121.92  37.21
cylinder 2 1 0.5945         121.92  37.21
cuboid   0 1 4p.762          121.92  37.21
unit 3
cuboid   3 1 4p.762          37.21  -2.07
unit 4
array 1 3*0.0
unit 5
array 2 3*0.0
global unit 6
array 3 3*0.0
reflector 3 1 4r13.72 2r0  1
reflector 4 1 5r0.0  1.27 1
reflector 3 1 4r15 0  0.48 1
reflector 4 1 5r0.0  5.08 1
end geometry

read array
ara=1 nux=31 nuy=31 nuz=1 fill
310rl
10rl 3 2rl 3q3 9rl
31rl
12rl 3 4rl 3 13rl
10rl 3 8rl 3 11rl
62rl
10rl 3 8rl 3 11rl
12rl 3 4rl 3 13rl
31rl

```

```

10r1 3 2r1 3q3 9r1
341rl
end fill
ara=2 nux=31 nuy=31 nuz=1 fill 31r2 30q31 end fill
ara=3 nux=1 nuy=1 nuz=2 fill 4 5 end fill
end array
end data
end

w3269w2

#csas25
w3269w2
44group latticecell
uo2 1 0.930 293 92235 5.70 92238 94.30
ss304 2 1.0
h2o 3 1.0
al 4 1.0
uo2 5 0.930 293 92235 5.70 92238 94.30
end comp
squarepitch 1.4224 0.9068 1 3 0.9931 2 0.9169 0
more data dan(5)=.927954 res=5 cyl .4534 end more
Core of 27x17 positions: 453 fuel rods and 6 water holes, 37.21 cm 'water
height
read parm run=yes gen=405 npg=600 nsk=5 nub=yes end parm

read geom
unit 1
cylinder 1 1 .4534 45.72 0.0
cylinder 0 1 .4585 45.72 0.0
cylinder 2 1 .4966 45.72 -1.27
cuboid 3 1 4p.7112 45.72 -1.27
unit 2
cylinder 1 1 .4534 0.635 0.0
cylinder 0 1 .4585 0.635 0.0
cylinder 2 1 .4966 0.635 0.0
cuboid 4 1 4p.7112 0.635 0.0
unit 3
cylinder 1 1 .4534 5.575 0.0
cylinder 0 1 .4585 5.575 0.0
cylinder 2 1 .4966 5.575 0.0
cuboid 3 1 4p.7112 5.575 0.0
unit 4
cylinder 5 1 .4534 92.964 51.93
cylinder 0 1 .4585 92.964 51.93
cylinder 2 1 .4966 93.979 51.93
cuboid 0 1 4p.7112 93.979 51.93
unit 5
cuboid 3 1 4p.7112 45.72 -1.27
unit 6
cuboid 4 1 4p.7112 0.635 0.0
unit 7
cuboid 3 1 4p.7112 5.575 0.0
unit 8
cuboid 0 1 4p.7112 93.979 51.93
unit 9
array 1 3*0.0
reflector 3 1 2r11.2776 2r18.3896 2r0 1
reflector 4 1 5r0 3.175 1
reflector 3 1 2r3.7224 3r0 6.35 1
reflector 4 1 5r0 5.08 1

```

```

unit 10
array 2 3*0.0
reflector 4 1 2r11.2776 2r18.3896 2r0 1
reflector 3 1 2r3.7224 4r0 1
unit 11
array 3 3*0.0
reflector 3 1 2r15. 2r18.3896 2r0 1
unit 12
array 4 3*0.0
reflector 0 1 2r15. 2r18.3896 2r0 1
reflector 4 1 4r0 1.27 0 1
global
unit 13
array 5 3*0.0
end geom

read array
ara=1 nux=27 nuy=17 nuz=1 fill
113r1 5 7r1 5 7r1 5 199r1 5 7r1 5 7r1 5 113r1 end fill
ara=2 nux=27 nuy=17 nuz=1 fill
113r2 6 7r2 6 7r2 6 199r2 6 7r2 6 7r2 6 113r2 end fill
ara=3 nux=27 nuy=17 nuz=1 fill
113r3 7 7r3 7 7r3 7 199r3 7 7r3 7 7r3 7 113r3 end fill
ara=4 nux=27 nuy=17 nuz=1 fill
113r4 8 7r4 8 7r4 8 199r4 8 7r4 8 7r4 8 113r4 end fill
ara=5 nux=1 nuy=1 nuz=4 fill 9 10 11 12 end fill
end array
end data
end

w3385s11

#csas25
w3385s11
44group latticecell
uo2 1 den=10.1928 1.0 291.0 92235 5.742 92238 94.258
end
ss304 2 1.0 291.0
h2o 3 1.0 291.0
al 4 1.0 291.0
uo2 5 den=10.1928 1.0 291.0 92235 5.742 92238 94.258
end
al 6 .85 293
end
h2o 6 .15 293
end
end comp
squarepitch 1.4224 .9068 1 3 .9931 2 .9169 0
end
more data res=5 cyl .4534 dan(5)=.922095 end more
Core of 19x19 fuel rods, 83.71 cm water height
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom
unit 1
cylinder 2 1 .4966 .635 0
cylinder 3 1 .5042 .635 0
cuboid 4 1 .7112 -.7112 .7112 -.7112 .635 0
unit 2
cylinder 1 1 .4534 47.625 1.905
cylinder 0 1 .4585 47.625 1.905
cylinder 2 1 .4966 47.625 .635

```

