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ABSTRACT

The work performed in the reporting period was primarily concerned with the continued preanalysis of the first experimental sequence (Task B) and the loading of the first blanket (Task C). Progress on testing experimental equipment and performing checkout tests is also summarized.

A comparison of calculated spectra for the original FBBF design, the "as-built" facility, and a large LMFBR is reported. A description of the one- and two-dimensional models used for reaction rate and spectrum calculations are summarized together with a comparison of the results.

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TASK B

(R.C. Borg and R.H. Johnson)

B.1. Introduction

The object of this task is to perform a detailed preanalysis of the first experimental sequence. Initially a boron carbide region next to the wall of the inner and outer converters was explicitly represented in the calculational models. Also, during the initial construction phase of the facility the exact quantity of some materials (e.g., B_4C) was not precisely known. Thus, the estimated number densities and volume fractions were slightly different from the final values. In Sec. B.2, a description and comparison is given of the one- and two-dimensional models which were the basis of the initial preanalysis. Comparisons of most recent diffusion and transport calculations are presented in Sec. B.4.

B.2. Description and Comparison of Calculational Models (R.C. Borg and M.P. Sohn)

B.2.1. Introduction

A comparison of the various calculational models used in the preanalysis calculations is presented in this subsection. First, a comparison and description of the one- and two-dimensional models are presented. Then, flux spectra and k_{eff} values evaluated from the models are given. Further spectral comparisons of the two-dimensional models with a modified CRBR are also given.

The one-dimensional calculations were performed using the computer code LAZARUS.¹ The one-dimensional models depict a radial traverse through the active midplane of the FBBF. A 21-group cross section set described in Ref. 2 was used in these calculations. Also an external source of 1.0×10^{10} neutrons/

second, with an energy distribution of the fission spectrum of the ^{252}Cf source, was placed in the first mesh interval to simulate the source used in the FBBF. For a more complete description of the one-dimensional calculational procedure see Refs. 2, 3 and 4.

The two-dimensional calculation was performed using the computer code 2DB.⁵ The same 21-group library of group constants was used. An external source (similar to that used for LAZARUS) was distributed axially as four discrete sources to correspond with the actual source arrangement. A more complete description of the two-dimensional calculational procedure and axial source distribution is contained in Refs. 4 and 6.

B.2.2. Description of Models

The original one-dimensional model is described in Refs. 2, 3 and 4 (Model 1). It is an 11 region model (Fig. B.1) which explicitly treats B_4C transition zones in the inner and outer converters. Associated material number densities and regional volume fractions are given in Tables B.1 and B.2, respectively.

The material number densities used in Model 1 were calculated based on an atom-percentage, rather than the correct weight-percentage. Updated material number densities (based on weight-percentages) are presented in Table B.3. The difference between Model 2 and Model 1 is the use of correct material number densities.

To make the one- and two-dimensional models more compatible, the one-dimensional model was modified so that it had the same regional structure as the active midplane of the two-dimensional model. The 11 regions of Model 1 and 2 were reduced to a 6 region model (Model 3), by combining and homogenizing several of the smaller regions. Thus, the basic change in this step was the elimination of explicit treatment of the B_4C transition regions. Regional volume

Figure B.2: 6 Region One-Dimensional Model
(dimensions in cm)

Figure B.1: 11 Region One-Dimensional Model
(dimensions in cm)

TABLE B.1

Model I Material Number Densities based on Atom Percent

SS-304 (density - 7.75 gm/cc, Fe - 69%,
Mn = 2%, Cr - 19%, Ni - 10%)

Fe 5.814974E-2 atoms/barn-cm
Mn 1.685500E-3
Cr 1.601225E-2
Ni 8.427498E-3

SS-306 (density - 7.90 gm/cc, Fe - 70.8%
Cr - 19.6%, Ni - 9.6%)

Fe 5.9635E-2
Cr 1.6471E-2
Ni 8.1039E-3

SS-316 (density - 7.75 gm/cc, Fe - 67.5%,
Ni - 12%, Cr - 17%, Mn - 1%, Mo - 2.5%)

Fe 5.573269E-2
Ni 9.908034E-3
Cr 1.403638E-2
Mn 8.256695E-4
Mo 2.06417E-3

4.8% Enriched UO_2 fuel 0.94 T.D.

