**CRITICAL EXPERIMENTS AND
COOPERATIVE EVALUATIONS
PROGRAM**

**THIRD QUARTERLY REPORT
APRIL-JUNE 1972**

PREPARED FOR
THE UNITED STATES ATOMIC ENERGY COMMISSION
UNDER CONTRACT NO. AT(04-3)-189 PROJECT AGREEMENT NO. 59

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Prepared for the
United States Atomic Energy Commission
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Project Agreement No. 59

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ABSTRACT

This report is the third in a series of quarterly progress reports published under the Critical Experiments and Cooperative Evaluations Program. Current activities and technical progress for the period April through June, 1972, are reported for two tasks. Task A covers the planning and analysis of critical experiments in ZPPR-3. Task B progress is reported for nuclear data evaluation and testing and methods development in support of Task A.

1. S U M M A R Y

TASK A - CRITICAL EXPERIMENT PLANNING AND ANALYSIS

The experimental program of ZPPR Assembly 3 Phase 1A has been completed. Preliminary foil irradiation and small sample reactivity traverse data has been received and compared with analysis. Preliminary control rod experiment analysis shows substantial power distortions due to control rod insertion.

The final specification of the Phase 1B configuration and experimental program has been completed.

The master cross section library for ZPPR Assembly 3 analysis using ENDF/B-III data has been completed and is ready for checkout.

TASK B - COOPERATIVE NUCLEAR DATA AND METHODS DEVELOPMENT

Phase II data testing for ENDF/B-III was completed for the ZPR3-11 and SEFOR Doppler benchmark problems. For ZPR3-11, k_{eff} was within 1% of the experimental result. The computed SEFOR Doppler coefficient ($T \frac{dk}{dT}$) was -0.0085, compared to -0.0081 measured.

A direct comparison of TRIAL results, using three-dimensional linking, and more accurate CITATION results shows a good comparison for axial flux solutions outside of control rods. The TRIAL results using the most simple code options showed considerable difference for an axial flux distribution through a one-half-inserted control rod in the vicinity of the control rod tip. Options which will improve the TRIAL results are being evaluated.

2. TASK A - CRITICAL EXPERIMENT PLANNING AND ANALYSIS

Task Leader: H. S. Bailey

2.1 Phase 1A Data Analysis

The experimental program for Phase 1A of ZPPR Assembly 3 has been completed. Preliminary foil irradiation data and small sample reactivity traverse data have been received* and compared with analysis.

Preliminary analysis consists of two-dimensional (X-Y) diffusion theory calculations in six energy groups, using cross sections defined for ZPPR-3 core materials to define reaction rate distribution.

Figures 2-1, 2-2, and 2-3 show the calculated and measured radial distribution for the U-235(n,f) U-238(n,f) and U-238(n, γ) reactions, respectively, along Row 137 (horizontal traverse). Figures 2-4, 2-5 and 2-6 show the radial traverse of same reactions along Column 36 (vertical traverse). Foils were irradiated $\sim$ 3 inches from the core midplane. Figures 2-1 and 2-4 show relatively good agreement between calculated and measured U-235 fission traverses. The measured U-238 fission traverses (Figures 2-2 and 2-5) and capture traverses (Figures 2-3 and 2-6) show substantial disagreement in the sodium filled control rod positions. The U-238 fission rate is much lower than calculated and the capture rate is much higher. The reasons for these differences are under investigation.

The small sample reactivity traverses were computed with two-dimensional (X-Y) diffusion perturbation theory in 6 energy groups. Traverse measurements were performed in the slot in Row 137. Figures 2-7 through 2-11 show the measured and calculated small sample reactivity radial traverse for U-235, U-238, Pu-239, Boron 10 and sodium, respectively. Both measured and calculated values have been normalized to a value of 1.0 (or -1.0), at the core center.

Some preliminary analysis of the Phase 1A control rod experiments

*Private communication W. G. Davey.

has been performed. Analysis again consists of two-dimensional (X-Y) diffusion theory calculations in six energy groups. The preliminary calculated control worths (6 group diffusion theory) are presented in Table 2-1. These calculations are based on the initial B_{4C} densities defined for the experiment and are primarily used to assist in the planning of Phases 1B, 2 and 3 experiments. The necessary corrections (for transport, number of energy groups, etc.) to these calculated values will be evaluated when the analysis is repeated with ENDF/B-III cross section data.

