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**THE ISOTOPIC COMPOSITIONS DATABASE SYSTEM ON
SPENT FUELS IN LIGHT WATER REACTORS(SFCOMPO)**

February 1997

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The Isotopic Compositions Database System on
Spent Fuels in Light Water Reactors(SFCOMPO)

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In the framework of the activity of the nuclide production evaluation WG in the Sigma Committee in Japan, we have been collecting the assay data on the isotopic composition of LWR spent fuels. Those data are required for verification of accuracy of the burnup calculation codes.

To supply worldwide users with these types of data, the isotopic composition database system SFCOMPO was constructed on an IBM PC-AT (compatible computers). The SFCOMPO includes the isotopic composition data from 10 LWRs (the 6 PWRs and 4 BWRs) and several sets of axial burnup profiles of spent fuel rods.

Keywords: Database System, Isotopic Composition, Spent Fuel,
Light Water Reactor, Burnup, Benchmark Data, Assay Data

* The Japan Research Institute, Ltd.

軽水炉使用済燃料核種組成データベースシステム

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(1996年10月25日受理)

日本におけるシグマ委員会の核種生成量評価WG活動の一環として、軽水炉使用済燃料の核種組成分析データの収集を行ってきた。これらのデータは燃焼計算コードの精度評価に必要なものである。

これらのデータを世界のユーザーに提供するため、核種組成 データベースシステム SFCOMPO がパーソナルコンピュータ IBM PC-AT（又はその互換機）上で作成された。SFCOMPO には、10基の軽水炉（6基のPWR 及び 4基のBWR）から収集された核種組成分析データ及び数組の使用済燃料棒の軸方向燃焼度分布データが収納されている。

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1. Introduction

The electric power using nuclear power reactors has been increasing and so are the storage of spent fuels. There will be many subjects which should be studied on the spent fuel safety in near future fuel cycle, such as storage, transport, and reprocessing. It is important to understand the isotopic compositions of spent fuels in order to study these themes. Many burnup calculation codes have been developed for the estimation of isotopic compositions of spent fuels. In the Nuclide Production Evaluation WG of the Sigma Committee in Japan, we have collected measured data on the isotopic compositions of spent fuels for the verification of the burnup calculation codes.

Many spent fuel assay data from 13 LWRs(7 PWRs) and have been reviewed and summarized so that they can be provided for the users. As a result, the report of "Databook of the Isotopic Composition of Spent Fuel in Light Water Reactors", JAERI-M 94-034, was published in cooperation of the NEA/BUC group in February, 1994¹⁾. After that, we have been investigating isotopic composition data of LWR spent fuels, and several sets of assay data introduced by ORNL, were collected from the nuclear reactors in the USA. And, some assay data and axial burnup profile data were collected from the Japanese nuclear reactors.

To supply worldwide users with these types of data, the isotopic composition database system SFCOMPO was constructed on an IBM PC-AT(compatible computers). In the database, the 10 LWRs(6PWRs and 4 BWRs) isotopic composition data and several sets of burnup profile data were stored, which were selected from the collected data by considering the data quality, etc. There are many functions in the database system; the new data storage, the stored data change, the data search to be required, the data table print and the preparation of graphical output, etc. We can easily store new data and search the data to be required for us by using this SFCOMPO database .

Chapter 2 of this report are the general descriptions of the database described. Chapter 3 summarize the isotopic composition data by a reactor. In the 4th Chapter, axial burnup profile data are described. In the 5th chapter, we describe the users manual of the SFCOMPO database.

2. General Descriptions

2.1 Outline of the SFCOMPO database

2.1.1 Structure of the Database SFCOMPO

The SFCOMPO database is a relational database. As a relational database management system, the "R:BASE V. 4.0" is used in it. The database was installed on a personal computer IBM PC-AT, which can be utilized easily by worldwide users.

The database consists of 7 relational data tables as shown in Table 2.1. And, the relations among the tables are shown in Fig. 2.1. Each data(isotopic composition data and axial burnup profile data) has a number(condition id), the information data on its(reactor name, initial enrichment,etc.) are described on the Survey Condition Table(Condition Table). The isotopic composition data are described on the Experiment Table, and the burnup profile(axial gamma activity profile) data are described in Distribution Table.

The burnup measurement method and the axial location in the Condition Table are identified by the IDs defined with the Burnup Table and the Height Table. The item name and the unit in the Experiment Table are identified by IDs defined with the Selection Table and sUnit Table.

2.1.2 Isotopic Composition Data Search

(1) Specification of the area of the data to be searched

There are two steps in the specification. In the first step, the search area is specified with 4 parameters in the Survey Condition Table, and if you need, a more smaller area, is specified with the other 5 parameters in the second step. The 1st and 2nd step parameters are described below.

1st step parameters:

Reactor Type (reac_type)	PWR or BWR
Initial Enrichment (enrich)	
Sample Burnup (sam_burnup)	
Cooling Time (cooling)	

2nd step parameters

Reactor Core Name (reac_name)	
Fuel Assembly Name (assembly)	
Fuel Rod Location (rod_location)	
Sample Height in Rod (height_id)	
Measurement Laboratory (laboratory)	

(2) The kind of the measured data

There are two kinds of data in the isotopic composition database, they are burnup as well as isotopic composition data.

For burnup measurement, there are many methods. Most samples whose data are stored in SFCOMPO have several burnup values that are measured by different measurement methods. Then, the representative burnup of each sample is decided and chosen among the burnup values, and only this value is the sample burnup to be searched in SFCOMPO. The burnup measurement methods stored in SFCOMPO are described below.

- 1) Nd-148 method
- 2) Heavy metal method(using U, Pu compositions)
- 3) Chemical analysis Cs-137 method
- 4) Non-destructive Cs-137 method

The numbers at the top of these show priority when the representative burnup is decided.

There is only one representative burnup on a sample but the burnup values by the other methods on the sample are also stored in SFCOMPO. You can compare the representative value with the others after the sample data searched.

Details of the isotopic composition data are described in the Chapter 3.

(3) Kinds of Output

There are 3 kinds of output in SFCOMPO described below.

- 1) Table print by a printer
- 2) Table output to a disc file
- 3) Preparation of the disc file for graphical output

SFCOMPO has no function for graphic display, but has a function of the input preparation for external graphic soft. You can generate the input data file for graphic output by your specification of items corresponding to the X-axis and Y-axis, and you can easily get graphic output by using this input file and external graphic soft.

The details are described in Chapter 5.

2.1.3 Burnup (Axial gamma activity) profile data search

(1) Specifications of the area of data to be searched

There are two steps in the specifications. In the first step the search area is specified with 2 parameters in the survey Ccondition table, and if you need, the more small area is specified with the other 3 parameters in the second step. The 1st step parameters and 2nd step parameters are described below.

1st step parameters:

Reactor type (reac_type)	PWR or BWR
Average burnup of assembly (averae_bunup)	

2nd step parameters

Reactor core name (reac_name)
Fuel assembly name (assembly)
Fuel rod location (rod_location)

(2) The estimated burnup input

There are two sets of the axial gamma activity profile data in the distribution table. 1st is a profile represented with the gamma ray counts measured, 2nd is a profile represented with the relative values normalized. SFCOMPO has a normalization function with a relative profile being generated and stored on a occasion of the measured values storage operation.

There are Cs-134, Cs-137 and Eu-154 gamma profile data in the distribution table. If you input the estimated average burnup of the objective fuel rod, you can get the axial burnup profile of the fuel rod obtained by multiplying the relative Cs-137 gamma profile with the estimated average burnup.

Details of the burnup (axial gamma activity) profile data are described in Chapter 4.

(3) Kinds of Output

There are 3 kinds of output in SFCOMPO described before. The details are described in Chapter 5.

2.2 Stored data content

2.2.1 Outline of the isotopic composition data

Assay data of the spent fuels from the 10 nuclear reactors; 6 PWRs and 4 BWRs, are stored in SFCOMPO. A summary of the reactors is shown in Table 2.2. The details of the following 6 reactors are described in the report:JAERI-M 94-034. "DATA BOOK OF THE ISOTOPIC COMPOSITION OF SPENT FUEL IN LIGHT WATER REACTORS" published in 1994.

- The Trino Vercellese reactor(PWR)
- The Obligheim reactor(PWR)
- The Genkai-1 reactor(PWR)
- The Mihama-3 reactor(PWR)
- The Gundremmngen reactor(BWR)
- The Monticello reactor(BWR)

The data from the following 4 reactors were collected after the report had been published.

- The H.B Robinson-2 reactor(PWR)
- The Calvert Cliffs-1 reactor(PWR)
- The Cooper reactor(BWR)
- The Fukushima-Daiichi-3 reactor(BWR)

Details of these reactors and data are described in Chapter 3.

2.2.2 Outline of the burnup(Axial gamma activity) profile data

It is important to estimate the burnup profile of spent fuels in the criticality safety evaluation of spent fuels while considering the burnup credit. We have collected axial gamma activity(Cs-134, Cs-137, Eu-154 and total gamma) profile data of the spent fuels as basic data for this estimation.

The following reactors' data are stored in SFCOMPO.

- The Genkai-1 Reactor(PWR)
- The Tsuruga Reactor(BWR)

Details of these reactors and data are described in Chapter 4.

Table 2.1 Relational Data Tables of the Database

Data Table Name	Stored Data Contents	Relational Table	Relational Item
Condition Table	Paameters to be specified	-----	-----
Experiment Table	Isotopic Composition Data	Condition Table	condition_id
Distribution Table	Burnup Profile Data	Condition Table	condition_id
Height Table	Axilal Location of Sample	Condition Table	height_id
Burnup Table	Burnup Measurement Method	Condition Table	id_of_burnup
Unit Table	Unit Data	Experiment Table	unit_id
Selection Table	Items of Isotopic Composition	Experiment Table	item-name

Table 2.2 Outline of the Reactors whose Data are Stored in SFCOMPO

No	Reactor Name	Reac Type	Power	Rod Array	Enrichment
1	Trino Vercellese	PWR	825 MWth	15 x 15	2.7/3.1/3.9
2	Obligheim	PWR	908	14 x 14	2.5/2.8/3.1
3	Mihama-3	PWR	2440	15 x 15	3.24 w/o
4	Genkai-1	PWR	1650	14 x 14	3.42
5	Robinson-2	PWR	2200	15 x 15	1.9/2.6/3.1
6	Gundremmingen	BWR	(250MWe)	6 x 6	1.87/2.53
7	Monticello	BWR	(536MWe)	8 x 8	1.5/1.9/2.1/2.9
8	Calvert Cliffs-1	PWR		14 x 14	3.04
9	Cooper	BWR		7 x 7	1.3/1.7/1.9/2.9
10	Fukushima-No1-3	BWR		8 x 8	1.5/1.9/2.2/3.0

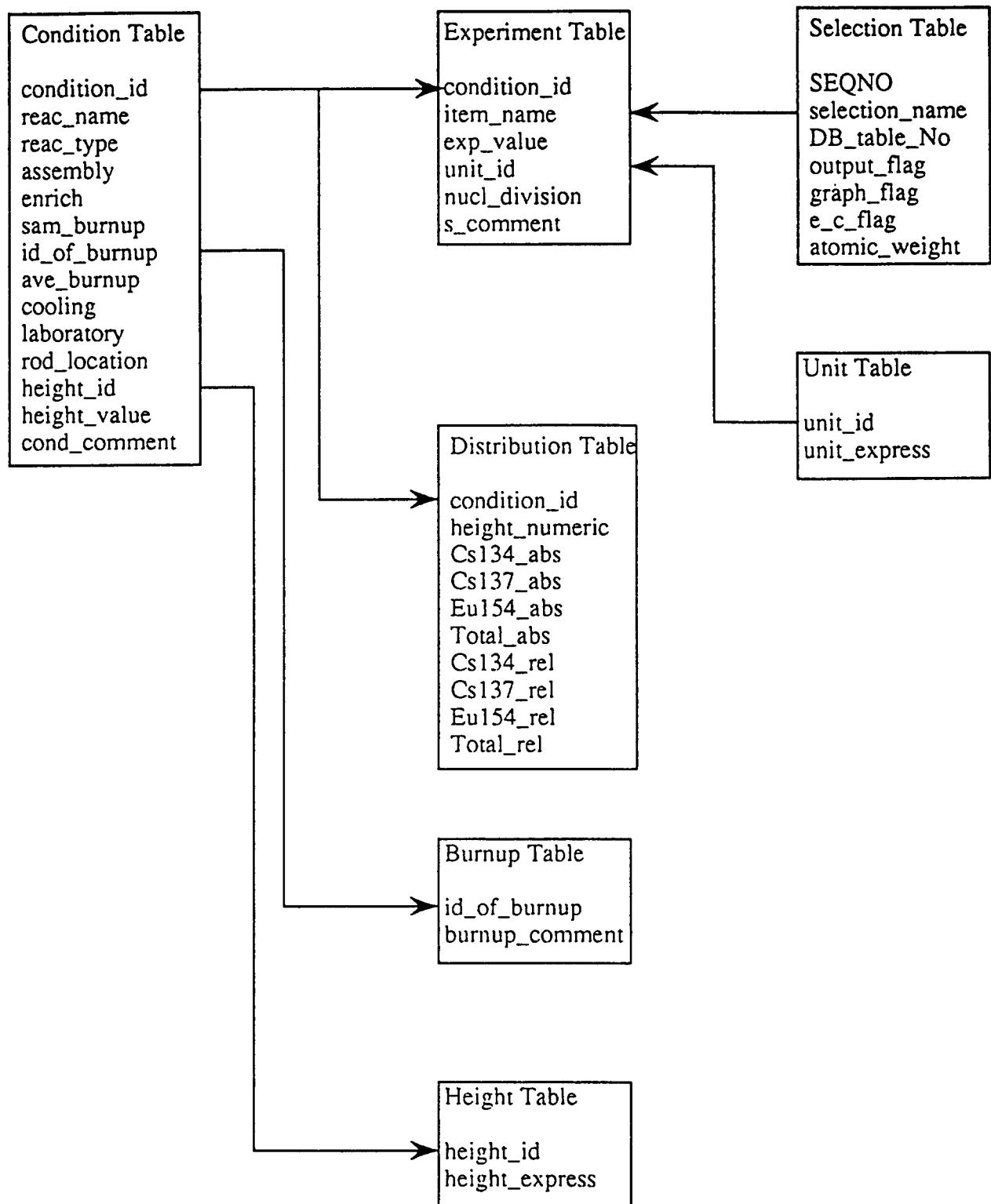


Fig. 2.1 The Relations among the Data Tables of the Database

3. Isotopic Composition Data

In this chapter, the measured isotopic compositions of the spent fuels from the following 4 reactors are describe, except for 6 reactors whose details are shown in the report JAERI-M 94-034¹⁾.

3.1 H.B. Robinson-2 Reactor(PWR, USA)

3.2 Calvert Cliffs Reactor(PWR, USA)

3.3 Cooper Reactor (BWR, USA)

3.4 Fukushima Daiichi-3 Reactor (BWR, JAPAN)

The data of 3.1, 3.2 and 3.3 were obtained as a result of the PID of the spent fuels by the Material Characterization Center(MCC) of Pacific Northwest Laboratory(PNL). The summary of the PID can be seen in Table 3.1.

Table 3.1 Summary of Spent Fuel ATMs Being Characterized by the MCC

<u>ATM</u>	<u>Fuel Type</u>	<u>Reactor</u>	<u>Burnup Range, MWd/kgM(a)</u>	<u>Range of Fission Gas Release, %(a)</u>	<u>No. of Rods</u>
101	PWR	H. B. Robinson, No. 2	16-32	0.2-0.3	9 as 27 1.2-m (4-ft) segments
103	PWR	Calvert Cliffs, No. 1	13-33	0.25	176 full length
104	PWR	Calvert Cliffs, No. 1	20-44	0.4-1.1	128 full length
105	BWR	Cooper	18-34	0.6-7.9	88 full length
106	PWR	Calvert Cliffs, No. 1	27-47	7.8-18	20 full length

(a) Measured in the fuel rods examined to date. These ranges may expand as more rods are examined.

3.1 H.B. Robinson-2 Reactor (PWR)

These isotopic composition measurements were performed as one of the characterizations of LWR spent fuel MCC-approved testing materials by MCC.

The tables and figures in this section were reprinted from the following report.

- 2) R.J. Guenther et.al., "Characterization of LWR Spent Fuel MCC-Approved Testing Material-ATM-101", PNL-5109 Rev.1(1985).

3.1.1 Core configuration and performance

The H.B. Robinson-2 reactor is a PWR with the power of 2192 MWth(665MWe). The core consists of 157 assemblies of 15 x 15 rods. Each assembly consists of 204 fuel rods and 20 control rod guide tubes and 1 nuclear instrument guide tube.

The core configuration and assembly rod array are shown in Figs. 3.1.1 and 3.1.2. The specifications of the fuel rod are shown in Table 3.1.1.

3.1.2 Irradiation history and samples

These sample rods are called ATM-101, and were irradiated in the fuel assembly BO-5 for two cycles; 1st cycle and 2nd cycle. The assembly is located at the position of F9 in 1st cycle, and M11 in 2nd cycle. The irradiation history is shown in Table 3.1.2 and Fig. 3.1.3. The assay samples were 4 pieces(N-9C-D, N-9C-J, N-9B-N, N-9B-S) from N-9 rod(See Fig. 3.1.2). The axial locations of these samples are shown in Figs. 3.1.4 and 3.1.5. The assays of N-9C-D and N-9C-J were performed 9.9 years after irradiation, assays of N-9B-N and N-9B-S were performed 10.8 years after the irradiation.

3.1.3 Isotopic composition data

The measured burnup and isotopic composition data are shown in Table 3.1.3 and 3.1.4. The measured actinoids are U, Pu and Np-237. The measured fission products(FPs) are Nd, Tc-99 and Cs-137.

Table 3.1.1 As-Fabricated Fuel Rod Characteristics for ATM-101

Cladding O.D., mm	10.70
Cladding I. D., mm	9.46
Cladding wall thickness, mm	0.62
Diametral gap, mm	0.165
Cladding material	Zircaloy-4
Fuel rod length, m	3.86
Fuel pellet material	Sintered UO ₂
Pellet type	Solid, dished
Fuel density, g/cm ³ (% T.D.)	10.08 (92)
²³⁵ U enrichment, wt%	2.55
Pellet diameter, mm	9.30
Pellet length, mm	15.2
Fuel stack height, m	3.65
Plenum length, mm	173.5
End cap length, mm	17.5

Table 3.1.2 Power History for Assembly BO-5

Date	Cycle I		
	Average	Peak	EFPD
October 1971	22.9	31.3	95.7
November 1971	22.9	31.7	120.0
December 1971	23.3	32.7	149.9
January 1972	23.8	31.3	177.2
February 1972	23.9	31.1	205.3
March 1972	22.9	28.6	235.5
April 1972	22.9	29.2	265.2
May 1972	22.5	28.6	270.7
June 1972	22.5	28.6	289.5
July 1972	22.7	28.3	312.6
August 1972	21.6	27.1	341.2
September 1972	21.3	25.6	369.0
October 1972	21.5	27.5	398.6
November 1972	20.8	27.3	423.6
December 1972	20.4	27.0	443.9
January 1973	21.4	26.9	460.4
February 1973	21.8	27.9	475.7
March 1973	20.1	26.4	487.2

Date	Cycle II		
	Average	Peak	EFPD
May 1973	17.8	22.9	6.5
June 1973	16.9	21.5	25.4
July 1973	18.3	24.6	58.8
August 1973	18.4	24.4	87.6
September 1973	17.9	23.1	116.6
October 1973	17.3	22.7	145.2
November 1973	17.5	21.9	166.2
December 1973	17.6	22.2	192.6
January 1974	17.7	22.2	221.2
February 1974	17.6	22.1	247.8
March 1974	17.6	21.9	278.1
April 1974	17.5	21.9	307.2
May 1974	17.5	21.2	311.8

Total	799 EFPD
-------	----------

Average burnup - 28.0 MWd/kgM
 Peak burnup - 31.4 MWd/kgM
 Removed May 6, 1974

Table 3.1.3 Burnup Results for ATM-101 Samples^(a)

Specimen No.	Burnup (¹⁴⁸ Nd basis)		Burnup (¹³⁷ Cs basis) MWd/kgM ^(b)	Sample Location
	At. % ^(c)	MWd/kgM ^(c)		
N-9C-D	3.32 ^(c)	31.66 ^(c)	31.8	Typical peak burnup in center segment of rod N-9.
N-9C-J	2.98 ^(c)	28.47 ^(c)	27.9	Burnup in grid spacer location of rod N-9.
N-9B-N	2.50	23.81	--	Representative of approximately 75% of peak ¹³⁷ Cs activity in bottom segment of rod N-9.
N-9B-S	1.68	16.02	--	Representative of approximately 50% of peak ¹³⁷ Cs activity in bottom segment of rod N-9.

(a) See sectioning diagrams in Appendix B for sample locations with respect to gamma activity.

(b) Calculation based upon ¹³⁷Cs half-life of 30.174 yr and effective fission yield of 6.138%.

(c) Results listed for specimens N-9C-D and N-9C-J are the average two analyses. Ranges were 0.07 at.% (0.70 MWd/kgM) for N-9C-D and 0.02 at.% (0.15 MWd/kgM) for N-9C-J.

Table 3.1.4 Radioisotopes Determined During Burnup Analyses

Isotope	N-9C-D ^(a)	N-9C-J ^(a)	N-9B-N ^(b)	N-9B-S ^(b)
<u>Uranium</u>				
U, g/g oxide	0.8497	0.8430	0.8575	0.8597
²³⁴ U, wt.%	0.013	0.014	0.016	0.018
²³⁵ U, wt.%	0.572	0.733	0.841	1.240
²³⁶ U, wt.%	0.353	0.335	0.319	0.255
²³⁸ U, wt.%	99.063	98.919	98.823	98.487
<u>Plutonium</u>				
Pu, g/g oxide	7.67×10^{-3}	7.73×10^{-3}	6.54×10^{-3}	5.17×10^{-3}
²³⁸ Pu, wt.%	1.700	1.475	1.643	0.547
²³⁹ Pu, wt.%	54.760	58.869	61.422	70.444
²⁴⁰ Pu, wt.%	27.625	25.500	25.477	21.162
²⁴¹ Pu, wt.%	9.019	8.818	7.713	5.877
²⁴² Pu, wt.%	6.897	5.339	4.324	1.970
<u>Neodymium</u>				
Nd, atoms $\times 10^{15}$ g oxide	1.184	1.109	0.937	0.626
¹⁴³ Nd/ ¹⁴⁸ Nd	2.055	2.208	2.264	2.628
¹⁴⁴ Nd/ ¹⁴⁸ Nd	3.619	3.497	3.462	3.392
¹⁴⁵ Nd/ ¹⁴⁸ Nd	1.811	1.841	1.884	2.016
¹⁴⁶ Nd/ ¹⁴⁸ Nd	1.843	1.829	1.798	1.785
¹⁵⁰ Nd/ ¹⁴⁸ Nd	0.487	0.485	0.472	0.455
<u>Technetium</u>				
⁹⁹ Tc, Ci/g oxide	1.01×10^{-5}	8.95×10^{-6}	8.09×10^{-6}	5.44×10^{-6}
<u>Cesium</u>				
¹³⁷ Cs, Ci/g oxide	7.13×10^{-2}	6.27×10^{-2}	5.39×10^{-2}	3.59×10^{-2}
<u>Neptunium</u>				
²³⁷ Np, g/g oxide	3.33×10^{-4}	3.037×10^{-4}	2.603×10^{-4}	1.545×10^{-4}

(a) Analyses made in April 1984.

(b) Analyses made in February 1985.

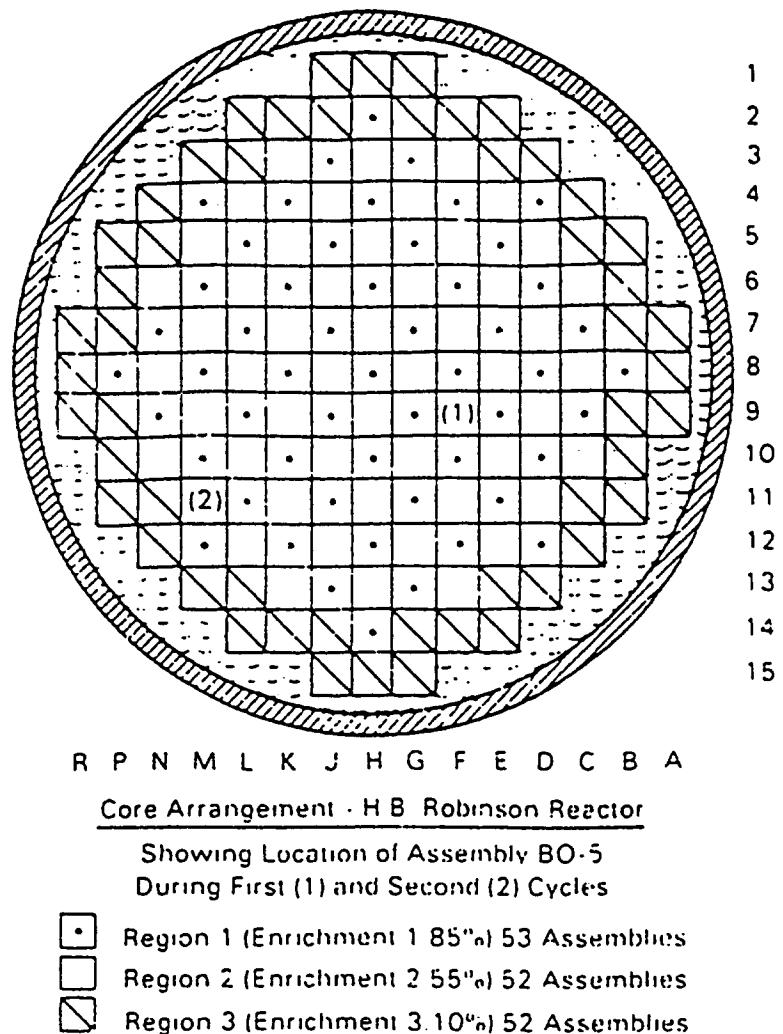


Fig. 3.1.1 Core Arrangement of H. B. Robinson Unit 2 Reactor

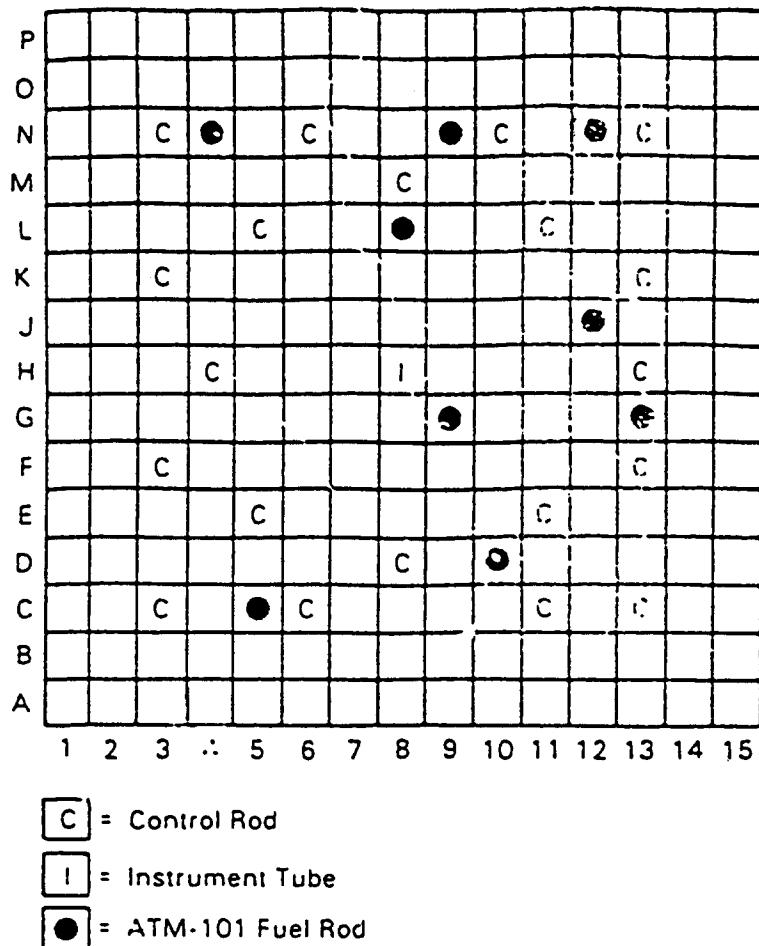


Fig. 3.1.2 Layout of H. B. Robinson Assembly BO-5

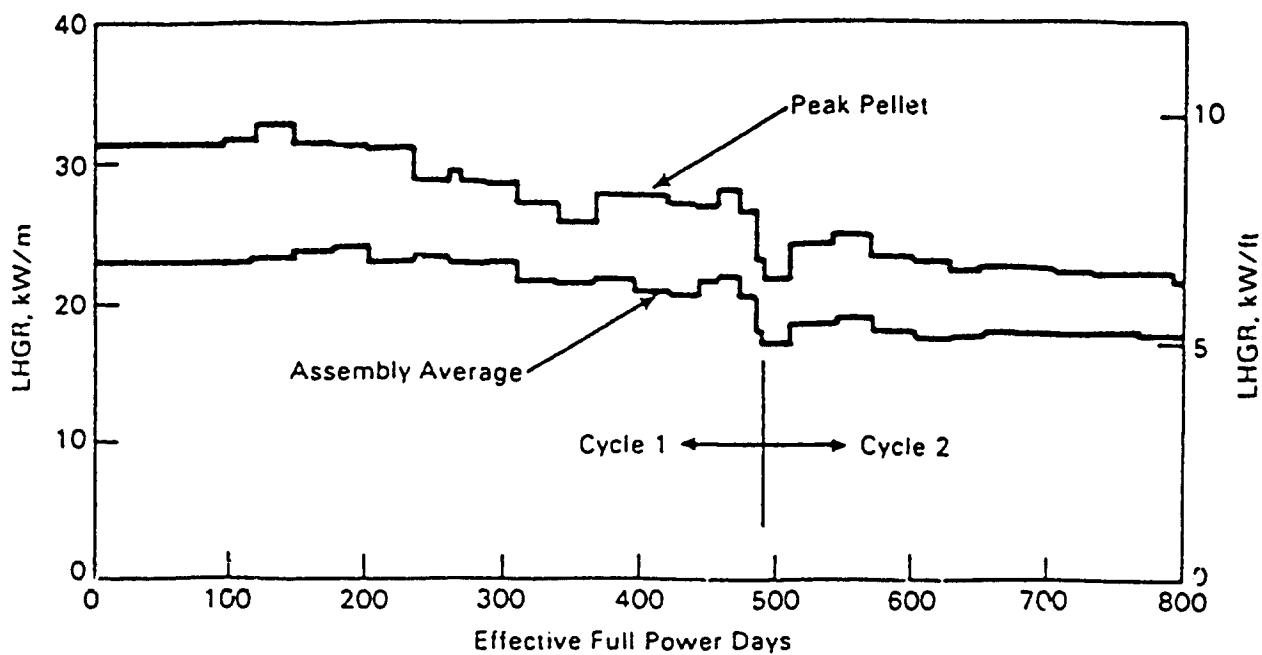
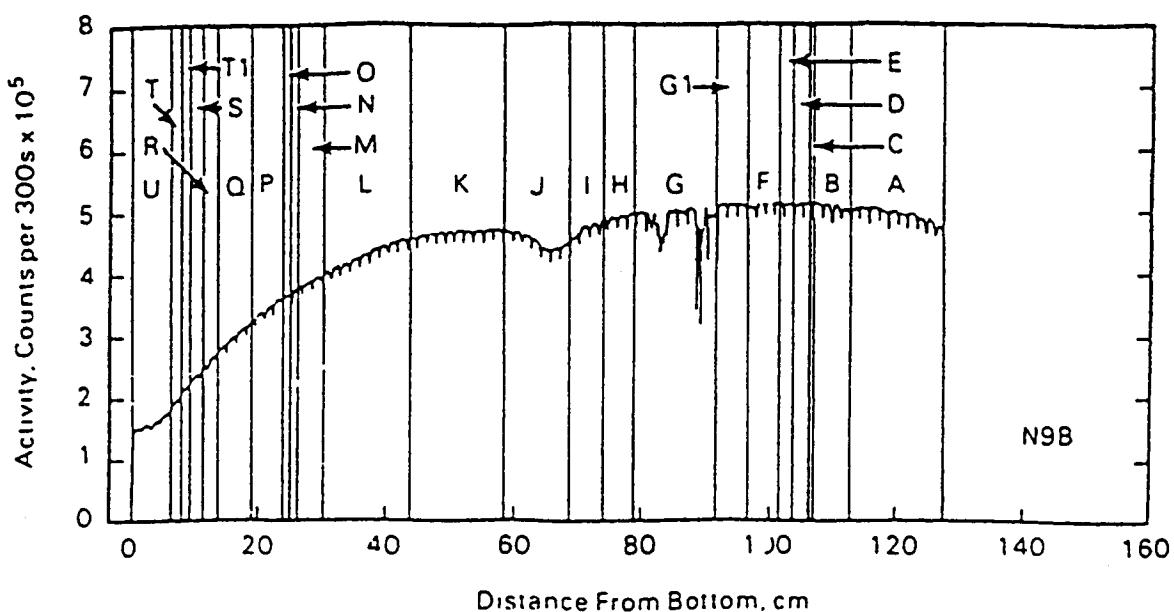