^{235}U 1.102300E-3
 ^{238}U 2.186228E-2
 ^{16}O 4.592917E-2

1.3% Enriched UO_2 fuel 0.94 T.D.

^{235}U 2.985396E-4
 ^{238}U 2.266604E-2
 ^{16}O 4.592917E-2

Nat. UO_2 fuel 0.94 T.D.

^{235}U 1.639671E-4
 ^{238}U 2.280062E-2
 ^{16}O 4.592917E-2

Sodium (density - 0.97 gm/cc)

^{23}Na 2.539996E-2 atoms/barn-cm

Aluminum (density - 2.702 gm/cc)

^{27}Al 6.028590E-2

Boron Carbide (B_4C , density - 2.52
gm/cc 0.60 T.D.)

^{12}C 1.647166E-2
 ^{10}B 1.304556E-2
 ^{11}B 5.284109E-2

Boron-SS (Density - 7.75 gm/cc,
SS-304 with 1% by weight Boron)

Fe 5.525966E-2
Ni 8.008646E-3
Cr 1.521643E-2
Mn 1.601729E-3
 ^{10}B 8.725077E-4
 ^{11}B 3.534097E-3

Carbon Steel (1020, density - 7.75
gm/cc 0.2% C, 0.45% Mn)

Fe 8.299773E-2
C 1.670815E-4
Mn 3.759334E-4

TABLE B.2

11 Region Models & and 2 Material Volume Fractions

Region	Volume Fraction	Material
1. Source	1.000	Source Steel (SS-306)
2. Steel Surrounding Source	0.101183	Source Holder (SS-306)
	0.581197	Guide Tube & Inner Transformer Wall (SS-304)
3. Inner Transformer B ₄ C Ring I	1.000	B ₄ C (100% in ring area)
4. Inner transformer	0.743390	4.8% Enriched UO ₂ Fuel 0.94 T.D.
	0.084855	B ₄ C (between fuel rods)
	0.150364	Clad (SS-316)
5. Inner Transformer B ₄ C Ring II	0.234788	Inner Transformer Wall (SS-304)
	0.751888	B ₄ C (100% in ring area)
6. Outer Transformer B ₄ C Ring I	0.207268	Outer Transformer Wall (SS-304)
	0.653200	B ₄ C (100% in ring area)
7. Outer Transformer	0.090221	Sodium Cans (SS-304)
	0.067845	Clad (SS-316)
	0.496862	Sodium
	0.335420	4.8% Enriched UO ₂ Fuel 0.94 T.D.
8. Outer Transformer B ₄ C Ring II	0.223436	Outer Transformer Wall (SS-304)
	0.776564	B ₄ C (100% in ring area)
9. & 10. Blanket Regions I & II	0.1151	Aluminum Cladding
	0.1678	Secondary Clad (Aluminum or SS-316)
	0.5969	Nat. UO ₂ Fuel 0.94 T.D.
11. Reflector	0.056708	Reflector Wall (SS-304)
	0.565975	Carbon Steel
	0.377317	Sodium

Note: The remainder of each region is void.

TABLE B.3

Corrected Material Number Densities
Models 2 - 5 and 2D Model

SS-304 (density - 7.75 gm/cc, Fe - 69% Mn - 2%, Cr - 19%, Ni - 10%)		Nat. UO_2 fuel 0.94 T.D.	
Fe	5.766724E-2	^{235}U	1.655909E-4
Cr	1.705547E-2	^{238}U	2.285615E-2
Ni	7.950014E-3	^{16}O	4.604347E-2
SS-316 (density - 7.90 gm/cc, Fe - 70.8% Ni - 12%, Cr - 17%, Mn - 1%, Mo - 2.5%)		4.8% Enriched UO_2 fuel 0.94 T.D.	
Fe	5.641361E-2	^{235}U	1.104441E-3
Cr	1.526015E-2	^{238}U	1.104441E-3
Ni	9.540016E-3	^{16}O	4.601838E-2
Mn	8.495855E-4		
Mo	1.216243E-3		
B_4C (61.2% T.D. in IT)		Carbon Steel (1020, density - 7.75 gm/cc 0.2% C, 0.45% Mn)	
^{12}C	1.682100E-2	Fe	8.303247E-2
^{10}B	1.332300E-2	C	7.771964E-4
^{11}B	5.396300E-3	Mn	3.823135E-4
B_4C (53.8% T.D. in OT)		Aluminum (density - 2.702 gm/cc)	
^{12}C	1.475650E-2	^{27}Al	6.031114E-2
^{10}B	1.165540E-2		
^{11}B	4.721050E-3		
B_4C (60.0% T.D.)		Sodium (in OT)	
^{12}C	1.647969E-2	^{23}Na	2.332400E-2
^{10}B	1.305192E-2		
^{11}B	5.286686E-3	Sodium (in Reflector)	
		^{23}Na	2.541059E-2

