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The GCFR Grid Plate Shield Design Confirmation Experiment

F. J. Muckenthaler
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OAK RIDGE NATIONAL LABORATORY
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THE GCFR GRID PLATE SHIELD DESIGN CONFIRMATION EXPERIMENT*

F. J. Muckenthaler, J. L. Hull, and J. J. Manning

ABSTRACT

This report presents measurements of neutron fluxes and energy spectra made in the Grid Plate Shield Design Confirmation Experiment at the ORNL Tower Shielding Facility (TSF) for the Gas Cooled Fast Breeder Reactor (GCFR) shielding program. The experimental configuration consisted of four basic segments: a concrete shadow shield placed directly in the Tower Shielding Reactor II (TSR-II) reactor beam; a simulated GCFR core positioned behind the shadow shield; a prototypic grid plate shield following the simulated core; and, finally, a prototypic grid plate. The segments were added to the configuration in sequence with measurements made beyond each segment.

Calculations indicated the presence of the concrete shadow shield reduced the TSR-II neutron contribution to the source term beyond the fuel pins to less than 10%. Because radiation damage to the GCFR grid plate due to neutrons streaming through the helium coolant passages of the core was of primary concern, the experiment included measurements in which both the spacing between subassemblies in the simulated core and grid plate shield and the pitch of the fuel pins within the subassemblies were varied. In addition, neutron streaming measurements were made beyond an iron-rod configuration and an iron-plate configuration, each being positioned immediately behind the concrete shadow shield.

*Work performed under DOE 189a No. 01351, GCFR Shielding Studies - Experiment.

INTRODUCTION

An experiment was conducted at the ORNL Tower Shielding Facility (TSF) to provide data against which the validity of the calculation methods used in the design of a grid plate shield for the Gas Cooled Fast Breeder Reactor (GCFR) could be tested. The grid plate shield, positioned directly above the GCFR core, was designed to reduce below established tolerances the radiation damage to the grid plate caused by neutrons streaming upward through the helium coolant passages in the core. Analytical methods are not yet sufficiently developed to calculate neutron streaming in such complex geometries, particularly when a high void fraction is involved. Therefore, the TSF experiment was proposed by ORNL to measure the neutron streaming through prototypic mockups of GCFR fuel pin subassemblies and the proposed grid plate shield. A subsequent analysis of the experiment, to be published separately, will then indicate the adequacy of the calculational methods for predicting this streaming effect and the radiation damage to the grid plate in the GCFR design.

The experimental configuration consisted of four basic segments: a concrete shadow shield placed directly in the collimated neutron beam from the Tower Shielding Reactor II (TSR-II); a simulated GCFR core positioned behind the shadow shield; a prototypic grid plate shield following the simulated core; and finally a prototypic grid plate. The individual segments were introduced into the configuration sequentially with measurements made beyond each segment.

The two basic variables in the experiment were the number of fuel pins per subassembly and the spacing between subassemblies. Measurements were made for three spacings (1.27 cm, 0.635 cm, and 0.318 cm) with the assumption that the final design would be somewhere within these widths. The number of pins selected per subassembly were 127 and 91, resulting in pin pitches of 1.58 cm and 1.80 cm respectively. Studies with the 127 pin group were made for all three spacings, whereas only the maximum spacing was investigated for the 91 pins. For the

latter configuration one series of measurements were included where the seven center pins were removed from the central assembly to simulate the void created by the removal of a control rod.

The experiment also included a series of measurements to compare neutron streaming through a mockup of 1.27-cm-diam iron rods placed on 1.657 cm centers with that through a mockup made up of 0.304-cm-thick iron plates spaced 0.304 cm apart. For these measurements each of the mockups was placed in the same position as the simulated core.

The exact measurements made are shown in the Data Plan presented on pages v-xiv. As noted there, the detectors employed were Bonner balls, Hornyak buttons, and neutron spectrometers consisting of a NE213 liquid scintillator and hydrogen-filled proton recoil counters. Since the total number of measurements desired was quite large the configurations were divided into groups according to spacing and number of pins and assigned a priority. Assigning these priorities assured that the most important phases of the program would be accomplished in the time allotted for the experiment. However, as a result of the radioactivity induced in the fuel pins during priority 1A measurements, an excessive waiting period was required before personnel could change the subassembly spacers for priority 1B. For this reason the schedule was changed to allow measurements using the 91 pin subassemblies as noted for priority 1C. This was followed by priorities 2, 1B, and 3, in that order.

2. INSTRUMENTATION

A Bonner ball detector measures an integral of the neutron energy flux weighted by the energy-dependent response function for that ball. The detection device of the Bonner ball consists of a 2-in.-diam spherical proportional counter filled with approximately one-half atmosphere of $^{10}BF_3$. This proportional counter is used bare, cadmium covered, or enclosed in various thicknesses of polyethylene shells surrounded by cadmium. Bonner ball experimental results are predicted analytically by folding a calculated neutron spectrum with the Bonner ball response functions calculated by Maerker et al.[1] and C. E. Burgart et al.[2]

The Hornyak button has a response to neutrons that closely approaches that of a single collision dose and is closely related to a major portion of the stainless steel damage function. Two different sizes were used, 0.635- and 1.27-cm diameter, each having a thickness of 0.159 cm, and were mounted on photomultiplier tubes. Calibration procedures consisted of first exposing the scintillator to a 2 R/h gamma-ray dose rate and adjusting the electronic gain until a prescribed count rate was obtained for a pulse height setting (PHS) of 6 volts. The button was then exposed to a known strength of ^{252}Cf neutron source and the dose rate to count rate ratio obtained. For this experiment, it was necessary to obtain this calibration ratio at a higher PHS to bias against the increased number of gamma-ray pulses resulting from a much more intense gamma-ray field where the experimental neutron measurements were made. This meant that the neutron energy bias level was also higher but since the PHS curves for the calibration and measurements had basically the same slope, the procedure was considered valid.

Neutron spectral measurements were obtained in the region from about 800 keV to 15 MeV using the NE213 liquid scintillator and from about 200 keV to 1 MeV using spherical proton recoil counters filled with hydrogen to pressures of 1, 3, and 10 atmospheres.

3. EXPERIMENTAL CONFIGURATIONS

3.1 Concrete Shadow Shield and Surrounding Reflector

One of the objectives of this experiment was to establish a neutron source term as close as feasible to that expected to be axially streaming from the GCFR core. To do this, it was necessary to minimize the neutron contribution from the TSF reactor (TSR-II) with respect to the flux whose origin lies within the fuel pins. Calculations[3] indicated that the contribution from the TSR-II to the flux emerging axially from the fuel pins would be reduced to less than 10% if a 76.2-cm-diameter, 20.5-cm-thick concrete shadow shield with a surrounding void were placed between the TSR-II and the fuel pins. The circumference and the face of the shadow shield away from the reactor were covered with 0.318 cm of iron (Fe) and attached to the Fe forming the fuel pin cavity. A 15.2-cm void region around the concret shadow shield was designed to maximize the flux generation in the fuel pins. This region was extended along the initial 61 cm of the fuel region after which the remaining length of the void (45.7 cm) widened to the Fe liner that formed the cavity for the fuel pin region. The outside of this 15.2 cm void was lined with 0.95 cm Fe. All of this was contained in a 157.5-cm-thick concrete slab that is 305 cm wide by 213 cm high (see Fig. 1). The composition of the slab and the shadow shield are given in Table 1.*

3.2 GCFR Simulated Core

The GCFR core was simulated by seven subassemblies containing slightly enriched UO_2 fuel pins (1.99% ^{235}U) clad in 0.815 mm wall aluminum tubing having an OD of 1.27 cm (see Fig. 2). Each pin contained 1035.495 g of U in the form of small pellets placed end-on to give a length of 121.9 cm. Aluminum studs were placed on each end, giving an overall rod length of 127 cm.

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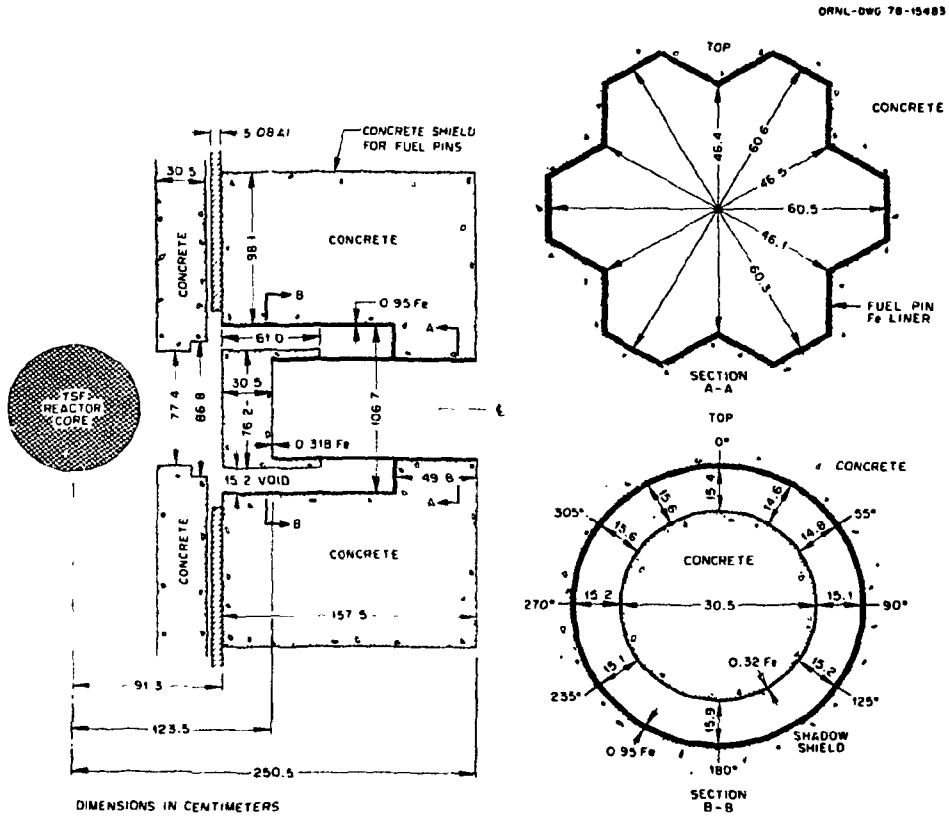

Fig. 1. The initial mockup of concrete shadow shield and surrounding concrete.

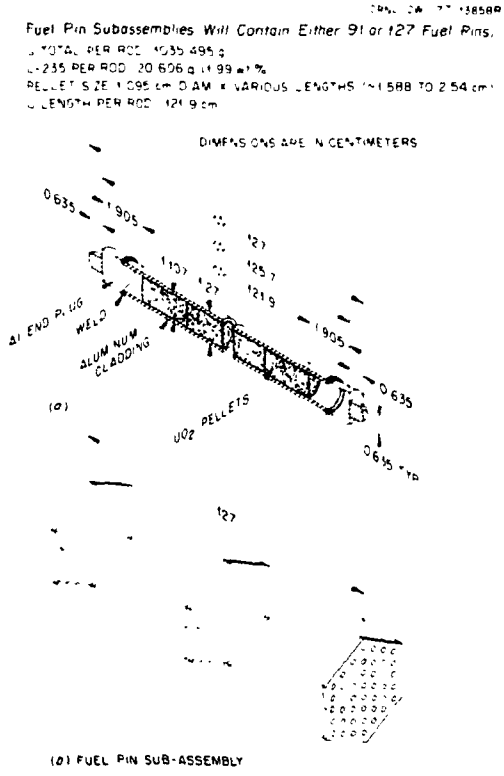

Fig. 2. Schematic of fuel pin and fuel pin subassembly.

The subassemblies were hexagonal in shape and the walls were fabricated from 0.030-cm-thick carbon steel. Two groups of seven subassemblies were made, one to contain 127 pins each (pin pitch 1.58 cm) and the other 91 pins each (pin pitch 1.80 cm). The design of the subassemblies called for 18.3 cm between opposite flat surfaces. Each subassembly was 127 cm long and contained 0.318-cm-thick support grids, one in the middle and one on each end to maintain proper pitch between the pins (see Fig. 3). A semi-quantitative analysis of the impurities in the Fe is given in Table 2.

One of the variables in this experiment was the spacing between subassemblies. This was accomplished through the use of a series of small steel pieces of different thicknesses placed near the ends of the flat surfaces on the subassemblies and at the middle. A picture of the fuel pins, subassemblies, and spacers is presented in Fig. 4. Seven of these subassemblies were then placed in the cavity behind the concrete shadow shield to simulate the GCFR cor, as shown in Fig. 5. A picture of the mockup as seen by the detector is given in Fig. 6.

3.3 Grid Plate Shield

The outer liners of the subassemblies mocking up the grid plate shield were hexagonal in shape to match those of the fuel pin subassemblies (see Fig. 7). The inner liner of each subassembly was also hexagonal but tapered along the axis, reducing the thickness of the subassembly wall from 3.0 cm at the grid plate interface to 1.10 cm at the fuel pin interface. This thickness was defined by Fe pieces at each end of the subassembly (see Fig. 8). The void between the liners was vibra packed with B_4C to densities varying from 76.2 to 77.2% of theoretical for the seven subassemblies. The actual length of the B_4C was 32 cm, and when added to the Fe end pieces gave an overall length of 45 cm. The analysis and density of the B_4C in the subassemblies are listed in Tables 3 and 4 respectively.

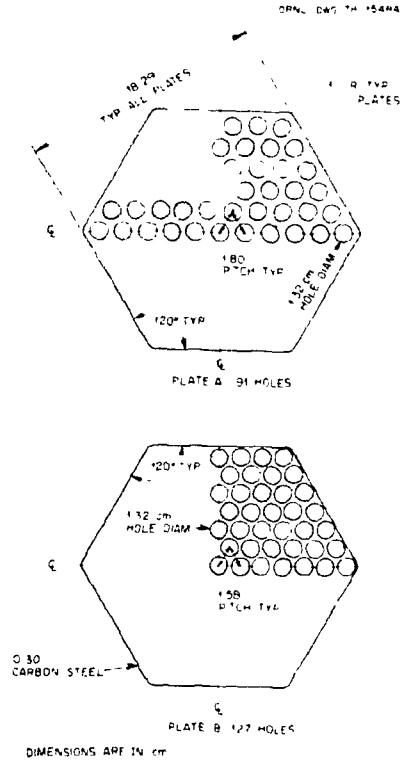

Fig. 3. Fuel pin grid plates for subassemblies.

Fig. 4. Fuel pin subassemblies showing empty assembly (right), full assembly (left), and complete assembly with end plates (center).

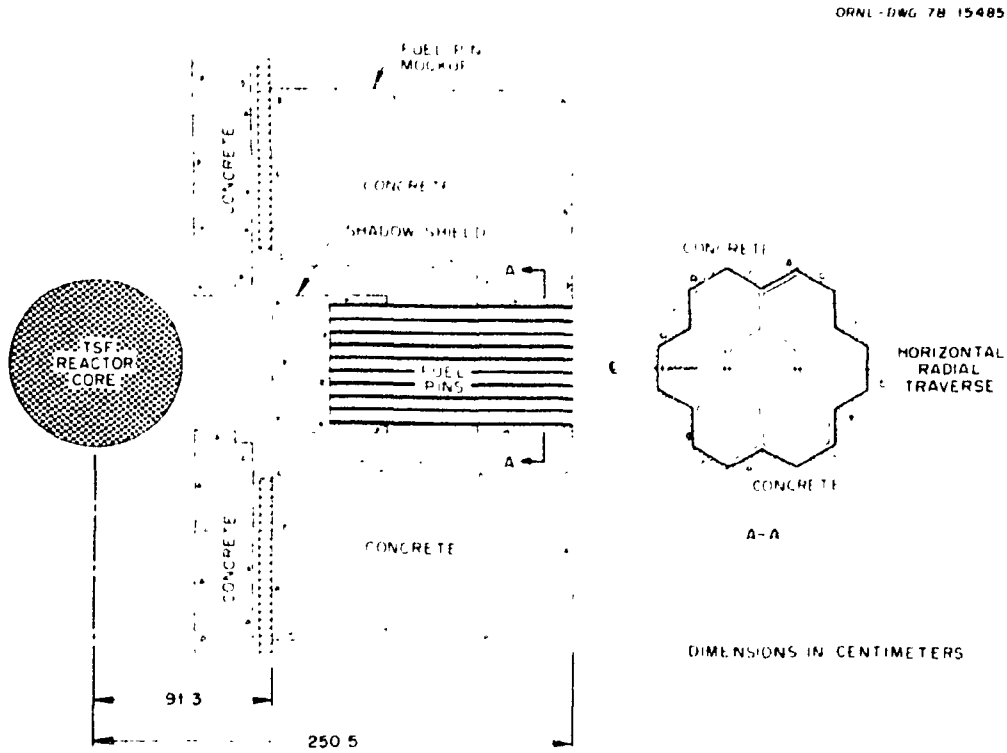

Fig. 5. Second configuration that includes the seven hexagonal fuel pin subassemblies.

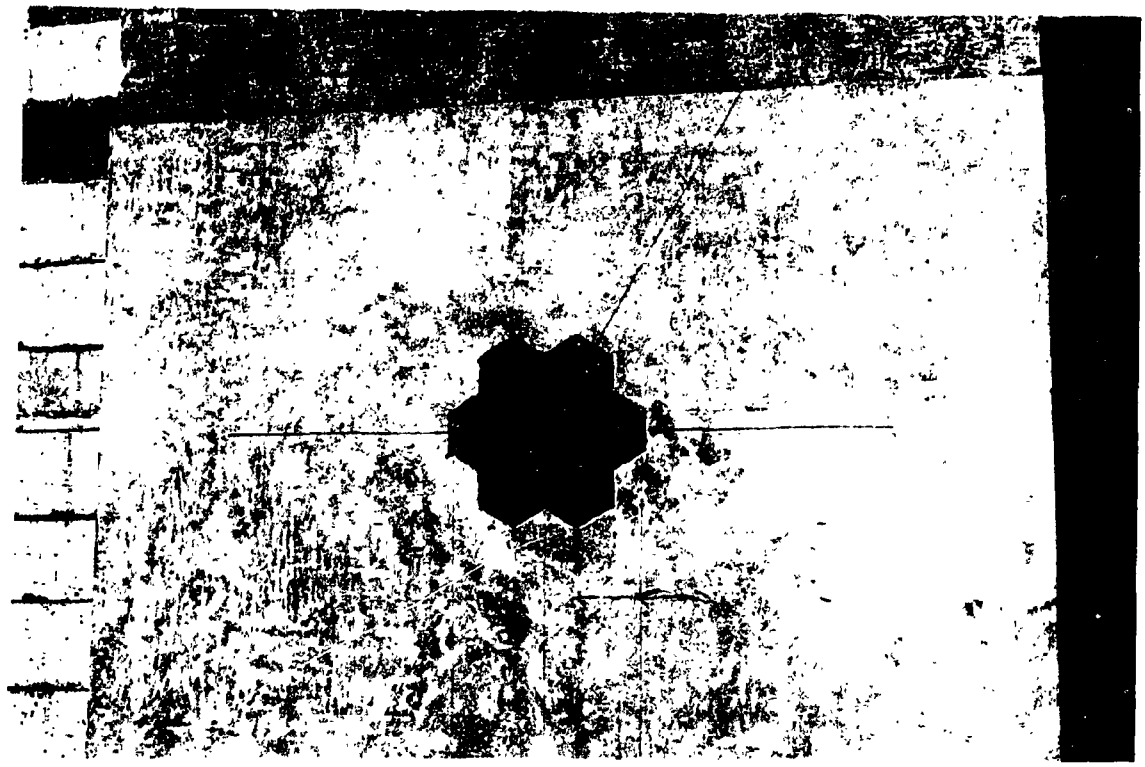

Fig. 6. Mockup of the fuel pin subassemblies.

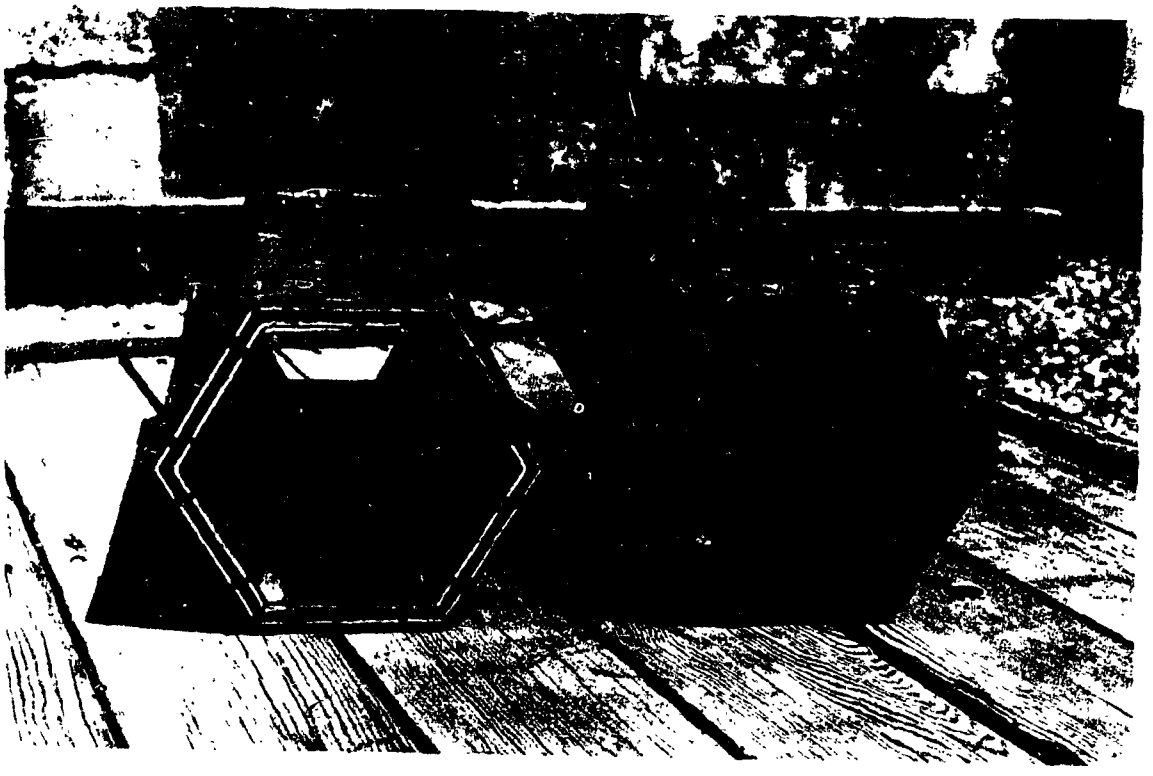

Fig. 7. Grid plate shield B_4C subassemblies showing fuel pin interface (left) and grid plate interface (right).

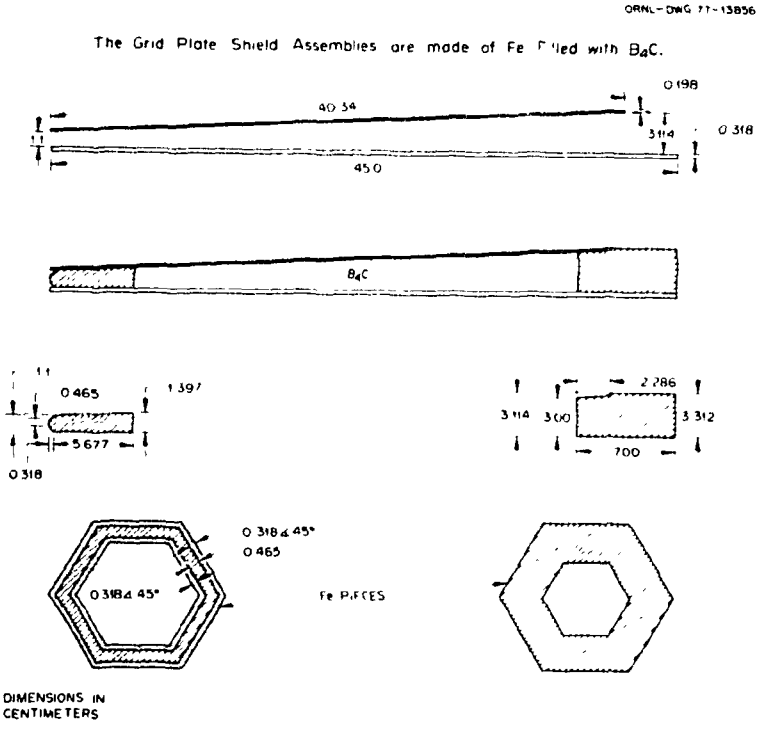

Fig. 8. Schematic of grid plate shield (B_4C) subassembly.

The concrete envelope surrounding the subassemblies also contained an inner Fe liner that matched the one surrounding the fuel pins. When the grid plate shield was placed in the configuration (see Fig. 9) the spacings between the shield subassemblies were the same as those between the fuel pin subassemblies. A mockup of the subassemblies is pictured in Fig. 10. Analyses for the concrete and the Fe in the grid plate shield mockup are given in Tables 1 and 2 respectively.

It was anticipated that traverses behind the grid plate shield might indicate rapid changes in the flux distribution over short distances and any uncertainties in the detector position relative to the grid plate shield could lead to significant discrepancies between calculations and measurements. To minimize this type of error 61 cm of Fe were placed behind the grid plate shield leaving a 15.2-cm void in which the measurements were made (see Fig. 11). Presence of the Fe provides a reflective surface which is readily calculable and this reflection of neutrons provides a near flat distribution across the gap. The sides of the void and the Fe were surrounded with concrete.

3.4 Prototypic Grid Plate

The prototypic grid plate was placed in the configuration only for measurements in priority 1A. The grid plate (see Fig. 12) consisted of a series of 2.54-cm-thick slabs combined with a 15.2 cm slab to form a 63.5-cm-thick rectangular Fe piece 76.2 cm by 76.2 cm. Seven cylindrical holes, 16.5-cm ID, were drilled through the 63.5-cm thickness to simulate the voids for passage of the helium coolant and the control rod drives. The axes of these holes coincided with the axes of the subassemblies in the grid plate shield for the case where the spacing between subassemblies was 1.27 cm (see Fig. 13). Removable sleeves (see Fig. 12), filled with B_4C followed by 5.9-cm Fe, were fabricated to mock up the portion of the grid plate shield which projects into the grid plate. Measured densities of the B_4C in each of the sleeves are listed in Table 4 and an analysis of the Fe in the grid plate is given in Table 5.

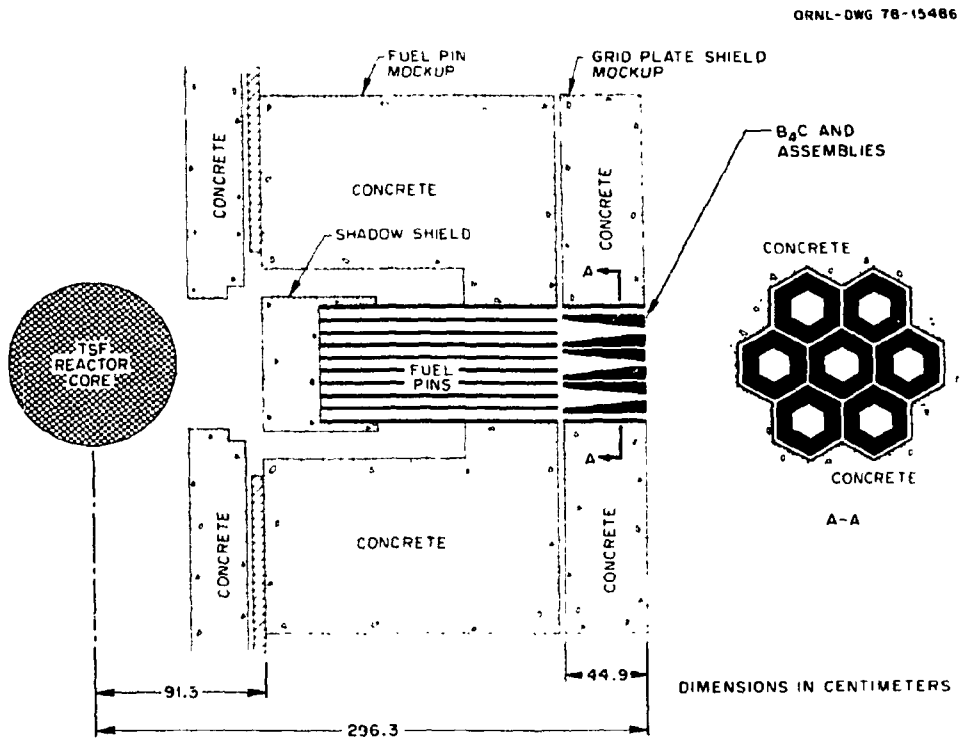

Fig. 9. Third configuration, which includes addition of seven hexagonal grid plate shield B_4C subassemblies.

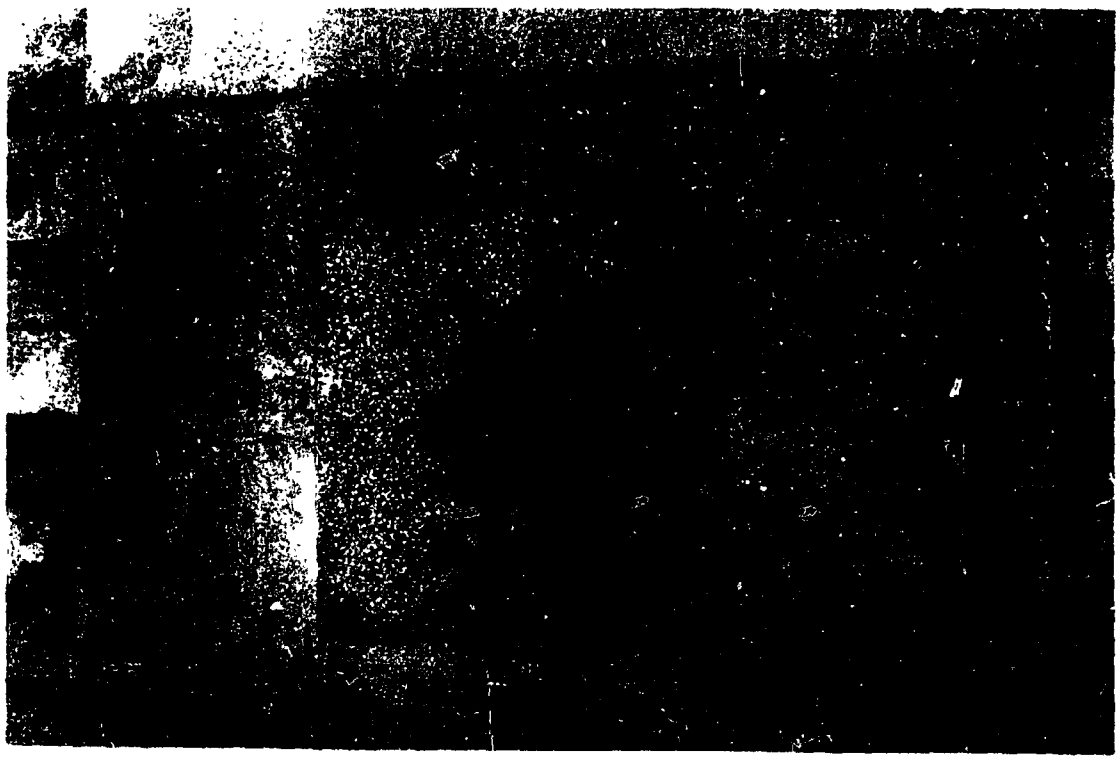

Fig. 10. Mockup of the grid plate shield subassemblies.

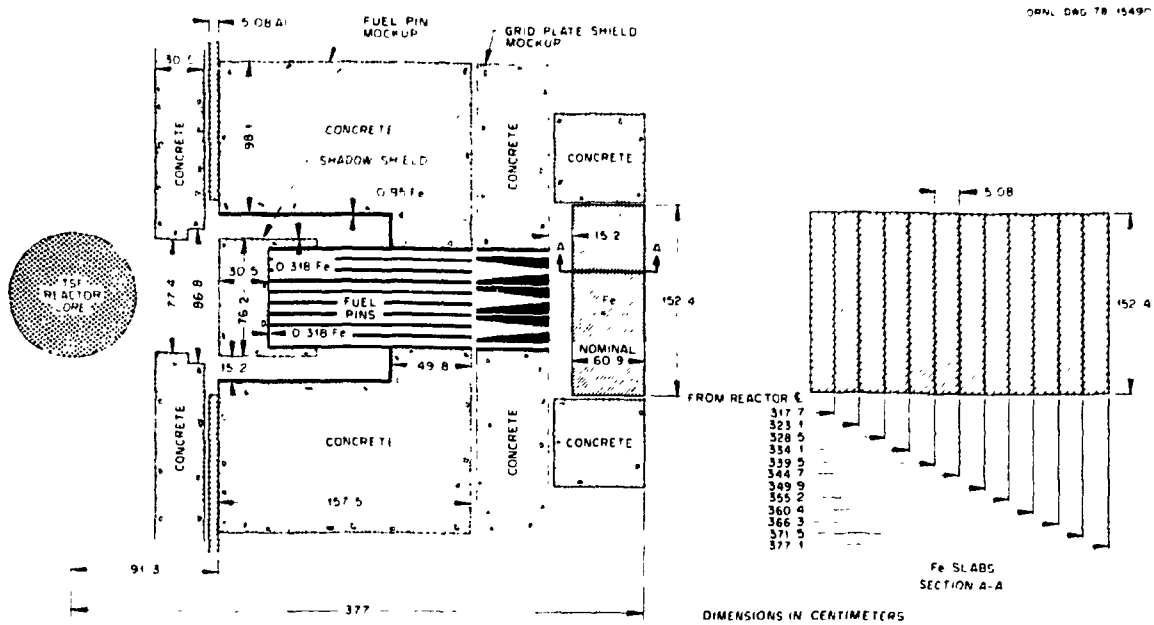

Fig. 11. Fourth configuration, which includes addition of a 61-cm reflecting Fe slab following the 15.24-cm void behind grid plate shield.

