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Measurements for the JASPER Program Gap Streaming Experiment

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MASTER

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ABSTRACT

The Gap Streaming Experiment was conducted at the Oak Ridge National Laboratory (ORNL) Tower Shielding Facility (TSF) during the three month period from February to April, 1992, as part of the continuing series of eight experiments planned for the Japanese-American Shielding Program for Experimental Research (JASPER) program that was started in 1986. This series of experiments which are intended to provide support in the development of current reactor shield designs proposed for Liquid Metal Reactor (LMR) systems both in Japan and the United States. The program is a cooperative effort between the United States Department of Energy (U.S. DOE) and the Japanese Power Reactor and Nuclear Development Corporation (PNC).

The program was designed to study neutron streaming in annular gaps typical of those anticipated in future reactor enclosure systems for advanced LMRs. The two configurations studied in this experiment were: (1) an iron-lined, concrete-filled, vessel that was designed to allow changes in annular gap widths and/or their locations; or (2) a solid piece of concrete. In two of the studies, Items IIID and IIIE, stainless steel slabs were added to simulate the effect of a cover plate above the reactor head. The configurations were preceded by either a spectrum modifier that modeled the sodium pool above the LMR core or the bare Tower Shielding Reactor II (TSR-II) beam. Bonner ball measurements were made behind each configuration and neutron spectra and Hornyak button measurements were made behind selected configurations.

1. INTRODUCTION

This experiment is the sixth of eight experiments to be performed at the TSF that were jointly planned by ORNL, participant for the U.S. DOE, and the PNC. This phase of the program, called the Gap Streaming Experiment, was preceded by the Radial Shield Attenuation (ORNL/TM-10371) and Fission Gas Plenum Experiments (ORNL/TM-10422) completed in 1986-87, the Axial Shield Experiment (ORNL/TM-11839) completed in 1990, the In-Vessel Fuel Storage (IVFS) Experiment (ORNL/TM-11989) completed in 1991, and the Intermediate Heat Exchanger (IHX) Activation Experiment (ORNL/TM-12064) completed in early 1992.

The Gap Streaming Experiment was designed to investigate the magnitude of neutron streaming as a function of gap width and/or gap offset. These studies are important since the neutron flux, hence dose rate, above the reactor vessel usually results from neutron streaming in voids created in enclosure systems. The results are intended to provide a data base against which analytical methods developed for predicting neutron streaming in future reactor vessel designs may be tested, with an expected reduction in accompanying uncertainties.

Two iron-lined vessels containing concrete were fabricated for these studies. One vessel contained a central cylinder of concrete surrounded by an annular void followed by additional concrete. Cylindrical sleeves were inserted into the gap to vary the width of the void as well as change a straight slit into two slits with a single offset. The second vessel contained concrete without any gaps. Measurements were made behind each of these vessels when preceded by a spectrum modifier of iron, aluminum, boral and sodium, or by the bare beam without modifier. The mockups studied and the measurements made are described in the program plan in Appendix A.

2. INSTRUMENTATION

The Bonner ball detector system used at the TSF consists of a series of different-sized polyethylene balls, each of which measures an integral of the neutron flux weighted by the energy-dependent response function for that ball. The detection device inside the ball consisted of a 5.1-cm-diam spherical proportional counter filled with BF_3 gas ($^{10}B/B$ concentration = 0.96) to a pressure of 0.5 atmospheres. In order to cover a range of neutron energies from thermal to several MeV, the counter may be used bare, covered with cadmium (Cd), or enclosed in various thicknesses of polyethylene shells surrounded by cadmium, each detector being identified by the diameter of the polyethylene sphere. Data from the Bonner ball measurements are predicted analytically by folding a calculated neutron spectrum with the Bonner ball response functions determined by Maerker et al.[1] and C. E. Burgart et al.[2]

An NE 213 liquid scintillator spectrometer system measured the neutron spectrum from about 800 keV to 15 MeV. This system makes use of pulse-shape discrimination to distinguish neutron pulses from gamma-ray pulses. The resulting neutron pulse-height data obtained with the spectrometer were unfolded with the FERD code[3] to yield absolute neutron energy spectra.

Spherical proton-recoil counters, filled with hydrogen to pressures of 1, 3, and 10 atmospheres, covered the neutron energy range from about 50 keV to 1 MeV. Pulse-height data from the counters were unfolded with the SPEC-4 code,[4] which makes use of the unfolded NE 213 spectrum to correct for the contribution from higher-energy neutrons.

The Hornyak button detector consisted of a 0.635-cm-diam, 0.159-cm-thick button of lucite interspersed with zinc sulfide mounted on a photomultiplier tube. The calibration procedure was based on first exposing the scintillator to a 2 R/h gamma-ray dose rate and adjusting the amplifier gain so that a prescribed count rate was obtained at a pulse height setting (PHS) of 0.06 volts. This procedure kept the gain of the system constant on a daily basis. The button was then exposed to a known strength of ^{252}Cf neutron source and a dose rate/count rate ratio obtained. However, for this particular experiment, it was necessary to obtain this neutron dose rate ratio at a higher PHS, namely 3.5 volts, to guard against a gamma ray contribution to the count rate when run in gamma ray fields greater than 2 R/h. Thus, even though the detector response no longer corresponds to that of a dosimeter, it was elected to continue expressing the measurements in terms of a dose rate. At that PHS, even though the lower limit of the neutron energy response for the button is not known, it did not detract from its usage to define the neutron streaming effect where small gaps existed in the mockup structure.

The measurements for each detector were referenced to the reactor power (watts) using the data from two fission chambers positioned along the reactor centerline as a basis. The response of these chambers as a function of reactor power level was established previously through several calorimetric measurements of the heat generated in the reactor during a temperature equilibrium condition (heat power run).

3. EXPERIMENTAL CONFIGURATION

The experimental program plan was divided essentially into two parts, listing the mockups and measurements requested when the vessels were preceded by either a bare TSR-II reactor beam or one modified by the presence of iron, aluminum, boral, and sodium. The gap widths and the offset locations studied were considered typical of the range of voids anticipated in a reactor enclosure system for advanced LMRs. The sleeves that were inserted to provide the different gap widths were made of iron or concrete enclosed in iron.

It should be noted that the thicknesses of the material mentioned in the program plan are nominal, the actual thicknesses for each of the slabs are given in the left corner of the slabs as displayed in the figures in Appendix C. These thicknesses refer to dimensions as measured along the beam centerline, that is, at the center of the slab, and for the sodium tanks and the concrete vessels these values include the thickness of the vessel faces. Distance from the reactor centerline to the detector side of each slab in the mockup as indicated in the schematics was measured along the centerline of the collimated reactor beam.

3.1 SPECTRUM MODIFIER

A preanalysis calculation indicated that nominally 10 cm of iron, 10 cm of aluminum, 2.5 cm of boral followed by six slabs of nominally 30.48-cm-thick sodium would provide the desired neutron spectrum expected in the area of the reactor top head. The sodium was contained in type 6061 aluminum cans whose faces were 0.635 cm thick and 155 cm on edge as seen in Figure 1. It should be mentioned that these slabs had been used in earlier experiments at the TSF and down through the years the slabs have developed a slight bulge in the middle attributed to some settling of the sodium. The amount of the bulge can be noted in the difference between the centerline thickness noted in the left portion of each slab in the schematics and the thickness of 31.75 cm (30.48 cm sodium plus 1.27 cm aluminum) measured along the edge of the slabs. In the JASPER experiments prior to this one, the slabs in the spectrum modifiers (SM) were usually surrounded by 10.16 or 20.3 cm of lithiated paraffin bricks. Since the two vessels that followed the SM in this experiment were filled with concrete, it was decided to place concrete around all four edges of both the SM and the concrete vessels to reduce background as pictured for one side in Figure 2. Compositions of the iron, aluminum, boral, and sodium are given in Tables 1, 2, 3, and 4 respectively. The composition of the 61- x 61-cm concrete blocks placed outside the slab mockup is given in Table 5. (Note: All tables are included in Appendix B.)

3.2 SOLID CONCRETE ASSEMBLY

The solid concrete assembly was an iron-lined concrete-filled slab having the same concrete mixture that was used to fill a second vessel capable of receiving annular rings to form annular slits. The slab without gaps was studied to provide reference data for the neutron penetration studies in the slit mockup. A schematic of the vessel is shown in Figure 3. The thicknesses of the front, back, and side iron plates forming the box averaged 1.24 cm. When the vessel was inserted into the mockup, as shown in Figure 4, it was necessary to place a 2.51-cm-thick iron plate preceding the concrete box to simulate the iron thickness that was included as part of the vessel with the cylindrical gaps. The composition of the concrete in both vessels is given in Table 6, that of the iron liners is the same as in Table 1. The water content of the concrete in these vessels was found to be 8.0 ± 0.5 wt percent[5] in an experiment conducted at the TSF.

3.3 SLIT CONCRETE ASSEMBLY

The Gap Streaming Experiment was designed to measure neutron streaming in narrow annular gaps that simulated voids which are typical in reactor enclosure designs. For this study, an iron-lined vessel was fabricated that contained a solid concrete central cylinder enclosed in iron surrounded by iron and/or concrete-filled, iron-lined cylinders placed to provide specific gap thicknesses as demonstrated in Figure 5. The box was designed so that an upper quarter of it could be removed to allow insertion and removal of the annular sleeves if other methods were unsuccessful. Both parts of the box were filled with the same concrete mixture as described for the solid concrete vessel in section 3.2. The central cylinder was supported by attaching it to a 2.34-cm-thick iron plate that acted as one face of the box, see Figure 5. The iron at the end of the central cylinder attached to this iron plate was 4.88 cm thick to give added strength for securing the cylinder. At the other end the iron thickness was only 1.27 cm.

The outer cylindrical surface of the central cylinder and the surfaces of the cylindrical inserts were machined to close tolerances to avert neutron streaming paths between the surfaces when inserted. The resulting iron thickness around the concrete in the central cylinder and the iron linings forming the concrete in two of the six sleeves, X1 and X6, could not be measured as the outer surfaces were machined after they were sealed but it had to be less than 1.27 cm, the original thickness of the iron before machining. The remaining cylinders were solid iron. The dimensions of all the cylinders are included in Figure 6. The composition of the concrete in the cylinder and in the sleeves was the same as that in the vessels (see Table 6).

3.4 STAINLESS STEEL SLABS

Stainless steel slabs, type 304, were used in two of the configurations to mockup the top head portion of the reactor enclosure. The slabs were 5.28 and 5.27 cm thick and 152.4 cm on an edge. Their elemental composition can be found in Table 7.

3.5 SODIUM SLABS

The sodium slabs used in this experiment as part of the spectrum modifier were obtained from Atomic International during the 1960s and have been used in earlier TSF experiments as well as in previous JASPER experiments. A description of the slabs was given previously in section 3.1.

3.6 ALUMINUM SLABS

Aluminum slabs were used as part of the spectrum modifier as mentioned earlier. These slabs are of the same aluminum (type 6061) as mentioned earlier for the sodium tank enclosures, and their composition, as noted earlier, is given in Table 2.

3.7 IRON SLABS

The two iron slabs used in the spectrum modifier were 5.16 and 5.11 cm thick and 152.4 cm on an edge. The composition of the iron is given in Table 1.

3.8 BORAL SLABS

The boral thickness in the spectrum modifier was 2.5 cm with a width of 152.4 cm on an edge. The composition of the boral is given in Table 3.

3.9 LEAD SLABS

Two lead slabs, each 3.81 cm thick, were used to attenuate the gamma-ray flux during the spectral measurements. The composition of the lead slabs is given in Table 8.

3.10 BACKGROUND SHIELDS

The procedure in the previous JASPER experiments was to obtain background measurements along with foreground measurements when the measurements were located at sufficient distances behind the mockup and neutron contributions to that detector from areas other than the mockup itself might not be negligible. In this experiment background measurements were obtained for the detector position at 150 cm on centerline by placing a 40.6-cm-thick, 91.4-cm by 91.4-cm shadow shield of lithiated paraffin bricks between the detector and mockup. Use of a shadow shield gives a measure of the neutron flux reaching the detector from sources other than directly from the mockup slabs themselves. Because the Bonner balls vary in size and the shape of the shadow shield is fixed, this measurement contains some margin for error and this should be considered in its use. The composition of the lithiated paraffin bricks is given in Table 9.

3.11 MOCKUPS

The slabs comprising the mockups, including the two concrete-filled vessels, were supported by concrete whose thickness positioned the center of the vessels at the reactor beam centerline in the horizontal plane. As was mentioned earlier in section 3.1, the concrete vessels were surrounded with concrete, no lithiated paraffin was involved. The two sides of the mockups were covered with blocks 61 cm x 61 cm x 30.5 cm thick. Concrete slabs were also placed above the mockups to serve as a background shield. It should be noted that the concrete surrounding the mockup pieces may have protruded beyond the thickness of the mockup as indicated in the mockup schematics.

With one exception, the mockups were obtained by the insertion and/or removal of cylinders, iron or iron plus concrete, to provide the gap widths and locations called for in the program plan. The exception was the location of slabs following the vessel. A typical mockup is shown in the photograph in Figure 7.

4. MEASUREMENTS

The typical mockup in this experiment consisted of concrete in an iron-lined vessel preceded by a spectrum modifier or the bare beam from the TSR-II reactor. The vessel of concrete was either solid or contained cylindrical gaps whose thickness and location could be varied by the insertion of cylindrical sleeves. With the proper selection of these sleeves, the gap could be converted from one running the full thickness of the vessel to one with a single offset. The concrete vessel, as well as the spectrum modifier, was surrounded with concrete in the form of blocks or slabs that provided an albedo medium for neutron reflection back into the mockup and acted as a means of attenuating the background contribution at the detector location.

Results from the measurements with the Hornyak button behind the solid concrete vessel in Phase III indicated that the low neutron sensitivity of the detector would prevent adequate counting rates to make meaningful measurements. The maximum count rate obtained on centerline at full power was approximately five counts per minute. A second attempt was made to make measurements behind the 3-cm-wide void in the mockup for Item IIIC and again the count rate was not sufficient to obtain meaningful data. The results from these two attempts led to elimination of the traverses with the Hornyak button in Phase III.

Added to the program plan, however, were two new mockups described in the plan under Items IIIH and IIIHH. In Item IIIH, the gaps were completely filled with the proper sleeves to give a solid vessel of iron and concrete. This was done to provide measurements typical of the attenuation of that vessel without the gaps. In Item IIIHH, 15 cms of borated polyethylene were added to Item IIIH in an attempt to obtain a measurement of the background component that would exist in the previous Bonner ball measurements at 30 cm when gaps were present.

In this experiment, measurements were made for the Item II mockup first, followed by those indicated for Items I and III. The data, however, will be reported in the same sequence as listed in the data plan. The plan in Appendix A reflects only the measurements that were made, not what was originally planned. Throughout this report, the words configuration, item, and mockup are used interchangeably when referring to the contents of the program plan.

4.1 SPECTRUM MODIFIER (ITEM IA)

The spectrum modifier was used in the previous JASPER experiment, so the measurements behind it in this experiment were limited to 3-, 5-, and 8-inch Bonner balls on centerline at 150 cm and radial traverses with the same detectors at 30 cm. A schematic of the spectrum modifier is given in Figure 2.

Results from the measurements with the 3-, 5-, and 8-in Bonner balls on centerline at 150 cm are listed in Table 10. Radial traverse data at 30 cm behind the spectrum modifier with the 3-, 5-, and 8-in Bonner balls are given in Tables 11, 12, and 13, and plotted in Figures 8, 9, and 10.

4.2 BARE BEAM PLUS MOCKUPS (ITEMS IIA-E)

The solid concrete vessel was placed in the bare beam, preceded by 2.51 cm of iron as seen previously in Figure 4. Two lead slabs, 7.62 cm in total thickness, were added to the mockup, Item IIA, so that the gamma-ray flux would be reduced to a level acceptable for making the NE 213 spectral measurements. The spectrometer was placed on centerline at 25 cm behind the lead and the resultant high energy spectrum is listed in Table 14 and plotted in Figure 11. The low energy part of the neutron spectrum was obtained with the 1-, 3-, and 10-atmosphere hydrogen-filled detectors at the NE 213 location and these results are reported in Table 15 and plotted in Figure 12. Results from the 3-, 5-, and 10-in Bonner ball measurements at the NE 213 location are in Table 16.

Data obtained on centerline with the 3-, 5-, and 8-in Bonner balls at 150 cm are listed in Table 10. Radial traverses were made with the same Bonner balls at 30 cm and these results are given in Tables 11, 12, and 13, and plotted in Figures 8, 9, and 10. Similar traverses were made with the Hornyak button at 2 cm and 30 cm behind the mockup and these results are listed in Tables 17 and 18, with plots in Figures 13 and 14.

The solid concrete vessel and the 2.51 cm iron slab were replaced with the concrete vessel having annular slits to give Item IIB as seen in Figure 15. The combination of the sleeves X1 and X2 (see Figure 6 for their dimensions) in the mockup provided a 1.03-cm-wide straight slit as measured. This value is the average of the four measurements obtained at selected locations within the void. These locations, indicated by the hour positions on a clock, and the resulting measurements are included in the figure.

Radial traverses were made with the 3-, 5-, and 8-inch Bonner balls at 30 cm behind the mockup and these results are listed in Tables 11, 12, and 13 and plotted in Figures 8, 9, and 10. The same Bonner balls were run on centerline at 150 cm, both foreground and background, and these data are given in Table 10. Hornyak button traverses were run at 2 cm and 30 cm behind the vessel and the results are in Tables 17 and 18 and plotted in Figures 13 and 14.

One of the sleeves, X2, was removed, leaving a 3.04-cm-wide slit, as measured, for the mockup in Item IIC as shown in Figure 16. Again it was necessary to add two lead slabs, indicated in the figure, for the NE 213 measurements. This spectrum, obtained at 25 cm behind the lead, is plotted in Figure 17 and recorded in Table 19. The data from the 1-, 3-, and 10-atmosphere hydrogen-filled counter at 25 cm also are listed in Table 20 and plotted in Figure 18. The 3-, 5-, and 10-inch Bonner ball measurements at 25 cm are part of Table 16. The lead slabs were removed and the 3-, 5-, and 8-inch Bonner ball data taken at 150 cm behind the mockup are listed in Table 10. Results from the radial traverses with the same three balls at 30 cm are given in Tables 11, 12, and 13 and plotted in Figures 8, 9, and 10. The Hornyak button traverse data at 2 cm is given in Table 17 and that at 30 cm is in Table 18, with plots in Figures 13 and 14.

Sleeves X3, X4, and X5 replaced sleeve X1, giving a 2.04-cm slit, as measured, with a 4-cm offset, Item IID, indicated in Figure 19. Traverses with the 3-, 5-, and 8-inch Bonner balls were made at 30 cm behind the mockup and these results are in Tables 11, 12, and 13 and plotted in Figures 8, 9, and 10. Measurements with the same balls on centerline at 150 cm are given in Table 10. The Hornyak button radial traverse data at 2 cm and 30 cm are included in Tables 17 and 18 and plotted in Figures 13 and 14.

Sleeves X4 and X5 were replaced by sleeve X6 to give a mockup with a 2.03-cm slit, as measured, and 8-cm offset, shown in Figure 20 for Item IIE. Results from the traverses with the Bonner balls at 30 cm are listed in Tables 11, 12, and 13 and plotted in Figures 8, 9, and 10. The centerline measurements are given in Table 10. The data with the Hornyak button are given in Tables 17 and 18 and plotted in Figures 13 and 14.

4.3 SPECTRUM MODIFIER PLUS MOCKUPS (ITEMS IIIA-HH)

The spectrum modifier described in section 3.1 was placed in the mockup and followed by the solid concrete vessel to give the mockup for Item IIIA as shown in the schematic in Figure 21. Centerline measurements were made at 150 cm, with the 3-, 5-, and 8-inch Bonner balls and these results are listed in Table 21. The radial traverses with the same balls were made at 30 cm and these values are reported in Tables 22, 23, and 24 and plotted in Figures 22, 23, and 24. An attempt was made to do the radial traverses with the Hornyak button as discussed earlier in section 4.0 but the count rate at 500 kW of power was only several counts per minute and the traverse was discontinued.

The solid concrete vessel and the iron slab were replaced with the vessel containing slits to get Item IIIB as shown in Figure 25. The wide straight slit was obtained again by placing sleeves X2 and X1 in the vessel as in IIB. Centerline measurements were made behind the vessel and the results are included in Table 21. Plots of the radial traverses with the Bonner balls are given in Figures 22, 23, and 24, and the data are located in Tables 22, 23, and 24.

Sleeve X2 was removed from the mockup to give the 3.04 cm wide, as measured, straight slit for Item IIIC, a repeat of the arrangement shown previously in Figure 16 for Item IIC. Both sets of Bonner ball measurements, centerline at 150 cm and radial traverses at 30 cm, were run and these results are given in Tables 21, 22, 23, and 24, respectively, as in Item IIIB. The plots for the radial traverses are in Figures 22, 23, and 24. Another attempt was made to run the Hornyak button traverse behind the slit in the mockup, but, with the detector centered on the void, the count rate was still approximately 12 counts per minute. As mentioned earlier, these results terminated any attempt to make Hornyak button measurements behind mockups in Item III.

A 5.28-cm-thick slab of stainless steel was placed behind the slit arrangement in Item IIIC to obtain the mockup for Item IIID. Bonner ball measurements, both radially and on centerline, were repeated. The count rates obtained are listed in Tables 22, 23, and 24 for the radial measurements and in Table 21 for the centerline measurements. The radial data are plotted in Figures 22, 23, and 24.

In Item IIIE a second slab of stainless steel, 5.27 cm thick, was added to the mockup as part of the reactor top head study, making the total SS thickness equal to 10.55 cm. The measurements made for Item IIID were repeated here and the results are listed in the same tables as in Item IIID. Plots of the radial data, however, are given in Figures 26, 27, and 28.

The stainless steel slabs were removed and sleeve X1 was replaced with the combination of sleeves X3, X4, and X5 to obtain a 2.04 cm slit, as measured, with a 4-cm offset requested in the program plan for Item IIIF. This arrangement is a duplicate of that previously shown in Figure 19 for Item IID. Radial traverses with the three Bonner balls were repeated and the results grouped with previous runs in Tables 22, 23, and 24. Plots of the data can be seen in Figures 26, 27, and 28. The measurements on centerline at 150 cm with the same three detectors are included in Table 21.

Sleeves X4 and X5 were replaced with sleeve X6 to get a 2.03 cm slit, as measured, in the mockup with the 8-cm offset called for in Item IIIG. The centerline measurements behind that arrangement are included in Table 21 and the radial results are in Tables 22, 23, and 24. The plots for the radial data are in Figures 26, 27, and 28. A photograph displaying the face of the mockup and the detector-traverser arrangement for the centerline measurements was shown previously in Figure 7.

As was discussed earlier, two mockups were added to the experimental plan in Phase III. For the first of these, Item IIIH, sleeves X1, X2, and X3 were inserted into the concrete vessel to give a solid vessel without slits. Radial traverses were made with the 3-, 5-, and 8-inch Bonner balls at 30 cm behind the mockup. These results are included in Tables 22, 23, and 24, with plots in Figures 26, 27, and 28. No centerline measurements were scheduled.

The second mockup added called for the addition of 15 cm of borated polyethylene behind the previous mockup in IIIH in an attempt to measure any background contribution that would be an integral part of the foreground measurements at 30 cm behind the concrete vessel (see Figure 29). Again only radial traverses were made, with the results listed in Tables 22, 23, and 24, and plotted in Figures 26, 27, and 28. It should be noted that these count rates may include some contribution from neutrons backscattered from the polyethylene located near the back of the detector. This contribution could not be measured so the true background count rate may be actually less than what was measured.

In the plots for Item IIIE there is a sharp increase in the count rate at the last point on the north side of the traverse. This increase indicates a small void, or gap, between the vessel and the concrete blocks on the north side.

5. ANALYSIS OF EXPERIMENTAL ERRORS

The errors associated with the measurements are due to a number of uncertainties: (1) the sizes of the gaps between slabs, unavoidably introduced in mocking up the configurations, (2) the positioning of the detectors, (3) the detector count rate statistics and calibrations, (4) the reactor power determinations, and (5) the effects of the exposure of the configurations to the weather. Of these, the uncertainty due to the weather is the least understood and could not be simply estimated. The uncertainty lies in the amount of moisture collecting between the slabs and in the lithiated paraffin surrounding them. During this experiment, however, the mockups were covered with a plastic tarpaulin that would somewhat limit the amount of moisture reaching the slabs. Thus, for this experiment, the effect of the weather was assumed to be negligible.

The TSR-II power level for each measurement was determined from the output of two fission chambers located in the reactor shield along the midplane of the reactor. The response of these chambers to the reactor source was monitored prior to the experiment through the use of gold foils and this ratio, detector response to gold foil results, agreed within about 5% with a history of earlier such comparisons. These detectors were calibrated on a daily basis using a ^{252}Cf source, with the calibration values lying within about a 6% spread (± 3% of an average value). During any one detector traverse in a given day, the variation in the reactor power indicated by the monitor outputs was at most only 3%; however, during the several months the experiment was being performed, the monitors indicated a spread in any one power level of about ± 5%. Thus, the uncertainty in the reactor power determination was assumed to be ± 5%.

Count-rate statistics are expressed in a manner specific to each detector. For the NE 213 measurements, counting statistics and unfolding errors are included in the unfolding of the pulse-height spectra using the FERD code, with the resulting flux expressed in terms of lower and upper limits that represent at 68% confidence interval. Similar errors are expressed in the tabular data for the hydrogen measurements unfolded using SPEC4. Neither of the spectra, NE 213 or hydrogen counter, reflects the error in determining the reactor power since this error is not included in the unfolding program. This, as seen above, could be as much as ± 5%.

The error in the Hornyak button measurements was largely dependent on the ability to maintain a constant temperature around the detector in the presence of large swings in the ambient temperature. Comparison of the calibration factors using a ^{252}Cf source made before and after a traverse showed an average spread of about 4%. This variation, combined with error limits given for the power determinations, position locations, etc., does not project an overall error beyond that quoted for the other detectors, about ● 5%.