fractions for Model 3 are presented in Table B.4. The 6 region model is shown in Fig. B.2.

During the course of the preanalysis the steel in the source region was changed from SS-306 to SS-316. Model 4 includes all the features of Model 3, with the updated source steel material.

The previous four models were based on theoretical estimates of the exact quantities of the various materials in the facility. As construction of the FBBF was completed, it was possible to substitute the actual regional volume fractions for these materials. Thus, the volume fraction, presented in Table B.5, reflect the physical construction of the FBBF and represent the final model, (Model 5).

The two-dimensional model has been described previously in Refs. 4 and 6. The only major modifications were to update the number densities. For purposes of comparison, the geometry representation of the model is shown in Fig. B.3. The region description and volume fractions are presented in Table B.6.

A modified CRBR model was used for the spectra comparison. It was prepared by scaling the existing CRBR design to provide typical spectra characteristics of a 1000 MWe fast reactor. Another modification was to replace the blanket and reflector with those of the FBBF. This provides a model of a 1000 MWe fast reactor with a blanket identical to that of the FBBF.

B.2.3. Calculational Comparisons

The flux spectrum was calculated at two radial positions for each of the models. These positions were:

- (1) The outer transformer - blanket interface. This is abbreviated OT/BL and corresponds to a radius of 22.16 cm.
- (2) The interface between the stainless steel and aluminum secondary clad in the blanket. This is abbreviated BL1/BL2 and corresponds to a radius of 56.81 cm.

TABLE B.4
Volume Fractions for 6 Region Models 3 and 4

Region	Material	Volume Fraction
Smeared Source Region	SS-316	0.130898
	SS-304	0.561983
Smeared Inner Transformer	SS-304	0.024740
	SS-316	0.131713
	B ₄ C (0.60 T.D.)	0.172224
	4.8% UO ₂	0.651182
Smeared Outer Transformer	SS-304	0.126240
	SS-316	0.048461
	B ₄ C (0.60 T.D.)	0.206293
	4.8% UO ₂	0.239585
	Na	0.354901
Inner Blanket	SS-316	0.1678
	Al	0.1151
	Nat UO ₂	0.5969
Outer Blanket	Al	0.2829
	Nat UO ₂	0.5969
Reflector	C Steel	0.565975
	Na	0.377317
	SS-304	0.056708

The remainder of each region is void

TABLE B.5
Volume Fractions of the 6 Region Constructed FBBF Model 5

Region	Material	Volume Fraction
Smeared Source Region	SS-316	0.130896
	SS-304	0.561983
Smeared Inner Transformer	SS-304	0.024740
	SS-316	0.131729
	B,C (0.612 T.D.)	0.172224
	4.8% UO ₂	0.651182
Smeared Outer Transformer	SS-304	0.121706
	SS-316	0.048460
	B,C (0.538 T.D.)	0.220681
	4.8% UO ₂	0.239585
	Na	0.345058
Inner Blanket	SS-316	0.172929
	Al	0.118628
	Nat UO ₂	0.615044
Outer Blanket	Al	0.291552
	Nat UO ₂	0.615032
Reflector	C Steel	0.492652
	Na	0.234680

The remainder of each region is void

Figure B.3: Two-Dimensional Model
(all dimensions in cm)