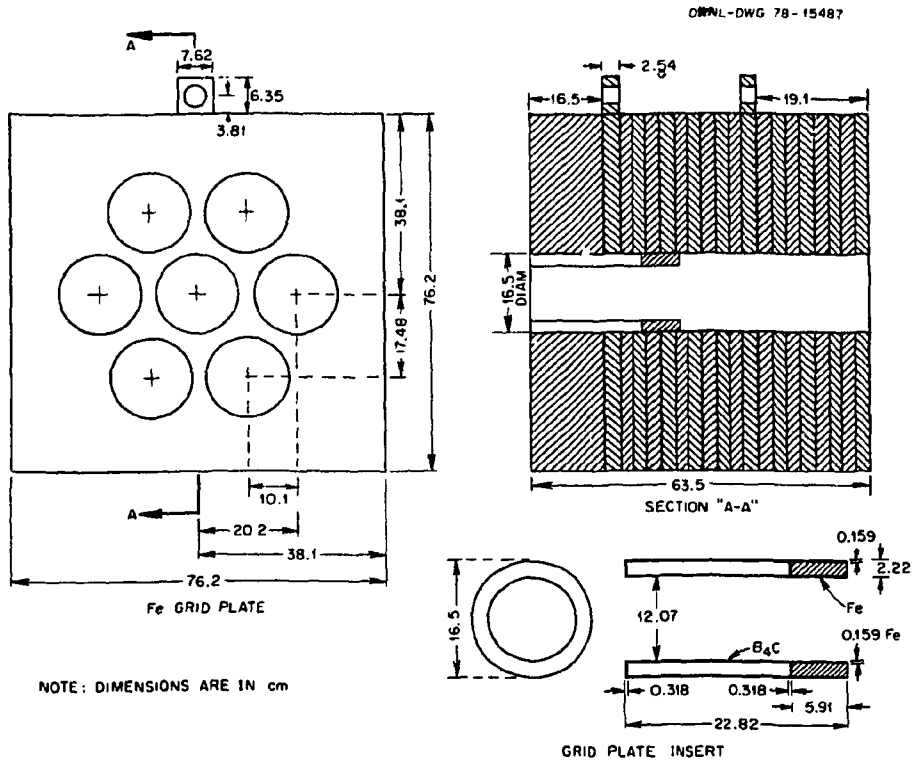

Fig. 12. Schematic of the prototypic grid plate and grid plate inserts (B_4C).

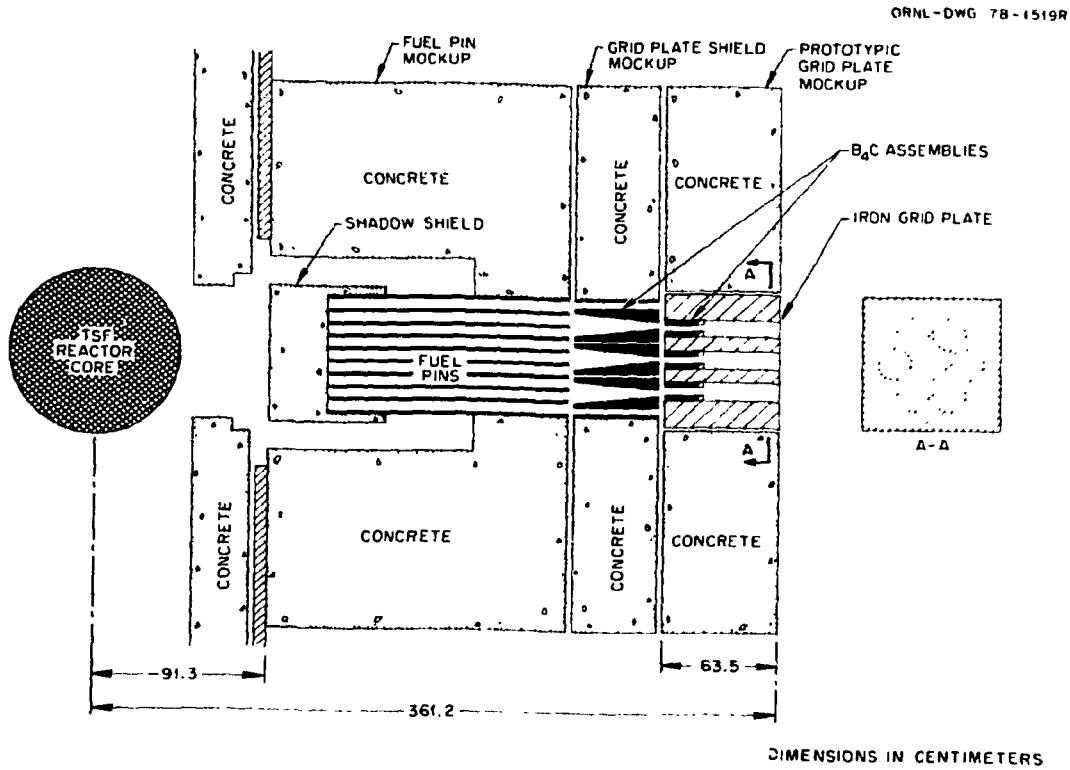

Fig. 13. Final configuration which includes addition of prototypic grid plate.

3.5 Fe-Rod Configuration

A series of measurements were added to the experimental program to compare the neutron streaming through a mockup of 1.27-cm-diameter Fe rods with that of homogeneous Fe plates. The rods were 127-cm long and placed on 1.657-cm centers (see Fig. 14). The spacing of the rods was maintained through the use of three 0.318-cm-thick Fe grids, one at each end and one in the middle. A total of 967 rods in the mockup were placed in the space following the concrete shadow shield previously occupied by the fuel pins.

3.6 Homogeneous Fe-Plate Configurations

A series of 0.304-cm-thick Fe plates were spaced 0.304 cm apart through the use of a series of small washers. These washers were placed on the six 1.27-cm-diameter Fe rods that were used to contain the plates (see Fig. 15). For this mockup the plates replaced the Fe pin assembly in the cavity following the concrete shadow shield.

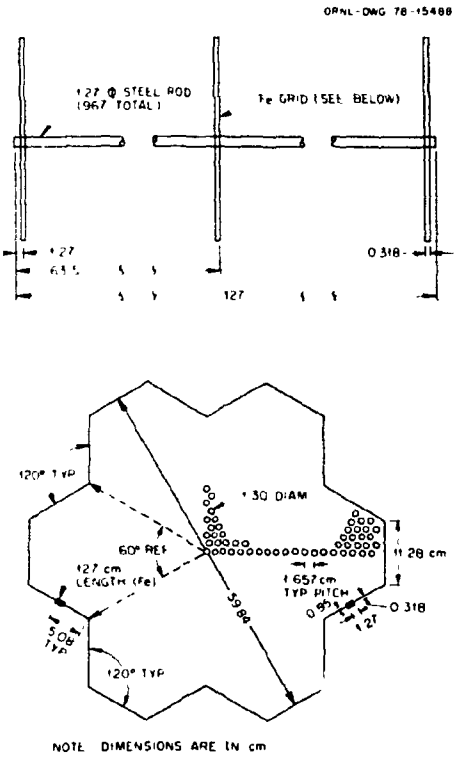

Fig. 14. Schematic of the 967 Fe-rod assembly.

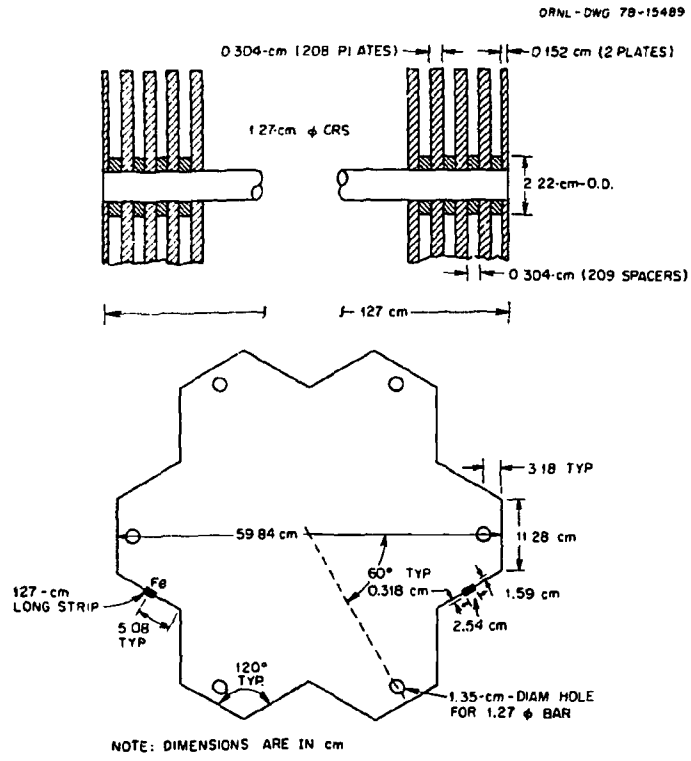

Fig. 15. Schematic of the homogeneous Fe-plate assembly.

4. MEASUREMENTS - PRIORITY 1A

For the initial configuration a slab of concrete containing the previously mentioned features (see section 3.1) was placed next to the reactor shield collimator (see Fig. 1). The view "BB" in Fig. 1 shows the void around the concrete shadow shield was not symmetric but varied from about 14.6 cm to 15.7 cm. The first series of measurements in the cavity beyond the shadow shield were made to check the calculations of the flux distribution from the TSR-II prior to insertion of the fuel pins. Axial traverses were made with the bare, Cd-covered, and 5-in.-diam Bonner balls and the 1.27-cm Hornyak button from the shadow shield to 457.2 cm beyond it. These results are given in Table 6 and plotted in Fig. 16. Radial traverses were made at 30.5 cm behind the concrete shield containing the cavity (157.5 cm beyond the shadow shield). Radial traverses throughout the experiment were always made in the horizontal plane unless otherwise noted. Results from these measurements are given in Table 7 and plotted in Fig. 17. For this configuration an additional radial traverse at 30.5 cm behind the shield was made at 60^{o} to the horizontal plane to check the symmetry of the flux leaving the cavity. This measurement was made with a 1.27-cm right cylinder Hornyak button and when compared with the same detector run in the horizontal plane there was indication of good symmetry in the flux distribution (see Table 8 and Fig. 18). Added to the original data plan were centerline measurements with the 3-, 6-, and 10-in.-diam Bonner balls at 370.8 cm behind the shadow shield. These measurements, given in Table 9, served as a check on the calculations of the emerging neutron spectrum.

The fuel pin subassemblies (889 pins, 1.58 cm pitch) were then placed in the cavity following the concrete shadow shield (see Fig. 5). For pirority 1A the spacing between subassemblies was 1.27 cm. A view of the subassemblies in their concrete "housing" is shown in Fig. 9. A radial traverse, directly behind the fuel pins, with the 0.635-cm Hornyak button indicated some neutron streaming in the void between subassemblies (See Table 10 and Fig. 19). This particular measurement was limited to just half a traverse since it was obtained only to determine if such a measurement would provide any useful information and was

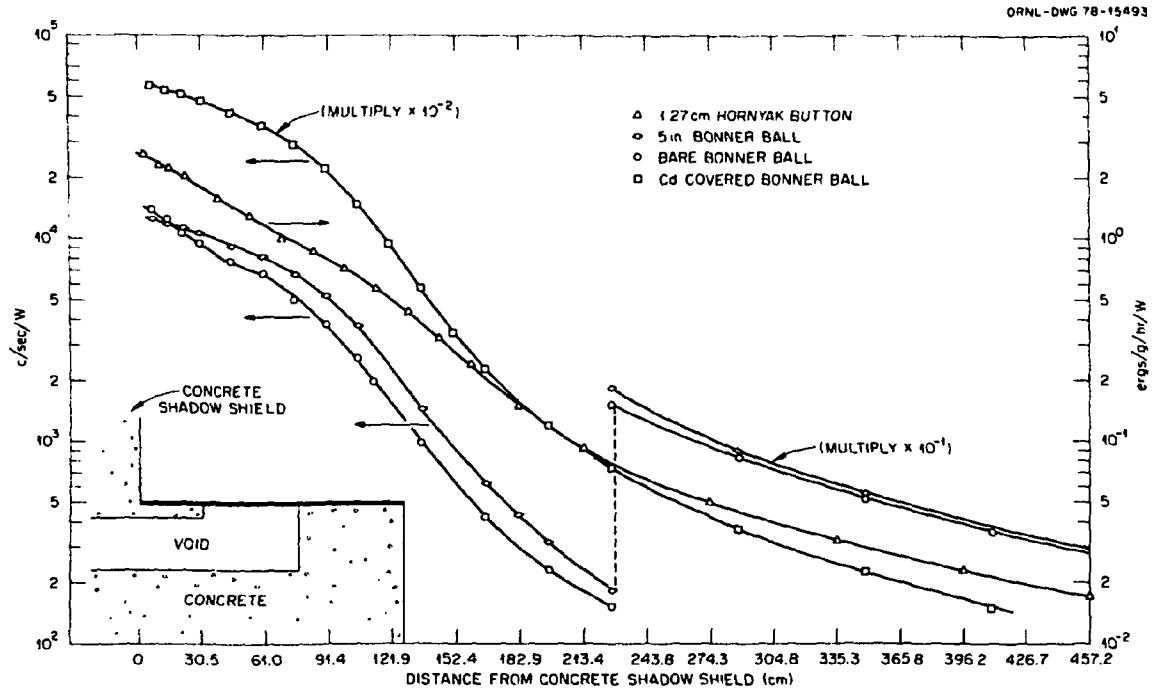

Fig. 16. Axial traverses beyond the concrete shadow shield with the Hornyak button and Bonner balls. *(Item II-A)*

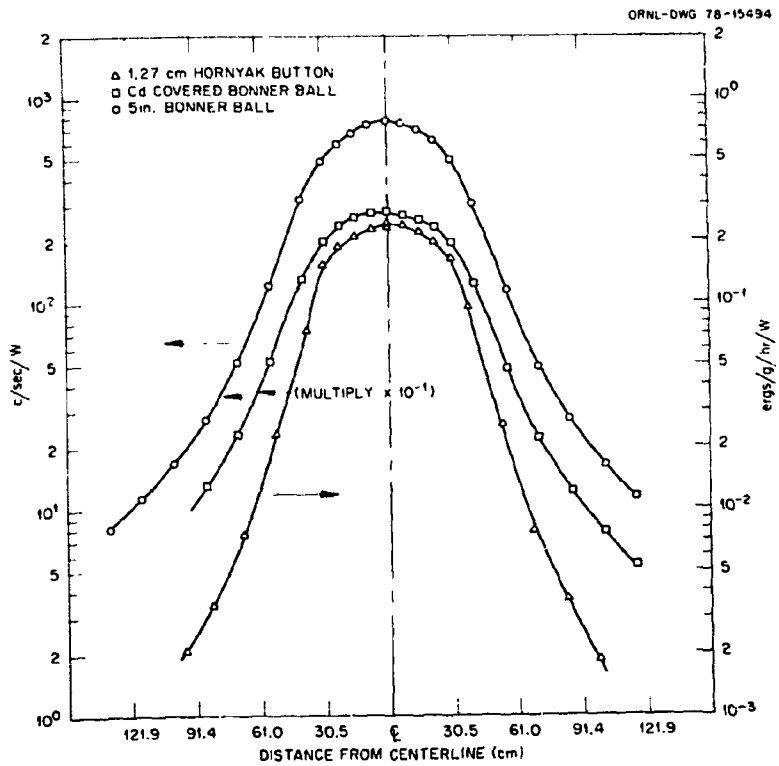

Fig. 17. Radial traverses at 157.5 cm beyond the shadow shield with the Hornyak button and Bonner balls. *(Item II-A)*

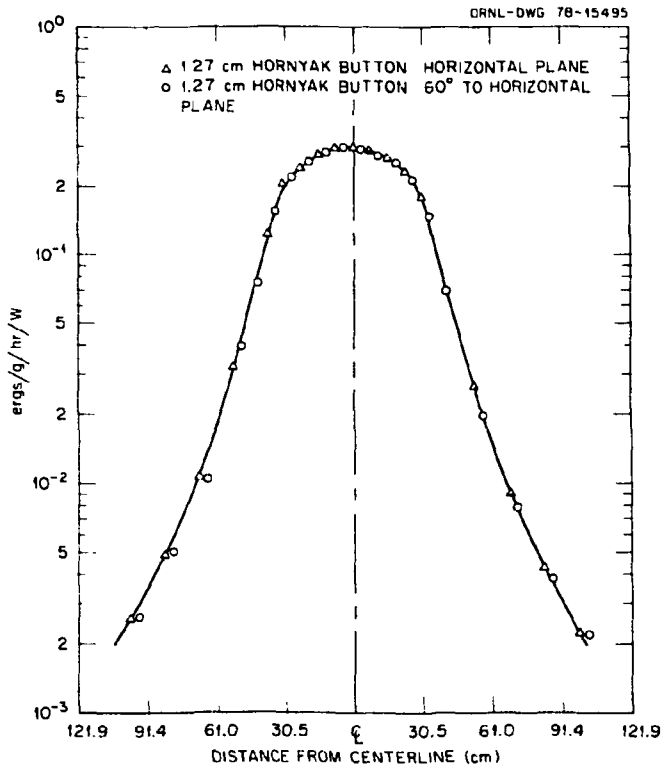

Fig. 18. Radial traverses in two planes (horizontal and 60° to horizontal) at 157.5 cm beyond shadow shield using 1.27-cm right cylinder Hornyak button. *(Item II-A)*

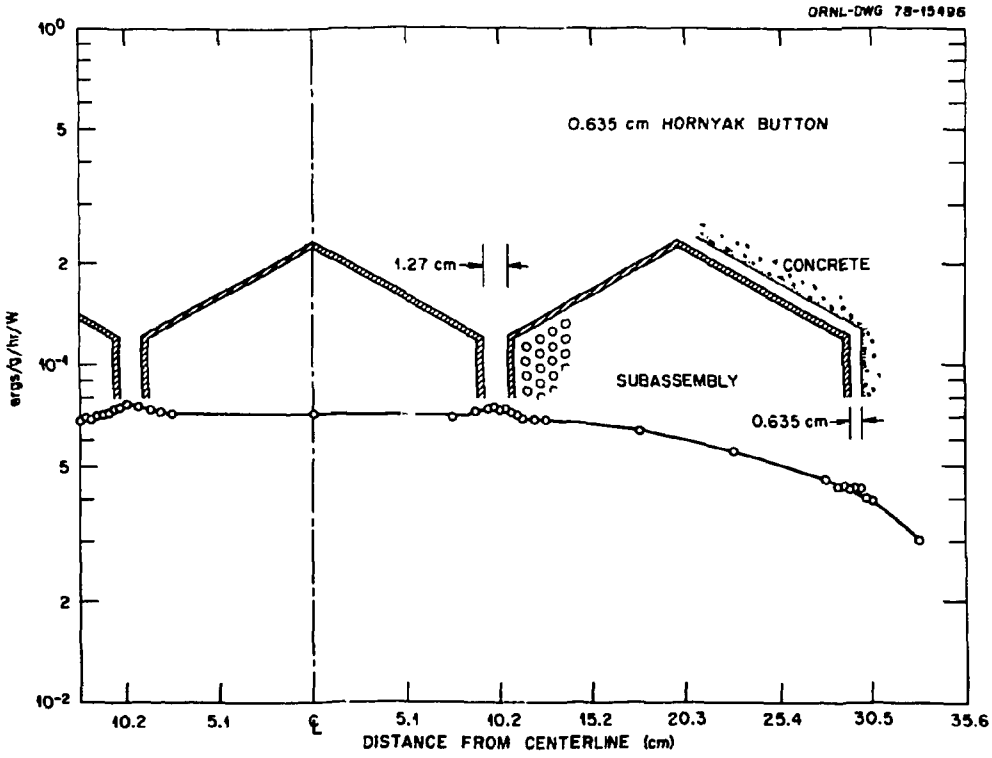

Fig. 19. Radial traverse directly behind 889 fuel pins using Hornyak button. *(Item II-B)*

not included in the original plan. The results did arouse sufficient interest to include the measurement behind other fuel pin subassembly configurations.

Radial traverses were made at 30.5 cm and 305 cm beyond the fuel pins with the Cd-covered and 5-in.-diam Bonner balls and the 1.27-cm Hornyak button. These measurements are recorded in Table 11 and 12, respectively. A plot (see Fig. 20) of the data obtained with the 1.27-cm Hornyak button indicates that neutron streaming between subassemblies was still observable at 30.5 cm beyond the pins. At 305 cm (see Fig. 21) any semblance of peaking between subassemblies seemed to disappear. Three points were repeated with the 0.635-cm Hornyak button (see Table 13) to compare detectors since measurements throughout the experiment were made with both detectors. The agreement was better than 5%, well within the errors of the measurements.

Spectral measurements were made with both the NE213 scintillator and the proton recoil hydrogen counters at 138 cm beyond the fuel pins. The fast neutron spectrum values (NE213) are listed in Table 14 and plotted in Fig. 22. The two curves represent the upper and lower limits of the error of the measurements, exclusive of reactor power. The neutron spectrum between 100 keV and 1.5 MeV, obtained with the Hydrogen counters is listed in Table 15 and plotted in Fig. 23.

Centerline measurements with the 3-, 6-, and 10-in.-diam Bonner balls (Table 16) were made at the same location as the NE213. They provide another check on the calculations of the neutron spectrum.

The concrete slab for containment of the grid plate shield was next added to the configuration (see Fig. 24). Centerline measurements were made at 30.5 cm beyond the concrete as another step in the check on the calculations. Data for the Cd-covered and 5-in.-diam Bonner balls and 1.27-cm Hornyak button are given in Table 17.

The grid plate shield, in the form of B_4C-filled subassemblies, was placed directly behind the fuel pins in the above-noted concrete slab (see Fig. 9). The axes of these subassemblies were matched

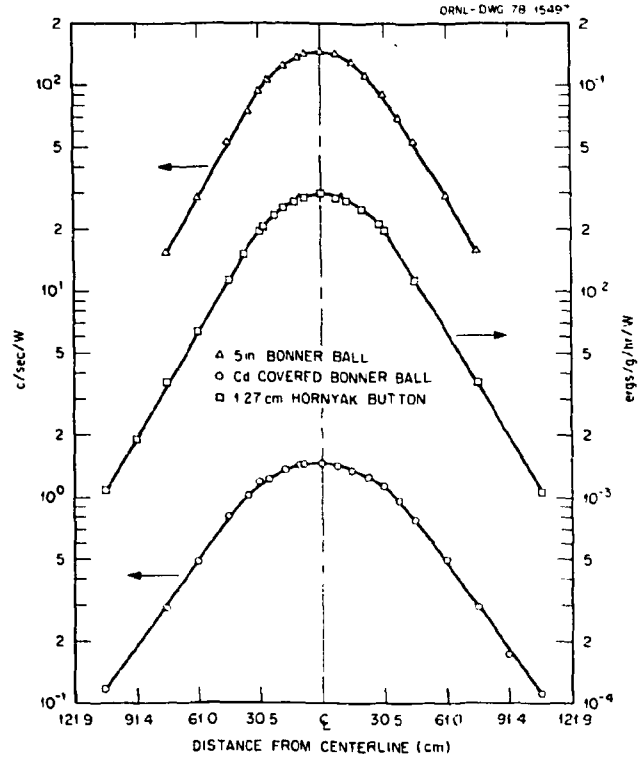

Fig. 20. Radial traverses at 30.5 cm behind 889 fuel pins using Hornyak button and Bonner balls. *(Item II-B)*

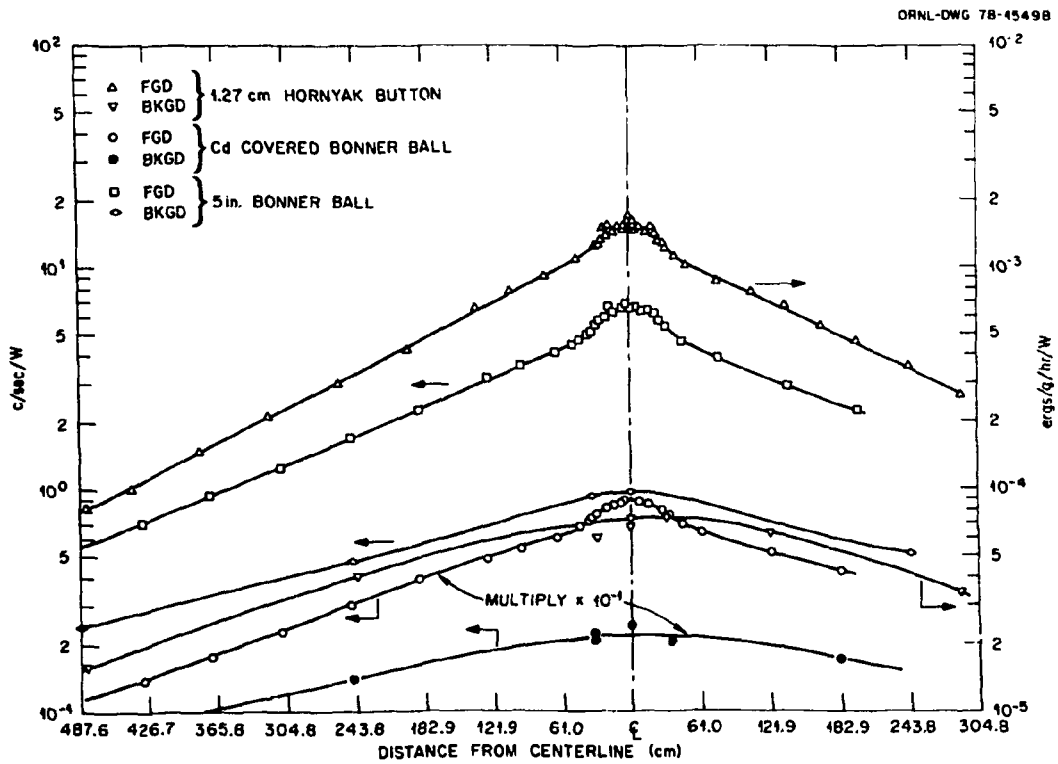

Fig. 21. Radial traverses at 305 cm behind 889 fuel pins using Hornyak button and Bonner balls. *(Item II-B)*

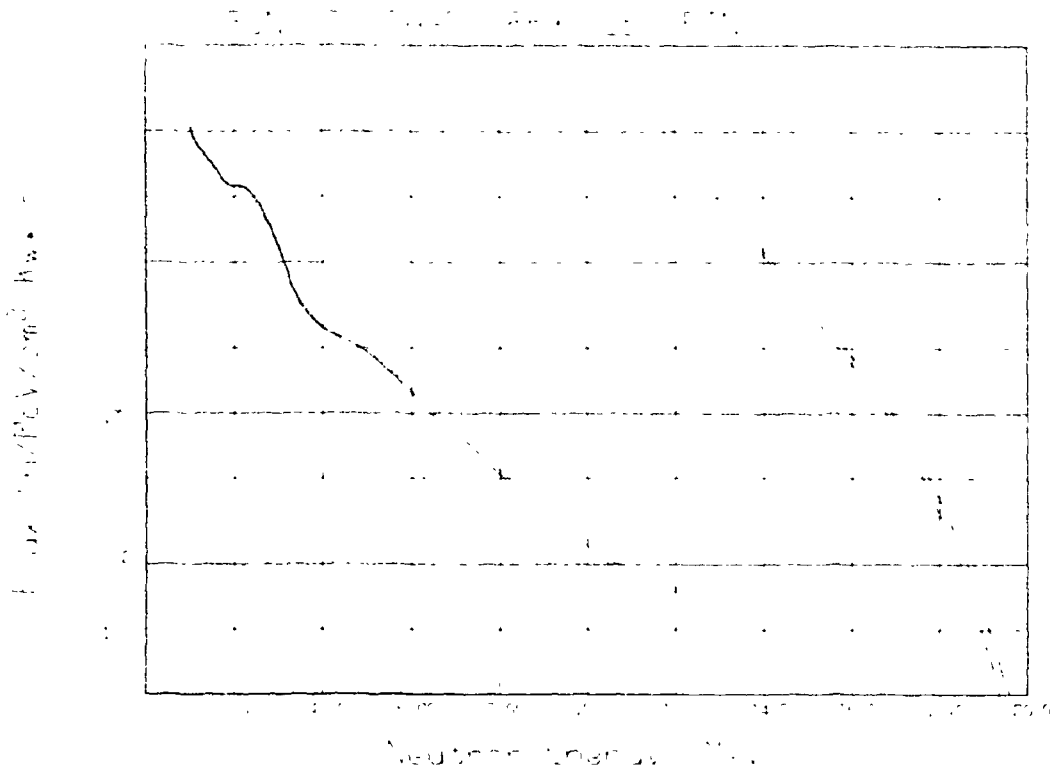

Fig. 22. High energy neutron spectrum on centerline at 138 cm beyond 889 fuel pins. *(Item II-B)*

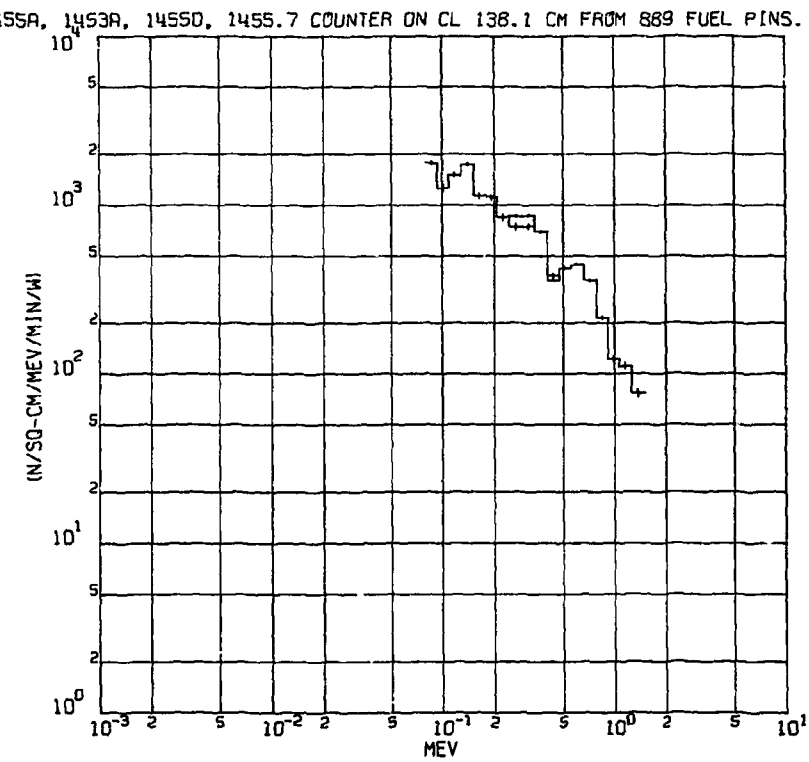

Fig. 23. The spectrum of neutrons from 100 keV to 1.4 MeV on centerline at 138 cm beyond 889 fuel pins. *(Item II-B)*

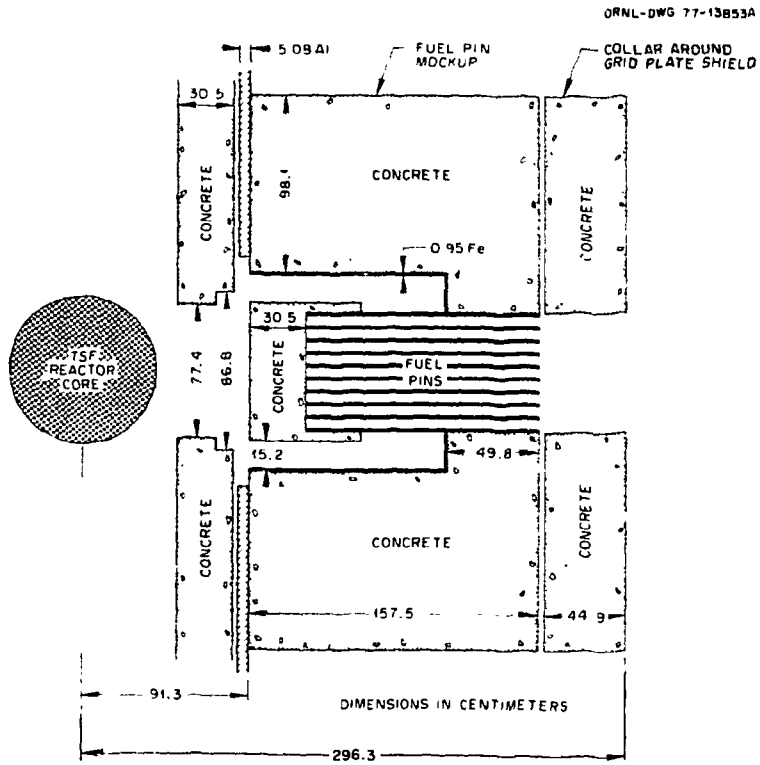

Fig. 24. Concrete envelope that surrounds grid plate shield added to second configuration. *(Item II-C)*

to those of the fuel pin subassemblies, maintaining the requested spacings between subassemblies. A picture of the grid plate shield mockup was previously shown in Fig. 10.

Radial traverses were made directly behind the grid plate shield with the Cd-covered Bonner ball and the 0.635-cm Hornyak button. These results are tabulated in Table 18 and plotted in Fig. 25. The resolution of the Hornyak button was sufficient to indicate a significant streaming component between subassemblies. It also indicated that for this mockup the fast flux was slightly greater through the central subassembly when compared to the outside assemblies. For the Cd-covered Bonner ball the trend was just the opposite, with a greater concentration of low energy flux existing near the fuel pin concrete interface.