Although the above calculations are of a preliminary nature, some interesting observations are possible. For example, substantial flux and power tilting exists when control rods are inserted. The power distortions due to insertion of single control rods has been previously reported.⁽¹⁾ A power density map is presented in Figure 2-12 for a multiple control rod insertion pattern with control rods #2, 4, 6, 10, 14 and 18 inserted. As observed in Figure 2-12 substantial flux and power distortions exist for this control rod insertion pattern. The peak power density in Zone 1 exists at the Zone 1 - Zone 2 boundary next to control rod #8. This control configuration is of particular interest since it is the current reference control configuration for Phase 2. It is not yet clear that a "better" 6 control rod insertion pattern exists or that the power distortions in Phase 2 will be as severe since the core diameter and control rod pitch is smaller than in Phase 1A.

2.2 Modification of Core Loading Plan

The specifications for the core loadings for ZPPR Assembly 3, Phases 1B, 2 and 3, have been modified to reflect the revisions proposed by ANL. The overall experimental program remains unchanged.

The modification provides Phases 1B, 2 and 3 with the same horizontal core dimensions as Assembly 2, thus allowing a direct comparison with Assembly 2 data.

The new layout of ZPPR Assembly 3 is shown in Figure 2-13. ZPPR-3

TABLE 2-1

PRELIMINARY CALCULATED ROD WORTHS FOR PHASE 1A EXPERIMENTS

<u>Control Rods Inserted</u>	<u>Preliminary Calculated Value, \$</u>
#1	1.58
#8 in position 1	2.85
#2 in position 1	1.79
#2	1.64
#8	1.76
#8 & 14	3.95
#2 & 5	3.42
All inserted but #1	31.58
Outer ring inserted (#8,9,10,11,12,13,14,15, 16,17,18 & 19)	20.70
Outer ring even inserted (#8,10,12,14,16 & 18)	10.96
#2, 4 & 6	5.03
#2,4,6,10,14 & 18	10.59

contains 19 simulated control locations in a triangular array with an average pitch of 13 inches. The quantity of B_4C in each control rod position will provide a nominal control rod worth of \$2.2. For Phases 1B, 2 and 3, ZPPR Assembly 3, Core Zone 1 contains 410 Matrix positions (radius 64.6 cm.), of which 52 positions simulate control; Core Zone 2 contains 410 Matrix positions (radius 91.3 cm.), of which 24 simulate control. This arrangement provides for identical inner and outer core volumes.

2.3 Fuel Spiking Plan

Changing the size of ZPPR-3 will result in a reactivity loss of $\sim 3.8\%$ when compared to the Phase 1A design. The reactivity loss will be compensated by "fuel spiking." The \$12.5 and \$25 worth of control to be loaded into Phases 2 and 3, respectively, will be compensated by the same technique. The spiking pattern will attempt to simulate changes in the plutonium enrichment during all three phases while keeping the core geometry constant for all three phases.

Approximately 24 and 32 evenly spaced spiked drawers were estimated for Core Zones 1 and 2, respectively, to achieve critical in Phase 1B. Estimated fuel spiking requirements for Phases 1B, 2 and 3 are listed in Table 2-2. The actual number of fuel spikes loaded in Phase 1B were 24 and 36 in Core Zones 1 and 2, respectively.

The fuel spiking plan is shown in Figure 2-14 for Phase 1B and in Figure 2-13 for Phase 3. The spiked drawers, for each phase, are located in a manner where the plutonium content is equally distributed throughout the core. With the revised loading plan, which provides outer core symmetry, the angular distribution of plutonium in Zone 2 is no longer a problem.

2.4 Phase 1B Specification-End-of-Cycle Configuration

The Phase 1B experimental plan specifications are listed below. This specification was developed in a cooperative effort with the ZPPR staff.