```

cuboid    3 1     .7112 -.7112 .7112 -.7112 47.625 .635
unit 3
cylinder 1 1 .4534 48.26 47.625
cylinder 0 1 .4585 48.26 47.625
cylinder 2 1 .4966 48.26 47.625
cylinder 3 1 .5042 48.26 47.625
cuboid    6 1     .7112 -.7112 .7112 -.7112 48.26 47.625
unit 4
cylinder 1 1 .4534 83.955 48.26
cylinder 0 1 .4585 83.955 48.26
cylinder 2 1 .4966 83.955 48.26
cuboid    3 1     .7112 -.7112 .7112 -.7112 83.955 48.26
unit 5
cylinder 5 1 .4534 94.869 83.955
cylinder 0 1 .4585 94.869 83.955
cylinder 2 1 .4966 94.869 83.955
cuboid    0 1     .7112 -.7112 .7112 -.7112 94.869 83.955
unit 6
cylinder 2 1 .4966 95.885 94.869
cuboid    0 1     .7112 -.7112 .7112 -.7112 95.885 94.869
unit 7
cylinder 2 1 .4966 97.155 95.885
cylinder 0 1 .5042 97.155 95.885
cuboid    4 1     .7112 -.7112 .7112 -.7112 97.155 95.885
unit 8
array     1 0 0 0
reflector 3 1 30 30 30 30 0 0 1
reflector 4 1 0 0 0 0 0 2.54 1
reflector 3 1 0 0 0 0 0 6.35 1
reflector 4 1 0 0 0 0 0 5.08 1
unit 9
array     2 0 0 0
reflector 0 1 30 30 30 30 0 0 1
end geom

read array
ara=1 nux=19 nuy=19 nuz=4      fill 361r1 361r2 361r3 361r4 end fill
ara=2 nux=19 nuy=19 nuz=3      fill 361r5 361r6 361r7 end fill
ara=3 gbl=3 nux=1 nuy=1 nuz=2 fill 8 9      end fill
end array
end data
end

w3385s12
#csas25
w3385s12
44group      latticecell
uo2    1 den=10.1928 1.0 290.3   92235 5.742   92238 94.258      end
ss304   2 1.0 290.3      end
h2o     3 1.0 290.3      end
al      4 1.0 290.3      end
uo2    5 den=10.1928 1.0 290.3   92235 5.742   92238 94.258      end
al      6 .94 293       end
h2o     6 .06 293       end
end comp
squarepitch 2.01168 .9068 1 3 .9931 2 .9169 0      end
more data res=5 cyl .4534 dan(5)=.945902 end more
Core of 13x14 fuel rods, 90.60 cm water height
read parm gen=405 npg=600 nsk=5 nub=yes run=yes end parm

read geom

```

```

unit 1
cylinder 2 1 .4966 .635 0
cylinder 3 1 .5042 .635 0
cuboid   4 1     1.00584 -1.00584 1.00584 -1.00584 .635 0
unit 2
cylinder 1 1 .4534 47.625 1.905
cylinder 0 1 .4585 47.625 1.905
cylinder 2 1 .4966 47.625 .635
cuboid   3 1     1.00584 -1.00584 1.00584 -1.00584 47.625 .635
unit 3
cylinder 1 1 .4534 48.26 47.625
cylinder 0 1 .4585 48.26 47.625
cylinder 2 1 .4966 48.26 47.625
cylinder 3 1 .5042 48.26 47.625
cuboid   6 1     1.00584 -1.00584 1.00584 -1.00584 48.26 47.625
unit 4
cylinder 1 1 .4534 90.865 48.26
cylinder 0 1 .4585 90.865 48.26
cylinder 2 1 .4966 90.865 48.26
cuboid   3 1     1.00584 -1.00584 1.00584 -1.00584 90.865 48.26
unit 5
cylinder 5 1 .4534 94.869 90.865
cylinder 0 1 .4585 94.869 90.865
cylinder 2 1 .4966 94.869 90.865
cuboid   0 1     1.00584 -1.00584 1.00584 -1.00584 94.869 90.865
unit 6
cylinder 2 1 .4966 95.885 94.869
cuboid   0 1     1.00584 -1.00584 1.00584 -1.00584 95.885 94.869
unit 7
cylinder 2 1 .4966 97.155 95.885
cylinder 0 1 .5042 97.155 95.885
cuboid   4 1     1.00584 -1.00584 1.00584 -1.00584 97.155 95.885
unit 8
array     1 0 0 0
reflector 3 1 30 30 30 30 0 0 1
reflector 4 1 0 0 0 0 0 2.54 1
reflector 3 1 0 0 0 0 0 6.35 1
reflector 4 1 0 0 0 0 0 5.08 1
unit 9
array     2 0 0 0
reflector 0 1 30 30 30 30 0 0 1
end geom