Centerline measurements with the bare, Cd-covered, and 5-in.-diam Bonner balls were made at 30.5 cm and 305 cm beyond the grid plate shield. These are listed in Table 19. An axial traverse was made through the

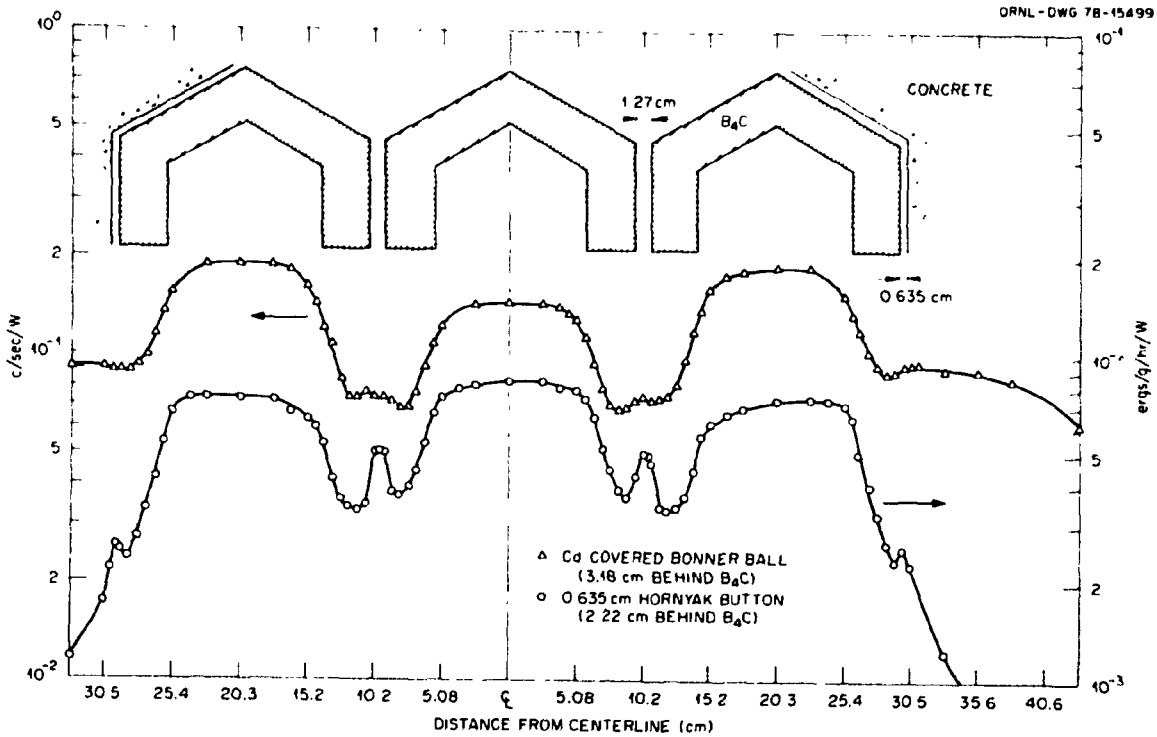

Fig. 25. Radial traverses directly behind grid plate shield using Hornyak button and Bonner ball. *(Item II-D)*

central subassembly from the fuel pins to 30.5 cm beyond the grid plate shield using the Cd-covered Bonner ball and the 1.27-cm Hornyak button. The slope of the curve for the Cd-covered Bonner ball was much steeper initially and then basically approached that of the Hornyak button. These results are given in Table 20 and plotted in Fig. 26.

Radial traverses behind the grid plate shield were repeated, this time in a 15.24 cm void followed by 61 cm of Fe. This mockup was previously discussed (see Section 3.3) and shown in Fig. 11. These measurements were limited to the use of the Cd-covered and 5-in.-diam Bonner balls since the depth of the void was not sufficient for the Hornyak button. The results from these radial measurements are given in Table 21 and plotted in Fig. 27.

The full configuration was reached by removing the Fe slabs and placing the prototypic grid plate directly behind the grid plate shield (see Fig. 13). The axes of the holes in the grid plate were placed

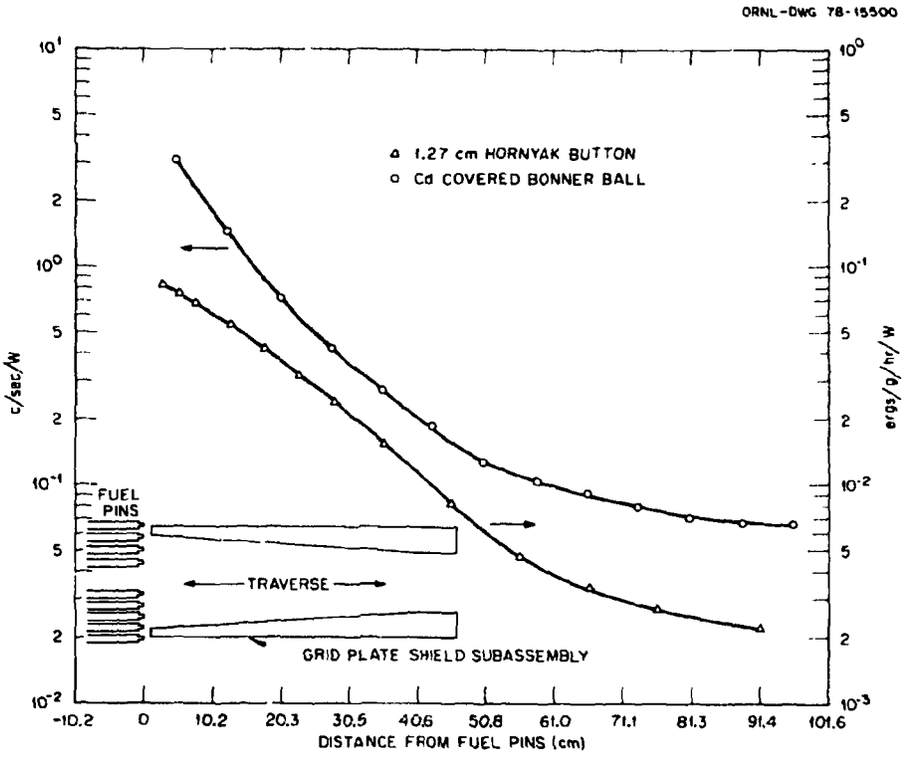

Fig. 26. Axial traverse through grid plate shield central subassembly using Hornyak button and Bonner ball. *(Item II-D)*

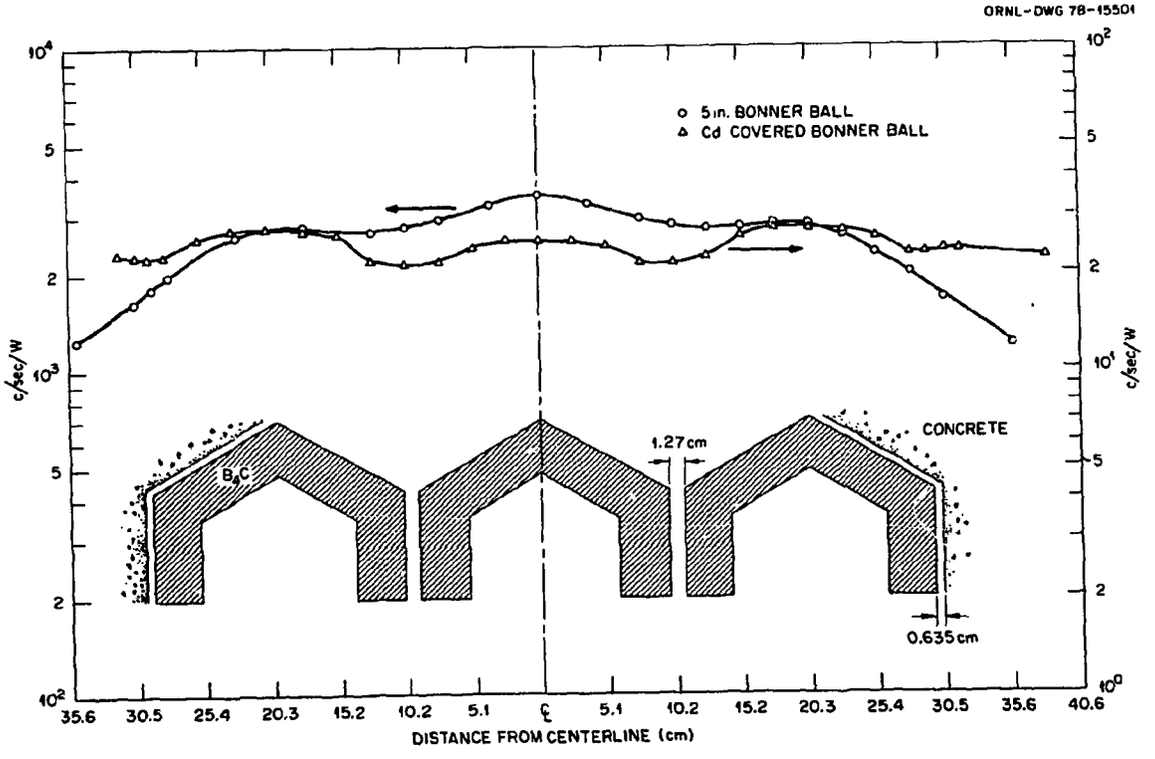

Fig. 27. Radial traverse in 15.24-cm void between grid plate shield and 61-cm Fe reflector using Bonner balls. *(Item II-E)*

coincident with the axes of the B_4C subassemblies. The sides of the grid plate were then surrounded by concrete to minimize background as shown in Fig. 28. Radial traverses were made at 30.5 cm (Tables 22 and 23, Figs. 29 and 30) and 305 cm (Table 24, Fig. 31) with and without the B_4C inserts in the grid plate. The data at 30.5 cm using the Hornyak button indicated peaks behind the Fe portion of the grid plate that separated the cylindrical voids. This was assumed to be due to scattering from the holes directly above and below this Fe position since a traverse closer to the grid plate (Table 25, Fig. 32) eliminated these peaks. Centerline measurements were also made with a series of Bonner balls at 305 cm behind the grid plate to provide another check on the source term to be used for calculations of the upper axial shield. The data are given in Table 26.

Spectral measurements were made on centerline at 34.3 cm behind the grid plate. The high energy spectrum (NE213) is recorded in Table 27 and plotted in Fig. 33, and the low energy spectrum (Hydrogen counters) is given in Table 28 and plotted in Fig. 34.

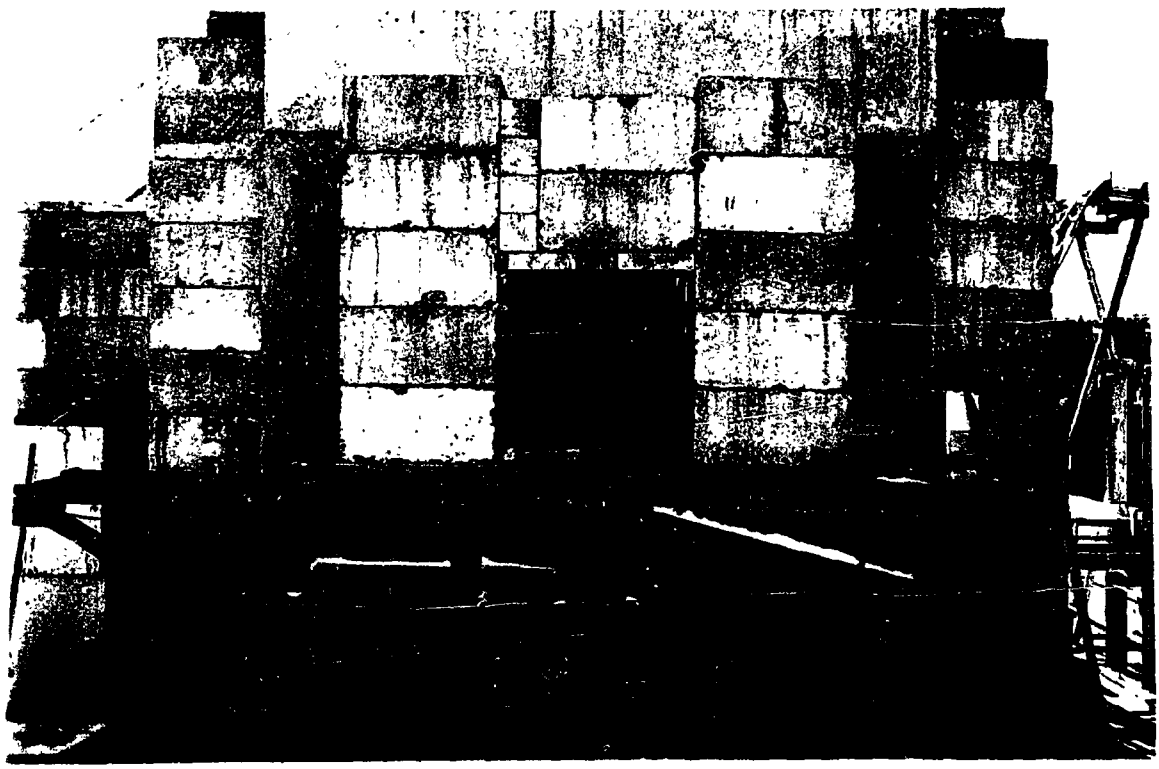

Fig. 28. Prototypic grid plate mockup. *(Item II-F)*

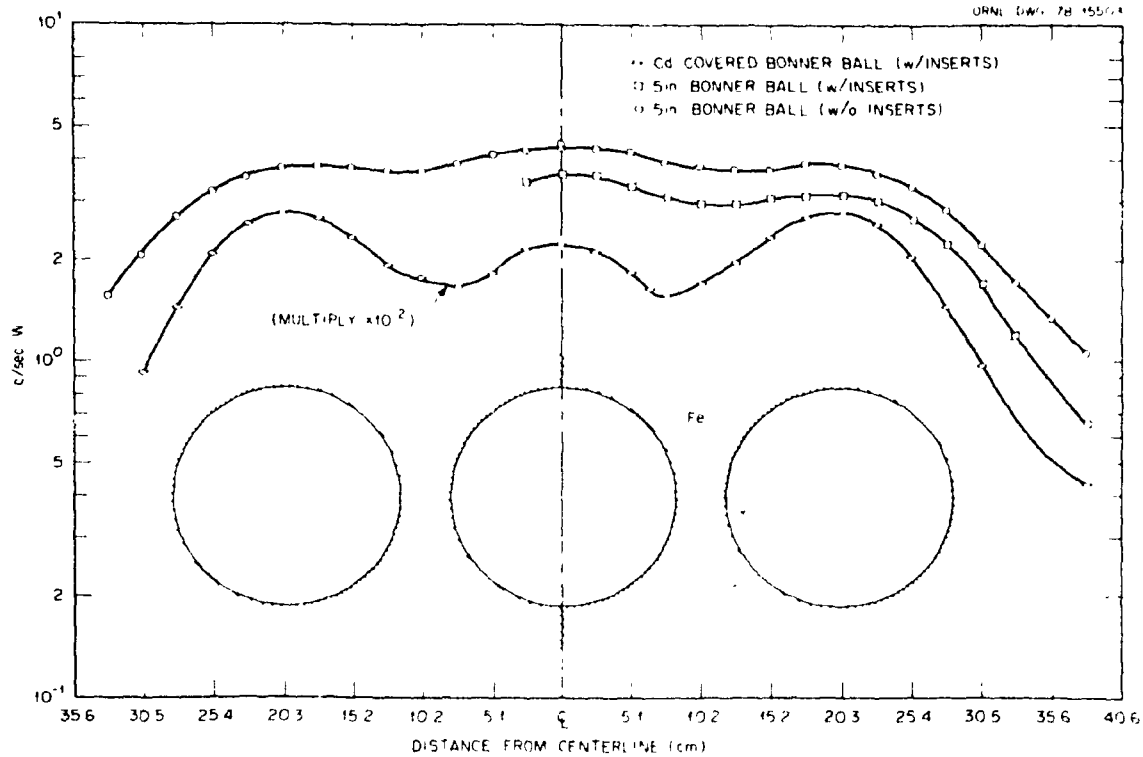

Fig. 29. Radial traverse at 30.5 cm behind prototypic grid plate (with and without inserts) using Bonner balls. *(Item II-F)*

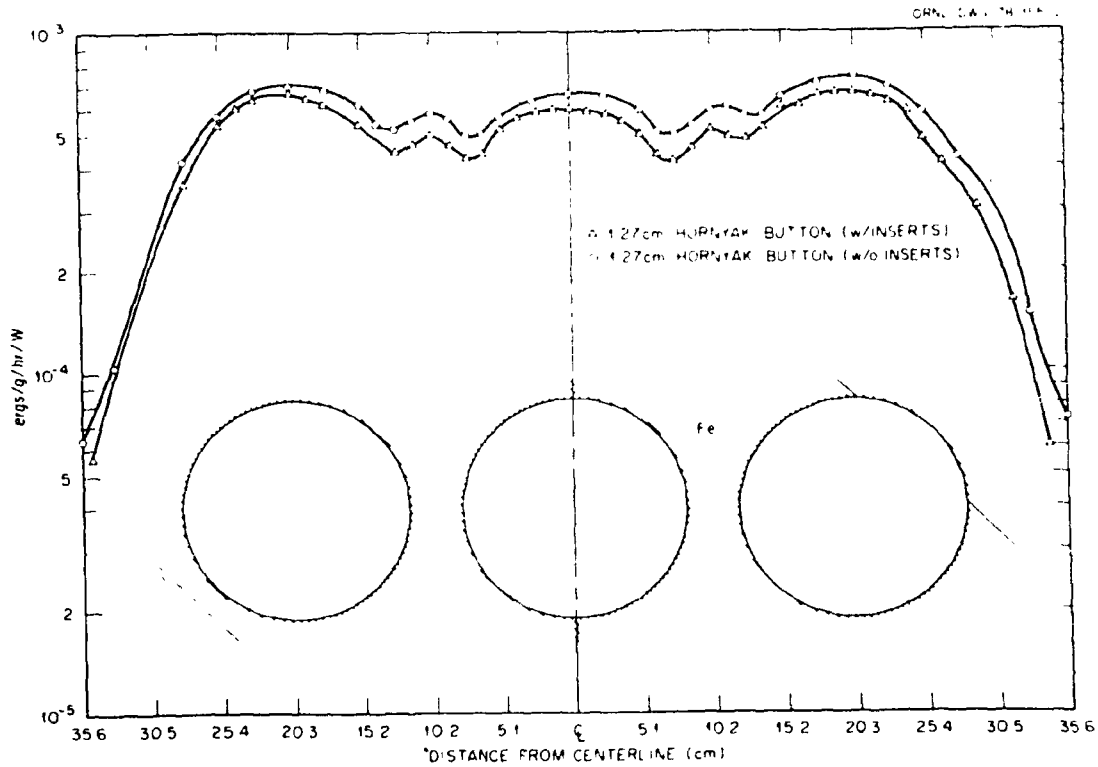

Fig. 30. Radial traverse at 30.5 cm behind prototypic grid plate (with and without inserts) using Hornyak button. *(Item II-F)*

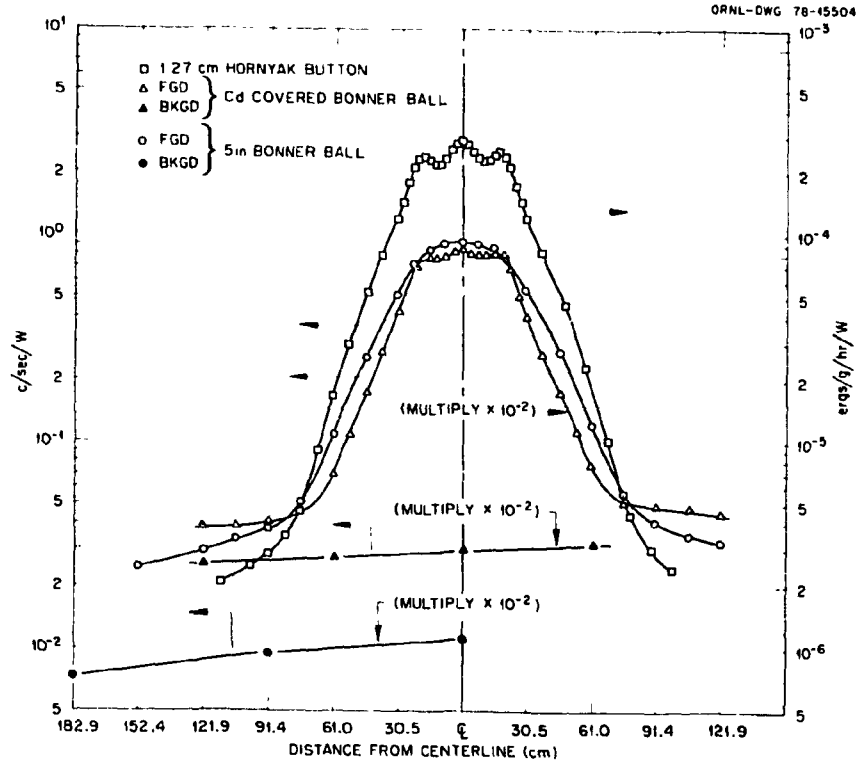

Fig. 31. Radial traverse at 305 cm behind prototypic grid plate with inserts using the Hornyak button and Bonner balls. *(Item II-F)*

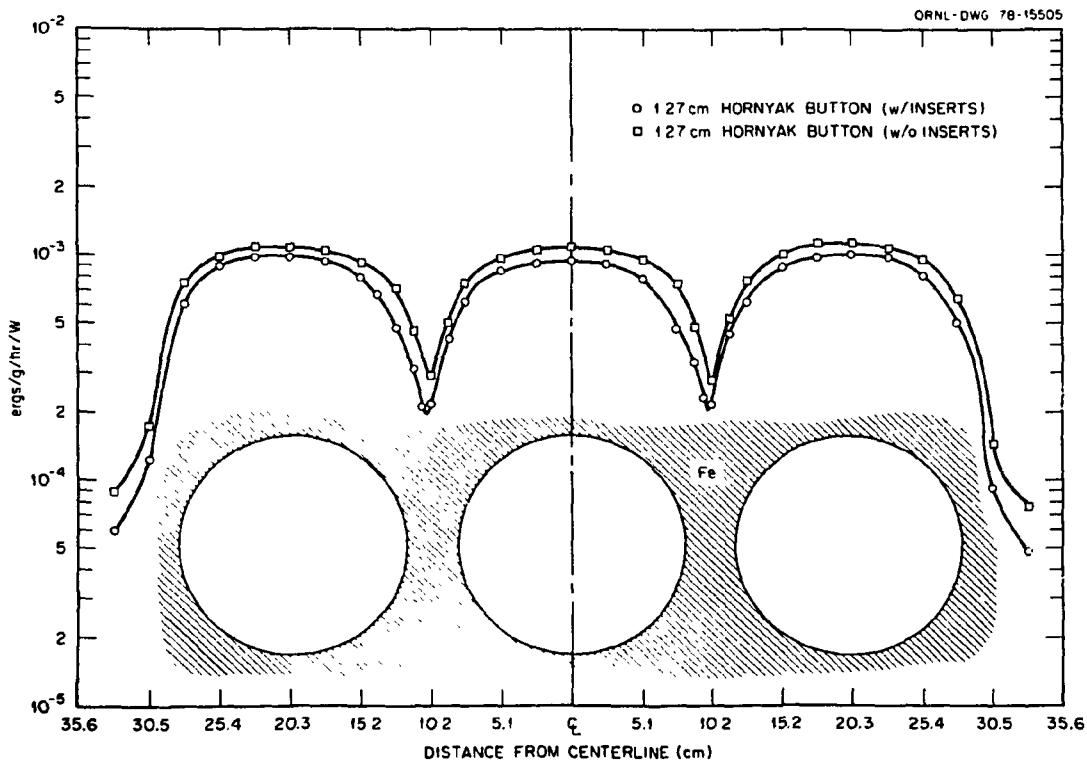

Fig. 32. Radial traverses at 7.62 cm behind prototypic grid plate (with and without inserts) using Hornyak button. *(Item II-F)*

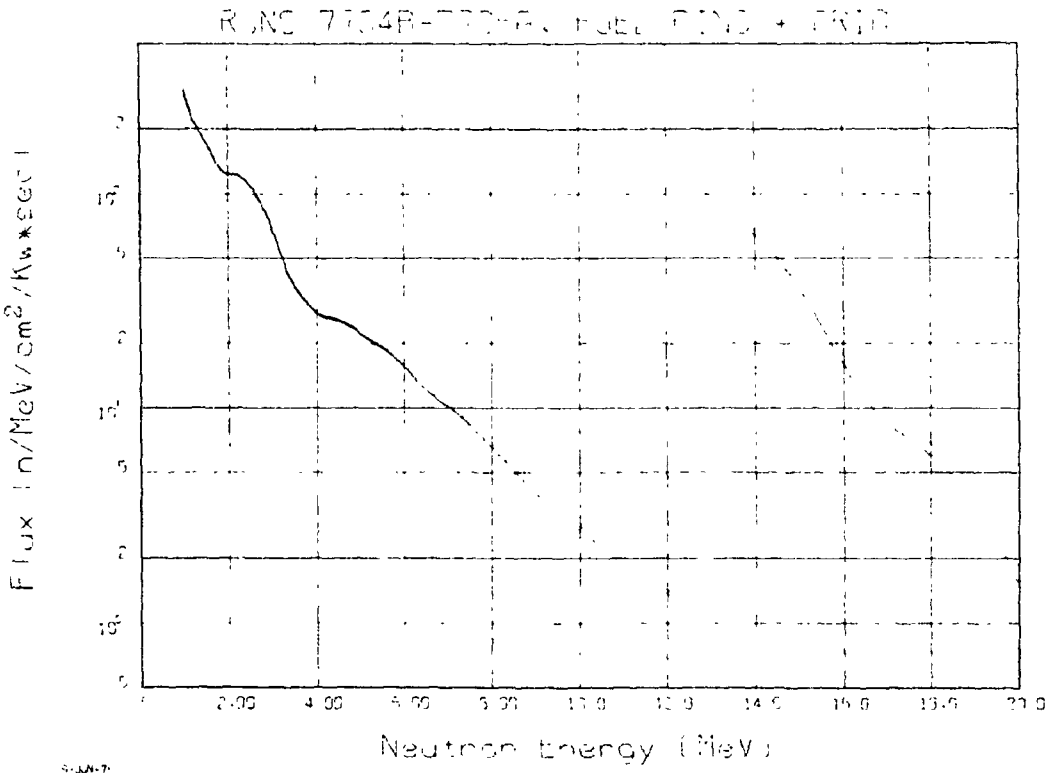

Fig. 33. High energy neutron spectrum on centerline at 34.3 cm beyond prototypic grid plate (with inserts). *(Item II-F)*

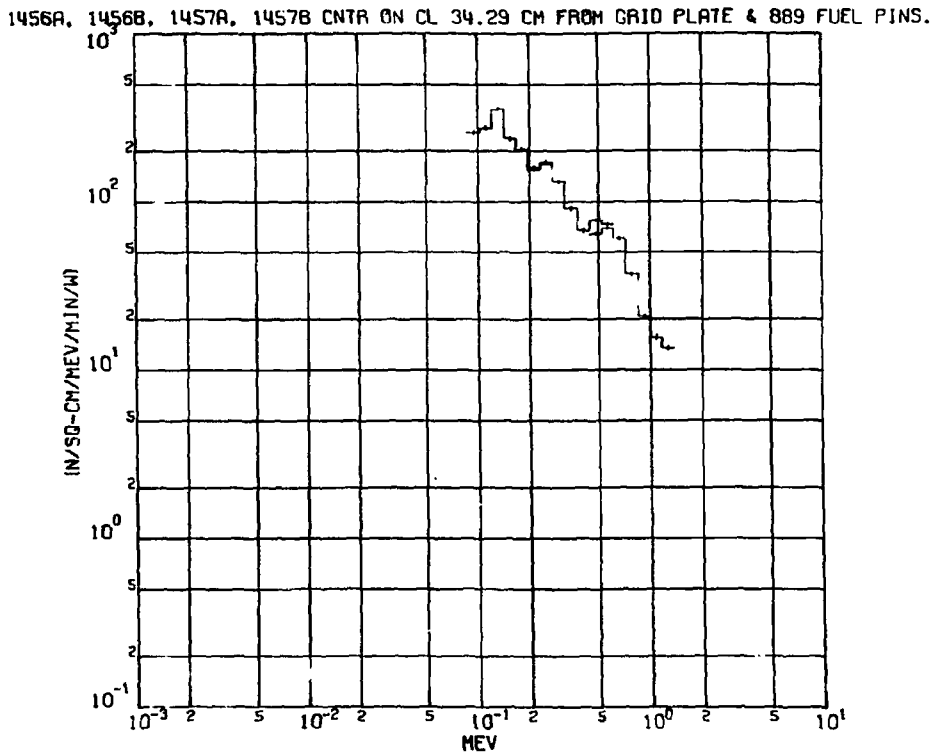

Fig. 34. The spectrum of neutrons from 100 keV to 1.4 MeV on centerline at 34.3 cm beyond prototypic grid plate (with inserts). *(Item II-F)*

5. MEASUREMENTS - PRIORITY 1B

The number of configurations studied under this priority was reduced from priority 1A by eliminating the grid plate mockup. The number of radial traverses was also minimal, putting emphasis on just the centerline measurements. For the fuel pin configuration the same fuel pin subassemblies were used as those in priority 1A except that the spacings between subassemblies were reduced from 1.27 cm to 0.635 cm. A radial traverse was made with the Hornyak button directly behind the fuel pins, the results of which are given in Table 29 and plotted in Fig. 35. Centerline measurements were made at 30.5 cm and 305 cm behind the pins using the Hornyak button, the Cd-covered Bonner ball, and the 5-in.-diam Bonner ball. These results are given in Table 30. These measurements were repeated later and the results also given in the above tables and figure are indicative of the error that might be expected in this experiment.

The grid plate shield was then added to the configuration, again keeping each of the B_4C subassembly centerlines coincident with those for the fuel pin subassemblies. Results from a radial traverse directly behind the shield with the Cd-covered Bonner ball and Hornyak button are given in Table 31 and Fig. 36. Centerline measurements at 30.5 cm and 305 cm behind the grid plate shield are listed in Table 32.

The final measurements for this priority were radial traverses with the Cd-covered and 5-in.-diam Bonner balls in the 15.24 cm void between the grid plate shield and 61-cm Fe. These data are presented in Table 33 and Fig. 37.

6. MEASUREMENTS - PRIORITY 1C

For this priority the number of pins per subassembly was changed from 127 to 91 (pitch 1.80) and the spacing between subassemblies returned to 1.27 cm. Data behind this mockup were limited to centerline measurements at 30.5 cm and 305 cm and these measurements are listed in Table 34.

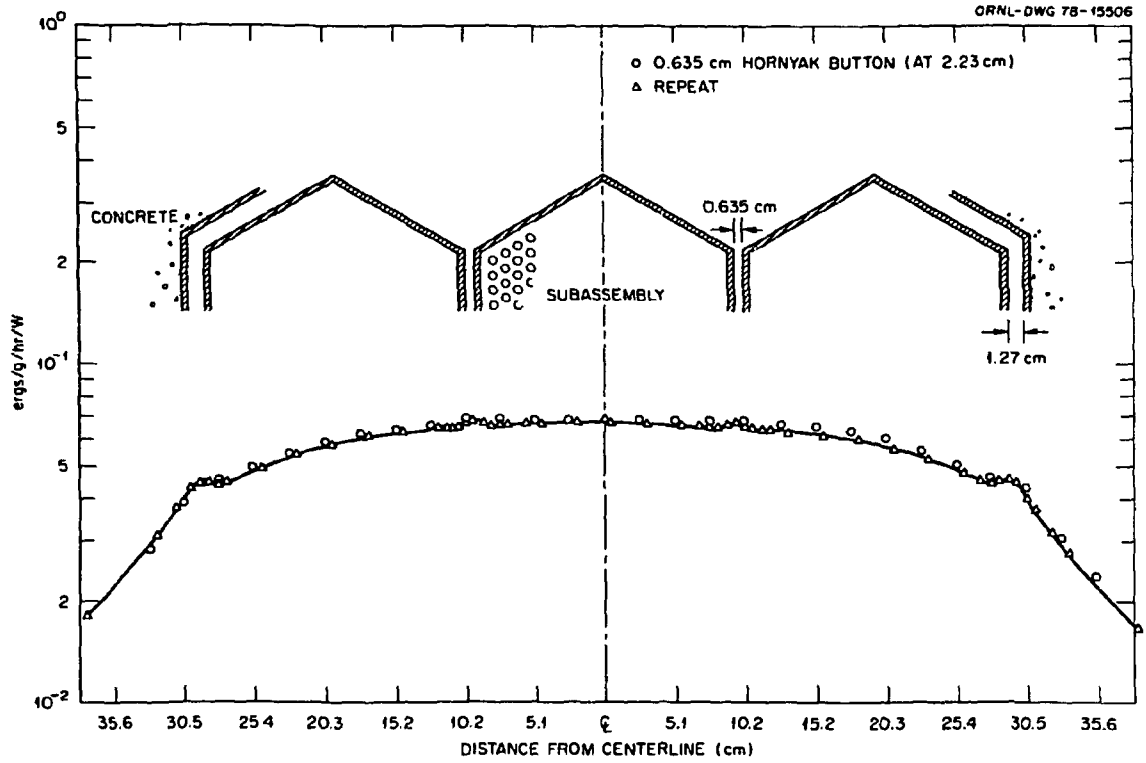

Fig. 35. Radial traverse directly behind 889 fuel pins using Hornyak button. *(Item III-A)*

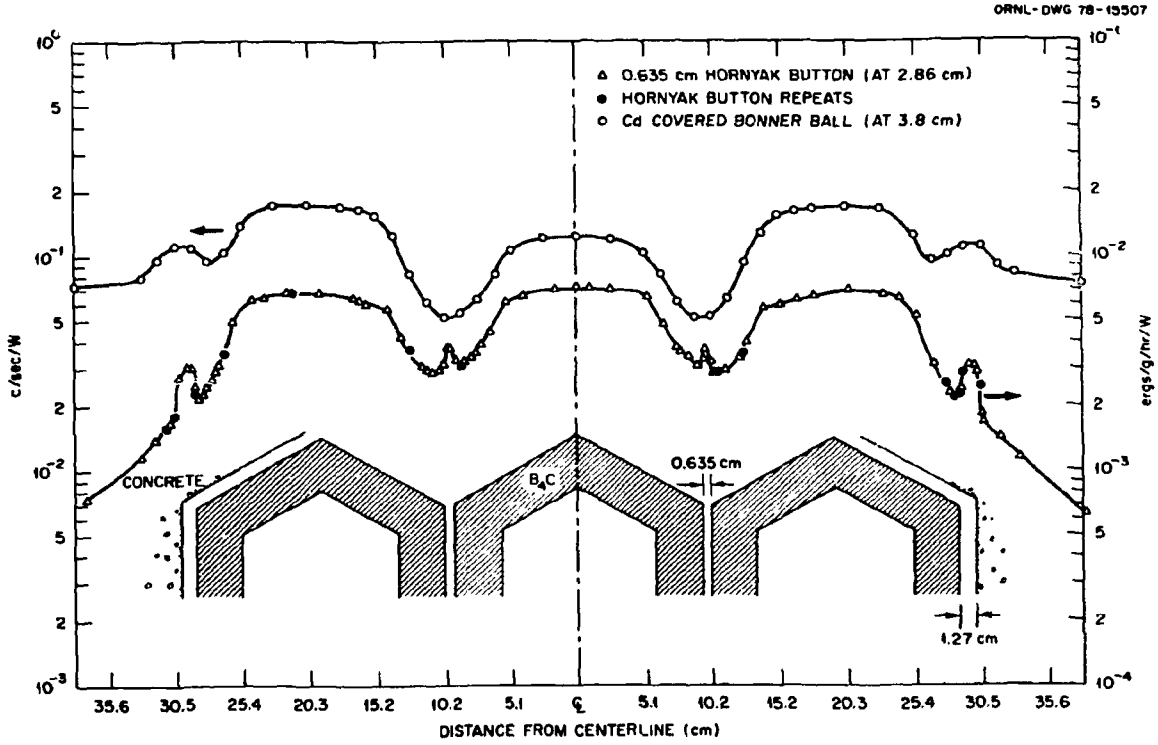

Fig. 36. Radial traverse directly behind the grid plate shield using the Hornyak button and Bonner balls. *(Item III-B)*

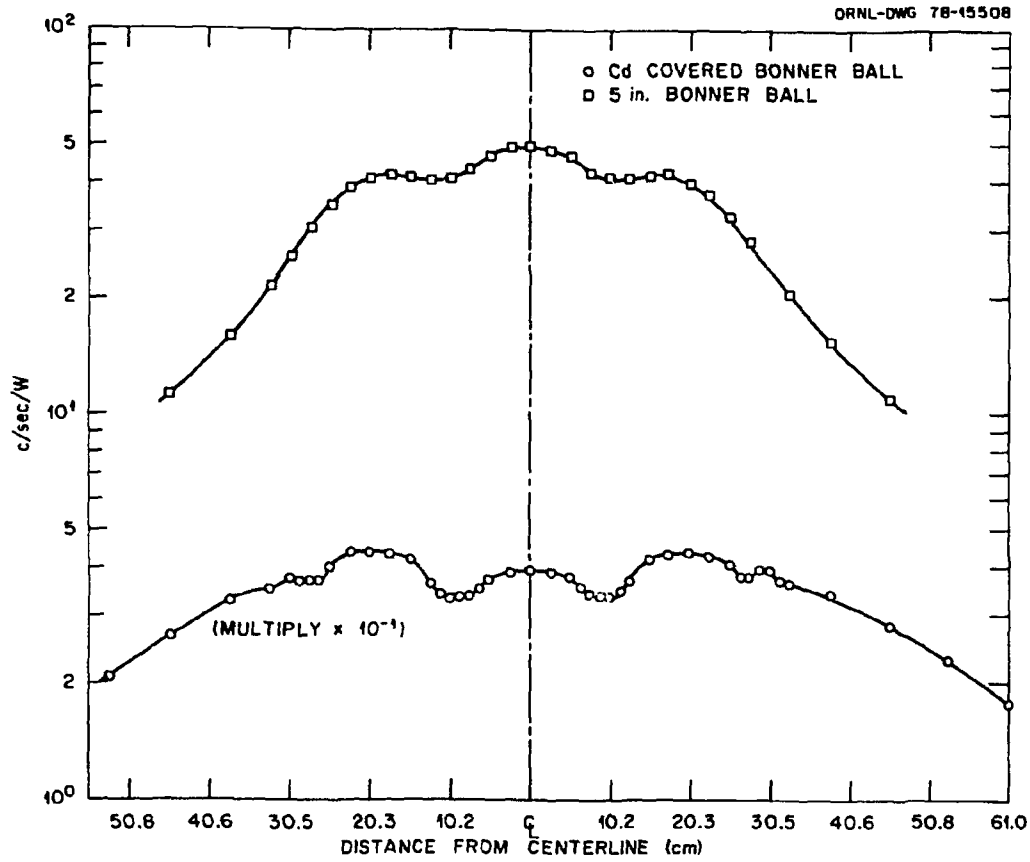

Fig. 37. Radial traverse in 15.24-cm void between grid plate shield and 61-cm Fe reflector using Bonner balls. *(Item III-C)*

Radial traverses were made directly behind the grid plate shield following its addition to the configuration (see Table 36 and Fig. 38). Increasing the pitch of the pins also increased the streaming from the core about a factor of two. The magnitude of the streaming between subassemblies was in the same ratio to the streaming through the subassemblies as it was for the lower pin pitch mockup but in this case there was apparently less collimation of the flux as indicated by the resolution of the peak between subassemblies. Centerline measurements were again obtained at 30.5 cm and 305 cm beyond the subassemblies and the data are listed in Table 35.