TABLE 2-2

ZPPR ASSEMBLY 3 ESTIMATED SPIKING REQUIREMENTS

<u>Phase</u>	<u># Spikes Core Zone 1</u>	<u># Spikes Core Zone 2</u>
1-B	24	32
2	42	60
3	60	88

A. Approach to Critical

At the end of Phase 1A experiments (end-of-cycle configuration in larger critical size), the size of the assembly loading will be reduced to the configuration shown in Figure 2-13. The compositions of each reactor zone, on a column basis, are unchanged from Phase 1A. The simulated withdrawn control rod positions, number 1 through 19, as in Phase 1A, contain four columns of 1/2-inch Na per drawer and extend +36 inches.

The approach to critical will be accomplished by loading fuel spikes. A fuel spike is defined as a 1/4-inch U_3O_8 column replaced by a 1/8-inch Pu-Al column and a 1/8-inch Fe_2O_3 column. An estimated 56 fuel spikes will be required to make the reactor critical. The fuel spiking pattern is shown in Figure 2-14.

B. Initial Adjustments and Measurements

1. The fuel spiking pattern is adjusted, if necessary. Edge drawer worths at a few selected positions at the IC/OC boundary are measured. Worths of drawers at the OC/RB boundary are measured as needed for reactor operations.

2. ZPPR operational measurements, i.e., ZPPR rod worths and temperature coefficient of reactivity will be measured.

C. Power Distribution Measurements

The object is to supply a detailed power distribution to be compared with data obtained in Phases 1A, 2 and 3. The reactions U-235 (n,f), U-238(n,f), and Pu-239(n,f) will be measured using foils. An X-Y map including IC and OC axial traverses and the effect of the CRP(s) upon the distribution will be examined.

After examining foil irradiation data from Phase 1A, it was decided that a full core map of U-235 fission distribution should be obtained in Phase 1B. Every core matrix position, in a representative quadrant, will contain a U-235 foil for irradiation. This provides a total core map since Assembly 3 contains quarter core symmetry. U-238 and Pu-239 foils will be irradiated in positions comparable with those used in Phase 1A.

D. Small Sample Reactivity Traverses

Each of the following samples would be traversed radially in Row 137 near the core center and axially through 136-33.

Pu-30 ($\sim$ 1% Pu-240)	Pu-48 ($\sim$ 45% Pu-240)	U-6 ($\sim$ 93% U-235)
DU (Dummy)	B-1 (enriched B)	Ta-1
Na	BeO	Pu-241
Fe	Ni	Cr

The Na sample will be measured in five positions in the OC and five positions in the IC, including the CIC in the radial traverse and in ten positions in the axial traverse. The worths of the other samples are obtained at three axial and three radial positions. The shape of the worth of all samples will be obtained in the process of measuring the static points.

E. Partial Sodium Void Measurement

The reactivity effect of voiding Na ± 6 inches in a 6x6 matrix array (36 drawers) at the center of the inner core will be measured.

F. Single Control Rod Experiments

These experiments provide data in support of the design of the rods for Phases 2 and 3 configurations as well as check points for the analytical program.

1. Comparison of B_4C rods at different radii, and CIC

a. Based upon the data of D, a shim loading which will result in $-2.20\% \pm 0.10$ at CRP position 8 will be chosen. This will be loaded and the worth adjusted to the above value by subcritical methods. The reactor will then be made critical with this loading by fuel spiking.

b. Based upon the data of D and F.1.a, a shim rod loading having an estimated worth of -2.20% will be chosen for CRP position 2. This worth will be measured.

c. As in b, above, a loading estimated to have a worth of -2.20% will be chosen for CRP position 1. This worth will be measured.

d. The worth of the shim rod loadings of a and b are to be measured at position 1.

e. A shim rod loading, using enriched $B_{10}C$, which has an estimated worth of 2.2\$ will be measured in CRP position 8.

Note: The reference for F.1.b, c, and d is the F.1.a critical loading.

2. Plate/Pin Comparison, Natural $B_{10}C$

This is an experiment to examine the differences in worth and power distribution, both interior and exterior to a natural $B_{10}C$ shim rod mockup in plate and pin composition located in the CIC.