TABLE B.6
Volume Fractions for Two-Dimensional Model

Region Number	Region	Material	Volume Fraction
1	Smeared Source Region	SS-316	0.130896
		SS-304	0.561983
2	Smeared Inner Transformer	SS-304	0.024740
		SS-316	0.131729
		B ₄ C (0.612 T.D.)	0.172224
		4.8% UO ₂	0.651182
3	Smeared Outer Transformer	SS-304	0.121706
		SS-316	0.048460
		B ₄ C (0.538 T.D.)	0.220681
		4.8% UO ₂	0.239585
		Na	0.345058
4	Inner Blanket	SS-316	0.172929
		Al	0.118628
		Nat UO ₂	0.615044
5	Outer Blanket	Al	0.291552
		Nat UO ₂	0.615032
6	Reflector	C Steel	0.492652
		Na	0.234680
7 and 9	Non-active Inner Transformer	SS-304	0.206102
		SS-316	0.131713
		B ₄ C (0.612 T.D.)	0.172224
8 and 10	Non-active Outer Transformer	SS-304	0.206102
		SS-316	0.048461
		B ₄ C (0.538 T.D.)	0.206293
		Na	0.354901
11 and 12			
	Axial Blanket Steel Plates	C-Steel	1.000
13	Top Plug (Source Region)	SS-304	1.000
14	Bottom Plug (Source Region)	SS-304	0.330518
15	Carbon Steel Base	C-Steel	1.000

The remainder of each region is void.

The presented spectra are normalized to a total flux of 100.0 at each spatial point. The spectra are plotted with connected midpoints rather than histograms to provide for ease in comparison.

A comparison of the flux spectra for the five one-dimensional models is presented in Figs. B.4 and B.5. These plots show that the changes in the models have had very little impact on the flux spectrum. The largest change in the normalized flux between Model 1 and Model 5 is 0.1% for any group. This agreement is sufficiently good to disregard the effects of changes in the models.

A further comparison of spectra is provided in Figs. B.6 and B.7. These plots show the flux spectra of the one- and two-dimensional models and the modified CRBR model. The one- and two-dimensional models have normalized flux spectra that differ by less than 0.05% for any group. This comparison shows that spectra from the one- and two-dimensional calculations are essentially the same. Agreement with the modified CRBR spectrum is within 0.65% at the OT/BL interface and improves to less than 0.35% at the BL1/BL2 interface. These are the extreme group values so that the overall agreement is much better.

A comparison of the values of k_{eff} for the five one-dimensional models and the two-dimensional model are presented in Table B.7. The various models show very little difference in k_{eff} except between Models 2 and 3. This difference is due to the homogenization of the B_4C rings of Model 2 into the single region transformers of Model 3. Also note that the value of k_{eff} calculated from the one- and two-dimensional models is in very good agreement.

B.2.4. Conclusions

As can be seen from the above discussion, there is no significant difference in spectra and neutron multiplication between any of the five one-dimensional models. There is also close agreement between the one- and two-dimensional models.

This indicates for further preanalysis, that the one-dimensional model can continue to be used to approximate a radial slice through the active midplane of the FBBF.

Agreement of spectra calculated with FBBF models and the modified CRBR model is also extremely good and the differences between them decreases with distance into the blanket. One of the goals of the FBBF was to model the flux spectrum of a typical fast reactor in the blanket region. The presented material indicates that the FBBF blanket Spectra are characteristic of a fast reactor blanket spectra.

Figure B.4: Comparison of spectra at the blanket-converter interface calculated with various one-dimensional models.

Figure B.5: Comparison of spectra at the inner-outer blanket interface calculated with various one-dimensional models.

Figure B.6: Comparison of spectra at the converter-blanket interface of the FBBF and core blanket interface of 1000 MWe CRBR.

Figure B.7: Comparison of spectra at the inner and outer blanket interface of the FBBF and 1000 MWe CRBR.

TABLE B.7

Values of k_{eff} for One- and Two-Dimensional Models

One-Dimensional Models

Model 1	0.308657
Model 2	0.309371
Model 3	0.301812
Model 4	0.301812
Model 5	0.302656

Two Dimensional Model

2D Model	0.300256
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B.3. Group Constant Generation
(R.C. Borg, M.P. Sohn and N.A. Hanan)

A copy of the multigroup library DLC-40/LIB-IV⁷ has recently been obtained from Oak Ridge National Laboratory. This library contains 50 groups and 101 isotopes. The computer code IDX⁸, a one-dimensional diffusion code for producing energy group collapsed and self-shielded cross sections, has also been acquired. Several modifications have been implemented into the IDX source to make it operational at Purdue University. New input and output options were added for zonal flux guesses. Coding modifications to execute external source type problems required for the FBBF were also implemented.