Results from the traverses within the 15.24-cm void between grid plate shield and 61 cm of Fe are given in Table 37 and plotted in Fig. 39.

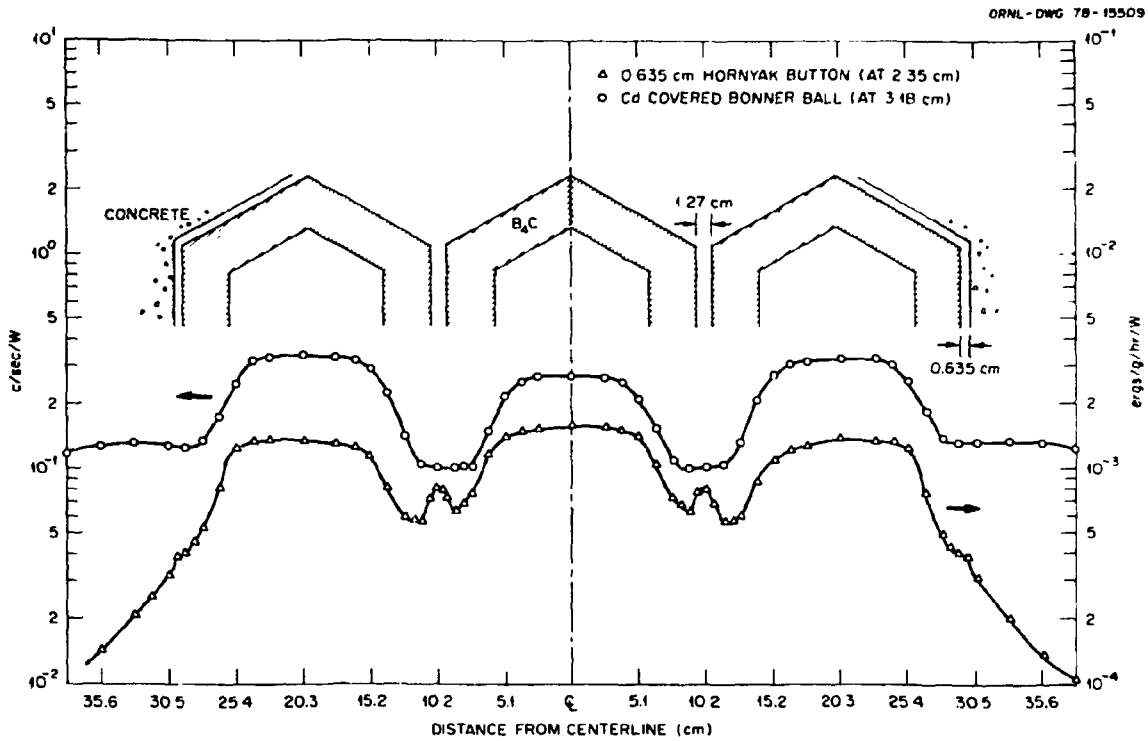

Fig. 38. Radial traverse directly behind the grid plate shield using the Hornyak button and Bonner ball. *(Item IV-B)*

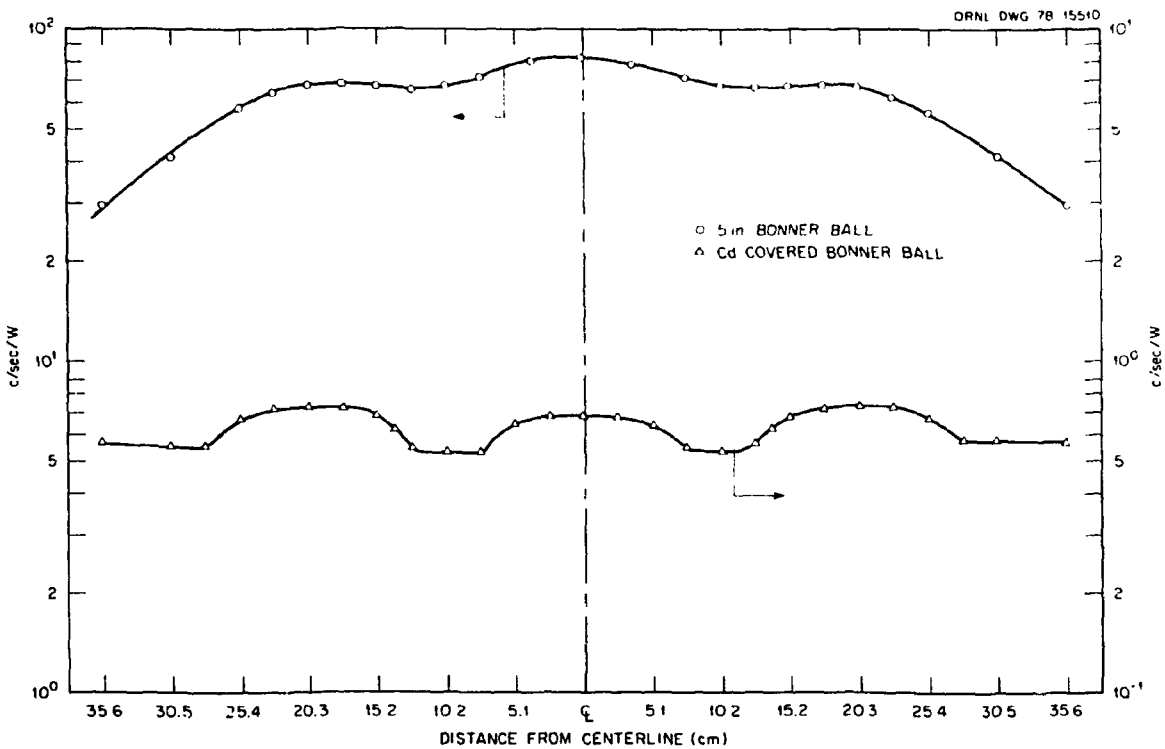

Fig. 39. Radial traverse in 15.24-cm void between grid plate shield and 61-cm Fe reflector using Bonner balls. *(Item IV-C)*

7. MEASUREMENTS - PRIORITY 2

For priority 2 the pin pitch and subassembly separation were maintained the same as for priority 1C but the middle seven pins were removed from the central assembly to simulate the void that remained following control rod removal. Radial traverses directly behind the fuel pins with the Cd-covered Bonner ball and the Hornyak button are given in Table 38 and plotted in Fig. 40. Centerline measurements were made at 30.5 cm and 305 cm (see Table 39).

The grid plate shield was placed in the configuration and an axial traverse through the central B_4C subassembly was made from behind the fuel pins to 30.5 cm beyond the grid plate shield (see Table 40 and Fig. 41) using the Hornyak button and the Cd-covered Bonner ball. Radial traverses were run directly behind the B_4C subassemblies and the results are given in Table 41 and Fig. 42. The void in the center fuel pin subassembly increased the high energy flux at the back of the central B_4C subassembly about 10%. Centerline measurements with these detectors at 30.5 cm and 305 cm behind the grid plate shield are listed in Table 42.

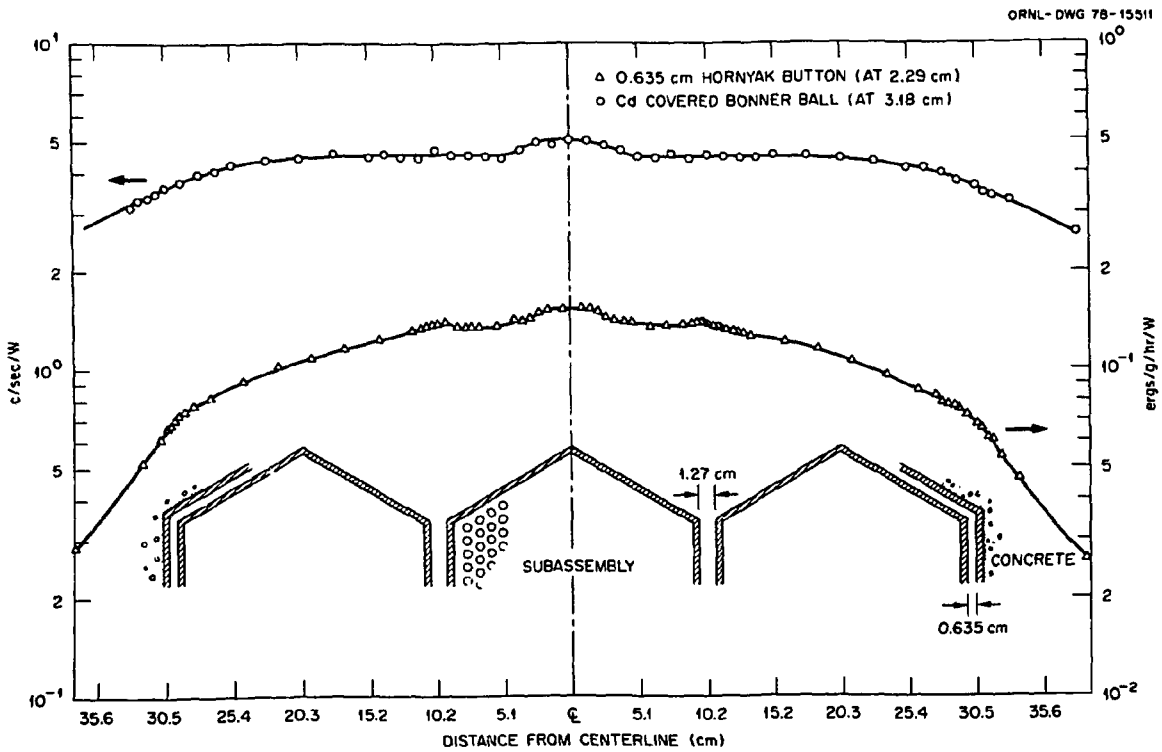

Fig. 40. Radial traverse directly behind 630 fuel pins using Hornyak button and Bonner ball. *(Item V-A)*

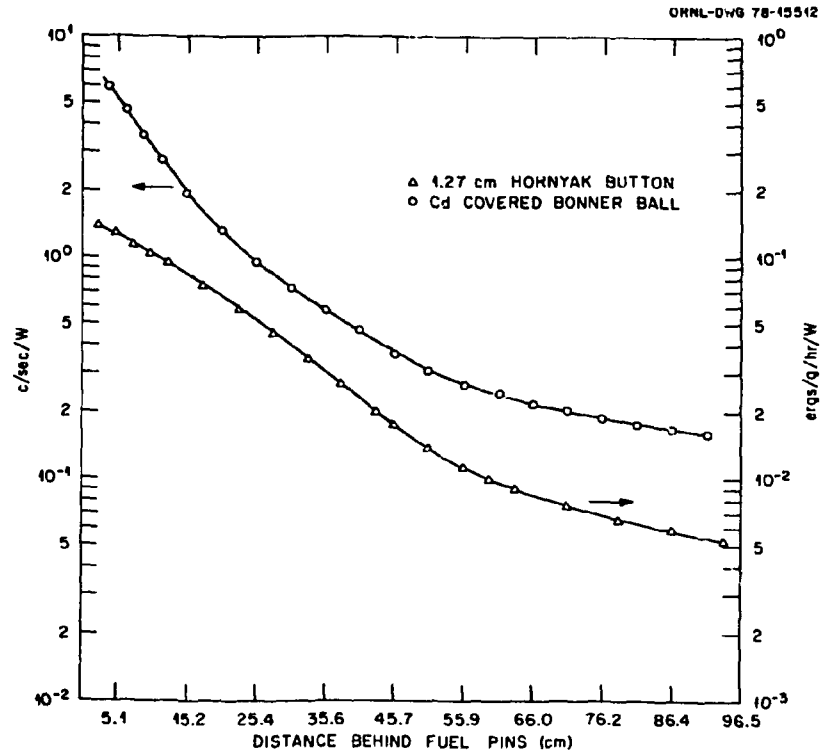

Fig. 41. Axial traverse through grid plate shield central subassembly using the Hornyak button and Bonner ball. *(Item V-B)*

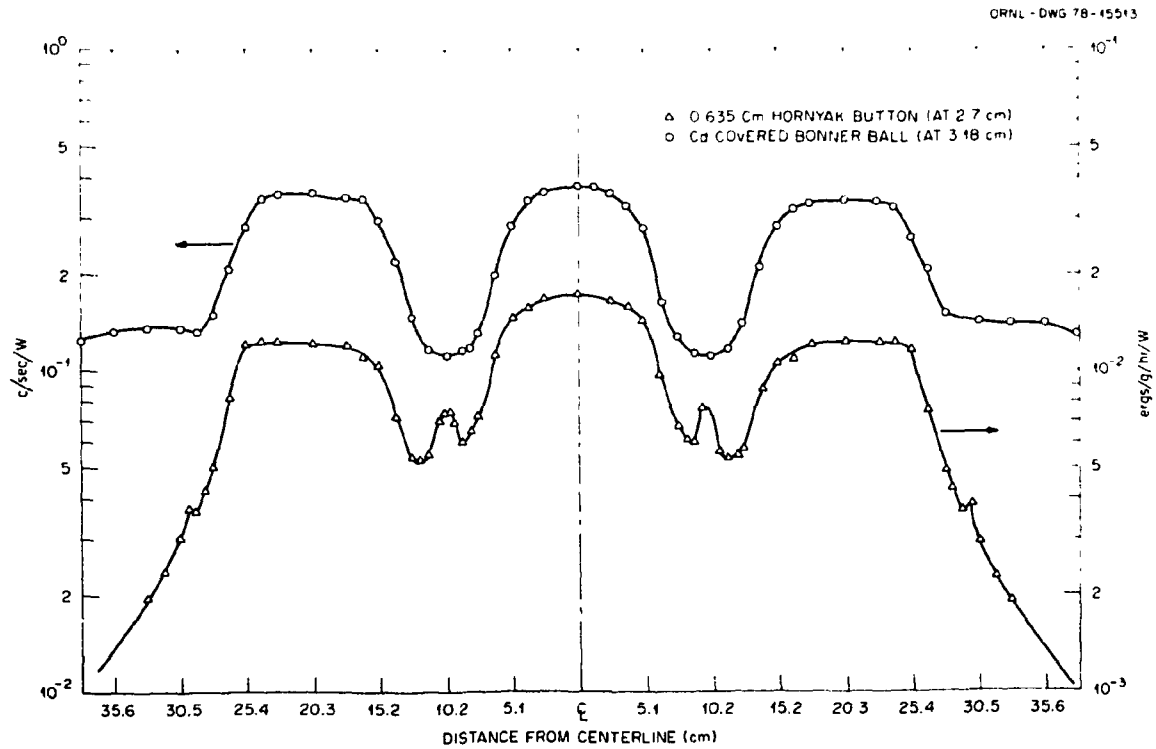

Fig. 42. Radial traverse directly behind the grid plate shield using Hornyak button and Bonner ball. *(Item V-B)*

8. MEASUREMENTS - PRIORITY 3

The last priority mockup contained subassemblies of 127 fuel pins each (pitch 1.58), spaced 0.318 cm apart. A radial traverse directly behind the pins with the Hornyak button is given in Table 43 and plotted in Fig. 43. Comparisons of the data for the three spacings (1.27 cm, 0.635 cm, and 0.318 cm) between subassemblies show that all three measurements lie within a difference of about 10% in dose rates which is within the error of the experiment. Results from centerline measurements at 30.5 cm and 305 cm behind the pins are given in Table 44.

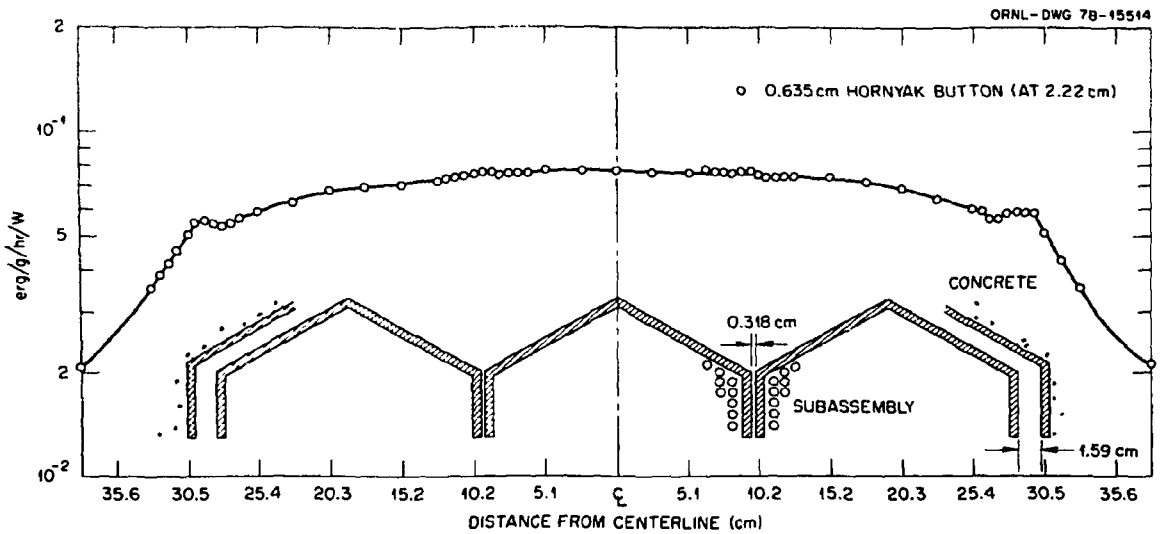

Fig. 43. Radial traverse directly behind 889 fuel pins using the Hornyak button. *(Item VI-A)*

Results from the radial measurements directly behind the grid plate shield, listed in Table 45 and plotted in Fig. 44, indicate a substantial reduction in the streaming between subassemblies when compared to the results from the 1.27-cm spacing (priority 1A). Such a comparison may be somewhat unclear since the size of the detector used was larger than the spacing for priority 3 which tends to increase that measured value. Centerline measurements at 30.5 cm and 305 cm behind the grid plate shield are given in Table 46.

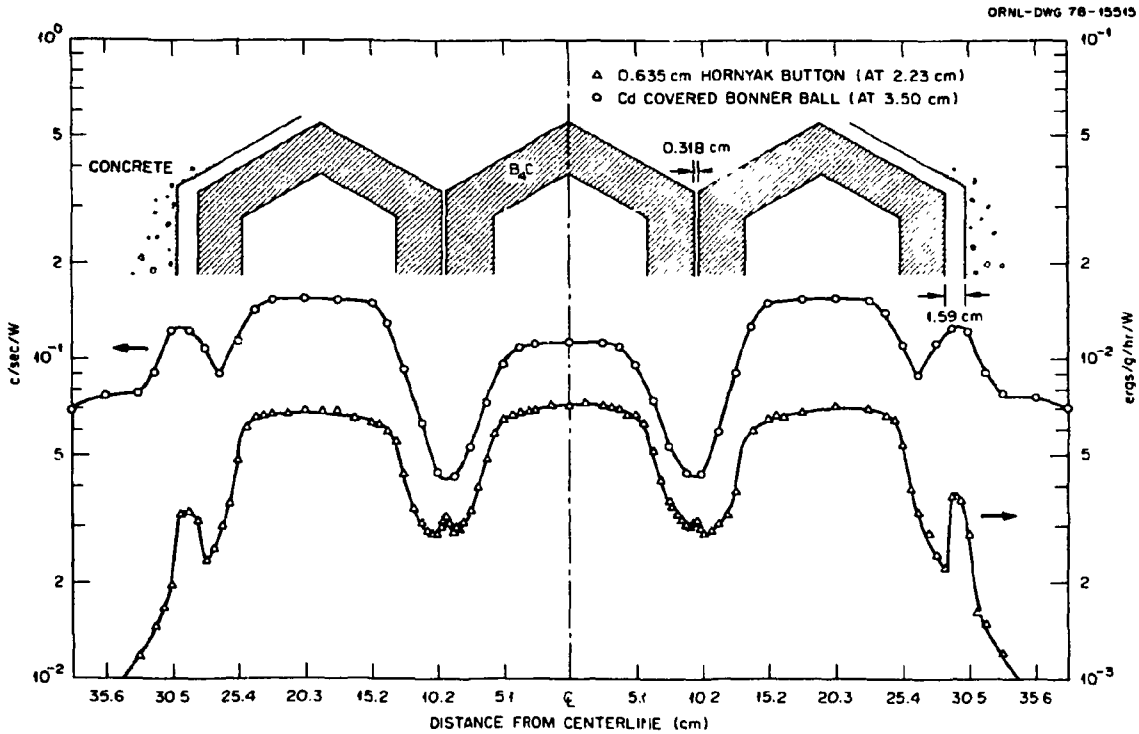

Fig. 44. Radial traverse directly behind the grid plate shield using the Hornyak button and Bonner balls. *(Item VI-B)*

9. MEASUREMENTS - IRON-ROD ASSEMBLIES

The iron-rod assembly (see Section 3.5) was placed in the cavity following the concrete shield (see Fig. 45). Three radial traverses were made, one directly behind the assembly and the other two at 30.5 cm and 305 cm behind the pins. These results are listed in Tables 47, 48, and 49 and plotted in Figs. 46, 47, and 48. Axial traverses were made with the three detectors out to 152.4 cm beyond the pins. These results are given in Table 50 and plotted in Fig. 49. The peaks observed in the curves result from neutron streaming between the assembly and the Fe liner in the concrete slab and do not add any interpretable value to the data.

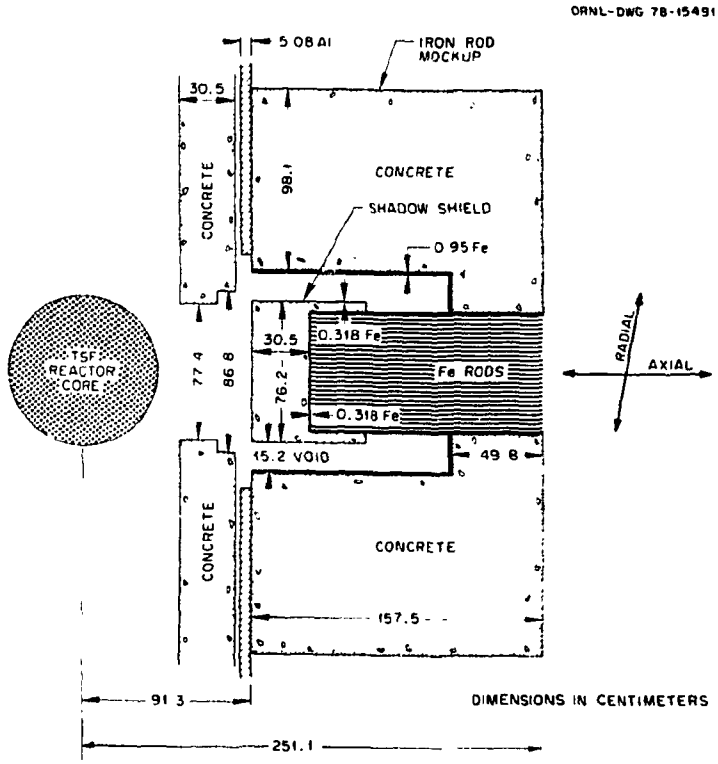

Fig. 45. Schematic of the Fe-rod configuration.

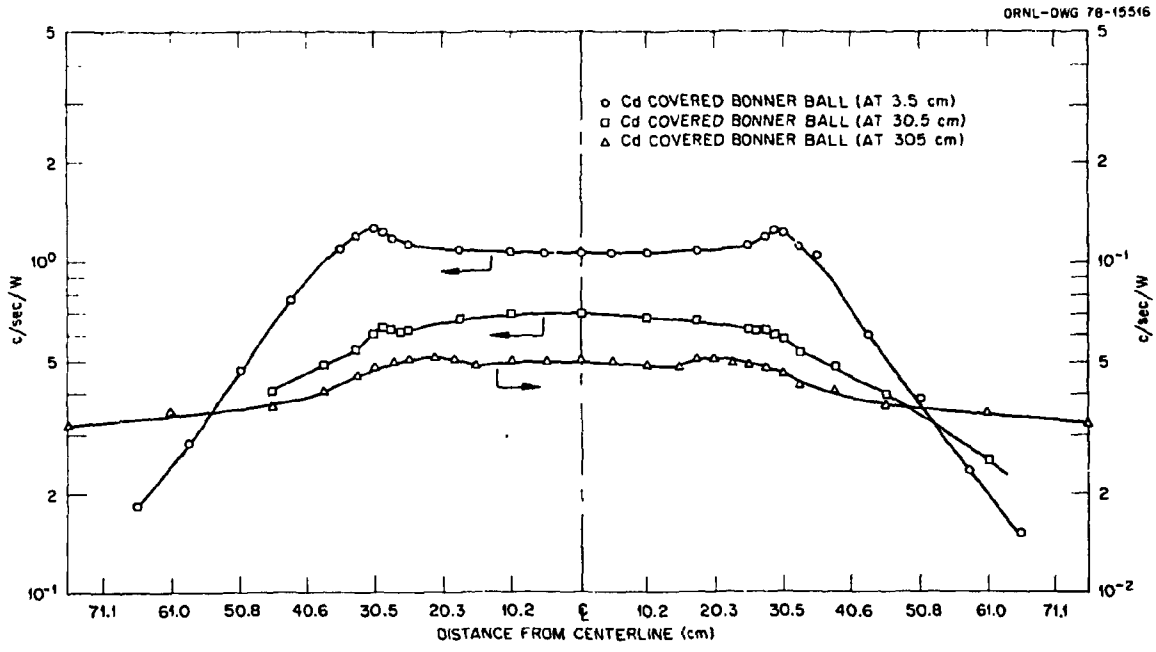

Fig. 46. Radial traverses at 3.5-, 30.5-, and 305-cm behind 967 Fe-rod assembly using Cd-covered Bonner ball. *(Items VII-B, C, D)*

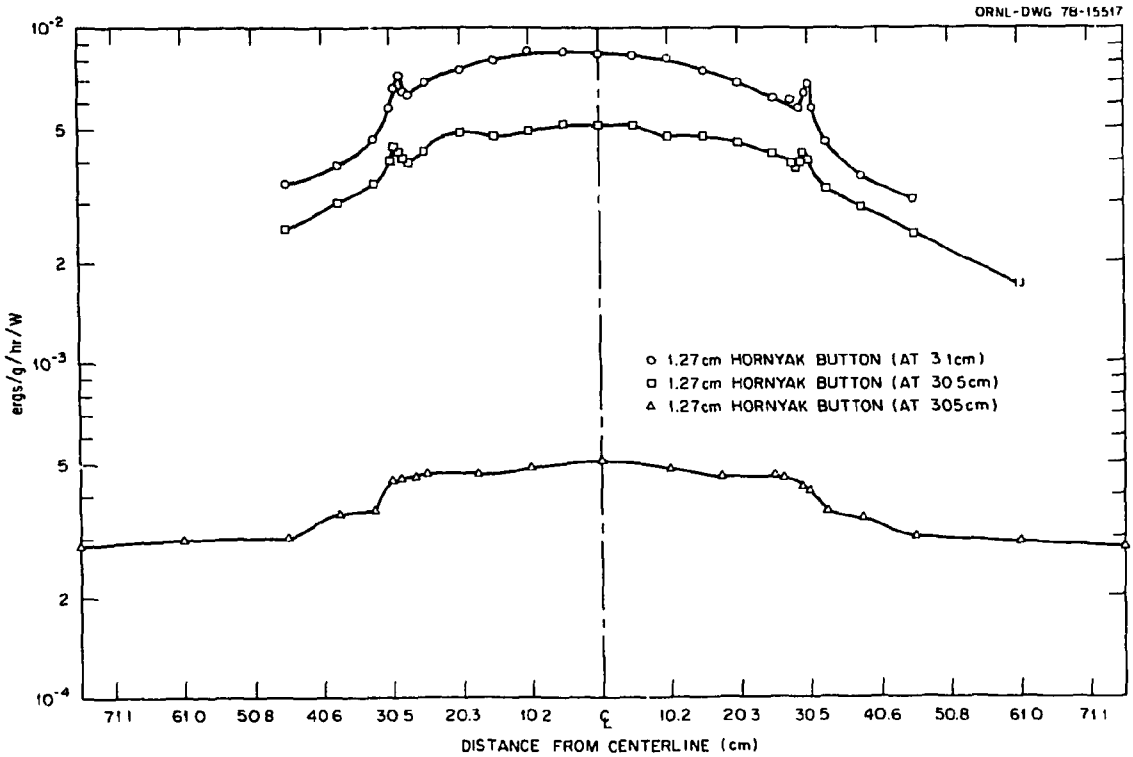

Fig. 47. Radial traverses at 3.1-, 30.5-, and 305-cm behind 967 Fe-rod assembly using Hornyak button. *(Items VII-B, C, D)*

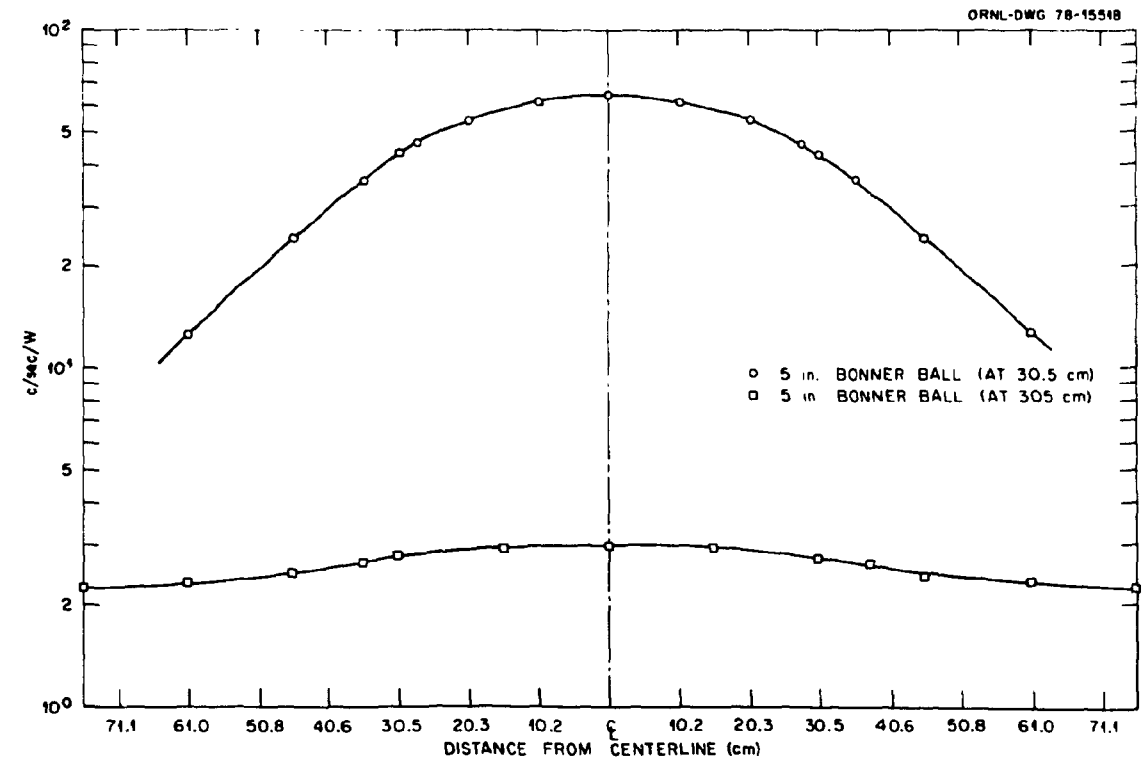

Fig. 48. Radial traverses at 30.5 cm and 305 cm behind 967 Fe-rod assembly using 5-in.-diam Bonner ball. *(Items VII-C, D)*

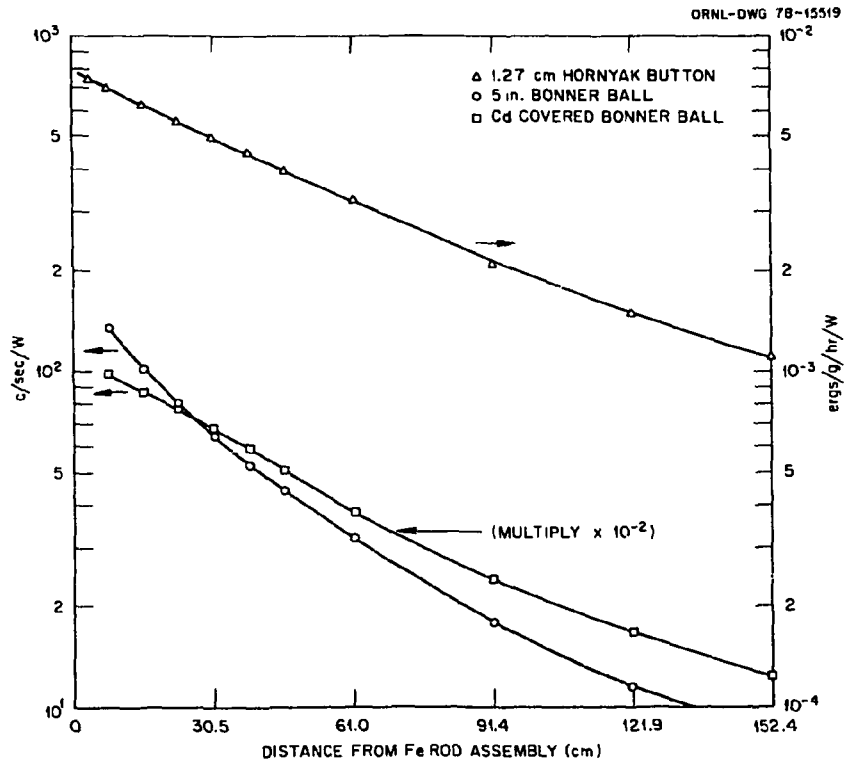

Fig. 49. Axial traverses behind 967 Fe-rod assembly using Hornyak button and Bonner balls. *(Item VII-A)*

10. MEASUREMENTS - IRON-PLATE ASSEMBLY

Similar measurements were made when the iron-plate assembly (see Fig. 50) replaced the iron-rod assembly. The axial traverse data is given in Table 51 and plotted in Fig. 51. Radial traverses were run again as for the Fe-rod assembly and the data listed in Tables 52, 53, and 54 and plotted in Figs. 52, 53, and 54. Comparison of the traverses behind the two assemblies indicated about a 10% greater flux directly behind the Fe rods than the plates, with this ratio increasing to about a factor of two at 305-cm distance behind the configuration when comparing Hornyak button measurements. For the 5-in.-diam Bonner ball it was only about 35% more. This indicated that a large portion of the flux being collimated down the void between the pins was uncollided. For these two configurations, the void fraction was less for the rod assembly than for the plates (.47/.50).