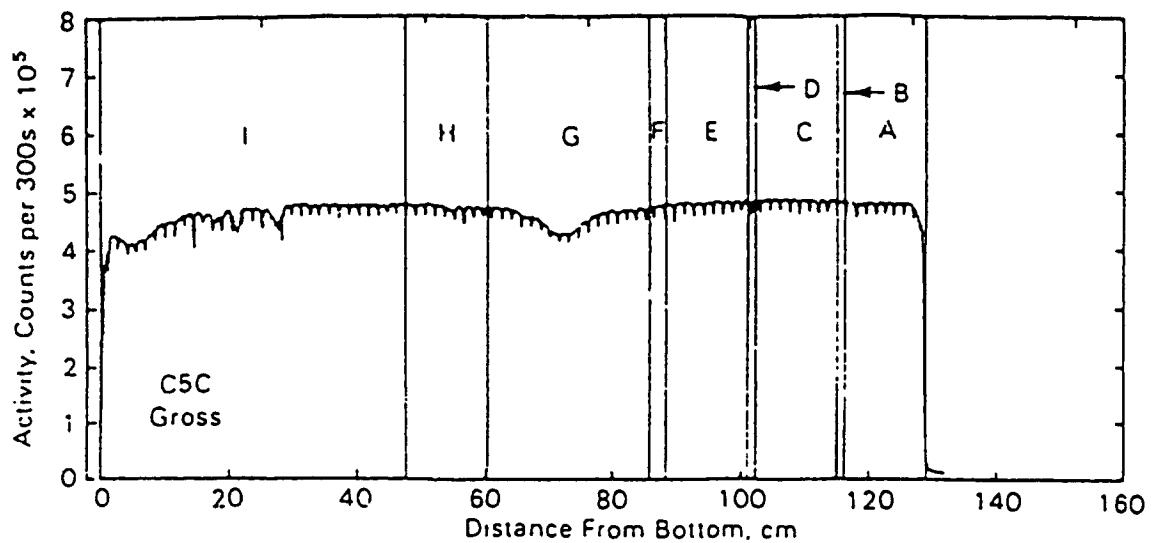
Fig. 3.1.3 Power History for Assembly BO-5

Legend^(a)

- | | |
|---|---|
| A. (1-Q) CSFMPO Cladding Defect Specimen | K. (2-Q) CSFMPO Cladding Defect Specimen |
| B. (1-I) CSFMPO Declad Specimen | L. MCC Archive |
| C. MCC Transverse Ceramography Specimen (not submitted) | M. MCC Longitudinal Ceramography Specimen |
| D. MCC Burnup Sample | N. MCC Burnup Samples |
| E. MCC Longitudinal Ceramography Specimen (not submitted) | O. MCC Transverse Ceramography Specimen (upper surface) |
| F. (2-I) CSFMPO Declad Specimen | P. (1-J) CSFMPO Declad Specimen |
| G1. Spare Material | Q. (2-J) CSFMPO Declad Specimen |
| G. Spare Material | R. MCC Longitudinal Ceramography Specimen (not submitted) |
| H. (1-N) CSFMPO Cladding Ring Specimen | S. MCC Burnup Sample |
| I. (2-N) CSFMPO Cladding Ring Specimen | T1. Material Discarded |
| J. Spare Material | T. MCC Transverse Ceramography Specimen (not submitted) |
| | U. Spare Material |

(a) Identification suffixes in parentheses in CSFMPO identification for samples.

Fig. 3.1.4 Preliminary Sectioning Diagram for Segment N9B

Legend

- | | |
|--|--|
| A. BWIP Material | I. MCC Transverse Ceramography (lower surface) |
| B. MCC ^{14}C Sample | J. MCC Burnup Sample |
| C. MCC Transverse Ceramography (upper surface) | K. MCC Longitudinal Ceramography |
| D. MCC Burnup Sample | L. Spare Material |
| E. MCC SEM Sample | M. MCC Archive |
| F. MCC Longitudinal Ceramography | N. BWIP Material |
| G. BWIP Material | O. Spare Material |
| H. Spare Material | |

Fig. 3.1.5 Final Sectioning Diagram for Segment N9C

3.2 Calvert Cliffs-1 Reactor (PWR)

This isotopic composition measurements were performed as one of the characterization of the LWR spent fuel MCC-approved testing materials by MCC.

The tables and figures in this section were reprinted from the following reports.

- 3) R.J.Guenther et.al., "Characterization of LWR Spent Fuel MCC-Approved Testing Material-ATM-103", PNL-5109-103(1988).
- 4) R.J.Guenther et.al., "Characterization of LWR Spent Fuel MCC-Approved Testing Material-ATM-104", PNL-5109-104(1991).
- 5) R.J.Guenther et.al., "Characterization of LWR Spent Fuel MCC-Approved Testing Material-ATM-106", PNL-5109-106(1988).

3.2.1 Core configuration and performance

The Calvert Cliffs-1 reactor is the PWR in the U.S. The core consists of assemblies of 14 x 14 rods. Each assembly consists of 176 fuel rods.

The assembly dimension and fuel rod dimension are shown in Figs. 3.2.1 and 3.2.2.

3.2.2 Irradiation history and samples

These assay samples were called ATM-103, ATM-104 and ATM-106, and irradiated in the fuel assemblies D101, D047 and BT03 respectively. The locations of these assemblies are shown in Figs. 3.2.3, 3.2.4 and 3.2.5. Also, the irradiation histories are shown in Figs. 3.2.6, 3.2.7 and 3.2.8, respectively.

The assay samples of ATM-103 were in 3 pieces(ATM-103-MLA098-P, ATM-103-MLA098-BB, ATM-103-MLA098-JJ) from the MLA098 rod. The power history for rod MLA098 and rod location in D101 assembly shown in Table 3.2.1, Table 3.2.2, Figs. 3.2.9 and 3.2.10. The axial locations of these samples are shown in Fig.

3.2.11. The assays were performed 6.5 years after irradiation.

The assay samples of ATM-104 were in 3 pieces(ATM-104-MKP109-P, ATM-104-MKP109-CC, ATM-104-MKP109-LL) from MKP109 rod. The power history for rod MKP109 and rod location in D047 assembly shown in Table 3.2.3, Table 3.2.4, Fig. 3.2.12 and Fig. 3.2.13. The axial locations of these samples are shown in Fig.

3.2.14. The assays were performed 5.08 years after the irradiation.

The assay samples of ATM-106 were in 3 pieces(ATM-106-NBD107-Q, ATM-106-NBD107-GG, ATM-106-NBD107-MM) from NBD107 rod. The power history for rod NBD107 and rod location in BT03 assembly shown in Table 3.2.5, Table 3.2.6, Fig.s 3.2.15 and 3.2.16. The axial locations of these samples are shown in Fig.

3.2.17. The assays were performed 6.7 years after irradiation.

Table 3.2.1 Detailed Power History of Rod MLA098

Cycle 2		Cycle 3 ^(a)		Cycle 4	
Time Interval, Days	LHGR, kW/m (kW/ft)	Time Interval, Days	LHGR, kW/m (kW/ft)	Time Interval, Days	LHGR, kW/m (kW/ft)
7.1	19.1 (5.81)	6.8	19.1 (5.83)	47.0	17.4 (5.30)
30.8	23.5 (7.17)	14.3	18.6 (5.68)	24.1	17.2 (5.25)
16.4	23.5 (7.17)	19.5	13.1 (3.98)	22.5	17.3 (5.26)
11.4	23.5 (7.17)	16.5	20.7 (6.32)	25.5	17.3 (5.28)
12.5	23.5 (7.17)	16.1	21.1 (6.42)	30.7	8.4 (2.56)
23.4	23.5 (7.16)	15.1	22.4 (6.83)	41.0	8.6 (2.63)
22.8	23.4 (7.14)	38.8	21.1 (6.43)	50.1	8.6 (2.61)
22.9	23.3 (7.11)	31.0	21.3 (6.48)	10.9	14.9 (4.55)
8.5	23.3 (7.09)	31.6	21.1 (6.44)	10.7	17.7 (5.40)
31.4	23.5 (7.16)	31.6	20.9 (6.37)	45.1	17.9 (5.45)
34.2	23.3 (7.11)	43.9	20.9 (6.37)	29.3	17.6 (5.37)
16.6	23.7 (7.22)	61.7	21.1 (6.43)	28.0	18.1 (5.51)
19.1	23.3 (7.11)	30.2	22.0 (6.71)	65.1	18.0 (5.50)
12.8	23.5 (7.15)			35.7	18.2 (5.54)
34.3	22.2 (6.77)				
1.9	22.2 (6.78)				

(a) Reactor was shut down for 25 days starting with day 270 of Cycle 3.

Table 3.2.2 ATM-103 Power History, Based on Rod MLA098

Cycle No.	Time Interval,	Power Density, w/g
	days	
2	306.0	32.09
down	71.0	0
3	21.1	25.21
3	19.5	17.59
3	228.4	28.51
3	25.0	0
3	88.0	28.51
down	81.0	0
4	119.1	24.56
4	121.8	12.13
4	225.1	25.25

Table 3.2.3 Detailed Power History for Rod MKP104

Cycle 2		Cycle 3 ^(a)		Cycle 4		Cycle 5	
Time Interval, Days	LHGR, kW/m (kW/ft)	Time Interval, Days	LHGR, kW/m (kW/ft)	Time Interval, Days	LHGR, kW/m (kW/ft)	Time Interval, Days	LHGR, kW/m (kW/ft)
7.1	19.5 (5.94)	7.8	22.2 (6.77)	46.1	19.4 (5.90)	29.7	12.9 (3.93)
30.8	24.0 (7.33)	14.1	21.7 (6.60)	24.0	19.2 (5.85)	5.9	13.7 (4.18)
16.4	24.1 (7.35)	19.4	15.2 (4.63)	22.6	19.2 (5.85)	7.1	13.8 (4.22)
11.4	24.1 (7.36)	16.9	23.6 (7.20)	25.6	19.2 (5.86)	42.2	14.0 (4.26)
12.5	24.1 (7.35)	16.4	23.8 (7.25)	30.5	9.4 (2.87)	16.8	14.0 (4.27)
23.4	24.1 (7.34)	15.4	25.1 (7.65)	41.1	9.6 (2.92)	29.4	14.2 (4.34)
22.8	24.0 (7.31)	39.4	23.3 (7.11)	50.2	9.4 (2.88)	24.7	14.3 (4.37)
23.2	23.9 (7.27)	31.4	23.3 (7.10)	11.1	16.3 (4.98)	30.0	11.3 (3.45)
8.1	23.8 (7.26)	31.9	23.0 (7.01)	10.8	19.4 (5.90)	55.3	13.5 (4.12)
31.4	24.0 (7.32)	32.0	22.6 (6.88)	45.4	19.4 (5.92)	27.1	14.8 (4.52)
34.3	23.8 (7.26)	44.3	22.5 (6.85)	29.4	19.1 (5.82)	45.7	15.1 (4.59)
16.5	24.2 (7.39)	59.1	22.4 (6.84)	28.1	19.5 (5.95)	23.5	15.2 (4.62)
19.2	23.8 (7.26)	28.9	23.3 (7.11)	65.4	19.4 (5.91)	30.2	13.8 (4.21)
12.8	24.0 (7.31)			35.7	19.5 (5.93)	20.8	15.2 (4.62)
34.3	22.7 (6.93)					66.6	15.5 (4.73)
1.8	22.8 (6.94)						

(a) Reactor was shut down for 25 days starting with day 270 of Cycle 3.

Table 3.2.4 ATM-104 Power History Based on Rod MKP104

<u>Cycle No.</u>	<u>Time Interval, days</u>	<u>Power Density, W/g</u>
2	306.0	32.87
down	71.0	0
3	21.9	30.76
3	19.4	20.41
3	227.7	38.14
3	25.0	0
3	88.0	31.14
down	81.0	0
4	118.3	27.27
4	121.8	13.43
4	225.9	27.25
down	85.0	0
5	461.0	21.43

Table 3.2.5 Detailed Power History for Rod NBD107

Cycle 1		Cycle 2		Cycle 3 ^(a)		Cycle 4	
Time Interval, Days	LHGR, kW/m (kW/ft)	Time Interval, Days	LHGR, kW/m (kW/ft)	Time Interval, Days	LHGR, kW/m (kW/ft)	Time Interval, Days	LHGR, kW/m (kW/ft)
24.2	19.2 (5.84)	7.2	13.3 (4.06)	10.9	12.6 (3.84)	45.0	13.8 (4.21)
19.6	24.1 (7.36)	31.0	17.1 (5.20)	14.1	12.4 (3.78)	24.1	13.8 (4.20)
39.7	24.1 (7.34)	16.4	19.0 (5.80)	25.3	6.7 (2.03)	22.4	13.9 (4.23)
39.7	23.9 (7.27)	11.4	18.9 (5.77)	12.2	14.0 (4.27)	25.2	14.1 (4.29)
32.4	23.7 (7.22)	12.6	18.9 (5.76)	16.3	14.2 (4.33)	31.0	6.7 (2.05)
39.3	23.6 (7.18)	23.2	18.9 (5.76)	15.1	15.2 (4.63)	44.8	6.3 (1.91)
39.1	23.5 (7.17)	22.7	18.9 (5.76)	38.1	14.3 (4.37)	48.1	7.0 (2.13)
38.9	23.6 (7.18)	23.0	18.9 (5.76)	30.9	14.6 (4.44)	10.9	12.4 (3.78)
39.0	23.6 (7.18)	8.2	18.8 (5.74)	31.4	14.6 (4.45)	10.6	14.9 (4.54)
39.1	23.5 (7.16)	31.0	19.3 (5.88)	31.5	14.6 (4.44)	45.3	15.2 (4.63)
39.1	23.3 (7.11)	33.8	19.4 (5.90)	43.2	14.8 (4.52)	28.7	15.1 (4.59)
39.4	23.1 (7.05)	16.5	19.8 (6.03)	60.0	14.9 (4.53)	27.9	15.6 (4.75)
39.3	22.9 (6.97)	19.1	19.6 (5.97)	28.0	16.1 (4.92)	65.9	15.5 (4.71)
39.3	22.6 (6.90)	12.3	19.8 (6.02)			36.1	15.7 (4.79)
39.3	22.4 (6.82)	35.2	18.4 (5.62)				
39.3	22.2 (6.76)	1.9	18.3 (5.57)				
19.6	22.0 (6.72)						
20.4	21.1 (6.44)						
30.8	14.9 (4.54)						
32.8	12.3 (3.76)						

(a) Reactor was shut down for 25 days starting with day 270 of Cycle 3.

Table 3.2.6 ATM-106 Power History Based on Rod NBD107

<u>Cycle No.</u>	<u>Time Interval, days</u>	<u>Power Density, W/g</u>
1	465.0	29.66
1	33.0	0
1	168.7	28.33
1	63.3	17.28
down	81.0	0
2	306.0	25.18
down	71.0	0
3	25.0	16.72
3	25.3	8.93
3	218.7	19.32
3	25.0	0
3	88.0	20.98
down	81.0	0
4	116.7	19.44
4	123.9	9.33
4	225.4	21.34

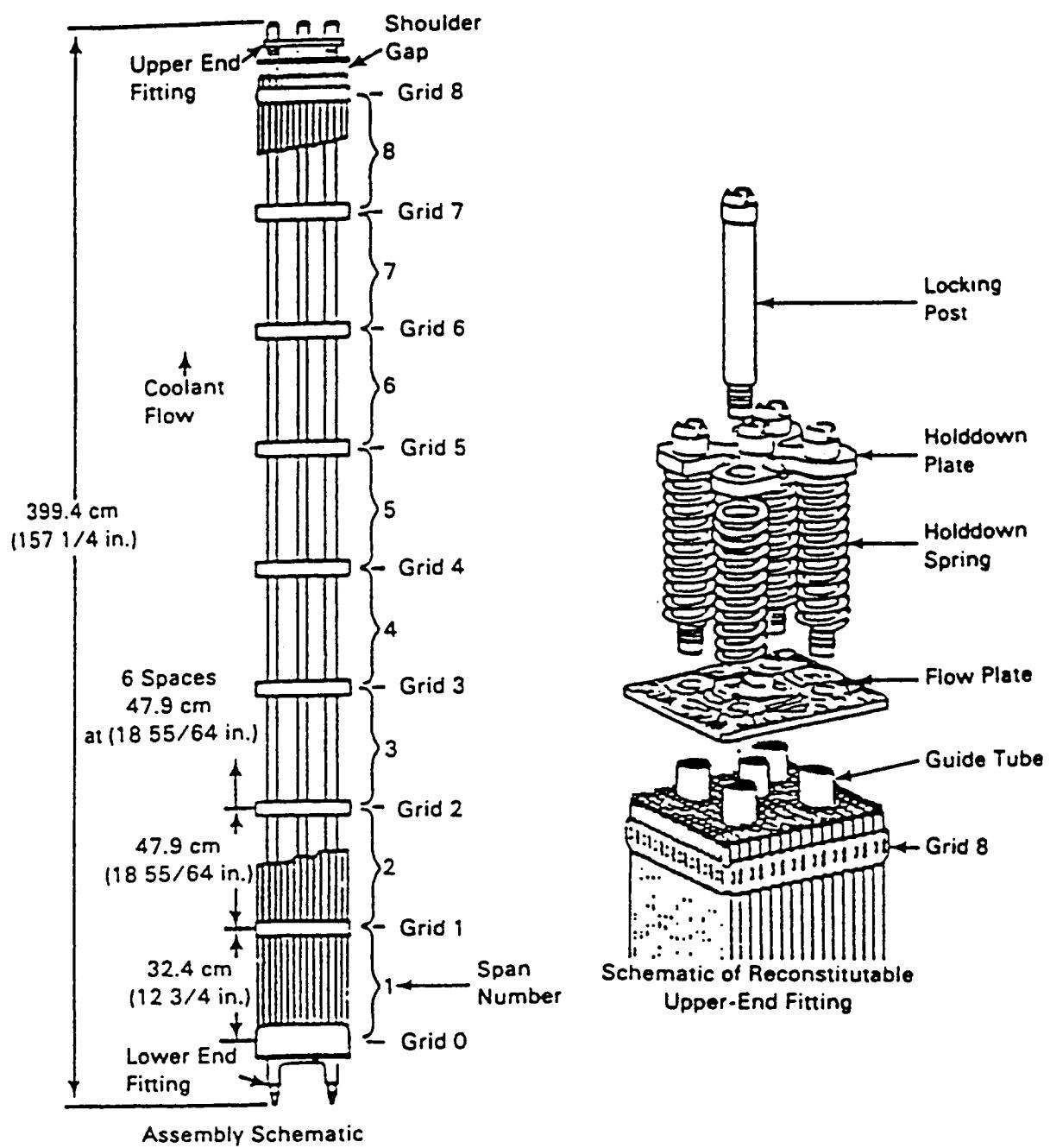


Fig. 3.2.1 Combustion Engineering 14 x 14 Fuel Assembly Schematic

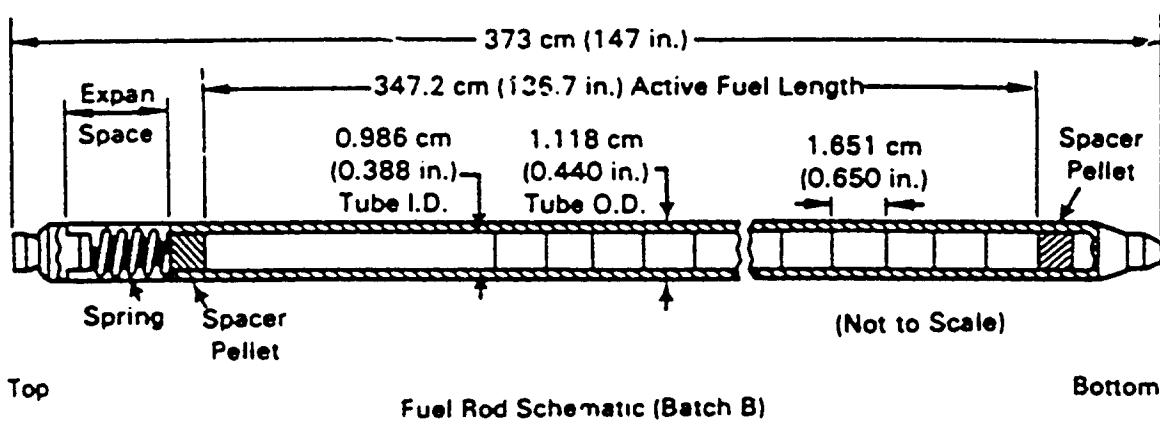
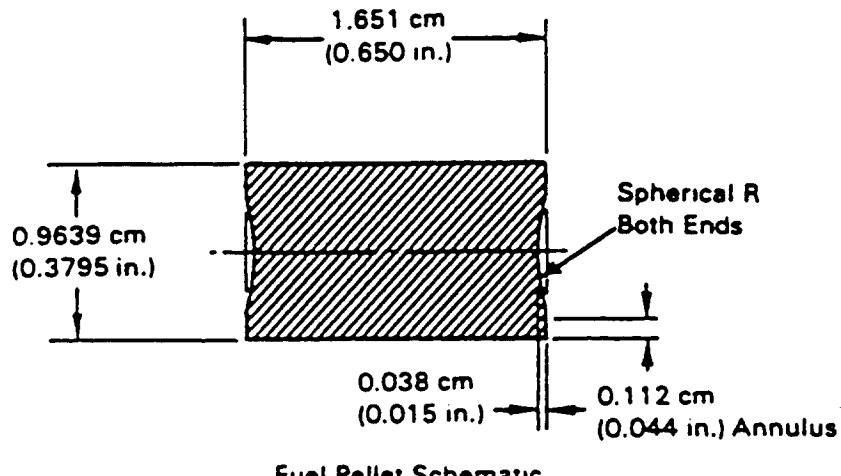


Fig. 3.2.2 ATM-106 Pellet and Fuel Rod Dimensions

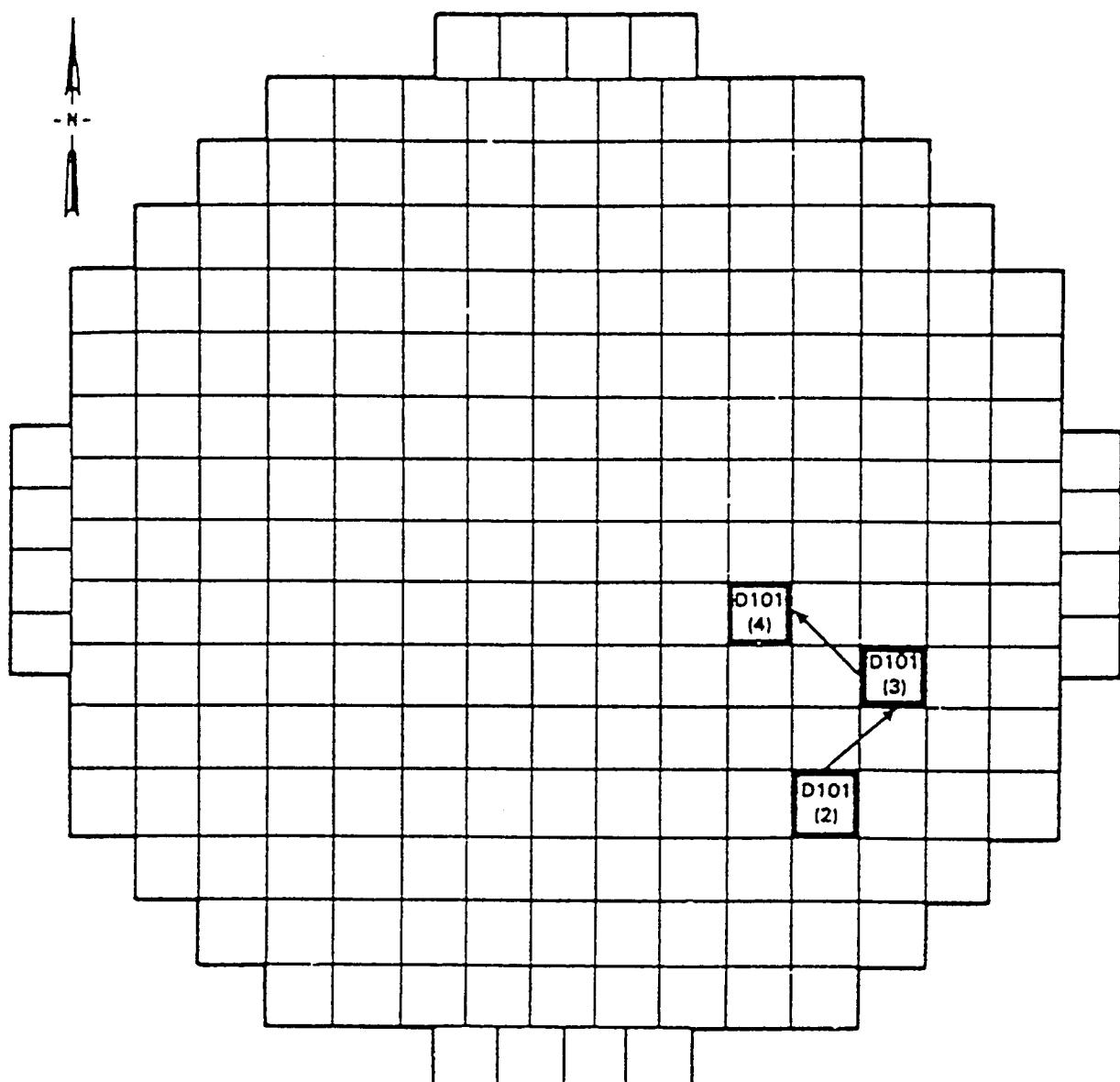


Fig. 3.2.3 Core Map Showing the Location of Assembly D101 (ATM-103) in Calvert Cliffs 1 for Cycles 2, 3, and 4