Currently, a new group constant library based on the IDX code is being generated for diffusion theory calculations. This library will consist of energy groups given in Table B.8, and will be used for future preanalysis of the initial loading sequence.

B.4. Coupled Neutron-Gamma-Ray Transport Calculations for Initial FBBF Loading
(R.H. Johnson and J.H. Paczolt)

The gamma-ray heating calculations were performed using the DLC-37C/EPR cross section set^{9,10} and the discrete ordinates code ANISN-W,¹¹ a CDC version of ANISN.¹² DLC-37C/EPR is based on ENDF/B-IV data and contains coupled 100N-21G* multigroup cross sections of the important nuclides for the first FBBF loading. DLC-37C/EPR also includes neutron and gamma-ray kerma factors for many of the elements in the cross section set. The coupled neutron and gamma-ray transport calculations were also used to give radially-dependent fission rates for comparison with the two-dimensional diffusion calculations discussed in Ref. 4

*Read as 100 neutron groups, 21 gamma-ray groups.

TABLE B.8
Group Structure of the
30 Group Cross Section Library

Group	Maximum Energy	Au
1	15.000 MeV	1.192
2	6.0653	0.5
3	3.6788	0.5
4	2.2313	0.5
5	1.3534	0.5
6	820.85 keV	0.5
7	497.87	0.5
8	301.97	0.5
9	183.16	0.5
10	111.09	0.5
11	67.379	0.5
12	40.868	0.5
13	24.788	0.5
14	15.034	0.5
15	9.1188	0.5
16	5.5308	0.5
17	3.3546	0.5
18	2.0347	0.5
19	1.2341	0.5
20	748.53 eV	0.5
21	454.00	0.5
22	275.36	0.5
23	167.02	0.5
24	101.30	0.5
25	61.442	0.5
26	37.267	1.0
27	13.710	1.0
28	5.0435	1.0
29	1.8554	1.0
30	0.68256	11.31

The DLC-37C/EPR (100N-21G) cross section set was collapsed and mixed to a 23N-21G (P_3) cross section set for 11 radial zones.^{4,13} Model 1 of the FBBF was used. P_0 absorption and fission microscopic cross sections for uranium-235, uranium-238 and plutonium-239 and the gamma-ray kerma factors were collapsed and combined with the P_3 cross sections for the 11 mixtures.

ANISN-W calculations of fission rates were compared with results from two-dimensional diffusion calculations⁴ made using the code 2DB.⁵ An axial midplane comparison of the calculated uranium-235 fission rates is shown in Fig. B.8; agreement is poor. The two-dimensional model for the 2DB calculations used the four point sources rather than the line source used for ANISN; Therefore, the large discrepancies for radii less than 10 cm are to be expected because the axial midplane actually lies between the two middle point sources. The large discrepancies for radii greater than 20 cm (i.e., the blanket and reflector regions) could not be attributed simply to differences in the geometrical models.

Differences in the cross section sets were investigated. DLC-37C/EPR contains infinitely dilute cross sections; a 1/E weighting spectrum was used in the fast groups. The 21-group cross section set used for the 2DB calculations were generated using the MC²-2 code^{14,15} and was self-shielded. The weighting spectra used were fine group spectra calculated for various regions of the proposed CRBR. The 21-group cross section set neglects neutrons with energies greater than 10 MeV; it also neglects thermal neutrons. The 21-group cross section set was self-shielded for a temperature of 1000°K. Macroscopic mixtures were formed using the one-dimensional diffusion code LAZARUS.¹

The major difference between the two cross section sets appeared to be self-shielding. Resonance self-shielding in uranium is quite important for the blanket region (containing natural uranium) and differences of approximately

Figure B.8: Ratio of 2DB calculation to initial ANISN-W calculation for ^{235}U fission rate.

a factor of two were found in the macroscopic absorption cross sections for some energy groups. A simple approach was taken to incorporate the effects of self-shielding into the 23N-21G cross section set collapsed from DLC-37C/EPR. Macroscopic absorption and fission cross sections for groups 4 through 21 of the 21-group cross section set for the 2DB calculations were substituted into the corresponding groups 5 through 22 of the 23N-21G FBBF library. The macroscopic total cross sections were reduced by the same amount as the absorption cross section; the scattering cross sections were not changed. The energy groups modified are those for neutron energies below 1 MeV.