The Bonner ball detector was calibrated on a daily basis using ^{252}Cf as a source, with the resulting count rates, normalized to the source strength. This ratio normally falls within about ± 3% of an average value that has been obtained over a period of years. Experimental data is then obtained through the use of a traversing mechanism that moves the detector with respect to the mockup while maintaining reactor power. Physical limitations of the traversing mechanism allows movement of the Bonner ball several millimeters to either side of a straight line as it travels from point to point. For the measurements perpendicular to the configuration centerline at 30 cm behind the configurations, such variations in the detector position could correspond to changes in the count rate of about ● 2%. For the measurements on centerline beyond the 30 cm point, the error in positioning several millimeters either side of the selected location would lie within the statistics of the measurement.

Rather than calculate probable errors for each measurement in a series of measurements during a traverse we preferred, in general, to quote a value for the error in the measurements for a given experiment. Thus, assuming the estimated upper limit for all the errors noted above, the errors assigned to both the Bonner ball and Hornyak button detector measurements should lie within about ± 10%.

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APPENDIX A

EXPERIMENTAL PROGRAM PLAN FOR THE JASPER GAP STREAMING EXPERIMENT

I. Neutron Spectrum Modifier
   A. SM-2 (10 cm Fe + 9 cm Al + 2.5 cm Boral + 180 cm Na)
      1. 3-, 5-, and 8-in Bonner ball measurement on centerline at 150 cm beyond spectrum modifier (foreground and background)
      2. 3-, 5-, and 8-in Bonner ball horizontal traverses at 30 cm behind the shield mockup

II. Bare Beam + Slit Mockups
   A. Bare beam + 100 cm concrete slab
      1. 3-, 5-, and 8-in Bonner ball measurement on centerline at 150 cm beyond mockup (foreground and background)
      2. 3-, 5-, and 8-in Bonner ball horizontal traverses at 30 cm behind shield mockup
      3. NE 213 and hydrogen counter spectrum measurements on centerline as close as feasible behind shield mockup (include background if possible)
      4. 3-, 5-, and 10-in Bonner ball measurements on centerline at NE 213 location (background also where necessary)
      5. Hornyak button (1/4-in-diam) horizontal traverse as close as feasible behind shield mockup and at 30 cm
   B. Bare beam + 1 cm straight slit mockup
      1. 3-, 5-, and 8-in Bonner ball horizontal traverses at 30 cm behind shield mockup
      2. 3-, 5-, and 8-in Bonner ball measurements on centerline at 150 cm beyond mockup (foreground and background)
      3. Hornyak button traverse as close as feasible behind shield mockup and at 30 cm
   C. Bare beam + 3 cm straight slit mockup
      1. 3-, 5-, and 8-in Bonner ball measurement on centerline at 150 cm beyond mockup (foreground and background)
      2. 3-, 5-, and 8-in Bonner ball horizontal traverses at 30 cm behind shield mockup
      3. NE 213 and hydrogen counter spectrum measurements on centerline as close as feasible behind shield mockup (include background if possible)
      4. 3-, 5-, and 10-in Bonner ball measurements on centerline at NE 213 location (background also where necessary)
      5. Hornyak button (1/4-in-diam) horizontal traverse as close as feasible behind shield mockup and at 30 cm

D. Bare beam + 2 cm slit, 4 cm offset
   1. 3-, 5-, and 8-in Bonner ball horizontal traverses at 30 cm behind shield mockup
   2. 3-, 5-, and 8-in Bonner ball measurements on centerline at 150 cm beyond mockup (foreground and background)
   3. Hornyak button traverse as close as feasible behind shield mockup and at 30 cm

E. Bare beam + 2 cm slit, 8 cm offset
   1. 3-, 5-, and 8-in Bonner ball horizontal traverses at 30 cm behind shield mockup
   2. 3-, 5-, and 8-in Bonner ball measurements on centerline at 150 cm beyond mockup (foreground and background)
   3. Hornyak button traverse as close as feasible behind shield mockup and at 30 cm

III. Neutron Spectrum Modifier + Slit Mockups

A. SM-2 (10 cm Fe + 9 cm Al + 2.5 cm boral + 180 cm Na) + 100 cm solid concrete
   1. 3-, 5-, and 8-in Bonner ball horizontal traverses at 30 cm behind shield mockup
   2. 3-, 5-, and 8-in Bonner ball measurements on centerline at 150 cm beyond mockup (foreground and background)

B. SM-2 + mockup with 1 cm straight slit
   1. 3-, 5-, and 8-in Bonner ball horizontal traverses at 30 cm behind shield mockup
   2. 3-, 5-, and 8-in Bonner ball measurements on centerline at 150 cm beyond mockup (foreground and background)

C. SM-2 + mockup with 3 cm straight slit
   1. 3-, 5-, and 8-in Bonner ball horizontal traverses at 30 cm behind shield mockup
   2. 3-, 5-, and 8-in Bonner ball measurements on centerline at 150 cm beyond mockup (foreground and background)

D. SM-2 + mockup with 3 cm straight slit + 5 cm SS
   1. 3-, 5-, and 8-in Bonner ball horizontal traverses at 30 cm behind shield mockup
   2. 3-, 5-, and 8-in Bonner ball measurements on centerline at 150 cm beyond mockup (foreground and background)

E. SM-2 + mockup with 3 cm straight slit + 10 cm SS
   1. 3-, 5-, and 8-in Bonner ball horizontal traverses at 30 cm behind shield mockup
   2. 3-, 5-, and 8-in Bonner ball measurements on centerline at 150 cm beyond mockup (foreground and background)

F. SM-2 + mockup with 2 cm slit, 4 cm offset
   1. 3-, 5-, and 8-in Bonner ball horizontal traverses at 30 cm behind shield mockup
   2. 3-, 5-, and 8-in Bonner ball measurements on centerline at 150 cm beyond mockup (foreground and background)

G. SM-2 + mockup with 2 cm slit, 8 cm offset

1. 3-, 5-, and 8-in Bonner ball horizontal traverses at 30 cm behind shield mockup
2. 3-, 5-, and 8-in Bonner ball measurements on centerline at 150 cm beyond mockup (foreground and background)

H. SM-2 + mockup with all slits filled

1. 3-, 5-, and 8-in Bonner ball horizontal traverses at 30 cm behind shield mockup

HH. SM-2 + mockup with all slits filled + 15 cm borated polyethylene

1. 3-, 5-, and 8-in Bonner ball horizontal traverses at 30 cm behind shield mockup

APPENDIX B

TABLES OF DATA

Table 1. Analysis of iron slabs (ρ = 7.86 g/cc) used in spectrum modifier

Element	wt %
Fe	98.4
C	.25
Cr	.15
Cu	.03
Mn	1.0
Mo	.02
Ni	.05
Si	.25

Table 2. Analysis of aluminum slabs (ρ = 2.70 g/cc) used in spectrum modifier

Element	wt %	ppm
Al	97.5	
Cr	.22	
Cu	.23	
Fe	.47	
Mg	.86	
Mn	.01	
Si	.63	
Ti	.042	
Zn	.07	
Li		3
Ni		50
Sn		<10
V		150

Table 3. Composition of boral slabs used in spectrum modifier

Component	(B_4C - 40-43 vol % in B_4C-Al mixture) Density (g/cc)	Elemental Composition (wt %)	With Al Cladding (wt %)
B_4C	2.3		
Al	2.70	65	~75
B		27.5	~19.6
C		7.5	~5.4

Table 4. Composition of sodium slabs (ρ = 0.945 g/cc)

Element	wt %
Na	99.7
Ca, Zn	0.3

Table 5. Analysis of 61-cm x 61-cm x 30.5-cm (ρ = 2.40 g/cc) concrete blocks used to surround configuration

Component	wt%	Component	wt%
CO_3	41.9	Al_2O_3	2.2
Ca	27.4	Fe_2O_3	.60
SiO_2	18.1	SO_3	.32
H_2O	4.0	P_2O_5	.035
Mg	3.66	K	.30
O_2	1.4		

Table 6. Composition of concrete in the iron-lined vessels (ρ = 2.26 g/cc)

Element	Wt%
C	8.90
Ca	30.08
Fe	1.00
Si	3.27
Mg	1.04
S	0.28
P	0.03
Na	0.04
Ti	0.07
Cr	0.03
K	0.50
Al	1.21
H	0.32
O	56.5

Table 7. Analysis of type 304 stainless steel slabs (ρ = 7.92 g/cc)

Element	2.54-cm-thick (wt %)	5.08-cm-thick (wt %)
Fe	71.2	68.1 - 69.3
Cr	18.3	18.7 - 19.1
Ni	8.8	9.6 - 9.8
Mn	1.3	1.04 - 1.65
Si	0.35	0.33 - 0.65
C	0.039	0.024 - 0.085
O_2	0.015	0.013 - 0.021
P	0.028	0.028
S	0.022	0.022
Mo	0.30	0.30
Cu	0.26	0.26
Co	0.10	0.10

Table 8. Analysis of lead slabs (ρ = 11.35 g/cc)

Element	wt%	PPM
Pb	99.9	
Al		<3
Ag		30
B		<1
Ca		1
Cr		10
Cu		800
Fe		1
Li		20
Mg		<3
Mn		5
Na		1
Ni		30
P		5
Si		<3
Sn		30

Table 9. Composition of lithiated paraffin bricks (ρ = 1.15 g/cc)

Component	wt %
C_nH_{2n+2}	60
Li_2CO_3	40

Table 10. Bonner ball measurements on centerline at 150 cm behind mockups (Items IA, IIA-E)

	Bonner ball count rates ($s^{-1}W^{-1}$)					
	3-inch-Diam Ball		5-inch-Diam Ball		8-inch-Diam Ball	
Configuration[a]	Foreground[b]	Background[c]	Foreground	Background	Foreground	Background
IA	1.05 (1)[d]	1.05 (0)	1.63 (1)	1.27 (0)	5.95 (0)	3.59 (-1)
IIA	7.46 (-2)	1.13 (-2)	2.42 (-1)	2.72 (-2)	2.47 (-1)	1.92 (-2)
IIB	1.98 (-1)	2.38 (-2)	7.14 (-1)	5.39 (-2)	5.87 (-1)	3.53 (-2)
IIC	1.72 (0)	1.61 (-1)	5.93 (0)	3.51 (-1)	5.25 (0)	2.23 (-1)
IID	4.26 (-1)	5.18 (-2)	1.61 (0)	1.13 (-1)	1.23 (0)	6.13 (-2)
IIE	1.98 (-1)	2.47 (-2)	5.97 (-1)	5.27 (-2)	4.90 (-1)	3.52 (-2)

[a]See experimental program plan in Appendix A for description of configurations.
[b]Neutron flux without shadow shield between detector and configuration.
[c]Neutron flux with shadow shield between detector and configuration.
[d]Read 1.05×10^1.

Table 11. 3-inch Bonner ball traverses through the horizontal midplane at 30 cm behind a series of configurations (Items IA, IIA-E)

Distance from Centerline (cm)	Bonner ball count rates ($s^{-1}W^{-1}$)					
	Item IA[a]	Item IIA	Item IIB	Item IIC	Item IID	Item IIE
90S		8.39 (-2)[b]				
85		1.08 (-1)				
80	2.14 (1)	1.77 (-1)				
77				1.91 (0)		
76			4.00 (-1)			
75		3.44 (-1)				
70	2.78 (1)	1.92 (-1)			8.45 (-1)	4.37 (-1)
65		2.12 (-1)		2.66 (0)		
60	3.30 (1)	2.29 (-1)	4.57 (-1)		1.16 (0)	5.79 (-1)
55				3.61 (0)		
50	3.74 (1)		5.86 (-1)		1.62 (0)	7.71 (-1)
45		2.76 (-1)		5.27 (0)	2.00 (0)	9.57 (-1)
42.5						1.14 (0)
40	4.03 (1)		7.85 (-1)	6.54 (0)	2.48 (0)	1.48 (0)
38					2.78 (0)	1.79 (0)
36					3.20 (0)	1.87 (0)
35			9.24 (-1)	1.14 (1)		
34					3.56 (0)	1.61 (0)
33				2.25 (1)		
32.5			1.09 (0)			
32					3.53 (0)	1.26 (0)
31				4.87 (1)		
30	4.26 (1)	3.22 (-1)	2.02 (0)		3.15 (0)	1.11 (0)
29			3.93 (0)	7.51 (1)		
28			5.47 (0)	7.83 (1)	2.73 (0)	1.15 (0)
27			6.24 (0)	7.42 (1)		
26			6.48 (0)	6.31 (1)	2.51 (0)	1.17 (0)
25			6.39 (0)	4.73 (1)		
24			5.48 (0)	3.22 (1)		1.13 (0)
23			3.65 (0)	1.97 (1)	2.37 (0)	
22			1.71 (0)			1.08 (0)
21			1.13 (0)	9.64 (0)		
20	4.52 (1)		1.09 (0)		2.30 (0)	1.03 (0)
19				8.86 (0)		
17.5						1.03 (0)
17				8.86 (0)		
15		3.53 (-1)	1.05 (0)		2.26 (0)	1.02 (0)
12				8.45 (0)		
10	4.62 (1)		1.07 (0)		2.24 (0)	1.02 (0)
6				8.38 (0)		
5			1.08 (0)		2.24 (0)	1.03 (0)
0	4.70 (1)	3.65 (-1)	1.05 (0)	8.28 (0)	2.23 (0)	1.02 (0)

Table 11. (continued)

Distance from Centerline (cm)	Bonner ball count rates ($s^{-1}W^{-1}$)					
	Item IA	Item IIA	Item IIB	Item IIC	Item IID	Item IIE
5			1.06 (0)		2.24 (0)	1.03 (0)
6				8.32 (0)		
10	4.66 (1)		1.11 (0)		2.25 (0)	1.02 (0)
12				8.56 (0)		
15		3.48 (-1)	1.09 (0)		2.29 (0)	1.04 (0)
17				8.60 (0)		
19				8.92 (0)		
20	4.51 (1)		1.12 (0)		2.35 (0)	1.05 (0)
21			1.16 (0)	1.03 (1)		
22			1.41 (0)			1.08 (0)
23			3.07 (0)	2.47 (1)	2.44 (0)	
24			5.62 (0)	3.98 (1)		1.14 (0)
25			7.30 (0)	5.71 (1)		
26			7.89 (0)	7.45 (1)	2.57 (0)	1.17 (0)
27			7.87 (0)	8.30 (1)		
28			7.32 (0)	8.50 (1)	2.86 (0)	1.16 (0)
29			5.86 (0)	7.76 (1)		
30	4.32 (1)	3.21 (-1)	3.31 (0)		3.41 (0)	1.15 (0)
31			1.72 (0)	4.71 (1)		
32					3.81 (0)	1.28 (0)
33			1.14 (0)	2.06 (1)	3.82 (0)	
34					3.72 (0)	1.65 (0)
35			9.77 (-1)	1.07 (1)		
36					3.28 (0)	1.97 (0)
38					2.83 (0)	1.97 (0)
40	4.05 (1)		8.00 (-1)	6.44 (0)	2.50 (0)	1.60 (0)
42.5						1.20 (0)
45		2.75 (-1)		5.22 (0)	1.96 (0)	9.95 (-1)
50	3.71 (1)		5.95 (-1)	4.26 (0)	1.58 (0)	7.82 (-1)
55				3.57 (0)		
60	3.27 (1)	2.19 (-1)	4.50 (-1)		1.13 (0)	5.81 (-1)
65	3.08 (1)	2.01 (-1)		2.52 (0)		
70		1.80 (-1)			8.21 (-1)	4.40 (-1)
75		1.74 (-1)		1.98 (0)		
76			4.62 (-1)			
80		1.44 (-1)				
85		1.06 (-1)				
90N		8.31 (-2)				

[a]See experimental program plan in Appendix A for description of configurations.
[b]Read: 8.39×10^{-2}.

Table 12. 5-inch Bonner ball traverses through the horizontal midplane at 30 cm behind a series of configurations (Items IA, IIA-E)

Distance from Centerline (cm)	Bonner ball count rates ($s^{-1}W^{-1}$)					
	Item IA[a]	Item IIA	Item IIB	Item IIC	Item IID	Item IIE
90S		2.66 (-1)[b]				
80	3.31 (1)					
76			1.03 (0)			
75		8.50 (-1)		5.55 (0)		
70	4.27 (1)				2.78 (0)	1.25 (0)
65				7.72 (0)		
60	5.12 (1)	7.45 (-1)	1.42 (0)		3.96 (0)	1.64 (0)
55			1.64 (0)	1.10 (1)		
50	5.77 (1)				6.09 (0)	2.26 (0)
45		8.89 (-1)	2.17 (0)	1.65 (1)		2.92 (0)
42.5						3.53 (0)
40	6.33 (1)		2.69 (0)	2.20 (1)	1.07 (1)	4.23 (0)
38						4.70 (0)
37.5					1.21 (1)	
36						4.75 (0)
35			3.73 (0)	5.55 (1)	1.31 (1)	
34						4.56 (0)
33				1.10 (2)		
32.5			6.20 (0)		1.31 (1)	
32						4.19 (0)
31				1.76 (2)		
30	6.72 (1)	1.07 (0)	1.47 (1)		1.20 (1)	3.92 (0)
29				2.21 (2)		
28			1.86 (1)	2.30 (2)		3.78 (0)
27.5					1.08 (1)	
27				2.26 (2)		
26			1.99 (1)	2.14 (2)		3.72 (0)
25				1.93 (2)	9.76 (0)	
24			1.85 (1)			3.65 (0)
23				1.27 (2)		
22			1.35 (1)			3.45 (0)
21				6.41 (1)		
20	7.10 (1)		6.00 (0)		8.55 (0)	3.21 (0)
19				3.22 (1)		
18			3.62 (0)			
17.5						3.01 (0)
17				2.85 (1)		
16			3.52 (0)			
15		1.14 (0)				2.90 (0)
12				2.72 (1)		
10	7.28 (1)		3.53 (0)		7.75 (0)	2.92 (0)
6				2.65 (1)		
5			3.44 (0)			2.91 (0)

Table 12. (continued)

Distance from Centerline (cm)	Bonner ball count rates ($s^{-1}W^{-1}$)					
	Item IA	Item IIA	Item IIB	Item IIC	Item IID	Item IIE
0	7.37 (1)	1.19 (0)	3.44 (0)	2.63 (1)	7.65 (0)	2.89 (0)
5			3.40 (0)	2.63 (1)		2.88 (0)
10	7.26 (1)		3.49 (0)	2.68 (1)	7.87 (0)	2.94 (0)
14			3.53 (0)			
15		1.15 (0)		2.75 (1)		2.93 (0)
16			3.60 (0)			
17.5						3.01 (0)
18			3.69 (0)			
20	7.10 (1)		5.83 (0)	4.51 (1)	8.77 (0)	3.21 (0)
22			1.52 (1)			3.45 (0)
23				1.37 (2)		
24			2.22 (1)	1.79 (2)		3.75 (0)
25				2.13 (2)	1.02 (1)	
26			2.45 (1)	2.34 (2)		3.86 (0)
27				2.45 (2)		
27.5					1.15 (1)	
28			2.31 (1)	2.49 (2)		3.84 (0)
29				2.42 (2)		
30	6.76 (1)	1.05 (0)	1.80 (1)	2.24 (2)	1.30 (1)	4.00 (0)
31				1.98 (2)		
32						4.41 (0)
32.5			7.40 (0)		1.38 (1)	
33				1.23 (2)		
34						4.74 (0)
35			3.89 (0)	6.09 (1)	1.36 (1)	
36						4.96 (0)
37.5					1.24 (1)	
38				2.74 (1)		4.89 (0)
40	6.34 (1)		2.73 (0)		1.07 (1)	4.47 (0)
42.5						3.66 (0)
45		8.90 (-1)		1.64 (1)		2.93 (0)
50	5.67 (1)		1.91 (0)		5.91 (0)	2.30 (0)
60	4.95 (1)	7.06 (-1)	1.40 (0)	8.91 (0)	3.87 (0)	1.64 (0)
65	3.08 (1)					
67.5		6.16 (-1)				
70					2.69 (0)	1.24 (0)
75		5.45 (-1)		5.62 (0)		
76			1.12 (0)			
82.5		3.90 (-1)				
90N		2.59 (-1)				

[a]See experimental program plan in Appendix A for description of configurations.
[b]Read: 2.66×10^{-1}.

Table 13. 8-inch Bonner ball traverses through horizontal midplane at 30 cm behind a series of configurations (Items IA, IIA-E)

Distance from Centerline (cm)	Bonner ball count rates ($s^{-1}W^{-1}$)					
	Item IA[a]	Item IIA	Item IIB	Item IIC	Item IID	Item IIE
90S		2.61 (-1)[b]				
80	1.18 (1)					
75		6.78 (-1)				
71.8				4.69 (0)		
70	1.53 (1)		8.83 (-1)		1.97 (0)	1.02 (0)
65				5.91 (0)		
60	1.81 (1)	7.19 (-1)	1.14 (0)		2.83 (0)	1.31 (0)
55				8.72 (0)		
50	2.06 (1)		1.52 (0)		4.65 (0)	1.83 (0)
45		9.09 (-1)		1.40 (1)	6.18 (0)	2.47 (0)
42.5						2.88 (0)
40	2.25 (1)		2.32 (0)	2.32 (1)	8.13 (0)	3.22 (0)
38						3.40 (0)
37.5					8.88 (0)	
36						3.48 (0)
35			5.82 (0)	8.86 (1)	9.30 (0)	
34						3.48 (0)
33				1.23 (2)		
32.5			9.72 (0)		9.25 (0)	
32						3.46 (0)
31				1.55 (2)		
30	2.45 (1)	1.04 (0)	1.31 (1)		8.83 (0)	3.27 (0)
29			1.40 (1)	1.72 (2)		
28			1.47 (1)			3.10 (0)
27.5					8.12 (0)	
27			1.50 (1)	1.76 (2)		
26			1.54 (1)			2.93 (0)
25			1.52 (1)	1.66 (2)	7.35 (0)	
24			1.48 (1)			2.78 (0)
23				1.42 (2)		
22			1.30 (1)			2.68 (0)
21				1.06 (2)		
20	2.53 (1)		1.01 (1)		6.21 (0)	2.55 (0)
19				6.62 (1)		
18			6.47 (0)			
17.5						2.42 (0)
15		1.19 (0)	2.94 (0)	2.45 (1)	5.62 (0)	2.28 (0)
10	2.65 (1)		2.72 (0)	2.18 (1)	5.42 (0)	2.24 (0)
5			2.71 (0)	2.11 (1)	5.29 (0)	2.24 (0)

Table 13. (continued)

Distance from Centerline (cm)	Bonner ball count rates ($s^{-1}W^{-1}$)					
	Item IA	Item IIA	Item IIB	Item IIC	Item IID	Item IIE
0	2.63 (1)	1.22 (0)	2.73 (0)	2.10 (1)	5.31 (0)	2.22 (0)
5			2.77 (0)	2.11 (1)	5.34 (0)	2.23 (0)
10	2.59 (1)		2.77 (0)	2.19 (1)	5.50 (0)	2.26 (0)
15		1.19 (0)	3.23 (0)	2.58 (1)	5.87 (0)	2.33 (0)
17.5						2.46 (0)
19				7.90 (1)		
20	2.52 (1)		1.34 (1)		6.55 (0)	2.62 (0)
21				1.25 (2)		
22						2.78 (0)
22.5					7.16 (0)	
23				1.64 (2)		
24						2.87 (0)
25			1.92 (1)	1.88 (2)	8.01 (0)	
26						2.99 (0)
27				1.94 (2)		
27.5					8.81 (0)	
28						3.22 (0)
29				1.87 (2)		
30	2.40 (1)	1.05 (0)	1.53 (1)		9.46 (0)	3.40 (0)
31				1.67 (2)		
32						3.56 (0)
32.5					9.81 (0)	
33				1.32 (2)		
34						3.62 (0)
35			6.02 (0)	9.14 (1)	9.54 (0)	
36						3.52 (0)
37.5					8.85 (0)	
38						3.41 (0)
40	2.25 (1)		2.30 (0)	2.25 (1)	7.98 (0)	3.23 (0)
42.5						2.84 (0)
45		9.07 (-1)		1.35 (1)	5.80 (0)	2.40 (0)
50	2.01 (1)		1.50 (0)		4.26 (0)	1.79 (0)
55				8.48 (0)		
60	1.78 (1)	7.12 (-1)	1.10 (0)		2.71 (0)	1.29 (0)
65	1.65 (1)			5.64 (0)		
70					1.91 (0)	1.01 (0)
72.2				4.41 (0)		
75N		5.11 (-1)				

[a]See experimental program plan in Appendix A for description of configurations.
[b]Read: 2.61×10^{-1}.