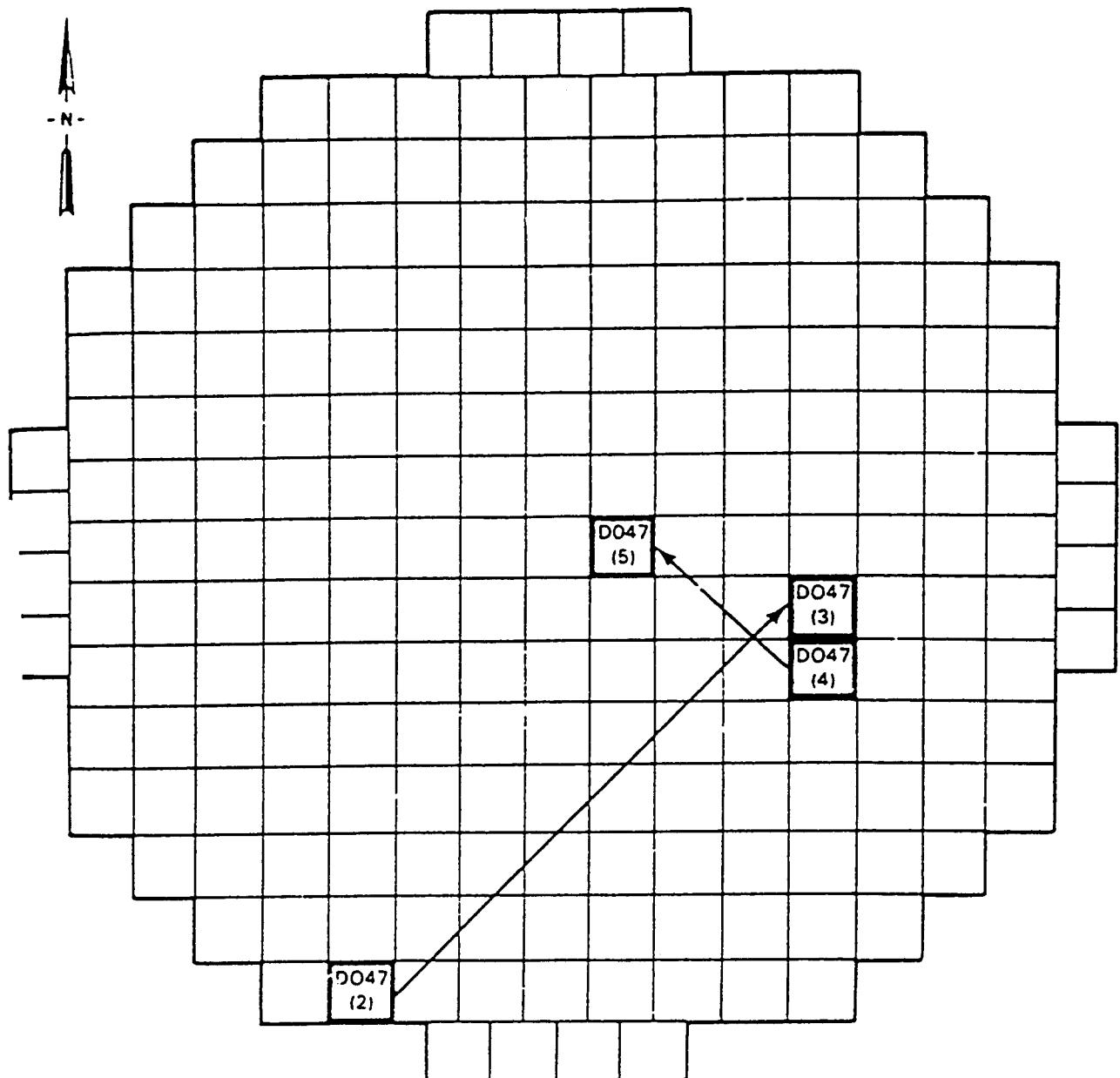


Fig. 3.2.4 Core Map Showing the Location of Assembly D047 (ATM-104) in Calvert Cliffs No. 1 for Cycles 2, 3, 4, and 5

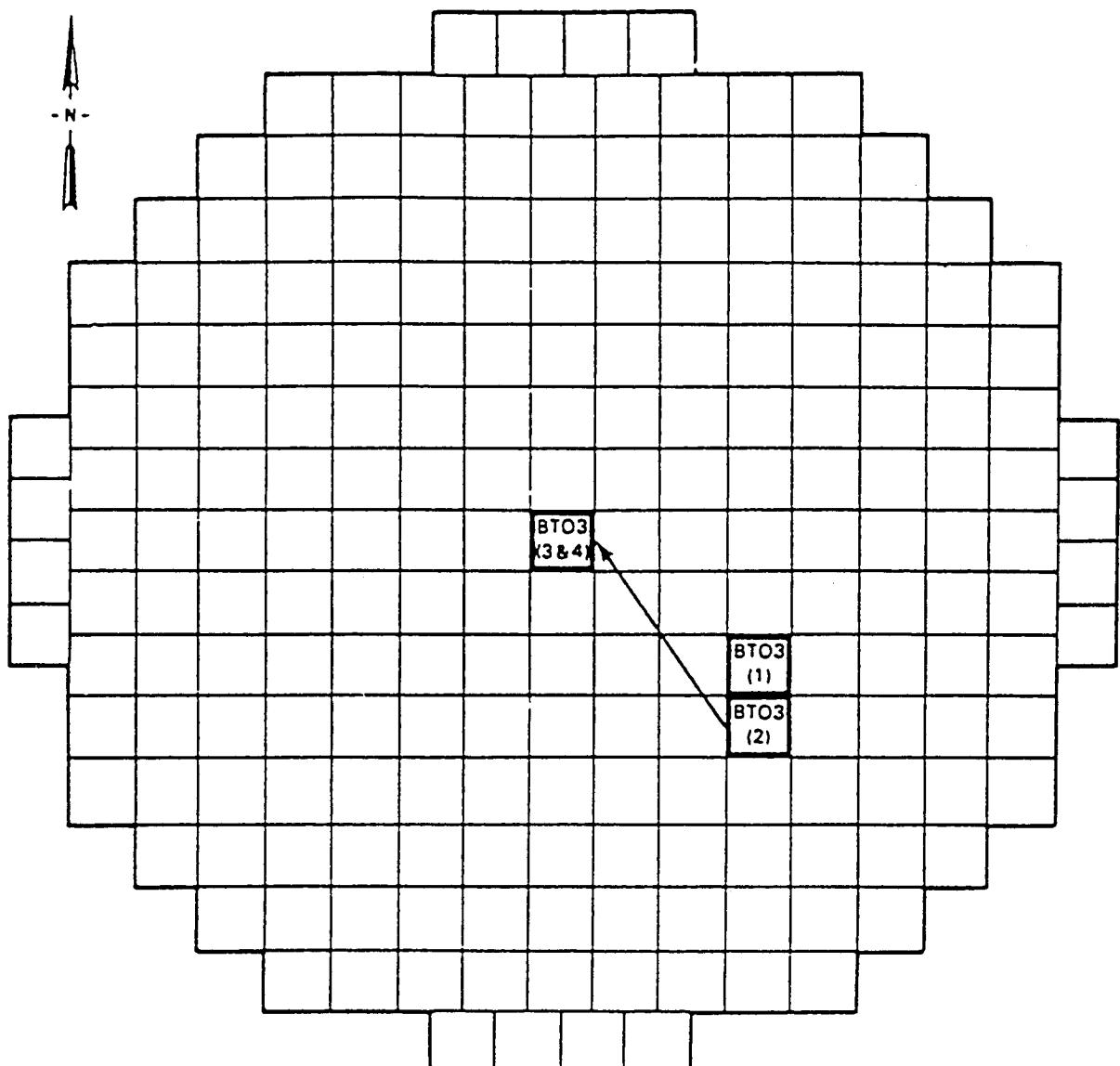
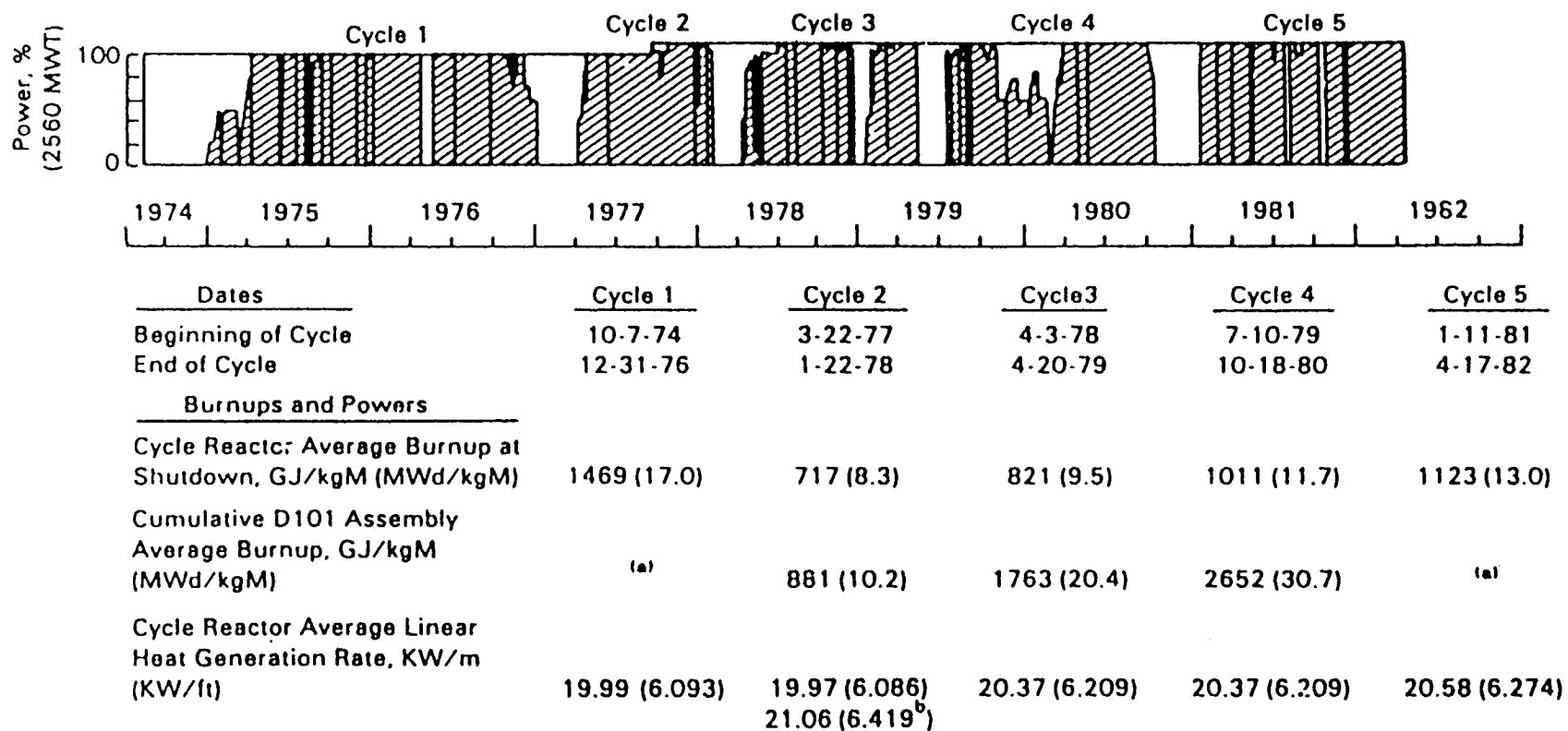


Fig. 3.2.5 Core Map Showing the Location of Assembly BT03 (ATM-106) in Calvert Cliffs No. 1 for Cycles 1, 2, 3, and 4



(a) Not in reactor during this cycle.

(b) After increase to stretch power.

Fig. 3.2.6 Calvert Cliffs 1 Reactor Operating History

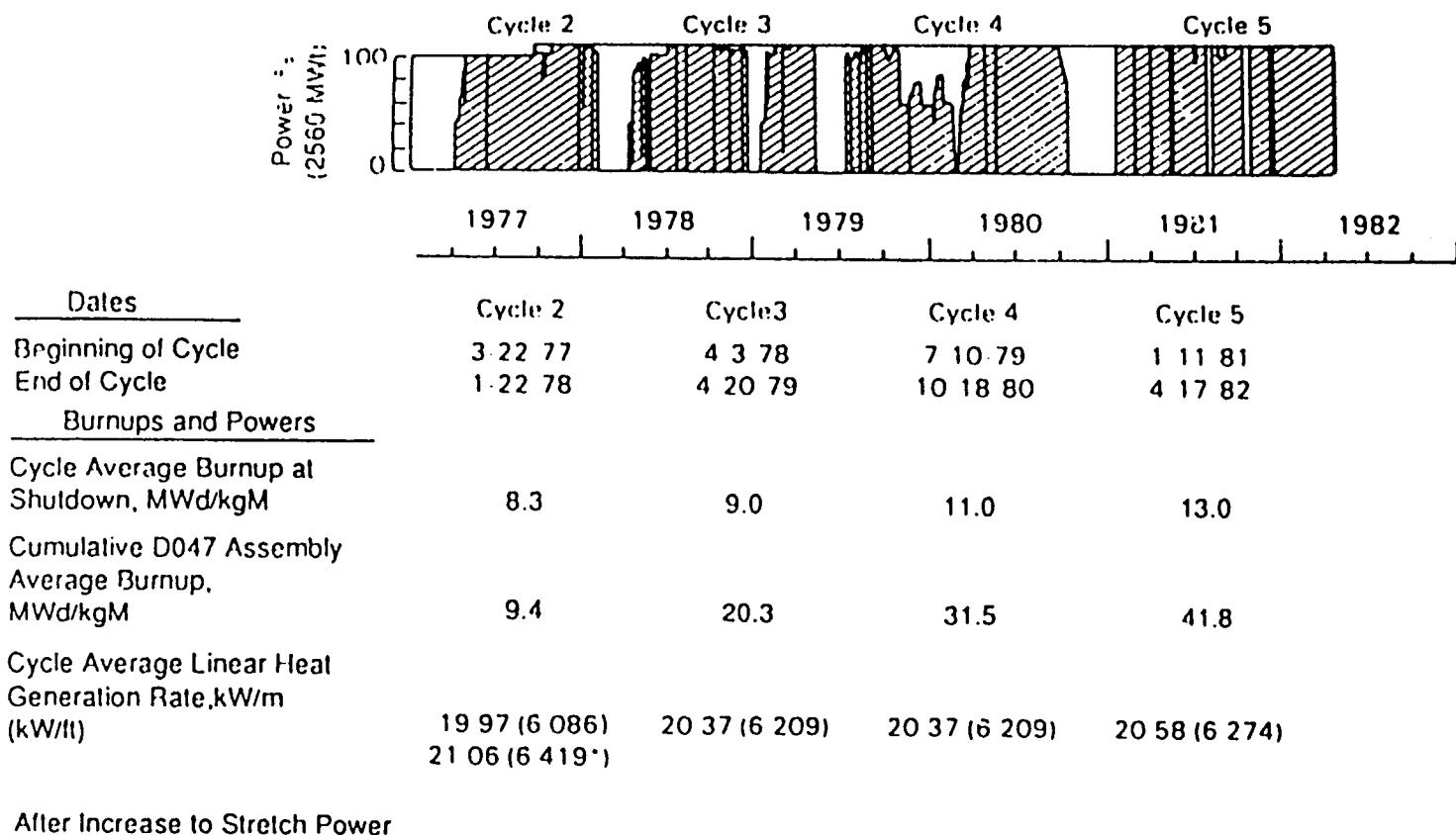
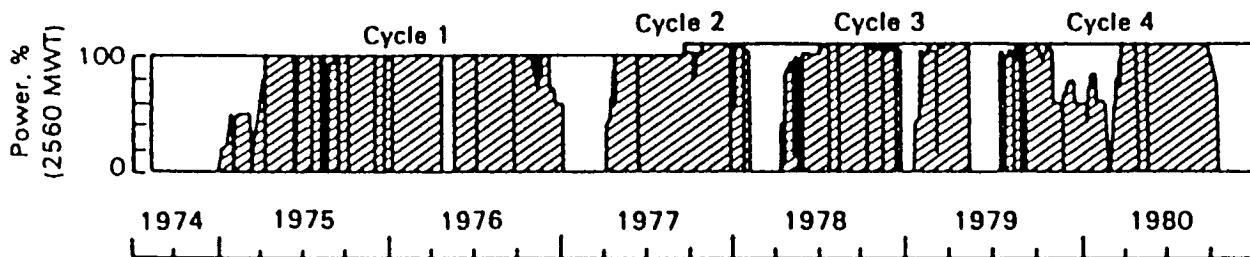


Fig. 3.2.7 Calvert Cliffs No. 1 Operating History



Dates	Cycle 1	Cycle 2	Cycle 3	Cycle 4
Beginning of Cycle	10-7-74	3-22-77	4-3-78	7-10-79
End of Cycle	12-31-76	1-22-78	4-20-79	10-18-80
<u>Burnups and Powers</u>				
Cycle average Burnup at Shutdown, GJ/kgM (MWd/kgM)	1469 (17.0)	717 (8.3)	821 (9.5)	1011 (11.7)
Accumulative BT03 Assembly Average Burnup, GJ/kgM (MWd/kgM)	1680 (19.4)	2340 (27.1)	2950 (34.1)	3650 (42.7)
Cycle Average Linear Heat Generation Rate, kW/m (kW/ft)	19.99 (6.093)	19.97 (6.086)	20.37 (6.209)	20.37 (6.209)
	21.06 (6.419°)			

After Increase to Stretch Power

Fig. 3.2.8 Calvert Cliffs No. 1 Operating History

Cycle No.	2	3	4
Start/End of Cycle	3-22-77/1-28-78	4-3-78/4-20-79	7-10-79/10-18-80
Cycle Duration	~10 months	~12.5 months	~15 months
Cycle Burnup GJ/kgM (MWd/kgM)	848 (9.82)	855 (9.90)	871 (10.08)
Cumulative Burnup GJ/kgM (MWd/kgM)	848 (9.82)	1704 (19.72)	2575 (29.80)

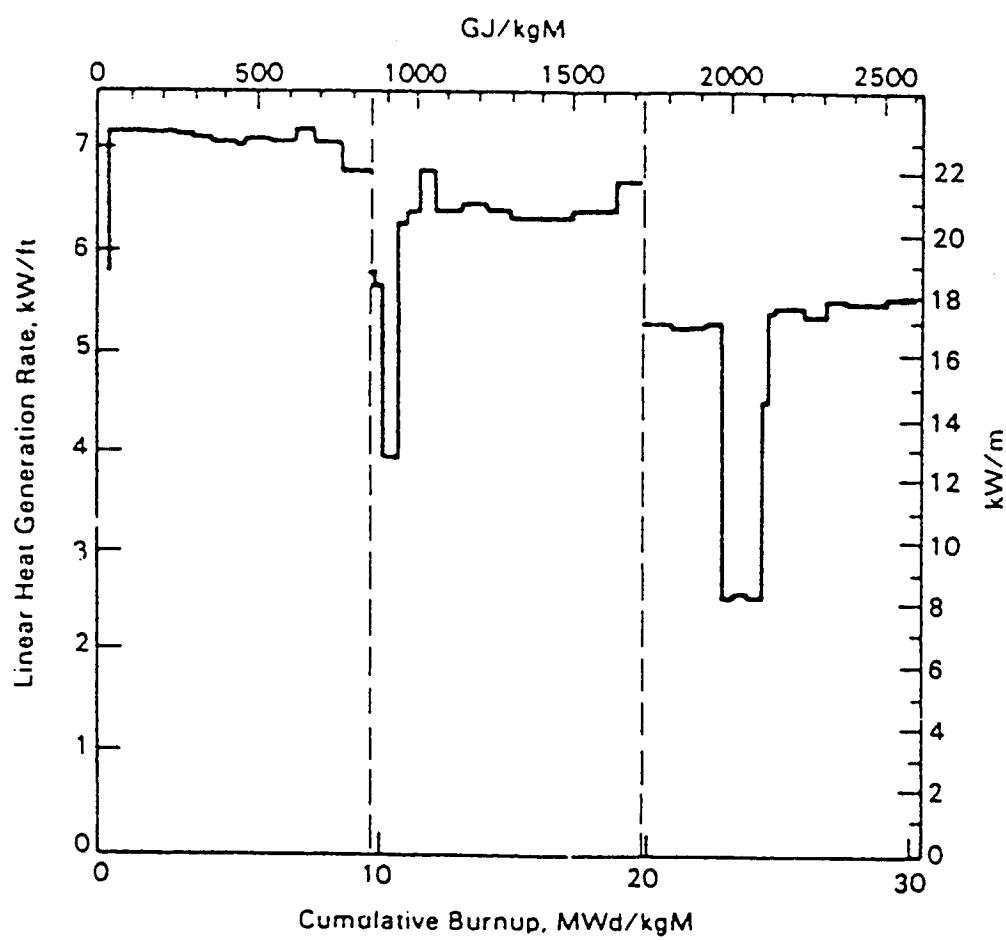


Fig. 3.2.9 Power History for Rod MLA098 from Assembly D101

A	MLB 003	MLA 027	MLA 046	MLA 045	MLA 069	MLA 099	MLA 053	MLA 098	MLA 105	MLA 158	MLA 154	MLA 196	MLB 016	MLB 018
B	MLA 002	MLA 026	MLA 036	MLA 048	MLA 072	MLA 100	MLA 093	MLA 097	MLA 104	MLA 157	MLA 153	MLA 195	MLB 015	MLB 009
C	MLA 001	MLA 029			MLA 073	MLA 052	MLA 092	MLA 145	MLA 103	MLA 155			MLB 014	MLA 170
D	MLA 003	MLA 028			MLA 075	MLA 094	MLA 091	MLA 095	MLA 101	MLA 147			MLB 013	MLA 189
E	MLA 004	MLA 031	MLA 035	MLA 047	MLA 074	MLA 078	MLA 090	MLA 122	MLA 102	MLA 146	MLA 151	MLA 197	MLB 011	MLB 010
F	MLA 008	MLA 030	MLA 039	MLA 051	MLA 077	MLA 079	MLA 089	MLA 120	MLA 148	MLA 143	MLA 200	MLA 194	MLA 188	MLB 007
G	MLA 005	MLA 034	MLA 038	MLA 049	MLA 076	MLA 085			MLA 150	MLA 144	MLA 171	MLA 193	MLA 168	MLB 008
H	MLA 010	MLA 033	MLA 041	MLA 059	MLA 063	MLA 086			MLA 114	MLA 141	MLA 175	MLA 191	MLA 169	MLB 005
I	MLA 012	MLA 021	MLA 040	MLA 050	MLA 064	MLA 128	MLA 088	MLA 119	MLA 113	MLA 142	MLA 177	MLA 190	MLA 165	MLB 006
J	MLA 015	MLA 020	MLA 043	MLA 058	MLA 065	MLA 126	MLA 087	MLA 118	MLA 111	MLA 138	MLA 176	MLA 179	MLA 166	MLA 199
K	MLA 017	MLA 022			MLA 066	MLA 080	MLA 134	MLA 117	MLA 112	MLA 139			MLA 163	MLB 012
L	MLA 018	MLA 023			MLA 067	MLA 081	MLA 133	MLA 116	MLA 110	MLA 183			MLA 164	MLB 002
M	MLA 019	MLA 024	MLA 042	MLA 060	MLA 068	MLA 082	MLA 132	MLA 130	MLA 109	MLA 182	MLA 181	MLA 178	MLA 162	MLB 001
N	MLB 004	MLA 025	MLA 044	MLA 061	MLA 070	MLA 084	MLA 131	MLA 129	MLA 108	MLA 184	MLA 180	MLA 137	MLA 160	MLB 017
	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Fig. 3.2.10 ATM-103 Rod Locations in Assembly D101 (characterized rods denoted in highlighted boxes)

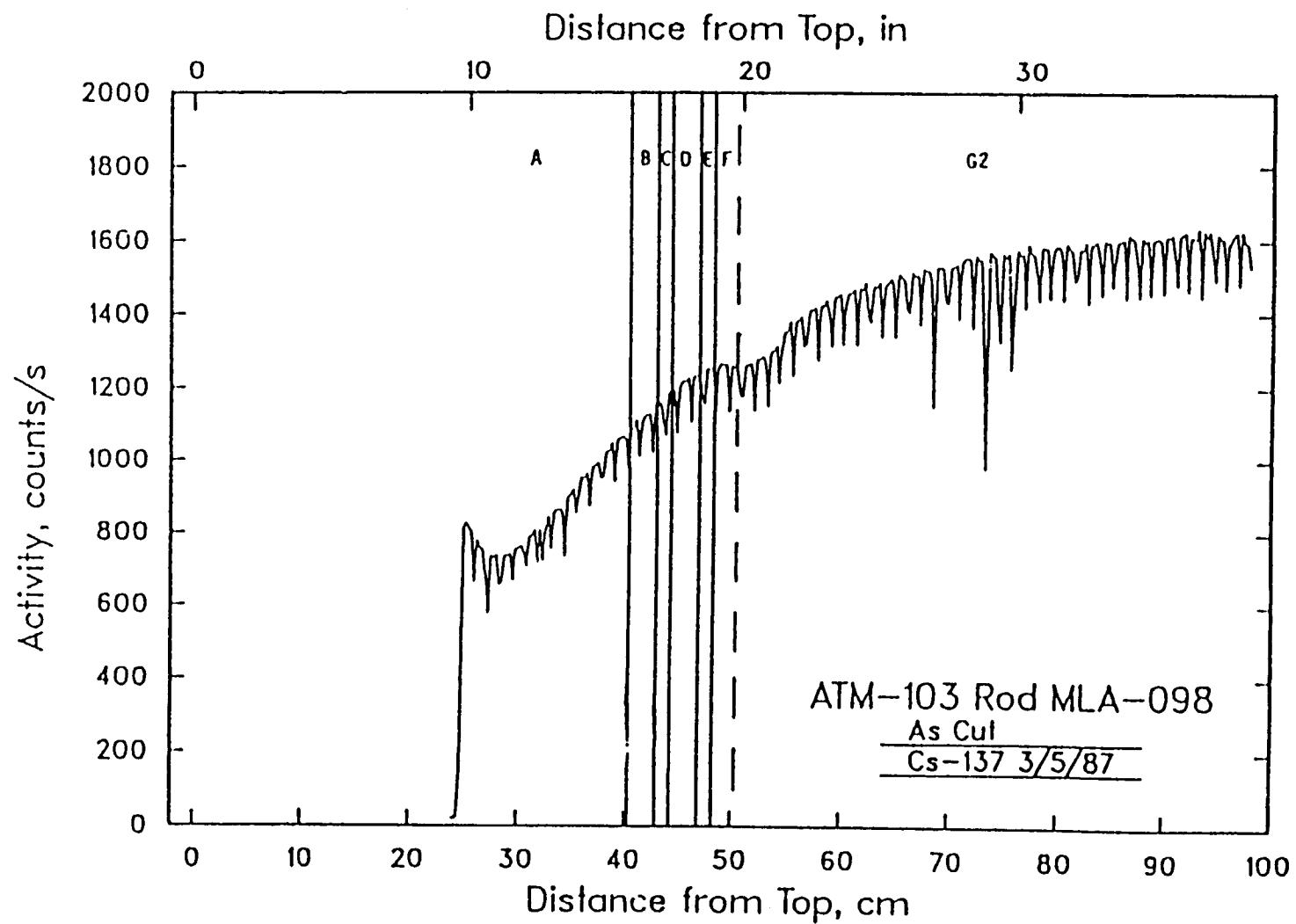


Fig. 3.2.11 As-Cut Sectioning Diagram for Rod MLA098

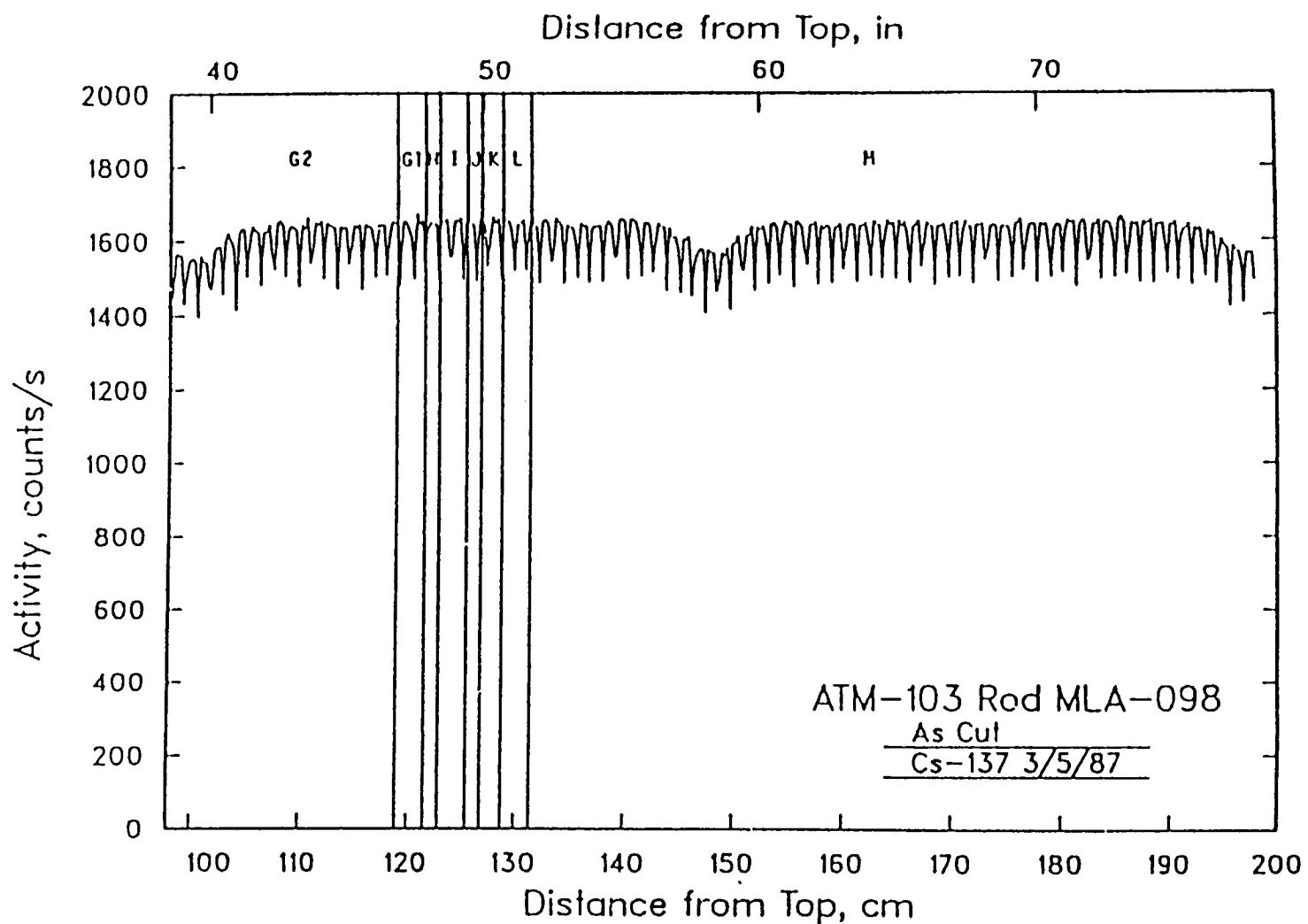


Fig. 3.2.11 As-Cut Sectioning Diagram for Rod MLA098 (contd)