read array
ara=1 nux=13 nuy=14 nuz=4      fill 182r1 182r2 182r3 182r4 end fill
ara=2 nux=13 nuy=14 nuz=3      fill 182r5 182r6 182r7      end fill
ara=3 gbl=3 nux=1 nuy=1 nuz=2 fill 8 9      end fill
end array
end data
end

ydr14p12
#csas25
ydr14p12
44group      infhommedium
u-235   1 0 1.1191e-4      end
u-238   1 0 5.4152e-3      end
h       1 0 4.5472e-2      end
c       1 0 2.1861e-2      end
f       1 0 2.2109e-2      end
para(h2o) 2 1.0      end

```

```

plexiglas 3 0.918
al         3 0.062
end comp
2.00 wt% 235U UF4-paraffin parallelpiped, paraffin reflected
read param run=yes gen=405 npg=600 nsk=5 nub=yes fdn=yes end param

read geom
unit 1
cuboid 1 1 4p26.835 2p27.145
reflector 2 1 5*15.2 0.0 1
unit 2
cuboid 3 1 4p42.035 15.2 0.0
end geom
read array
nux=1 nuy=1 nuz=2 fill 2 1 end fill
end array
end data
end

ydr14pl3

#csas25
ydr14pl3
44group infhommedium
u-235 1 0 2.3494e-4
u-238 1 0 7.4999e-3
h     1 0 3.1341e-2
c     1 0 1.5067e-2
f     1 0 3.0939e-2
para(h2o) 2 1.0
plexiglas 3 0.918
al         3 0.062
end comp
3.00 wt% 235U UF4-paraffin parallelpiped,paraffin reflected
read param gen=405 npg=600 nsk=5 run=yes nub=yes end param

read geom
unit 1
cuboid 1 1 2p21.735 2p21.735 2p43.1950
reflector 2 1 5*15.2 0.0 1
unit 2
cuboid 3 1 2p36.935 2p36.935 15.2 0.
end geom
read array
end
end
gbl=1 ara=1 nux=1 nuy=1 nuz=2 fill 2 1 end fill
end array
end data
end

ydr14un2

=csas25
ydr14un2
44group infhommedium
u-235 1 0 1.3303e-4
u-238 1 0 6.4370e-3
h     1 0 3.9097e-2
c     1 0 1.8797e-2
f     1 0 2.6280e-2
end comp
2.00 wt% 235U UF4-paraffin parallelpiped, unreflected
read param gen=405 npg=600 nsk=5 nub=yes fdn=yes run=yes end param

read geom
cuboid 1 1 28.11 -28.11 28.11 -28.11 61.235 -61.235
end geom
end data
end

ydr14un3

=csas25
ydr14un3
44group infhommedium
u-235 1 0 2.3494e-4
u-238 1 0 7.4999e-3
h     1 0 3.1341e-2
c     1 0 1.5067e-2
f     1 0 3.0939e-2
end comp
3.00 wt% 235U UF4-paraffin parallelpiped, unreflected
read param gen=405 npg=600 nsk=5 nub=yes fdn=yes run=yes end param