Table 14. Spectrum of high-energy neutrons (>0.8 MeV) on centerline at 25 cm behind the lead slabs (Item IIA): Run 7925A

	Flux (neutrons $cm^{-2}MeV^{-1}kW^{-1}s^{-1}$)			Flux (neutrons $cm^{-2}MeV^{-1}kW^{-1}s^{-1}$)	
Neutron Energy (MeV)	Lower Limit	Upper Limit	Neutron Energy (MeV)	Lower Limit	Upper Limit
8.11E -01	1.26E +02	1.30E +02	5.94E +00	8.80E +00	9.07E +00
9.07E -01	1.27E +02	1.28E +02	6.25E +00	7.79E +00	8.11E +00
1.01E +00	1.12E +02	1.13E +02	6.55E +00	6.71E +00	6.97E +00
1.11E +00	1.05E +02	1.07E +02	6.84E +00	5.64E +00	5.82E +00
1.20E +00	1.06E +02	1.07E +02	7.24E +00	4.20E +00	4.34E +00
1.31E +00	1.07E +02	1.09E +02	7.74E +00	2.75E +00	2.93E +00
1.41E +00	1.06E +02	1.08E +02	8.24E +00	1.91E +00	2.10E +00
1.51E +00	1.03E +02	1.04E +02	8.76E +00	1.42E +00	1.50E +00
1.61E +00	9.67E +01	9.77E +01	9.26E +00	1.08E +00	1.16E +00
1.71E +00	9.09E +01	9.19E +01	9.74E +00	8.31E -01	8.91E -01
1.81E +00	8.69E +01	8.79E +01	1.03E +01	5.83E -01	6.38E -01
1.93E +00	8.68E +01	8.77E +01	1.08E +01	4.04E -01	4.52E -01
2.10E +00	9.34E +01	9.43E +01	1.12E +01	3.05E -01	3.42E -01
2.30E +00	9.61E +01	9.69E +01	1.18E +01	2.34E -01	2.64E -01
2.50E +00	7.99E +01	8.05E +01	1.24E +01	1.61E -01	1.90E -01
2.70E +00	5.44E +01	5.50E +01	1.32E +01	7.66E -02	9.64E -02
2.90E +00	3.50E +01	3.55E +01	1.40E +01	1.92E -04	1.92E -02
3.10E +00	2.26E +01	2.32E +01	1.48E +01	-7.01E -03	9.35E -03
3.30E +00	1.57E +01	1.62E +01	1.56E +01	4.01E -02	5.51E -02
3.50E +00	1.20E +01	1.25E +01	1.65E +01	4.38E -02	5.73E -02
3.71E +00	1.03E +01	1.07E +01	1.75E +01	4.75E -03	1.38E -02
3.91E +00	9.85E +00	1.02E +01	1.85E +01	-4.24E -03	3.13E -03
4.15E +00	1.02E +01	1.06E +01	1.95E +01	-1.50E -03	5.57E -03
4.45E +00	1.11E +01	1.14E +01	2.05E +01	-6.41E -03	4.09E -03
4.75E +00	1.11E +01	1.14E +01	2.16E +01	-8.10E -03	2.99E -03
5.04E +00	1.05E +01	1.08E +01	2.26E +01	-4.68E -03	3.00E -03
5.34E +00	9.93E +00	1.02E +01	2.35E +01	-2.96E -03	3.53E -03
5.64E +00	9.46E +00	9.76E +00			

E1 (MeV)	E2 (MeV)	Integral neutrons $cm^{-2}kW^{-1}s^{-1}$	Error neutrons $cm^{-2}kW^{-1}s^{-1}$
0.811	1.000	2.37E +01	1.93E -01
1.000	1.200	2.15E +01	1.35E -01
1.200	1.600	4.22E +01	2.30E -01
1.600	2.000	3.59E +01	1.93E -01
2.000	3.000	7.20E +01	3.39E -01
3.000	4.000	1.44E +01	2.43E -01
4.000	6.000	2.08E +01	3.08E -01
6.000	8.000	1.06E +01	2.08E -01
8.000	10.000	2.73E +00	1.00E -01
10.000	12.000	8.11E -01	4.24E -02
12.000	16.000	2.56E -01	3.93E -02
16.000	20.000	5.86E -02	1.86E -02
3.000	10.000	4.84E +01	8.63E -01
1.500	15.000	1.67E +02	1.52E +00
3.000	12.000	4.92E +01	9.05E -01

Table 15. Neutron spectrum (50 keV to 1.4 MeV) on centerline at 25 cm behind the lead slabs (Item IIA) Runs 1594.A, 1594.B, 1595.SUM

N	Energy Boundary (MeV)		Flux (neutrons $cm^{-2}MeV^{-1}kW^{-1}s^{-1}$)	Error (%)
		<u>RUN 1595.SUM</u>		
1	0.0445	0.0529	1.24E +03	2.51
2	0.0529	0.0629	5.85E +02	4.91
3	0.0629	0.0730	4.44E +02	7.44
4	0.0730	0.0864	4.53E +02	6.01
5	0.0864	0.1015	3.96E +02	6.90
6	0.1015	0.1200	3.56E +02	6.97
7	0.1200	0.1401	3.15E +02	8.23
8	0.1401	0.1653	3.16E +02	7.11
9	0.1653	0.1955	2.68E +02	7.63
		<u>RUN 1594.B</u>		
1	0.1414	0.1655	2.77E +02	3.69
2	0.1655	0.1955	2.63E +02	3.63
3	0.1955	0.2316	2.41E +02	3.83
4	0.2316	0.2737	2.28E +02	4.01
5	0.2737	0.3219	2.37E +02	3.91
6	0.3219	0.3760	1.85E +02	5.09
7	0.3760	0.4482	1.54E +02	5.02
		<u>RUN 1594.A</u>		
1	0.3265	0.3818	1.76E +02	2.90
2	0.3818	0.4482	1.40E +02	3.52
3	0.4482	0.5257	1.71E +02	2.86
4	0.5257	0.6142	1.91E +02	2.53
5	0.6142	0.7249	1.69E +02	2.53
6	0.7249	0.8577	1.52E +02	2.59
7	0.8577	1.0126	9.90E +01	3.84
8	1.0126	1.1897	9.49E +01	3.93
9	1.1897	1.4000	1.05E +02	3.25

Table 16. **Bonner ball measurements on centerline at NE 213 location (Items IIA, C)**

		Bonner ball count rates ($s^{-1}W^{-1}$)		
Configuration[a]	Detector Location	3-inch Diam Ball[c]	5-inch Diam Ball[c]	10-inch Diam Ball[c]
IIA	25 cm behind lead[b]	1.53 (-1)[d]	5.64 (-1)	3.96 (-1)
IIC	25 cm behind lead	9.38 (0)	3.47 (1)	2.23 (1)

[a]See experimental program plan in Appendix A for description of configurations.
[b]Lead slab between configuration and detector (see schematics).
[c]Foreground only. Count rate without shadow shield between detector and configuration.
[d]Read: 1.53×10^{-1}.

Table 17. Hornyak button traverse through the horizontal midplane at 2 cm behind a series of configurations (Items IIA-E)

Distance from Centerline (cm)	Neutron Dose Rate (ergs $g^{-1}h^{-1}W^{-1}$)				
	Item IIA[a]	Item IIB	Item IIC	Item IID	Item IIE
72.5S	3.43 (-4)[b]				
70		3.00 (-4)		2.98 (-4)	3.25 (-4)
60	4.55 (-4)	3.68 (-4)	8.95 (-4)	3.82 (-4)	4.37 (-4)
50		4.18 (-4)	1.63 (-3)	4.97 (-4)	6.26 (-4)
45	6.39 (-4)	5.02 (-4)		5.97 (-4)	7.56 (-4)
42.5					8.50 (-4)
40		5.78 (-4)	3.65 (-3)	8.69 (-4)	1.03 (-3)
39					1.17 (-3)
38				1.10 (-3)	1.43 (-3)
37					2.76 (-3)
36.5					3.64 (-3)
36				1.27 (-3)	3.84 (-3)
35		7.23 (-4)	7.13 (-3)	1.49 (-3)	3.40 (-3)
34.5					2.44 (-3)
34				1.78 (-3)	1.47 (-3)
33			9.90 (-3)	3.10 (-3)	1.22 (-3)
32.5				4.71 (-3)	
32				4.66 (-3)	1.16 (-3)
31.5				4.28 (-3)	
31				3.79 (-3)	
30.5				2.65 (-3)	
30	8.15 (-4)	1.31 (-3)	2.34 (-2)	1.63 (-3)	1.17 (-3)
29.5			3.44 (-2)	1.43 (-3)	
29			7.49 (-2)	1.27 (-3)	
28.5			2.82 (-1)	1.20 (-3)	
28		2.21 (-3)	3.99 (-1)	1.15 (-3)	1.10 (-3)
27.5			3.88 (-1)	1.08 (-3)	
27		5.76 (-3)	3.67 (-1)	1.07 (-3)	
26.8		1.57 (-2)			
26.5		6.68 (-2)	3.43 (-1)	1.13 (-3)	
26.3		8.65 (-2)			
26.1		8.19 (-2)			
26			3.07 (-1)	1.02 (-3)	9.67 (-4)
25.9		7.78 (-2)			
25.7		6.72 (-2)			
25.5		4.04 (-2)	2.26 (-1)		
25.2		6.45 (-3)			
25		3.56 (-3)	4.08 (-2)		
24		1.98 (-3)	1.77 (-2)		9.12 (-4)
23			1.27 (-2)	8.71 (-4)	
22		1.37 (-3)	1.14 (-2)		
20		1.18 (-3)	9.09 (-3)	8.01 (-4)	8.64 (-4)
15	9.57 (-4)	9.57 (-4)	5.30 (-3)	7.80 (-4)	8.65 (-4)
10			4.37 (-3)	7.45 (-4)	8.56 (-4)
5		7.36 (-4)	3.59 (-3)	7.65 (-4)	9.09 (-4)

Table 17. (continued)

Distance from Centerline (cm)	Neutron Dose Rate (ergs $g^{-1}h^{-1}W^{-1}$)				
	Item IIA	Item IIB	Item IIC	Item IID	Item IIE
0	1.04 (-3)	8.05 (-4)		8.07 (-4)	8.90 (-4)
5		8.10 (-4)	3.68 (-3)	7.77 (-4)	8.84 (-4)
10		8.16 (-4)	4.44 (-3)	7.85 (-4)	8.91 (-4)
15	1.00 (-3)		5.91 (-3)	8.15 (-4)	9.20 (-4)
20		1.39 (-3)	9.28 (-3)	8.58 (-4)	9.00 (-4)
22		1.58 (-3)	1.16 (-2)		
23			1.34 (-2)	9.34 (-4)	
24		2.25 (-3)	1.70 (-2)		9.55 (-4)
25		4.03 (-3)	3.42 (-2)		
25.5		4.41 (-2)	1.68 (-1)		
25.7		7.78 (-2)			
25.9		8.97 (-2)			
26			3.31 (-1)	1.08 (-3)	1.04 (-3)
26.1		9.72 (-2)			
26.3		1.02 (-1)			
26.5		9.12 (-2)	3.71 (-1)	1.26 (-3)	
26.7		5.86 (-2)			
27		1.13 (-2)	4.05 (-1)	1.11 (-3)	
27.5			4.28 (-1)	1.19 (-3)	
28		2.85 (-3)	4.43 (-1)	1.23 (-3)	1.18 (-3)
28.5			4.33 (-1)	1.28 (-3)	
29			1.45 (-1)	1.36 (-3)	
29.5			5.67 (-2)		
30	8.85 (-4)	1.54 (-3)	3.35 (-2)	1.78 (-3)	1.21 (-3)
31				4.19 (-3)	
32				5.05 (-3)	1.21 (-3)
33			1.10 (-2)	3.63 (-3)	1.22 (-3)
34				1.93 (-3)	1.51 (-3)
34.5					2.61 (-3)
35		8.70 (-4)	7.97 (-3)	1.52 (-3)	3.29 (-3)
35.5					3.62 (-3)
36				1.28 (-3)	3.84 (-3)
36.5					3.76 (-3)
37					2.60 (-3)
38				1.05 (-3)	1.47 (-3)
39					1.19 (-3)
40			3.97 (-3)	8.62 (-4)	1.08 (-3)
42.5					9.15 (-4)
45	6.75 (-4)	5.41 (-4)		6.31 (-4)	8.15 (-4)
50			1.61 (-3)	5.33 (-4)	6.50 (-4)
60	4.77 (-4)		8.69 (-4)	3.71 (-4)	4.50 (-4)
70			5.51 (-4)		3.19 (-4)
71.5N	3.55 (-4)				

[a]See experimental program plan in Appendix A for description of configurations.
[b]Read: 3.43×10^{-4}.

Table 18. Hornyak button traverse through the horizontal midplane at 30 cm behind a series of configurations (Items IIA-E)

Distance from Centerline (cm)	Neutron Dose Rate (ergs $g^{-1}h^{-1}W^{-1}$)				
	Item IIA[a]	Item IIB	Item IIC	Item IID	Item IIE
90S	1.10 (-4)[b]				
75	2.37 (-4)				
70					3.06 (-4)
60	3.28 (-4)	3.44 (-4)	1.62 (-3)	3.65 (-4)	4.07 (-4)
50		4.41 (-4)		4.90 (-4)	5.24 (-4)
45	4.33 (-4)		3.25 (-3)	6.27 (-4)	6.22 (-4)
42.5					7.51 (-4)
40		5.15 (-4)		8.14 (-4)	9.67 (-4)
39					1.13 (-3)
38				9.97 (-4)	1.38 (-3)
37				1.13 (-3)	1.60 (-3)
36.5					1.62 (-3)
36				1.28 (-3)	1.59 (-3)
35.5					1.51 (-3)
35		6.65 (-4)	7.61 (-3)	1.47 (-3)	1.40 (-3)
34.5					1.05 (-3)
34				1.65 (-3)	1.22 (-3)
33.5				1.83 (-3)	
33				1.89 (-3)	8.25 (-4)
32.5				1.90 (-3)	
32			2.33 (-2)	1.82 (-3)	7.66 (-4)
31.5				1.75 (-3)	
31			4.27 (-2)	1.62 (-3)	7.63 (-4)
30.5			6.29 (-2)	1.47 (-3)	
30	5.02 (-4)	1.04 (-3)	8.52 (-2)	1.19 (-3)	7.68 (-4)
29.5			1.20 (-1)		
29			1.74 (-1)		7.74 (-4)
28.7			2.13 (-1)		
28.5			2.19 (-1)		
28.2			2.26 (-1)		
28		6.44 (-3)		8.40 (-4)	7.60 (-4)
27.9			2.25 (-1)		
27.5		1.60 (-2)	2.18 (-1)		
27.3		2.44 (-2)			
27		3.99 (-2)	2.03 (-1)		7.26 (-4)
26.8		4.95 (-2)			
26.5		5.18 (-2)	1.93 (-1)	8.40 (-4)	
26.3		4.94 (-2)			
26		3.97 (-2)	1.73 (-1)		6.95 (-4)
25.5		1.14 (-2)	1.49 (-1)		
25		1.64 (-3)	8.84 (-2)	7.56 (-4)	7.23 (-4)
24.5		1.12 (-3)			
24		1.03 (-3)	1.62 (-2)		
22.5					6.74 (-4)
22		8.13 (-4)			
20		7.44 (-4)	7.60 (-3)	7.01 (-4)	6.43 (-4)
15	5.88 (-4)	8.17 (-4)		6.71 (-4)	6.48 (-4)
10		7.61 (-4)	5.82 (-3)	6.69 (-4)	6.62 (-4)
5		7.49 (-4)		6.67 (-4)	6.68 (-4)
0	6.12 (-4)	7.65 (-4)	5.23 (-3)	6.70 (-4)	6.63 (-4)

Table 18. (continued)

Distance from Centerline (cm)	Neutron Dose Rate (ergs $g^{-1}h^{-1}W^{-1}$)				
	Item IIA	Item IIB	Item IIC	Item IID	Item IIE
5				6.68 (-4)	6.40 (-4)
10		7.31 (-4)	5.93 (-3)	6.58 (-4)	6.67 (-4)
15	5.89 (-4)			6.64 (-4)	6.49 (-4)
20		8.60 (-4)	7.95 (-3)	7.02 (-4)	6.81 (-4)
22		9.15 (-4)			
22.5					6.75 (-4)
24		1.35 (-3)	1.39 (-2)		
24.5		2.60 (-3)			
25		3.15 (-3)	6.21 (-2)	7.75 (-4)	7.35 (-4)
25.2		4.37 (-2)			
25.4		5.22 (-2)			
25.5			1.36 (-1)		
25.6		5.77 (-2)			
25.8		6.23 (-2)			
26		6.44 (-2)	1.78 (-1)	8.10 (-4)	7.34 (-4)
26.2		6.24 (-2)			
26.4		5.03 (-2)			
26.5			2.05 (-1)		
26.6		3.72 (-2)			
26.8		2.67 (-2)			
27		1.84 (-2)	2.21 (-1)	8.47 (-4)	7.62 (-4)
27.5		8.06 (-3)	2.36 (-1)	8.53 (-4)	
28		3.39 (-3)	2.48 (-1)	8.72 (-4)	7.65 (-4)
28.2			2.50 (-1)		
28.5			2.54 (-1)	9.25 (-4)	
28.7			2.53 (-1)		
29			2.38 (-1)	9.90 (-4)	7.99 (-4)
29.3			2.09 (-1)		
29.5			1.78 (-1)		
30	5.40 (-4)	1.08 (-3)	1.20 (-1)	1.33 (-3)	7.91 (-4)
31			6.28 (-2)	1.70 (-3)	7.86 (-4)
31.5				1.83 (-3)	
32			3.16 (-2)	1.93 (-3)	7.72 (-4)
32.5				2.04 (-3)	
33				1.99 (-3)	8.74 (-4)
33.5				1.92 (-3)	
34				1.85 (-3)	1.20 (-3)
34.5				1.66 (-3)	1.31 (-3)
35		7.47 (-4)	8.63 (-3)	1.60 (-3)	1.48 (-3)
35.5					1.56 (-3)
36				1.39 (-3)	1.60 (-3)
36.5					1.70 (-3)
37				1.16 (-3)	1.60 (-3)
38				1.06 (-3)	1.33 (-3)
39				9.32 (-4)	1.11 (-3)
40		5.53 (-4)		8.54 (-4)	9.55 (-4)
42.5					7.55 (-4)
45	4.43 (-4)		3.61 (-3)	6.31 (-4)	6.28 (-4)
50		4.27 (-4)		4.96 (-4)	5.27 (-4)
60	3.50 (-4)	3.09 (-4)	1.79 (-3)	3.65 (-4)	4.03 (-4)
70					3.01 (-4)
75	2.51 (-4)				
82N	1.77 (-4)				

[a]See experimental program plan in Appendix A for description of configurations.
[b]Read: 1.10×10^{-4}.

Table 19. Spectrum of high-energy neutrons (>0.8 MeV) on centerline at 25 cm behind the lead slabs (Item IIC) Run 7926.A

Neutron Energy (MeV)	Flux (neutrons $cm^{-2}MeV^{-1}kW^{-1}s^{-1}$) Lower Limit	Flux (neutrons $cm^{-2}MeV^{-1}kW^{-1}s^{-1}$) Upper Limit	Neutron Energy (MeV)	Flux (neutrons $cm^{-2}MeV^{-1}kW^{-1}s^{-1}$) Lower Limit	Flux (neutrons $cm^{-2}MeV^{-1}kW^{-1}s^{-1}$) Upper Limit
8.11E -01	7.53E +03	7.67E +03	5.94E +00	1.64E +02	1.70E +02
9.07E -01	7.95E +03	8.04E +03	6.25E +00	1.24E +02	1.31E +02
1.01E +00	7.30E +03	7.35E +03	6.55E +00	9.96E +01	1.06E +02
1.11E +00	6.64E +03	6.70E +03	6.84E +00	8.59E +01	9.00E +01
1.20E +00	6.15E +03	6.20E +03	7.24E +00	6.89E +01	7.20E +01
1.31E +00	5.69E +03	5.74E +03	7.74E +00	4.81E +01	5.20E +01
1.41E +00	5.30E +03	5.34E +03	8.24E +00	3.50E +01	3.89E +01
1.51E +00	4.97E +03	5.00E +03	8.76E +00	2.71E +01	2.90E +01
1.61E +00	4.65E +03	4.69E +03	9.26E +00	2.03E +01	2.20E +01
1.71E +00	4.36E +03	4.40E +03	9.74E +00	1.48E +01	1.61E +01
1.81E +00	4.10E +03	4.14E +03	1.03E +01	1.04E +01	1.16E +01
1.93E +00	3.83E +03	3.86E +03	1.08E +01	7.28E +00	8.36E +00
2.10E +00	3.44E +03	3.47E +03	1.12E +01	5.31E +00	6.14E +00
2.30E +00	3.02E +03	3.05E +03	1.18E +01	3.78E +00	4.45E +00
2.50E +00	2.61E +03	2.64E +03	1.24E +01	2.40E +00	3.03E +00
2.70E +00	2.16E +03	2.18E +03	1.32E +01	1.51E +00	1.93E +00
2.90E +00	1.77E +03	1.79E +03	1.40E +01	3.28E -01	7.48E -01
3.10E +00	1.42E +03	1.44E +03	1.48E +01	-2.78E -01	5.53E -02
3.30E +00	1.15E +03	1.17E +03	1.56E +01	4.42E -01	7.31E -01
3.50E +00	9.38E +02	9.57E +02	1.65E +01	6.85E -01	9.69E -01
3.71E +00	7.76E +02	7.89E +02	1.75E +01	8.39E -02	2.61E -01
3.91E +00	6.59E +02	6.71E +02	1.85E +01	-6.56E -02	7.62E -02
4.15E +00	5.60E +02	5.71E +02	1.95E +01	-2.58E -02	1.10E -01
4.45E +00	4.65E +02	4.74E +02	2.05E +01	-1.43E -01	5.86E -02
4.75E +00	3.82E +02	3.90E +02	2.16E +01	-1.73E -01	3.84E -02
5.04E +00	3.12E +02	3.19E +02	2.26E +01	-8.93E -02	5.63E -02
5.34E +00	2.54E +02	2.60E +02	2.35E +01	-4.95E -02	7.46E -02
5.64E +00	2.08E +02	2.14E +02			

E1 (MeV)	E2 (MeV)	Integral neutrons $cm^{-2}kW^{-1}s^{-1}$	Error neutrons $cm^{-2}kW^{-1}s^{-1}$
0.811	1.000	1.48E +03	8.43E +00
1.000	1.200	1.35E +03	5.14E +00
1.200	1.600	2.16E +03	8.18E +00
1.600	2.000	1.67E +03	6.61E +00
2.000	3.000	2.61E +03	1.21E +01
3.000	4.000	9.99E +02	7.94E +00
4.000	6.000	6.97E +02	7.68E +00
6.000	8.000	1.71E +02	4.70E +00
8.000	10.000	5.10E +01	2.19E +00
10.000	12.000	1.45E +01	9.52E -01
12.000	16.000	4.39E +00	8.28E -01
16.000	20.000	9.81E -01	3.70E -01
3.000	10.000	1.92E +03	2.26E +01
1.500	15.000	6.70E +03	4.48E +01
3.000	12.000	1.93E +03	2.35E +01

Table 20. Neutron spectrum (50 keV to 1.4 MeV) on centerline at 25 cm behind the lead slabs (Item IIC) Runs 1597.B, 1597.A, 1596.A

N	Energy Boundary (MeV)		Flux (neutrons $cm^{-2}MeV^{-1}kW^{-1}s^{-1}$)	Error (%)
		RUN 1597.B		
1	0.0391	0.0455	3.26E +04	3.78
2	0.0455	0.0535	2.73E +04	4.11
3	0.0535	0.0630	2.57E +04	4.14
4	0.0630	0.0742	2.89E +04	3.58
5	0.0742	0.0870	2.55E +04	4.01
6	0.0870	0.1029	1.99E +04	4.57
7	0.1029	0.1205	2.30E +04	4.11
8	0.1205	0.1412	2.45E +04	3.61
9	0.1412	0.1668	2.05E +04	3.82
10	0.1668	0.1971	1.83E +04	3.95
		RUN 1597.A		
1	0.1425	0.1668	1.87E +04	1.89
2	0.1668	0.1971	1.66E +04	1.97
3	0.1971	0.2335	1.46E +04	2.17
4	0.2335	0.2759	1.65E +04	1.90
5	0.2759	0.3245	1.67E +04	1.89
6	0.3245	0.3790	1.30E +04	2.45
7	0.3790	0.4457	9.68E +03	3.02
8	0.4457	0.5246	1.03E +04	2.71
9	0.5246	0.6216	1.20E +04	2.03
		RUN 1596.A		
1	0.4486	0.5243	1.04E +04	1.98
2	0.5243	0.6216	1.18E +04	1.50
3	0.6216	0.7297	1.07E +04	1.67
4	0.7297	0.8595	8.83E +03	1.84
5	0.8595	1.0108	6.70E +03	2.28
6	1.0108	1.1838	5.76E +03	2.54
7	1.1838	1.4000	5.29E +03	2.30

Table 21. **Bonner ball measurements on centerline at 150 cm behind the mockup (Items IIIA-G)**

	Bonner ball count rates ($s^{-1}W^{-1}$)					
	3-inch-Diam Ball		5-inch-Diam Ball		8-inch-Diam Ball	
Configuration[a]	Foreground[b]	Background[c]	Foreground	Background	Foreground	Background
IIIA	4.99 (-4)[d]	4.45 (-4)	9.11 (-4)	8.42 (-4)	4.12 (-4)	3.82 (-4)
IIIB	5.16 (-4)	4.30 (-4)	9.15 (-4)	7.82 (-4)	4.18 (-4)	3.62 (-4)
IIIC	1.18 (-3)	4.40 (-4)	1.92 (-3)	8.47 (-4)	7.54 (-4)	3.60 (-4)
IIID	1.02 (-3)	4.46 (-4)	1.73 (-3)	8.11 (-4)	7.29 (-4)	3.81 (-4)
IIIE	6.65 (-4)	4.46 (-4)	1.22 (-3)	8.29 (-4)	5.44 (-4)	3.78 (-4)
IIIF	5.17 (-4)	4.69 (-4)	9.64 (-4)	8.70 (-4)	4.33 (-4)	3.87 (-4)
IIIG	5.01 (-4)	4.58 (-4)	9.14 (-4)	8.45 (-4)	4.15 (-4)	3.82 (-4)

[a]See experimental program plan in Appendix A for description of configurations.
[b]Count rate without shadow shield between detector and configuration.
[c]Count rate with shadow shield between detector and configuration.
[d]Read 4.99 x 10^{-4}.