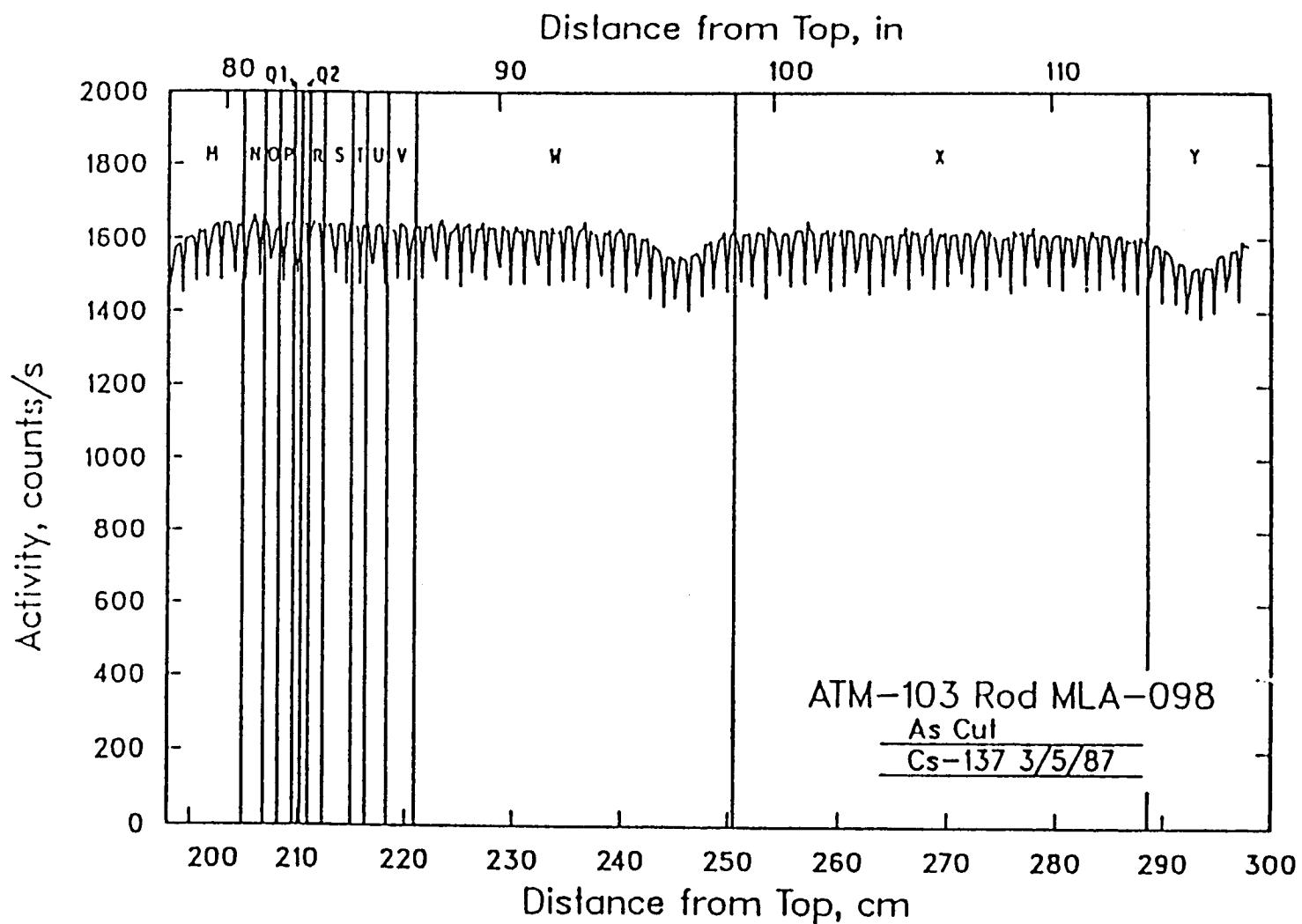


Fig. 3.2.11 As-Cut Sectioning Diagram for Rod MLA098 (contd)

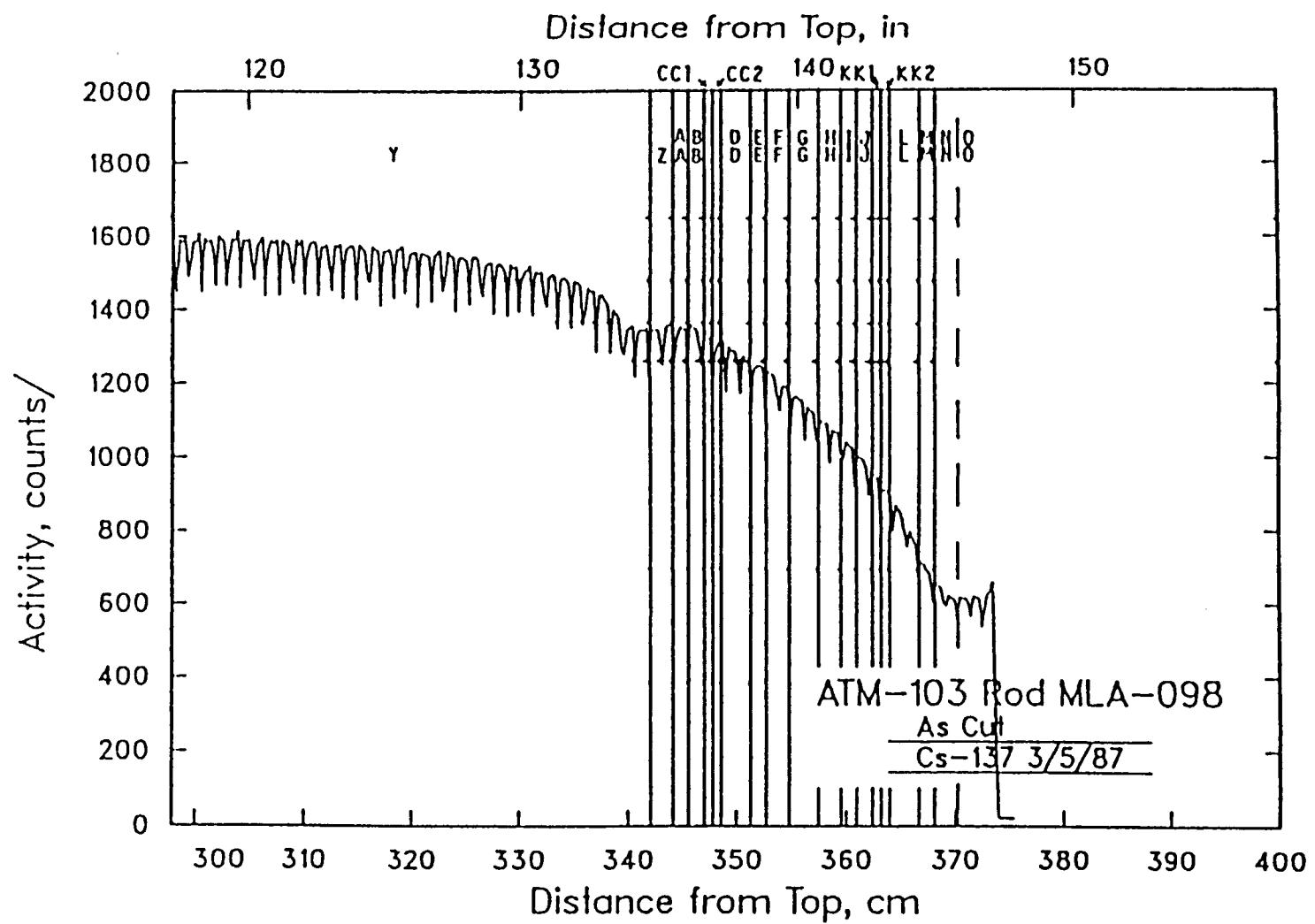


Fig. 3.2.11 As-Cut Sectioning Diagram for Rod MLA098 (contd)

Cycle No	2	3	4	5
Start End of Cycle	3-22-77/1-22-78	4-3-78/4-20-79	7-10-79/10-18-80	1-11-81/4-17-82
Cycle Duration	10 months	12 5 months	15 months	15 5 months
Cycle Burnup MWd/kgM	10.06	10.90	11.02	9.87
Cumulative Burnup, MWd/kgM	10.06	20.96	31.98	41.85

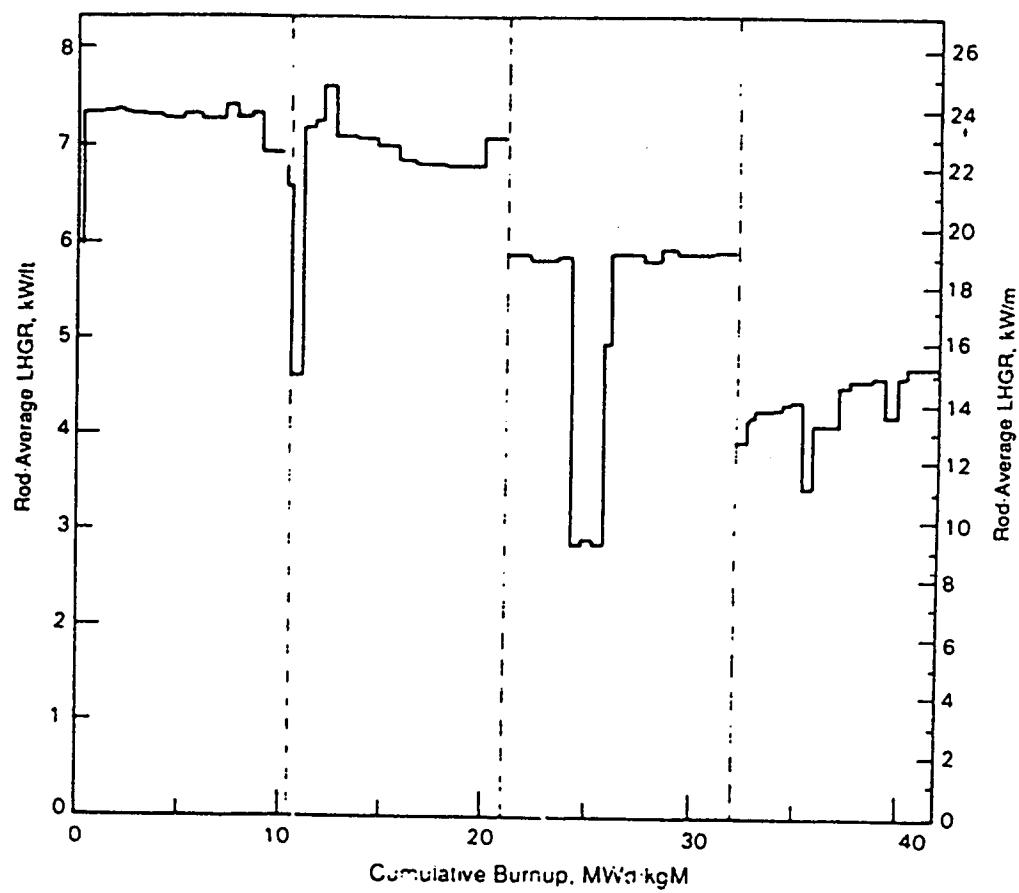


Fig. 3.2.12 Power History for Rod MKP104 from Assembly D047

A	MKP 033	MKP 030	MKP 061	MKP 007	MKP 034	MKP 043	MKP 081	MKP 039	MKP 067	MKP 080	MKP 079	MKP 092		MKP 029
B	MKP 047	MKP 051	MKP 032	MKP 017	MKP 073		MKP 063	MKP 106		MKP 118	MKP 116	MKP 005	MKP 124	
C	MKN 011	MKN 160		MKP 119	MKN 047	MKP 109	MKP 054	MKP 056	MKP 112				MKP 025	
D	MKN 002	MKP 001		MKP 042	MKN 033	MKP 070	MKP 087	MKP 045	MKP 108			MKP 090		
E	MKN 150	MKP 019	MKP 014	MKN 104	MKP 110	MKP 150	MKP 083	MKP 103	MKP 026	MKP 077		MKP 115		MKP 048
F	MKN 139		MKP 018	NBD 112	MKP 057	MKP 060	MKP 059	MKP 068	MKP 101	MKP 096	NBD 067			
G	MKP 003	MKN 073	MKP 013	MKP 072	MKP 050	MKP 020		MKP 069	MKP 100		MKP 120		MKP 028	
H	MKN 153	MKP 021	MKP 046	MKP 075	MKP 015	MKP 011		MKP 093		MKP 125	NBD 005	MKP 044		
I	MKP 002	AHS 040	MKP 035	AHS 044	MKP 008	MKP 041	MKP 038	MKP 058	MKP 104	AHS 111	MKP 040	MKP 121	MKP 005	MKP 053
J	MKP 076	MKP 071	MKP 009	MKP 036	MKP 004	MKP 010	MKP 086	MKP 126	MKP 085		MKP 102		MKP 127	
K	MKP 037	MKP 040			MKP 062		MKP 117	AHS 077	MKP 105				MKP 024	
L	MKP 184			MKP 022		MKP 052		MKP 084				MKP 082		
M		MKP 016		MKP 031			MKP 065	AHS 060	MKP 074		MKP 122		MKP 012	
N	MKN 169		MKP 023		MKP 078		MKP 064		MKP 107		MKP 091		MKP 099	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14

R9004195.1

Fig. 3.2.13 Locations of 128 ATM-104 Rods in Assembly D047
(characterized rods denoted in highlighted boxes)

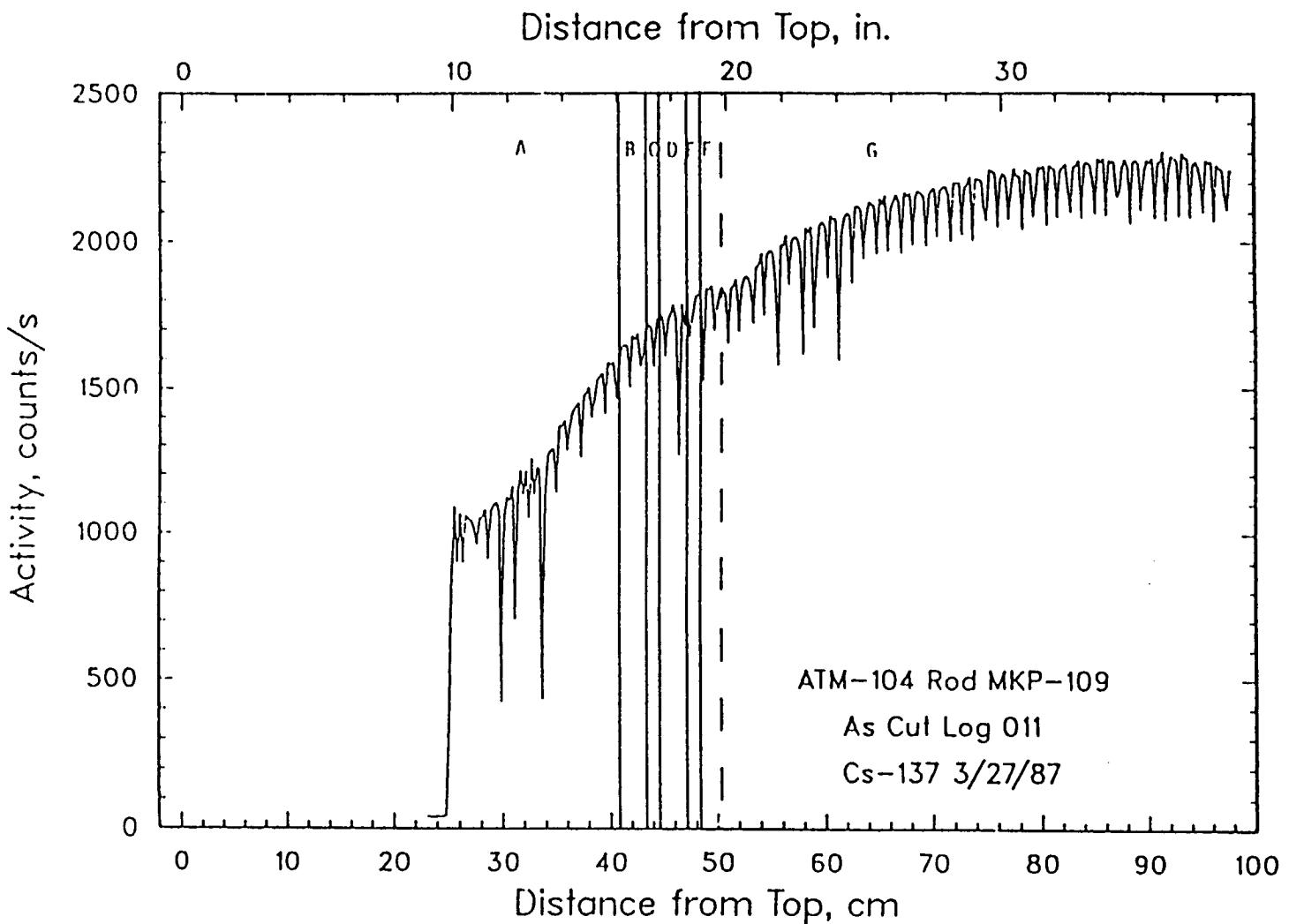


Fig. 3.2.14 Sectioning Diagram for Rod MKP109

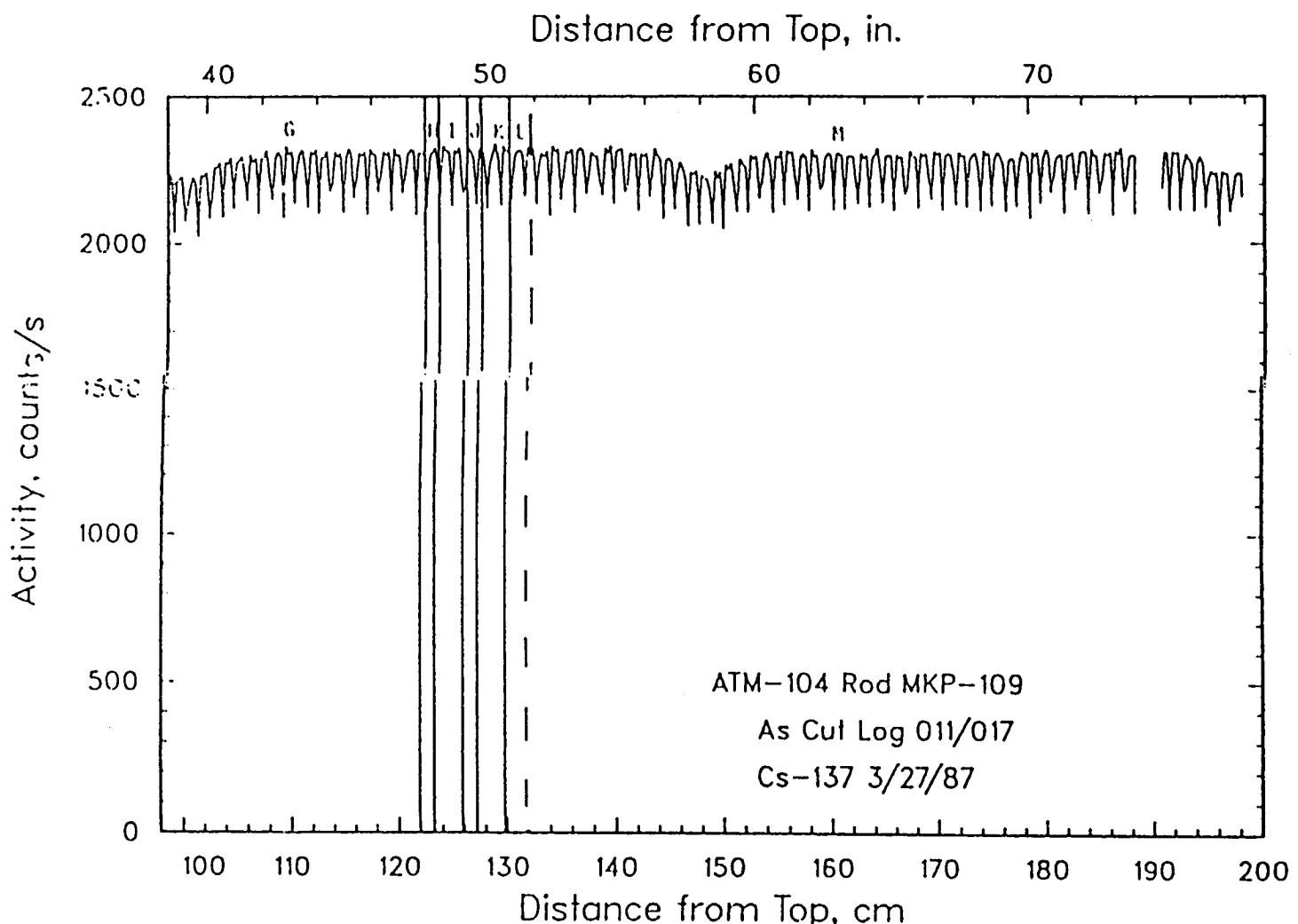


Fig. 3.2.14 (contd)

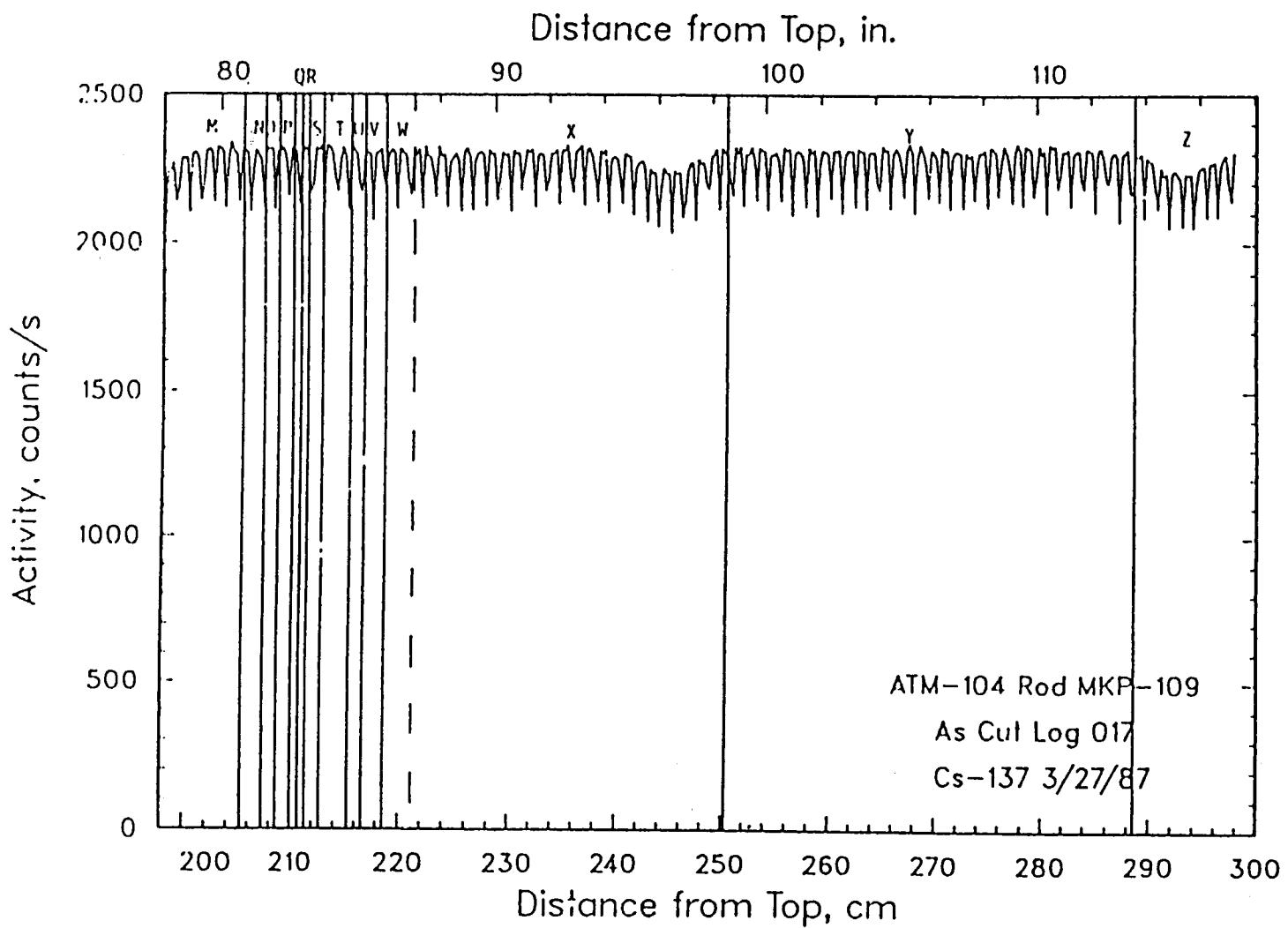


Fig. 3.2.14 (contd)

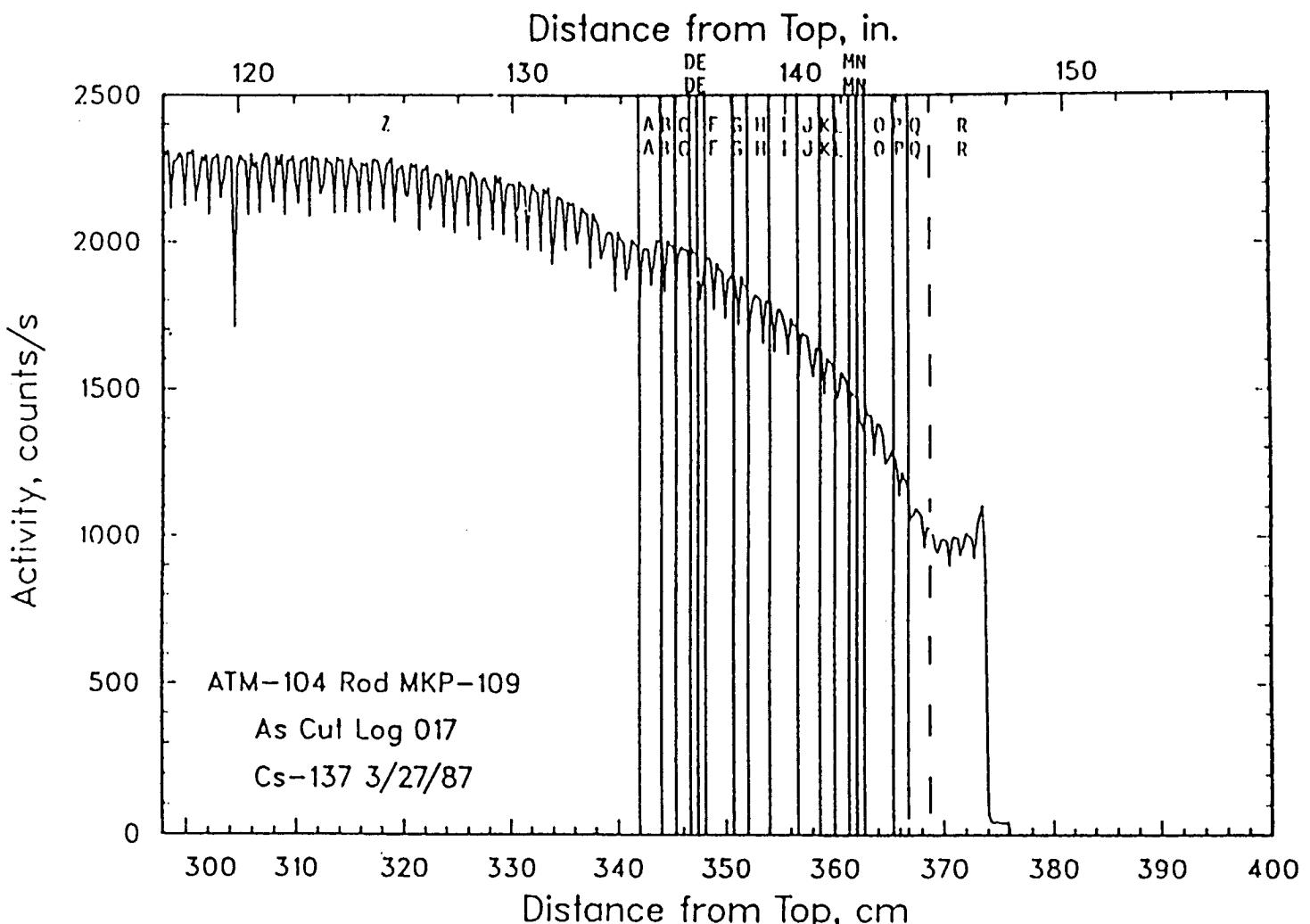


Fig. 3.2.14 (contd)

Cycle No	1	2	3	4
Start End of Cycle	10-7-74/12-31-76	3-22-77-1-22-78	4-3-78/4-20-79	7-10-79/10-18-80
Cycle Duration	~24 months	~10 months	~12.5 months	~15 months
Cycle Burnup MWd/kgM	19.67	7.70	6.72	8.23
Cumulative Burnup MWd/kgM	19.67	27.37	34.09	42.32