Calandria (IC composition) will be loaded in a 5x5 zone one corner of which is occupied by CRP position 1. Foil irradiations will be performed in the mockup rod (CRP #1) and adjacent matrix position (calandria).. See Figure 2-16.

a. The plate $B_{10}C$ configuration is loaded in CRP #1. Worth is measured and foils irradiated.

b. CRP #1 is loaded with calandria containing a pin mockup of the control rod. $B_{10}C$ pins are uniformly distributed in the 4 matrix positions. Worth is measured.

c. The same $B_{10}C$ pin loading as in 2.b is used with the $B_{10}C$ pins concentrated at the center of the mockup rod. Worth is measured and foils are irradiated.

d. The plate mockup of a withdrawn control rod (four 1/2-inch Na plates/drawers) is loaded in CRP #1. Remove fuel spikes to remain critical. Irradiate foils.

3. Perturbation of Power Distribution Due to Rods

The objective is to measure the change in power distribution from C due to the rods loaded in F.1.a, b, and c. These measurements may be made as part of the experimental moves of F.1 and possibly F.2. Selected foil measurements are made for each rod insertion.

4. Sodium Worth in the Central Control Rod Position

The worth of voiding the Na in the central control rod position for the full height will be measured relative to void.

5. Single Ta Control Rod Measurement

The worth of a simulated Ta control rod will be individually measured subcritically at CRP positions 1, 2, and 8, respectively.

G. Rod Interaction Experiment

The worth of the following rod combinations are measured subcritically. The reference loading is that of F.1.a.

Rod Measured	Other Rod(s) Inserted	Comments
8	2,9	Measured between F.1.a & F.1.b
8	2	"
2,9	None	
8,9	None	

H. Control Rod Group Experiment

These measurements are all subcritical. The k_{eff} of the system is measured after each insertion. All rods are fully inserted. The experimental sequence, listed in Table 2-3, is similar to Phase 1A.

2.5 Cross Section Data Processing

A master cross section library has been generated for the study of ZPPR Assembly 3. The master cross section library will contain, in a comprehensive form, all of the cross sections required for the analysis of ZPPR Assembly 3. All other cross section files will be generated, either through transferring or condensing cross sections, from the master library.

ENDF/B-III data, compiled by Brookhaven National Laboratory, will be used for the analysis of ZPPR-3 experimental data. The techniques used to process ENDF/B-III data are detailed in the second quarterly report.⁽¹⁾

TABLE 2-3
CONTROL ROD GROUP EXPERIMENTS
EXPERIMENTAL SEQUENCE

Step	CRP(s)		
	Added	Removed	In Assembly
1	8,14	---	8,14
2	2,5	9,15	2,5
3	4,6	5	2,4,6
4	8,10,12,14, 16,18	---	2,4,6,8,10,12,14, 16,18
5	3,5,7,9,11, 13,15,17,19	---	2,3,4,5,6,7,8,9,10,11, 12,13,14,15,16,17,18,19
6	---	2,3,4,5,6,7	8,9,10,11,12,13,14, 15,16,17,18,19
7	---	9,11,13,15,17,19	8,10,12,14,16,18
8	2,4,6	8,12,16	2,4,6,10,14,18

Fifty-nine group cross sections were obtained by processing through the ENDRUN⁽²⁾ code. A group structure⁽³⁾ was defined giving special emphasis to the large resonances of sodium, iron and oxygen. Spatial and composition dependent 59 group cross sections were generated by the TDOWN⁽⁴⁾ code. Use of the Bell rational approximation, available in TDOWN, requires each drawer configuration to be homogenized into two regions, as shown in Figures 2-17 through 2-19. The concentration values shown in these figures are the homogenized values over the entire drawer.

In addition, sodium cross sections processed through TDOWN, have been generated for the sodium filled control locations simulating a withdrawn control rod. Pu-239 and Pu-240 cross sections have been generated for the spiked drawer locations described in the fuel spiking plan.