Table 22. 3-inch Bonner ball traverses through the horizontal midplane at 30 cm behind a series of configurations (Items IIIA-HH)

Distance from Centerline (cm)	Bonner ball count rates ($s^{-1}W^{-1}$)								
	Item IIIA[a]	Item IIIB	Item IIIC	Item IIID	Item IIIE	Item IIIF	Item IIIG	Item IIIH	Item IIIHH
75S					6.08 (-4)[b]				
70		3.76 (-4)							
66.4				1.37 (-3)					
65	3.70 (-4)		1.08 (-3)			3.77 (-4)	3.35 (-4)	3.26 (-4)	2.49 (-4)
60	3.74 (-4)	3.96 (-4)	1.23 (-3)	1.68 (-3)	7.92 (-4)	3.75 (-4)	3.37 (-4)	3.26 (-4)	2.43 (-4)
55									
50		4.13 (-4)	1.67 (-3)	2.41 (-3)		4.05 (-4)	3.46 (-4)	3.36 (-4)	2.46 (-4)
45	3.78 (-4)		2.06 (-3)		1.17 (-3)	4.24 (-4)	3.48 (-4)		
40		4.57 (-4)	2.52 (-3)	3.33 (-3)	1.37 (-3)	4.61 (-4)	3.87 (-4)	3.33 (-4)	2.52 (-4)
37.5		4.75 (-4)	2.94 (-3)		1.43 (-3)	5.01 (-4)	4.12 (-4)		
36							4.05 (-4)		
35		4.93 (-4)	6.53 (-3)	3.93 (-3)	1.49 (-3)	5.69 (-4)		3.35 (-4)	
34			1.16 (-2)	4.06 (-3)					
33			2.25 (-2)	4.33 (-3)					
32.5		5.21 (-4)			1.62 (-3)	6.02 (-4)	3.67 (-4)		
32			3.70 (-2)	4.60 (-3)					
31			5.44 (-2)	4.89 (-3)					
30	3.90 (-4)	8.34 (-4)	6.91 (-2)	5.08 (-3)	1.74 (-3)	5.47 (-4)	3.59 (-4)	3.44 (-4)	2.48 (-4)
29		2.46 (-3)	7.66 (-2)	5.41 (-3)					
28		4.99 (-3)	7.59 (-2)	5.49 (-3)		4.83 (-4)			
27.5					1.78 (-3)		3.62 (-4)		
27		6.33 (-3)	6.53 (-2)	5.46 (-3)					
26		7.03 (-3)	4.91 (-2)	5.29 (-3)		4.49 (-4)			
25		7.11 (-3)	3.19 (-2)	5.10 (-3)	1.84 (-3)		3.63 (-4)	3.47 (-4)	

Table 22. (continued)

Distance from Centerline (cm)	Bonner ball count rates ($s^{-1}W^{-1}$)								
	Item IIIA	Item IIIB	Item IIIC	Item IIID	Item IIIE	Item IIIF	Item IIIG	Item IIIH	Item IIIHH
24		6.32 (-3)	1.69 (-2)	4.96 (-3)		4.41 (-4)			
23		4.63 (-3)	7.71 (-3)	4.92 (-3)					
22.5					1.86 (-3)				
22		1.99 (-3)	4.19 (-3)	4.81 (-3)		4.31 (-4)			
21		6.49 (-4)		4.86 (-3)					
20		5.97 (-4)	3.58 (-3)	4.84 (-3)	1.89 (-3)	4.29 (-4)	3.53 (-4)	3.36 (-4)	2.46 (-4)
15	3.95 (-4)	5.45 (-4)	3.29 (-3)	4.96 (-3)	1.95 (-3)	4.27 (-4)			
10		5.40 (-4)	3.06 (-3)	4.93 (-3)	1.98 (-3)	4.27 (-4)	3.59 (-4)	3.38 (-4)	2.53 (-4)
5				4.95 (-3)	1.98 (-3)				
0	3.97 (-4)	5.31 (-4)	2.94 (-3)	4.94 (-3)	1.99 (-3)	4.20 (-4)	3.55 (-4)	3.35 (-4)	2.49 (-4)
5				5.01 (-3)	1.97 (-3)				
10		5.28 (-4)	2.99 (-3)	5.05 (-3)	1.97 (-3)	4.23 (-4)	3.56 (-4)	3.43 (-4)	2.50 (-4)
15	3.99 (-4)	5.31 (-4)	3.10 (-3)	5.01 (-3)	1.95 (-3)	4.39 (-4)			
20		5.44 (-4)	3.62 (-3)	4.87 (-3)	1.89 (-3)	4.35 (-4)	3.60 (-4)	3.40 (-4)	2.49 (-4)
21		5.47 (-4)	6.44 (-3)	4.93 (-3)					
22		6.04 (-4)	1.49 (-2)	4.86 (-3)		4.32 (-4)			
22.5					1.86 (-3)				
23		1.63 (-3)	2.87 (-2)	5.01 (-3)					
24		4.38 (-3)	4.74 (-2)	5.20 (-3)		4.43 (-4)			
25		6.36 (-3)	6.45 (-2)	5.30 (-3)	1.88 (-3)		3.73 (-4)	3.47 (-4)	

Table 22. (continued)

Distance from Centerline (cm)	Bonner ball count rates ($s^{-1}W^{-1}$)								
	Item IIIA	Item IIIB	Item IIIC	Item IIID	Item IIIE	Item IIIF	Item IIIG	Item IIIH	Item IIIHH
26		7.35 (-3)	7.65 (-2)	5.41 (-3)		4.61 (-4)			
27		7.55 (-3)	8.11 (-2)	5.47 (-3)					
27.5					1.87 (-3)		3.78 (-4)		
28		7.00 (-3)	7.41 (-2)	5.43 (-3)		4.85 (-4)			
29		5.60 (-3)	6.18 (-2)	5.18 (-3)					
30	3.96 (-4)	3.15 (-3)	4.50 (-2)	4.90 (-3)	1.78 (-3)	5.75 (-4)	3.71 (-4)	3.52 (-4)	2.52 (-4)
31		1.04 (-3)	2.79 (-2)	4.62 (-3)					
32			1.52 (-2)	4.30 (-3)					
32.5		5.36 (-4)			1.69 (-3)	6.50 (-4)	3.83 (-4)		
33			7.70 (-3)	4.15 (-3)					
34			4.49 (-3)	3.98 (-3)			3.95 (-4)		
35		4.94 (-4)	3.24 (-3)	3.81 (-3)	1.59 (-3)	6.29 (-4)		3.49 (-4)	
36							4.28 (-4)		
37.5		4.90 (-4)	2.49 (-3)		1.48 (-3)	5.36 (-4)	4.22 (-4)		
40		4.65 (-4)	2.18 (-3)	3.25 (-3)	1.42 (-3)	4.83 (-4)	4.00 (-4)	3.46 (-4)	2.49 (-4)
45	3.87 (-4)				1.24 (-3)	4.42 (-4)	3.68 (-4)		
50		4.42 (-4)	1.48 (-3)	2.33 (-3)		4.23 (-4)	3.64 (-4)	3.50 (-4)	2.53 (-4)
60	3.88 (-4)	4.39 (-4)	1.09 (-3)	1.71 (-3)	8.64 (-4)	4.13 (-4)	3.67 (-4)	3.61 (-4)	2.55 (-4)
65	3.96 (-4)	4.36 (-4)				4.38 (-4)	3.78 (-4)	3.71 (-4)	2.63 (-4)
70				1.36 (-3)					
75N					2.19 (-3)				

[a]See experimental program plan in Appendix A for description of configurations.
[b]Read: 6.08×10^{-4}.

Table 23. 5-inch Bonner ball traverses through the horizontal midplane at 30 cm behind a series of configurations (Items IIIA-HH)

Distance from Centerline (cm)	Bonner ball count rates ($s^{-1}W^{-1}$)								
	Item IIIA[a]	Item IIIB	Item IIIC	Item IIID	Item IIIE	Item IIIF	Item IIIG	Item IIIH	Item IIIHH
75S					1.06 (-3)[b]				
70		5.60 (-4)		1.97 (-3)					
65	6.12 (-4)					6.64 (-4)	5.59 (-4)	5.64 (-4)	4.18 (-4)
60	6.30 (-4)	6.17 (-4)	1.79 (-3)	2.61 (-3)	1.42 (-3)	6.70 (-4)	5.68 (-4)	5.69 (-4)	4.22 (-4)
50		6.27 (-4)	2.47 (-3)	3.71 (-3)		7.31 (-4)	5.85 (-4)	5.87 (-4)	4.19 (-4)
45	6.50 (-4)				2.06 (-3)	8.15 (-4)	6.01 (-4)		
42.5		6.81 (-4)					6.23 (-4)		
40		7.22 (-4)	3.75 (-3)	5.25 (-3)	2.39 (-3)	9.49 (-4)	6.63 (-4)	5.84 (-4)	4.23 (-4)
38							6.61 (-4)		
37.5		7.29 (-4)	4.79 (-3)		2.53 (-3)	1.04 (-3)			
36							6.58 (-4)		
35		7.49 (-4)	1.28 (-2)	6.61 (-3)	2.73 (-3)	1.13 (-3)		6.22 (-4)	
34				7.00 (-3)			6.62 (-4)		
33				7.38 (-3)					
32.5		1.32 (-3)			3.04 (-3)	1.11 (-3)			
32			4.24 (-2)	8.03 (-3)			6.66 (-4)		
31		3.29 (-3)		8.47 (-3)					
30	6.49 (-4)	4.50 (-3)	7.30 (-2)	8.65 (-3)	3.29 (-3)	1.07 (-3)	6.49 (-4)	5.99 (-4)	4.31 (-4)
29		5.47 (-3)		8.99 (-3)					
28		6.27 (-3)		9.17 (-3)		9.97 (-4)	6.54 (-4)		
27.5			8.52 (-2)		3.41 (-3)				
27		6.75 (-3)		9.26 (-3)					
26		6.90 (-3)		9.17 (-3)		9.39 (-4)	6.47 (-4)		

Table 23. (continued)

Distance from Centerline (cm)	Bonner ball count rates ($s^{-1}W^{-1}$)								
	Item IIIA	Item IIIB	Item IIIC	Item IIID	Item IIIE	Item IIIF	Item IIIG	Item IIIH	Item IIIHH
25		6.89 (-3)	7.21 (-2)	8.93 (-3)	3.49 (-3)			6.04 (-4)	
24		6.53 (-3)		8.62 (-3)		8.73 (-4)	6.46 (-4)		
23		5.80 (-3)		8.21 (-3)					
22.5			3.84 (-2)		3.38 (-3)				
22		4.73 (-3)		8.00 (-3)		8.32 (-4)	6.40 (-4)		
21				7.90 (-3)					
20		1.85 (-3)	1.01 (-2)	7.65 (-3)	3.31 (-3)	8.34 (-4)	6.23 (-4)	5.94 (-4)	4.32 (-4)
17.5		7.99 (-4)	5.19 (-3)			7.91 (-4)			
15	6.68 (-4)	8.27 (-4)	4.98 (-3)	7.75 (-3)	3.35 (-3)	7.89 (-4)	6.10 (-4)		
10		8.24 (-4)	4.55 (-3)	7.75 (-3)	3.45 (-3)	7.83 (-4)	6.07 (-4)	6.12 (-4)	4.32 (-4)
5		7.72 (-4)		7.75 (-3)	3.41 (-3)				
0	6.56 (-4)	8.01 (-4)	4.30 (-3)	7.74 (-3)	3.45 (-3)	7.89 (-4)	5.96 (-4)	5.84 (-4)	4.29 (-4)
5		7.86 (-4)		7.81 (-3)	3.42 (-3)				
10		8.08 (-4)	4.45 (-3)	7.84 (-3)	3.42 (-3)	7.97 (-4)	6.09 (-4)	5.92 (-4)	4.30 (-4)
15	6.66 (-4)	8.07 (-4)	4.61 (-3)	7.79 (-3)	3.39 (-3)	7.96 (-4)	6.06 (-4)		
17.5		8.18 (-4)				8.00 (-4)			
20		1.19 (-3)	8.63 (-3)	7.89 (-3)	3.31 (-3)	8.10 (-4)	6.16 (-4)	5.95 (-4)	4.31 (-4)
21				8.07 (-3)					
22		4.26 (-3)		8.26 (-3)		8.27 (-4)	6.42 (-4)		
22.5			3.53 (-2)		3.39 (-3)				
23		5.53 (-3)		8.50 (-3)					
24		6.59 (-3)		8.96 (-3)		8.65 (-4)	6.59 (-4)		
25		7.21 (-3)	7.28 (-2)	9.13 (-3)	3.45 (-3)			6.22 (-4)	

Table 23. (continued)

Distance from Centerline (cm)	Bonner ball count rates ($s^{-1}W^{-1}$)								
	Item IIIA	Item IIIB	Item IIIC	Item IIID	Item IIIE	Item IIIF	Item IIIG	Item IIIH	Item IIIHH
26		7.47 (-3)		9.33 (-3)		9.23 (-4)	6.66 (-4)		
27		7.37 (-3)		9.31 (-3)					
27.5			8.91 (-2)		3.52 (-3)				
28		6.97 (-3)		9.30 (-3)		9.99 (-4)	6.61 (-4)		
29		6.30 (-3)		9.01 (-3)					
30	6.67 (-4)	5.35 (-3)	7.83 (-2)	8.79 (-3)	3.46 (-3)	1.09 (-3)	6.56 (-4)	6.28 (-4)	4.31 (-4)
31				8.34 (-3)					
32				7.90 (-3)			6.65 (-4)		
32.5		2.04 (-3)	4.79 (-2)		3.19 (-3)	1.18 (-3)			
33				7.36 (-3)					
34				6.83 (-3)			6.74 (-4)		
35		7.84 (-4)	1.57 (-2)	6.47 (-3)	2.87 (-3)	1.17 (-3)		6.08 (-4)	
36							6.76 (-4)		
37.5		7.32 (-4)	5.02 (-3)		2.63 (-3)	1.09 (-3)			
38							6.75 (-4)		
40		6.98 (-4)	3.60 (-3)	5.15 (-3)	2.42 (-3)	1.02 (-3)	6.63 (-4)	6.06 (-4)	4.35 (-4)
42.5		6.75 (-4)					6.39 (-4)		
45	6.63 (-4)			4.40 (-3)	2.18 (-3)	8.59 (-4)	6.30 (-4)		
50		6.47 (-4)	2.33 (-3)	3.72 (-3)		7.91 (-4)	6.08 (-4)	6.00 (-4)	4.30 (-4)
60	6.55 (-4)	6.31 (-4)	1.73 (-3)	2.71 (-3)	1.52 (-3)	7.40 (-4)	6.09 (-4)	6.13 (-4)	4.34 (-4)
65	6.44 (-4)					7.22 (-4)	6.13 (-4)	6.03 (-4)	4.38 (-4)
70				2.22 (-3)					
75N					3.20 (-3)				

[a]See experimental program plan in Appendix A for description of configurations.
[b]Read: 1.06×10^{-3}.

Table 24. 8-inch Bonner ball traverses through the horizontal midplane at 30 cm behind a series of configurations (Items IIIA-HH)

Distance from Centerline (cm)	Bonner ball count rates ($s^{-1}W^{-1}$)								
	Item IIIA[a]	Item IIIB	Item IIIC	Item IIID	Item IIIE	Item IIIF	Item IIIG	Item IIIH	Item IIIHH
70S					5.06 (-4)[b]				
66				8.71 (-4)					
65	2.49 (-4)	2.58 (-4)				2.69 (-4)	2.29 (-4)	2.29 (-4)	1.79 (-4)
60	2.59 (-4)	2.67 (-4)	6.69 (-4)	1.05 (-3)		2.88 (-4)	2.32 (-4)	2.29 (-4)	1.77 (-4)
55					7.19 (-4)				
50		2.89 (-4)	9.00 (-4)	1.47 (-3)		3.33 (-4)	2.55 (-4)	2.38 (-4)	1.80 (-4)
45	2.68 (-4)		1.11 (-3)	1.76 (-3)	9.09 (-4)		2.58 (-4)		
40		3.19 (-4)	1.82 (-3)	2.11 (-3)	1.08 (-3)	4.48 (-4)	2.68 (-4)	2.43 (-4)	1.81 (-4)
37.5		3.46 (-4)	4.68 (-3)			4.76 (-4)			
35		7.14 (-4)	1.03 (-2)	2.93 (-3)	1.30 (-3)	5.02 (-4)	2.83 (-4)	2.53 (-4)	
32.5		1.23 (-3)	1.55 (-2)	3.28 (-3)	1.43 (-3)	4.86 (-4)			
30	2.69 (-4)	1.61 (-3)	1.92 (-2)	3.55 (-3)	1.50 (-3)	4.78 (-4)	2.85 (-4)	2.57 (-4)	1.85 (-4)
28		1.87 (-3)				4.64 (-4)			
27.5			2.08 (-2)	3.77 (-3)	1.58 (-3)				
26		1.97 (-3)				4.36 (-4)			
25			2.01 (-2)	3.78 (-3)	1.59 (-3)		2.85 (-4)	2.60 (-4)	
24		1.95 (-3)				4.05 (-4)			
22.5			1.69 (-2)	3.65 (-3)	1.58 (-3)				
22		1.78 (-3)				3.88 (-4)			
20		1.51 (-3)	1.13 (-2)	3.41 (-3)	1.53 (-3)	3.62 (-4)	2.70 (-4)	2.48 (-4)	1.79 (-4)
17.5		9.58 (-4)	5.00 (-3)						
15	2.77 (-4)	3.73 (-4)	1.88 (-3)	3.09 (-3)	1.45 (-3)	3.45 (-4)	2.57 (-4)		
12.5		3.49 (-4)							
10		3.55 (-4)	1.64 (-3)	3.05 (-3)	1.48 (-3)	3.33 (-4)	2.57 (-4)	2.46 (-4)	1.83 (-4)
5				3.07 (-3)	1.49 (-3)				
0	2.72 (-4)	3.52 (-4)	1.54 (-3)	3.08 (-3)	1.47 (-3)	3.32 (-4)	2.58 (-4)	2.45 (-4)	1.83 (-4)

Table 24. (continued)

Distance from Centerline (cm)	Bonner ball count rates ($s^{-1}W^{-1}$)								
	Item IIIA	Item IIIB	Item IIIC	Item IIID	Item IIIE	Item IIIF	Item IIIG	Item IIIH	Item IIIHH
5				3.01 (-3)	1.48 (-3)				
10		3.41 (-4)	1.56 (-3)	3.06 (-3)	1.48 (-3)	3.53 (-4)	2.58 (-4)	2.44 (-4)	1.84 (-4)
12.5		3.52 (-4)							
15	2.80 (-4)	3.61 (-4)	1.75 (-3)	3.08 (-3)	1.48 (-3)	3.49 (-4)	2.63 (-4)		
17.5		8.74 (-4)	4.29 (-3)						
20		1.53 (-3)	1.08 (-2)	3.43 (-3)	1.54 (-3)	3.78 (-4)	2.74 (-4)	2.54 (-4)	1.85 (-4)
22		1.89 (-3)				3.85 (-4)			
22.5			1.70 (-2)	3.67 (-3)	1.56 (-3)				
24		2.09 (-3)				4.13 (-4)			
25			2.06 (-2)	3.80 (-3)	1.59 (-3)		2.83 (-4)	2.57 (-4)	
26		2.08 (-3)				4.38 (-4)			
27.5			2.15 (-2)	3.75 (-3)	1.59 (-3)				
28		1.99 (-3)				4.69 (-4)			
30	2.74 (-4)	1.70 (-3)	2.00 (-2)	3.58 (-3)	1.52 (-3)	4.91 (-4)	2.88 (-4)	2.60 (-4)	1.80 (-4)
32.5		1.33 (-3)	1.64 (-2)	3.21 (-3)	1.44 (-3)	5.11 (-4)			
35		7.96 (-4)	1.11 (-2)	2.86 (-3)	1.32 (-3)	5.18 (-4)	2.87 (-4)	2.53 (-4)	
37.5		3.57 (-4)	5.41 (-3)			4.93 (-4)			
40		3.19 (-4)	1.97 (-3)	2.10 (-3)	1.09 (-3)	4.63 (-4)	2.76 (-4)	2.46 (-4)	1.82 (-4)
45	2.79 (-4)		1.02 (-3)	1.77 (-3)	9.40 (-4)	3.93 (-4)	2.66 (-4)		
50		2.93 (-4)	8.60 (-4)	1.48 (-3)		3.37 (-4)	2.55 (-4)	2.42 (-4)	1.80 (-4)
55					7.33 (-4)				
60	2.64 (-4)	2.86 (-4)	6.47 (-4)	1.09 (-3)		2.97 (-4)	2.52 (-4)	2.47 (-4)	1.86 (-4)
65		2.87 (-4)		9.53 (-4)		3.03 (-4)	2.52 (-4)	2.52 (-4)	1.83 (-4)
70N					8.62 (-4)				

[a]See experimental program plan in Appendix A for description of experiments.
[b]Read: 5.06×10^{-4}.

APPENDIX C

FIGURES

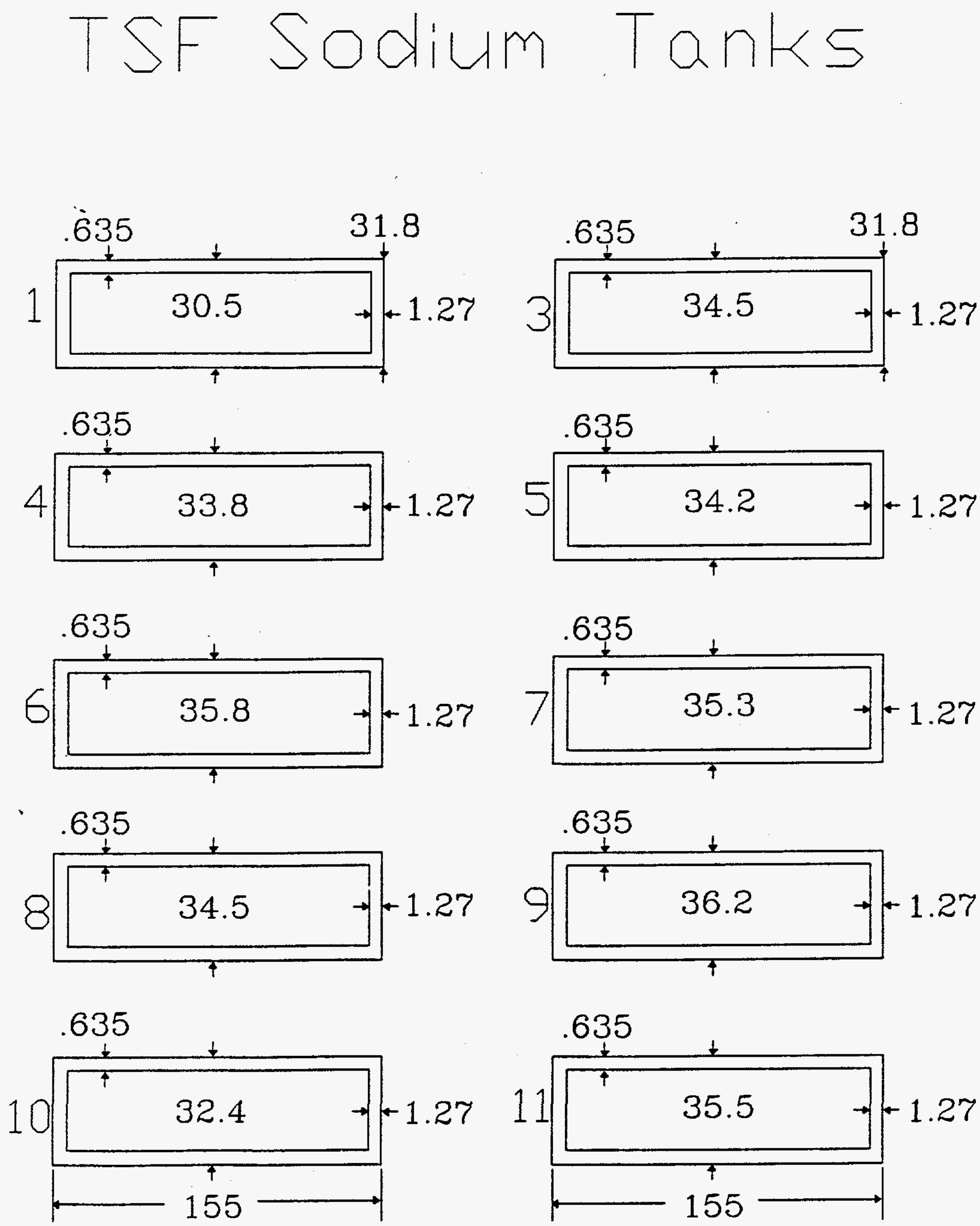


Figure 1. Schematic of the aluminum containers filled with sodium.

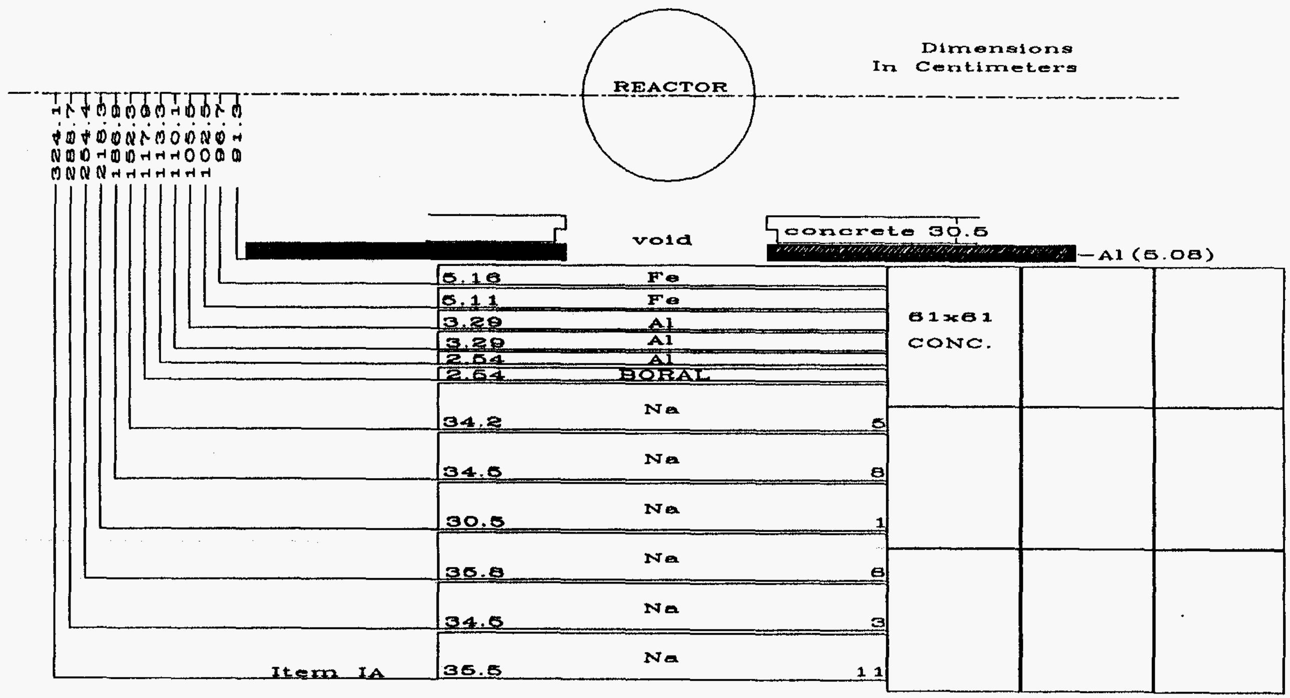


Figure 2. Schematic of the SM-2 (Item IA).