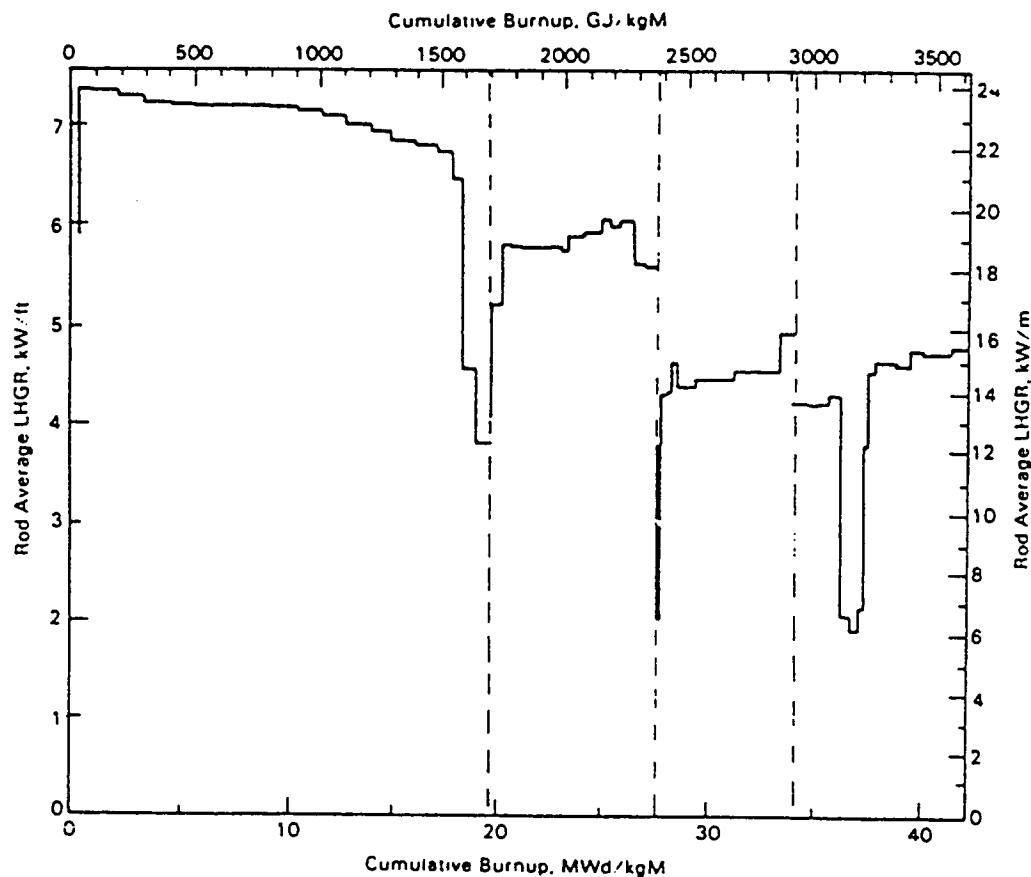


Fig. 3.2.15 Power History for Rod NBD107 from Assembly BT03

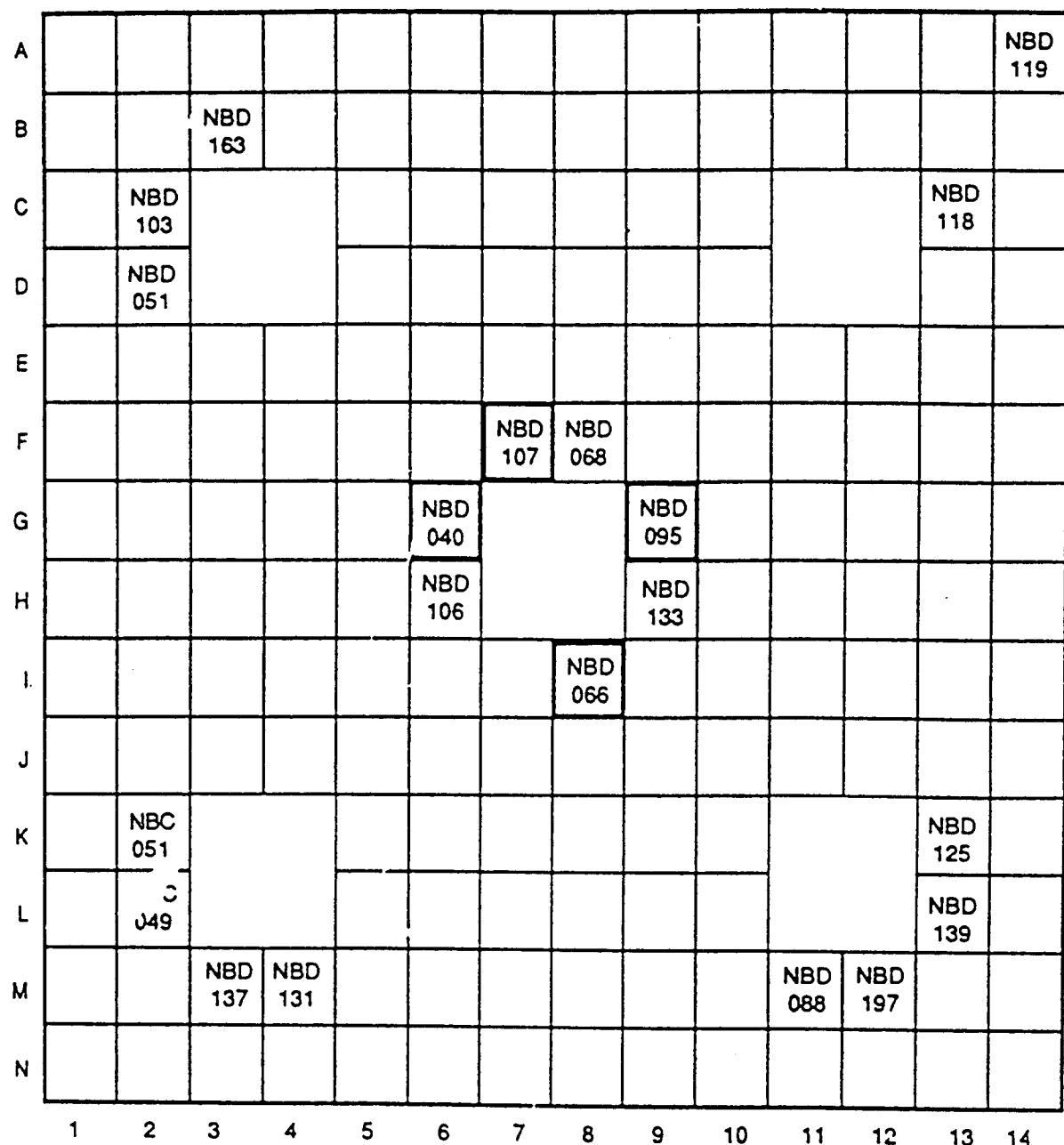


Fig. 3.2.16 Locations of Twenty Rods in Assembly BT03
(characterized rods denoted in highlighted boxes)

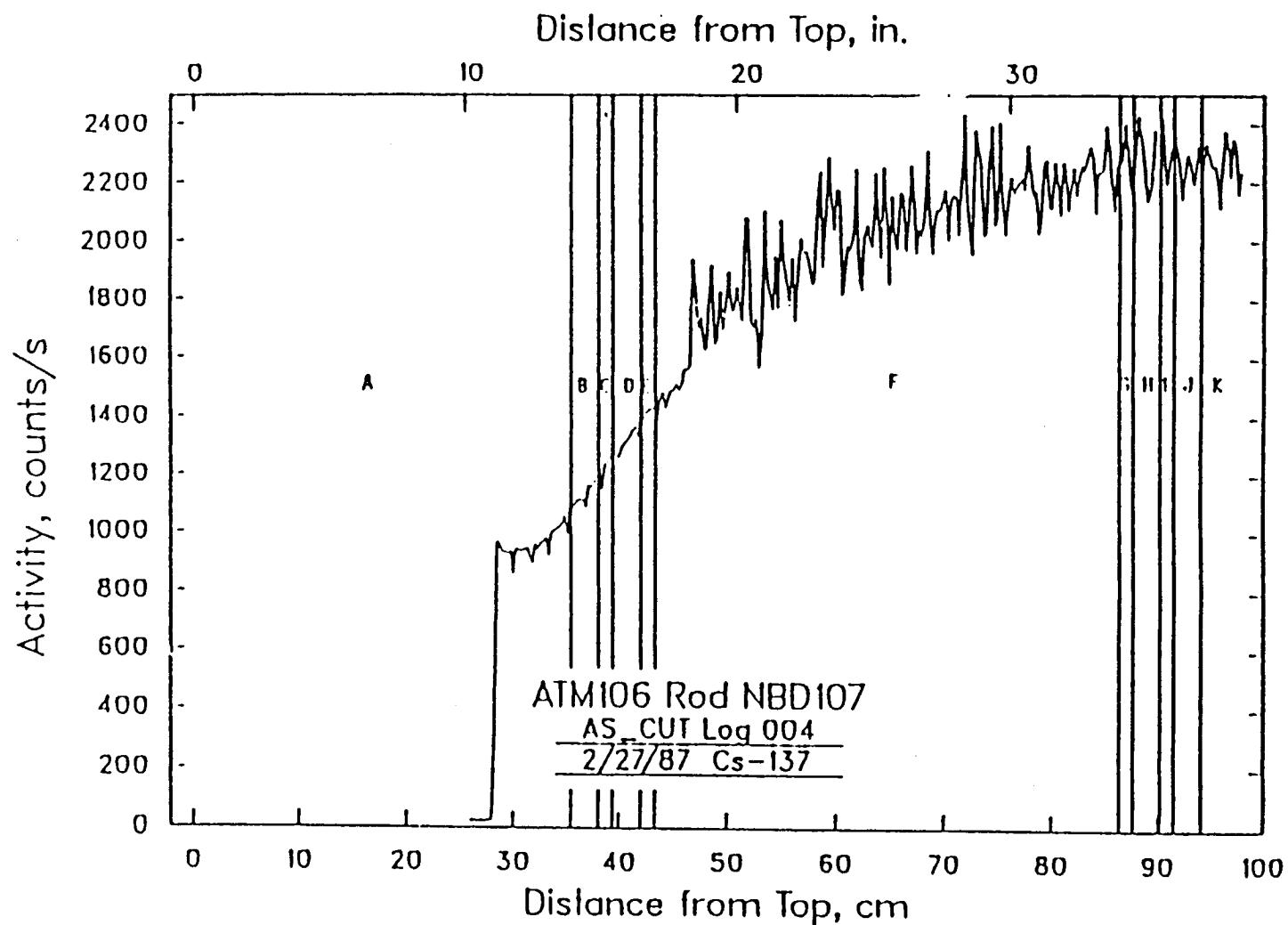


Fig. 3.2.17 As-Cut Sectioning Diagram for Rod NBD107 (contd)

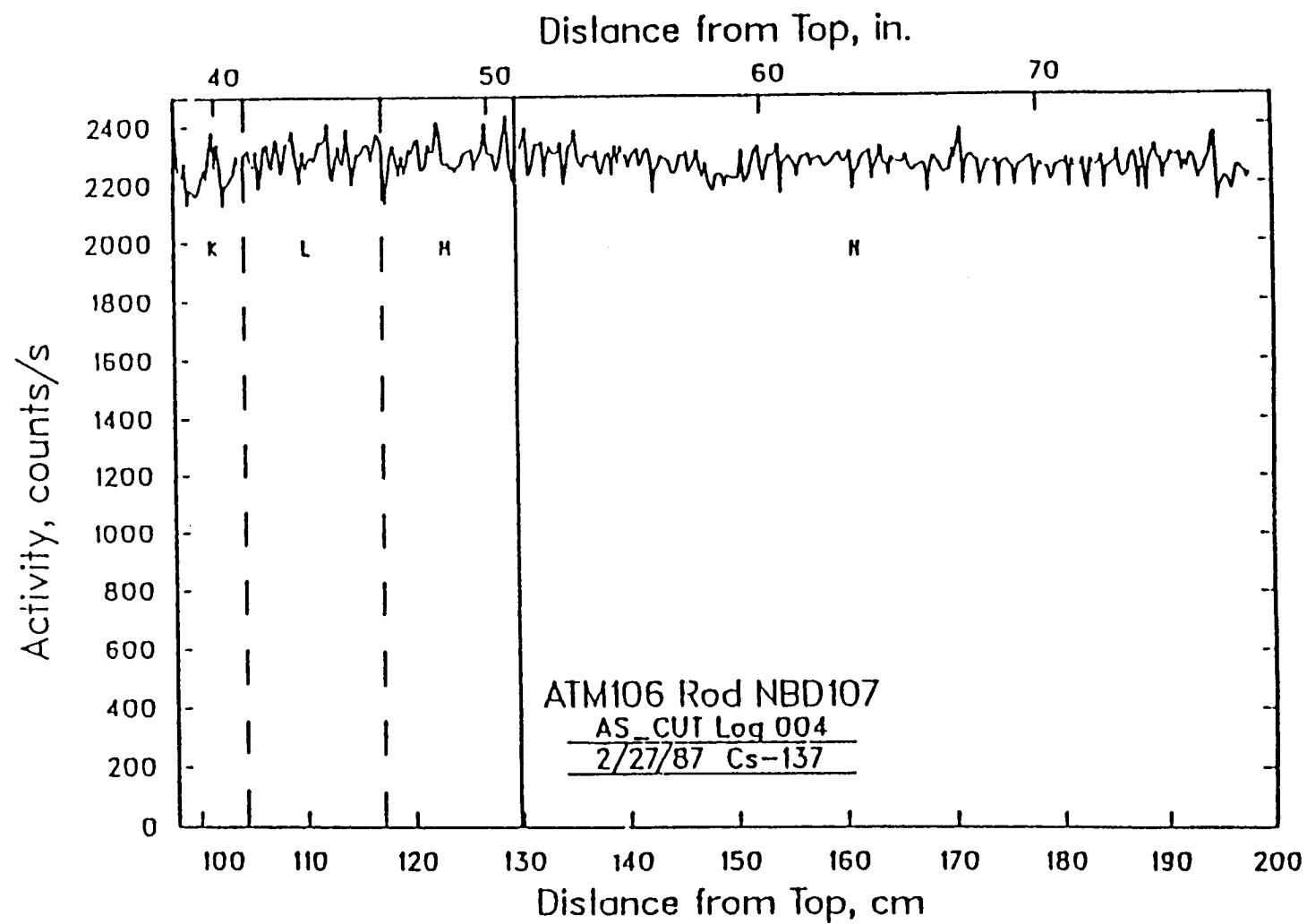


Fig. 3.2.17 As-Cut Sectioning Diagram for Rod NBD107 (contd)

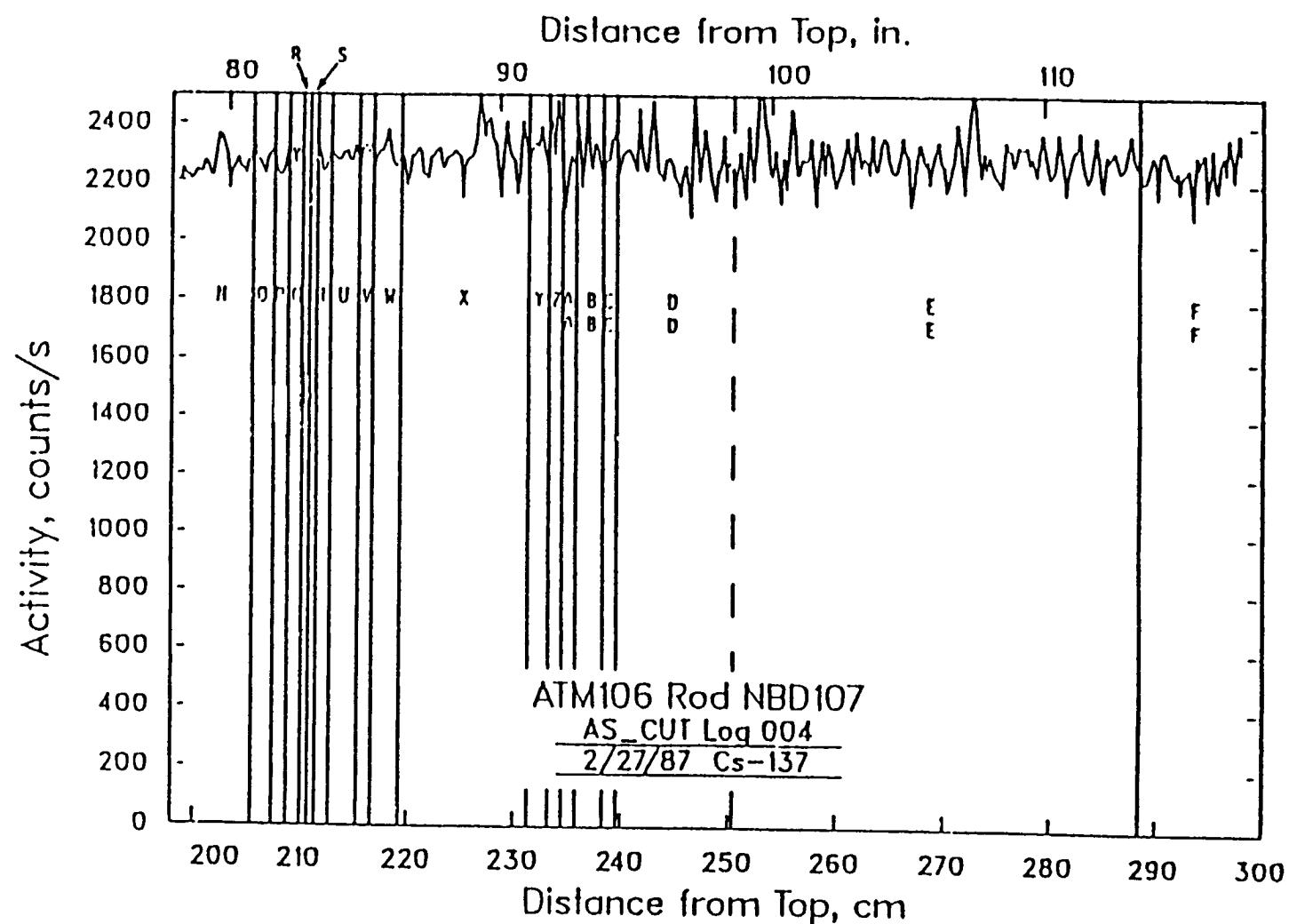


Fig. 3.2.17 As-Cut Sectioning Diagram for Rod NBD107 (contd)

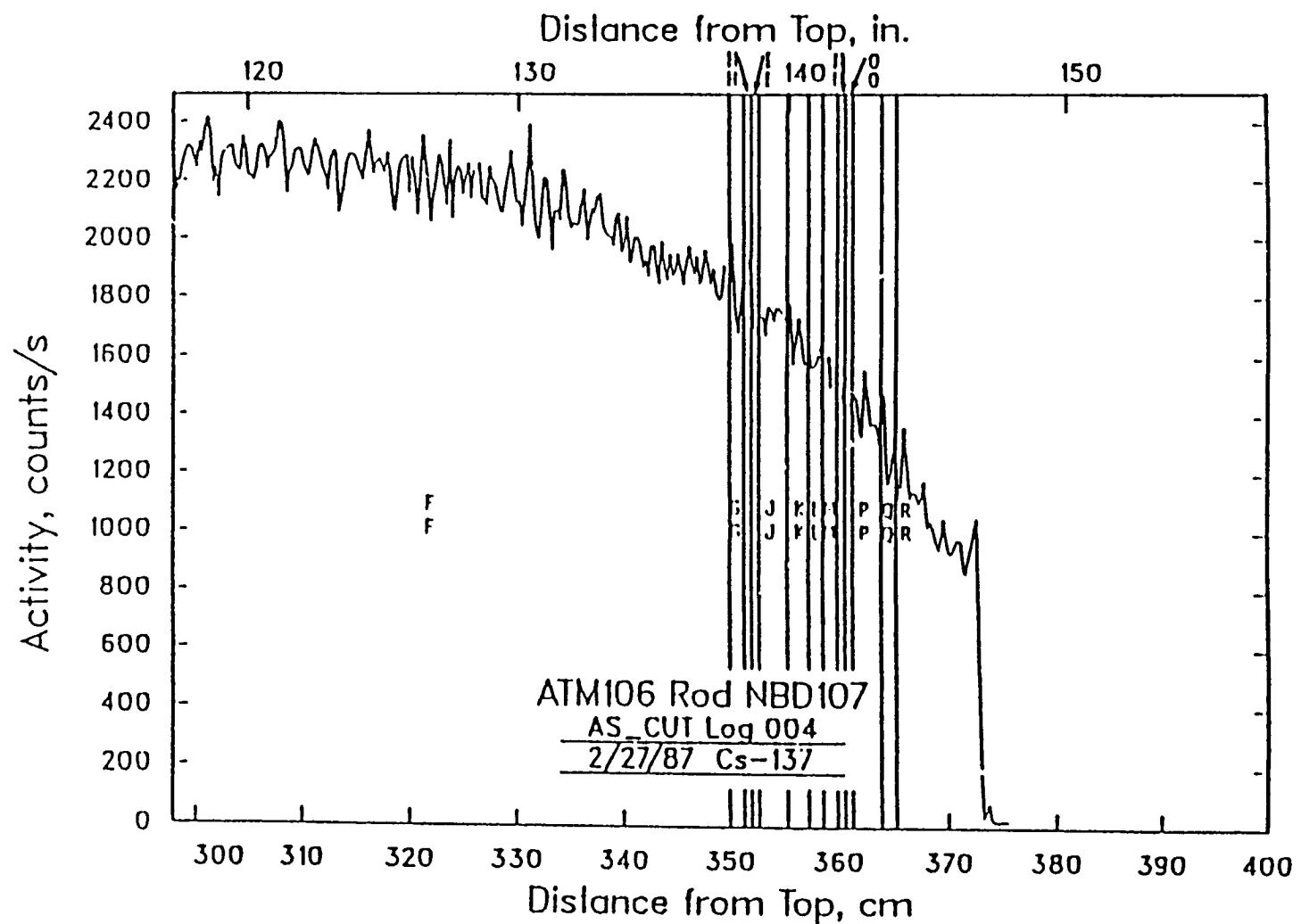


Fig. 3.2.17 As-Cut Sectioning Diagram for Rod NBD107 (contd)

3.2.3 Isotopic composition data

The fuel compositions of ATM-103, ATM-104 and ATM-106 are shown in Table 3.2.7, Table 3.2.8 and Table 3.2.9, respectively.

The measured burnup are shown in Table 3.2.10, Table 3.2.11 and Table 3.2.12, respectively. The burnup was measured by two methods; Nd-148 basis and Cs-137 basis.

And the isotopic composition data are shown in Table 3.2.13, Table 3.2.14 and Table 3.2.15 respectively. The measured actinoids are U, Pu, Np-237, Am-241 and Cm-243.& 244. The measured fission products(FPs) are Nd-148, Se-79, Sr-90,Tc-99, Sn-126 and Cs-135,Cs-137.

Table 3.2.7 Fuel Composition of ATM-103 Assumed for ORIGEN2 Calculations

Parameter	Value(a)
Enrichment, wt%	2.72
^{234}U , ppm	221(b)
Total Uranium, wt%	88.15
Oxygen, wt%	11.85
Carbon, ppm	12
Nitrogen, ppm	24
Fluorine, ppm	5
Chlorine, ppm	5
Iron, ppm	52
Silver, ppm	1
Calcium, ppm	40
Aluminum, ppm	40
Silicon, ppm	40
Nickel, ppm	25

(a) Based on measured values (see Table 4.1).

(b) Based on other fuel enrichments.

Table 3.2.8 Fuel Composition of ATM-104 Assumed for ORIGEN2 Calculations

<u>Parameter</u>	<u>Value (a)</u>
Enrichment, wt%	3.038
^{234}U , ppm	246(b)
Total Uranium, wt%	88.143
Oxygen, wt%	11.857
Carbon, ppm	18
Nitrogen, ppm	23
Fluorine, ppm	5
Chlorine, ppm	5
Iron, ppm	45
Silver, ppm	1
Calcium, ppm	32
Aluminum, ppm	32
Silicon, ppm	32
Nickel	25

- (a) Based on measured value unless otherwise noted (see Table 3.1).
(b) Based on other fuel enrichments.

Table 3.2.9 Fuel Composition of ATM-106 Assumed for ORIGEN2 Calculations

<u>Parameter</u>	<u>Value (a)</u>
Enrichment, wt%	2.453
^{234}U , ppm	199(b)
Total Uranium, wt%	88.143
Oxygen, wt%	11.857
Carbon, ppm	19
Nitrogen, ppm	44
Fluorine, ppm	10
Chlorine, ppm	10
Iron, ppm	45
Silver, ppm	1
Calcium, ppm	40
Aluminum, ppm	40
Silicon, ppm	40
Nickel, ppm	25

(a) Based on measured values (see Table 4.1).

(b) Based on other fuel enrichments.

Table 3.2.10 Burnup Results for ATM-103 Samples^(a)

Sample No.	Burnup, (¹⁴⁸ Nd Basis)		Measured Gamma Activity, Counts/s	Burnup (¹³⁷ Cs Basis), GJ/kgM (MWd/kgM) ^(b)	Sample Location
	Atom%	GJ/kgM (MWd/kgM)			
103-MLA098-P	3.474	2866 (33.17)	1645	2911 (33.69)	Typical peak burnup in center portion of Rod MLA098.
103-MLA098-BB	2.790	2300 (26.62)	1343	2338 (27.06)	Representative of approximately 80% of peak ¹³⁷ Cs activity in bottom portion of Rod MLA098.
103-MLA098-JJ	1.961	1614 (18.68)	964	1673 (19.36)	Representative of approximately 57% of peak ¹³⁷ Cs activity in bottom portion of Rod MLA098.

(a) See sectioning diagrams in Appendix D for sample locations with respect to gamma activity.

(b) Calculation based on ¹³⁷Cs half-life of 30.174 years and effective fission yield of 6.318% for Sample 103-MLA098-P, 6.302% for Sample 103-MLA098-BB, and 6.288% for 103-MLA098-JJ. Based on ASTM Standard E-219, "Standard Test Method for Atom Percent Fission in Uranium Fuel," (Radiation Method).

Table 3.2.11 Burnup Results for ATM-104 Fuel Samples^(a)

<u>Sample No.</u>	<u>Measured Atom%</u>	<u>Burnup (b)</u> <u>MWd/kgM</u>	<u>Measured 137Cs Activity</u> <u>Counts/s(c)</u>	<u>Sample Location</u>
104-MKP109-P	4.642	44.34	2308	Typical peak burnup in center portion of Rod MKP109.
104-MKP109-CC	3.889	37.12	1962	Representative of ~84% of peak ¹³⁷ Cs activity in bottom portion of Rod MKP109.
104-MKP109-LL	2.869	27.35	1535	Representative of ~63% of peak ¹³⁷ Cs activity in bottom portion of Rod MKP109.

- (a) See sectioning diagrams in Appendix C for sample locations with respect to gamma activity.
- (b) Burnup analyses were conducted in May 1987, 5.08 years after discharge. The calculation procedure used was ASTM Standard E-219, "Standard Test Method for Atom Percent Fission in Uranium Fuel (Radiochemical Method)."
- (c) Cesium-137 activities are corrected as explained in Appendix B.

Table 3.2.12 Burnup Results for ATM-106 Fuel Samples^(a)

<u>Sample No.</u>	<u>Burnup (¹⁴⁸Nd Basis)</u>	<u>Measured Gamma Activity, Counts/s</u>	<u>Burnup (¹³⁷Cs Basis), GJ/kgM (MWD/kgM)</u>	<u>Sample Location</u>
	<u>At.%</u>	<u>GJ/kgM (MWD/kgM)</u>	<u>(b)</u>	
106-NBD107-Q	4.859	4014 (46.46)	2310	4294 (49.70) Typical peak burnup in center portion of Rod NBD107.
106-NBD107-GG	3.901	3220 (37.27)	1828	3255 (37.67) Representative of approximately 80% of peak Cs ac- tivity in bottom portion of Rod NBD107.
106-NBD107-MM	3.289	2713 (31.40)	1553	2863 (33.14) Representative of approximately 67% of peak Cs ac- tivity in bottom portion of Rod NBD107.

(a) See sectioning diagrams in Appendix D for sample locations with respect to gamma activity.

(b) Calculation based on Cs half-life of 30.174 years and effective fission yield of 6.31% for Sample 106-NBD107-Q, 6.31% for Sample 106-NBD107-GG, and 6.29% for Sample 106-NBD107-MM. The calculation procedure used was ASTM Standard E-219 "Standard Test Method for Atom Percent Fission in Uranium Fuel" (Radiochemical Method).