read geom
cuboid 1 1 28.235 -28.235 28.235 -28.235 43.32 -43.32
end geom
end data
end

```


APPENDIX B

Comparison of 44- and 238-Group Results

To address the effectiveness of the broad-group structure in the 44GROUPNDF5 library, the benchmark calculations were repeated using SCALE-4.3 and the 238GROUPNDF5 library. The calculated k_{eff} values obtained with the two libraries are compared in Table B.1. These results indicate that, on average, the fine-group library underpredicts the critical condition by 0.35% while the broad-group library predicts the critical condition almost exactly. Note, however, that the additional group structure in the 238-group library enables it to more accurately predict most of the homogeneous uranium critical experiments.

Appendix B

Table B.1 Comparison of 44- and 238-group results

Case No.	Case designation	44-Group k_{eff}	238-Group k_{eff}	$\Delta k_{\text{eff}} (\%)$	Case No.	Case designation	44-Group k_{eff}	238-Group k_{eff}	$\Delta k_{\text{eff}} (\%)$
1	ANS33AL1	1.0027	1.0036	-0.09	48	EPRU65	0.9977	0.9900	0.77
2	ANS33AL2	1.0129	1.0092	0.37	49	EPRU65B	0.9985	0.9965	0.20
3	ANS33AL3	1.0035	0.9991	0.44	50	EPRU75	0.9974	0.9941	0.33
4	ANS33EB1	0.9979	0.9906	0.73	51	EPRU75B	1.0023	1.0004	0.19
5	ANS33EB2	1.0096	1.0073	0.23	52	EPRU87	0.9986	0.9974	0.12
6	ANS33EP1	0.9964	0.9941	0.23	53	EPRU87B	0.9985	0.9968	0.17
7	ANS33EP2	1.0020	0.9984	0.36	54	NSE71H1	0.9982	0.9939	0.43
8	ANS33SLG	0.9964	0.9960	0.04	55	NSE71H2	1.0009	0.9973	0.36
9	ANS33STY	0.9909	0.9876	0.33	56	NSE71H3	1.0036	0.9979	0.57
10	B1645SO1	0.9976	0.9947	0.29	57	NSE71SQ	1.0014	0.9959	0.55
11	B1645SO2	1.0007	0.9983	0.24	58	NSE71W1	0.9993	0.9919	0.74
12	BW1231B1	0.9969	0.9936	0.33	59	NSE71W2	0.9976	0.9957	0.19
13	BW1231B2	0.9985	0.9947	0.38	60	P2438AL	0.9951	0.9943	0.08
14	BW1273M	0.9947	0.9943	0.04	61	P2438BA	0.9972	0.9958	0.14
15	BW1484A1	0.9965	0.9948	0.17	62	P2438CU	0.9957	0.9958	-0.01
16	BW1484A2	0.9954	0.9888	0.66	63	P2438SLG	0.9997	0.9954	0.43
17	BW1484B1	0.9973	0.9964	0.09	64	P2438SS	0.9978	0.9987	-0.09
18	BW1484B2	0.9973	0.9940	0.33	65	P2438ZR	0.9956	0.9937	0.19
19	BW1484B3	0.9992	0.9955	0.37	66	P2615AL	1.0004	0.9940	0.64
20	BW1484C1	0.9937	0.9914	0.23	67	P2615BA	0.9970	0.9961	0.09
21	BW1484C2	0.9936	0.9937	-0.01	68	P2615CD1	0.9985	0.9986	-0.01
22	BW1484S1	0.9981	0.9947	0.34	69	P2615CD2	0.9990	0.9930	0.60
23	BW1484S2	0.9989	0.9980	0.09	70	P2615CU	1.0003	0.9968	0.35
24	BW1484SL	0.9966	0.9911	0.55	71	P2615SS	0.9998	0.9969	0.29
25	BW1645S1	1.0010	0.9906	1.04	72	P2615ZR	0.9980	0.9940	0.40
26	BW1645S2	1.0035	0.9940	0.95	73	P2827L1	1.0023	1.0006	0.17
27	BW1645T1	1.0062	0.9951	1.11	74	P2827L2	0.9997	0.9964	0.33
28	BW1645T2	1.0068	0.9965	1.03	75	P2827L3	1.0081	1.0088	-0.07
29	BW1645T3	1.0007	0.9924	0.83	76	P2827L4	1.0073	1.0044	0.29
30	BW1645T4	0.9986	0.9888	0.98	77	P2827SLG	0.9948	0.9939	0.09
31	BW1810A	0.9971	0.9945	0.26	78	P2827U1	1.0004	0.9955	0.49
32	BW1810B	0.9980	0.9969	0.11	79	P2827U2	0.9998	0.9979	0.19
33	BW1810C	1.0005	0.9984	0.21	80	P2827U3	1.0018	0.9999	0.19
34	BW1810D	0.9999	0.9962	0.37	81	P2827U4	1.0042	1.0011	0.31
35	BW1810E	0.9976	0.9940	0.36	82	P3314AL	0.9973	0.9944	0.29
36	BW1810F	1.0032	0.9983	0.49	83	P3314BA	1.0002	1.0075	-0.73
37	BW1810G	0.9971	0.9949	0.22	84	P3314BC	1.0008	1.0072	-0.64
38	BW1810H	0.9973	0.9939	0.34	85	P3314BF1	1.0022	1.0055	-0.33
39	BW1810I	1.0022	0.9953	0.69	86	P3314BF2	0.9981	0.9985	-0.04
40	BW1810J	0.9980	0.9970	0.10	87	P3314BS1	0.9970	0.9965	0.05
41	CR1071AS	1.0207	1.0125	0.82	88	P3314BS2	0.9959	0.9926	0.33
42	CR1653AS	1.0169	1.0097	0.72	89	P3314BS3	0.9972	0.9936	0.36
43	CR2500S	1.0194	1.0129	0.65	90	P3314BS4	1.0005	0.9941	0.64
44	DSN399-1	1.0056	0.9973	0.83	91	P3314CD1	1.0001	0.9939	0.62
45	DSN399-2	1.0010	0.9948	0.62	92	P3314CD2	0.9929	0.9910	0.19
46	DSN399-3	1.0024	0.9977	0.47	93	P3314CU1	0.9941	0.9877	0.64
47	DSN399-4	0.9965	0.9910	0.55	94	P3314CU2	1.0005	0.9953	0.52

Table B.1 (continued)

Case No.	Case designation	44-Group k_{eff}	238-Group k_{eff}	$\Delta k_{\text{eff}} (\%)$	Case No.	Case designation	44-Group k_{eff}	238-Group k_{eff}	$\Delta k_{\text{eff}} (\%)$
95	P3314CU3	0.9972	0.9989	-0.17	141	P3926SL1	0.9942	0.9926	0.16
96	P3314CU4	0.9992	0.9950	0.42	142	P3926SL2	0.9990	0.9928	0.62
97	P3314CU5	0.9938	0.9926	0.12	143	P3926U1	0.9979	0.9939	0.40
98	P3314CU6	0.9958	0.9910	0.48	144	P3926U2	0.9980	0.9931	0.49
99	P3314SLG	0.9982	0.9942	0.40	145	P3926U3	1.0001	0.9959	0.42
100	P3314SS1	0.9969	0.9946	0.23	146	P3926U4	1.0026	0.9974	0.52
101	P3314SS2	1.0011	0.9960	0.51	147	P3926U5	0.9999	0.9998	0.01