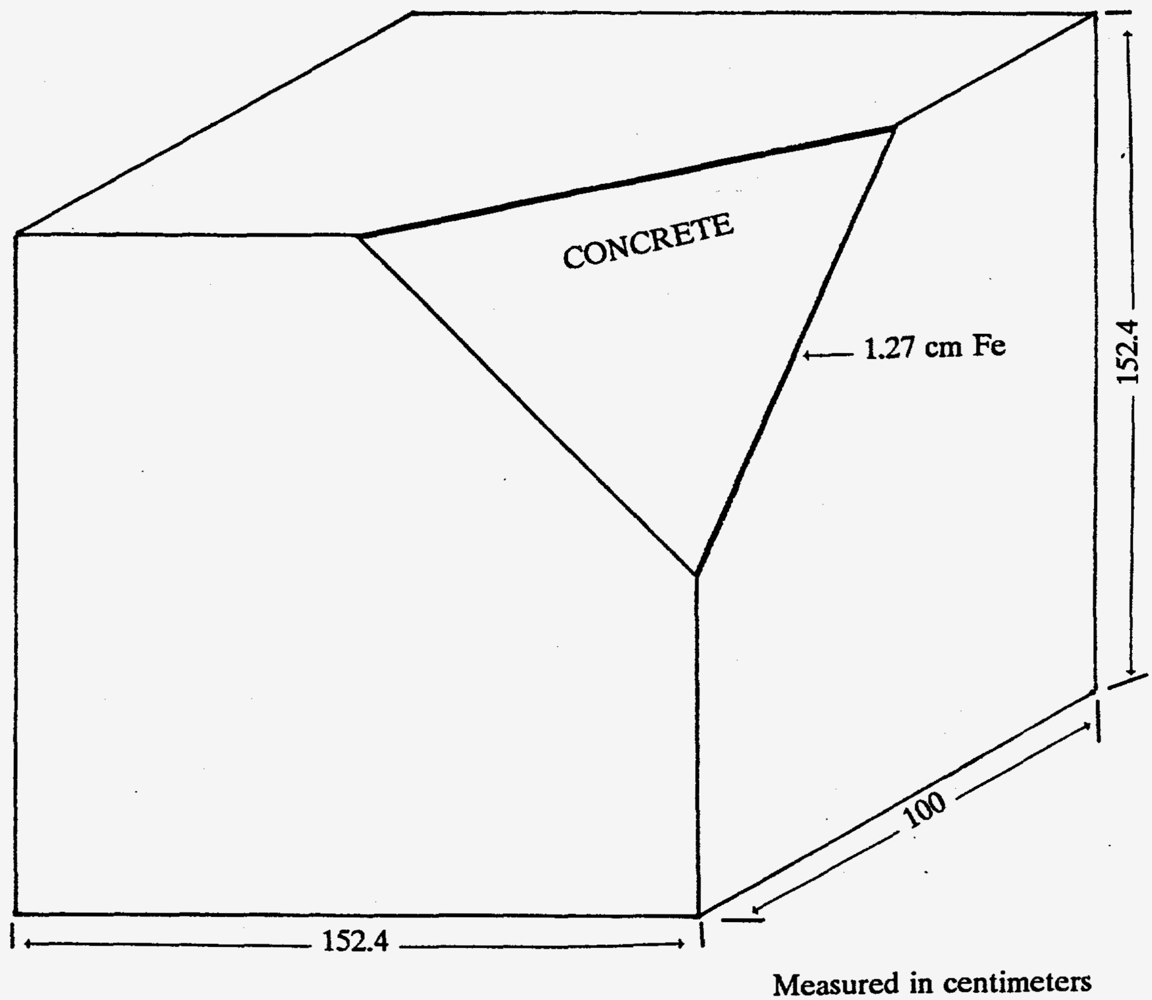


Figure 3. Schematic of the iron-lined, concrete-filled vessel.

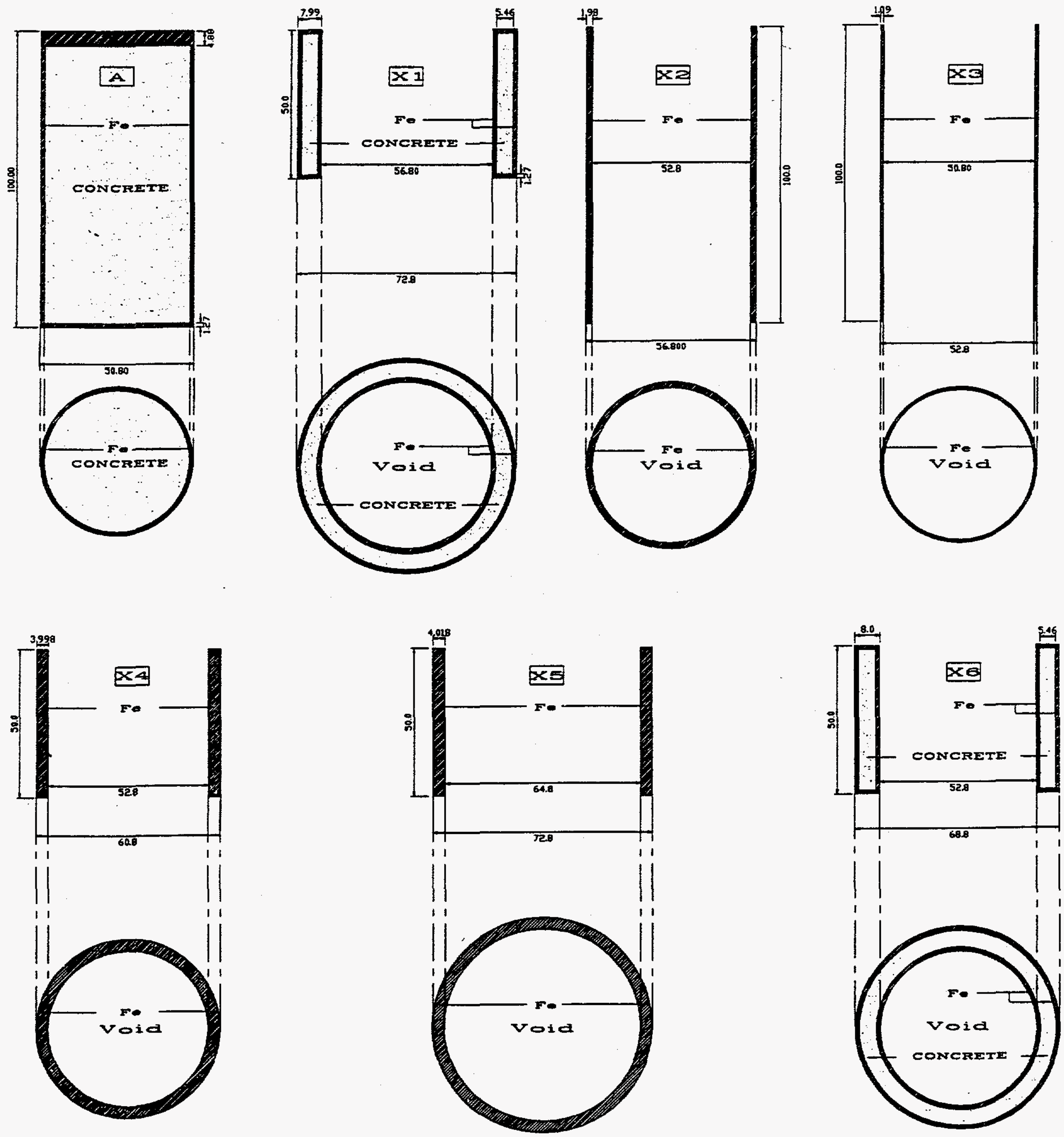


Figure 6. Schematic of the central cylinder and sleeves for the vessel with the gap.

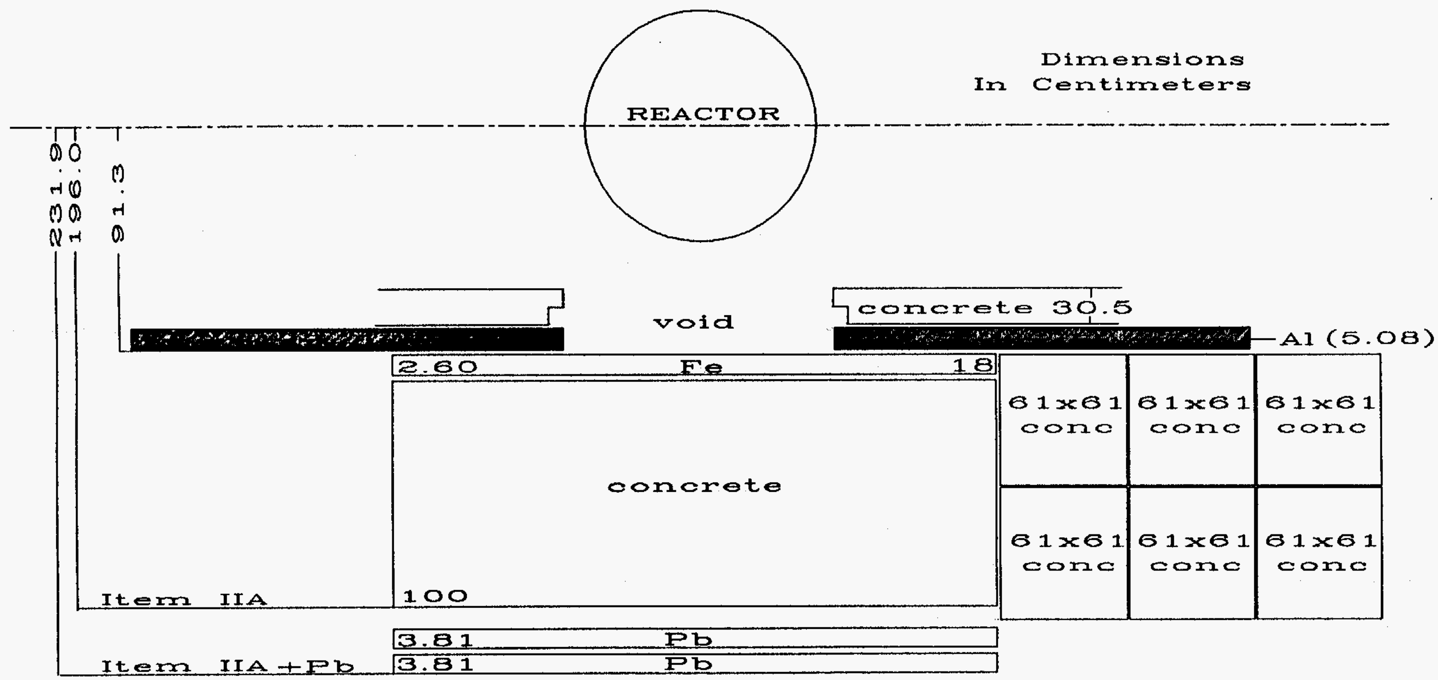


Figure 4. Schematic of the iron slab and solid concrete vessel (Item IIA).

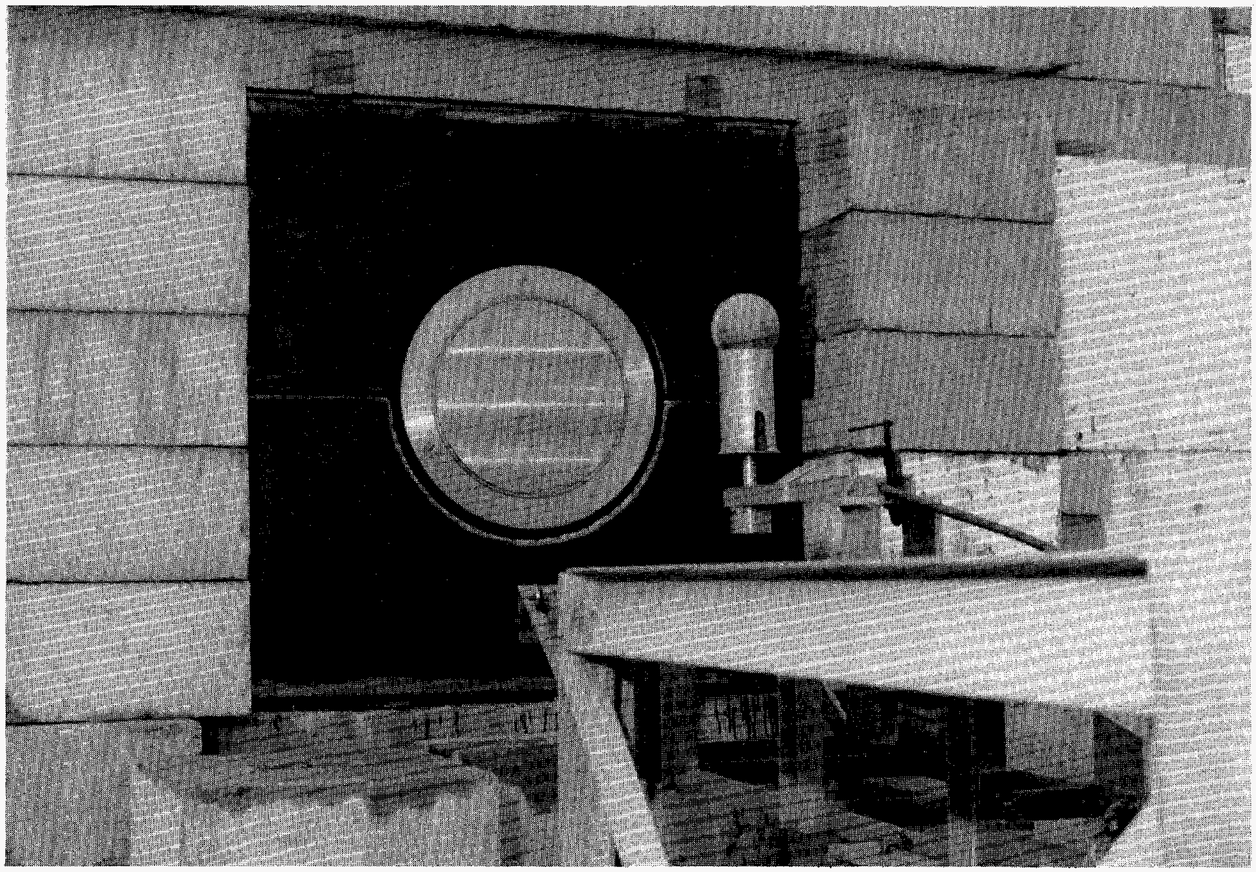


Figure 7. Photograph displaying the mockup for Item IIIG and the Bonner ball traversing mechanism.

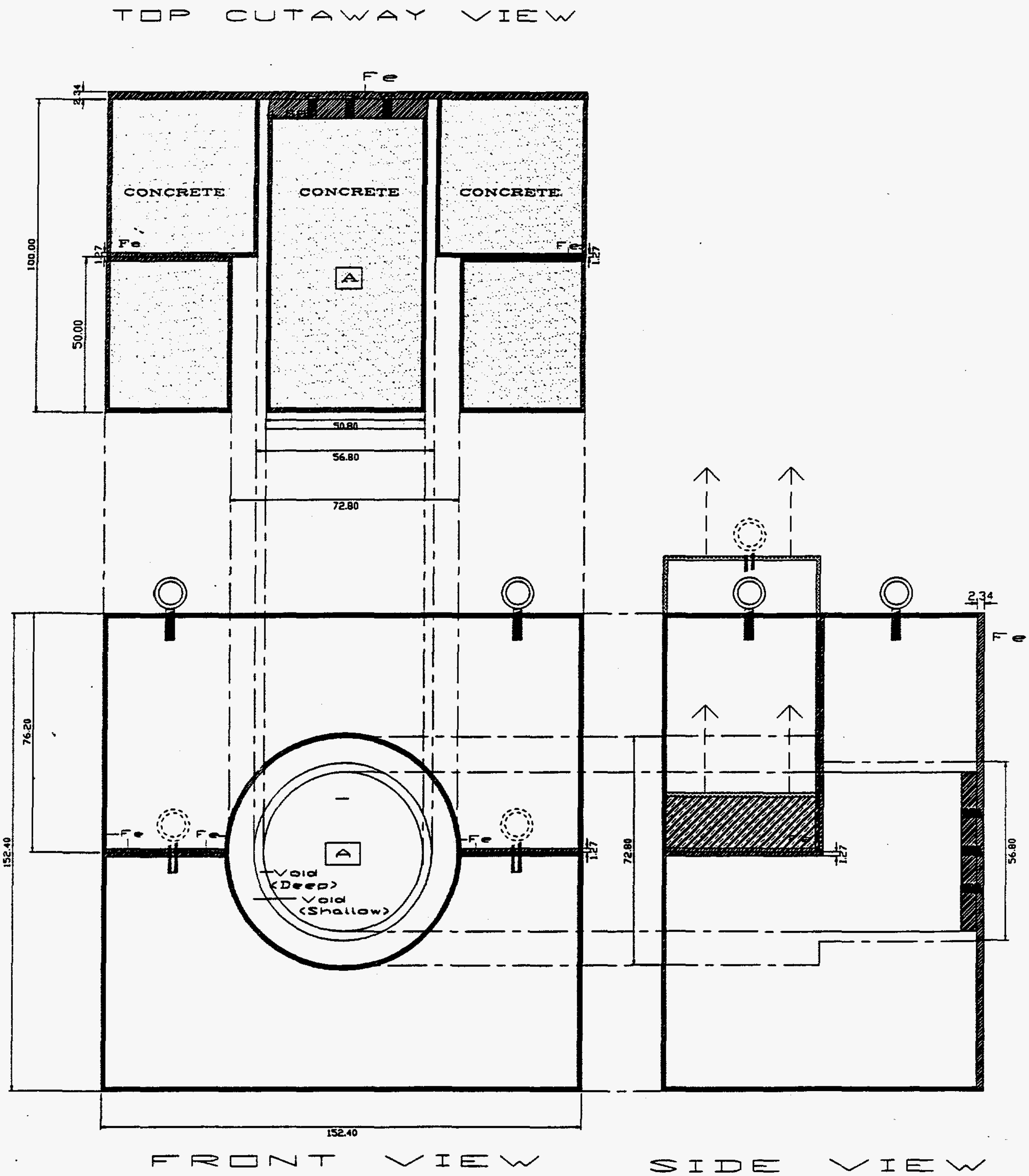


Figure 5. Schematic of the concrete vessel containing annular slits.

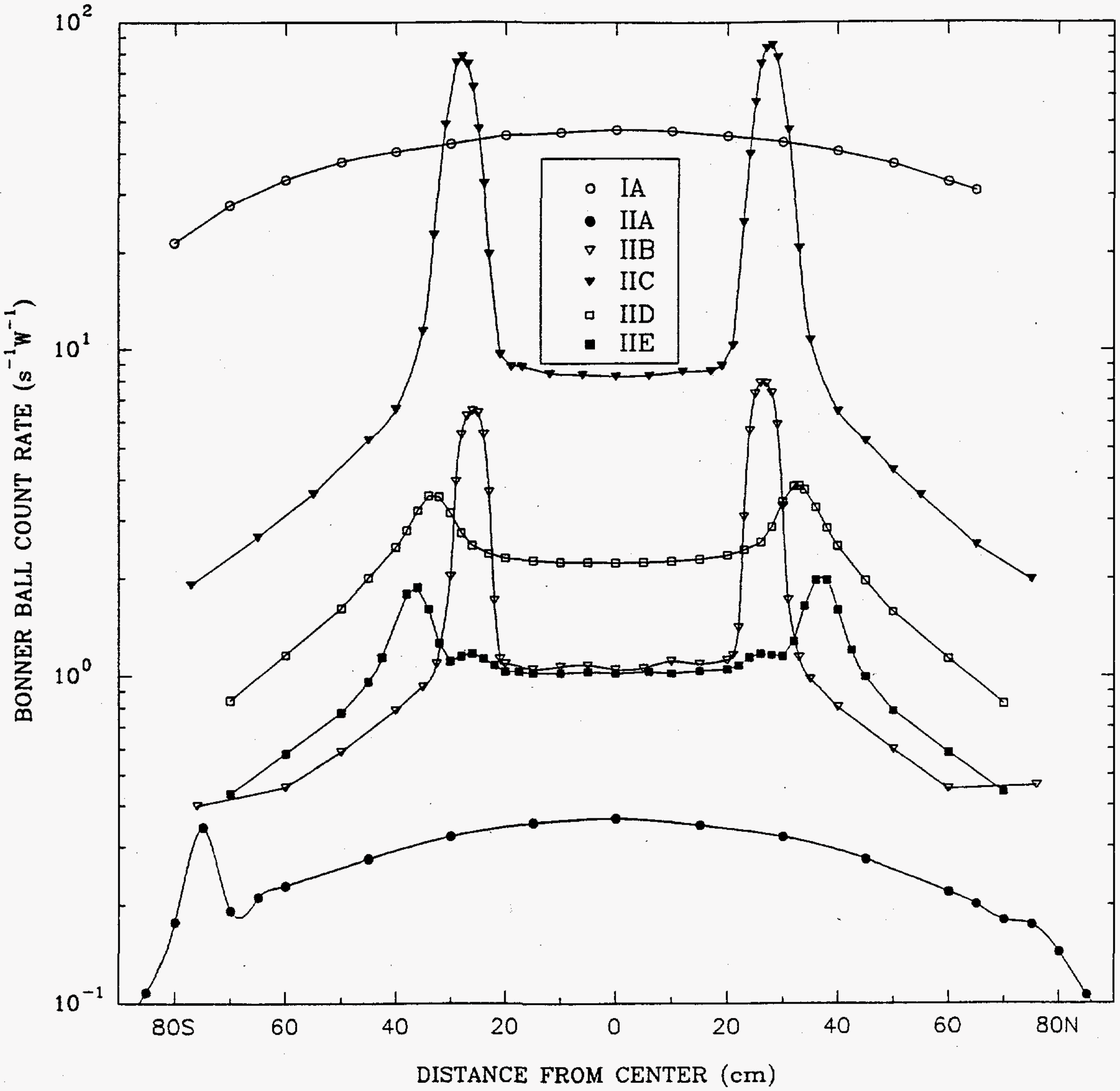


Figure 8. Radial traverses with the 3-inch Bonner ball at 30 cm behind the SM-2 (Item IA) and the concrete vessels (Items IIA-E).

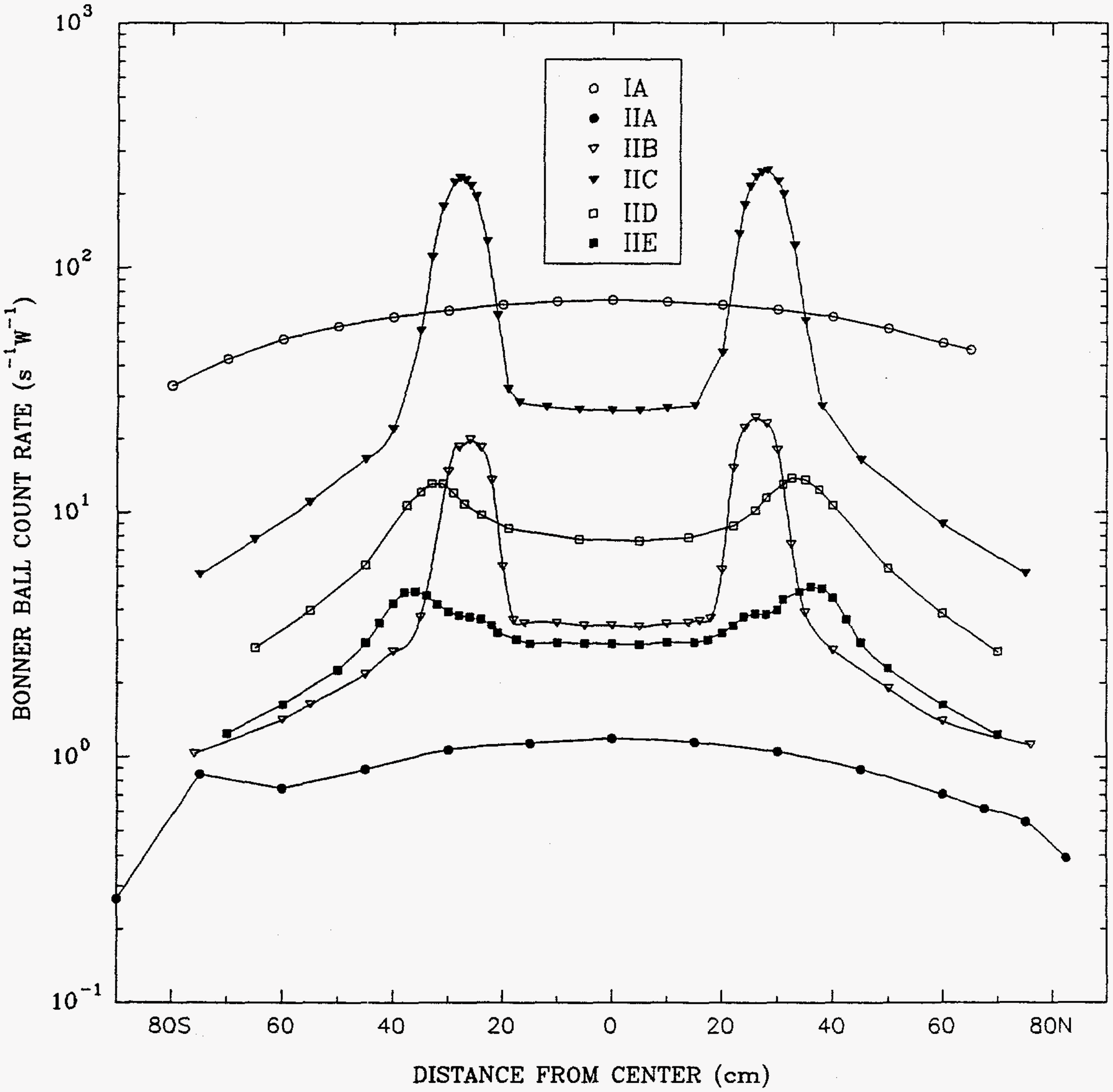


Figure 9. Radial traverses with the 5-inch Bonner ball at 30 cm behind the SM-2 (Item IA) and the concrete vessels (Items IIA-E).