**Table 3.2.13 Fuel Radiochemical Analyses Results and Comparisons
with ORIGEN2-calculated Radionuclide Inventory**

Sample ID and Radionuclide	Burnup, (a) Mwd/kgH	Analytical Value	ORIGEN2 Value(b)	Ratio, Analytical to ORIGEN2
<u>103-MLA098-E</u>				
C-14	24.83	5.40×10^{-7} Ci/gUO ₂ (c)	4.562×10^{-7} Ci/gUO ₂	1.18
<u>103-MLA098-J</u>				
C-14	33.44	7.33×10^{-7} Ci/gUO ₂ (c)	6.367×10^{-7} Ci/gUO ₂	1.15
<u>103-MLA098-P</u>				
U-234	33.17	1.2×10^{-4} g/gUO ₂	1.226×10^{-4} g/gUO ₂	0.98
U-235		4.78×10^{-3} "	5.116×10^{-3} "	0.94
U-236		3.26×10^{-3} "	3.061×10^{-3} "	1.07
U-238		8.422×10^{-1} "	8.342×10^{-1} "	1.01
Pu-238		1.483×10^{-4} "	1.456×10^{-4} "	1.02
Pu-239		4.187×10^{-3} "	4.472×10^{-3} "	0.94
Pu-240		2.111×10^{-3} "	2.145×10^{-3} "	0.98
Pu-241		8.125×10^{-4} "	8.532×10^{-4} "	0.95
Pu-242		5.474×10^{-4} "	4.909×10^{-4} "	1.12
Np-237		2.41×10^{-7} Ci/gUO ₂	2.730×10^{-7} Ci/gUO ₂	0.88
Am-241		1.20×10^{-3} "	1.213×10^{-3} "	0.99
Cm-243 & 244		2.11×10^{-3} "	2.079×10^{-3} "	1.01
Se-79		5.58×10^{-8} "	3.576×10^{-7} "	0.15
Sr-90		5.23×10^{-2} "	5.128×10^{-2} "	1.02
Tc-99		1.13×10^{-5} "	1.142×10^{-5} "	0.99
Sn-113		1.69×10^{-7} "	7.328×10^{-7} "	0.23
Cs-135		3.32×10^{-7} "	3.377×10^{-7} "	0.98
Cs-137		8.06×10^{-2} "	7.813×10^{-2} "	1.03
<u>103-MLA098-S</u>				
I-129	33.01	3.36×10^{-8} Ci/gUO ₂	2.869×10^{-8} Ci/gUO ₂	1.17
<u>103-MLA098-T</u>				
C-14	33.01	7.69×10^{-7} Ci/gUO ₂ (c)	6.262×10^{-7} Ci/gUO ₂	1.23
<u>103-MLA098-88</u>				
U-234	26.62	1.21×10^{-4} g/gUO ₂	1.338×10^{-4} g/gUO ₂	0.90
U-235		6.94×10^{-3} "	7.242×10^{-3} "	0.96
U-236		2.99×10^{-3} "	2.807×10^{-3} "	1.07
U-238		8.538×10^{-1} "	8.393×10^{-1} "	1.02
Pu-238		9.69×10^{-5} "	9.106×10^{-5} "	1.06
Pu-239		4.252×10^{-3} "	4.348×10^{-3} "	0.98
Pu-240		1.766×10^{-3} "	1.800×10^{-3} "	0.98
Pu-241		6.822×10^{-4} "	6.959×10^{-4} "	0.98
Pu-242		3.301×10^{-4} "	3.084×10^{-4} "	1.07
Np-237		2.11×10^{-7} Ci/gUO ₂	2.066×10^{-7} Ci/gUO ₂	1.02
Am-241		9.91×10^{-4} "	10.07×10^{-4} "	0.98
Cm-243 & 244		8.15×10^{-4} "	7.60×10^{-4} "	1.07
Se-79		4.59×10^{-8} "	29.18×10^{-8} "	0.16
Sr-90		4.41×10^{-2} "	4.333×10^{-2} "	1.02

Table 3.2.13 (contd)

Sample ID and Radionuclide	Burnup, (a) Mwd/kgM	Analytical Value	ORIGEN2 Value(b)	Ratio, Analytical to ORIGEN2
<u>103-MLA098-BB (contd)</u>				
Tc-99		9.37×10^{-6} Ci/gUO ₂	9.43×10^{-6} Ci/gUO ₂	0.99
Sn-126		1.36×10^{-7} "	5.673×10^{-7} "	0.24
Cs-135		3.12×10^{-7} "	3.134×10^{-7} "	1.00
Cs-137		6.53×10^{-2} "	6.265×10^{-2} "	1.04
<u>103-MLA098-DD</u>				
I-129	25.49	2.41×10^{-8} Ci/gUO ₂	2.185×10^{-8} Ci/gUO ₂	1.10
<u>103-MLA098-EE</u>				
C-14	24.61	5.03×10^{-7} Ci/gUO ₂ (c)	4.501×10^{-7} Ci/gUO ₂	1.12
<u>103-MLA098-JJ</u>				
U-234	18.68	1.4×10^{-4} g/gUO ₂	1.491×10^{-4} g/gUO ₂	0.94
U-235		1.025×10^{-2} "	1.067×10^{-2} "	0.96
U-236		2.50×10^{-3} "	2.310×10^{-3} "	1.08
U-238		8.551×10^{-1} "	8.450×10^{-1} "	1.01
Pu-238		4.85×10^{-5} "	4.060×10^{-5} "	1.19
Pu-239		3.954×10^{-3} "	4.042×10^{-3} "	0.98
Pu-240		1.243×10^{-3} "	1.281×10^{-3} "	0.97
Pu-241		4.543×10^{-4} "	4.623×10^{-4} "	0.98
Pu-242		1.394×10^{-4} "	1.308×10^{-4} "	1.07
Np-237		1.23×10^{-7} Ci/gUO ₂	1.279×10^{-7} Ci/gUO ₂	0.96
Am-241		6.67×10^{-4} "	6.800×10^{-4} "	0.98
Cm-243 & 244		1.64×10^{-4} "	1.380×10^{-4} "	1.19
Se-79		3.43×10^{-8} "	2.091×10^{-7} "	0.16
Sr-90		3.36×10^{-2} "	3.253×10^{-2} "	1.03
Tc-99		7.07×10^{-6} "	6.837×10^{-6} "	1.03
Sn-126		8.60×10^{-8} "	3.778×10^{-7} "	0.23
Cs-135		2.79×10^{-7} "	2.771×10^{-7} "	1.01
Cs-137		4.59×10^{-2} "	4.390×10^{-2} "	1.05
<u>103-MLA098-LL</u>				
I-129	15.58	1.45×10^{-8} Ci/gUO ₂	1.291×10^{-8} Ci/gUO ₂	1.12
<u>103-MLA098-MM</u>				
C-14	12.92	2.82×10^{-7} Ci/gUO ₂ (c)	2.270×10^{-7} Ci/gUO ₂	1.24

- (a) Burnup values were measured for Samples 103-MLA098-P, 103-MLA098-BB, and 103-MLA098-JJ. All other burnups estimated using equation in Section 4.8.1 and ¹³⁷Cs activity in Appendix D for specific sample.
- (b) Interpolated ORIGEN2 values obtained from Appendix F using burnup derived with equation in Section 4.8.1 and ¹³⁷Cs activity in Appendix D, except for specimens 103-MLA098-P, 103-MLA098-BB, and 103-MLA098-JJ, for which these values were specifically calculated using ORIGEN2 and the given sample burnup.
- (c) Average of triplicate portions which varied within less than $\pm 8\%$.

Table 3.2.14 Fuel Radiochemical Analyses Results and Comparisons with ORIGEN2 Radionuclide Inventory

<u>Sample ID and Radionuclide</u>	<u>Burnup, (a) MWd/kgM</u>	<u>Analytical Value</u>	<u>ORIGEN2 Value(b)</u>	<u>Ratio, Analytical to ORIGEN2</u>
<u>104-MKP109-E</u> C-14	33.4	9.00×10^{-7} Ci/g fuel (c)	5.734×10^{-7} Ci/g fuel	1.57
<u>104-MKP109-J</u> C-14	44.3	9.31×10^{-7} Ci/g fuel (c)	8.105×10^{-7} Ci/g fuel	1.15
<u>104-MKP109-P</u>				
U-234	44.34	1.2×10^{-4} g/g fuel	1.200×10^{-4} g/g fuel	1.00
U-235		3.54×10^{-3} "	3.420×10^{-3} "	1.04
U-236		3.69×10^{-3} "	3.599×10^{-3} "	1.03
U-238		8.249×10^{-1} "	8.239×10^{-1} "	1.00
Pu-238		2.688×10^{-4} "	2.688×10^{-3} "	1.00
Pu-239		4.357×10^{-3} "	4.501×10^{-3} "	0.97
Pu-240		2.543×10^{-3} "	2.437×10^{-3} "	1.04
Pu-241		1.020×10^{-3} "	1.099×10^{-3} "	0.93
Pu-242		8.401×10^{-4} "	7.696×10^{-4} "	1.09
Np-237		3.31×10^{-7} Ci/g fuel	3.913×10^{-7} Ci/g fuel	0.85
Am-241		1.31×10^{-3} "	1.245×10^{-3} "	1.05
Cm-243 & 244		6.40×10^{-3} "	6.038×10^{-3} "	1.06
Se-75		6.49×10^{-8} "	4.695×10^{-7} "	0.14
Sr-90		6.58×10^{-2} "	6.667×10^{-2} "	0.99
Tc-99		1.35×10^{-5} "	1.457×10^{-7} "	0.93
Sn-126		2.2×10^{-7} "	9.916×10^{-7} "	0.22
Cs-135		4.95×10^{-1} "	4.884×10^{-1} "	1.01
Cs-137		1.09×10^{-1} "	1.059×10^{-1} "	1.03
<u>104-MKP109-T</u>				
I-129	44.4	3.75×10^{-8} Ci/g fuel	3.816×10^{-8} Ci/g fuel	0.98
<u>104-MKP109-U</u>				
C-14	44.4	1.63×10^{-6} Ci/g fuel (c)	8.068×10^{-7} Ci/g fuel	2.02
<u>104-MKP109-CC (c)</u>				
U-234	37.12	1.4×10^{-4} g/g fuel	1.317×10^{-4} g/g fuel	1.06
U-235		5.17×10^{-3} "	5.111×10^{-3} "	1.01
U-236		3.53×10^{-3} "	3.479×10^{-3} "	1.01
U-238		8.327×10^{-1} "	8.297×10^{-1} "	1.00
Pu-238		1.893×10^{-4} "	1.891×10^{-4} "	1.00
Pu-239		4.357×10^{-3} "	4.475×10^{-3} "	0.97
Pu-240		2.239×10^{-3} "	2.242×10^{-3} "	1.00
Pu-241		9.028×10^{-4} "	9.493×10^{-4} "	0.95
Pu-242		5.761×10^{-4} "	5.419×10^{-4} "	1.06
Np-237		2.51×10^{-7} Ci/g fuel	3.193×10^{-7} Ci/g fuel	0.79
Am-241		1.18×10^{-3} "	1.104×10^{-3} "	1.07
Cm-243 & 244		2.93×10^{-3} "	2.738×10^{-3} "	1.07
Se-75		6.036×10^{-8} "	3.997×10^{-7} "	0.15
Sr-90		5.90×10^{-2} "	5.877×10^{-2} "	1.00
Tc-99		1.23×10^{-5} "	1.262×10^{-5} "	0.97
Sn-126		1.82×10^{-7} "	8.030×10^{-7} "	0.23
Cs-135		4.59×10^{-2} "	4.556×10^{-2} "	1.01
Cs-137		9.01×10^{-2} "	8.867×10^{-2} "	1.02

Table 3.2.14 Fuel Radiochemical Analyses Results and Comparisons with ORIGEN2 Radionuclide Inventory (contd)

Sample ID and Radionuclide	Burnup, (a) Mwd/kgM	Analytical Value	ORIGEN2 Value(b)	Ratio, Analytical to ORIGEN2
<u>104-MKP109-FF</u>				
I-129	34.9	3.39×10^{-8} Ci/g fuel	2.975×10^{-8} Ci/g fuel	1.14
<u>104-MKP109-GG</u>				
C-14	33.8	9.26×10^{-7} Ci/g fuel (c)	5.977×10^{-7} Ci/g fuel	1.55
<u>104-MKP109-LL</u>				
U-234	27.35	1.6×10^{-4} g/g fuel	1.502×10^{-4} g/g fuel	1.07
U-235		8.47×10^{-3} "	8.467×10^{-3} "	1.00
U-236		3.14×10^{-3} "	3.084×10^{-3} "	1.02
U-238		8.425×10^{-1} "	8.371×10^{-1} "	1.01
Pu-238		1.01×10^{-4} "	9.713×10^{-5} "	1.04
Pu-239		4.264×10^{-3} "	4.318×10^{-3} "	0.99
Pu-240		1.719×10^{-3} "	1.770×10^{-3} "	0.97
Pu-241		6.812×10^{-4} "	6.947×10^{-4} "	0.98
Pu-242		2.886×10^{-4} "	2.771×10^{-4} "	1.04
Np-237		1.89×10^{-7} Ci/g fuel	2.137×10^{-7} Ci/g fuel	0.88
Am-241		8.56×10^{-4} "	8.423×10^{-4} "	1.02
Ca-243 & 244		7.34×10^{-4} "	6.539×10^{-4} "	1.12
Sr-79		4.55×10^{-8} "	3.014×10^{-7} "	0.15
Sr-90		4.59×10^{-2} "	4.657×10^{-2} "	0.99
Tc-99		9.59×10^{-6} "	9.713×10^{-6} "	0.99
Sn-126		1.25×10^{-7} "	5.602×10^{-7} "	0.22
Cs-135		4.16×10^{-7} "	4.094×10^{-7} "	1.02
Cs-137		6.71×10^{-2} "	6.526×10^{-2} "	1.03
<u>104-MKP109-OO</u>				
I-129	22.7	2.10×10^{-8} Ci/g fuel	1.885×10^{-8} Ci/g fuel	1.11
<u>104-MKP109-PP</u>				
C-14	20.4	6.45×10^{-7} Ci/g fuel (c)	3.223×10^{-7} Ci/g fuel	2.00

- (a) Burnup values were measured for Samples 104-MKP109-P, 104-MKP109-CC, and 104-MKP109-LL. All other burnups are estimated using the equation [1] in Section 7.1.1 and ^{137}Cs activity in Appendix C for specific samples. Estimated burnups are probably accurate to about ± 0.5 Mwd/kgM.
- (b) ORIGEN2 values obtained from Appendix D using burnup derived with equation [1] in Section 7.1.1 and ^{137}Cs activity in Appendix C, except for Samples 104-MKP109-P, 104-MKP109-CC, and 104-MKP109-LL, for which these values were directly calculated using ORIGEN2 and the measured sample burnup. Values in Appendix D were converted from g/g U to g/g UO_2 . 1 g of unirradiated UO_2 is equivalent to 1 g of as-irradiated fuel with all fission products.
- (c) Average of two measurements that varied within less than 10%, except 104-MKP109-J, which varied $\pm 25\%$.

Table 3.2.15 Fuel Radiochemical Analyses Results and Comparisons with ORIGEN2-Calculated Radionuclide Inventory

Sample ID and Radionuclide	Burnup, (a) MWd/kgM	Analytical Value	ORIGEN2 Value (b)	Ratio, Analytical to ORIGEN2
<u>106-NBD107-E</u> C-14	28.89	1.038×10^{-6} Ci/g fuel (c)	0.970×10^{-6} Ci/g fuel	1.07
<u>106-NBD107-I</u> C-14	46.36	1.38×10^{-6} Ci/g fuel (c)	1.658×10^{-6} Ci/g fuel	0.83
<u>106-NBD107-Q</u> (d)	46.46	7.49×10^{-5} g/g fuel 1.406×10^{-3} · 3.04×10^{-1} · 8.272×10^{-1} · 2.842×10^{-4} · 3.766×10^{-3} · 2.599×10^{-3} · 8.862×10^{-4} · 1.169×10^{-3} · 2.66×10^{-7} Ci/g fuel 2.18×10^{-3} · 9.86×10^{-8} · 5.99×10^{-8} · 6.04×10^{-2} · 1.09×10^{-5} · 2.10×10^{-7} · 4.79×10^{-1} · 1.12×10^{-1} ·	9.669×10^{-5} g/g fuel 1.930×10^{-3} · 2.919×10^{-1} · 8.236×10^{-4} · 3.133×10^{-3} · 4.519×10^{-3} · 2.543×10^{-3} · 1.086×10^{-3} · 0.971×10^{-3} · 3.750×10^{-7} Ci/g fuel 1.657×10^{-3} · 1.007×10^{-2} · 4.819×10^{-7} · 6.028×10^{-5} · 1.486×10^{-6} · 1.122×10^{-7} · 5.137×10^{-7} · 1.059×10^{-1} ·	0.77 0.73 1.04 1.00 0.91 0.83 1.02 0.82 1.20 0.71 1.32 0.98 0.12 1.00 0.73 0.19 0.93 1.06
<u>106-NBD107-U</u> I-129	46.51	3.83×10^{-8} Ci/g fuel	4.140×10^{-8} Ci/g fuel	0.93
<u>106-NBD107-V</u> C-14	46.83	1.76×10^{-6} Ci/g fuel (c)	1.677×10^{-6} Ci/g fuel	1.05
<u>106-NBD107-BB</u> I-129	47.05	4.34×10^{-8} Ci/g fuel	4.187×10^{-8} Ci/g fuel	1.04
<u>106-NBD107-CC</u> C-14	46.63	1.62×10^{-6} Ci/g fuel (c)	1.670×10^{-6} Ci/g fuel	0.97
<u>106-NBD107-GG</u> (d)	37.27	1.27×10^{-4} g/g fuel 2.71×10^{-3} · 3.03×10^{-1} · 8.438×10^{-1} · 1.947×10^{-4} · 3.835×10^{-3} · 2.321×10^{-3} · 8.130×10^{-4} · 7.753×10^{-4} · 2.26×10^{-7} Ci/g fuel 1.45×10^{-3} · 4.11×10^{-3} · 5.63×10^{-8} · 5.18×10^{-2} · 8.96×10^{-6} · 1.60×10^{-7} · 4.15×10^{-2} · 8.56×10^{-2} ·	1.061×10^{-4} g/g fuel 3.334×10^{-3} · 2.874×10^{-1} · 8.316×10^{-4} · 2.179×10^{-3} · 4.509×10^{-3} · 2.346×10^{-3} · 5.449×10^{-4} · 6.731×10^{-4} · 3.044×10^{-7} Ci/g fuel 1.487×10^{-3} · 4.170×10^{-3} · 3.950×10^{-7} · 5.169×10^{-2} · 1.246×10^{-5} · 8.701×10^{-7} · 4.650×10^{-2} · 8.482×10^{-2} ·	1.20 0.81 1.05 1.01 0.89 0.85 0.99 0.86 1.15 0.74 0.98 0.99 0.14 1.00 0.72 0.18 0.89 1.01

Table 3.2.15 (contd)

<u>Sample ID and Radionuclide</u>	<u>Burnup, (a) MWd/kgM</u>	<u>Analytical Value</u>	<u>ORIGEN2 Value (b)</u>	<u>Ratio, Analytical to ORIGEN2</u>
<u>106-NBD107-MM</u>				
U-234 (d)	31.40	1.53×10^{-4} g/g fuel	1.134×10^{-4} g/g fuel	1.35
U-235		3.86×10^{-3}	4.660×10^{-3}	0.83
U-236		2.86×10^{-3}	2.756×10^{-3}	1.04
U-238		8.446×10^{-1}	8.366×10^{-4}	1.01
Pu-238		1.426×10^{-4}	1.589×10^{-4}	0.90
Pu-239		3.814×10^{-3}	4.462×10^{-3}	0.85
Pu-240		2.067×10^{-3}	2.120×10^{-3}	0.98
Pu-241		7.260×10^{-4}	8.212×10^{-4}	0.88
Pu-242		5.463×10^{-4}	4.888×10^{-4}	1.12
Np-237		1.84×10^{-7} Ci/g fuel	2.514×10^{-7} Ci/g fuel	0.73
Am-241		1.18×10^{-3}	1.326×10^{-3}	0.89
Cm-243 & 244		1.87×10^{-3}	2.018×10^{-3}	0.93
Se-79		4.18×10^{-8}	3.378×10^{-7}	0.12
Sr-90		4.64×10^{-2}	4.561×10^{-2}	1.02
Tc-99		7.70×10^{-6}	1.083×10^{-5}	0.71
Sn-116		1.41×10^{-7}	7.138×10^{-7}	0.20
Cs-135		4.04×10^{-7}	4.347×10^{-7}	0.93
Cs-137		7.47×10^{-2}	7.141×10^{-2}	1.05
<u>106-NBD107-PP</u>				
I-129	29.49	2.19×10^{-8} Ci/g fuel	2.602×10^{-8} Ci/g fuel	0.84
<u>106-NBD107-00</u>				
C-14	26.75	5.40×10^{-7} Ci/g fuel (c)	8.908×10^{-7} Ci/g fuel	0.61

- (a) Burnup values were measured for Samples 106-NBD107-Q, 106-NBD107-GG, and 106-NBD107-MM. All other burnups are estimated using the equation in Section 4.7.1 and ^{137}Cs activity in Appendix D for specific samples. Estimated burnups are probably accurate to about ± 0.5 MWd/kgM.
- (b) ORIGEN2 values obtained from Appendix F using burnup derived with equation in Section 4.7.1 and ^{137}Cs activity in Appendix D, except for Samples 106-NBD107-Q, 106-NBD107-GG, and 106-NBD107-MM, for which these values were directly calculated using ORIGEN2 and the measured sample burnup. Values in Appendix F were converted from g/gU to g/g UO_2 . 1 g of unirradiated UO_2 is equivalent to 1 g of as-irradiated fuel with all fission products.
- (c) Average of two measurements that varied within less than 10%.
- (d) Measured values for ^{234}U were corrected for an apparent drift in measurement systems based on comparisons with standard samples before and after analyses. A new approach is being used for subsequent samples.

3.3 Cooper reactor (BWR)

This isotopic composition measurements were performed as one of the characterizations of LWR spent fuel MCC-approved testing materials by MCC.

The tables and figures in this section were reprinted from the following report.

6) R.J. Guenther et.al., "Characterization of LWR Spent Fuel MCC-Approved Testing Material-ATM-105", PNL-5109-105(1991).

3.3.1 Core configuration and performance

The Cooper reactor is the BWR in USA. The assemblies were fabricated by a GE, 7 x 7 rods array.

The assembly dimension and specifications are shown in Fig. 3.3.1, Table 3.3.1 and Fig. 3.3.2.

3.3.2 Irradiation history and samples

These assay samples are called ATM-105, and they were irradiated in the fuel assembly CZ346. The rod locations of the assembly are shown in Fig. 3.3.3. The reactor power history is shown in Fig. 3.3.4. And the power history for CZ346 assembly shown in Table 3.3.2, Table 3.3.3, Table 3.3.4 and Fig. 3.3.5

The assay samples of ATM-105 are in 6 pieces(ATM-105-2966-B, ATM-105-2966-K, ATM-105-2966-T from ADD2966 rod and ATM-105-2974-B, ATM-105-2974-J, ATM-105-2974-U from ADD2974 rod) in CZ346 assembly. The axial locations of these samples are shown in Figs. 3.3.6 and 3.3.7. The assays of ADD2966 and ADD2974 were performed 5.35 years and 5.28 years after, irradiation, respectively.

3.3.3 Isotopic composition data

The fuel compositions of ATM-105 is shown in Table 3.3.5.

The measured burnup are shown in Table 3.3.6. The burnup was measured by the Nd-148 basis method.

The isotopic composition data are shown in Table 3.3.7. The measured actinoids are U, Pu, Np-237, Am-241 and Cm-243.& 244. The measured fission products(FPs) are Nd-148, Se-79, Sr-90, Tc-99, Sn-126 and Cs-135, Cs-137.

Table 3.3.1 ATM-105 Fuel Bundle and Rod Design Parameters

<u>Design Parameter</u>	<u>Description</u>	
Fuel rod array	7 x 7	
Overall bundle length	447.5 cm	(176.2 in.)
Nominal active fuel length	371 cm	(146 in.)
Fuel rod pitch	1.87 cm	(0.738 in.)
Outside rod diameter	1.43 cm	(0.563 in.)
Cladding thickness	0.094 cm	(0.037 in.)
Cladding material	Zircaloy-2	
Pellet outside diameter	1.21 cm	(0.477 in.)
Fuel pellet material	UO ₂ (a)	
Pellet immersion density	10.32 g/cm ³	(0.37 lb/in ³)
Fission gas plenum length	35.6 cm	(14 in.)
Helium fill gas pressure	1.0 atm	(14.7 psia)

(a) Five fuel rods that contain UO₂ and Gd₂O₃ have been redesignated as ATM-108; they will be removed from the bundles and characterized.

Table 3.3.2 Cooper Power History and Burnup Levels of Bundles CZ346 and CZ348 (McKinnon et al. 1986)

<u>Cycle</u>	<u>Ave. Reactor Power (MW)</u>	<u>Startup</u>	<u>Shutdown</u>	<u>Bundle Burnup, MWd/kgM</u>			
				<u>CZ-346</u>	<u>CZ-348</u>	<u>ΔBU</u>	<u>Total</u>
1	1500	07/04/74	09/17/76	13.90	13.90	13.10	13.10
2	1750	11/16/76	09/17/77	5.24	19.14	5.93	19.03
3	1750	10/18/77	03/31/78	2.78	21.92	3.08	22.11
6	2150	06/08/80	04/20/81	3.28	25.20	2.66	24.77
7	1750	06/08/81	05/21/82	2.85	28.05	2.71	27.48

Table 3.3.3 Burnup of Bundle CZ346

<u>Cycle No.</u>	Bundle-Average Burnup, MWd/kgM	
	<u>Incremental</u>	<u>Cumulative</u>
1	13.90	13.90
2	5.24	19.14
3	2.78	21.92
6	3.28	25.20
7	2.85	28.05

**Table 3.3.4 Power History for Cooper BWR and Bundle CZ346
During Cycles 1, 2, 3, 6, and 7**

Cycle	Elapsed Time, Days	Time Interval, Days	Core Power Density, MW/MTU	Bundle CZ346		
				Power Density, MW/MTU	Cumulative Burnup, MWd/kgM	Average LHGR, kW/m
1	19	19	12.15	15.63	0.297	16.34
	27	8	0	0	0.297	0
	90	63	11.04	14.21	1.192	14.84
	157	67	17.67	22.74	2.715	23.76
	174	17	0	0	2.715	0
	182	8	11.04	14.21	2.829	14.84
	215	33	19.88	25.58	3.673	26.73
	225	10	0	0	3.673	0
	296	71	20.99	27.01	5.591	28.22
	451	155	11.04	14.21	7.793	14.84
	486	35	0	0	7.793	0
	505	19	11.04	14.21	8.062	14.84
	525	20	19.88	25.58	8.574	26.73
	532	7	0	0	8.574	0
	554	22	17.67	22.74	9.074	23.76
	556	12	0	0	9.074	0
	621	55	17.67	22.74	10.325	23.76
	674	53	15.46	19.89	11.379	20.79
	693	19	0	0	11.379	0
	718	25	15.46	19.89	11.876	20.79
	807	89	17.67	22.74	13.900	23.76
2	866	59	0	0	13.900	0
	880	14	15.46	15.46	14.116	16.15
	904	24	20.98	20.98	14.620	21.92
	919	15	11.04	11.04	14.785	11.53
	945	26	20.99	20.99	15.331	21.93
	953	8	0	0	15.331	0
	996	43	20.99	20.99	16.234	21.93
	1001	5	8.84	8.84	16.278	9.24
	1017	16	20.99	20.99	16.614	21.93
	1022	5	0	0	16.614	0
	1044	22	19.88	19.88	17.051	20.77
	1083	39	13.25	13.25	17.568	13.84
	1172	89	17.67	17.67	19.140	18.46
3	1203	31	0	0	19.140	0
	1367	164	15.46	16.95	21.920	17.71

**Table 3.3.4 Power History for Cooper BWR and Bundle CZ346
During Cycles 1, 2, 3, 6, and 7 (contd)**

Cycle	Elapsed Time, Days	Time Interval, Days	Core Power Density, MW/MTU	Bundle CZ346		
				Power Density, MW/MTU	Cumulative Burnup, MWd/kgM	Average LHGR, kW/m
6	2166	799	0	0	21.920	0
	2189	23	19.88	10.33	22.158	10.80
	2214	25	22.09	11.48	22.445	12.00
	2228	14	11.04	5.74	23.525	6.00
	2326	98	20.99	10.91	23.594	11.40
	2335	9	0	0	23.594	0
	2377	42	20.99	10.91	24.052	11.40
	2393	16	22.09	11.48	24.236	12.00
	2452	59	20.99	10.91	24.880	11.40
	2483	31	19.88	10.33	25.200	10.80
7	2531	48	0	0	25.200	0
	2539	8	8.84	4.38	25.235	4.57
	2548	9	17.67	8.75	25.314	9.14
	2627	79	21.64	10.71	26.160	11.19
	2688	61	0	0	26.160	0
	2743	55	21.64	10.71	26.749	11.19
	2817	74	20.99	10.39	27.518	10.86
	2822	5	0	0	27.518	0
	2853	31	19.88	9.84	27.823	10.28
	2879	26	17.67	8.75	28.050	9.14

Table 3.3.5 Fuel Composition of ATM-105 Assumed for ORIGEN2 Calculations

<u>Parameter</u>	<u>Value (a)</u>
Enrichment, wt%	2.939(b)
^{234}U , ppm	238.2(c)
Total uranium, wt%	88.147
Oxygen, wt%	11.853
Carbon, ppm	18
Nitrogen, ppm	23
Fluorine, ppm	5
Chlorine, ppm	5
Chromium, ppm	0(d)
Iron, ppm	45
Silver, ppm	1
Calcium, ppm	32
Aluminum, ppm	32
Silicon, ppm	32
Nickel, ppm	25

- (a) Based on nominal values for low-enriched fuel used in other ATMs; measured data not available.
 (b) Provided by GE.
 (c) Interpolated value based on ^{235}U fuel enrichments.
 (d) Although assumed to be absent for the ORIGEN2 calculations, chromium and a few other elements were detected by AEM as minor impurities (see Section 4.6.2).

Table 3.3.6 Burnup Results for ATM-105 Fuel Samples(a)

Rod and Sample Numbers	Burnup Based on ^{148}Nd		Measured Gamma Activity, Counts/s	Sample Location
	Atom %	GJ/kgM (MWd/kgM)		
<u>Rod ADD2966</u>				
105-ADD2966-B	1.992	1638 (18.96)	1142	Representative of approximately 56% of peak ^{137}Cs activity in top portion of Rod ADD2966.
105-ADD2966-K	3.469	2857 (33.07)	1972	Representative of approximately 97% of peak ^{137}Cs activity in mid portion of Rod ADD2966.
105-ADD2966-T	3.561	2932 (33.94)	1991	Typical peak burnup in lower portion of Rod ADD2966.
<u>Rod ADD2974</u>				
105-ADD2974-B	1.874	1541 (17.84)	1086	Representative of approximately 57% of peak ^{137}Cs activity in top portion of Rod ADD2974.
105-ADD2974-J	3.064	2525 (29.23)	1705	Representative of approximately 94% of peak ^{137}Cs activity in upper portion of Rod ADD2974.
105-ADD2974-U	3.257	2682 (31.04)	1848	Typical peak burnup in lower portion of Rod ADD2974.

(a) See sectioning diagrams in Appendix 2 for sample locations with respect to gamma activity.