102	P3314SS3	0.9990	0.9926	0.64	148	P3926U6	1.0024	0.9970	0.54
103	P3314SS4	0.9957	0.9957	0.00	149	P4267B1	0.9969	0.9981	-0.12
104	P3314SS5	0.9944	0.9875	0.69	150	P4267B2	1.0035	1.0010	0.25
105	P3314SS6	1.0003	0.9935	0.68	151	P4267B3	1.0025	1.0053	-0.28
106	P3314W1	1.0015	0.9992	0.23	152	P4267B4	0.9993	0.9977	0.16
107	P3314W2	0.9958	0.9927	0.31	153	P4267B5	1.0031	1.0007	0.24
108	P3314ZR	0.9978	0.9957	0.21	154	P4267SL1	0.9974	0.9940	0.34
109	P3602BB	0.9988	0.9947	0.41	155	P4267SL2	0.9993	0.9958	0.35
110	P3602BS1	1.0000	0.9928	0.72	156	P49-194	1.0081	0.9981	1.00
111	P3602BS2	1.0001	0.9977	0.24	157	P62FT231	1.0005	0.9958	0.47
112	P3602CD1	0.9988	0.9943	0.45	158	P71F14F3	1.0029	0.9944	0.85
113	P3602CD2	1.0002	0.9931	0.71	159	P71F14V3	0.9973	0.9929	0.44
114	P3602CU1	0.9964	0.9945	0.19	160	P71F14V5	0.9977	0.9959	0.18
115	P3602CU2	0.9980	0.9926	0.54	161	P71F214R	1.0010	0.9949	0.61
116	P3602CU3	1.0039	0.9938	1.010	162	PAT80L1	1.0031	0.9987	0.44
117	P3602CU4	1.0040	0.9944	0.96	163	PAT80L2	0.9920	0.9954	-0.34
118	P3602N11	1.0003	0.9918	0.85	164	PAT80SS1	1.0004	1.0003	0.01
119	P3602N12	0.9963	0.9943	0.20	165	PAT80SS2	0.9926	0.9946	-0.20
120	P3602N13	0.9957	0.9939	0.18	166	W3269A	0.9934	0.9920	0.14
121	P3602N14	0.9984	0.9951	0.33	167	W3269B1	0.9963	0.9900	0.63
122	P3602N21	0.9995	0.9972	0.23	168	W3269B2	0.9964	0.9898	0.66
123	P3602N22	0.9967	0.9972	-0.05	169	W3269B3	0.9948	0.9878	0.70
124	P3602N31	1.0010	0.9966	0.44	170	W3269C	0.9986	0.9946	0.40
125	P3602N32	1.0015	0.9967	0.48	171	W3269SL1	0.9952	0.9919	0.33
126	P3602N33	1.0045	0.9976	0.69	172	W3269SL2	1.0040	0.9947	0.93
127	P3602N34	1.0027	0.9961	0.66	173	W3269W1	0.9957	0.9938	0.19
128	P3602N35	1.0036	0.9960	0.76	174	W3269W2	1.0009	0.9995	0.14
129	P3602N36	1.0009	0.9964	0.45	175	W3385SL1	0.9964	0.9918	0.46
130	P3602N41	1.0002	0.9948	0.54	176	W3385SL2	1.0005	0.9995	0.10
131	P3602N42	1.0019	0.9995	0.24	177	YDR14PL2	1.0011	1.0011	0.00
132	P3602N43	0.9994	0.9967	0.27	178	YDR14PL3	1.0115	1.0089	0.26
133	P3602SS1	0.9978	0.9904	0.74	179	YDR14UN2	1.0047	1.0024	0.23
134	P3602SS2	1.0012	0.9962	0.50	180	YDR14UN3	1.0163	1.0128	0.35
135	P3926L1	0.9996	0.9966	0.30					
136	P3926L2	1.0028	0.9994	0.34		MEAN	0.9999	0.9964	
137	P3926L3	1.0017	0.9959	0.58		MEDIAN	0.9993	0.9957	
138	P3926L4	1.0055	1.0114	-0.59		STD. DEV.	0.0045	0.0064	
139	P3926L5	1.0070	1.0032	0.38		MIN.	0.9909	0.9875	
140	P3926L6	1.0026	0.9994	0.32		MAX.	1.0207	1.0129	

APPENDIX C

USER'S MANUAL FOR *USLSTATS* V1.0

C.1 Introduction

The ANS/ANSI-8.1 Standard³⁹ recommends that calculational methods used in determining criticality safety limits for applications outside reactors be validated by comparison with appropriate critical experiments. An upper safety limit (USL) provides a high degree of confidence that a given system is subcritical if a criticality calculation based on the system yields a multiplication factor (k_{eff}) below the USL. Section 4 describes two different methods for the determination of a USL for criticality based on any set of calculations based on criticality experiments.

The *USLSTATS* computer program uses these two methods [i.e., (1) confidence band with administrative margin and (2) single-sided uniform-width closed-interval] to calculate and print USL correlations based on a set of user-supplied k_{eff} values and corresponding values of a single associated parameter X [e.g., lattice pitch, fuel enrichment, average energy group causing fission (AEG), etc.], for a set of criticality benchmark calculations. In addition, other statistical parameters computed as a part of the USL calculation are included in the output. The user is referred to Sect. 4 for the definition of these factors and for additional details relative to the theory and application of upper safety limit calculations.

C.2 Background

The *USLSTATS* program is derived from the *V_STATS* program,⁴⁵ originally developed to calculate and plot the USL based on a single-sided, uniform-width, closed-interval approach^{40,41} (method 2). Because USL method 1 is essentially a simplification of method 2, the calculation of USLs via the results of a method 2 calculation are straightforward. In creating *USLSTATS*, the input was simplified somewhat, and the output was completely redesigned, in order to print only the information required for USL calculations using the nomenclature given in Sect. 4.

C.3 Input Description