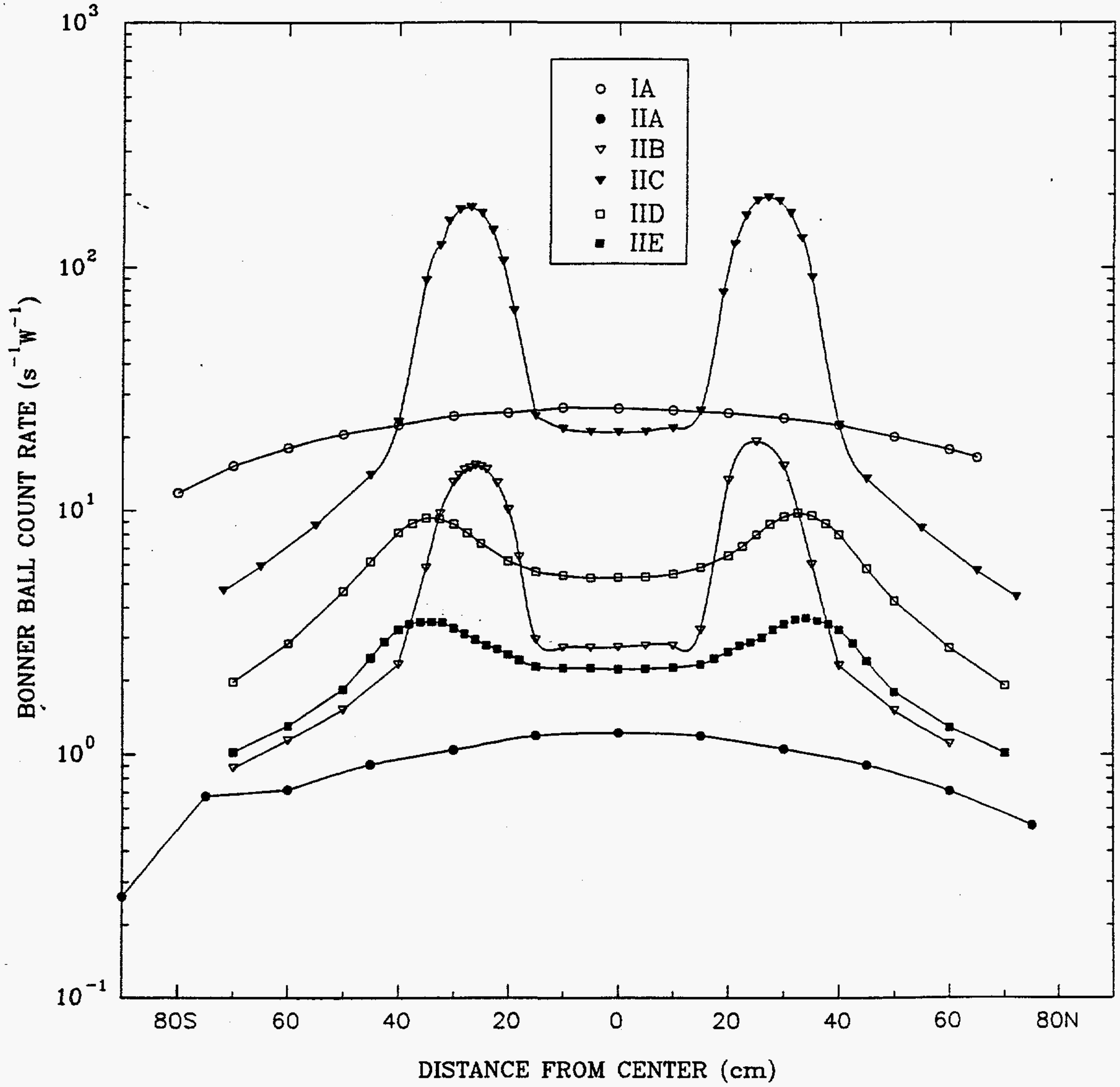


Figure 10. Radial traverses with the 8-inch Bonner ball at 30 cm behind the SM-2 (Item IA) and the concrete vessels (Items IIA-E).

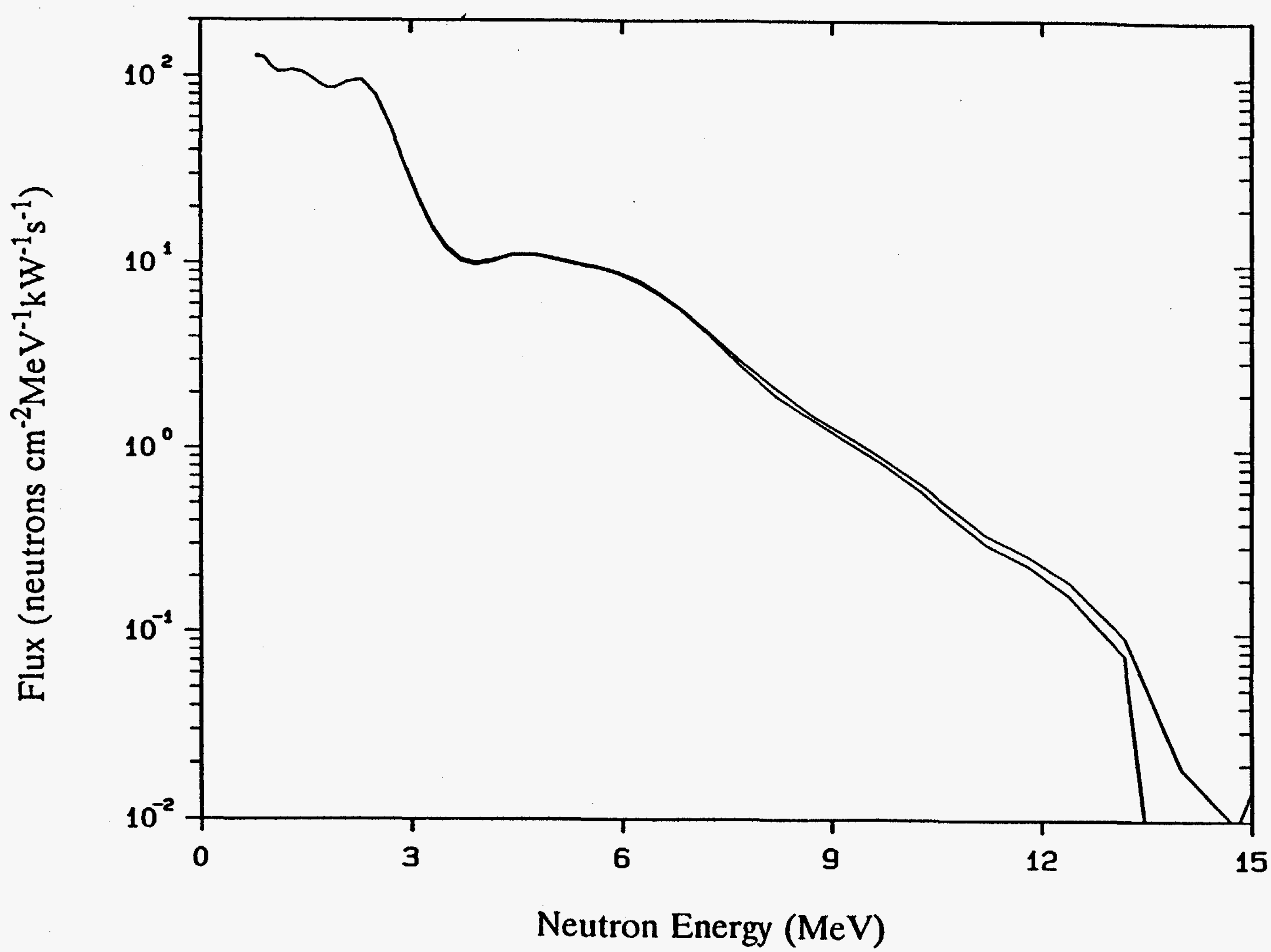


Figure 11. Spectrum of high-energy neutrons (>0.8 MeV) on centerline at 25 cm behind the lead slabs (Item IIA) Run 7925A.

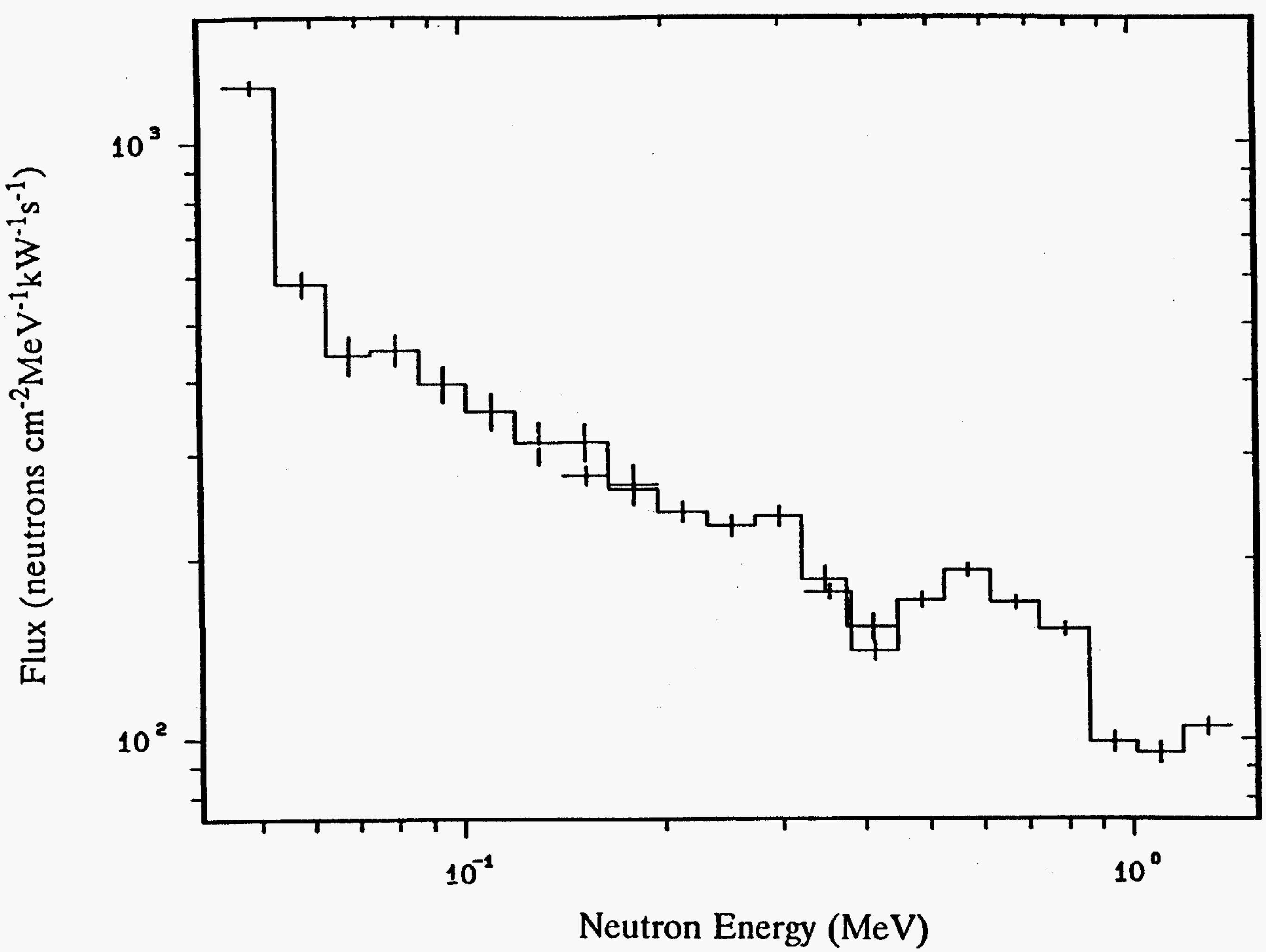


Figure 12. Neutron spectrum (50 keV to 1.4 MeV) on centerline at 25 cm behind the lead slabs (Item IIA) Runs 1594A, 1594B, 1595SUM.

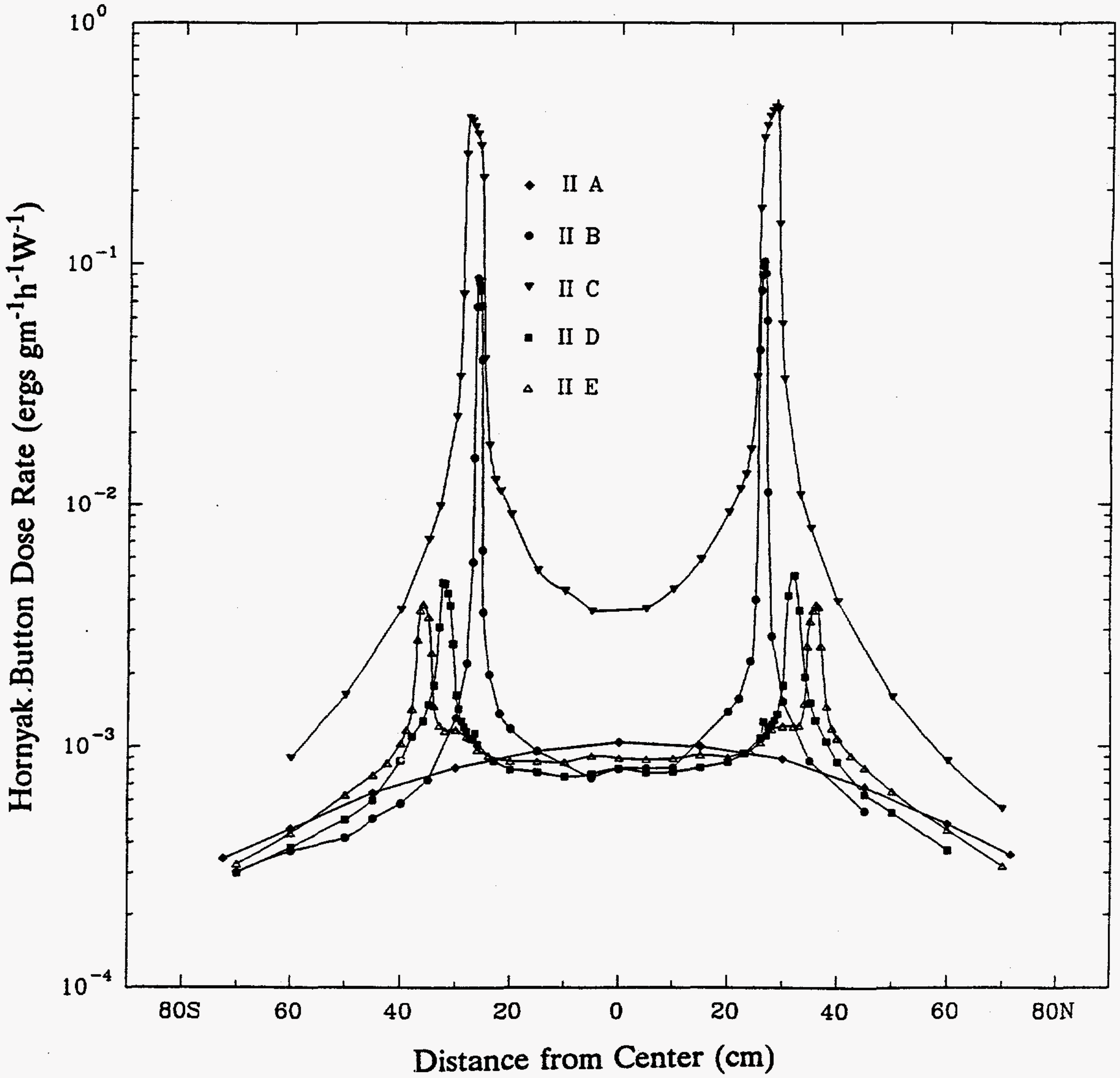


Figure 13. Radial traverses with the Hornyak button at 2 cm behind the concrete vessels (Items IIA-E).

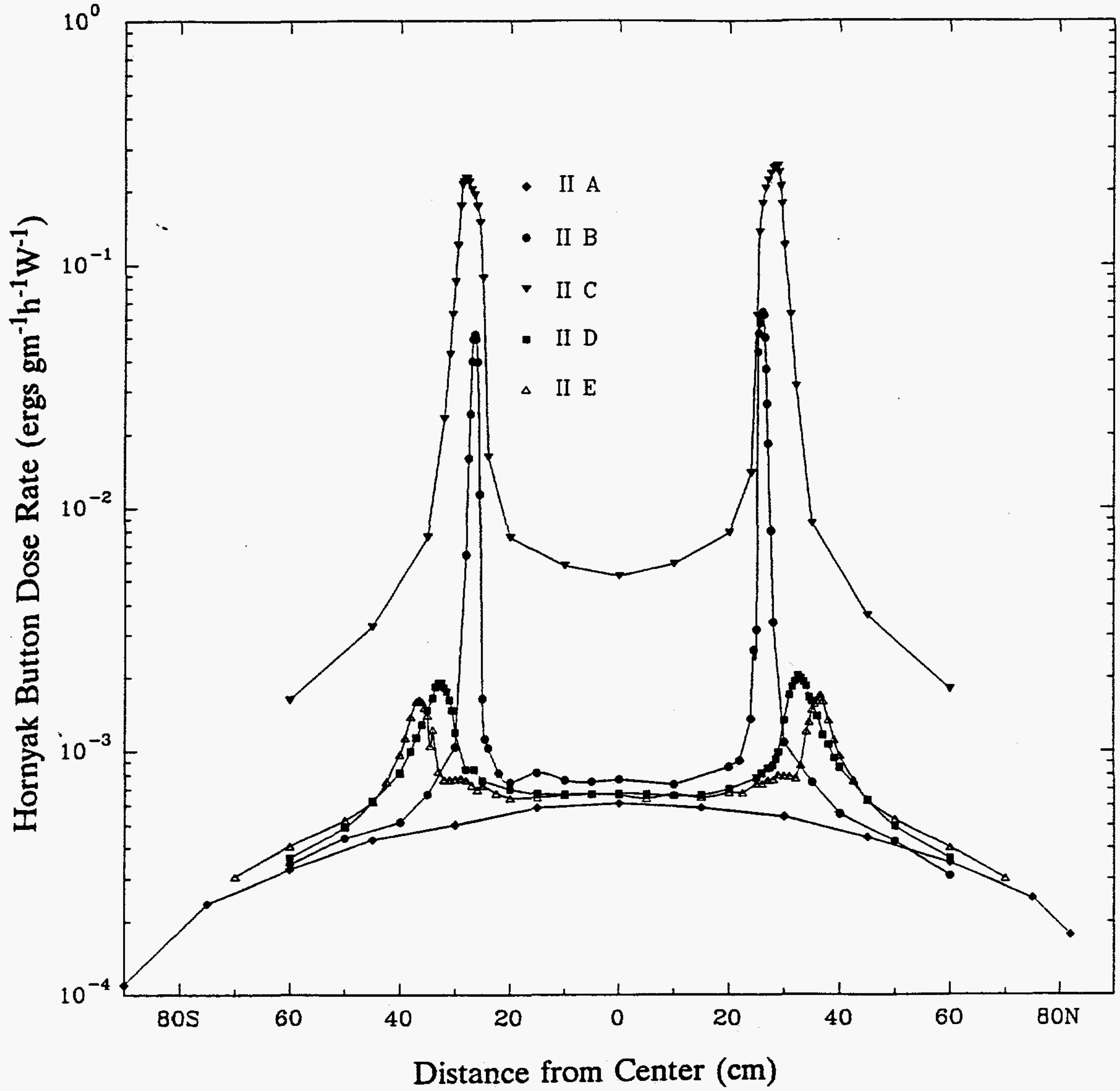


Figure 14. Radial traverses with the Hornyak button at 30 cm behind the concrete vessels (Items IIA-E).

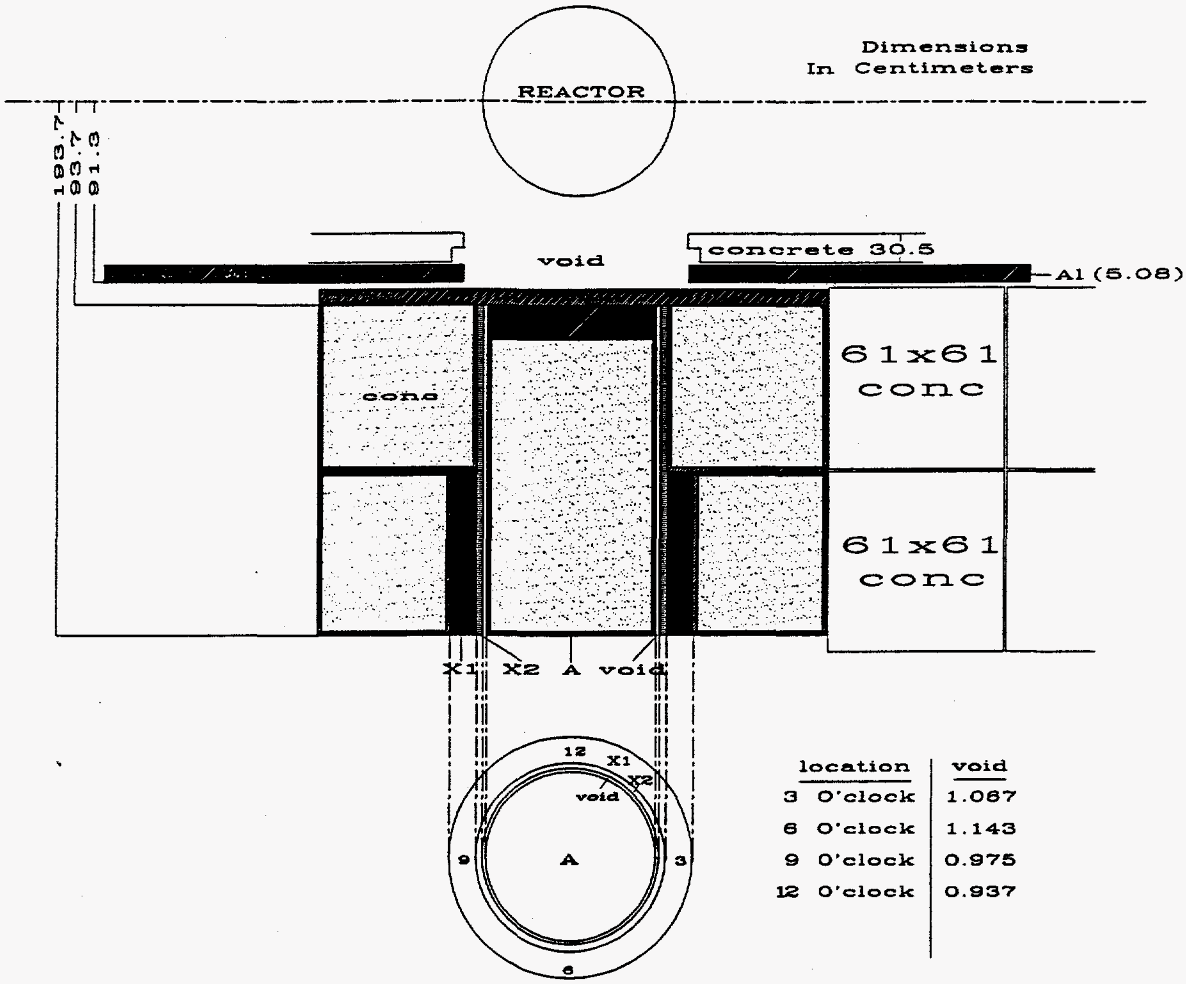
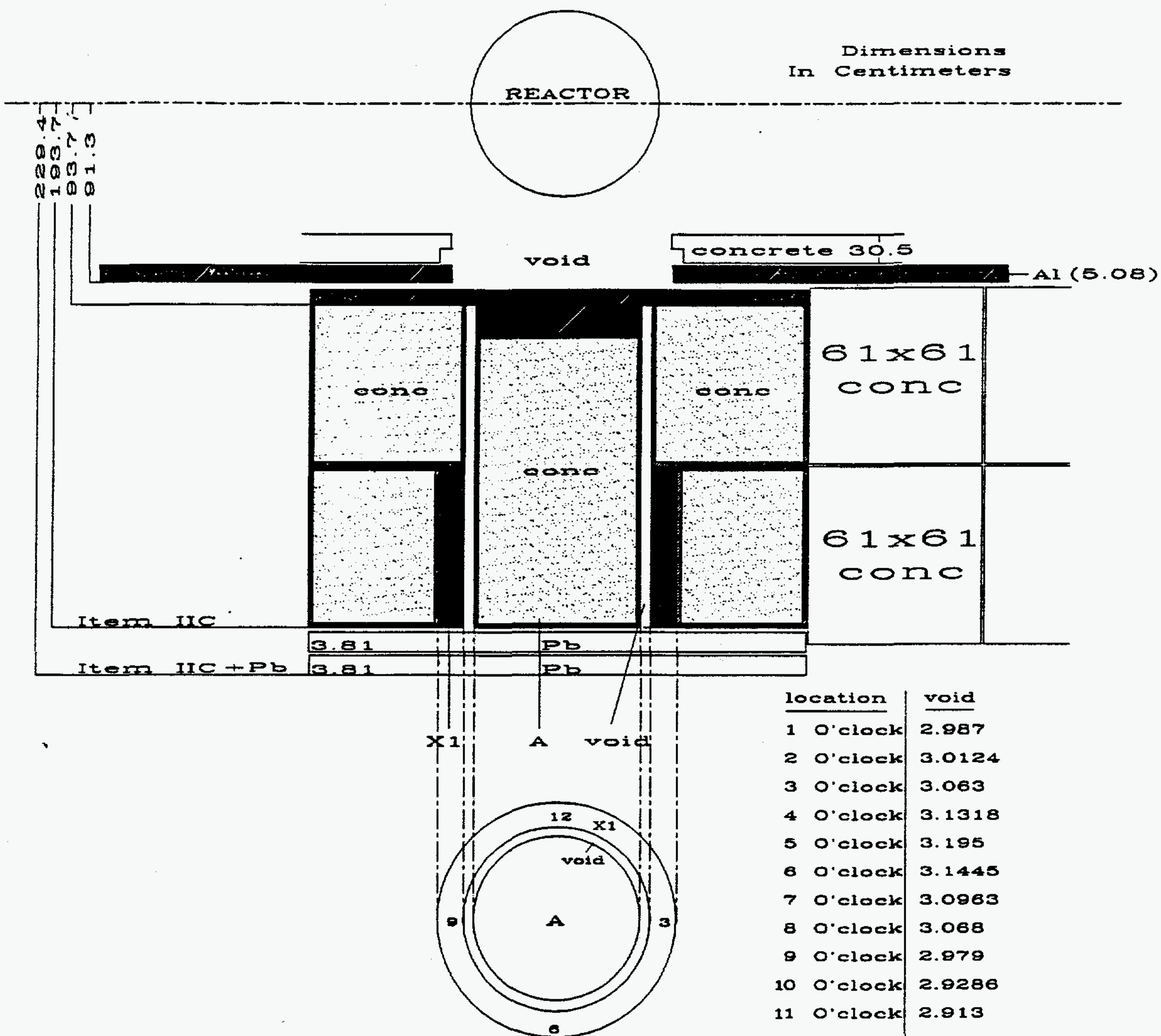


Figure 15. Schematic of the concrete vessel with an annular void plus sleeves X1 and X2 (Item IIB).



location	void
1 O'clock	2.987
2 O'clock	3.0124
3 O'clock	3.063
4 O'clock	3.1318
5 O'clock	3.195
6 O'clock	3.1445
7 O'clock	3.0963
8 O'clock	3.068
9 O'clock	2.979
10 O'clock	2.9286
11 O'clock	2.913
12 O'clock	2.921

Figure 16. Schematic of the concrete vessel with an annular void plus sleeve X1 (Item IIC).