Table 3.3.7 Fuel Radiochemical Analyses Results and Comparisons with ORIGEN2-Calculated Radionuclide Inventory

Sample ID and Radionuclide	Burnup, (a) Mwd/kgm	Analytical Value	ORIGEN2 Value ^(b)	Ratio, Analytical to ORIGEN2
<u>105-ADD2966-B</u>				
U-234	18.96	1.7×10^{-4} g/g fuel	1.607×10^{-4} g/g fuel	1.06
U-235		1.191×10^{-3} "	1.151×10^{-3} "	1.03
U-236		2.63×10^{-1} "	2.494×10^{-1} "	1.05
U-238		8.437×10^{-1} "	8.439×10^{-1} "	1.00
Pu-238		5.35×10^{-5} "	4.825×10^{-5} "	1.11
Pu-239		3.738×10^{-3} "	3.896×10^{-3} "	0.96
Pu-240		1.220×10^{-4} "	1.239×10^{-4} "	0.98
Pu-241		3.403×10^{-5} "	4.125×10^{-4} "	0.82
Pu-242		9.892×10^{-7} "	1.128×10^{-7} "	0.88
Np-237		1.11×10^{-4} Ci/g fuel	1.248×10^{-4} Ci/g fuel	0.89
Am-241		5.18×10^{-4} "	6.714×10^{-4} "	0.77
Cm-243 & 244		1.10×10^{-8} "	1.147×10^{-7} "	0.96
Se-79		2.77×10^{-2} "	2.109×10^{-2} "	0.13
Sr-90		3.21×10^{-6} "	3.250×10^{-6} "	0.99
Tc-99		6.26×10^{-6} "	7.013×10^{-7} "	0.89
Sn-113		7.79×10^{-8} "	3.463×10^{-7} "	0.22
Cs-135		3.74×10^{-7} "	3.710×10^{-7} "	1.01
Cs-137		4.27×10^{-2} "	4.274×10^{-2} "	1.00
<u>105-ADD2966-C</u>				
I-129	19.89	1.71×10^{-8} Ci/g fuel	1.618×10^{-8} Ci/g fuel	1.06
<u>105-ADD2966-D</u>				
C-14	21.18	6.01×10^{-7} Ci/g fuel ^(c)	3.505×10^{-7} Ci/g fuel	1.71
<u>105-ADD2966-K</u>				
U-234	33.07	1.35×10^{-4} g/g fuel	1.330×10^{-4} g/g fuel	1.02
U-235		5.34×10^{-3} "	5.533×10^{-3} "	0.97
U-236		3.53×10^{-1} "	3.300×10^{-1} "	1.07
U-238		8.346×10^{-4} "	8.339×10^{-4} "	1.00
Pu-238		1.743×10^{-3} "	1.778×10^{-3} "	0.98
Pu-239		3.579×10^{-3} "	4.324×10^{-3} "	0.83
Pu-240		2.216×10^{-4} "	2.064×10^{-4} "	1.07
Pu-241		6.390×10^{-4} "	8.208×10^{-4} "	0.78
Pu-242		4.407×10^{-7} "	4.421×10^{-7} "	1.00
Np-237		2.54×10^{-4} Ci/g fuel	2.789×10^{-3} Ci/g fuel	0.91
Am-241		8.78×10^{-3} "	1.219×10^{-3} "	0.72
Cm-243 & 244		1.45×10^{-8} "	1.765×10^{-7} "	0.82
Se-79		4.59×10^{-2} "	3.545×10^{-2} "	0.13
Sr-90		4.86×10^{-2} "	5.045×10^{-2} "	0.96

Table 3.3.7 (contd)

<u>Sample ID and Radionuclide</u>	<u>Burnup, (a) MWh/kgM</u>	<u>Analytical Value</u>	<u>ORIGEN2 Value^(b)</u>	<u>Ratio, Analytical to ORIGEN2</u>
<u>105-AD02966-K (contd)</u>				
Tc-99		1.03×10^{-5} Ci/g fuel	1.157×10^{-5} Ci/g fuel	0.89
Sn-126		1.52×10^{-7} "	6.669×10^{-7} "	0.23
Cs-135		4.66×10^{-2} "	4.617×10^{-2} "	0.97
Cs-137		7.48×10^{-2} "	7.468×10^{-2} "	1.00
<u>105-AD02966-N</u>				
I-129	31.75	2.01×10^{-8} Ci/g fuel	2.670×10^{-8} Ci/g fuel	0.75
<u>105-AD02966-O</u>				
C-14	31.81	5.21×10^{-7} Ci/g fuel ^(c)	5.587×10^{-7} Ci/g fuel	0.93
<u>105-AD02966-T</u>				
U-234	33.94	1.44×10^{-4} g/g fuel	1.315×10^{-4} g/g fuel	1.10
U-235		4.83×10^{-3} "	5.269×10^{-3} "	0.92
U-236		3.62×10^{-1} "	3.328×10^{-1} "	1.09
U-238		8.391×10^{-6} "	8.332×10^{-4} "	1.01
Pu-238		1.706×10^{-3} "	1.880×10^{-3} "	0.91
Pu-239		3.336×10^{-3} "	4.333×10^{-3} "	0.77
Pu-240		2.190×10^{-4} "	2.097×10^{-4} "	1.04
Pu-241		6.201×10^{-4} "	8.440×10^{-4} "	0.73
Pu-242		4.737×10^{-7} "	4.682×10^{-4} "	1.01
Np-237		2.46×10^{-4} Ci/g fuel	2.886×10^{-3} Ci/g fuel	0.85
Am-241		8.38×10^{-3} "	1.246×10^{-3} "	0.67
Cm-243 & 244		1.50×10^{-8} "	1.994×10^{-7} "	0.75
Se-79		4.96×10^{-8} "	3.630×10^{-7} "	0.14
Sr-90		5.09×10^{-2} "	5.141×10^{-2} "	0.99
Tc-99		1.06×10^{-5} "	1.182×10^{-5} "	0.90
Sn-126		1.60×10^{-7} "	6.878×10^{-7} "	0.23
Cs-135		4.29×10^{-7} "	4.658×10^{-7} "	0.92
Cs-137		7.70×10^{-2} "	7.666×10^{-2} "	1.00
<u>105-AD02966-X</u>				
I-129	34.45	2.40×10^{-8} Ci/g fuel	2.911×10^{-8} Ci/g fuel	0.82
<u>105-AD02966-Y</u>				
C-14	34.33	3.80×10^{-7} Ci/g fuel ^(c)	6.12×10^{-7} Ci/g fuel	0.62

Table 3.3.7 (contd)

Sample ID and Radionuclide	Burnup, (a) Mwd/kgM	Analytical Value	ORIGEN2 Value ^(b)	Ratio, Analytical to ORIGEN2
<u>105-ADD2974-B</u>				
U-234	17.84	1.74×10^{-4} g/g fuel	1.632×10^{-4} g/g fuel	1.07
U-235		1.30×10^{-2} "	1.214×10^{-2} "	1.07
U-236		2.48×10^{-3} "	2.397×10^{-3} "	1.03
U-238		8.545×10^{-1} "	8.447×10^{-1} "	1.01
Pu-238		5.21×10^{-5} "	4.132×10^{-5} "	1.26
Pu-239		4.056×10^{-3} "	3.825×10^{-3} "	1.06
Pu-240		1.184×10^{-4} "	1.158×10^{-4} "	1.02
Pu-241		3.415×10^{-5} "	3.771×10^{-5} "	0.91
Pu-242		8.742×10^{-7} "	9.573×10^{-7} "	0.91
Np-237		1.09×10^{-4} Ci/g fuel	1.137×10^{-4} Ci/g fuel	0.96
Am-241		5.23×10^{-4} "	6.111×10^{-5} "	0.86
Cm-243 & 244		1.14×10^{-8} "	8.433×10^{-7} "	1.35
Se-79		2.70×10^{-2} "	1.990×10^{-2} "	0.14
Sr-90		2.92×10^{-6} "	3.092×10^{-6} "	0.94
Tc-99		6.17×10^{-8} "	6.626×10^{-7} "	0.93
Sn-113		7.34×10^{-8} "	3.227×10^{-7} "	0.23
Cs-135		3.83×10^{-7} "	3.604×10^{-2} "	1.06
Cs-137		4.05×10^{-2} "	4.028×10^{-2} "	1.01
<u>105-ADD2974-C</u>				
I-129	18.39	1.40×10^{-8} Ci/g fuel	1.488×10^{-8} Ci/g fuel	0.94
<u>105-ADD2974-J</u>				
U-234	29.23	1.46×10^{-4} g/g fuel	1.397×10^{-4} g/g fuel	1.05
U-235		7.76×10^{-3} "	6.836×10^{-3} "	1.14
U-236		3.36×10^{-3} "	3.154×10^{-3} "	1.07
U-238		8.490×10^{-1} "	8.368×10^{-1} "	1.01
Pu-238		1.64×10^{-4} "	1.357×10^{-3} "	1.21
Pu-239		4.526×10^{-3} "	4.263×10^{-3} "	1.06
Pu-240		2.164×10^{-4} "	1.893×10^{-4} "	1.14
Pu-241		6.649×10^{-4} "	7.157×10^{-4} "	0.93
Pu-242		3.247×10^{-7} "	3.341×10^{-7} "	0.97
Np-237		2.35×10^{-4} Ci/g fuel	2.354×10^{-3} Ci/g fuel	1.00
Am-241		9.46×10^{-3} "	1.082×10^{-4} "	0.87
Cm-243 & 244		1.10×10^{-8} "	9.822×10^{-7} "	1.12
Se-79		4.26×10^{-8} "	3.165×10^{-7} "	0.13
Sr-90		4.38×10^{-2} "	4.608×10^{-2} "	0.95
Tc-99		9.86×10^{-6} "	1.039×10^{-5} "	0.95
Sn-113		1.41×10^{-7} "	5.756×10^{-7} "	0.24
Cs-135		5.23×10^{-2} "	4.427×10^{-2} "	1.18
Cs-137		7.25×10^{-2} "	6.609×10^{-2} "	1.10

Table 3.3.7 (contd)

Sample ID and Radionuclide	Burnup, (a) MWh/kgM	Analytical Value	ORIGEN2 Value ^(b)	Ratio, Analytical to ORIGEN2
<u>105-AD02974-M</u>				
I-129	29.37	2.75×10^{-8} Ci/g fuel	2.457×10^{-8} Ci/g fuel	1.12
<u>105-AD02974-N</u>				
C-14	29.55	4.06×10^{-7} Ci/g fuel ^(c)	5.117×10^{-7} Ci/g fuel	0.79
<u>105-AD02974-U</u>				
U-234	31.04	1.54×10^{-6} g/g fuel	1.364×10^{-4} g/g fuel	1.13
U-235		6.28×10^{-3} "	6.193×10^{-3} "	1.01
U-236		3.48×10^{-3} "	3.229×10^{-3} "	1.08
U-238		8.455×10^{-1} "	8.354×10^{-4} "	1.01
Pu-238		1.389×10^{-4} "	1.550×10^{-3} "	0.90
Pu-239		3.668×10^{-3} "	4.297×10^{-3} "	0.85
Pu-240		2.082×10^{-3} "	1.981×10^{-4} "	1.05
Pu-241		6.139×10^{-4} "	7.669×10^{-4} "	0.80
Pu-242		3.823×10^{-4} "	3.835×10^{-4} "	1.00
Np-237		2.36×10^{-7} Ci/g fuel	2.560×10^{-3} Ci/g fuel	0.92
Am-241		8.69×10^{-4} "	1.143×10^{-3} "	0.76
Cm-243 & 244		1.07×10^{-8} "	1.310×10^{-7} "	0.82
Se-79		4.50×10^{-8} "	3.345×10^{-7} "	0.13
Sr-90		4.82×10^{-2} "	4.822×10^{-2} "	1.00
Tc-99		1.00×10^{-5} "	1.095×10^{-5} "	0.91
Sn-116		1.46×10^{-7} "	6.183×10^{-7} "	0.24
Cs-135		4.31×10^{-7} "	4.519×10^{-7} "	0.95
Cs-137		6.85×10^{-2} "	7.020×10^{-2} "	0.98
<u>105-AD02974-Y</u>				
I-129	31.20	3.05×10^{-8} Ci/g fuel	2.710×10^{-8} Ci/g fuel	1.13
<u>105-AD02974-Z</u>				
C-14	31.29	7.00×10^{-7} Ci/g fuel ^(c)	5.478×10^{-7} Ci/g fuel	1.28

(a) Burnup values were measured for Samples 105-AD02966-B, 105-AD02966-K, 105-AD02966-T, 105-AD02974-B, 105-AD02974-J, and 105-AD02974-U. All other burnups are estimated using the equation in Section 4.8.1 and ^{137}Cs activity in Appendix D for specific samples. These estimated burnups are probably accurate to about ± 0.5 MWh/kgM.

(b) ORIGEN2 values obtained from Appendix F using burnup derived with equation in Section 4.8 and ^{137}Cs activity in Appendix D, except for Samples 105-AD02966-B, 105-AD02966-K, 105-AD02966-T, 105-AD02974-B, 105-AD02974-J, and 105-AD02974-U, for which these values were directly calculated using ORIGEN2 and the measured sample burnup. Values in Appendix F were converted from g/gU to g/g UO_2 . One gram of unirradiated UO_2 is equivalent to 1 g of as-irradiated fuel with all fission products.

(c) Average of two measurements that varied within less than 10%.

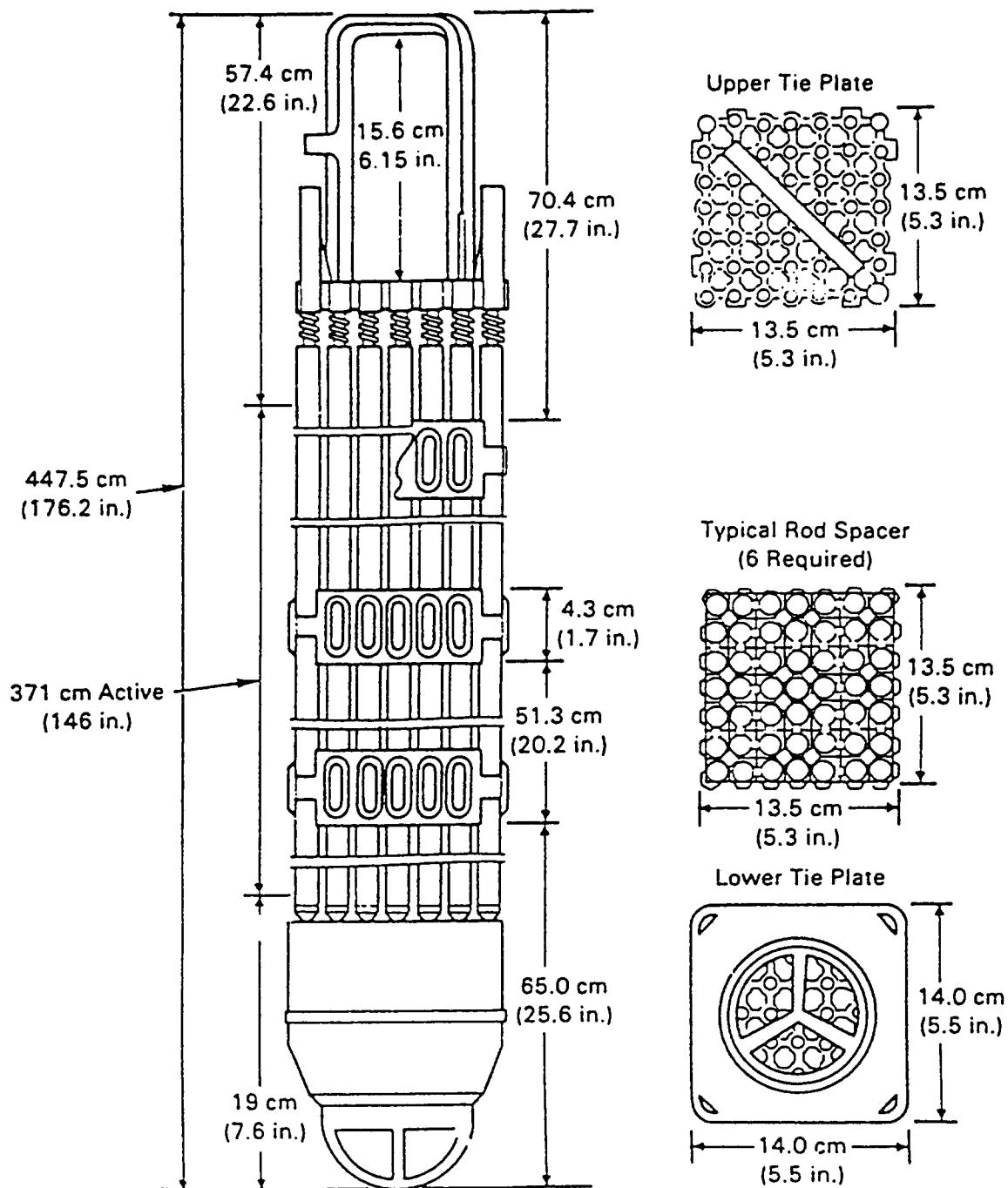


Fig. 3.3.1 General Electric 7 x 7 Fuel Bundle

Wide-Wide Corner

4	3	T 3	2	T 2	2	3
3	7	1	1	1	1	2
T 3	1	1	1	1	5	T 1
2	1	1	5	1	1	1
T 2	1	1	1	1	1	T 1
2	1	5	1	1	6	2
3	2	1	1	1	2	2

Fuel Bundle Map

Rod Type	Enrichment, Wt%, U-235	Wt% Gd_2O_3	Number of Rods
1	2.93	0	26
2	1.94	0	11
3	1.69	0	6
4	1.33	0	1
5	2.93	3.0	3
6	2.93	4.0	1
7	1.94	4.0	1

Legend

S - Spacer Capture Rod

T - Tie Rods

Fig. 3.3.2 Location of Different Type Fuel Rods in Bundles CZ346 and CZ348

	a	b	c	d	e	f	g
1	ADH	ADG	ADC	ADE	ADB	ADE	ADG
	0429	0646	0547	2270	0321	1575	0653
2	ADG	ADP	ADD	ADD	ADD	ADD	ADE
	0621	0262	2965	2963	2967	2961	1553
3	ADC	ADD	ADD	ADD	ADD	ADN	ADA
	0506	2966	2974	2937	2950	0206	0724
4	ADE	ADD	ADD	ADZ	ADD	ADD	ADD
	1507	2964	2945	0472	2946	4319	2931
5	ADB	ADD	ADD	ADD	ADD	ADD	ADA
	0309	4320	4352	4361	4326	4373	0714
6	ADE	ADD	ADN	ADD	ADD	ADS	ADE
	1527	4368	1313	4353	4363	0134	1569
7	ADG	ADE	ADA	ADD	ADA	ADE	ADE
	0662	1540	1715	4347	1771	1548	1537

Fig. 3.3.3 Loading Diagram for Bundle CZ346 (characterized rods are denoted in highlighted boxes)

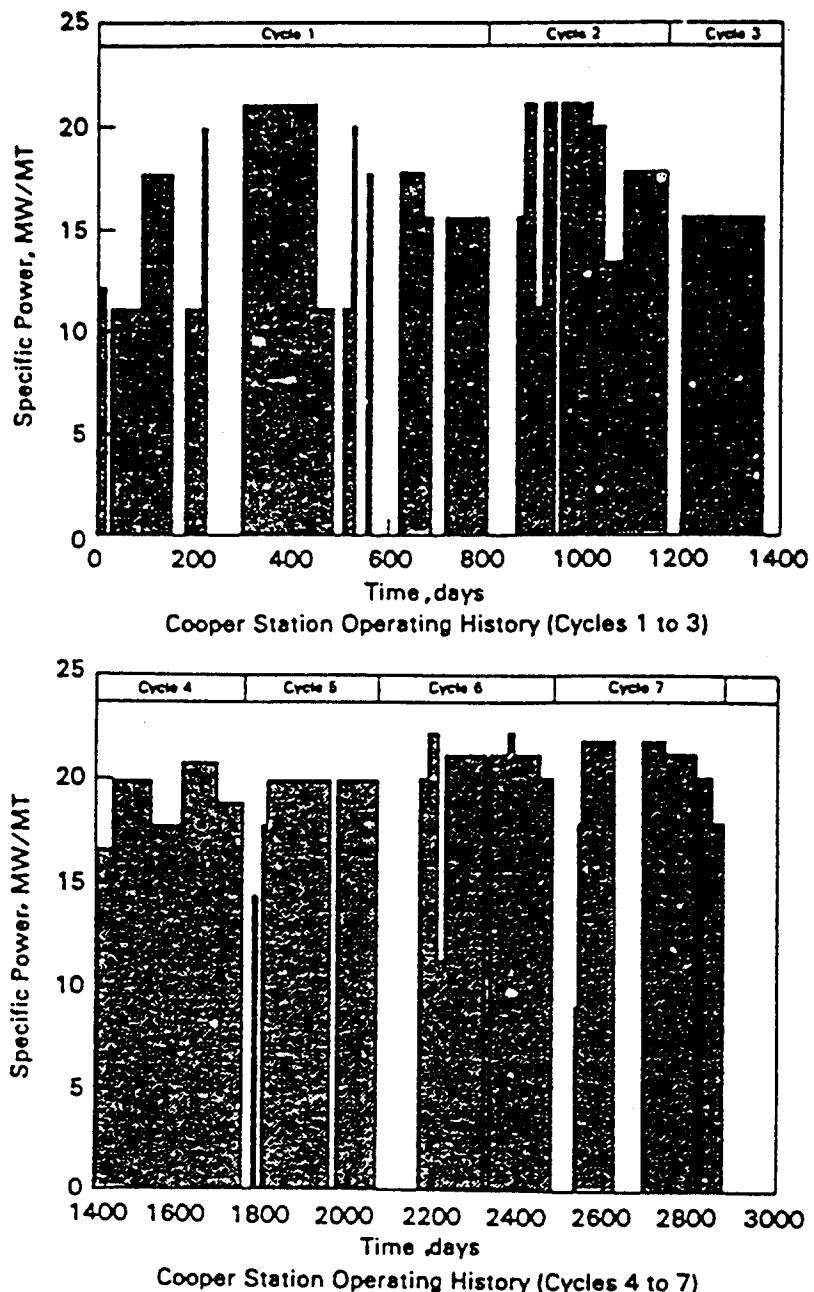


Fig. 3.3.4 Cooper Nuclear Power Plant Operating History
(McKinnon et al. 1986)

Cycle No.	1	2	3	6	7
Start/End of Cycle	07-04-74/ 09-17-76	11-16-76 09-17-77	10-18-77 03-31-78	06-08-80/ 04-20-81	06-08-81/ 05-21-82
Cycle Duration, months	-27	-10	-55	-105	-11.5
Cycle Burnup, GJ/kgM (MWd/kgM)	1201 (13.90)	453 (5.24)	240 (2.78)	283 (3.28)	246 (2.85)
Cumulative Burnup, GJ/kgM (MWd/kgM)	1201 (13.90)	1654 (19.14)	1894 (21.92)	2177 (25.20)	2424 (28.05)

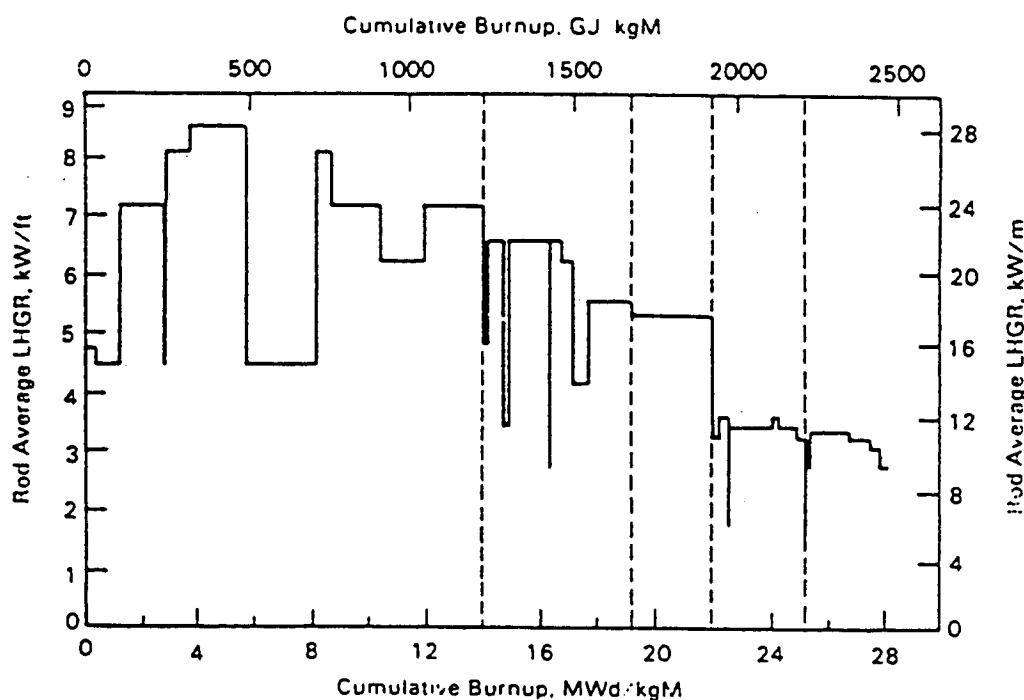


Fig. 3.3.5 Power History for Bundle CZ346 (based on data from McKinnon et al. 1986)

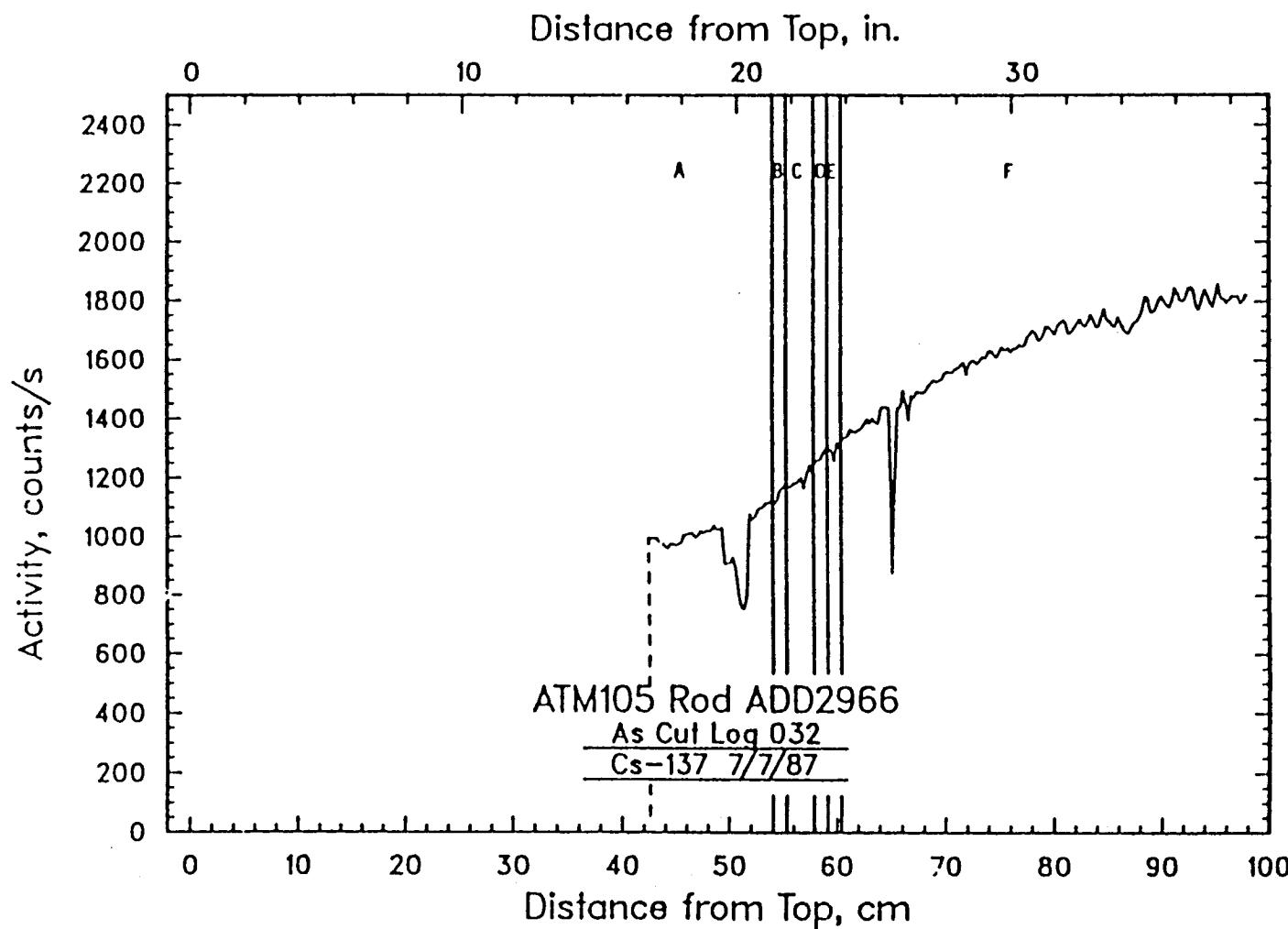


Fig. 3.3.6 As-Cut Sectioning Diagram for Rod ADD2966

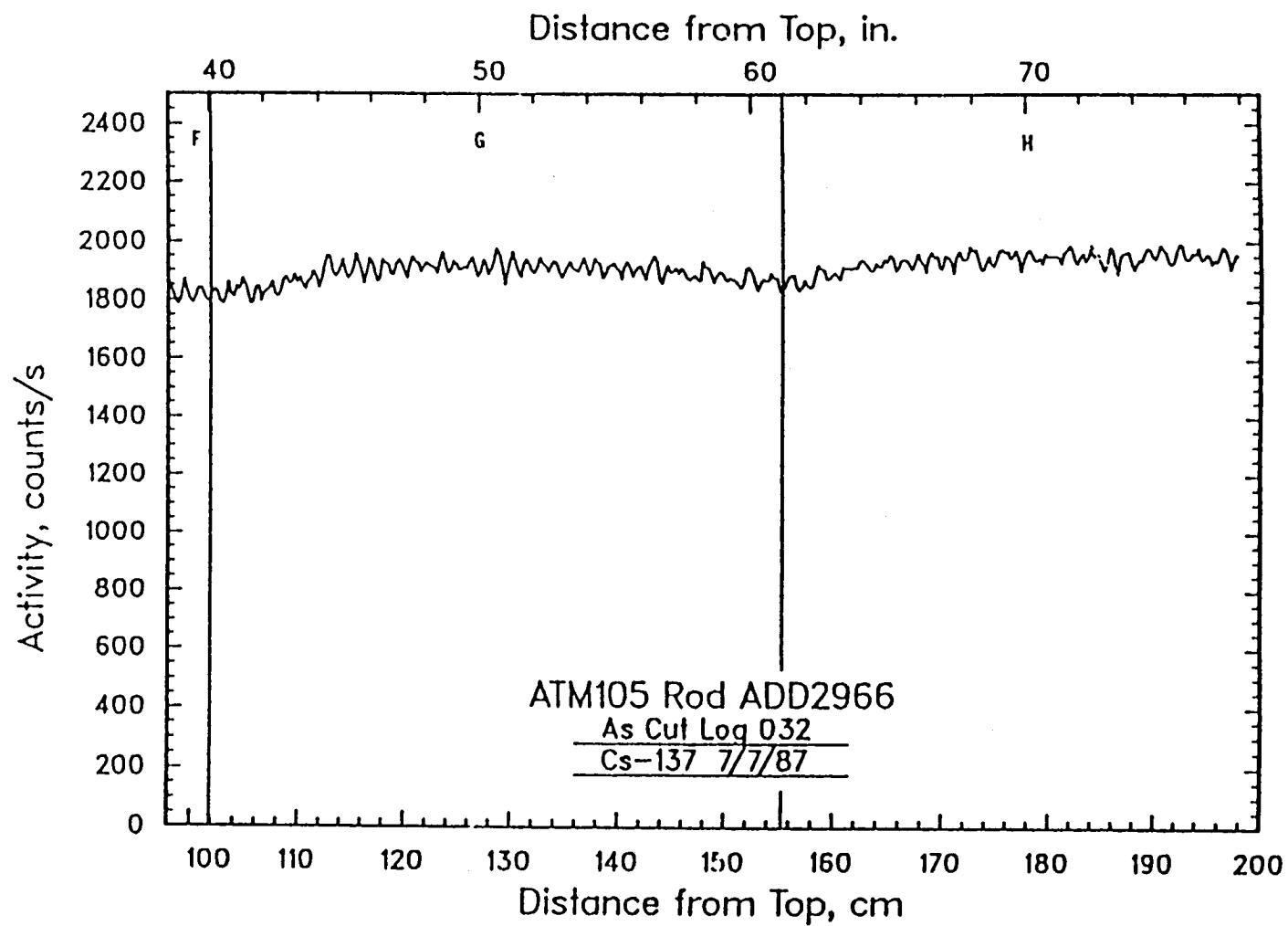


Fig. 3.3.6 As-Cut Sectioning Diagram for Rod ADD2966 (contd)