The self-shielded FBBF library was used with ANISN-W to recalculate the fission rates, capture rates, and gamma heating rates. A comparison of the resulting fission rates for uranium-235 and uranium-238 with those calculated by 2DB are shown in Fig. B.9. The 2DB and ANISN-W calculations for uranium-235 agree within several percent in the blanket regions. The uranium-235 fission rates calculated by ANISN-W are shown in Fig. B.10. Agreement of 2DB and ANISN-W for uranium-238 is seen in Fig. B.9 to be fair, although not nearly as good as for uranium-235. The uranium-238 fission rates calculated by ANISN-W are shown in Fig. B.11. The plutonium-239 fission rate and capture traverses are shown in Fig. B.12 and Fig. B.13, respectively. The capture traverse for uranium-238 is shown in Fig. B.14.

Gamma-ray heating rates are calculated by ANISN-W by folding a response matrix containing gamma-ray kerma factors with the calculated gamma-ray flux. Gamma-ray heating rates in the FBBF were calculated for each element in the kerma factor response matrix. The resulting heating rates are output by ANISN-W as activities by spatial interval. Kerma factors for uranium were not included with DLC-37C/EPR. Rather than to attempt to extrapolate the kerma factors, the gamma-ray heating rates were plotted as a function of atomic number and extrapolated to obtain gamma-ray heating rates in uranium.¹⁶ Lead

Figure B.9: Ratio of 2DB calculation to ANISN-W calculation using self-shielded cross sections.

Figure B.10: ANISN-W calculation of ^{235}U fission rate using self-shielded cross sections.

Figure B.11: ANISN-W calculation of ^{238}U fission rate using self-shielded cross sections.

Figure B.12: ANISN-W calculation of ^{239}Pu fission rate using self-shielded cross sections.

Figure B.13: ANISN-W calculation of ^{239}Pu capture rate using self-shielded cross sections.

Figure B.14: ANISN-W calculation of ^{238}U capture rate using self-shielded cross sections.

was the highest-Z material for which kerma factors were included in the response matrix included in the DLC-37C/EPR library. Gamma-ray heating rates are shown for UO_2 in Fig. B.15 and for lead in Fig. B.16.

Resonance self-shielding is vital in preanalysis calculations of the fission rates and the gamma-ray heating rates in the FBBF. The amount of self-shielding will vary from region to region as well as from one blanket loading to the next; therefore, a self-shielding method such as that of Bondarenko¹⁷ should be used to allow changes to be easily made. Self-shielding should be performed at room temperature.

Figure B.16: Calculated gamma-ray heating rate in lead.

Figure B.15: Calculated gamma-ray heating rate in UO₂

TASK C
(F.M. Clikeman)

INTRODUCTION

The objectives of this task are: 1. testing experimental equipment and techniques for the FBBF facility; 2. performing checkout tests and preparing operating procedures required for licensing purposes and for the safe operation of the FBBF facility; and 3. loading the first blanket configuration of the FBBF. Progress on these objectives are summarized in the following sections.

C.1. Testing Experimental Equipment and Techniques
(F.M. Clikeman, R.H. Johnson, D.W. Vehar,
G.A. Harms, H.P. Chou, and K.R. Koch)

Preliminary testing of equipment and techniques for neutron spectroscopy, foil activation, solid state fission track recorder measurements, and gamma dosimetry measurements continued during the quarter. Although the FBBF facility was not available for measurements, testing of techniques and equipment was carried out using the PUR-I reactor as well as radioactive source including the small 262 DF source.