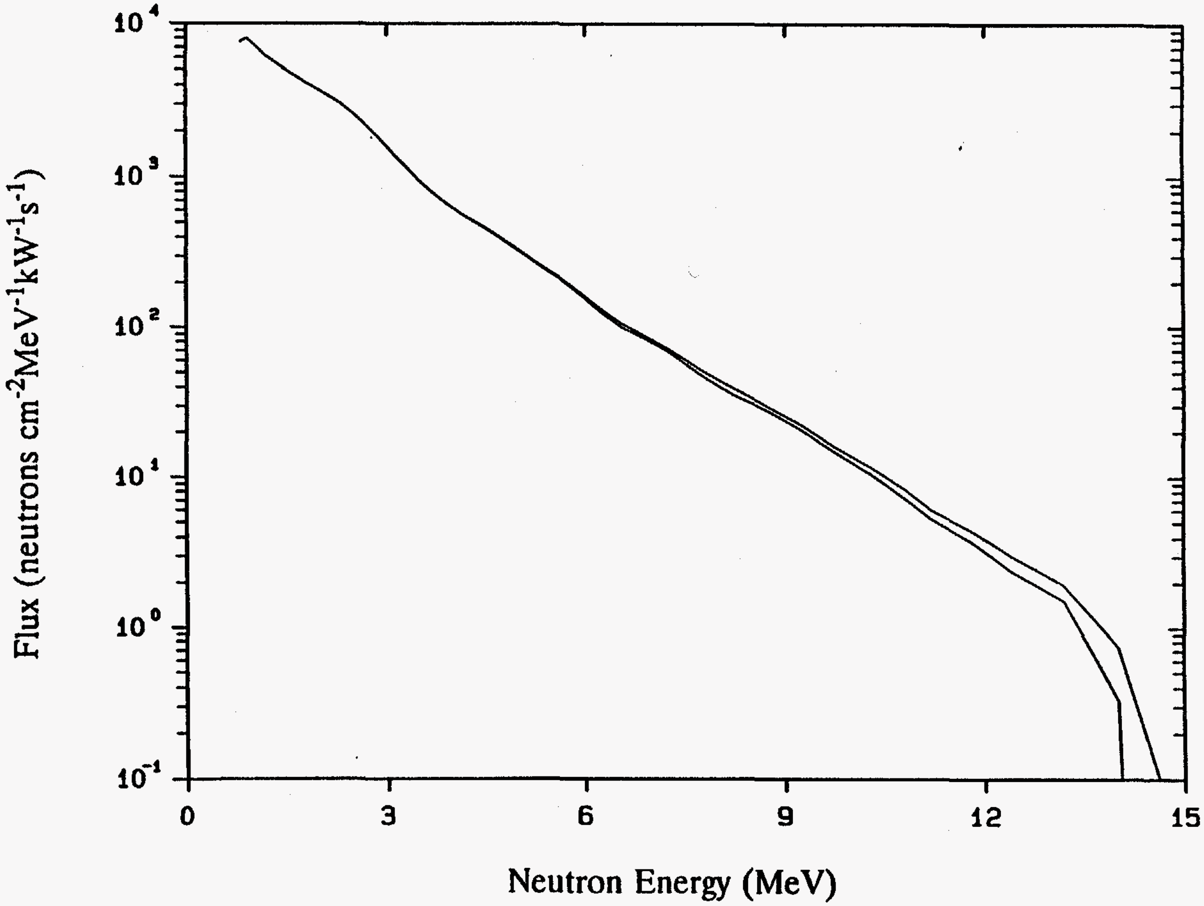


Figure 17. Spectrum of high-energy neutrons (>0.8 MeV) on centerline at 25 cm behind the lead slabs (Item IIC) Run 7926A.

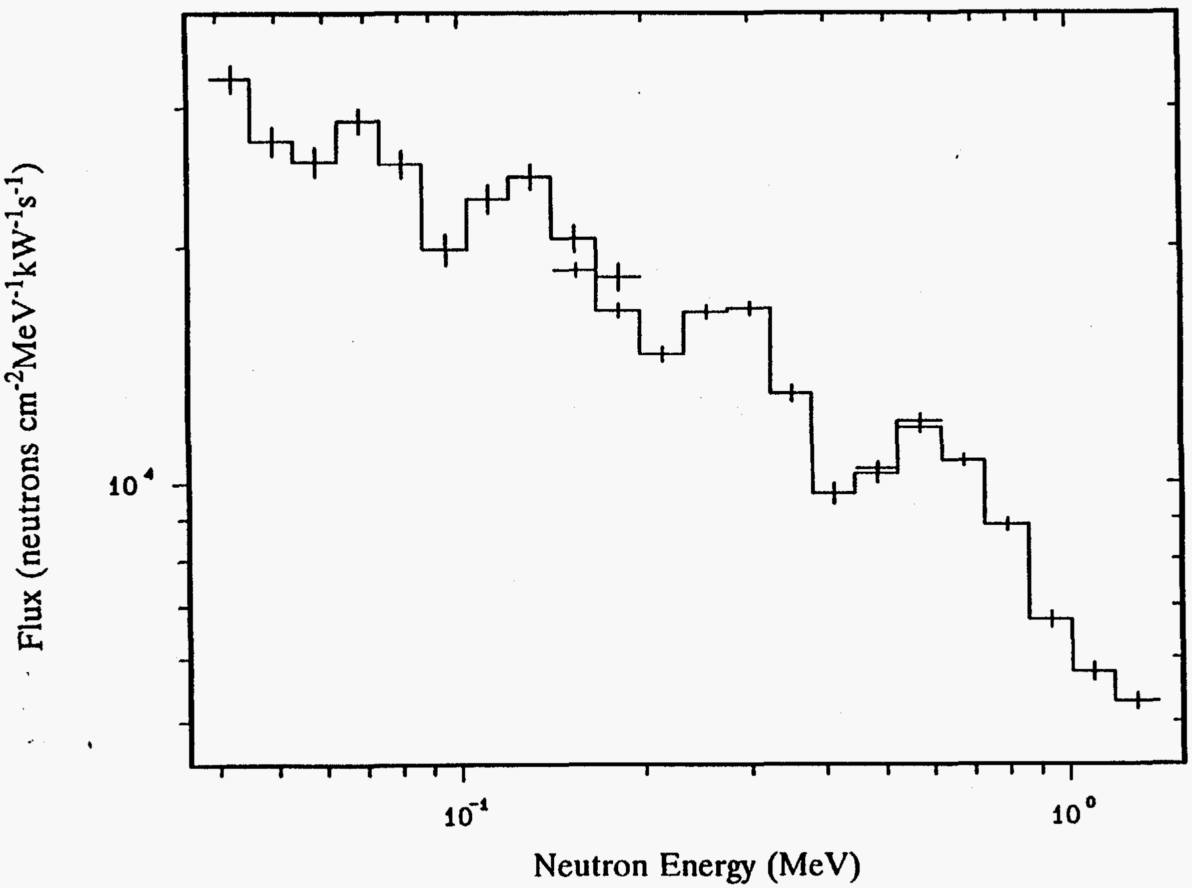


Figure 18. Neutron spectrum (50 keV to 1.4 MeV) on centerline at 25 cm behind the lead slabs (Item IIC) Runs 1596A, 1597A, 1597B.

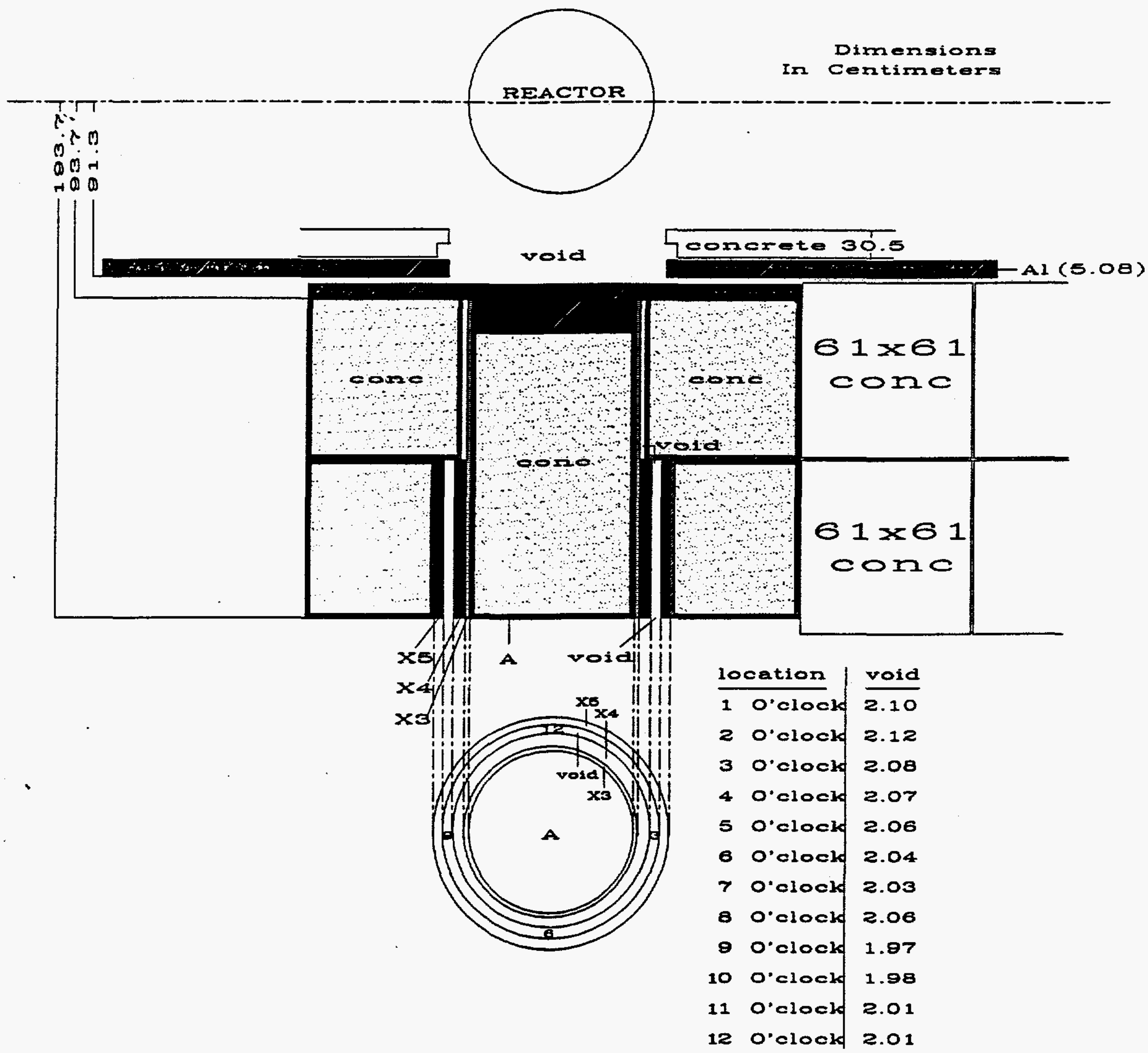
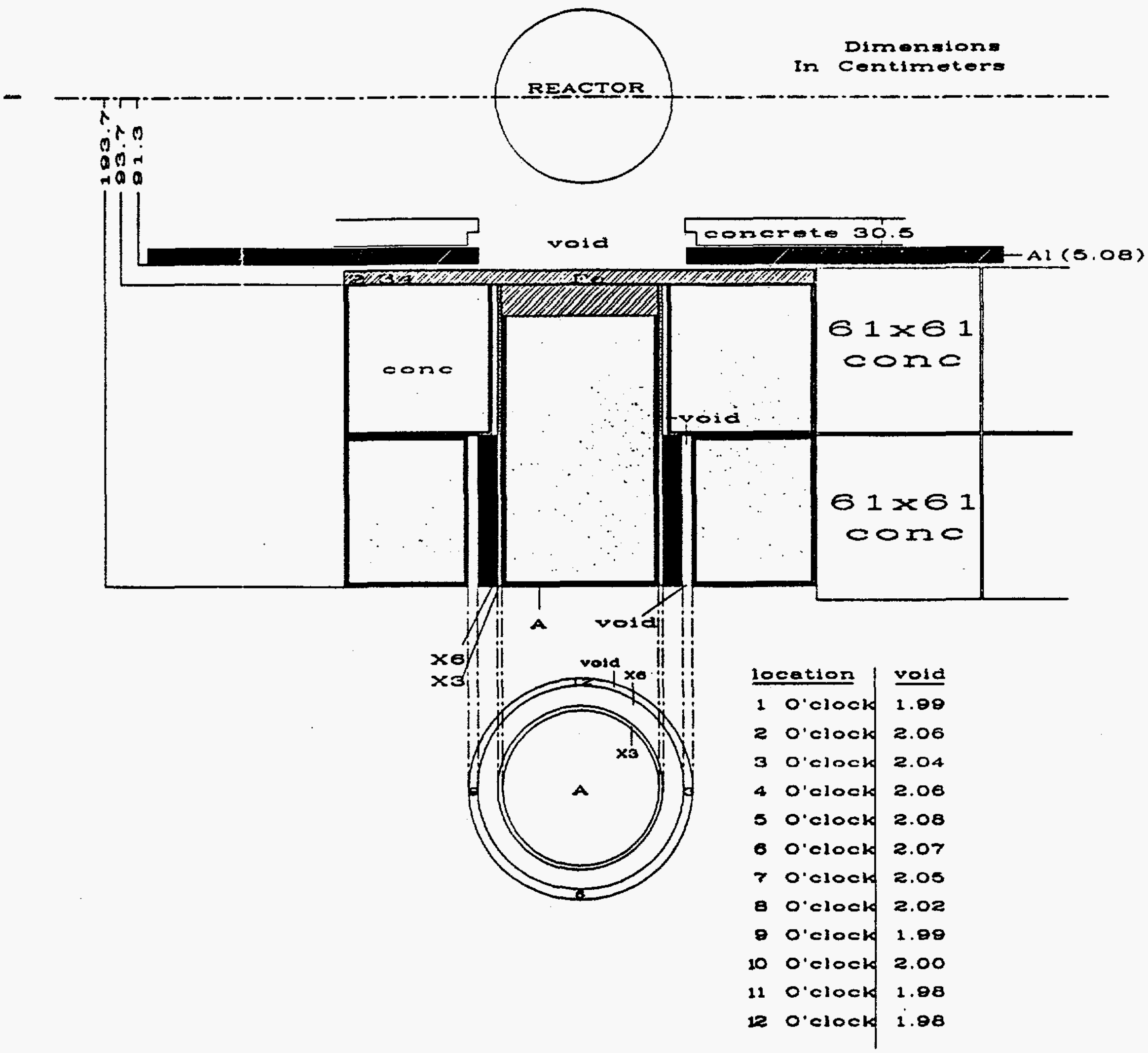


Figure 19. Schematic of the concrete vessel with an annular void plus sleeves X3, X4, and X5 (Item IID).



location	void
1 O'clock	1.99
2 O'clock	2.06
3 O'clock	2.04
4 O'clock	2.06
5 O'clock	2.08
6 O'clock	2.07
7 O'clock	2.05
8 O'clock	2.02
9 O'clock	1.99
10 O'clock	2.00
11 O'clock	1.98
12 O'clock	1.98

Figure 20. Schematic of the concrete vessel with an annular void plus sleeves X3 and X6 (Item IIE).

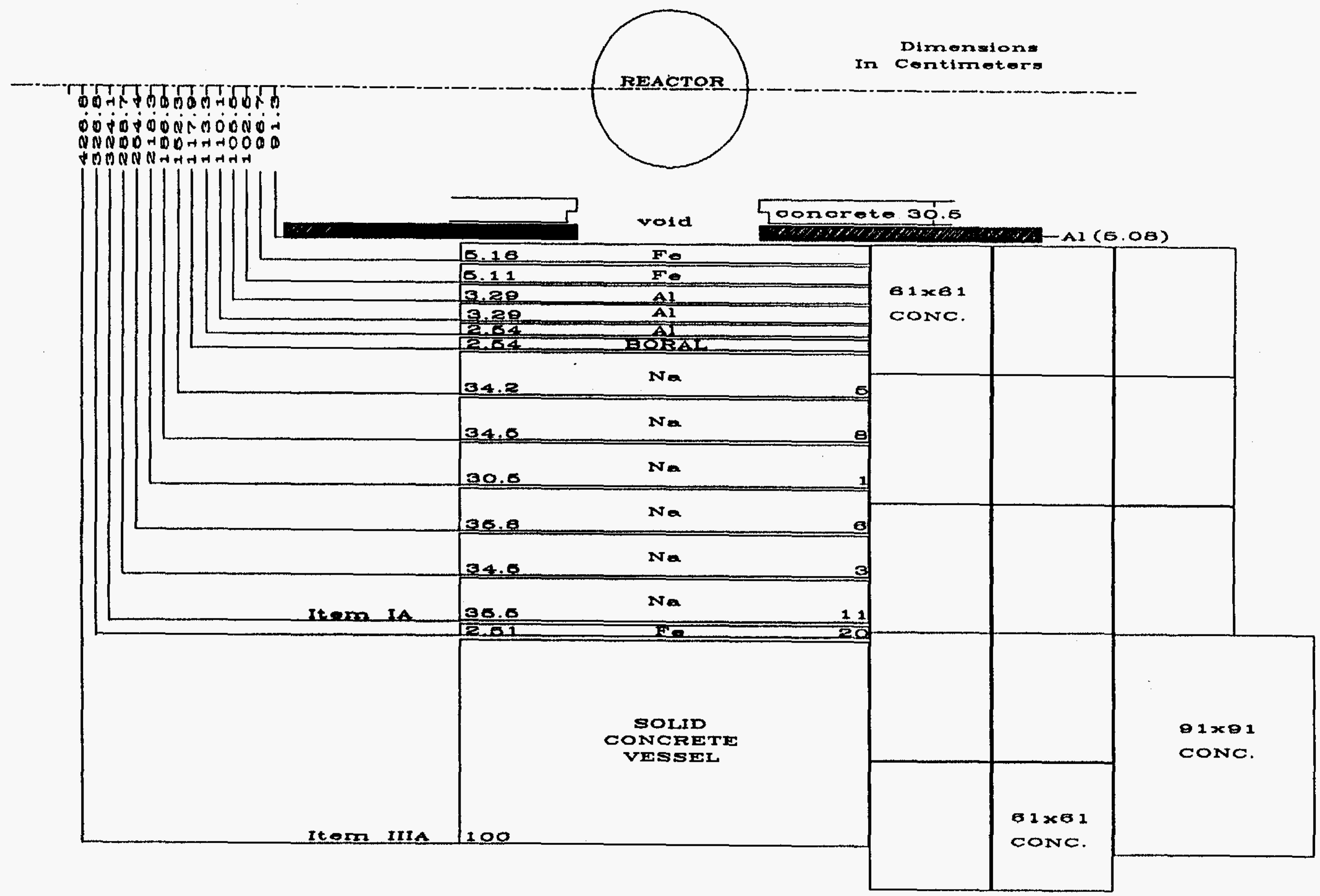


Figure 21. Schematic of the SM-2 (Item IA) plus the iron slab and solid concrete vessel (Item IIIA).

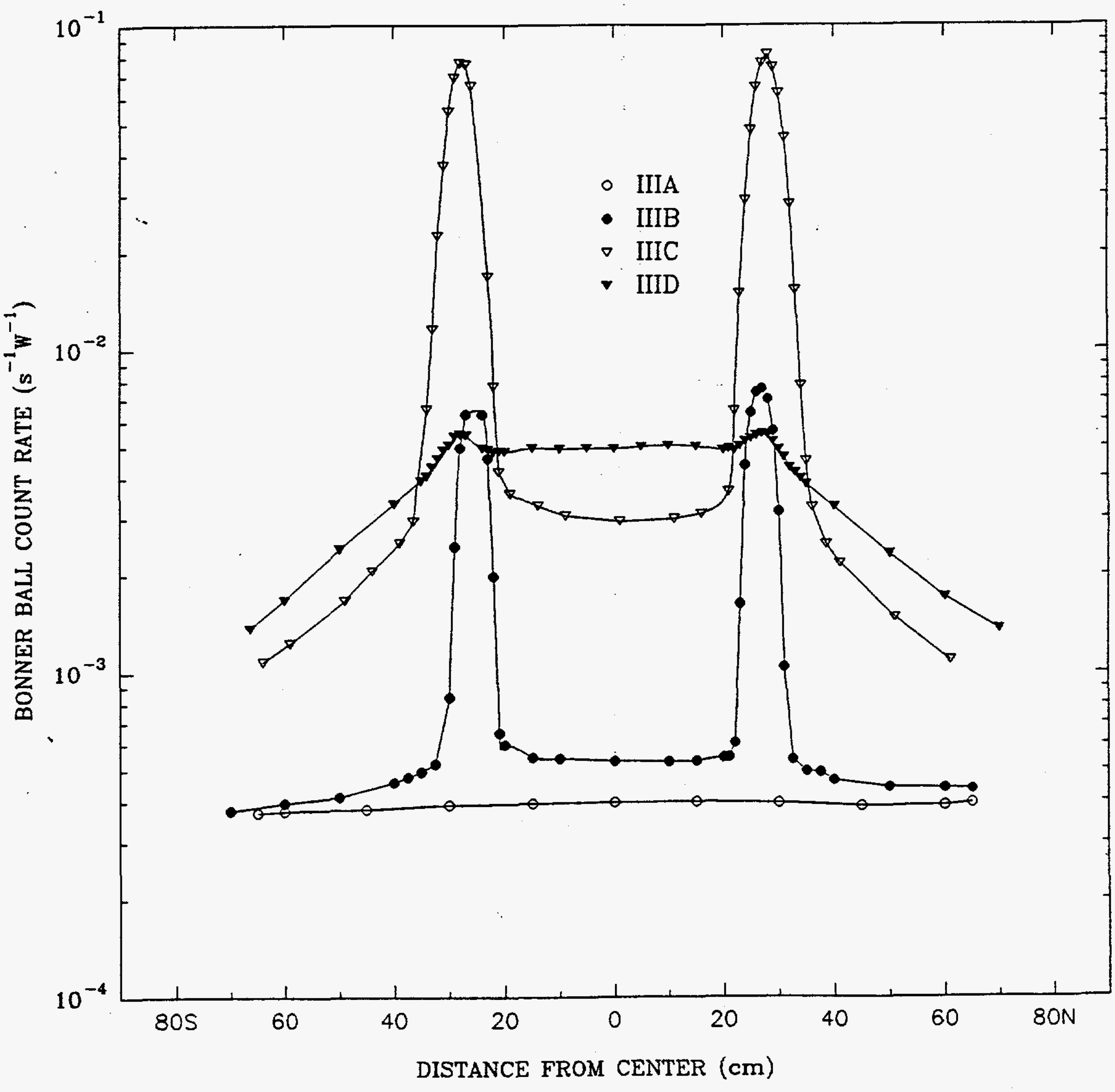


Figure 22. Radial traverses with the 3-inch Bonner ball at 30 cm behind the SM-2 plus the concrete vessels (Items IIIA-D).