The cross sections from TDOWN were condensed to 29 groups using diffusion theory. The condensed group structure was chosen to be identical to the 29 group structure used in the pre-analysis. With this group structure,⁽³⁾ the flux weighting factors obtained from ANL-Idaho were applied to the condensed cross sections.

Cross sections, for use in two-dimensional (R,Z) calculations where the control rod locations are homogenized in with the fuel, are flux weighted by a similar method.

All material cross sections available in the master cross section library have been identified according to the system of material identification described in reference 1.

The master cross section library has been completed and is ready for checkout. Analysis of ZPPR Assembly 3 will immediately follow the successful checkout of the master cross section library.

Parallel calculations of ZPPR-3, Phase 1B, using nuclear data processed through the ETOX-IDX codes⁽⁵⁾ are in process. Cross sections and self-shielding factors based on ENDF/B-III were obtained from HEDL. This 29-group set was used with IDX for a radial problem identical to that run with the TDOWN code to generate data for two-dimensional analyses. It was found that the original problem, containing six different heterogeneous cell descriptions to obtain self-shielded cross sections, required

too much core for 1DX and would not run. The problem has been broken down into smaller steps, which are now being processed.

FIGURE 2-1

Calculated & Measured U-235 (n, f)
Reaction Rate Distribution in Row 137

GEAP-13771-3
FIGURE 2-2
Calculated & Measured U-238(n,f)
Reaction Rate Distribution in Row 137

FIGURE 2-3

Calculated & Measured U-235(n, γ)
Reaction Rate Distribution in Row 137

FIGURE 2-4

Calculated & Measured U-235 (n,f)
Reaction Rate Distribution in Column 36

GEAP-13771-3
FIGURE 2-5
Calculated & Measured U-238(n,f)
Reaction Rate Distribution in Column 36

Calculated & Measured U-238(n, γ)
Reaction Rate Distribution in Column 36

FIGURE 2-7

U-235 Radial Reactivity Traverse (Row 137)

FIGURE 2-8
U-235 Radial Reactivity Traverse (Row 137)

FIGURE 2-9

Pu-239 Radial Reactivity Traverse (Row 137)

FIGURE 2-10

Boron 10 Radial Reactivity Traverse (Row 137)

FIGURE 2-11

Sodium Radial Reactivity Traverse (Row 137)

FIGURE 2-12

POWER DENSITY MAP FOR A SIX CONTROL ROD INSERTION PATTERN

Zone 1, % Peak Power Density

Inserted Control Rod

Withdrawn Control Rod

Zone 2, % Peak Power Density

GEAP-13771-3

GEAP-13771-3
 FIGURE 2-13
 ZPPR-3 Phase 1B Core Layout

ZPPR HALF 1

GEAP-13771-3
 FIGURE 2-14
 Phase 3 Fuel Spiking Plan

ZPPR HALF 1

GEAP-13771-3

FIGURE 2-15
Phase 3 Fuel Spiking Plan

ZPPR HALF 1

FIGURE 2-16

ZPPR-3 Phase 1B Core Layout

ZPPR HALF 1

FIGURE 2-17

CORE ZONE 1 CELL DESCRIPTION USED FOR BELL APPROXIMATION

CORE ZONE 1

Region 1 $D_1 = 0.279405$ cmatoms/cm³ x 10^{-24}

Pu-239	8.439-4
Pu-240	1.118-4
Pu-241	1.520-5
Pu-242	5.500-6
Mo	2.356-4
U-235	5.300-6
U-238	2.394-3

Region 2 $D_2 = 2.54$ cmatoms/cm³ x 10^{-24}

Na	8.864-3
Ox	1.313-2
Fe	1.230-2
Cr	2.610-3
Ni	1.190-3
Mn	2.193-4
Si	1.307-4
Cu	2.870-5
C	2.920-5
Al	1.310-5
U-235	7.000-6
U-238	3.159-3

FIGURE 2-18

CORE ZONE 2 CELL DESCRIPTION USED FOR BELL APPROXIMATION

Core Zone 2
(Drawers A&B)