The input required by the *USLSTATS* program is very minimal. The input consists of three sections, all read in a free-format fashion. The first line contains a title, up to 80 characters. The second line contains problem-specification parameters: P , $(1 - \gamma)$, α , x_{\min} , x_{\max} , σ_{sample} , and Δk_m , where

- P = proportion of population falling above lower tolerance level,
- $1 - \gamma$ = confidence on fit,
- α = confidence on proportion P ,
- x_{\min} = minimum value of parameter X for which USL correlations are computed,
- x_{\max} = maximum value of parameter X for which USL correlations are computed,
- σ_{sample} = estimate in average standard deviation of all input values of k_{eff} ,
- Δk_m = administrative margin used to ensure subcriticality.

The final section of input read is the set of values (parameter X, k_{eff} , and, if $\sigma_{\text{sample}} < 0.0$, the value of σ corresponding to k_{eff}) for each of up to 1000 benchmark critical experiments. A minimum of 25 experiments is recommended to have a sufficient number of data points to determine the statistical normality of the data. *USLSTATS* reads X, k_{eff}

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pairs (or X , k_{eff} , σ triplets) until the end-of-file marker is reached. Again, X is the value of an independent parameter for which a trend in k_{eff} is known or suspected to exist.

The value of P is typically selected as 0.995. This statistical parameter is used only in the computation of USL by method 2, and represents the proportion of the population of criticality experiments that will lie above the line representing one tolerance level below the linear regression fit to k_{eff} . The value $1 - \gamma$, used in the Student-t calculation of USL methods 1 and 2, is typically assigned a value of 0.95 and represents the desired confidence level to be assigned the linear regression fit of k_{eff} values. (It is also used in a χ^2 test for normality of input data. USL methods 1 and 2 are valid only for normally distributed data.) The third statistical parameter, α , represents the confidence on the proportion P , and is also typically assigned a value of 0.95.

The parameters x_{min} and x_{max} represent the lower and upper limits, respectively, for parameter X in the USL correlations of methods 1 and 2. These limit the range in which the USL correlation is valid, but a smaller range will raise the USL. Typically, values of 0.0 are entered for both x_{min} and x_{max} ; this instructs the code to use the minimum and maximum values of X found in the user-supplied data.

The parameter σ_{sample} is the average standard deviation estimated for the supplied values of k_{eff} . For the results of a set of deterministic calculations, an average standard deviation of 0.0 may be specified; a positive value may be supplied to account for modeling and numerical uncertainties associated with the set of values. However, if an estimate of the standard deviation associated with each value of k_{eff} is available (such as is computed for Monte Carlo criticality calculations), *USLSTATS* may be instructed to read this value for each value of k_{eff} by supplying any negative value for σ_{sample} .

The final parameter supplied in line 2 of the input file is the administrative margin that is to be included in calculation of the USL by method 1. Based on general experience, a value of 0.05 is most often used in criticality calculations as the value for the administrative subcritical margin. A statistically based margin is computed and used in the method 2 approach, and is supplied in output as the "minimum margin of subcriticality." Typically, this statistical margin is found to be less than the arbitrary 5% margin; for this reason, the method 2 USL is generally less restrictive.

A sample input case is given on the following page. In this case, entitled "34.fresh fuel LWR-type criticals," typical values for P , $1 - \gamma$, and α of 0.995, 0.95, and 0.95, respectively, are given. A value of 0.0 is assigned to both x_{min} and x_{max} , indicating that the minimum and maximum limits of the USL correlations are to be set as the minimum and maximum values of X from the list supplied by the user. A value of -1.0 is given for σ_{sample} , indicating that individual uncertainties are to be read for each value of k_{eff} . Finally, 34 sets of X , k_{eff} , and σ are supplied. (In this case, parameter X is the AEG computed by KENO V.a based on the SCALE 27-group library group structure.)

Sample input for a *USLSTATS* calculation