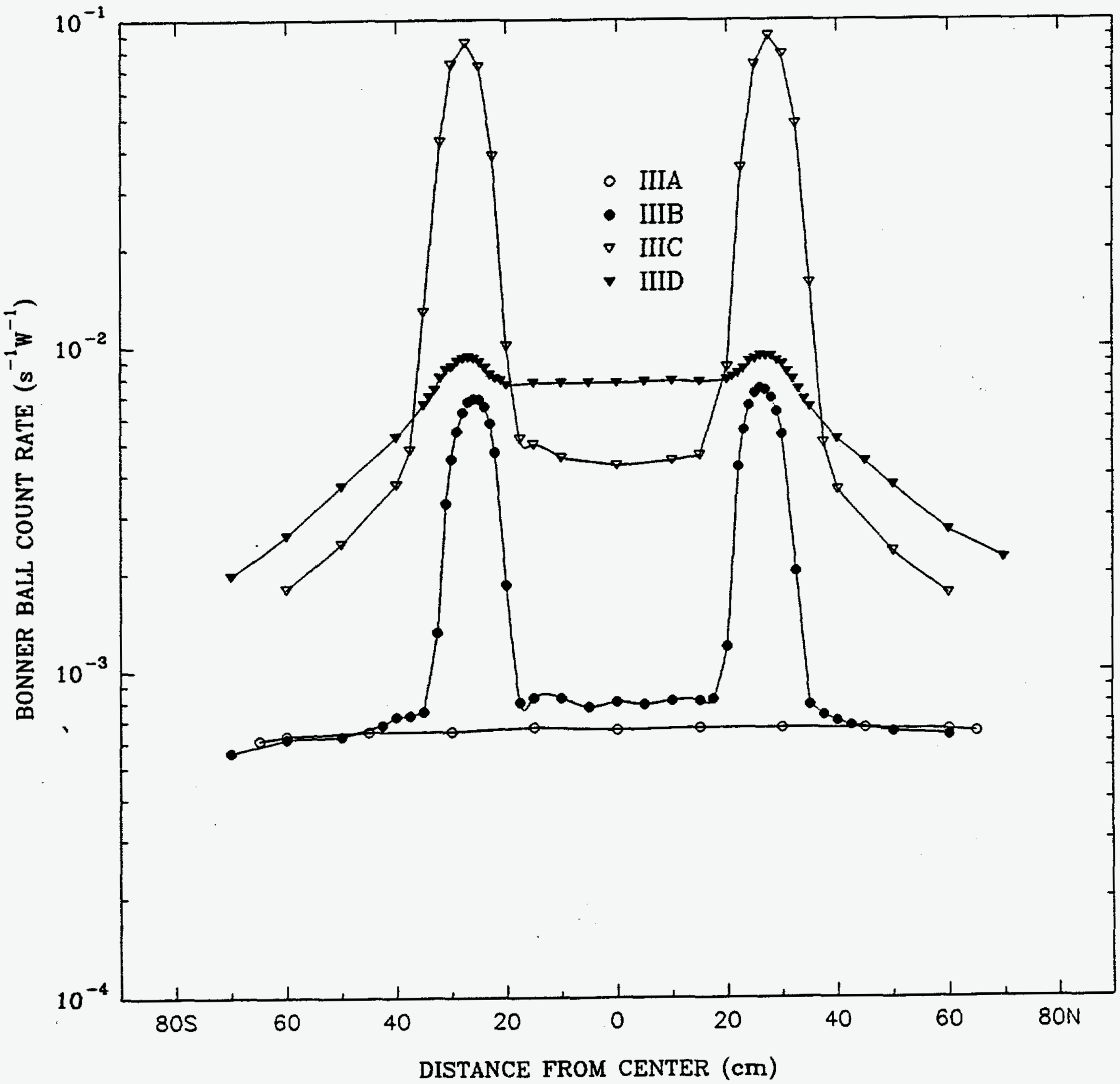


Figure 23. Radial traverses with the 5-inch Bonner ball at 30 cm behind the SM-2 plus the concrete vessels (Items IIIA-D).

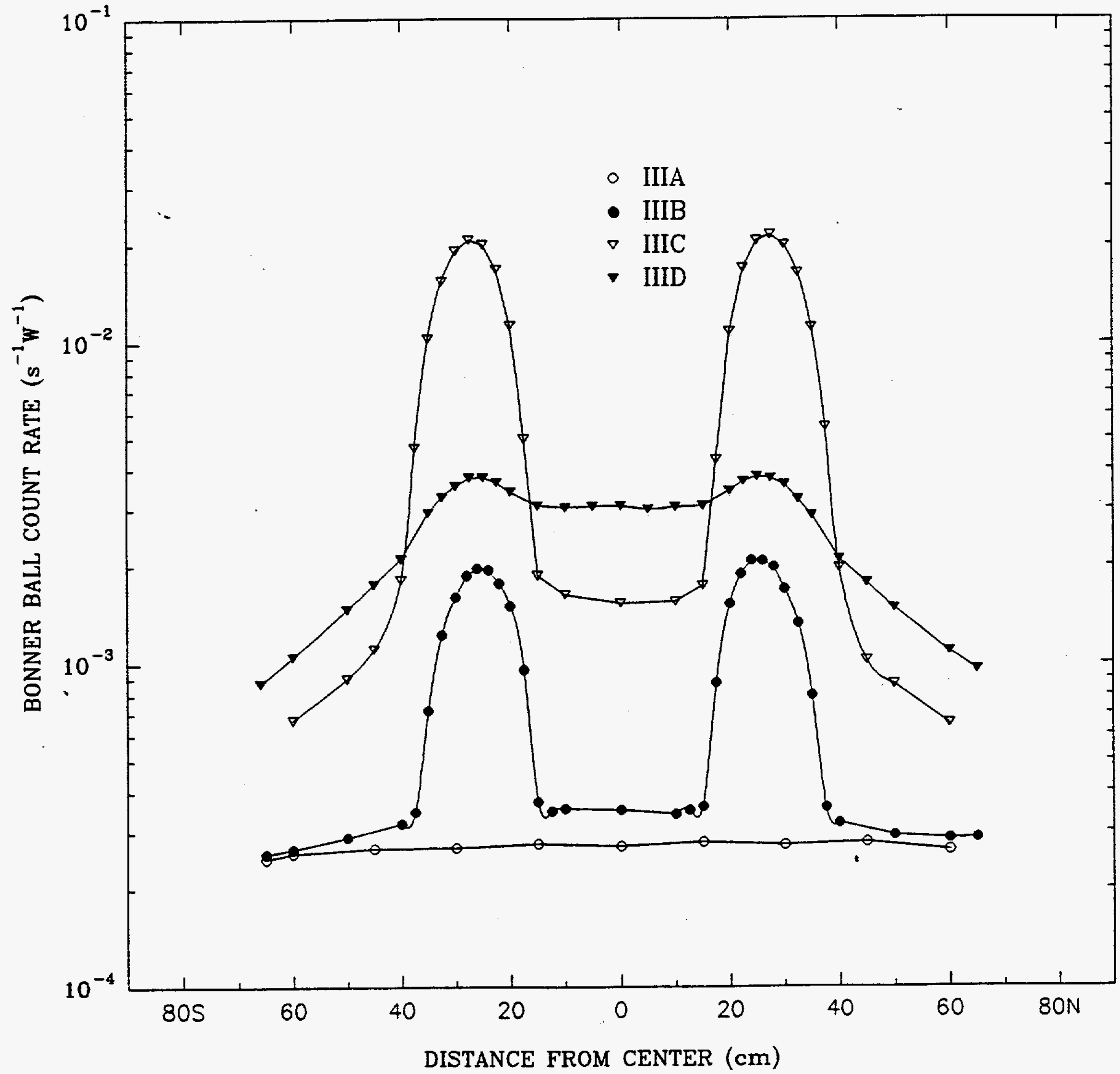


Figure 24. Radial traverses with the 8-inch Bonner ball at 30 cm behind the SM-2 plus the concrete vessels (Items IIIA-D).

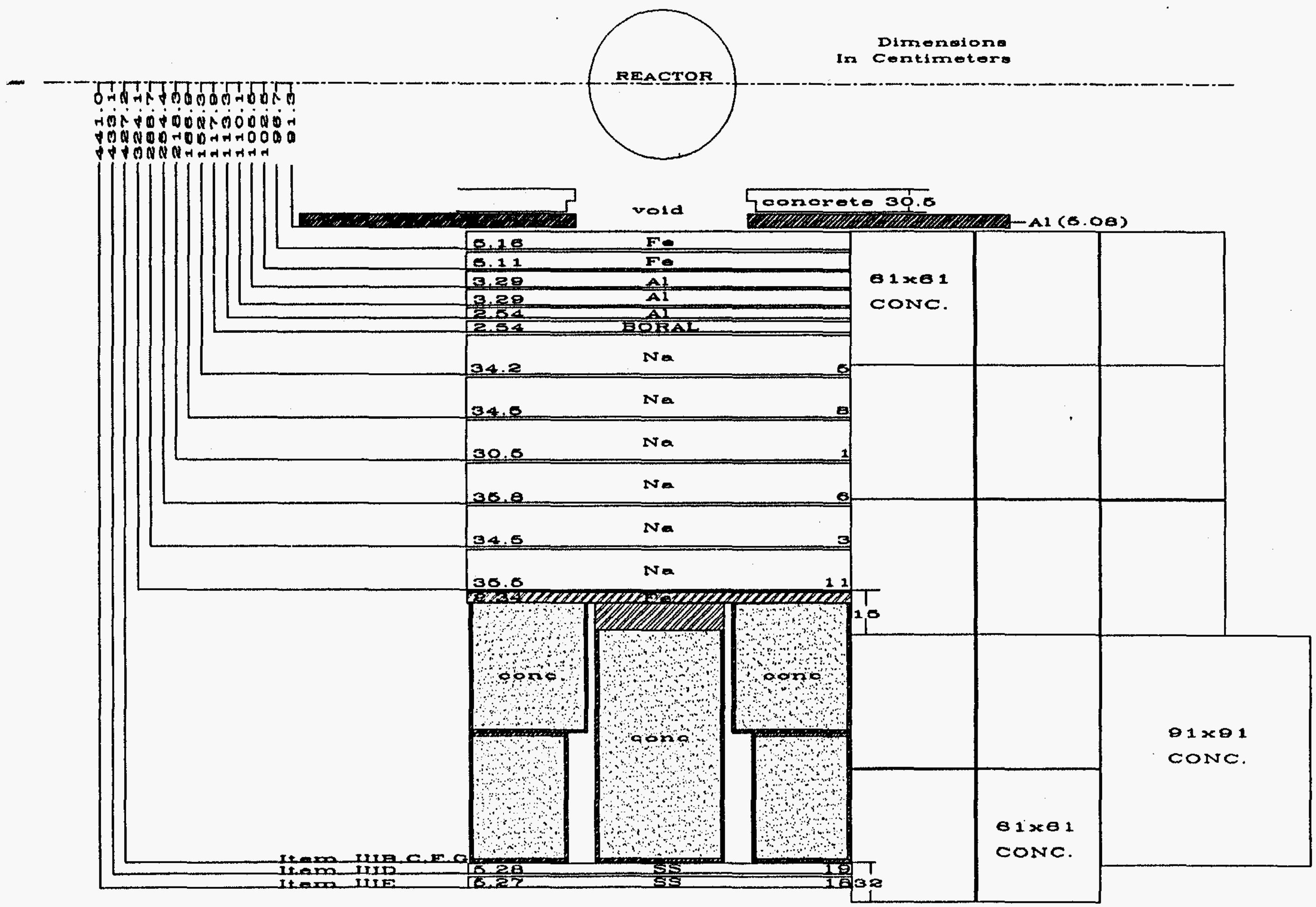


Figure 25. Schematic of the SM-2 plus the concrete vessel with an annular void (Items IIIB-G).

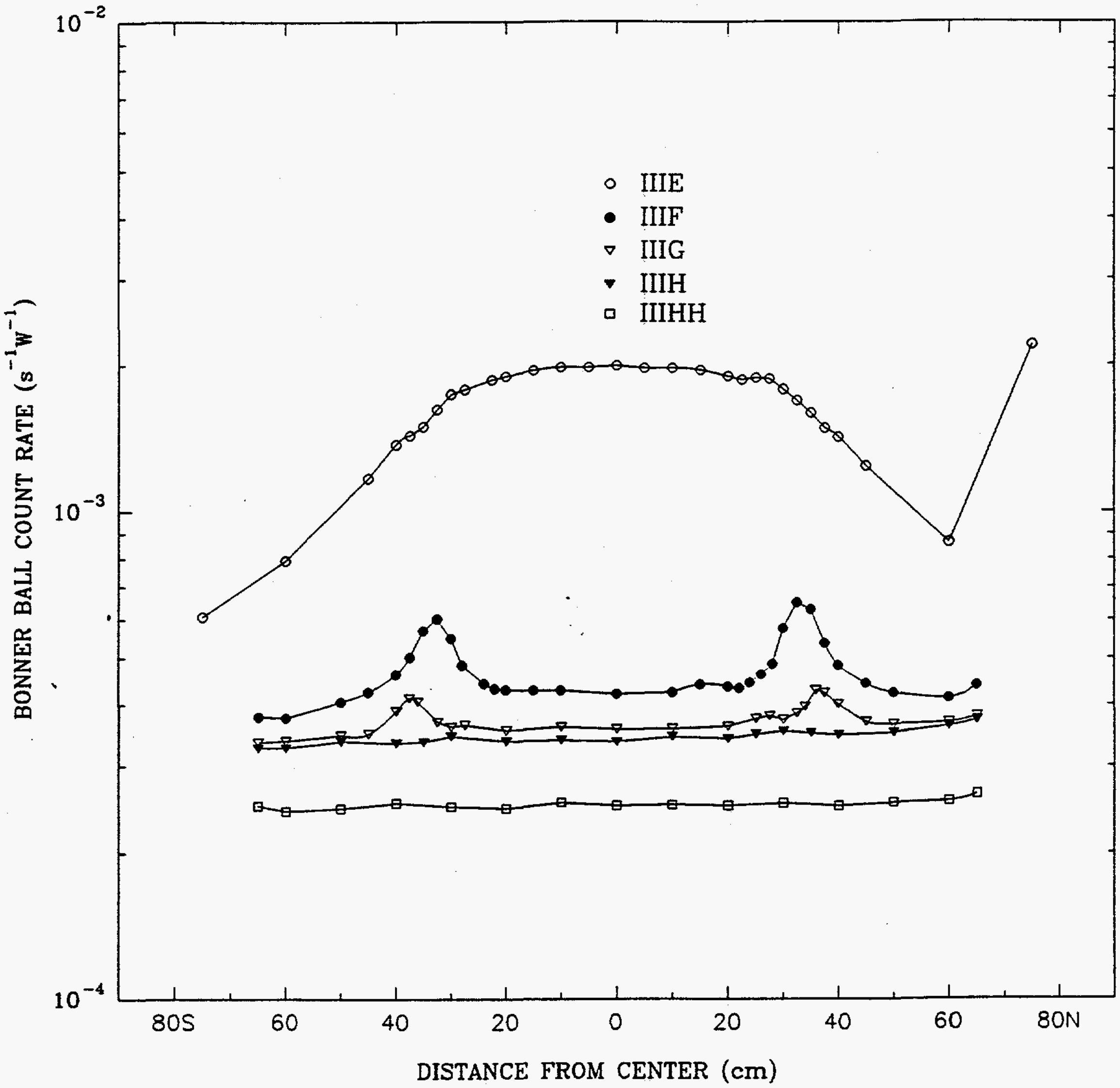


Figure 26. Radial traverses with the 3-inch Bonner ball at 30 cm behind the SM-2 and the concrete vessel (Items IIIE-HH).

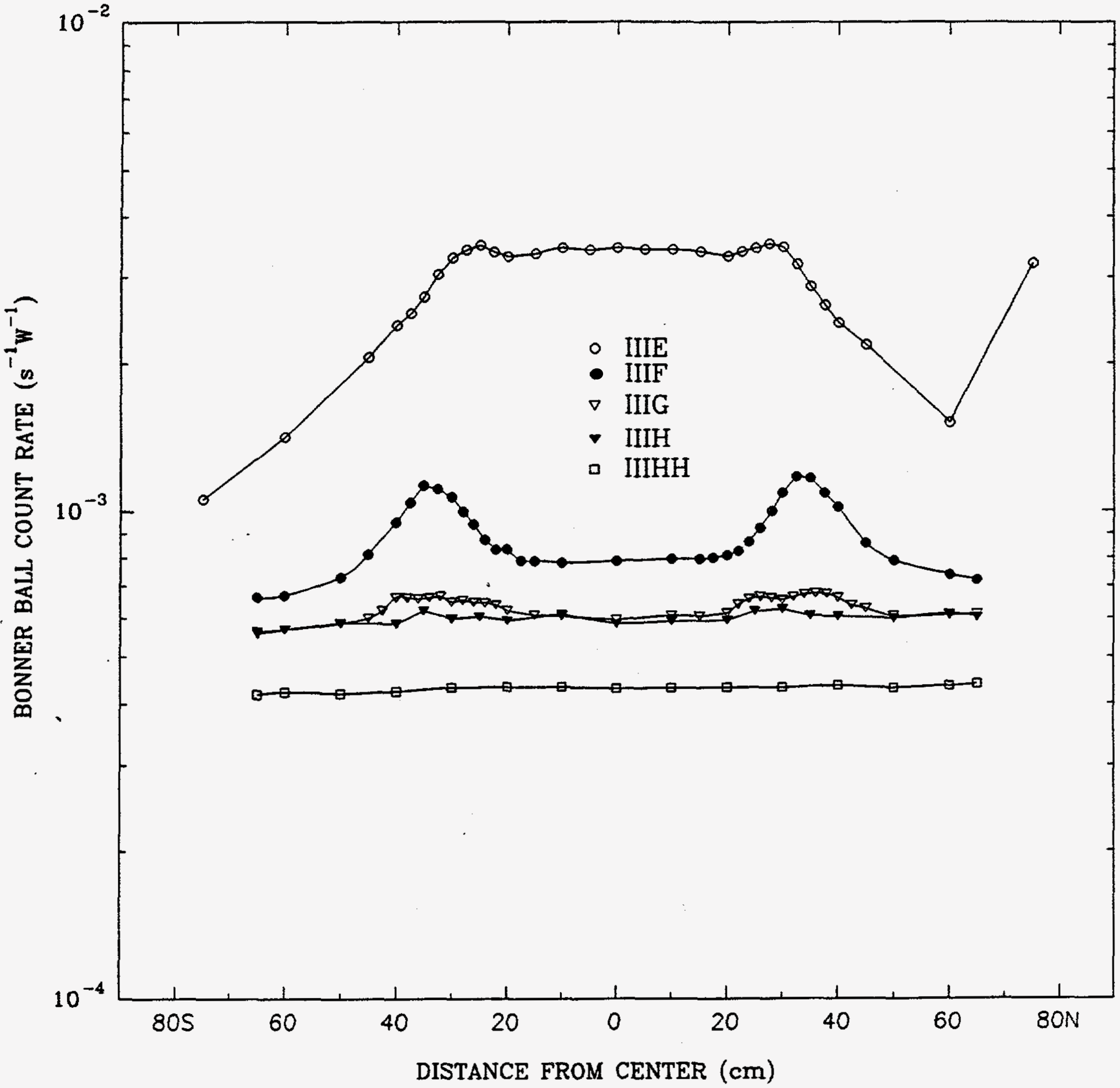


Figure 27. Radial traverses with the 5-inch Bonner ball at 30 cm behind the SM-2 and the concrete vessel (Items IIIE-HH).

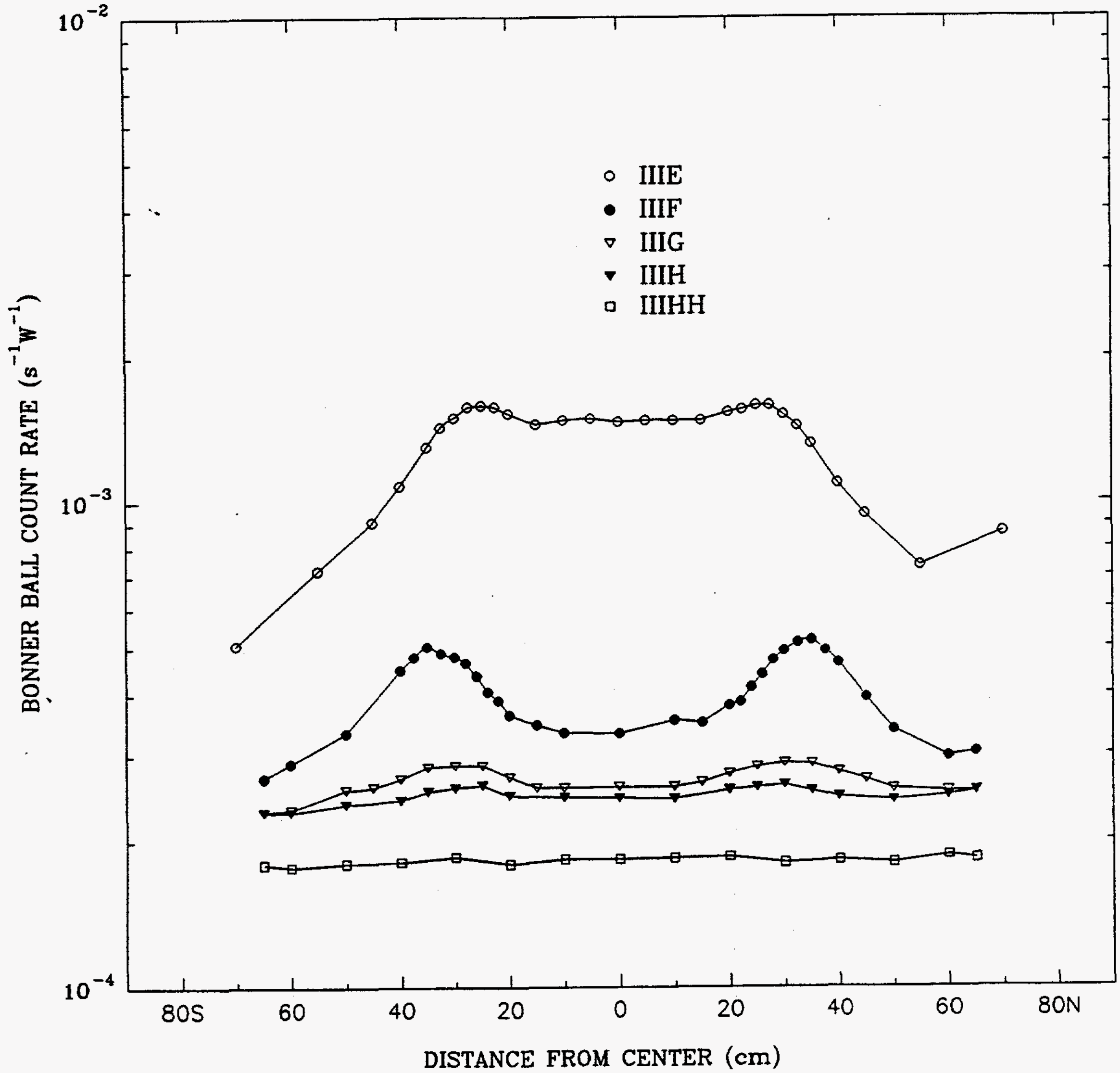


Figure 28. Radial traverses with the 8-inch Bonner ball at 30 cm behind the SM-2 and the concrete vessel (Items IIIE-HH).

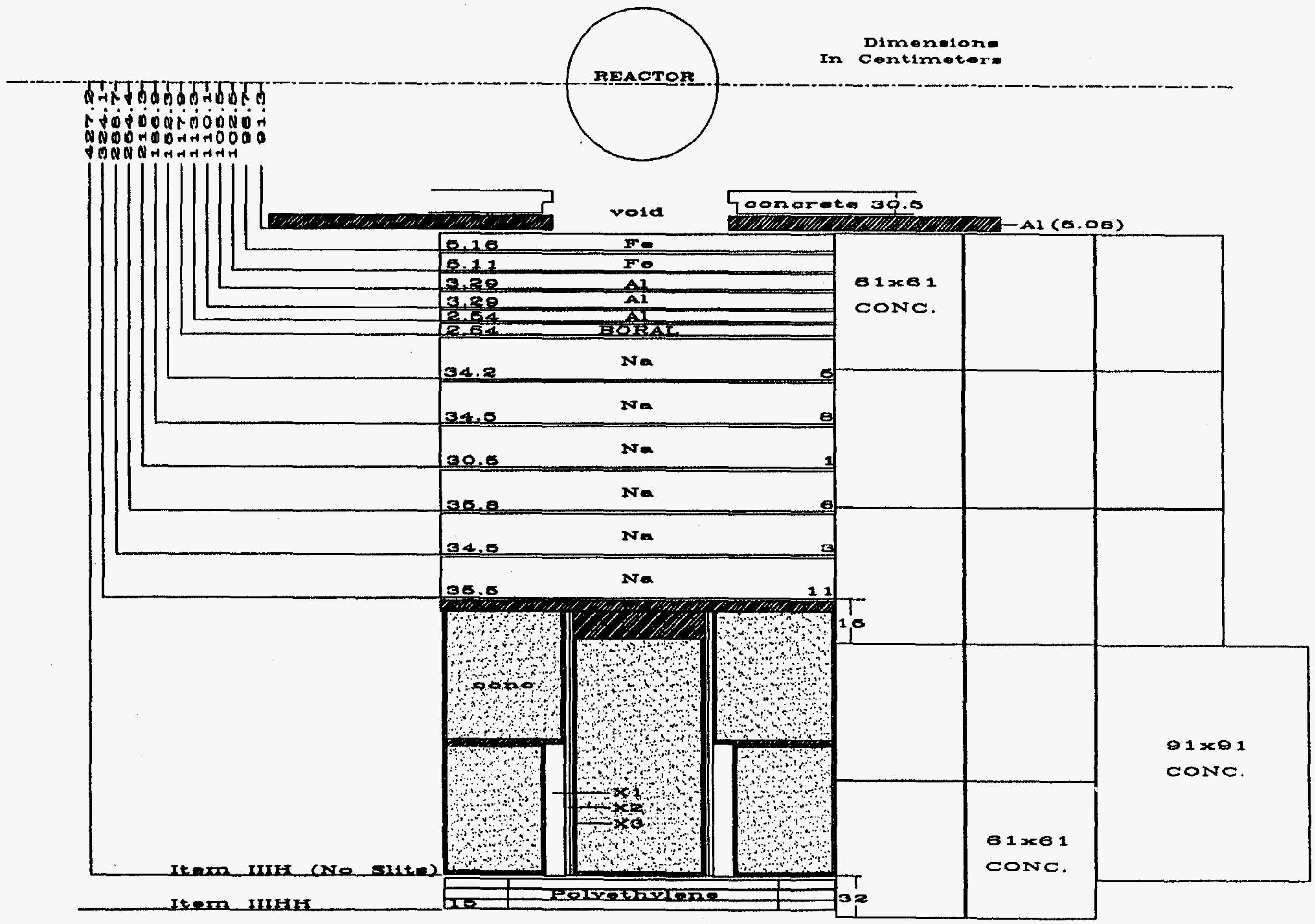


Figure 29. Schematic of the mockup in Item IIIH plus 15 cm of polyethylene.

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