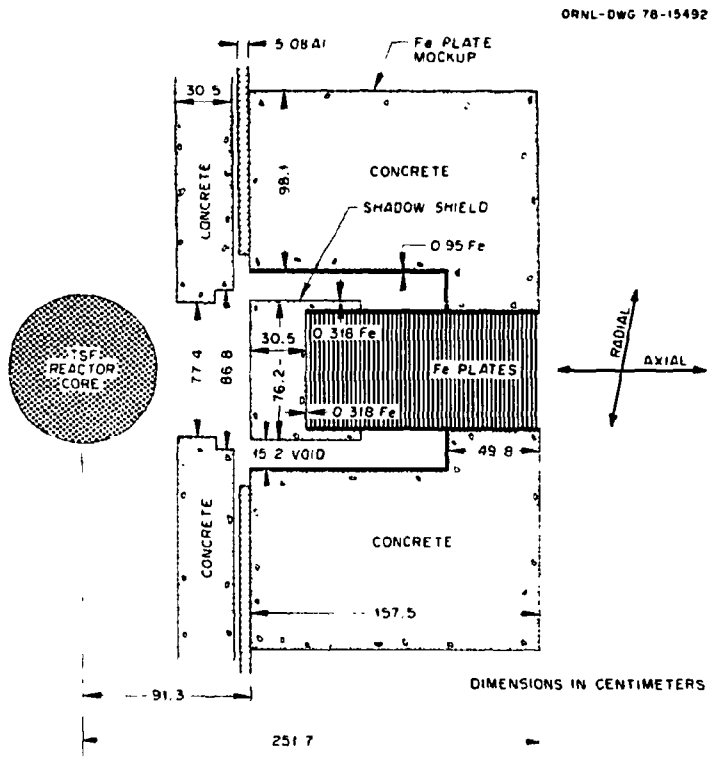

Fig. 50. Schematic of the homogeneous Fe-plate configuration.

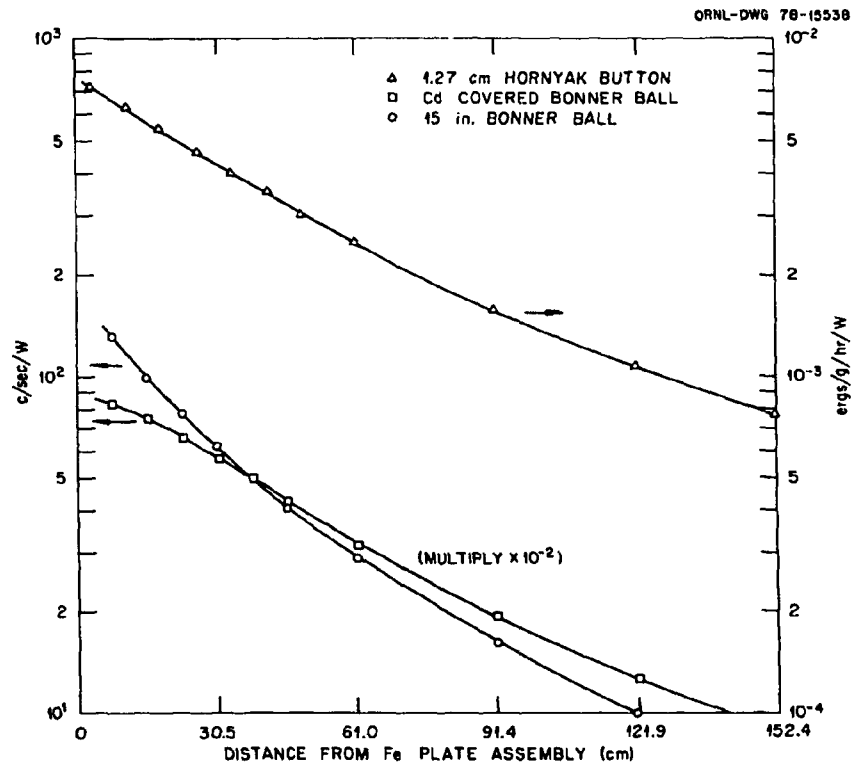

Fig. 51. Axial traverse behind homogeneous Fe-plate assembly using Hornyak button and Bonner balls. *(Item VIII-A)*

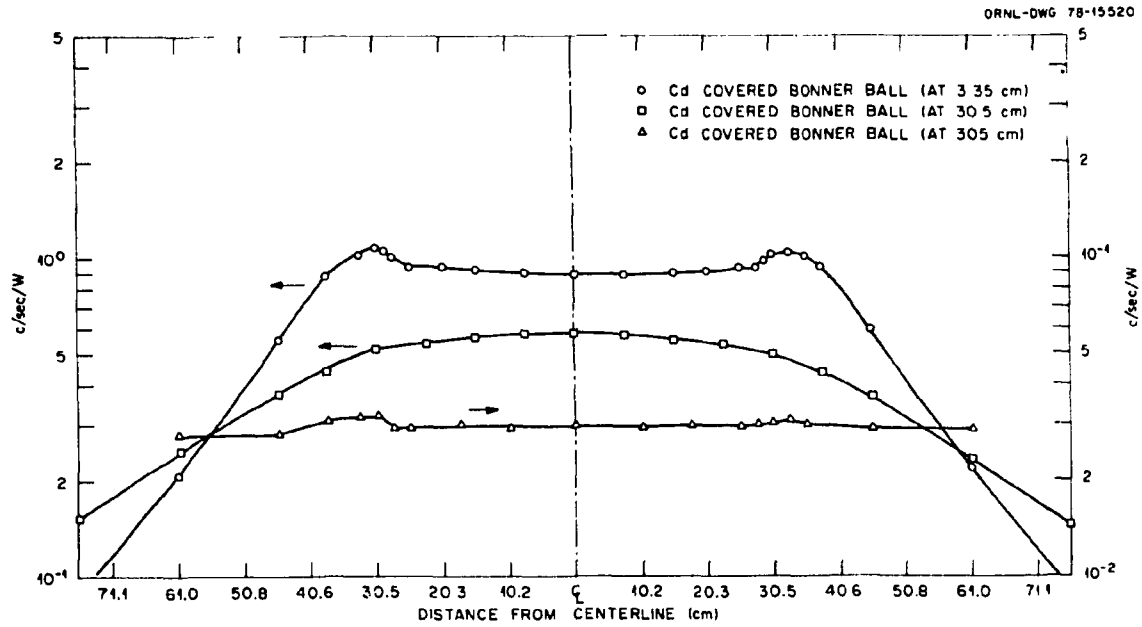

Fig. 52. Radial traverses at 3.35-, 30.5-, and 305-cm behind homogeneous Fe-plate assembly using Cd-covered Bonner ball. *(Items VIII-B, C, D)*

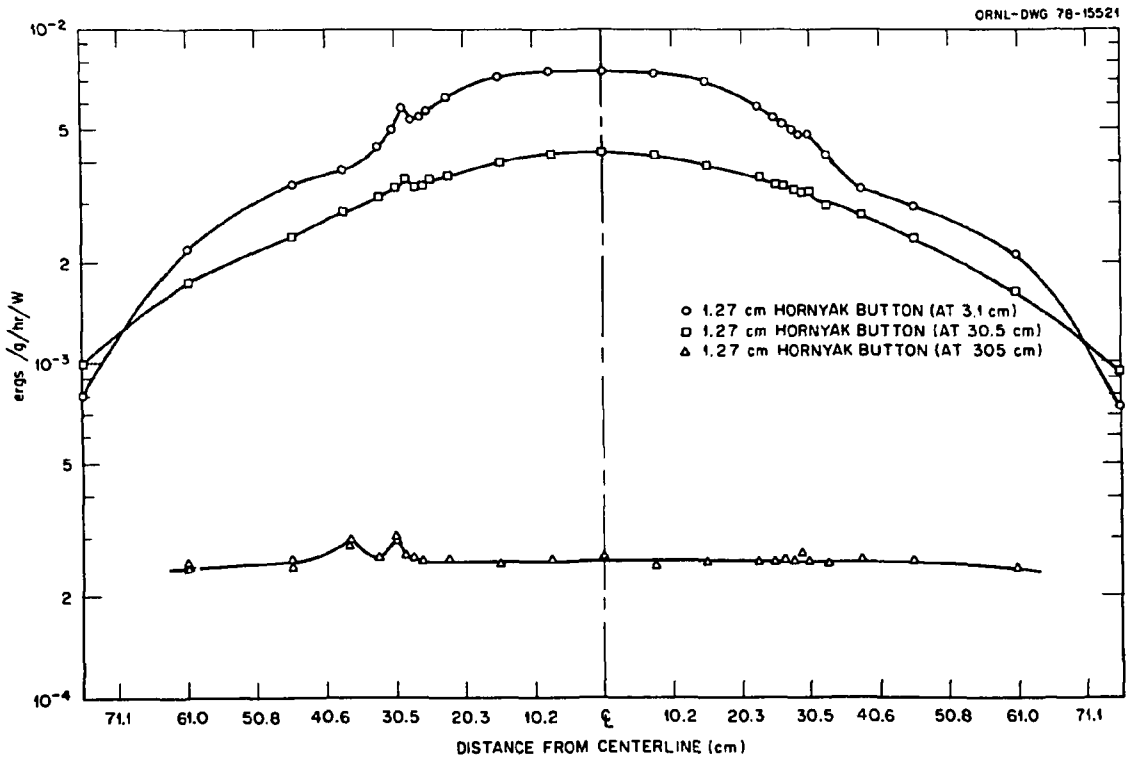

Fig. 53. Radial traverses at 3.1-, 30.5-, and 305-cm behind homogeneous Fe-plate assembly using Hornyak button. *(Items VIII-B, C, D)*

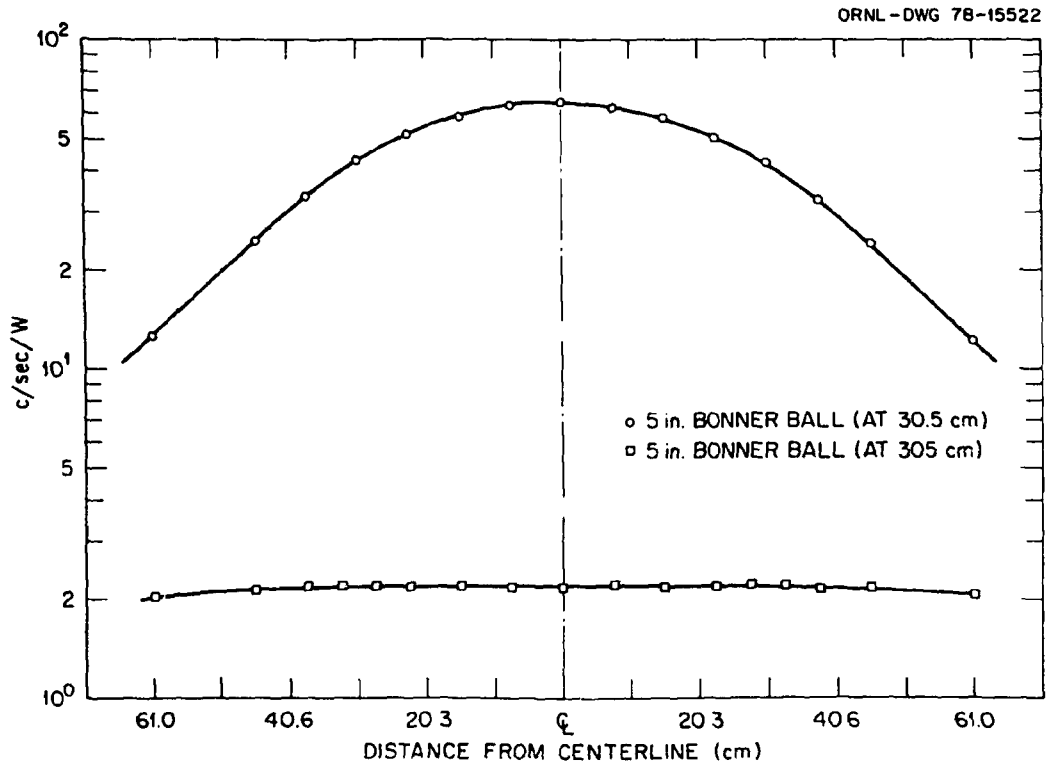

Fig. 54. Radial traverses at 30.5 cm and 305 cm behind homogeneous Fe-plate assembly using 5-in.-diam Bonner ball. *(Items VIII-C, D)*

11. EXPERIMENTAL ERRORS

The error in measurements results mainly from a combination of the uncertainties in the reactor power determination, detector calibrations, count rate statistics, detector positioning, and exposure of the experimental configurations to the weather. Of these, the effects due to changes in the weather are least understood and basically undeterminable since the experiment contained so many configuration changes. Positioning of the detector with respect to the configuration was critical only when radial traverses were made near the configuration where small changes in axial distance could produce significant changes in count rate. It is estimated that during a radial traverse the detector position might oscillate several millimeters on each side of a given line. For measurements 50 mm behind the configuration this amounts to an error of $\pm$ 4%. The error in the measurement due to this small change in detector position can only be estimated if

the change in flux intensity over the same span is known. For the few occasions where axial measurements were included the flux intensity was found to vary about 3% over this distance.

The largest sources of error were the uncertainties in the detector calibrations and determination of the reactor power. Calibrations of the detectors used for data measurements behind the configurations and for monitoring the reactor power varied about $\pm$ 3%. The repeatability of the fission chambers used to monitor the reactor power were checked indiscriminately against gold foils at the detector locations and agreement lies within about 5%. If one includes both the error in calibration and the error in repeatability the overall error in determining the reactor power was estimated to be about $\pm$ 5%.

APPENDIX

Table 1. Analysis of concrete in fuel pin and grid plate shield slabs

Element	Fuel pin shield concrete (%)	Grid plate shield concrete (%)
Free H_2O	2.30	0.97
Bound H_2O	4.02	2.44
LOI	37.62	35.25
SiO_2	11.28	9.41
Fe_2O_3	0.94	0.94
Al_2O_3	1.30	1.57
CaO	33.34	36.96
MgO	13.6	13.2
Na_2O	<0.01	0.022
K_2O	0.50	0.53
SO_3	0.091	0.16
P_2O_5	0.09	0.10
CO_3	45.9	43.9

Table 2. Analysis of Fe used in fabrication of the components listed below

Sample	C	O	Fe
1. B_4C subassembly liner	844 ppm	51 ppm	99.6%
2. Fuel pin subassembly liner	484 ppm	24 ppm	99.0%
3. Concrete slab liner	0.21%	193 ppm	97.3%
4. B_4C end pieces	0.24%	559 ppm	97.3%

Semi-quantitative spectrochemical analysis of Fe*

	#1	#2	#3	#4		#1	#2	#3	#4
Ag	<.005	<.005	<.005	<.005	Mn	.4	.3	.7	.5
Al	.07	.05	.05	<.02	Mo	.05	.05	.05	.25
B	<.01	<.01	<.01	<.01	Nb	<.05	<.05	<.05	<.05
Ba	<.01	<.01	<.01	<.01	Ni	≤.01	≤.02	≤.02	≤.04
Be	<.01	<.01	<.01	<.01	Pb	<.02	<.02	<.02	<.02
Bi	<.02	<.02	<.02	<.02	Sb	<.05	<.05	<.05	<.05
Ca	<.02	<.02	<.02	<.02	Si	.03	.01	.02	.2
Cd	<.05	<.05	<.05	<.05	Sn	<.02	<.02	<.02	<.02
Co	<.02	<.02	<.02	<.02	Ta	<.05	<.05	<.05	<.05
Cr	.02	.05	.1	.07	Ti	<.01	<.01	<.01	<.01
Cu	.02	.02	.05	.1	V	<.02	<.02	<.02	<.02
Fe	M	M	M	M	W	<.05	<.05	<.05	<.05
Ga	<.02	<.02	<.02	<.02	Zn	<.05	<.05	<.05	<.05
Ge	<.02	<.02	<.02	<.02	Zr	<.05	<.05	<.05	<.05
Mg	<.01	<.01	<.01	<.01					

* wt %

Table 3. Analysis of B_4C used in grid plate shield and grid plate inserts

Grit	Percentage by weight	
	Boron	Carbon
120	76.6	21.0
16	73.0	24.6

Semi-quantitative spectrochemical analysis of B_4C*

	120 Grit	16 Grit		120 Grit	16 Grit		120 Grit	16 Grit
Ag	<.005	<.005	Ga	<.02	<.02	Pt	<.05	<.05
Al	<.02	<.02	Ge	<.02	<.02	Rb	<.02	<.02
Au	<.05	<.05	Hg	<.05	<.05	Sb	<.05	<.05
B	M	M	K	<.01	<.01	Si	.1	.05
Ba	<.01	<.01	Li	<.005	<.005	Sn	<.02	<.02
Be	<.001	<.001	Mg	<.01	<.01	Ta	<.05	<.05
Bi	<.02	<.02	Mn	<.01	<.01	Te	<.05	<.05
Ca	≤.01	≤.01	Mo	<.01	<.01	Ti	<.01	<.01
Cd	<.05	<.05	Na	<.01	<.01	V	<.02	<.02
Co	<.02	<.02	Nb	<.05	<.05	W	<.05	<.05
Cr	<.02	<.02	Ni	<.02	<.02	Zn	<.05	<.05
Cu	<.01	<.01	Pb	<.02	<.02	Zr	<.02	<.02
Fe	.02	.1						

* wt %

Table 4. Measured density of B_4C (Theoretical density = 2.52 g/cc)

Subassembly	Weight of B_4C (g)	Measured volume (cc) average	% of theoretical density
	Grid plate shield subassemblies		
1	7626.6	3930 ±5	77.0
2	7619.0	3930 ±5	76.9
3	7569.6	3930 ±5	76.4
4	7643.8	3930 ±5	77.2
5	7580.6	3930 ±5	76.5
6	7593.7	3930 ±5	76.7
7	7591.7	3930 ±5	76.2
	Grid plate inserts in subassemblies		
1	2697.1	1375 ±5	77.8
2	2686.4	1375 ±5	77.5
3	2684.1	1375 ±5	77.5
4	2687.8	1375 ±5	77.6
5	2690.1	1375 ±5	77.6
6	2688.9	1375 ±5	77.6
7	2690.4	1375 ±5	77.6

Table 5. Analysis of Fe pieces used to mockup prototypic grid plate*

Element	2.54-cm slabs	15.24-cm slabs
Fe	M	M
Cr	.043	.029
Ni	.01	.04
C	.21	.28
O	.022	.087
Cu	.03	.05
Mn	.5	.7
Si	.05	.2
Ti	<.01	<.01
V	<.02	<.02

* wt %

Table 6. Axial traverses beyond concrete shadow shield *(Item II-A)*

Distance from shadow shield (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)		Bonner ball count rate (counts/s/W)					
			Bare		Cd-covered		5-in.-diam	
	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground
2.54	2.59(0)	--	--	--	--	--	--	--
6.03	--	--	--	--	5.53(2)	--	--	--
6.51	--	--	--	--	--	--	1.26(4)	--
6.67	--	--	1.37(4)	--	--	--	--	--
10.2	2.35(0)	--	--	--	--	--	--	--
13.7	--	--	--	--	5.33(2)	--	--	--
14.1	--	--	--	--	--	--	1.19(4)	--
14.3	--	--	1.24(4)	--	--	--	--	--
15.2	2.28(0)	--	--	--	--	--	--	--
21.3	--	--	--	--	5.05(2)	--	--	--
21.7	--	--	--	--	--	--	1.15(4)	--
21.9	--	--	1.06(4)	--	--	--	--	--
22.9	2.06(0)	--	--	--	--	--	--	--
28.9	--	--	--	--	4.75(2)	--	--	--
29.4	--	--	--	--	--	--	1.09(4)	--
29.5	--	--	9.50(3)	--	--	--	--	--
38.1	1.60(0)	--	--	--	--	--	--	--
44.1	--	--	--	--	4.13(2)	--	--	--
44.6	--	--	--	--	--	--	9.15(3)	--
44.8	--	--	7.70(3)	--	--	--	--	--
53.3	1.31(0)	--	--	--	--	--	--	--
59.4	--	--	--	--	3.57(2)	--	--	--
59.8	--	--	--	--	--	--	8.12(3)	--
60.0	--	--	6.77(3)	--	--	--	--	--
68.6	1.02(0)	--	--	--	--	--	--	--
74.6	--	--	--	--	2.90(2)	--	--	--
75.1	--	--	--	--	--	--	6.67(3)	--
75.2	--	--	5.00(3)	--	--	--	--	--
83.8	8.75(-1)	--	--	--	--	--	--	--
89.9	--	--	--	--	2.18(2)	--	--	--
90.3	--	--	--	--	--	--	5.20(3)	--
90.5	--	--	3.78(3)	--	--	--	--	--
99.1	7.38(-1)	--	--	--	--	--	--	--
105.0	--	--	--	--	1.47(2)	--	--	--
105.6	--	--	--	--	--	--	3.68(3)	--
105.7	--	--	2.53(3)	--	--	--	--	--
113.3	--	--	2.00(3)	--	--	--	--	--
114.3	5.75(-1)	--	--	--	--	--	--	--
120.3	--	--	--	--	9.43(1)	--	--	--
129.5	4.43(-1)	--	--	--	--	--	--	--
135.6	--	--	--	--	5.63(1)	--	--	--
136.0	--	--	--	--	--	--	1.44(3)	--
136.2	--	--	9.90(2)	--	--	--	--	--
144.8	3.28(-1)	--	--	--	--	--	--	--
150.8	--	--	--	--	3.42(1)	--	--	--
160.0	2.41(-1)	--	--	--	--	--	--	--
166.1	--	--	--	--	2.23(1)	--	--	--
166.5	--	--	--	--	--	--	6.20(2)	--
166.7	--	--	4.25(2)	--	--	--	--	--
181.8	--	--	--	--	--	--	4.35(2)	--
182.9	1.53(-1)	--	--	--	--	--	--	--

*Read: 2.59×10^{0}

Table 6 (Continued)

Distance from shadow shield (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)		Bonner ball count rate (counts/s/W)					
			Bare		Cd-Covered		5-in.-diam	
	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground
196.5	--	--	--	--	1.19(1)*	--	--	--
197.0	--	--	--	--	--	--	3.17(2)	--
197.2	--	--	2.33(2)	--	--	--	--	--
213.4	9.45(-2)	--	--	--	--	--	--	--
227.0	--	--	--	--	7.32(0)	--	--	--
227.5	--	--	--	--	--	--	1.83(2)	--
227.6	--	--	1.54(2)	--	--	--	--	--
274.3	5.02(-2)	--	--	--	--	--	--	--
288.0	--	--	--	--	3.65(0)	--	--	--
288.4	--	--	--	--	--	--	9.03(1)	--
288.6	--	--	8.43(1)	--	--	--	--	--
330.2	--	--	--	--	--	--	--	1.98(0)
335.3	3.28(-2)	--	--	--	--	--	--	--
348.9	--	--	--	--	2.23(0)	--	--	--
349.4	--	--	--	--	--	--	5.60(1)	--
349.6	--	--	5.28(1)	--	--	--	--	--
396.2	2.31(-2)	--	--	--	--	--	--	--
409.9	--	--	--	--	1.50(0)	--	--	--
410.4	--	--	--	--	--	--	3.73(1)	--
410.5	--	--	3.62(1)	--	--	--	--	--
457.2	1.72(-2)	3.01(-4)	--	--	--	--	--	--
470.9	--	--	--	--	1.08(0)	1.25(-2)	--	--
471.3	--	--	--	--	--	--	2.73(1)	2.18(0)
471.5	--	--	2.68(1)	2.48(0)	--	--	--	--

*Read: 1.19×10^{1}

Table 7. Radial traverse in the horizontal plane at 30.5 cm behind the fuel pin cavity in the concrete shield (*Item II-A*)

Distance from centerline (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)	Bonner ball count rate (counts/s/W)	
		Cd-covered	5-in.-diam
132.1S	--	4.18(-1)*	8.18(0)
116.8	--	5.47(-1)	1.14(1)
101.6	--	7.83(-1)	1.70(1)
96.5	2.04(-3)	--	--
86.4	--	1.28(0)	2.73(1)
83.8	3.43(-3)	--	--
71.1	--	2.32(0)	5.27(1)
68.6	7.55(-3)	--	--
55.9	--	5.17(0)	1.23(2)
53.3	2.28(-2)	--	--
40.6	--	1.30(1)	3.22(2)
38.1	7.26(-2)	--	--
30.5	1.54(-1)	2.00(1)	4.97(2)
22.9	1.87(-1)	2.35(1)	5.90(2)
15.2	2.10(-1)	2.60(1)	6.65(2)
7.62	2.24(-1)	2.72(1)	7.43(2)
0	2.39(-1)	2.78(1)	7.72(2)
7.62N	2.37(-1)	2.68(1)	7.47(2)
15.2	2.18(-1)	2.57(1)	6.88(2)
22.9	1.96(-1)	2.32(1)	6.10(2)
30.5	1.62(-1)	1.95(1)	4.98(2)
38.1	9.53(-2)	--	--
40.6	--	1.21(1)	3.02(2)
53.3	2.49(-2)	--	--
55.9	--	4.78(0)	1.16(0)
68.6	7.77(-3)	--	--
71.1	--	2.17(0)	4.83(1)
83.8	3.57(-3)	--	--
86.4	--	1.20(0)	2.73(1)
99.1	1.82(-3)	--	--
101.6	--	7.63(-1)	1.63(1)
114.3	1.02(-3)	--	--
116.8	--	5.12(-1)	1.12(1)

*Read: 4.18×10^{-1}

Table 8. Radial traverses at 30.5 cm behind the fuel pin cavity in the concrete shield *(Item II-A)*

Distance from Centerline (cm)	Hornyak button dose rate (erg/g/h/W)		Distance from Centerline (cm)	Hornyak button dose rate (erg/g/h/W)	
	Horizontal plane	60° to horizontal plane		Horizontal plane	60° to horizontal plane
117.8S	--	1.39(-3)*	0	2.96(-1)	--
102.6	--	2.20(-3)	4.13N	--	2.98(-1)
99.1	2.60(-3)	--	7.62	2.88(-1)	--
87.3	--	3.87(-3)	11.7	--	2.79(-1)
83.8	4.93(-3)	--	15.2	2.63(-1)	--
72.1	--	7.96(-3)	19.4	--	2.56(-1)
68.6	1.08(-2)	--	22.9	2.33(-1)	--
56.8	--	2.00(-2)	27.0	--	2.21(-1)
53.3	3.25(-2)	--	30.5	1.80(-1)	--
41.6	--	6.98(-2)	34.6	--	1.57(-1)
38.1	1.23(-1)	--	38.1	9.48(-2)	--
34.0	--	1.50(-1)	42.2	--	7.56(-2)
30.5	2.02(-1)	--	49.8	--	4.00(-2)
26.4	--	2.13(-1)	53.1	2.64(-2)	--
22.9	2.43(-1)	--	65.1	--	1.06(-2)
18.7	--	2.50(-1)	68.6	9.00(-3)	--
15.2	2.71(-1)	--	80.3	--	5.12(-3)
11.1	--	2.71(-1)	83.8	4.26(-3)	--
7.62	2.94(-1)	--	95.6	--	2.64(-3)
3.49	--	2.91(-1)	99.1	2.23(-3)	--
			110.8	--	1.40(-3)

*Read: 1.39×10^{-3}

Table 9. Measurements on centerline behind the concrete shadow shield (no fuel pins) *(Item II-A)*

Distance from shadow shield (cm)	Bonner ball count rate (counts/s/W)		
	3-in.-diam	6-in.-diam	10-in.-diam
370.8	1.98(1)*	5.25(1)	3.08(1)

*Read: 1.98×10^{1}

Table 10. Radial traverse at 2.86 cm behind 889 fuel pins *(Item II-B)*

Distance from centerline (cm)	0.635-cm-diam Hornyak button dose rate (erg/g/h/W)	Distance from centerline (cm)	0.635-cm-diam Hornyak button dose rate (erg/g/h/W)
12.7S	6.86(-2)*	9.84	7.52(-2)
12.4	7.04(-2)	10.2	7.43(-2)
12.1	6.91(-2)	10.5	7.45(-2)
11.7	7.08(-2)	10.8	7.27(-2)
11.4	7.16(-2)	11.1	7.18(-2)
11.1	7.24(-2)	11.4	6.97(-2)
10.8	7.39(-2)	12.1	6.91(-2)
10.5	7.52(-2)	12.7	6.93(-2)
10.2	7.69(-2)	17.8	6.44(-2)
10.2	7.60(-2)	22.9	5.57(-2)
9.53	7.58(-2)	27.9	4.59(-2)
8.89	7.41(-2)	28.6	4.38(-2)
7.62	7.19(-2)	28.9	4.39(-2)
0	7.13(-2)	29.2	4.29(-2)
0	7.28(-2)	29.5	4.34(-2)
7.62N	7.19(-2)	29.8	4.31(-2)
8.89	7.34(-2)	30.2	4.02(-2)
9.21	7.39(-2)	30.5	3.99(-2)
9.53	7.46(-2)	33.0	3.03(-2)
		48.3	8.28(-3)