Region 1 $D_1 = .558810$ cm
atoms/cm³ x 10⁻²⁴

Region 2 $D_2 = 3.38667$ cm
atoms/cm³ x 10⁻²⁴

Pu-239	1.267-3
Pu-240	1.679-4
Pu-241	2.272-5
Pu-242	8.250-6
Mo	3.443-4
U-235	7.957-6
U-238	3.593-3

Na	8.627-3
Ox	1.172-2
Fe	1.496-2
Cr	2.841-3
Ni	1.306-3
Mn	2.361-4
Si	1.419-4
Cu	3.010-5
C	2.920-5
Al	1.410-5
U-235	3.543-6
U-238	1.580-3

FIGURE 2-19

RADIAL BLANKET CELL DESCRIPTION USED FOR BELL APPROXIMATION

RADIAL BLANKET

Region 1 $D_1 = 1.5875$ cm
atoms/cm³ x 10⁻²⁴

U-235	2.450-5
U-238	1.1076-2
Ox	1.7100-2

Region 2 $D_2 = 2.5400$ cm
atoms/cm³ x 10⁻²⁴

Ox	3.013-3
Fe	8.179-3
Cr	2.343-3
Ni	1.056-3
Mn	1.982-4
C	1.016-3
Si	1.185-4
Na	6.329-3
Cu	2.692-5
Mo	1.933-5
Al	1.946-5

3. TASK B - COOPERATIVE NUCLEAR DATA AND METHODS DEVELOPMENT

Task Leader: B. A. Hutchins

3.1 Nuclear Data

Phase II data testing of NEDF/B-III for the ZPR3-11 and SEFOR Doppler benchmark problems were completed. Table 3-1 shows the results for k_{eff} , compared to values for ZPPR-2 and ZPR6-7 and those obtained by other organizations and presented at the May 9-10, 1972 meeting of the Cross Section Evaluation Working Group.⁽⁶⁾ The GE results were computed with the 59-group nuclear data file generated by ENDRUN⁽²⁾ and processed by the TDOWN code.⁽⁴⁾ Agreement both with experiment and other analyses is good. The slightly lower k_{eff} value computed by GE for Pu-239 fueled assemblies is consistent with previous comparisons.

The Doppler coefficient for the SEFOR benchmark problem was computed to be -0.0085 for the value of $(T \frac{dk}{dT})$, as compared to the measured value of -0.0081. A Doppler calculation at BNL resulted in -0.00836.

Other comparative results in the CSEWG report were spectral indices and material worths. These showed that there was close agreement between the GE values and those obtained at other organizations.

3.2 Methods Development

First test results for the evaluation of the three-dimensional linking technique of the TRIAL code have been obtained. Evaluation of approach 1, as defined in the previous quarterly report,⁽¹⁾ is being accomplished by comparing three-dimensional flux solutions from TRIAL with those from direct three-dimensional solutions of the CITATION code,⁽⁷⁾ run by D. Vondy at ORNL.

The first CITATION problem was for the model described in the previous quarterly report.⁽¹⁾ This model is isotopically simple but a geometrically complex representation of an LMFBR core and blanket, with four off-center control rods one-half inserted. The neutron data file used was the same four-group set which was used for computing the two-dimensional flux sets for TRIAL.

TABLE 3-1

 k_{eff} VALUES FOR PHASE II DATA TESTING OF ENDF/B-III

<u>Assembly</u>	<u>GE</u>	<u>Computed k_{eff}</u>		<u>WARD</u>
		<u>AI</u>	<u>BNL</u>	
ZPR3-11	0.9915	0.9898	---	----
ZPPR-2	1.0000	1.0018	1.0006	1.0018
ZPR6-7	0.9902	0.9987	0.9944	0.9932

TABLE 3-2

 k_{eff} VALUES FOR 2- AND 3-DIMENSIONAL CALCULATIONS

R-Z	0.9916
X-Y (Control in)	1.0122
X-Y (Sodium hole)	0.8862
X-Y-X (CITATION)	1.0000

Two X-Y and one R-Z flux sets were computed for TRIAL input. The R-Z problem was run first to provide both the axial bucklings required for the X-Y solutions and the vertical planar fluxes used for the axial variation in TRIAL. The two X-Y solutions were run through planes at axial levels which included the sodium hole in one and the inserted control rod in the other. Bucklings were determined from axial, region-dependent leakages computed in the R-Z problem, where small axial regions were defined at the levels of the R-Z solutions. These bucklings were both energy and region-dependent in the R-Z calculations.