```
34.fresh fuel LWR-type criticals
0.995 0.95 0.95 0.0 0.0 -1.0 0.05
2.26322E+01    .9912  .0010
2.16825E+01    .9953  .0011
2.17734E+01    .9919  .0010
2.18186E+01    .9949  .0010
2.22143E+01    .9904  .0014
2.37713E+01    .9946  .0013
2.06628E+01    .9955  .0014
2.10962E+01    .9956  .0013
2.20739E+01    1.0071  .0012
2.26189E+01    1.0037  .0010
2.26746E+01    1.0072  .0009
2.30862E+01    1.0077  .0015
2.16605E+01    .9971  .0016
2.16390E+01    .9924  .0011
2.35796E+01    .9912  .0014
2.35464E+01    .9927  .0010
2.35761E+01    .9924  .0013
2.35623E+01    .9921  .0014
2.19304E+01    .9970  .0016
2.19636E+01    1.0000  .0015
2.13056E+01    .9994  .0014
2.20520E+01    .9952  .0011
2.09066E+01    .9991  .0012
2.11516E+01    .9940  .0011
1.99756E+01    .9904  .0013
1.82077E+01    .9869  .0012
2.34646E+01    1.0057  .0022
2.07944E+01    1.0027  .0015
2.25639E+01    1.0031  .0017
2.28514E+01    1.0040  .0018
2.03398E+01    1.0015  .0012
2.10385E+01    1.0014  .0018
2.18995E+01    .9861  .0016
2.34236E+01    .9972  .0011
```

C.4 Output Description

The output generated by *USLSTATS* (corresponding to the sample input supplied earlier) is given at the end of this appendix. The first section lists the filename corresponding to the input file and supplies all input in a descriptive format. The value of χ from the χ^2 test is printed and compared to the value required for normal data. A message is printed indicating whether or not the supplied data is normal. Note that if fewer than 25 data points are supplied, a warning message is also printed indicating that too few points are available for an accurate assessment of normality. The final section of the output supplies the two USLs, together with important input and intermediate parameters used in the calculation of the USL correlations.

C.5 How to Run *USLSTATS*

The *USLSTATS* program has an interactive interface to allow the user to specify the location of an input file and to select the name of the output file. Below is an example of typical *USLSTATS* usage. Input and output file names are limited to 20 characters. Note that text supplied by the user is shown in boldface in the following example.