*Read: 6.86×10^{-2}

Table 11. Radial traverse at 30.5 cm behind 889 fuel pins *(Item II-B)*

Distance from centerline (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)	Bonner ball count rate (counts/s/W)	
		Cd-covered	5-in.-diam
106.7S	1.07(-3)*	1.17(-1)	5.90(0)
91.4	1.90(-3)	1.90(-1)	9.28(0)
76.2	3.58(-3)	2.90(-1)	1.53(1)
61.0	6.38(-3)	4.85(-1)	2.82(1)
45.7	1.13(-2)	8.02(-1)	5.28(1)
38.1	1.51(-2)	--	--
35.6	--	1.03(0)	7.53(1)
30.5	1.93(-2)	--	--
30.2	--	1.18(0)	9.33(1)
29.8	2.02(-2)	--	--
29.5	2.02(-2)	--	--
29.2	2.03(-2)	--	--
28.9	2.03(-2)	--	--
28.6	2.02(-2)	--	--
28.3	2.05(-2)	--	--
27.9	2.05(-2)	--	--
25.4	--	1.24(0)	1.06(2)
22.9	2.32(-2)	--	--
17.8	2.57(-2)	1.37(0)	1.23(2)
12.7	2.72(-2)	--	--
11.4	2.76(-2)	--	--
11.1	2.79(-2)	--	--
10.8	2.87(-2)	1.43(0)	1.38(2)
10.5	2.86(-2)	--	--
10.2	2.92(-2)	1.45(0)	1.36(2)

*Read: 1.07×10^{-3}

Table 11. (Continued)

Distance from centerline (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)	Bonner ball count rate (counts/s/W)	
		Cd-covered	5-in.-diam
9.84	2.87(-2)*	--	--
9.53	2.87(-2)	1.45(0)	1.36(2)
8.89	2.84(-2)	--	1.37(2)
8.26	--	--	1.40(2)
7.62	2.82(-2)	1.43(0)	1.40(2)
0	2.99(-2)	1.47(0)	1.42(2)
0	2.99(-2)	1.45(0)	1.44(2)
0	3.06(-2)	--	--
7.62N	2.86(-2)	1.41(0)	1.40(2)
8.89	2.89(-2)	--	--
9.53	2.99(-2)	--	--
10.2	2.91(-2)	--	--
10.8	2.84(-2)	--	--
11.4	2.77(-2)	--	--
12.1	2.77(-2)	--	--
12.7	2.77(-2)	--	--
15.2	--	1.35(0)	1.28(2)
20.3	2.50(-2)	--	--
22.9	--	1.25(0)	1.11(2)
27.9	2.10(-2)	--	--
29.2	2.07(-2)	--	--
29.8	2.03(-2)	--	--
30.5	1.97(-2)	1.14(0)	8.85(1)
38.1	--	9.62(-1)	6.93(1)
45.7	1.15(-2)	7.85(-1)	5.25(1)
61.0	--	4.98(-1)	2.88(1)
76.2	3.58(-3)	2.90(-1)	1.56(1)
91.4	--	1.72(-1)	9.58(0)
106.7	1.05(-3)	1.12(-1)	5.83(0)

*Read: 2.87×10^{-2}

Table 12. Radial traverse at 305 cm behind 889 fuel pins *(Item II-B)*

Distance from centerline (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)		Bonner ball count rate (counts/s/W)			
			Cd-covered		5-in.-diam	
	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground
492.1S	--	--	1.13(-2)*	7.20(-3)	5.37(-1)	2.37(-1)
481.6	--	1.60(-5)	--	--	--	--
481.3	8.23(-5)	--	--	--	--	--
442.0	9.92(-5)	--	--	--	--	--
431.2	--	--	1.40(-2)	--	7.03(-1)	--
381.0	1.48(-4)	--	--	--	--	--
370.2	--	--	1.75(-2)	--	9.33(-1)	--
320.0	2.12(-4)	--	--	--	--	--
309.2	--	--	2.32(-2)	--	1.25(0)	--
259.1	3.03(-4)	--	--	--	--	--

*Read: 1.13×10^{-2}

Table 12. (Continued)

Distance from centerline (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)		Bonner ball count rate (counts/s/W)			
			Cd-covered		5-in.-diam	
	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground
248.3	--	--	3.05(-2)*	1.40(-2)	1.70(0)	4.73(-1)
243.8	--	4.16(-5)	--	--	--	--
198.1	4.31(-4)	--	--	--	--	--
187.3	--	--	3.95(-2)	--	2.25(0)	--
137.2	6.48(-4)	--	--	--	--	--
126.4	--	--	4.90(-2)	--	3.12(0)	--
106.7	7.67(-4)	--	--	--	--	--
95.9	--	--	5.45(-2)	--	3.57(0)	--
76.2	9.03(-4)	--	--	--	--	--
65.4	--	--	6.05(-2)	--	4.13(0)	--
50.2	--	--	--	--	4.48(0)	--
45.7	1.08(-3)	--	6.82(-2)	--	4.65(0)	--
45.7	--	--	--	--	4.68(0)	--
40.6	--	--	--	--	4.87(0)	--
38.1	--	--	7.32(-2)	--	4.92(0)	--
34.9	--	--	7.45(-2)	2.23(-2)	5.13(0)	7.82(-1)
35.6	--	--	--	--	5.23(0)	--
33.0	--	--	--	2.07(-2)	--	--
30.5	1.26(-3)	6.05(-5)	7.87(-2)	--	5.50(0)	--
30.5	--	--	--	--	5.30(0)	--
29.2	1.26(-3)	--	--	--	--	--
27.9	1.27(-3)	--	--	--	--	--
25.4	1.29(-3)	--	--	--	6.07(0)	--
25.4	1.33(-3)	--	--	--	--	--
22.9	1.39(-3)	--	8.25(-2)	--	5.92(0)	--
21.6	1.40(-3)	--	--	--	--	--
21.6	1.53(-3)	--	--	--	--	--
20.3	1.39(-3)	--	--	--	6.28(0)	--
20.3	1.41(-3)	--	--	--	--	--
20.3	1.54(-3)	--	--	--	--	--
19.7	--	--	--	--	6.55(0)	--
19.1	1.47(-3)	--	--	--	--	--
19.1	1.55(-3)	--	--	--	--	--
17.8	1.43(-3)	--	--	--	--	--
15.2	1.44(-3)	--	8.47(-2)	--	6.22(0)	--
15.2	1.46(-3)	--	--	--	6.62(0)	--
10.2	1.49(-3)	--	--	--	6.45(0)	--
10.2	1.51(-3)	--	--	--	--	--
7.62	--	--	8.87(-2)	--	6.50(0)	--
5.1	1.49(-3)	--	--	--	6.98(0)	--
5.1	1.57(-3)	--	--	--	--	--
4.45	--	--	9.05(-2)	--	6.92(0)	--
2.54	1.59(-3)	--	--	--	--	--
1.27	1.63(-3)	--	--	--	--	--
0	1.76(-3)	6.94(-5)	--	--	--	--
0	1.65(-3)	--	9.60(-2)	2.47(-2)	6.47(0)	8.07(-1)
0	1.74(-3)	--	--	--	--	--
0	1.63(-3)	--	9.67(-2)	--	6.60(0)	--
0	1.65(-3)	--	--	--	--	--
1.27N	1.66(-3)	--	--	--	--	--
2.54	1.64(-3)	--	--	--	--	--

*Read: 3.05×10^{-2}

Table 12. (Continued)

Distance from centerline (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)		Bonner ball count rate (counts/s/W)			
			Cd-covered		5-in.-diam	
	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground
5.1	1.46(-3)*	--	--	--	--	--
5.1	1.47(-3)	--	--	--	--	--
5.1	1.53(-3)	--	--	--	--	--
7.62	1.48(-3)	--	8.82(-2)	--	--	--
10.2	1.51(-3)	--	--	--	6.32(0)	--
12.7	1.47(-3)	--	--	--	--	--
15.2	1.42(-3)	--	8.58(-2)	--	6.37(0)	--
15.2	1.43(-3)	--	--	--	6.30(0)	--
15.2	1.47(-3)	--	--	--	--	--
16.5	1.42(-3)	--	--	--	--	--
17.8	1.45(-3)	--	--	--	--	--
17.8	1.48(-3)	--	--	--	--	--
19.1	1.50(-3)	--	--	--	--	--
19.1	1.54(-3)	--	--	--	--	--
20.3	1.47(-3)	--	--	--	6.12(0)	--
20.3	1.49(-3)	--	--	--	--	--
20.3	1.52(-3)	--	--	--	--	--
21.6	1.44(-3)	--	--	--	--	--
21.6	1.47(-3)	--	--	--	--	--
22.9	1.41(-3)	--	--	--	--	--
25.4	1.30(-3)	--	8.12(-2)	--	5.68(0)	--
27.9	1.30(-3)	--	--	--	--	--
30.5	1.23(-3)	--	--	--	5.33(0)	--
33.0	--	--	7.63(-2)	2.10(-2)	--	--
40.6	1.15(-3)	--	--	--	--	--
45.7	--	--	6.95(-2)	--	4.60(0)	--
50.8	1.03(-3)	--	--	--	--	--
61.0	--	--	6.37(-2)	--	--	--
76.2	8.57(-4)	--	--	--	3.83(0)	--
106.7	7.76(-4)	--	--	--	--	--
121.9	--	--	5.18(-2)	--	--	--
137.2	6.63(-4)	--	--	--	2.85(0)	--
167.6	5.37(-4)	--	--	--	--	--
182.9	--	--	4.25(-2)	1.72(-2)	--	--
198.1	4.62(-4)	--	--	--	2.22(0)	--
243.8	3.51(-4)	--	--	--	--	5.05(-1)
289.6	2.62(-4)	--	--	--	--	--

*Read: 1.46×10^{-3}

Table 13. Radial traverse at 30.5 cm behind 889 fuel pins *(Item II-B)*

Distance from centerline (cm)	0.635-cm-diam Hornyak button dose rate (erg/g/h/W)
30.5S	2.01(-2)*
0	3.09(-2)
30.5N	1.98(-2)

*Read: 2.01×10^{-2}

Table 14. Run 7702A. NE213 on centerline at 138 cm behind 889 fuel pins *(Item II-B)*

NEUTRON ENERGY (MEV)	FLUX (N/SQCM/MEV/KW/S) LOWER LIMIT	UPPER LIMIT	NEUTRON ENERGY (MEV)	FLUX (N/SQCM/MEV/KW/S) LOWER LIMIT	UPPER LIMIT
8.1135E-01	2.6426E+03	2.6772E+03	5.9380E+00	1.2852E+02	1.3099E+02
9.0694E-01	2.5172E+03	2.5358E+03	6.2542E+00	1.0941E+02	1.1274E+02
1.0066E+00	2.0819E+03	2.0972E+03	6.5557E+00	9.5488E+01	9.8327E+01
1.1069E+00	1.8089E+03	1.8246E+03	6.8390E+00	8.5885E+01	8.7855E+01
1.2047E+00	1.6809E+03	1.6949E+03	7.2352E+00	7.4398E+01	7.6142E+01
1.3096E+00	1.5888E+03	1.6023E+03	7.7365E+00	5.9564E+01	6.1543E+01
1.4121E+00	1.5013E+03	1.5142E+03	8.2364E+00	4.7154E+01	4.8856E+01
1.5107E+00	1.4123E+03	1.4247E+03	8.7578E+00	3.8012E+01	3.9311E+01
1.6100E+00	1.3209E+03	1.3327E+03	9.2613E+00	3.2096E+01	3.3313E+01
1.7095E+00	1.2323E+03	1.2437E+03	9.7411E+00	2.7310E+01	2.8426E+01
1.8125E+00	1.1584E+03	1.1698E+03	1.0259E+01	2.2072E+01	2.3030E+01
1.9323E+00	1.1143E+03	1.1254E+03	1.0777E+01	1.8544E+01	1.9397E+01
2.1000E+00	1.1082E+03	1.1190E+03	1.1247E+01	1.7310E+01	1.8050E+01
2.2961E+00	1.0811E+03	1.0908E+03	1.1751E+01	1.6112E+01	1.6765E+01
2.4988E+00	9.7202E+02	9.8044E+02	1.2393E+01	1.3101E+01	1.3606E+01
2.7026E+00	8.1650E+02	8.2461E+02	1.3201E+01	8.6163E+00	9.0007E+00
2.8984E+00	6.7386E+02	6.8140E+02	1.4021E+01	5.3865E+00	5.6512E+00
3.0975E+00	5.2786E+02	5.3473E+02	1.4792E+01	3.4735E+00	3.7078E+00
3.2965E+00	3.9846E+02	4.0412E+02	1.5629E+01	2.1314E+00	2.2942E+00
3.5009E+00	3.2208E+02	3.2805E+02	1.6539E+01	1.2053E+00	1.3115E+00
3.7074E+00	2.8472E+02	2.8922E+02	1.7533E+01	5.5031E-01	6.2967E-01
3.9061E+00	2.5928E+02	2.6311E+02	1.8521E+01	1.8862E-01	2.3028E-01
4.1528E+00	2.3662E+02	2.4034E+02	1.9498E+01	4.3597E-02	6.1385E-02
4.4540E+00	2.2115E+02	2.2438E+02	2.0556E+01	3.8673E-04	5.7844E-03
4.7521E+00	2.0671E+02	2.0984E+02	2.1580E+01	-6.8702E-03	-5.4664E-03
5.0422E+00	1.8912E+02	1.9185E+02	2.2560E+01	-6.9506E-03	-6.3590E-03
5.3459E+00	1.6852E+02	1.7114E+02	2.3471E+01	-5.4995E-03	-4.9243E-03
5.6453E+00	1.4785E+02	1.5078E+02			

E1 (MEV)	E2 (MEV)	INTEGRAL (N/SQCM/KW/S)	ERROR (N/SQCM/KW/S)
0.811	1.000	4.6874E+02	1.9590E+00
1.000	1.200	3.7210E+02	1.5295E+00
1.200	1.600	6.0650E+02	2.5966E+00
1.600	2.000	4.7602E+02	2.2701E+00
2.000	3.000	9.3374E+02	4.4503E+00
3.000	4.000	3.6155E+02	2.6799E+00
4.000	6.000	3.8028E+02	3.0066E+00
6.000	8.000	1.6845E+02	2.2727E+00
8.000	10.000	7.3693E+01	1.3269E+00
10.000	12.000	3.7944E+01	8.0336E-01
12.000	16.000	2.6852E+01	6.2606E-01
16.000	20.000	2.2094E+00	1.2623E-01
1.500	15.000	2.5941E+03	1.7959E+01

Table 15. Runs 1455A, 1453A, and 1455H. Hydrogen counter on centerline at 138 cm behind concrete shield and 889 fuel pins *(Item II-B)*

ENERGY BOUNDARY (MEV)		FLUX (N/SQ-CM/MEV/INC/W)	ERROR (PERCENT)
0.0793	0.0935	1.7737E 03	3.18
0.0935	0.1095	1.2452E 03	4.51
0.1095	0.1291	1.4989E 03	3.36
0.1291	0.1524	1.7287E 03	2.58
0.1524	0.1796	1.1247E 03	3.84
0.1796	0.2093	1.1040E 03	3.83
0.2093	0.2467	8.3927E 02	4.34
0.2467	0.2912	7.4392E 02	4.50
0.2479	0.2925	4.5348E 02	1.59
0.2912	0.3429	7.4596E 02	4.09
0.3429	0.3423	8.6669E 02	1.53
0.3423	0.4044	6.8704E 02	1.53
0.3444	0.4075	4.9086E 02	1.59
0.4064	0.4791	3.7748E 02	2.54
0.4175	0.4791	3.5510E 02	2.16
0.4791	0.5597	4.2038E 02	1.80
0.5597	0.6672	4.4045E 02	1.34
0.6672	0.7836	3.5653E 02	1.64
0.7836	0.9179	2.1197E 02	2.51
0.9179	1.0791	1.2159E 02	3.92
1.0791	1.2672	1.0913E 02	4.09
1.2672	1.5000	7.5847E 01	5.03

Table 16. Measurements on centerline at 138 cm behind fuel pins *(Item II-B)*

Distance behind fuel pins (cm)	Bonner ball count rate (counts/s/W)					
	3-in.-diam		6-in.-diam		10-in.-diam	
	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground
138	5.23(0)*	5.73(-1)	2.25(1)	1.33(0)	1.03(1)	2.48(-1)

*Read: 5.23×10^{0}

Table 17. Measurements on centerline at 30.5 cm behind fuel pins plus grid plate shield mockup without B_4C subassemblies *(Item II-C)*

Distance from shield mockup (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)	Bonner ball count rate (counts/s/W)	
		Cd-covered	5-in-diam
30.5	1.09(-2)*	9.63(-1)	6.85(1)

*Read: 1.09×10^{-2}

Table 18. Radial traverse directly behind 889 fuel pins plus grid plate shield *(Item II-D)*

Distance from centerline (cm)	0.635-cm-diam Hornyak button dose rate at 2.2 cm (erg/g/h/W)	Cd-covered Bonner ball count rate at 3.2 cm (counts/s/W)
66.0S	--	7.71(-3)*
58.4	--	1.42(-2)
50.8	1.70(-4)	2.83(-2)
43.2	3.22(-4)	8.68(-2)
38.1	--	8.18(-2)
35.6	7.69(-4)	8.88(-2)
33.0	1.14(-3)	9.07(-2)
31.1	--	9.15(-2)
30.5	1.70(-3)	9.18(-2)
29.8	2.18(-3)	8.98(-2)
29.5	2.56(-3)	--
29.2	2.48(-3)	8.95(-2)
28.6	2.36(-3)	8.87(-2)
27.9	2.71(-3)	9.27(-2)
27.3	3.32(-3)	9.88(-1)
26.7	4.11(-3)	1.16(-1)
26.0	5.33(-3)	1.35(-1)
25.4	6.67(-3)	1.56(-1)
24.1	7.34(-3)	--
22.9	7.38(-3)	1.90(-1)
20.3	7.33(-3)	1.90(-1)
17.8	7.21(-3)	1.90(-1)
16.5	6.64(-3)	1.83(-1)
15.2	6.35(-3)	1.64(-1)
14.6	6.05(-3)	1.45(-1)
14.0	5.31(-3)	1.21(-1)
13.3	4.09(-3)	1.08(-1)
12.7	3.51(-3)	8.42(-2)
12.1	3.43(-3)	7.43(-2)
11.4	3.32(-3)	7.42(-2)
11.4	--	7.25(-2)
10.8	3.43(-3)	7.35(-2)
10.8	--	7.77(-2)
10.2	5.01(-3)	7.42(-2)
10.2	--	7.40(-2)
9.84	5.02(-3)	--
9.53	5.02(-3)	7.42(-2)
8.89	3.77(-3)	7.27(-2)
7.98	3.65(-3)	6.92(-2)
7.62	3.94(-3)	6.98(-2)
6.99	4.44(-3)	7.77(-2)
6.35	5.34(-3)	9.22(-2)
5.72	6.52(-3)	1.08(-1)
5.72	6.61(-3)	1.23(-1)
5.08	7.32(-3)	1.20(-1)
5.08	7.40(-3)	--
3.81	7.95(-3)	1.39(-1)
2.54	8.07(-3)	--
0	8.29(-3)	1.46(-1)
0	8.37(-3)	--
0	8.32(-3)	--
2.54N	8.32(-3)	1.44(-1)
3.81	7.96(-3)	1.40(-1
4.45	--	1.33(-1)
5.08	7.80(-3)	1.29(-1)
5.72	7.35(-3)	1.13(-1)
6.35	6.45(-3)	9.50(-2)
6.99	5.16(-3)	7.98(-2)
7.62	4.46(-3)	7.08(-2)
7.98	3.85(-3)	6.87(-2)
8.89	3.67(-3)	6.98(-2)
9.53	4.24(-3)	7.30(-2)
10.2	4.89(-3)	7.42(-2)
10.2	4.99(-3)	--
10.5	4.93(-3)	--
10.8	4.65(-3)	7.30(-2)
11.4	3.39(-3)	7.40(-2)
12.1	3.32(-3)	7.48(-2)
12.7	3.38(-3)	8.12(-2)
13.3	3.68(-3)	9.75(-2)
14.0	4.45(-3)	1.19(-1)
14.6	5.61(-3)	1.38(-1)
15.2	6.15(-3)	1.61(-1)
16.5	6.59(-3)	1.77(-1)
17.8	6.95(-3)	1.83(-1)
20.3	7.31(-3)	1.88(-1)
22.9	7.35(-3)	1.88(-1)
24.1	7.30(-3)	--
25.4	7.04(-3)	1.54(-1)
26.0	6.47(-3)	1.35(-1)
26.7	5.02(-3)	1.19(-1)
27.3	3.97(-3)	1.03(-1)
27.9	3.21(-3)	9.38(-2)
27.9	3.34(-3)	--
28.6	2.66(-3)	8.90(-2)
29.2	2.35(-3)	9.07(-2)
29.2	2.30(-3)	--
29.8	2.53(-3)	9.30(-2)
30.5	2.24(-3)	9.45(-2)
31.1	--	9.53(-2)
33.0	1.21(-3)	9.13(-2)
35.6	8.47(-4)	9.08(-2)
38.1	--	8.52(-2)
43.2	3.46(-4)	6.22(-2)
50.8	1.94(-4)	3.12(-2)
58.4	--	1.56(-2)
66.0	--	8.78(-3)
91.4	--	3.00(-3)

*Read: 7.71×10^{-3}

Table 19. Measurements on centerline behind 889 fuel pins plus grid plate shield *(Item II-D)*

Distance behind grid plate (cm)	0.635-cm-diam Hornyak button dose rate (erg/g/h/W)		Bonner ball count rate (counts/s/W)				
			Bare	Cd-covered		5-in.-diam	
	Fore-ground	Back-ground	Fore-ground	Fore-ground	Back-ground	Fore-ground	Back-ground
30.5	2.91(-3)*	--	6.05(-1)	8.20(-2)	--	1.62(1)	--
305		5.33(-6)	--	2.17(-2)	1.38(-3)	2.03(0)	5.87(-2)

*Read: 2.91×10^{-3}

Table 20. Axial traverse through central B_4C subassembly in grid plate shield *(Item II-D)*

Distance from fuel pins (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)	Cd-covered Bonner ball count rate (counts/s/W)
2.69	8.06(-2)*	--
4.68	--	3.08(0)
5.23	7.46(-2)	--
7.77	6.79(-2)	--
12.3	--	1.48(0)
12.9	5.42(-2)	--
17.9	4.21(-2)	--
19.9	--	7.20(-1)
23.0	3.15(-2)	--
27.5	--	4.22(-1)
28.1	2.43(-2)	--
35.2	--	2.70(-1)
35.7	1.53(-2)	--
42.8	--	1.88(-1)
45.9	8.11(-3)	--
50.4	--	1.27(-1)
56.0	4.74(-3)	--
58.0	--	1.06(-1)
65.6	--	9.25(-2)
66.2	3.44(-3)	--
73.3	--	8.13(-2)
76.4	2.73(-3)	--
80.9	--	7.17(-2)
88.5	--	6.75(-2)
91.6	2.21(-3)	--
96.1	--	6.73(-2)
307.3	5.73(-4)	--

*Read: 8.06×10^{-2}

Table 21. Radial traverse in the 15.24-cm void between the grid plate shield and 61.0-cm Fe *(Item II-E)*

Distance from centerline (cm)	Cd-covered Bonner ball count rate at 4.1 cm (counts/s/W)	5-in.-diam Bonner ball count rate at 7.6 cm (counts/s/W)
65.4S	--	5.83(0)*
65.0	1.68(-1)	--
50.2	--	1.02(1)
45.7	2.88(-1)	--
40.0	--	1.61(1)
38.1	3.63(-1)	--
34.9	--	2.07(1)
31.8	3.82(-1)	--
30.5	3.80(-1)	2.72(1)
29.5	2.72(-1)	--
29.2	--	3.00(1)
28.3	3.78(-1)	--
27.9	--	3.30(1)
25.7	4.27(-1)	--
23.2	4.53(-1)	--
22.9	--	4.35(1)
20.6	4.57(-1)	--
17.8	4.50(-1)	4.62(1)
15.2	4.38(-1)	--
12.7	3.65(-1)	4.50(1)
10.2	3.60(-1)	4.62(1)
7.62	3.63(-1)	4.87(1)
5.08	3.97(-1)	--
3.81	--	5.45(1)
2.54	4.20(-1)	--
0	4.11(-1)	5.83(1)
0	4.18(-1)	--
2.54N	4.18(-1)	--
3.81	--	5.45(1)
5.08	4.02(-1)	--
7.62	3.58(-1)	4.92(1)
10.2	3.58(-1)	4.65(1)
12.7	3.75(-1)	4.55(1)
15.2	4.33(-1)	4.63(1)
17.8	4.55(-1)	4.70(1)
20.3	4.57(-1)	4.68(1)
22.9	4.52(-1)	4.40(1)
25.4	4.28(-1)	3.85(1)
27.9	3.83(-1)	3.35(1)
29.2	3.83(-1)	--
30.5	3.88(-1)	2.80(1)
31.8	3.90(-1)	--
35.6	--	2.00(1)
38.1	3.70(-1)	--
45.7	3.02(-1)	1.24(1)
61.0	--	7.32(0)
63.5	1.87(-1)	--

*Read: 5.83×10^{0}

Table 22. Radial traverse at 30.5 cm behind 889 fuel pins plus grid plate shield plus grid plate *(Item II-F)*

Distance from centerline (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)	
	With inserts	Without inserts
49.5S	1.80(-5)*	--
41.9	2.56(-5)	--
35.6	--	6.40(-5)
34.3	5.62(-5)	--
33.0	--	1.05(-4)
30.5	--	2.53(-4)
27.9	3.62(-4)	4.22(-4)
25.4	5.47(-4)	5.70(-4)
24.1	6.02(-4)	--
22.9	6.36(-4)	6.72(-4)
20.3	6.71(-4)	6.97(-4)
19.1	6.46(-4)	--
17.8	6.22(-4)	6.83(-4)
16.5	5.96(-4)	--
15.2	5.38(-4)	6.18(-4)
14.0	4.56(-4)	5.43(-4)
12.7	4.56(-4)	5.25(-4)
11.4	4.69(-4)	5.48(-4)
10.2	5.06(-4)	5.80(-4)
8.89	4.72(-4)	5.60(-4)
7.62	4.32(-4)	5.03(-4)
6.35	4.44(-4)	5.03(-4)
5.08	5.19(-4)	5.62(-4)
3.81	5.60(-4)	--
2.54	5.93(-4)	6.26(-4)
1.27	5.93(-4)	--
0	5.96(-4)	6.51(-4)
1.27N	5.88(-4)	--
2.54	5.79(-4)	6.49(-4)
3.81	5.42(-4)	5.96(-4)
3.81	5.37(-4)	--
5.08	5.04(-4)	--
6.35	4.37(-4)	5.11(-4)
7.62	4.21(-4)	5.03(-4)
8.89	4.61(-4)	5.33(-4)
10.2	5.19(-4)	5.88(-4)
11.4	4.94(-4)	6.00(-4)
12.7	4.84(-4)	5.72(-4)
14.0	5.24(-4)	5.70(-4)
15.2	6.05(-4)	6.45(-4)
16.5	6.12(-4)	--
17.8	6.57(-4)	7.05(-4)
19.1	6.66(-4)	--
20.3	6.67(-4)	7.31(-4)
21.6	6.49(-4)	--
22.9	6.24(-4)	6.87(-4)
24.1	5.87(-4)	--
25.4	4.80(-4)	5.80(-4)
26.7	4.13(-4)	--
27.9	--	4.34(-4)
27.9	--	4.26(-4)
29.2	3.03(-4)	--
30.5	--	3.23(-4)
30.5	--	3.50(-4)
31.8	1.64(-4)	--
33.0	--	1.53(-4)
33.0	--	1.47(-4)
34.3	5.94(-5)	--
35.6	--	7.17(-5)
41.9	2.80(-5)	--
49.5	1.76(-5)	--
57.2	1.07(-5)	--

*Read: 1.80×10^{-5}

Table 23. Radial traverse at 30.5 cm behind 889 fuel pins plus grid plate shield plus grid plate *(Item II-F)*

Distance from centerline (cm)	Cd-covered Bonner ball count rate (counts/s/W)	5-in.-diam Bonner ball count rate (counts/s/W)	
	With inserts	With inserts	Without inserts
71.1S	--	--	2.35(-1)*
63.5	--	--	3.22(-1)
61.0	2.18(-3)	--	--
55.9	--	--	4.40(-1)
53.3	2.77(-3)	--	--
48.3	--	--	6.28(-1)
45.7	3.38(-3)	--	--
40.6	--	--	9.02(-1)
38.1	4.22(-3)	--	--
33.0	--	--	1.59(0)
30.5	9.23(-3)	--	2.08(0)
27.9	1.45(-2)	--	2.73(0)
25.4	2.08(-2)	--	3.20(0)
22.9	2.58(-2)	--	3.53(0)
20.3	2.76(-2)	--	3.82(0)
17.8	2.67(-2)	--	3.85(0)
15.2	2.35(-2)	--	3.80(0)
12.7	1.93(-2)	--	3.73(0)
10.2	1.80(-2)	--	3.72(0)
7.62	1.67(-2)	--	3.93(0)
5.08	1.83(-2)	--	4.18(0)
2.54	2.17(-2)	3.45(0)	4.27(0)
0	2.22(-2)	3.65(0)	4.38(0)
0	2.25(-2)	--	4.48(0)
2.54N	2.13(-2)	3.58(0)	4.35(0)
5.08	1.87(-2)	3.33(0)	4.27(0)
7.62	1.60(-2)	3.12(0)	3.98(0)
8.89	1.67(-2)	--	--
10.2	1.78(-2)	2.95(0)	3.87(0)
12.7	1.98(-2)	2.95(0)	3.77(0)
15.2	2.38(-2)	3.08(0)	3.77(0)
17.8	2.72(-2)	3.12(0)	3.92(0)
20.3	2.80(-2)	3.17(0)	3.88(0)
22.9	2.60(-2)	3.05(0)	3.65(0)
25.4	2.08(-2)	2.68(0)	3.33(0)
27.9	1.47(-2)	2.28(0)	2.87(0)
30.5	9.87(-3)	1.72(0)	2.27(0)
33.0	--	1.22(0)	1.73(0)
35.6	--	--	1.37(0)
38.1	4.37(-3)	6.63(-1)	1.09(0)
45.7	3.60(-3)	4.47(-1)	7.38(-1)
53.3	2.87(-3)	--	5.03(-1)
61.0	1.88(-3)	--	3.37(-1)

*Read: 2.35×10^{-1}

Table 24. Radial traverse at 305 cm behind 889 fuel pins plus grid plate shield plus grid plate with inserts *(Item II-F)*

Distance from centerline (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)		Bonner ball count rate (counts/s/W)			
			Cd-covered		5-in.-diam	
	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground
182.9S	--	--	--	--	2.17(-2)*	7.30(-3)
152.4	--	--	--	--	2.53(-2)	--
121.9	--	--	3.90(-4)	2.57(-4)	2.98(-2)	--
114.3	2.08(-6)	--	--	--	--	--
106.7	--	--	3.92(-4)	--	3.43(-2)	--
99.1	2.50(-6)	--	--	--	--	--
91.4	2.86(-6)	2.42(-7)	4.08(-4)	--	3.83(-2)	9.57(-3)
83.8	3.50(-6)	--	--	--	--	--
76.2	4.58(-6)	--	4.52(-4)	--	5.12(-2)	--
68.6	9.10(-6)	--	--	--	--	--
61.0	1.64(-5)	--	7.02(-4)	2.70(-4)	1.08(-1)	--
53.3	2.96(-5)	--	1.08(-3)	--	--	--
45.7	5.26(-5)	--	1.73(-3)	--	2.58(-1)	--
38.1	7.92(-5)	--	2.73(-3)	--	--	--
30.5	1.19(-4)	--	4.20(-3)	--	5.20(-1)	--
27.9	1.43(-4)	--	--	--	--	--
25.4	1.80(-4)	--	--	--	--	--
22.9	2.10(-4)	--	7.17(-3)	--	7.25(-1)	--
20.3	2.32(-4)	--	--	--	--	--
17.8	2.36(-4)	--	--	--	--	--
15.2	2.28(-4)	--	7.77(-3)	--	8.58(-1)	--
12.7	2.20(-4)	--	--	--	--	--
11.4	--	--	7.68(-3)	--	--	--
10.2	2.20(-4)	--	--	--	--	--
7.62	2.30(-4)	--	7.78(-3)	--	9.10(-1)	--
7.62	--	--	7.85(-3)	--	--	--
5.08	2.54(-4)	--	--	--	--	--
3.81	--	--	8.28(-3)	--	--	--
2.54	2.74(-4)	--	--	--	--	--
0	2.82(-4)	4.72(-7)	8.45(-3)	3.05(-4)	9.30(-1)	1.12(-2)
0	--	--	8.52(-3)	--	--	--
2.54N	2.72(-4)	--	--	--	--	--
3.81	--	--	8.18(-3)	--	--	--
5.08	2.51(-4)	--	--	--	--	--
7.62	2.32(-4)	--	8.05(-3)	--	9.15(-1)	--
10.2	2.28(-4)	--	--	--	--	--
11.4	--	--	8.00(-3)	--	--	--
12.7	2.28(-4)	--	--	--	--	--
15.2	2.42(-4)	--	8.22(-3)	--	8.68(-1)	--
17.8	2.50(-4)	--	--	--	--	--
19.1	--	--	8.13(-3)	--	--	--
20.3	2.40(-4)	--	--	--	--	--
22.9	2.13(-4)	--	6.92(-3)	--	--	--
25.4	1.72(-4)	--	--	--	--	--
26.7	--	--	5.08(-3)	--	--	--
27.9	1.44(-4)	--	--	--	--	--
30.5	1.21(-4)	--	4.00(-3)	--	5.48(-1)	--
38.1	8.32(-5)	--	2.66(-3)	--	--	--
45.7	--	--	1.73(-3)	--	2.78(-1)	--

*Read: 2.17×10^{-2}

Table 24. (Continued)

Distance from centerline (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)		Bonner ball count rate (counts/s/W)			
			Cd-covered		5-in.-diam	
	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground
48.3	4.60(-5)*	--	--	--	--	--
53.3	--	--	1.14(-3)	--	--	--
58.4	2.30(-5)	--	--	--	--	--
61.0	--	--	7.73(-4)	3.18(-4)	1.22(-1)	--
68.6	1.01(-5)	--	--	--	--	--
76.2	--	--	5.13(-4)	--	5.67(-2)	--
78.7	4.48(-6)	--	--	--	--	--
88.9	3.04(-6)	--	--	--	--	--
91.4	--	--	4.85(-4)	--	4.15(-2)	--
99.1	2.42(-6)	--	--	--	--	--
106.7	--	--	4.73(-4)	--	3.57(-2)	--
121.9	--	--	4.47(-4)	--	3.27(-2)	--