Table 3-1 shows the k_{eff} values obtained for each of the two-dimensional and the three-dimensional runs. It is seen that the X-Y solutions, particularly the one with the sodium hole, did not give good agreement with either the R-Z or X-Y-Z results. The reason for this is differences in the geometrical descriptions of the model in R-Z and X-Y coordinates. However, a check on the radial flux distributions indicated fair agreement, so the X-Y flux sets were used in TRIAL.

Figures 3-1, 3-2 and 3-3 show comparisons of the axial flux distributions for group 3 (750eV to 100 keV) taken from the TRIAL results and from the CITATION results. The core centerline distribution is shown in Fig. 3-1 and the agreement between the two codes is reasonable. Fig. 3-2 is the distribution through the middle of a control rod, where the TRIAL approach is expected to be least accurate. This is borne out by the results, with a large departure from the X-Y-Z results in the vicinity of the control rod tip, at 11.0 cm. The departure peaks at 30 to 40 percent below the end of the tip. However, the curves shown here were normalized to the same area under the curve, rather than to the same total reactor power; and the latter normalization, which is more meaningful, may show a different peak discrepancy. The third distribution shows that the agreement is considerably better just a short distance from the control rod.

Other options in the way in which the TRIAL problem is run could improve the accuracy of the results and are being evaluated. These are a) more X-Y solutions, with one directly above and one directly below the control rod tip; b) improved bucklings in the X-Y solutions,

although this is not expected to improve the major departures seen;
c) different axial distributions from the R-Z solution used to link the X-Y flux sets; and d) different axial distributions from the R-X solution used to interpolate between X-Y flux sets.

Evaluation of the second linking approach,⁽¹⁾ in which the X-Y flux sets are taken from a three-dimensional problem, provides an opportunity to examine the effects of options a, c and d, independent of the problem of obtaining accurate X-Y bucklings. This is currently being done along with evaluation of the second approach. For the latter, a second CITATION problem was run at ORNL, identical to the first but with the control rods only one-fourth inserted.

FIGURE 3-1
AXIAL FLUX DISTRIBUTIONS ON CORE CENTERLINE FROM
TRIAL AND CITATION CODES

FIGURE 3-2
AXIAL FLUX DISTRIBUTIONS THROUGH CENTER OF A CONTROL ROD
FROM TRIAL AND CITATION CODES

FIGURE 3-3
AXIAL FLUX DISTRIBUTIONS NEAR A CONTROL ROD FROM
TRIAL AND CITATION CODES

4. QUALITY ASSURANCE

TASK A - CRITICAL EXPERIMENT PLANNING AND ANALYSIS

Quality Assurance efforts are primarily concentrated on obtaining the best cross section data available for analysis and comparing analytical results with ANL (ZPPR) analytical efforts. Cross sections used in analysis will be based on ENDF/B-III data, which is the current industry standard. Analytical results are compared with similar efforts by the ZPPR staff. A system of identifying cross sections data used in ZPPR Assembly 3 analysis, described in reference 1, is in affect to reduce the possibility of inadvertently using incorrect data. A minimum of two levels of GE-BRD management review all formal publications, consist with GE-BRD procedures.

TASK B - COOPERATIVE NUCLEAR DATA AND METHODS DEVELOPMENT

The cooperative nature of the Task B activities provides for a test of quality within themselves. Nuclear data evaluation and testing is performed as part of the Cross Section Evaluation Working Group program. This working group has established procedures for reviewing and comparing results obtained from all the participating organizations, in order to determine the quality and adequacy of the data and data processing methods used by these organizations. In a like manner, neutronics methods development is a cooperative program, requiring reviews of specifications and comparison of results. Consequently, reporting of progress generally includes a comparison of results with those reported by other organizations. Computer codes developed under Task B conform to the standard interfaces and programming practices specified by the Committee on Code Coordination. (8)

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