C.1.1. Foil Activation Measurements
(G.A. Harms and F.M. Clikeman)

During the progress period the data reduction program provided with the Cambarra Scorpio 3000 data acquisition system were tested. It was determined that the data analysis techniques incorporated in the software programs supplied by Cambarra should be adequate for analysis of data acquired using the Ge(Li) detector. However, the nuclear data, such as gamma-ray yields per decay, contained in the libraries supplied by Cambarra have been shown to contain errors. The best available nuclear data, from the Nuclear Data Tables, are currently being incorporated into the libraries.

During the progress period a National Bureau of Standards standard point source was acquired for both the energy and efficiency calibration of the detector. Although the absolute efficiency of the detector is not required for the relative foil activation measurements, it will be required for the activities used as input to the spectrum programs such as CRYSTAL BALL and SAND II.

C.1.2. Proton-Recoil Proportional Counting
(F.M. Clikeman and D.W. Vehar)

During the quarter progress has been made in adapting a newer version of the PSNS series¹⁸ of the data reduction codes for use with PDP-11/04 computer. These codes will soon be ready for use. These versions of the codes will allow greater flexibility in the use of the data reduction process.

Also during the period the design and fabrication of a new preamplifier for use with the proportional counters was completed. The new preamplifier is the same electronically as previous preamplifiers but by use of minitured components and tight placement on the printed placement board, the size was reduced so that the preamplifier and detector can be placed in an experimental fuel rod. A connector has also been designed which allows the detector to be mounted directly to the preamplifier board, while maintaining protection against arcing of the high voltage on the detector.

Finally, a new detector has been received from LND, Inc. for use with the proton-recoil spectroscopy system. This detector will be used primarily in the range of from 1 KeV to 100 KeV and will require gamma-ray discrimination below about 35 KeV. Before the detector is used in the FBBF facility it will be tested and calibrated using PUR-I reactor.

C.1.3. Fission Rate Measurements
(F.M. Clikeman and H.P. Chou)

Thorium-233, neptunium-237, uranium-235, uranium-238 and plutonium-239 foils have been acquired for the fission rate measurements in the FBBF facility. These foils have the material electroplated on a polished nickel disk and have an active diameter of 6.3 mm. Ground glass disks and a capsule capable of holding the fission foil and the glass disk are being fabricated for insertion into the experimental fuel rods. The mass of each of these fission foils has been determined from the alpha counting data by the manufacturer. These determinations will be varified by alpha counting at the FBBF laboratory before the foils are used in the FBBF facility.

Work has also progressed on the automatic scanning optical microscope for use in the track counting process. The design of the interface between the optical detector and the microcomputer is now underway. A program for recognizing and counting the tracks is available and will be implimented and tested on the computer.

C.2. Installation and Testing of Facility Equipment and Preperation of Operating Procedures
(F.M. Clikeman)

During the progress period fabrication of the reflector cans for the FBBF facility was completed. The new design of the reflector cans uses three inches of rolled steel plate to replace the steel punching originally specified.

Following the delivery of the reflector cans the loading of the first blanket into the FBBF facility was started. It was found that in order to fit the fuel rods into the aluminum or stainless steel sleeves that the welds on each end of the fuel rods had to be machined down. This necessitated

mounting each fuel rod in a lathe and turning the welds down. The procedure increased the time required for loading the first blanket, however, the loading of the first blanket was completed March 31, 1978.

During the month of April measurements of the k_{eff} of the FBBF facility and of the radiation levels surrounding the facility and in the adjacent areas of the Physics Building will be completed. These measurements will verify the calculations used in the design in the FBBF facility.

During this period procedures were developed for the moving of the natural uranium fuel into the FBBF facility, machining of the fuel rods, and for the loading of the fuel rods into the FBBF facility.

C.3. Experimental Programs for the FBBF Facility
(F.M. Clikeman, R.H. Johnson and K.O. Ott)

The experimental program for the FBBF facility was outlined in a previous progress report. Detailed plans for the initial blanket loading have also been reported in previous progress reports. Starting on or about May 1, 1978 the experiments in the first blanket will commence. The initial measurements will be the activation of gold foils to verify (1) the azimuthal symmetry of the facility, (2) the axial neutron distribution in the facility, (3) to provide gold activity measurements for comparison with integral reaction rate calculations, and (4) for eventual input into neutron spectra unfolding codes.

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