Read: 4.60×10^{-5}

Table 25. Radial traverse at 2.62 cm behind 889 fuel pins plus grid plate shield plus grid plate *(Item II-F)*

Distance from centerline (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)	
	With inserts	Without inserts
33.0S	5.95(-5)*	8.89(-5)
30.5	1.25(-4)	1.74(-4)
27.9	6.05(-4)	7.55(-4)
25.4	8.93(-4)	9.83(-4)
22.9	9.85(-4)	1.10(-3)
20.3	9.91(-4)	1.08(-3)
17.8	9.42(-4)	1.04(-3)
15.2	7.92(-4)	--
12.7	5.74(-4)	7.21(-3)
11.4	3.15(-4)	4.61(-3)
10.8	2.15(-4)	--
10.2	2.21(-4)	2.90(-3)
8.89	4.32(-4)	5.05(-3)
7.62	6.19(-4)	7.49(-3)
5.08	8.57(-4)	9.60(-4)
2.54	9.28(-4)	1.05(-3)
0	9.34(-4)	1.07(-3)
0	9.50(-4)	--
2.54N	9.22(-4)	1.05(-3)
5.08	7.92(-4)	9.48(-4)
7.62	5.74(-4)	7.43(-4)
8.89	3.39(-4)	4.79(-4)
9.53	2.33(-4)	--
10.2	2.19(-4)	2.93(-4)
11.4	4.57(-4)	5.22(-4)
12.7	6.25(-4)	7.61(-4)
15.2	8.93(-4)	1.00(-3)
17.8	9.87(-4)	1.12(-3)
20.3	1.01(-3)	1.14(-3)
22.9	9.57(-4)	1.08(-3)
25.4	8.08(-4)	9.48(-4)
27.9	5.03(-4)	6.46(-4)
30.5	9.27(-5)	1.47(-4)
33.0	4.89(-5)	7.74(-5)

*Read: 5.95×10^{-5}

Table 26. Measurements on centerline behind the grid plate (with inserts) *(Item II-F)*

Distance behind grid plate (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)		Bonner ball count rate (counts/s/W)						
			3-in.-diam		6-in.-diam		8-in.-diam	10-in.-diam	12-in.diam
	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Fore-ground	Fore-ground
2.62	9.42(-4)	--	--	--	--	--	--	--	--
34.3	5.64(-4)	7.10(-1)	--	--	--	--	--	--	--
305	2.82(-4)	4.72(-7)	2.08(-1)	4.22(-3)	1.05(0)	9.82(-3)	8.47(-1)	4.93(-1)	2.80(-1)

*Read: 9.42×10^{-4}

Table 27. Run 7704B. NE213 on centerline at 34.3 cm behind 889 fuel pins plus grid plate shield plus grid plate *(Item II-F)*

NEUTRON ENERGY (MEV)	FLUX (N/SQCM/MEV/KW/S) LOWER LIMIT	UPPER LIMIT	NEUTRON ENERGY (MEV)	FLUX (N/SQCM/MEV/KW/S) LOWER LIMIT	UPPER LIMIT
3.1135E-01	4.0829E+02	4.1127E+02	5.9380E+00	1.6041E+01	1.6332E+01
9.0694E-01	3.8401E+02	3.8577E+02	6.2542E+00	1.3626E+01	1.3972E+01
1.0066E+00	3.0993E+02	3.1119E+02	6.5557E+00	1.1893E+01	1.2180E+01
1.1069E+00	2.5462E+02	2.5596E+02	6.8390E+00	1.0720E+01	1.0933E+01
1.2047E+00	2.2285E+02	2.2400E+02	7.2352E+00	9.3297E+00	9.4968E+00
1.3096E+00	2.0091E+02	2.0205E+02	7.7365E+00	7.4709E+00	7.6915E+00
1.4121E+00	1.8407E+02	1.8537E+02	8.2364E+00	5.8440E+00	6.0593E+00
1.5107E+00	1.6953E+02	1.7068E+02	8.7578E+00	4.5030E+00	4.6236E+00
1.6100E+00	1.5521E+02	1.5619E+02	9.2613E+00	3.5813E+00	3.6812E+00
1.7095E+00	1.4183E+02	1.4282E+02	9.7411E+00	2.9865E+00	3.0808E+00
1.8125E+00	1.3120E+02	1.3216E+02	1.0259E+01	2.4612E+00	2.5475E+00
1.9323E+00	1.2435E+02	1.2526E+02	1.0777E+01	2.0142E+00	2.0930E+00
2.1000E+00	1.2202E+02	1.2294E+02	1.1247E+01	1.7116E+00	1.7808E+00
2.2961E+00	1.1971E+02	1.2054E+02	1.1751E+01	1.4696E+00	1.5288E+00
2.4988E+00	1.0938E+02	1.1006E+02	1.2393E+01	1.1970E+00	1.2498E+00
2.7026E+00	9.3178E+01	9.3842E+01	1.3201E+01	8.9623E-01	9.3492E-01
2.8984E+00	7.6778E+01	7.7431E+01	1.4021E+01	6.4073E-01	6.7234E-01
3.0975E+00	6.0394E+01	6.1053E+01	1.4792E+01	4.1797E-01	4.4344E-01
3.2965E+00	4.6542E+01	4.7050E+01	1.5629E+01	2.1577E-01	2.3648E-01
3.5009E+00	3.7388E+01	3.7985E+01	1.6539E+01	1.0721E-01	1.2192E-01
3.7074E+00	3.2076E+01	3.2519E+01	1.7533E+01	7.2660E-02	8.2017E-02
3.9061E+00	2.8724E+01	2.9115E+01	1.8521E+01	4.7872E-02	5.5066E-02
4.1528E+00	2.6567E+01	2.6946E+01	1.9498E+01	2.3937E-02	2.8717E-02
4.4540E+00	2.5694E+01	2.6017E+01	2.0556E+01	8.0814E-03	1.0248E-02
4.7521E+00	2.4177E+01	2.4492E+01	2.1580E+01	1.4525E-03	2.3756E-03
5.0422E+00	2.1856E+01	2.2143E+01	2.2560E+01	-7.1449E-04	-1.3325E-04
5.3459E+00	1.9906E+01	2.0182E+01	2.3471E+01	-1.0901E-03	-5.3317E-04
5.6453E+00	1.8212E+01	1.8534E+01			

E1 (MEV)	E2 (MEV)	INTEGRAL (N/SQCM/KW/S)	ERROR (N/SQCM/KW/S)
0.811	1.000	7.1337E+01	1.7819E-01
1.000	1.200	5.2621E+01	1.2862E-01
1.200	1.600	7.5153E+01	2.3448E-01
1.600	2.000	5.4123E+01	1.9114E-01
2.000	3.000	1.0453E+02	3.7414E-01
3.000	4.000	4.1355E+01	2.5825E-01
4.000	6.000	4.4527E+01	3.1477E-01
6.000	8.000	2.0999E+01	2.3785E-01
8.000	10.000	8.5991E+00	1.3042E-01
10.000	12.000	3.9197E+00	7.3617E-02
12.000	16.000	2.7773E+00	6.7543E-02
16.000	20.000	2.8230E-01	1.8276E-02
1.500	15.000	2.9692E+02	1.6947E+00

Table 28. Runs 1456A, 1456B, and 1457A. Hydrogen counter on centerline at 34.3 cm behind 889 fuel pins plus grid plate shield plus grid plate *(Item II-F)*

ENERGY BOUNDARY (MEV)		FLUX (N/SQ-CM/MEV/MIN/A)	ERROR (PERCENT)
0.0885	0.1030	2.5945E 02	2.82
0.1030	0.1209	2.7406E 02	2.73
0.1209	0.1424	3.5451E 02	1.[illegible]
0.1424	0.1674	2.3[illegible]E 02	2.[illegible]
0.1674	0.1961	2.0244E 02	2.[illegible]3
0.1961	0.2319	1.5639E 02	[illegible].7
0.1964	0.2329	1.5566E 02	1.24
0.2319	0.2731	1.7077E 02	2.[illegible]2
0.2329	0.2731	1.6716E 02	1.11
0.2731	0.3228	1.3043E 02	1.[illegible]3
0.3228	0.3819	8.9911E 01	1.[illegible]0
0.3819	0.4447	6.[illegible]E 01	2.[illegible]1
0.4447	0.5259	7.7370E 01	1.51
0.4488	0.5301	6.[illegible]E 01	1.[illegible]4
0.5259	0.6207	7.[illegible]E 01	1.[illegible]7
0.5301	0.6207	6.9430E 01	1.19
0.6207	0.7294	5.9206E 01	1.17
0.7294	0.8563	3.6737E 01	1.[illegible]5
0.8563	1.0104	2.0[illegible]E 01	2.[illegible]3
1.0104	1.1825	1.5312E 01	3.[illegible]5
1.1825	1.4000	1.[illegible]E 01	3.03

Table 29. Radial traverse directly behind 889 fuel pins *(Item III-A)*

Distance from centerline (cm)	0.635-cm-diam Hornyak button dose rate at 2.2 cm (erg/g/h/W)	
	Initial measurement	Repeat measurement
60.5S	4.02(-3)*	--
52.8	6.34(-3)	--
45.2	1.00(-2)	--
37.6	1.83(-2)	--
34.4	--	2.45(-2)
33.2	--	2.84(-2)
32.5	3.15(-2)	--
31.9	--	3.33(-2)
31.2	3.73(-2)	--
30.6	--	3.87(-2)
30.0	4.31(-2)	4.35(-2)
29.4	--	4.49(-2)
29.3	4.42(-2)	--
28.7	4.45(-2)	4.58(-2)
28.1	4.38(-2)	4.49(-2)
27.5	--	4.55(-2)
27.4	4.44(-2)	--
26.8	--	4.71(-2)
25.6	--	4.97(-2)
24.9	4.87(-2)	--
23.0	--	5.42(-2)
22.4	5.37(-2)	--
20.5	--	5.87(-2)
19.8	5.73(-2)	--
17.9	--	6.18(-2)
17.3	6.08(-2)	--
15.4	--	6.33(-2)
14.7	6.21(-2)	--
12.9	--	6.53(-2)
12.2	6.42(-2)	--
11.6	6.39(-2)	6.54(-2)
11.2	6.37(-2)	--
11.0	--	6.68(-2)
10.9	6.38(-2)	--
10.7	6.47(-2)	--
10.3	--	6.87(-2)
10.2	6.56(-2)	--
9.91	6.71(-2)	--
9.68	--	6.93(-2)
9.65	6.71(-2)	--
9.05	--	6.84(-2)
9.02	6.67(-2)	--
8.41	--	6.75(-2)
8.38	6.51(-2)	--
7.78	--	6.89(-2)
7.75	6.55(-2)	--
7.11	6.55(-2)	--
5.84	6.61(-2)	--
5.24	--	6.77(-2)
4.57	6.53(-2)	--
2.70	--	6.78(-2)
2.03	6.66(-2)	--
0.16	--	6.77(-2)
0	6.77(-2)	--
0.2N	6.64(-2)	--
2.38	--	6.87(-2)
3.05	6.57(-2)	--
4.92	--	6.78(-2)
5.59	6.47(-2)	--
6.86	6.53(-2)	--
7.46	--	6.80(-2)
7.49	6.44(-2)	--
8.10	--	6.69(-2)
8.13	6.41(-2)	--
8.73	--	6.78(-2)
8.76	6.51(-2)	--
9.08	6.51(-2)	--
9.37	--	6.95(-2)
9.40	6.64(-2)	--
9.72	6.61(-2)	--
10.0	6.47(-2)	6.78(-2)
10.6	--	6.72(-2)
10.7	6.37(-2)	--
11.3	6.31(-2)	6.63(-2)
11.9	6.34(-2)	6.66(-2)
12.5	--	6.57(-2)
13.2	6.19(-2)	--
15.1	--	6.51(-2)
15.7	6.08(-2)	--
17.6	--	6.32(-2)
18.3	5.92(-2)	--
20.2	--	6.03(-2)
20.8	5.55(-2)	--
22.7	--	5.54(-2)
23.4	5.21(-2)	--
25.2	--	5.06(-2)
25.9	4.71(-2)	--
26.5	--	4.91(-2)
27.1	--	4.67(-2)
27.2	4.50(-2)	--
27.8	4.39(-2)	4.59(-2)
28.4	4.45(-2)	4.64(-2)
29.1	4.52(-2)	4.70(-2)
29.7	4.44(-2)	4.58(-2)
30.3	--	4.32(-2)
30.4	3.99(-2)	--
31.0	3.70(-2)	--
31.6	--	3.59(-2)
32.3	3.15(-2)	--
32.9	--	3.09(-2)
33.5	2.74(-2)	--
35.4	--	2.36(-2)
38.6	1.65(-2)	--
46.2	8.89(-3)	--
53.8	5.45(-3)	--
61.5	3.44(-3)	--
69.1	2.09(-3)	--
76.7	1.26(-3)	--

*Read: 4.02×10^{-3}

Table 30. Measurements on centerline behind 889 fuel pins *(Item III-A)*

Distance from fuel pins (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)		Bonner ball count rate (counts/s/W)			
			Cd-covered		5-in.-diam	
	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground
	Initial measurement					
30.5	2.55(-2)*	--	1.44(0)	--	1.33(2)	--
305	1.51(-3)	8.05(-5)	7.87(-2)	2.40(-2)	6.10(0)	8.37(-1)
	Repeat measurement					
30.5	2.42(-2)	--	1.43(0)	--	1.32(2)	--
	2.41(-2)	--	1.47(0)	--	1.37(2)	--
	2.24(-2)	--	--	--	--	--
305	1.41(-3)	--	8.53(-2)	--	5.98(0)	--
	1.40(-3)	--	8.47(-2)	--	6.15(0)	--
	1.42(-3)	--	8.50(-2)	--	--	--

*Read: 2.55×10^{-2}

Table 31. Radial traverse directly behind 889 fuel pins plus grid plate shield *(Item III-B)*

Distance from centerline (cm)	0.635-cm-diam Hornyak button dose rate at 2.86 cm (erg/g/h/W)		Cd-covered Bonner ball count rate at 3.8 cm (counts/s/W)
	Initial Measurement	Repeat Measurement	
76.2S	--	--	4.98(-3)*
75.2	3.44(-5)	--	--
63.9	--	7.48(-5)	--
63.5	--	--	1.01(-2)
62.5	7.53(-5)	--	--
53.3	--	1.56(-4)	2.35(-2)
52.4	1.70(-4)	--	--
45.7	--	2.81(-4)	4.67(-2)
44.8	3.37(-4)	--	--
38.1	--	6.51(-4)	7.52(-2)
37.1	7.32(-4)	--	--
35.6	--	8.36(-4)	--
33.0	--	1.16(-3)	8.10(-2)
32.1	1.37(-3)	--	--
31.8	--	1.41(-3)	9.85(-2)
31.1	--	1.59(-3)	--
30.8	1.66(-3)	--	--
30.5	--	1.81(-3)	1.13(-1)
30.2	2.70(-3)	2.77(-3)	--
29.8	2.88(-3)	2.95(-3)	--
29.5	3.04(-3)	2.93(-3)	--
29.2	3.01(-3)	2.93(-3)	1.11(-1)
28.9	2.45(-3)	2.25(-3)	--
28.6	2.14(-3)	2.16(-3)	--

*Read: 4.98×10^{-3}

Table 31. (Continued)

Distance from centerline (cm)	0.635-cm-diam Hornyak button dose rate at 2.86 cm (erg/g/h/W)		Cd-covered Bonner ball count rate at 3.8 cm (counts/s/W)
	Initial Measurement	Repeat Measurement	
28.3	2.27(-3)*	2.30(-3)	--
27.9	2.45(-3)	2.47(-3)	9.67(-2)
27.6	2.63(-3)	--	--
27.0	3.10(-3)	--	--
26.7	--	3.48(-3)	1.06(-1)
26.0	4.95(-3)	--	--
25.4	--	--	1.39(-1)
24.4	6.25(-3)	--	--
23.5	6.34(-3)	--	--
22.9	--	--	1.75(-1)
21.9	6.67(-3)	--	--
21.6	--	6.60(-3)	--
20.3	--	--	1.77(-1)
19.4	6.57(-3)	--	--
17.8	--	--	1.72(-1)
16.8	6.35(-3)	--	--
16.5	--	6.16(-3)	1.68(-1)
15.9	5.89(-3)	--	--
15.2	--	--	1.56(-1)
14.3	5.65(-3)	--	--
14.0	--	--	1.26(-1)
13.3	4.12(-3)	--	--
12.7	--	3.61(-3)	8.35(-2)
11.7	3.05(-3)	--	--
11.4	--	.95(-3)	6.18(-2)
11.1	2.89(-3)	--	--
10.8	--	2.86(-3)	--
10.5	2.91(-3)	--	--
10.2	3.12(-3)	3.11(-3)	5.28(-2)
9.84	3.74(-3)	3.68(-3)	--
9.53	3.66(-3)	3.71(-3)	--
9.21	3.23(-3)	3.26(-3)	--
8.89	3.10(-3)	3.00(-3)	5.50(-2)
8.57	3.17(-3)	--	--
7.94	3.40(-3)	--	--
7.62	--	3.48(-3)	6.33(-2)
7.30	3.86(-3)	--	--
6.67	4.43(-3)	--	--
6.35	--	--	8.35(-2)
5.40	6.04(-3)	--	--
5.08	--	--	1.08(-1)
4.13	6.41(-3)	--	--
2.54	--	--	1.23(-1)
1.59	6.98(-3)	--	--
0	7.15(-3)	7.04(-3)	1.25(-1)
0	--	--	1.25(-1)
0.95N	6.96(-3)	--	--
2.54	6.85(-3)	--	1.23(-1)
5.08	--	--	1.05(-1)
5.28	6.42(-3)	--	--
6.35	--	--	8.40(-2)
6.55	4.79(-3)	--	--
7.62	--	3.72(-3)	6.17(-2)
7.82	3.58(-3)	--	--

*Read: 2.27×10^{-3}

Table 31. (Continued)

Distance from centerline (cm)	0.635-cm-diam Hornyak button dose rate at 2.86 cm (erg/g/h/W)		Cd-covered Bonner ball count rate at 3.8 cm (counts/s/W)
	Initial Measurement	Repeat Measurement	
8.46	3.34(-3) *	--	--
8.89	--	3.07(-3)	5.23(-2)
9.09	3.09(-3)	--	--
9.21	--	3.08(-3)	--
9.53	3.62(-3)	3.26(-3)	--
9.73	3.63(-3)	--	--
9.84	3.65(-3)	3.58(-3)	--
10.2	3.15(-3)	--	--
10.2	3.30(-3)	3.37(-3)	5.30(-2)
10.4	2.80(-3)	--	-
10.5	2.91(-3)	2.90(-3)	-
10.8	--	2.82(-3)	--
11.0	2.91(-3)	--	--
11.1	--	2.88(-3)	--
11.4	--	2.91(-3)	6.42(-2)
11.6	2.97(-3)	--	--
12.3	3.30(-3)	--	--
12.7	--	3.51(-3)	9.47(-2)
12.9	3.91(-3)	--	--
14.0	--	--	1.29(-2)
14.2	5.69(-3)	--	--
14.9	5.74(-3)	--	--
15.2	--	--	1.57(-2)
15.4	5.82(-3)	--	--
16.5	--	--	1.64(-2)
16.7	6.21(-3)	--	--
17.8	--	--	1.68(-2)
18.0	6.39(-3)	--	--
20.3	--	6.64(-3)	1.72(-2)
20.5	6.86(-3)	--	--
22.9	--	--	1.68(-2)
23.1	6.53(-3)	--	--
24.3	6.28(-3)	--	--
25.4	--	--	1.27(-1)
25.6	5.18(-3)	--	--
26.7	--	--	9.63(-2)
26.9	3.05(-3)	--	--
27.9	--	2.48(-3)	1.04(-1)
28.1	2.28(-3)	--	--
28.3	--	2.28(-3)	--
28.6	--	2.16(-3)	--
28.8	2.37(-3)	--	--
28.9	--	2.23(-3)	--
29.2	2.92(-3)	2.81(-3)	1.13(-1)
29.4	3.02(-3)	--	--
29.5	--	2.96(-3)	--
29.8	2.98(-3)	2.89(-3)	--
30.0	2.85(-3)	--	--
30.2	--	2.82(-3)	--
30.5	1.81(-3)	2.42(-3)	1.13(-1)
30.7	1.64(-3)	--	--
30.8	--	1.65(-3)	--
31.8	--	--	9.26(-2)
32.0	1.42(-3)	--	--

*Read: 3.34×10^{-3}

Table 31. (Continued)

Distance from centerline (cm)	0.635-cm-diam Hornyak button dose rate at 2.86 cm (erg/g/h/W)		Cd-covered Bonner ball count rate at 3.8 cm (counts/s/W)
	Initial Measurement	Repeat Measurement	
33.0	--	--	8.42(-2)*
33.2	1.12(-3)	--	--
38.1	--	--	7.62(-2)
38.3	6.36(-4)	--	--
45.7	--	--	4.65(-2)
45.9	2.79(-4)	--	--
53.3	--	--	2.32(-2)
53.5	1.45(-4)	--	--
63.5	--	--	9.95(-3)
63.7	7.21(-4)	--	--
76.2	--	--	4.70(-3)
76.4	3.22(-4)	--	--

*Read: 8.42×10^{-2}

Table 32. Measurements on centerline behind 889 pins plus grid plate shield *(Item III-B)*

Distance from grid plate shield (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)		Bonner ball count rate (counts/s/W)				
			Bare	Cd-covered		5-in.-diam	
	Fore-ground	Back-ground	Fore-ground	Fore-ground	Back-ground	Fore-ground	Back-ground
30.5	2.44(-3)*	--	5.72(-1)	7.92(-2)	--	1.48(1)	--
305	4.36(-4)	3.97(-6)	--	1.72(-2)	1.60(-3)	1.64(0)	5.45(-2)

Read: 2.44×10^{-3}

Table 33. Radial traverse in the 15.24-cm void between the grid plate shield and 61.0-cm Fe *(Item III-C)*

Distance from centerline (cm)	Cd-covered Bonner ball count rate at 4.5 cm (counts/s/W)	5-in.-diam Bonner ball count rate at 7.6 cm (counts/s/W)
66.7S	--	4.82(0)*
61.6	1.61(-1)	--
53.3	2.08(-1)	8.05(0)
45.7	2.68(-1)	1.10(1)
38.1	3.30(-1)	1.57(1)
33.0	3.53(-1)	2.12(1)
30.5	3.78(-1)	2.52(1)
29.2	3.72(-1)	--
27.9	3.70(-1)	3.00(1)
26.7	3.72(-1)	--
25.4	4.05(-1)	3.42(1)
22.9	4.40(-1)	3.80(1)
20.3	4.38(-1)	4.08(1)
17.8	4.35(-1)	4.12(1)
15.2	4.23(-1)	4.05(1)
12.7	3.65(-1)	3.90(1)
11.4	3.43(-1)	--
10.2	3.37(-1)	4.02(1)
8.89	3.40(-1)	--
7.62	--	4.27(1)
7.46	3.42(-1)	--
6.35	3.60(-1)	--
5.08	3.78(-1)	4.65(1)
2.54	3.92(-1)	4.87(1)
0	3.95(-1)	4.93(1)
2.54N	3.95(-1)	4.77(1)
5.08	3.82(-1)	4.48(1)
6.35	3.60(-1)	--
7.62	3.47(-1)	4.17(1)
8.89	3.42(-1)	--
10.2	3.37(-1)	4.03(1)
11.4	3.50(-1)	--
12.7	3.75(-1)	4.02(1)
15.2	4.28(-1)	4.10(1)
17.8	4.35(-1)	4.15(1)
20.3	4.47(-1)	3.93(1)
22.9	4.32(-1)	3.65(1)
25.4	4.13(-1)	3.23(1)
26.7	3.82(-1)	--
27.9	3.82(-1)	2.78(1)
29.2	4.00(-1)	--
30.5	3.98(-1)	2.37(1)
31.8	3.75(-1)	--
33.0	3.67(-1)	2.02(1)
38.1	3.43(-1)	1.53(1)
45.7	2.85(-1)	1.09(1)
53.0	--	8.15(0)
53.3	2.30(-1)	--
61.0	1.90(-1)	--

*Read: 4.82×10^{0}

Table 34. Measurements on centerline behind 637 fuel pins *(Item IV-A)*

Distance behind fuel pins (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)		Bonner ball count rate (counts/s/W)					
			Cd-covered		3-in.-diam	5-in.-diam		10-in.-diam
	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Fore-ground	Back-ground	Fore-ground
30.5	4.75(-2)*	--	2.38(0)	--	4.40(1)	2.08(2)	--	1.06(2)
30.5	--	--	--	--	--	2.07(2)	--	--
305	2.89(-3)	1.36(-4)	1.56(-1)	3.47(-2)	--	9.83(0)	1.08(0)	--
305	--	--	--	--	--	1.00(1)	--	--

Read: 4.75×10^{-2}

Table 35. Measurements on centerline behind 637 fuel pins plus grid plate shield *(Item IV-B)*

Distance behind fuel pins (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)		Cd-covered Bonner ball count rate (counts/s/W)		5-in.-diam Bonner ball count rate (counts/s/W)	
	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground
30.5	5.40(-3)*	--	1.57(-1)	--	2.45(1)	--
30.5	--	--	1.73(-1)	--	2.60(1)	--
305	9.91(-4)	7.10(-6)	3.47(-2)	2.40(-3)	2.92(0)	9.62(-2)
305	9.39(-4)	--	4.13(-2)	--	3.17(0)	--

Read: 5.40×10^{-3}

Table 36. Radial traverse directly behind 637 fuel pins plus grid plate shield (Item IV-B)

Distance from centerline (cm)	0.635-cm-diam Hornyak button dose rate at 2.35 cm (erg/g/h/W)	Cd-covered Bonner ball count rate at 3.18 cm (counts/s/W)
96.5S	--	3.72(-3)*
91.4	1.92(-5)	--
76.2	4.43(-5)	--
66.0	--	1.16(-2)
61.0	1.25(-4)	--
50.8	2.75(-4)	4.23(-2)
45.7	4.58(-4)	--
43.2	--	8.38(-2)
40.6	7.97(-4)	--
38.1	--	1.17(-1)
35.6	1.44(-3)	1.28(-1)
33.0	2.05(-3)	1.30(-1)
31.8	2.52(-3)	--
30.5	3.15(-3)	1.27(-1)
29.8	3.92(-3)	--
29.2	3.97(-3)	1.24(-1)
28.6	4.55(-3)	--
27.9	5.28(-3)	1.35(-1)
26.7	8.13(-3)	1.73(-1)
25.4	1.27(-2)	2.38(-1)
25.4	--	2.47(-1)
24.1	1.33(-2)	3.16(-1)
22.9	1.36(-2)	3.30(-1)
20.3	1.32(-2)	3.35(-1)
17.8	1.28(-2)	3.28(-1)
16.5	1.22(-2)	3.17(-1)
15.2	1.14(-2)	2.88(-1)
14.0	8.12(-3)	2.23(-1)
12.7	5.90(-3)	1.39(-1)
12.1	5.74(-3)	--
11.4	5.72(-3)	1.03(-1)
10.8	7.13(-3)	--
10.2	7.98(-3)	1.00(-1)
9.84	7.92(-3)	--
9.53	7.22(-3)	--
8.89	6.34(-3)	9.98(-2)
7.98	6.79(-3)	1.03(-1)
7.62	7.64(-3)	1.03(-1)
6.35	1.14(-2)	1.49(-1)
5.08	1.41(-2)	2.13(-1)
3.81	1.49(-2)	2.55(-1)
2.54	1.55(-2)	2.67(-1)
0	1.58(-2)	2.72(-1)
0	1.58(-2)	2.70(-1)
2.54N	1.54(-2)	2.65(-1)
3.81	1.50(-2)	2.55(-1)
5.08	1.41(-2)	2.12(-1)
6.35	1.05(-2)	1.56(-1)
7.62	7.33(-3)	1.08(-1)
7.98	6.78(-3)	--
8.89	6.23(-3)	1.01(-1)
9.53	7.74(-3)	--
9.84	8.04(-3)	--
10.2	8.01(-3)	1.03(-1)
10.8	6.81(-3)	--
11.4	5.67(-3)	1.04(-1)
12.1	5.72(-3)	--
12.7	6.02(-3)	1.32(-1)
14.0	8.71(-3)	2.08(-1)
15.2	1.11(-2)	2.72(-1)
16.5	1.21(-2)	3.03(-1)
17.8	1.28(-2)	3.15(-1)
20.3	1.38(-2)	3.22(-1)
22.9	1.35(-2)	3.25(-1)
24.1	1.32(-2)	3.05(-1)
25.4	1.26(-2)	2.52(-1)
26.7	7.64(-3)	1.83(-1)
27.9	4.97(-3)	1.37(-1)
28.6	4.34(-3)	--
29.2	4.01(-3)	1.31(-1)
29.8	3.79(-3)	--
30.5	3.10(-3)	1.32(-1)
33.0	2.00(-3)	1.33(-1)
35.6	1.37(-3)	1.33(-1)
38.1	1.03(-3)	1.24(-1)
43.2	--	8.87(-2)
50.8	--	4.37(-2)
61.0	--	1.72(-2)
91.4	--	4.12(-3)

*Read: 3.72×10^{-3}

Table 37. Radial traverse in 15.24-cm void between the grid plate shield and 61.0-cm Fe *(Item IV-C)*

Distance from centerline (cm)	Cd-covered Bonner ball count rate at 4.13 cm (counts/s/W)	5-in.-diam Bonner ball count rate at 7.62 cm (counts/s/W)
69.3S	2.33(-1)*	--
66.0	2.48(-1)	--
58.4	3.03(-1)	--
50.8	3.75(-1)	--
43.2	4.80(-1)	--
40.6	--	2.30(1)
35.6	5.68(-1)	2.98(1)
30.5	5.62(-1)	4.15(1)
27.9	5.58(-1)	--
25.4	6.62(-1)	5.80(1)
22.9	7.30(-1)	6.50(1)
20.3	7.37(-1)	6.87(1)
17.8	7.30(-1)	6.87(1)
15.2	6.98(-1)	6.82(1)
14.0	6.30(-1)	--
12.7	5.57(-1)	6.68(1)
10.2	5.45(-1)	6.75(1)
7.62	5.43(-1)	7.23(1)
5.08	6.62(-1)	--
3.81	--	8.12(1)
2.54	6.95(-1)	--
0	6.87(-1)	8.27(1)
2.54N	6.95(-1)	--
3.81	--	7.90(1)
5.08	6.53(-1)	--
7.62	5.60(-1)	7.18(1)
10.2	5.43(-1)	6.85(1)
12.7	5.77(-1)	6.75(1)
14.0	6.37(-1)	--
15.2	6.93(-1)	6.78(1)
17.8	7.32(-1)	6.83(1)
20.3	7.42(-1)	6.77(1)
22.9	7.33(-1)	6.27(1)
25.4	6.82(-1)	5.65(1)
27.9	5.85(-1)	--
30.5	5.87(-1)	4.15(1)
35.6	5.75(-1)	2.95(1)
40.6	--	2.36(1)
43.2	4.78(-1)	--
50.8	3.83(-1)	--
58.4	3.07(-1)	--
66.0	2.57(-1)	--
68.6	2.42(-1)	--

*Read: 2.33×10^{-1}

Table 38. Radial traverse directly behind 630 fuel pins *(Item V-A)*

Distance from centerline (cm)	0.635-cm-diam Hornyak button dose rate at 2.29 cm (erg/g/h/W)	Cd-covered Bonner ball count rate at 3.18 cm (counts/s/W)
61.0S	5.03(-3)*	--
53.3	9.05(-3)	8.45(-1)
45.7	1.47(-2)	1.55(0)
38.1	2.87(-2)	2.60(0)
33.0	5.20(-2)	3.17(0)
32.4	--	3.30(0)
31.8	6.11(-2)	3.38(0)
31.1	6.69(-2)	3.47(0)
30.8	6.85(-2)	--
30.5	7.05(-2)	3.63(0)
30.2	7.24(-2)	--
29.8	7.45(-2)	--
29.2	7.73(-2)	3.78(0)
27.9	8.21(-2)	4.00(0)
26.7	--	4.08(0)
25.4	9.30(-2)	4.25(0)
22.9	1.03(-1)	4.38(0)
20.3	1.09(-1)	4.42(0)
17.8	1.16(-1)	4.57(0)
17.8	--	4.55(0)
15.2	1.24(-1)	4.45(0)
14.0	--	4.53(0)
12.7	1.30(-1)	4.48(0)
12.1	1.34(-1)	--
11.7	1.35(-1)	--
11.4	1.36(-1)	4.40(0)
11.1	1.37(-1)	--
10.8	1.37(-1)	--
10.2	1.38(-1)	4.65(0)
9.53	1.36(-1)	--
8.89	1.34(-1)	4.50(0)
7.98	1.34(-1)	--
7.62	1.35(-1)	4.53(0)
6.35	1.36(-1)	4.45(0)
5.08	1.42(-1)	4.35(0)
4.45	1.40(-1)	--
3.81	1.42(-1)	4.63(0)
3.18	1.49(-1)	--
2.54	1.52(-1)	4.87(0)
2.54	--	4.90(0)
1.27	1.52(-1)	4.83(0)
1.27	--	4.78(0)
0	1.53(-1)	4.95(0)
0	1.54(-1)	--
.635N	1.52(-1)	--
1.27	1.50(-1)	4.93(0)
1.91	1.45(-1)	--
2.54	1.40(-1)	4.78(0)
3.18	1.40(-1)	--
3.81	--	4.63(0)
3.81	1.39(-1)	--
5.08	1.35(-1)	4.48(0)
6.35	1.36(-1)	4.43(0)
7.62	1.37(-1)	4.52(0)
7.98	1.38(-1)	--
8.57	1.38(-1)	--
8.89	1.39(-1)	4.35(0)
9.21	1.38(-1)	--
9.53	1.38(-1)	--
9.84	1.37(-1)	--
10.2	1.35(-1)	4.47(0)
10.5	1.34(-1)	--
10.8	1.33(-1)	--
11.1	1.31(-1)	--
11.4	1.30(-1)	4.43(0)
11.7	1.29(-1)	--
12.1	1.29(-1)	--
12.7	1.25(-1)	4.40(0)
14.0	--	4.38(0)
15.2	1.20(-1)	4.48(0)
17.8	1.15(-1)	4.48(0)
20.3	1.06(-1)	4.43(0)
22.9	9.61(-2)	4.48(0)
25.4	8.63(-2)	4.08(0)
26.7	8.29(-2)	4.07(0)
27.3	7.96(-2)	--
27.6	7.81(-2)	--
27.9	7.78(-2)	3.93(0)
28.3	7.66(-2)	--
28.6	7.53(-2)	--
29.2	7.22(-2)	3.73(0)
29.8	6.78(-2)	--
30.2	6.60(-2)	--
30.5	6.33(-2)	3.63(0)
30.8	6.14(-2)	--
31.1	6.03(-2)	3.43(0)
31.8	5.38(-2)	3.37(0)
33.0	4.60(-2)	3.27(0)
38.1	2.61(-2)	2.60(0)
45.7	1.33(-2)	--
53.3	7.97(-3)	8.25(-1)
61.0	4.64(-3)	--