```
$ uslstats
```

Enter filename containing input data.
(Enter "test" to generate test case input.)
list34_uslstats.in

Enter output filename (will overwrite existing file):
list34_uslstats.out
\$

Note that *USLSTATS* will create a sample input file and will then run using the information in the sample file if the word "test" is given as the name for the input file. This is illustrated in the sample interactive session below.

```
$ uslstats
```

Enter filename containing input data.
(Enter "test" to generate test case input.)
test

Input file named "usl_test.in" will be created.

Enter output filename (will overwrite existing file):
usl_test.out
\$

USLSTATS does not require significant computing space or time. It will typically execute in less than 1 second once the interactive input is completed.

C.6 How to Obtain *USLSTATS*

The *USLSTATS* program may be downloaded from the World Wide Web (WWW) by accessing the SCALE home page. A pointer for the SCALE home page may be found at <http://www.cad.ornl.gov>

Sample output from a *USLSTATS* calculation

```

uslstats: a utility to calculate upper subcritical
limits for criticality safety applications

*****
Version 1.2, December 9, 1996
Oak Ridge National Laboratory
*****


Input to statistical treatment from file:usl_test.in

Title: 34 Fresh-fuel UO2 criticals

Proportion of the population = .999
Confidence of fit = .950
Confidence on proportion = .950
Number of observations = 29
Minimum value of closed band = .00
Maximum value of closed band = .00
Administrative margin = .05

independent      dependent      deviation
variable - x    variable - y    in y

1.48200E+01    9.96470E-01    3.37000E-03
1.48100E+01    9.97760E-01    3.26000E-03
1.48300E+01    1.00764E+00    3.11000E-03
1.44400E+01    9.95870E-01    3.65000E-03
1.42800E+01    9.97440E-01    3.27000E-03
1.48400E+01    1.00337E+00    3.95000E-03
1.47300E+01    9.96090E-01    3.95000E-03
1.50800E+01    1.00108E+00    3.78000E-03
1.52000E+01    9.97370E-01    3.25000E-03
1.53100E+01    9.84080E-01    3.42000E-03
1.52600E+01    9.88710E-01    3.61000E-03
1.55000E+01    9.95270E-01    2.92000E-03
1.54900E+01    9.88040E-01    2.73000E-03
1.43600E+01    1.01363E+00    4.01000E-03
1.43600E+01    1.01660E+00    4.45000E-03
1.43600E+01    1.00874E+00    4.85000E-03
1.43800E+01    1.01190E+00    4.79000E-03
1.43500E+01    1.00980E+00    4.98000E-03
1.41000E+01    1.00565E+00    3.97000E-03
1.41200E+01    1.01929E+00    4.07000E-03
1.41000E+01    1.00860E+00    4.11000E-03
1.50400E+01    9.94870E-01    4.62000E-03
1.49000E+01    9.92570E-01    3.82000E-03
1.49000E+01    1.00132E+00    4.50000E-03
1.49000E+01    9.91540E-01    4.20000E-03
1.54300E+01    1.00028E+00    3.74000E-03
1.54400E+01    9.95650E-01    4.13000E-03
1.54300E+01    9.85740E-01    4.15000E-03
1.54300E+01    9.87330E-01    4.16000E-03

```

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WARNING *** the test for normal may be unreliable due to insufficient data.
chi = 4.2759 (upper bound = 9.49). The data tests normal.

Output from statistical treatment

34 Fresh-fuel UO₂ criticals

Number of data points (n)	29
Linear regression, k(X)	1.2267 + (-1.5296E-02)*X
Confidence on fit (1-gamma) [input]	95.0%
Confidence on proportion (alpha) [input]	95.0%
Proportion of population falling above lower tolerance interval (rho) [input]	99.9%
Minimum value of X	14.1000
Maximum value of X	15.5000
Average value of X	14.83414
Average value of k	.99975
Minimum value of k	.98408
Variance of fit, s(k,X)^2	3.8263E-05
Within variance, s(w)^2	1.5455E-05
Pooled variance, s(p)^2	5.3718E-05
Pooled std. deviation, s(p)	7.3293E-03
C(alpha,rho)*s(p)	3.6627E-02
student-t @ (n-2,1-gamma)	1.70300E+00
Confidence band width, W	1.3223E-02
Minimum margin of subcriticality, C*s(p)-W	2.3404E-02

Upper subcritical limits: (14.10000 <= X <= 15.50000)

USLs Evaluated Over Range of Parameter X:

X:	14.10	14.30	14.50	14.70	14.90	15.10	15.30	15.50
<hr/>								
-1:	.9368	.9368	.9368	.9368	.9355	.9325	.9294	.926
-2:	.9634	.9634	.9634	.9634	.9621	.9591	.9560	.952

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11. ABSTRACT (<i>200 words or less</i>) This report is designed as a guide for performing criticality benchmark calculations for light-water-reactor (LWR) fuel applications. The guide provides documentation of 180 criticality experiments with geometries, materials, and neutron interaction characteristics representative of transportation packages containing LWR fuel or uranium oxide pellets or powder. These experiments should benefit the U.S. Nuclear Regulatory Commission (NRC) staff and licensees in validation of computational methods used in LWR fuel storage and transportation concerns. The experiments are classified by key parameters such as enrichment, water/fuel volume, hydrogen-to-fissile ratio (H/X), and lattice pitch. Groups of experiments with common features such as separator plates, shielding walls, and soluble boron are also identified. In addition, a sample validation using these experiments and a statistical analysis of the results are provided. Recommendations for selecting suitable experiments and determination of calculational bias and uncertainty are presented as part of this benchmark guide.	
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