*Read: 5.03×10^{-3}

Table 39. Measurements on centerline behind 630 fuel pins (637 pins minus seven pins from central subassembly) *(Item V-A)*

Distance from fuel pins (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)		Bonner ball count rate (counts/s/W)					
			Bare		Cd-covered		5-in.-diam	
	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground
30.5	4.24(-2)*	--	--	--	2.43(0)	--	2.15(2)	--
305	2.89(-3)	1.02(-4)	2.02(0)	5.43(-1)	1.51(-1)	3.08(-2)	1.03(1)	1.14(0)

Read: 4.24×10^{-2}

Table 40. Axial traverse through central grid plate shield subassembly *(Item V-B)*

Distance from fuel pins (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)	Cd-covered Bonner ball count rate (counts/s/W)
2.36	1.40(-1)*	--
3.81	--	5.95(0)
4.90	1.27(-1)	--
6.35	--	4.65(0)
7.44	1.15(-1)	--
8.89	--	3.58(0)
9.98	1.04(-1)	--
11.4	--	2.75(0)
12.5	9.43(-2)	--
15.2	--	1.95(0)
17.6	7.42(-2)	--
20.3	--	1.33(0)
22.7	5.81(-2)	--
25.4	--	9.50(-1)
27.8	4.50(-2)	--
30.5	--	7.25(-1)
32.8	3.48(-2)	--
35.6	--	5.75(-1)
37.9	2.65(-2)	--
40.6	--	4.70(-1)
43.0	2.00(-2)	--
45.5	1.75(-2)	--
45.7	--	3.68(-1)
50.6	1.39(-2)	--
50.8	--	3.08(-1)
55.7	1.14(-2)	--
55.9	--	2.67(-1)
59.5	1.00(-2)	--
61.0	--	2.43(-1)
63.3	9.15(-3)	--
66.0	--	2.20(-1)
70.9	7.62(-3)	--
71.1	--	2.07(-1)
76.2	--	1.88(-1)
78.6	6.53(-3)	--
81.3	--	1.73(-1)
86.2	5.84(-3)	--
86.4	--	1.67(-1)
91.4	--	1.62(-1)
93.8	5.25(-3	--

*Read: 1.40×10^{-1}

Table 41. Radial traverse behind 630 fuel pins plus grid plate shield *(Item V-B)*

Distance from centerline (cm)	0.635-cm-diam Hornyak button dose rate at 2.7 cm (erg/g/h/W)	Cd-covered Bonner ball count rate at 3.18 cm (counts/s/W)
76.2S	--	7.37(-3)*
61.0	1.26(-4)	1.92(-2)
45.7	4.25(-4)	7.15(-2)
38.1	1.01(-3)	1.22(-1)
35.6	--	1.31(-1)
33.0	1.94(-3)	1.34(-1)
31.8	2.33(-3)	--
30.5	2.99(-3)	1.35(-1)
29.8	3.66(-3)	--
29.2	3.62(-3)	1.29(-1)
28.6	4.23(-3)	--
27.9	4.98(-3)	1.48(-1)
26.7	8.12(-3)	2.05(-1)
25.4	1.19(-2)	2.77(-1)
24.1	1.23(-2)	3.37(-1)
22.9	1.21(-2)	3.52(-1)
20.3	1.21(-2)	3.57(-1)
17.8	1.18(-2)	3.40(-1)
16.5	1.10(-2)	3.36(-1)
15.2	1.03(-2)	2.90(-1)
14.0	7.19(-3)	2.16(-1)
12.7	5.33(-3)	1.44(-1)
12.1	5.27(-3)	--
11.4	5.40(-3)	1.15(-1)
10.8	6.97(-3)	--
10.2	7.34(-3)	1.10(-1)
9.84	7.49(-3)	--
9.53	6.86(-3)	--
8.89	5.94(-3)	1.14(-1)
7.98	6.36(-3)	1.16(-1)
7.62	7.14(-3)	1.29(-1)
7.62	7.09(-3)	--
6.35	1.11(-2)	1.95(-1)
5.08	1.45(-2)	2.77(-1)
5.08	1.48(-2)	--
3.81	1.57(-2)	3.35(-1)
2.54	1.67(-2)	3.55(-1)
2.54	1.65(-2)	--
1.27	--	3.72(-1)
0	1.73(-2)	3.65(-1)
0	1.69(-2)	3.73(-1)
1.27N	--	3.73(-1)
2.54	1.64(-2)	3.55(-1)
3.81	1.57(-2)	3.27(-1)
5.08	1.43(-2)	2.78(-1)
6.35	9.65(-3)	1.62(-1)
7.62	6.70(-3)	1.26(-1)
7.98	6.05(-3)	--
8.89	5.94(-3)	1.11(-1)
9.53	7.54(-3)	--
9.53	7.59(-3)	--
9.84	7.54(-3)	--
10.2	7.26(-3)	1.10(-1)
10.2	7.35(-3)	--
10.8	5.72(-3)	--
10.8	5.61(-3)	--
11.4	5.23(-3)	1.14(-1)
11.4	5.31(-3)	--
12.1	5.45(-3)	--
12.1	5.43(-3)	--
12.7	5.67(-3)	1.39(-1)
12.7	5.75(-3)	--
14.0	8.71(-3)	2.07(-1)
15.2	1.05(-2)	2.78(-1)
16.5	1.08(-2)	3.17(-1)
17.8	1.18(-2)	3.27(-1)
20.3	1.23(-2)	3.38(-1)
22.9	1.23(-2)	3.33(-1)
24.1	1.23(-2)	3.25(-1)
25.4	1.17(-2)	2.58(-1)
26.7	7.63(-3)	2.05(-1)
27.9	4.89(-3)	1.48(-1)
28.6	4.25(-3)	--
29.2	3.66(-3)	--
29.8	3.78(-3)	--
30.5	2.90(-3)	1.42(-1)
31.8	2.30(-3)	--
33.0	1.91(-3)	1.40(-1)
35.6	--	1.39(-1)
38.1	9.92(-4)	1.30(-1)
45.7	4.67(-4)	7.68(-2)
61.0	1.11(-4)	1.80(-2)
76.2	--	7.10(-3)
91.4	--	4.37(-3)

*Read: 7.37×10^{-3}

Table 42. Measurements on centerline behind grid plate shield *(Item V-B)*

Distance from centerline (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)		Bonner ball count rate (counts/s/W)			
			Cd covered		5-in.-diam	
	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground
30.5	6.95(-3)*	--	2.05(-1)	--	2.75(1)	--
305	1.22(-4)	9.28(-6)	4.10(-2)	2.67(-3)	3.22(0)	1.09(-1)

*Read: 6.95×10^{-3}

Table 43. Radial traverse at 2.22 cm behind 889 fuel pins *(Item VI-A)*

Distance from centerline (cm)	0.635-cm-diam Hornyak button dose rate (erg/g/h/W)
45.7S	1.04(-2)*
38.1	1.90(-2)
33.0	3.23(-2)
32.4	3.51(-2)
31.8	3.80(-2)
31.1	4.10(-2)
30.5	4.58(-2)
29.8	4.97(-2)
29.2	5.03(-2)
28.6	4.95(-2)
27.9	4.87(-2)
27.3	4.97(-2)
26.7	5.08(-2)
25.4	5.33(-2)
22.9	5.72(-2)
20.3	6.13(-2)
17.8	6.28(-2)
15.2	6.42(-2)
12.7	6.62(-2)
12.1	6.64(-2)
11.4	6.71(-2)
10.8	6.77(-2)
10.2	6.80(-2)
9.53	6.84(-2)
8.89	6.91(-2)
7.98	6.81(-2)
7.62	6.84(-2)
6.99	6.83(-2)
6.35	6.90(-2)
5.08	7.03(-2)
2.54	7.03(-2)
0	7.03(-2)
2.54N	6.94(-2)
5.08	6.93(-2)
6.35	7.03(-2)
6.99	6.91(-2)
7.62	6.91(-2)
7.98	6.84(-2)
8.89	6.95(-2)
9.53	6.95(-2)
10.2	6.84(-2)
10.8	6.71(-2)
11.4	6.74(-2)
12.1	6.71(-2)
15.2	6.71(-2)
17.8	6.52(-2)
20.3	6.25(-2)
22.9	5.79(-2)
25.4	5.41(-2)
26.0	5.36(-2)
26.7	5.16(-2)
27.3	5.11(-2)
27.9	5.28(-2)
28.6	5.33(-2)
29.2	5.34(-2)
29.8	5.30(-2)
30.5	4.62(-2)
31.8	3.87(-2)
33.0	3.23(-2)
38.1	1.93(-2)
45.7	1.02(-2)

*Read: 1.04×10^{-2}

Table 44. Measurements on centerline behind 889 fuel pins (0.318-cm space between subassemblies) *(Item VI-A)*

Distance from fuel pins (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)		Bonner ball count rate (counts/s/W)			
			Cd-covered		5-in.-diam	
	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground
30.5	2.34(-2)*	--	1.45(0)	--	1.31(2)	--
305	1.41(-3)	6.33(-5)	8.13(-2)	2.12(-2)	5.82(0)	7.25(-1)

*Read: 2.34×10^{-2}

Table 45. Radial traverse directly behind 889 fuel pins plus grid plate shield *(Item VI-B)*

Distance from centerline (cm)	0.635-cm-diam Hornyak button dose rate at 2.23 cm (erg/g/h/W)	Cd-covered Bonner ball count rate at 3.50 cm (counts/s/W)	Distance from centerline (cm)	0.635-cm-diam Hornyak button dose rate at 2.23 cm (erg/g/h/W)	Cd-covered Bonner ball count rate at 3.50 cm (counts/s/W)
45.7S	--	4.50(-2)*	10.5	2.82(-3)	--
38.1	6.35(-4)	7.77(-2)	10.2	2.84(-3)	5.02(-2)
35.6	8.42(-4)	8.65(-2)	10.2	2.87(-3)	5.22(-2)
33.0	1.17(-3)	8.72(-2)	10.0	2.84(-3)	--
31.8	1.46(-3)	1.02(-1)	9.84	2.99(-3)	--
31.1	1.67(-3)	--	9.68	3.12(-3)	--
30.5	1.95(-3)	1.39(-1)	9.53	3.24(-3)	4.95(-2)
29.8	3.27(-3)	--	9.53	3.20(-3)	--
29.2	3.30(-3)	1.38(-1)	9.29	3.05(-3)	--
28.6	3.12(-3)	--	9.05	2.97(-3)	--
27.9	2.33(-3)	1.22(-1)	8.89	2.87(-3)	4.83(-2)
27.3	2.55(-3)	--	8.89	2.99(-3)	4.88(-2)
26.7	3.00(-3)	1.02(-1)	8.73	2.97(-3)	--
26.0	3.51(-3)	--	8.57	2.96(-3)	--
25.4	4.82(-3)	1.29(-1)	8.26	--	5.25(-2)
24.8	6.08(-3)	--	7.98	3.08(-3)	--
24.1	6.51(-3)	1.58(-1)	7.98	3.09(-3)	--
23.5	6.66(-3)	--	7.62	3.38(-3)	6.02(-2)
22.9	6.68(-3)	1.77(-1)	7.62	3.35(-3)	--
21.6	6.71(-3)	--	6.99	3.98(-3)	--
20.3	6.89(-3)	1.82(-1)	6.35	4.85(-3)	8.25(-2)
19.1	6.80(-3)	--	5.72	5.82(-3)	--
17.8	6.84(-3)	1.78(-1)	5.08	6.44(-3)	1.08(-1)
16.5	6.44(-3)	--	4.45	6.66(-3)	--
15.2	6.30(-3)	1.70(-1)	3.81	6.75(-3)	1.22(-1)
14.6	6.23(-3)	--	3.18	6.83(-3)	--
14.0	6.00(-3)	1.47(-1)	2.54	6.87(-3)	1.25(-1)
13.3	5.51(-3)	--	1.27	7.20(-3)	--
12.7	4.40(-3)	1.05(-1)	0	7.11(-3)	1.27(-1)
12.1	3.42(-3)	--	1.27N	7.23(-3)	--
11.4	3.09(-3)	7.07(-2)	2.54	7.13(-3)	1.26(-1)
11.4	3.09(-3)	--	3.18	6.98(-3)	--
10.8	2.88(-3)	--	3.81	6.92(-3)	1.23(-1)
10.8	2.88(-3)	--	4.45	6.66(-3)	--

*Read: 4.50×10^{-2}

Table 45. (Continued)

Distance from centerline (cm)	0.635-cm-diam Hornyak button dose rate at 2.23 cm (erg/g/h/W)	Cd-covered Bonner ball count rate at 3.50 cm (counts/s/W)	Distance from centerline (cm)	0.635-cm-diam Hornyak button dose rate at 2.23 cm (erg/g/h/W)	Cd-covered Bonner ball count rate at 3.50 cm (counts/s/W)
5.08	6.62(-3)*	1.08(-1)	12.1	3.24(-3)	--
5.72	6.21(-3)	--	12.7	3.84(-3)	1.02(-1)
6.35	5.12(-3)	8.38(-2)	14.0	5.96(-3)	1.42(-1)
6.99	4.17(-3)	--	15.2	6.41(-3)	1.68(-1)
7.62	3.59(-3)	6.05(-2)	15.9	6.57(-3)	--
7.66	3.62(-3)	--	16.5	6.56(-3)	--
7.94	3.47(-3)	--	17.8	6.74(-3)	1.78(-1)
7.98	3.26(-3)	--	20.3	7.02(-3)	1.82(-1)
8.57	3.17(-3)	--	22.9	6.96(-3)	1.78(-1)
8.76	3.09(-3)	--	24.1	6.65(-3)	1.58(-1)
8.89	3.02(-3)	4.93(-2)	24.8	6.47(-3)	--
9.05	2.96(-3)	--	25.4	5.39(-3)	1.23(-1)
9.21	2.96(-3)	--	26.0	3.90(-3)	--
9.37	3.05(-3)	--	26.7	3.32(-3)	1.00(-1)
9.53	3.12(-3)	--	27.3	2.84(-3)	--
9.56	3.09(-3)	--	27.9	2.45(-3)	1.24(-1)
9.72	3.11(-3)	--	28.6	2.22(-3)	--
9.84	3.09(-3)	--	29.2	3.71(-3)	1.40(-1)
10.0	2.93(-3)	--	29.8	3.66(-3)	--
10.0	3.11(-3)	--	30.5	2.82(-3)	1.37(-1)
10.2	2.82(-3)	4.97(-2)	31.1	1.62(-3)	--
10.2	2.87(-3)	--	31.8	1.49(-3)	1.03(-1)
10.3	2.87(-3)	--	33.0	1.21(-3)	8.78(-2)
10.5	2.82(-3)	--	35.6	8.30(-4)	8.58(-2)
10.8	2.90(-3)	--	38.1	6.32(-4)	7.92(-2)
11.4	3.03(-3)	6.67(-2)	45.7	2.75(-4)	4.58(-2)
12.1	3.23(-3)	--	61.0	--	1.15(-2)

*Read: 6.62×10^{-3}

Table 46. Measurements on centerline behind 889 pins plus grid plate shield (0.318-cm spacing between subassemblies) *(Item VI-B)*

Distance from grid plate shield (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)		Bonner ball count rate (counts/s/W)					
			Bare		Cd-covered		5-in.-diam	
	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground
30.5	2.26(-3)*	--	5.62(-1)	--	7.77(-2)	--	1.43(1)	--
305	4.22(-4)	5.37(-6)	1.26(-1)	2.62(-1)	1.52(-2)	1.54(-3)	1.54(0)	6.22(-2)

*Read: 2.26×10^{-3}

Table 47. Radial traverse behind 967 Fe-rod assembly *(Items VII-B, C, D)*

Distance from centerline (cm)	Cd-covered Bonner ball			
	Count rate at 3.5 cm (counts/s/W)	Count rate at 30.5 cm (counts/s/W)	Count rate at 305 cm (counts/s/W)	
	Foreground	Foreground	Foreground	Background
152.4S	--	--	2.43(-2)*	--
121.9	--	--	2.73(-2)	--
91.4	--	--	3.07(-2)	1.10(-2)
76.2	--	--	3.22(-2)	--
66.0	1.82(-1)	--	--	--
61.0	--	--	3.52(-2)	--
58.4	2.83(-1)	--	--	--
50.8	4.68(-1)	--	--	--
45.7	--	4.07(-1)	3.72(-2)	--
43.2	7.70(-1)	--	--	--
38.1	--	4.82(-1)	4.10(-2)	--
35.6	1.11(0)	--	--	--
33.0	1.21(0)	5.47(-1)	4.52(-2)	--
30.5	1.28(0)	6.05(-1)	4.82(-2)	--
29.2	1.26(0)	6.32(-1)	--	--
27.9	1.19(0)	6.28(-1)	4.97(-2)	--
26.7	--	6.17(-1)	--	--
25.4	1.15(0)	6.23(-1)	5.07(-2)	--
21.6	--	--	5.15(-2)	--
18.4	--	--	5.08(-2)	--
17.8	1.11(0)	6.70(-1)	--	--
15.2	--	--	4.87(-2)	--
10.2	1.07(0)	6.87(-1)	4.98(-2)	--
5.1	1.07(0)	--	4.98(-2)	--
0	1.06(0)	7.02(-1)	5.05(-2)	1.22(-2)
5.1N	1.07(0)	--	4.98(-2)	--
10.2	1.06(0)	6.75(-1)	4.93(-2)	--
15.2	--	--	4.88(-2)	--
17.8	1.08(0)	6.63(-1)	5.08(-2)	--
20.3	--	--	5.07(-2)	--
22.9	--	--	4.98(-2)	--
25.4	1.12(0)	6.26(-1)	4.88(-2)	--
26.7	--	6.23(-1)	--	--
27.9	1.19(0)	6.23(-1)	4.80(-2)	--
29.2	1.26(0)	6.07(-1)	--	--
30.5	1.22(0)	5.93(-1)	4.57(-2)	--
33.0	1.12(0)	5.33(-1)	4.28(-2)	--
35.6	1.05(0)	--	--	--
38.1	--	4.85(-1)	4.08(-2)	--
43.2	6.43(-1)	--	--	--
45.7	--	4.00(-1)	3.70(-2)	--
50.8	3.83(-1)	--	--	--
58.4	2.37(-1)	--	--	--
61.0	--	2.57(-1)	3.50(-2)	--
66.0	1.52(-1)	--	--	--
76.2	--	--	3.25(-2)	--
91.4	--	--	3.10(-2)	1.15(-2)
121.9	--	--	2.75(-2)	--
152.4	--	--	2.48(-2)	--

*Read: 2.43×10^{-2}

Table 48. Radial traverse behind Fe-rod assembly *(Items VII-B, C, D)*

Distance from centerline (cm)	1.27-cm Hornyak button			
	Dose rate at 3.1 cm (erg/g/h/W)	Dose rate at 30.5 cm (erg/g/h/W)	Dose rate at 305 cm (erg/g/h/W)	
	Foreground	Foreground	Foreground	Background
152.4S	--	--	1.40(-4)*	--
121.9	--	--	2.10(-4)	--
91.4	--	--	2.74(-4)	--
76.2	--	--	2.85(-4)	--
61.0	--	--	2.97(-4)	--
45.7	3.44(-3)	2.54(-3)	3.01(-4)	--
38.1	3.91(-3)	3.08(-3)	3.54(-4)	--
33.0	4.66(-3)	3.42(-3)	3.65(-4)	--
30.5	5.80(-3)	4.05(-3)	4.45(-4)	--
29.8	6.62(-3)	4.46(-3)	--	--
29.2	7.20(-3)	4.29(-3)	4.53(-4)	--
28.6	6.52(-3)	4.12(-3)	--	--
27.9	6.38(-3)	3.98(-3)	--	--
27.3	--	--	4.56(-4)	--
25.4	6.93(-3)	4.29(-3)	4.67(-4)	--
20.3	7.51(-3)	4.87(-3)	--	--
17.8	--	--	4.67(-4)	--
15.2	7.99(-3)	4.77(-3)	--	--
10.2	8.47(-3)	4.94(-3)	4.86(-4)	--
5.1	8.54(-3)	5.18(-3)	--	--
0	8.44(-3)	5.21(-3)	5.12(-4)	--
5.1N	8.31(-3)	5.15(-3)	--	--
10.2	8.13(-3)	4.77(-3)	4.82(-4)	--
15.2	7.51(-3)	4.77(-3)	--	--
17.8	--	--	4.56(-4)	--
20.3	6.93(-3)	4.63(-3)	--	--
25.4	6.17(-3)	4.25(-3)	4.60(-4)	--
26.7	--	--	4.56(-4)	--
27.9	6.11(-3)	3.94(-3)	--	--
28.6	--	3.84(-3)	--	--
29.2	5.80(-3)	3.98(-3)	4.27(-4)	--
29.8	6.38(-3)	4.25(-3)	--	--
30.5	6.79(-3)	4.05(-3)	4.16(-4)	--
31.1	5.83(-3)	--	--	--
33.0	4.63(-3)	3.29(-3)	3.60(-4)	--
38.1	3.64(-3)	2.93(-3)	3.44(-4)	--
45.7	3.11(-3)	2.43(-3)	3.03(-4)	--
61.0	--	1.73(-3)	2.93(-4)	--
76.2	--	--	2.82(-4)	--
91.4	--	--	2.03(-4)	--
152.4	--	--	1.59(-4)	2.12(-5)

*Read: 1.40×10^{-4}

Table 49. Radial traverse behind 967 Fe-rod assembly *(Items VII-C, D)*

Distance from centerline (cm)	5-in.-diam Bonner ball: Count rate at 30.5 cm, Foreground	5-in.-diam Bonner ball: Count rate at 305 cm, Foreground	5-in.-diam Bonner ball: Count rate at 305 cm, Background	Distance from centerline (cm)	5-in.-diam Bonner ball: Count rate at 30.5 cm, Foreground	5-in.-diam Bonner ball: Count rate at 305 cm, Foreground	5-in.-diam Bonner ball: Count rate at 305 cm, Background
152.4S	--	1.47(0)*	--	10.2N	6.10(1)	--	--
121.9	--	1.77(0)	--	15.2	--	2.93(0)	--
91.4	--	2.08(0)	3.23(-1)	20.3	5.40(1)	--	--
76.2	--	2.23(0)	--	27.9	4.62(1)	--	--
61.0	1.26(1)	2.28(0)	--	30.5	4.30(1)	2.73(0)	--
45.7	2.42(1)	2.48(0)	--	35.6	3.62(1)	--	--
38.1	--	2.65(0)	--	38.1	--	2.62(0)	--
35.6	3.58(1)	--	--	45.7	2.42(1)	2.40(0)	--
30.5	4.32(1)	2.78(0)	--	61.0	1.27(1)	2.32(0)	--
27.9	4.97(1)	--	--	76.2	--	2.20(0)	--
20.3	5.38(1)	--	--	91.4	--	2.03(0)	3.42(-1)
15.2	--	2.92(0)	--	121.9	--	1.75(0)	--
10.2	6.12(1)	--	--	152.4	--	1.47(0)	--
0	6.43(1)	2.98(0)	3.52(-1)				
0	--	2.93(0)	--				

*Read: 1.47×10^{0}

Table 50. Axial traverse behind 967 Fe-rod assembly *(Item VII-A)*

Distance from Fe rods (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W): Foreground	Bonner ball count rate (counts/s/W): Cd-covered, Foreground	Cd-covered, Background	5-in.-diam, Foreground	5-in.-diam, Background
3.3	7.44(-3)*	--	--	--	--
7.6	6.91(-3)	9.77(-1)	--	1.34(2)	--
15.2	6.24(-3)	8.72(-1)	--	1.01(2)	--
22.9	5.58(-3)	7.75(-1)	--	8.00(1)	--
30.5	4.95(-3)	6.78(-1)	--	6.38(1)	--
38.1	4.48(-3)	5.85(-1)	--	5.20(1)	--
45.7	3.95(-3)	5.03(-1)	--	4.40(1)	--
61.0	3.24(-3)	3.80(-1)	--	3.15(1)	--
91.4	2.10(-3)	2.42(-1)	--	1.77(1)	--
121.9	1.48(-3)	1.65(-1)	--	1.15(1)	--
152.4	1.10(-3)	1.24(-1)	1.55(-2)	8.18(0)	4.45(-1)

*Read: 7.44×10^{-3}

Table 51. Axial traverse directly behind Fe-plate assembly
(Run VIII-A)

Distance from Fe plates (cm)	1.27-cm-diam Hornyak button dose rate (erg/g/h/W)		Bonner ball count rate (counts/s/W)			
			Cd-covered		5-in.-diam	
	Fore-ground	Back-ground	Fore-ground	Back-ground	Fore-ground	Back-ground
3.3	7.25(-3)*	--	--	--	--	--
7.6	--	--	8.28(-1)	--	1.32(2)	--
10.9	6.34(-3)	--	--	--	--	--
15.2	--	--	7.55(-1)	--	9.95(1)	--
18.6	5.49(-3)	--	--	--	--	--
21.3	--	--	--	--	8.18(1)	--
22.9	--	--	6.62(-1)	--	7.82(1)	--
26.2	4.68(-3)	--	--	--	--	--
30.5	--	--	5.75(-1)	--	6.25(1)	--
33.8	4.03(-3)	--	--	--	--	--
38.1	--	--	4.98(-1)	--	5.00(1)	--
41.4	3.58(-3)	--	--	--	--	--
45.7	--	--	4.27(-1)	--	4.08(1)	--
49.0	3.07(-3)	--	--	--	--	--
61.0	2.53(-3)	--	3.18(-1)	--	2.92(1)	--
91.4	1.57(-3)	--	1.93(-1)	--	1.62(1)	--
121.9	1.07(-3)	--	1.26(-1)	--	1.00(1)	--
152.4	7.77(-4)	2.98(-5)	8.97(-2)	1.57(-2)	7.08(0)	5.32(-1)

*Read: 7.25×10^{-3}

Table 52. Radial traverse behind Fe-plate assembly *(Items VIII-B, C, D)*

Distance from centerline (cm)	Cd-covered Bonner ball			
	Count rate at 3.35 cm (counts/s/W)	Count rate at 30.5 cm (counts/s/W)	Count rate at 305 cm (counts/s/W)	
	Foreground	Foreground	Foreground	Background
152.4S	--	--	2.10(-2)*	--
121.9	--	--	2.33(-2)	--
91.4	4.18(-2)	9.28(-2)	2.48(-2)	8.40(-3)
76.2	8.80(-2)	1.53(-1)	--	--
61.0	2.08(-1)	2.47(-1)	2.78(-2)	--
45.7	5.55(-1)	3.73(-1)	2.82(-2)	--
38.1	8.80(-1)	4.43(-1)	3.08(-2)	--
33.0	1.02(0)	--	3.18(-2)	--
30.5	1.09(0)	5.20(-1)	3.22(-2)	--
29.2	1.05(0)	--	--	--
27.9	1.02(0)	--	2.95(-2)	--
25.4	9.45(-1)	--	2.93(-2)	--
22.9	--	5.3[illegible])	--	--
20.3	9.37(-1)	--	--	--
17.8	--	--	3.00(-2)	--
15.2	9.25(-1)	5.63(-1)	--	--
10.2	--	--	2.93(-2)	--
7.6	9.00(-1)	5.80(-1)	--	--
0	8.88(-1)	5.82(-1)	2.97(-2)	8.57(-3)
7.6N	8.90(-1)	5.73(-1)	--	--
10.2	--	--	2.93(-2)	--
15.2	8.95(-1)	5.53(-1)	--	--
17.8	--	--	2.98(-2)	--
20.3	9.12(-1)	--	--	--
22.9	--	5.38(-1)	--	--
25.4	9.33(-1)	--	2.98(-2)	--
27.9	9.32(-1)	--	3.00(-2)	--
29.2	9.82(-1)	--	--	--
30.5	1.02(0)	4.98(-1)	3.03(-2)	--
33.0	1.03(0)	--	3.08(-2)	--
35.6	1.01(0)	--	--	--
38.1	9.30(-1)	4.37(-1)	3.00(-2)	--
45.7	5.93(-1)	3.65(-1)	2.92(-2)	--
61.0	2.18(-1)	2.35(-1)	2.88(-2)	--
76.2	9.07(-2)	1.46(-1)	--	--
91.4	4.42(-2)	9.00(-2)	2.63(-2)	8.40(-3)
121.9	--	--	2.38(-2)	--
152.4	--	--	2.15(-2)	--

*Read: 2.10×10^{-2}

Table 53. Radial traverse behind Fe-plate assembly *(Items VIII-B, C, D)*

Distance from centerline (cm)	1.27 cm Hornyak button			
	Dose rate at 3.1 cm (erg/g/h/W)	Dose rate at 30.5 cm (erg/g/h/W)	Dose rate at 305 cm (erg/g/h/W)	
	Foreground	Foreground	Foreground	Background
15..4S	--	--	1.52(-4)*	1.57(-5)
121.9	--	--	1.89(-4)	--
91.4	2.56(-4)	5.72(-4)	2.39(-4)	--
91.4	--	--	2.49(-4)	--
76.2	8.03(-4)	1.00(-3)	--	--
61.0	2.22(-3)	1.76(-3)	2.42(-4)	--
61.0	--	--	2.51(-4)	--
45.7	3.45(-3)	2.40(-3)	2.46(-4)	--
45.7	--	--	2.59(-4)	--
38.1	3.78(-3)	2.84(-3)	2.84(-4)	--
38.1	--	--	2.91(-4)	--
38.1	--	--	2.98(-4)	--
33.0	4.46(-3)	3.12(-3)	2.60(-4)	--
33.0	--	--	2.63(-4)	--
30.5	5.04(-3)	3.33(-3)	2.95(-4)	--
30.5	--	--	3.07(-4)	--
29.2	5.80(-3)	3.52(-3)	2.66(-4)	--
27.9	5.33(-3)	3.37(-3)	2.61(-4)	--
26.7	5.51(-3)	3.40(-3)	2.55(-4)	--
25.4	5.69(-3)	3.53(-3)	2.55(-4)	--
22.9	6.26(-3)	3.67(-3)	2.60(-4)	--
15.2	7.20(-3)	4.00(-3)	2.52(-4)	--
7.6	7.60(-3)	4.25(-3)	2.57(-4)	--
0	7.49(-3)	4.28(-3)	2.61(-4)	1.85(-5)
7.6N	7.42(-3)	4.18(-3)	2.50(-4)	--
15.2	7.02(-3)	3.89(-3)	2.54(-4)	--
22.9	5.94(-3)	3.57(-3)	2.56(-4)	--
25.4	5.54(-3)	3.40(-3)	2.54(-4)	--
26.7	5.26(-3)	3.37(-3)	2.59(-4)	--
27.9	5.04(-3)	3.28(-3)	2.54(-4)	--
29.2	4.90(-3)	3.23(-3)	2.69(-4)	--
30.5	4.86(-3)	3.26(-3)	2.55(-4)	--
33.0	4.25(-3)	2.96(-3)	2.50(-4)	--
38.1	3.34(-3)	2.74(-3)	2.57(-4)	--
45.7	2.98(-3)	2.34(-3)	2.53(-4)	--
61.0	2.13(-3)	1.63(-3)	2.46(-4)	--
76.2	7.45(-4)	9.36(-4)	--	--
91.4	2.51(-4)	5.36(-4)	2.36(-4)	--
121.9	--	--	1.86(-4)	--
152.4	--	--	1.46(-4)	--

*Read: 1.52×10^{-4}

Table 54. Radial traverse behind Fe-plate assembly *(Items VIII-C, D)*

Distance from centerline (cm)	5-in.-diam Bonner ball count rate at 30.5 cm (counts/s/W)	5-in.-diam Bonner ball count rate at 305 cm (counts/s/W)	
	Foreground	Foreground	Background
152.4S	--	1.36(0)*	--
121.9	--	1.62(0)	--
91.4	4.12(0)	1.83(0)	2.85(-1)
76.2	7.05(0)	--	--
61.0	1.27(1)	2.03(0)	--
45.7	2.47(1)	2.12(0)	--
38.1	3.37(1)	2.17(0)	--
33.0	--	2.18(0)	--
30.5	4.37(1)	--	--
27.9	--	2.18(0)	--
22.9	5.22(1)	2.18(0)	--
15.2	5.88(1)	2.20(0)	--
7.6	6.37(1)	2.17(0)	--
0	6.50(1)	2.18(0)	3.10(-1)
7.6N	6.32(1)	2.22(0)	--
15.2	5.85(1)	2.18(0)	--
22.9	5.15(1)	2.18(0)	--
27.9	--	2.20(0)	--
30.5	4.30(1)	--	--
33.0	--	2.18(0)	--
38.1	3.30(1)	2.13(0)	--
45.7	2.42(1)	2.13(0)	--
61.0	1.24(1)	2.07(0)	--
76.2	6.73(0)	--	--
91.4	4.00(0)	1.88(0)	3.00(1)
121.9	--	1.61(0)	--
152.4	--	1.39(0)	--

*Read: 1.36×10^{0}

REFERENCES

1. R. E. Maerker et al., *Calibration of the Bonner Ball Neutron Detectors Used at the Tower Shielding Facility*, ORNL/TM-3465 (June 30, 1971).

2. C. E. Burgart and M. B. Emmett, *Monte Carlo Calculations of the Response Functions of Bonner Ball Neutron Detectors*, ORNL/TM-3739 (April 3, 1972).

3. D. T. Ingersoll et al., "Grid Plate Shield Design Confirmation Experiment," *Gas-Cooled Fast Reactor Program Annu. Prog. Rep. December 31, 1977*, ORNL-5426, pp. 109-110.

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