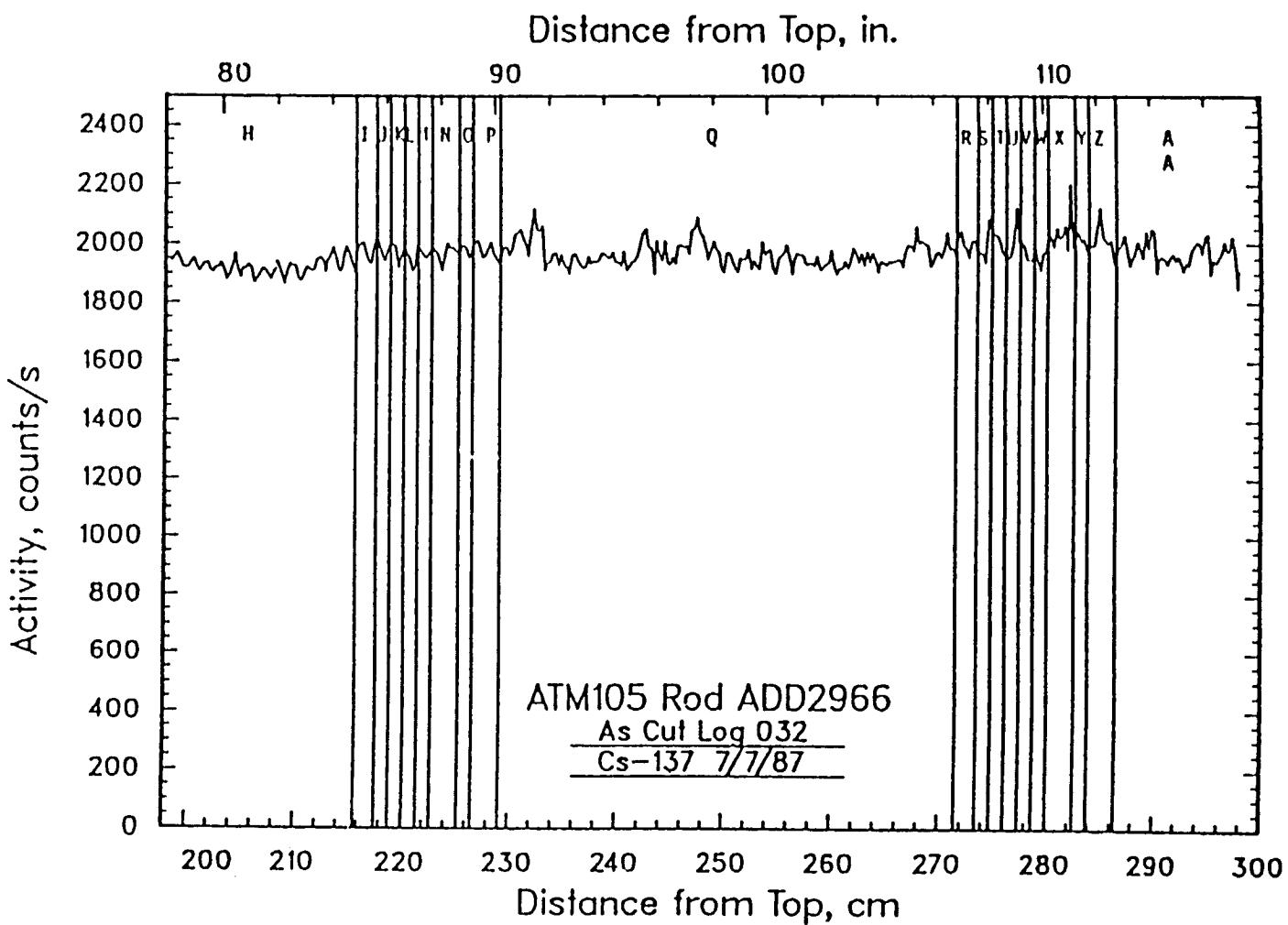


Fig. 3.3.6 s-Cut Sectioning Diagram for Rod ADD2966 (contd)

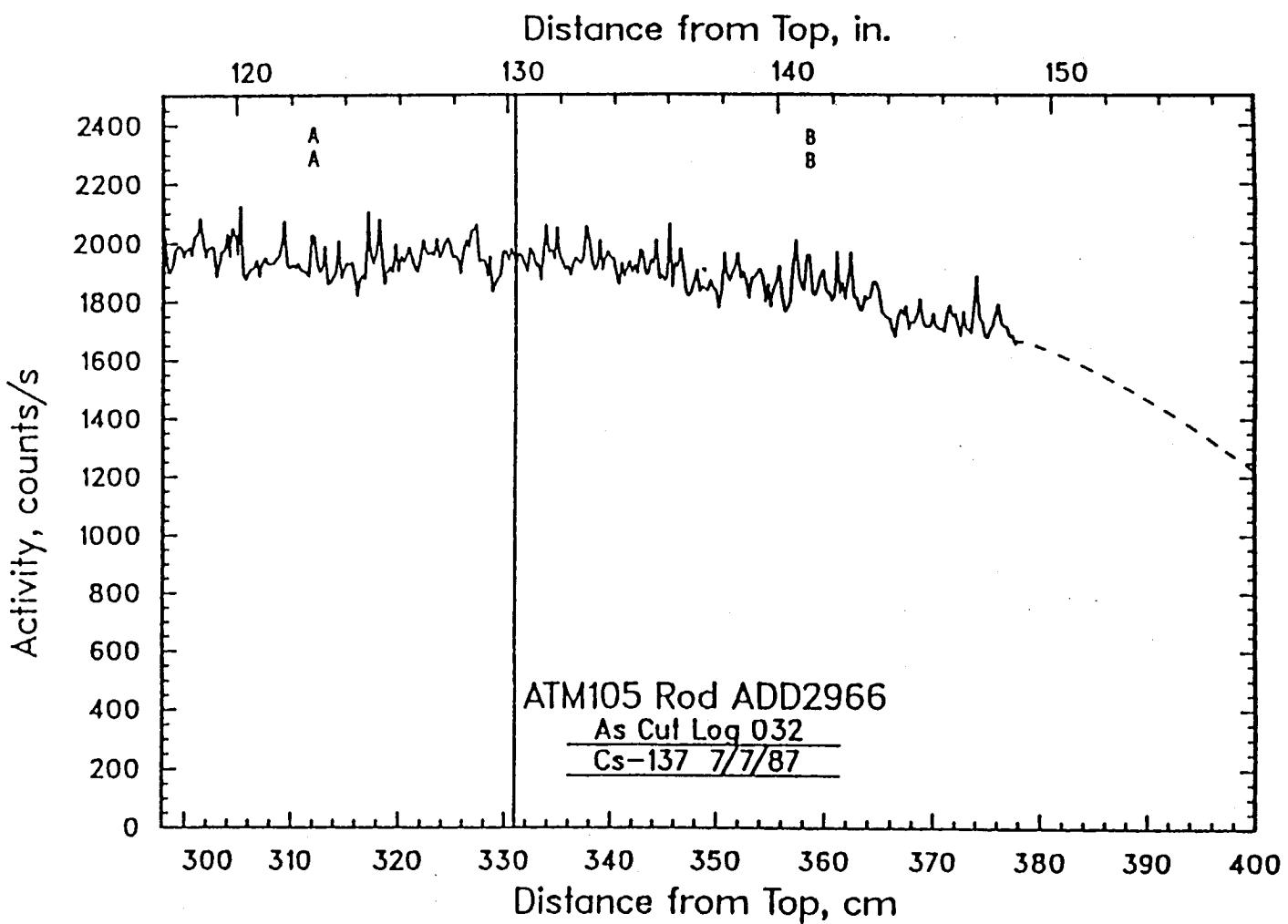


Fig. 3.3.6 As-Cut Sectioning Diagram for Rod ADD2966 (contd)

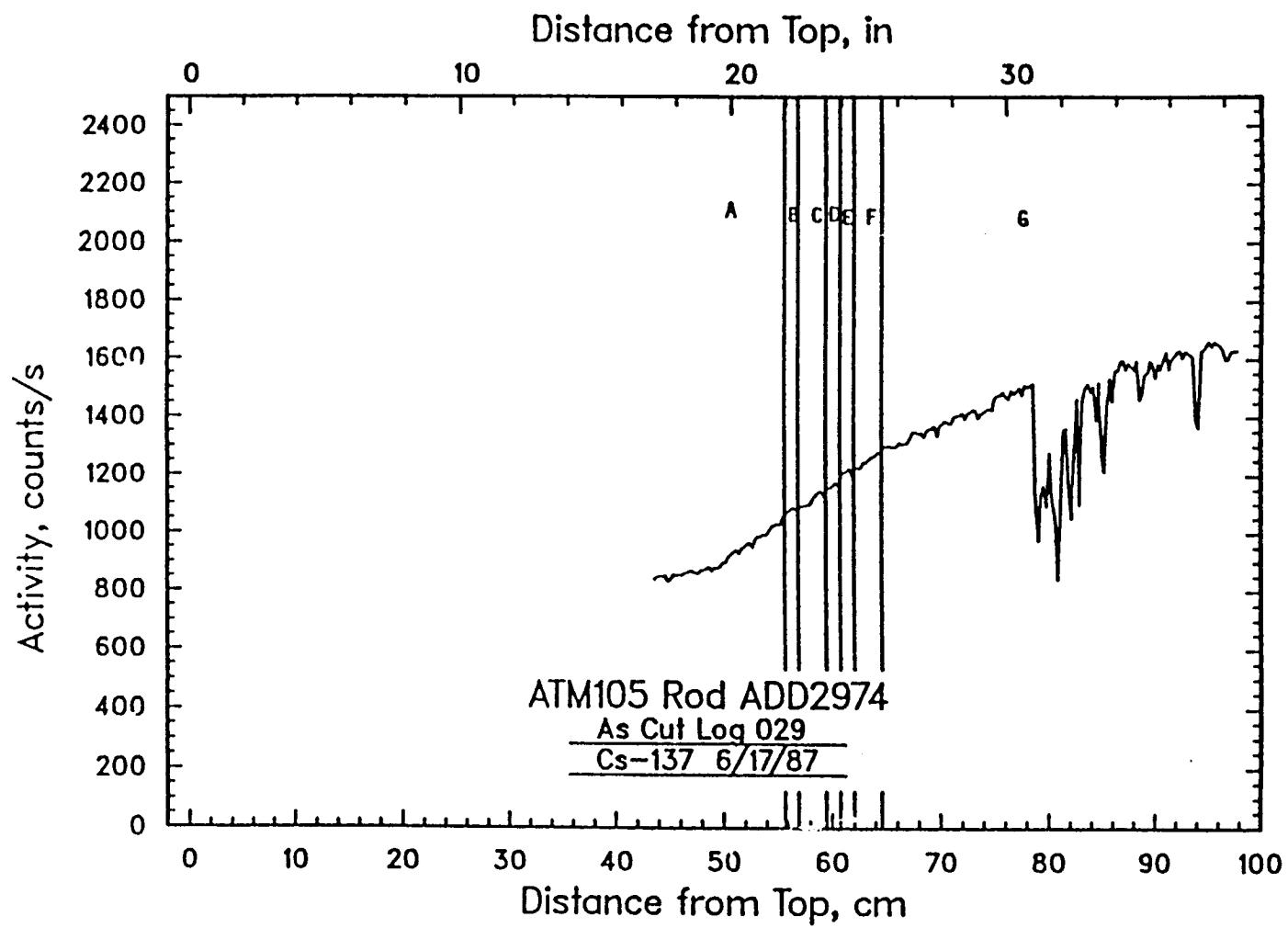


Fig. 3.3.7 As-Cut Sectioning Diagram for Rod ADD2974

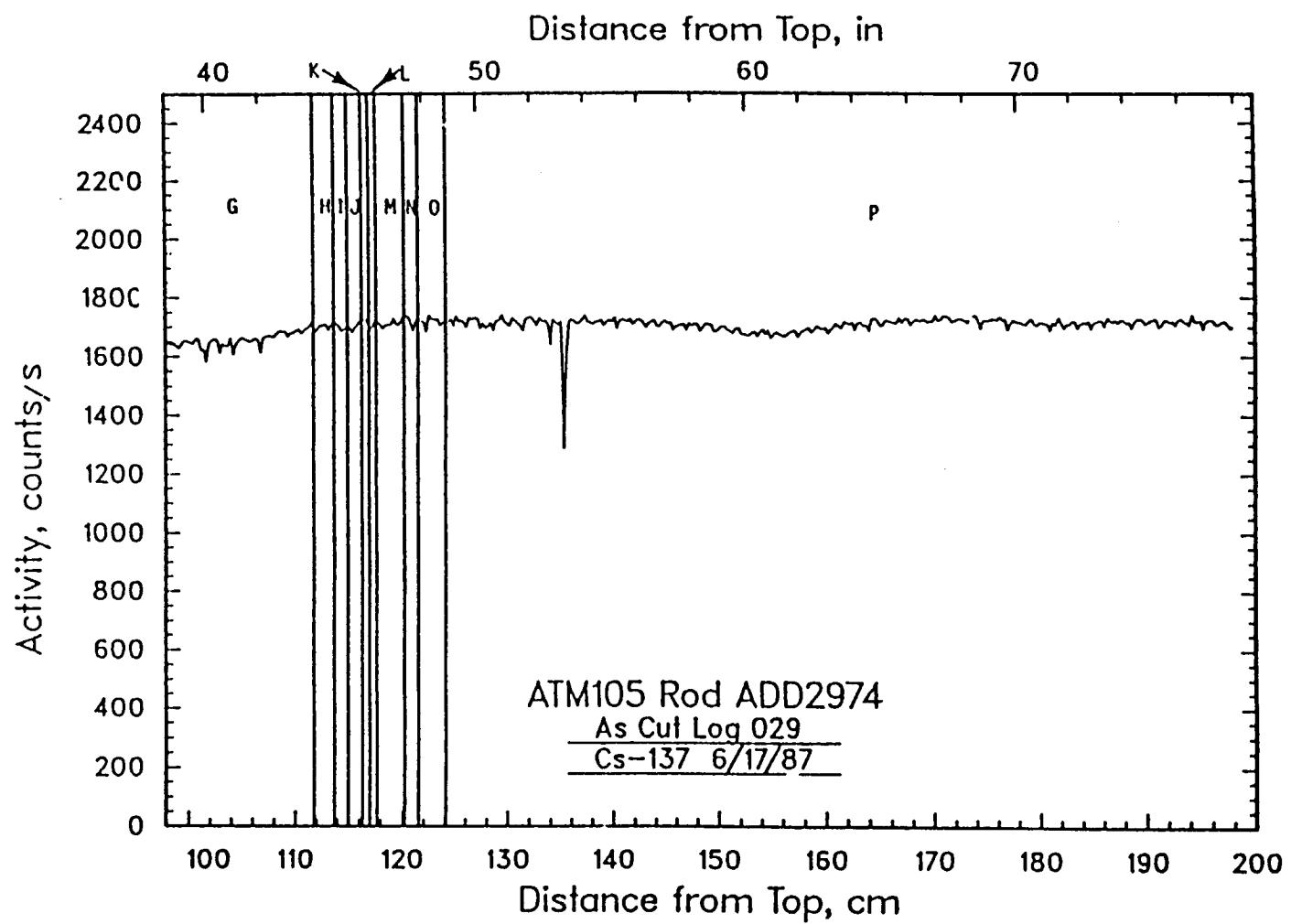


Fig. 3.3.7 As-Cut Sectioning Diagram for Rod ADD2974 (contd)

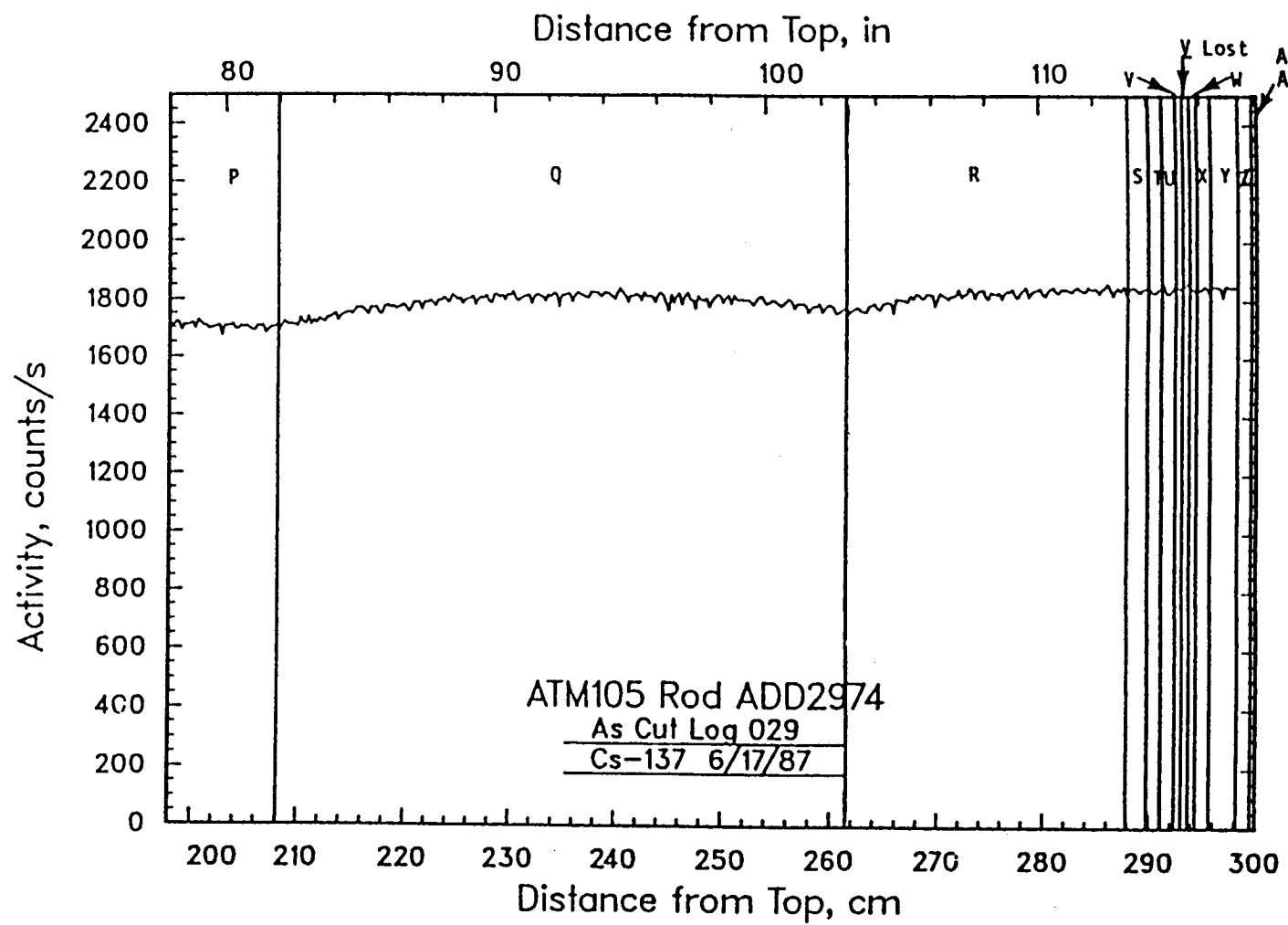


Fig. 3.3.7 As-Cut Sectioning Diagram for Rod ADD2974 (contd)

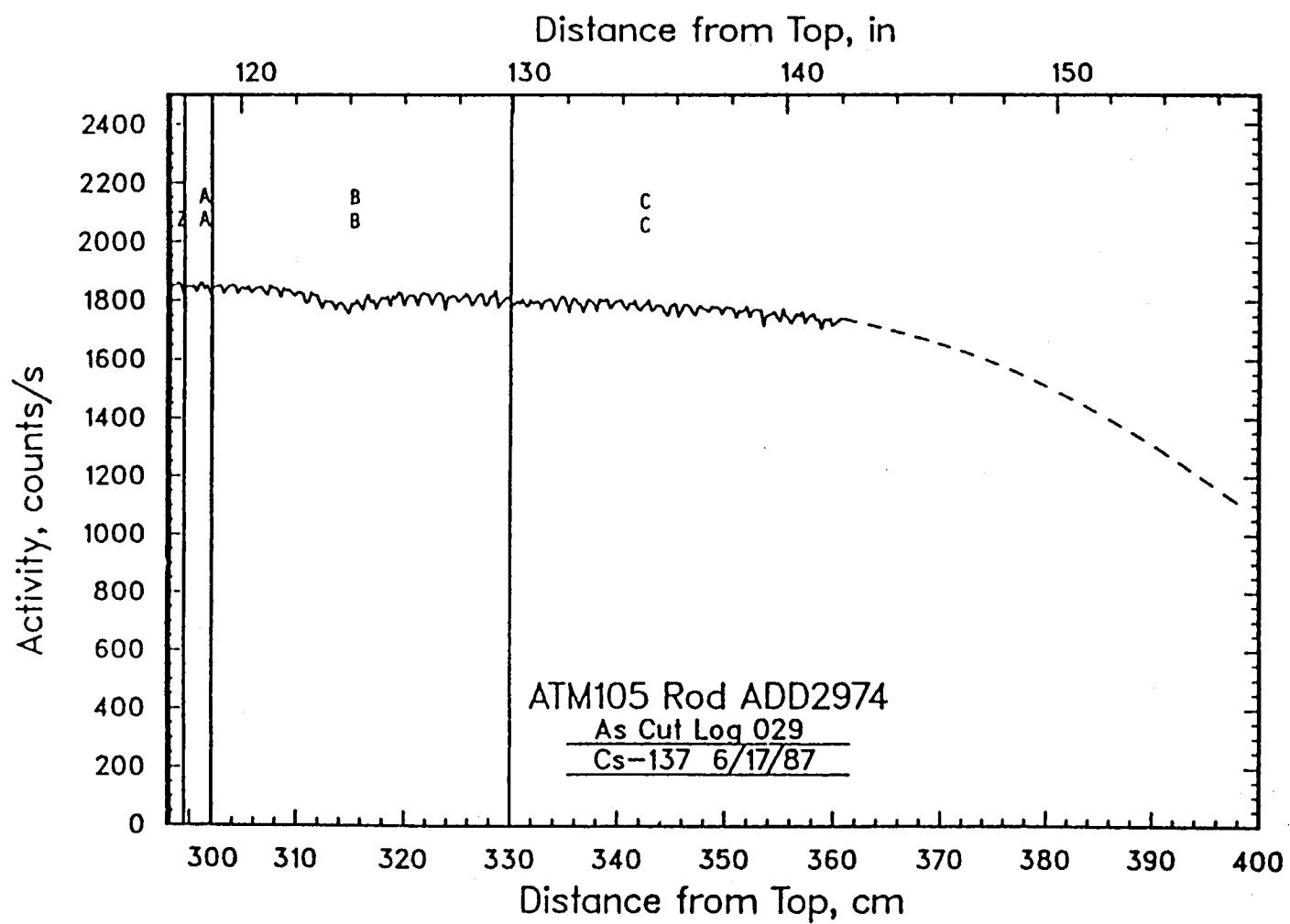


Fig. 3.3.7 As-Cut Sectioning Diagram for Rod ADD2974 (contd)

3.4 Fukushima-Daiichi-3 Reactor (BWR)

This isotopic composition measurements were performed as one of the post irradiation test of BWR fuel assemblies performed by Nuclear Fuel Developement(NFD) and conducted by the Nuclear Power Engineering Center(NUPEC).

The tables and figures in this section were reprinted from the following informaion.

7) M. Kitamura, Private Comunication "Post irradiation test of BWR fuel assemblies", 1996.

3.4.1 Core configuration and performance

The Fukushima-Daiichi-3 reactor is the BWR in Japan. The assemblies have 8 x 8 rod array.

The fuel rod specifications are shown in Table 3.4.1.

3.4.2 Irradiation history and samples

The rod locations of the assembly are shown in Fig. 3.4.1. The sample assemblies were irradiated for 4 cycles. The reactor power history and the sample assemblies' location in the core are shown in Figs. 3.4.2, 3.4.3, 3.4.4 and 3.4.5. Also, the burnup history of the 4 assemblies is shown in Table 3.4.2.

3.4.3 Isotopic composition data

The number of assay samples are 36(samples are named BU-1 to BU-36).

The measured burnup of BU-1 to BU-20 are shown in Table 3.4.3 and Table 3.4.4, Table 3.4.5 and Table 3.4.6.. The burnup was measured by two methods; Nd-148 basis method and U, Pu isotope basis method. The burnup of BU-21 to BU-36 samples were measured by the Nd-148 basis method, and they are shown in Table 3.4.7 and Table 3.4.8. The unit of these burnup data is %fission per initial heavy metal atoms. However, there is only a unit of MWd/t as a unit of burnup in the SFCOMPO databse. Then, the following equation is used for the unit transformation.

$$\text{Burnup(MWd/t)} = \text{Burnup}(\%FIMA) \times 9600(\text{MWd/t}/\%FIMA)$$

The U isotopic composition data are shown in Table 3.4.9, Table 3.4.10, Table 3.4.11 and Table 3.4.12. The Pu isotopic composition data is shown in Table 3.4.13.

Table 3.4.1 The Specification of Sample Fuel Pellet

Assembly	Fuel Rod	Enrichment	Pellet	Clad Lot.
F 3 A 5	A - 1	1.45 %	AEGGX301	01-30
	C - 3	3.01 %	AEGGL012	01-30
	G - 7	3.01 %	AEGG4024	01-30
F 3 A 8	A - 1	1.45 %	AEGGX301	02-5293
	C - 3	3.01 %	AEGGL013	02-5293
	G - 7	3.01 %	AEGG4024	02-5292
F 3 A 1	A - 1	1.45 %	AEGGX301	01-30
	C - 3	3.01 %	AEGGL012	01-30
	G - 7	3.01 %	AEGG4024	01-30
F 3 A 6	A - 1	1.45 %	AEGGX301	02-5293
F 3 A 7	A - 1	1.45 %	AEGGX301	01-30
	C - 3	3.01 %	AEGGL012	01-30
	G - 7	3.01 %	AEGG4024	01-31
F 3 A 3	A - 1	1.45 %	AEGGX301	02-5293
	H - 1	1.87 %	AEGGV101	02-5293
	G - 7	3.01 %	AEGG4024	02-5293
F 3 A 9	H - 1	1.87 %	AEGGV101	01-31
	C - 3	3.01 %	AEGGL012	01-30

Table 3.4.2 The Burnup History of the Sample Fuel Asemblies

Assembly	1st Cycle	2nd Cycle	3rd Cycle	4th Cycle
F3A5	5800 MWd/t	-----	-----	-----
F3A8	6100	-----	-----	-----
F3A1	5400	14500MWd/t	-----	-----
F3A6	5800	13800	-----	-----
F3A7	5600	14300	21300MWd/t	-----
F3A3	5500	14000	21100	28600MWd/t
F3A9	5600	14300	20300	26100
F3A2	5700	13900	20300	27100
F3A4	5800	13300	19000	25900
F3A10	5600	15000	21000	28000

Table 3.4.3 Axial Locations of Fuel Samples
(Distance from the bottom end of the effective fuel)

Effective Fuel Length = 365.0 cm

Sample No.	Position(cm)	Sample No.	Position(cm)
BU - 1	277.4	BU - 21	269.9
BU - 2	80.4	BU - 22	336.9
BU - 3	277.4	BU - 23	245.0
BU - 4	79.9	BU - 24	81.6
BU - 5	145.0	BU - 25	177.7
BU - 6	81.6	BU - 26	46.0
BU - 7	235.0	BU - 27	288.0
BU - 8	86.1	BU - 28	178.4
BU - 9	271.2	BU - 29	267.4
BU - 10	71.6	BU - 30	172.6
BU - 11	177.9	BU - 31	272.4
BU - 12	45.0	BU - 32	72.8
BU - 13	246.4	BU - 33	276.8
BU - 14	292.6	BU - 34	108.5
BU - 15	269.3	BU - 35	276.3
BU - 16	60.7	BU - 36	120.0
BU - 17	163.0		
BU - 18	288.3		
BU - 19	229.0		
BU - 20	77.6		

Table 3.4.4 The Burnup of BU-1 to BU-12 Samples by U,Pu Basis.

Sample No.	Burnup(atomic % U-235.)
BU- 1	0. 5 1 0
BU- 2	0. 6 3 7
BU- 3	0. 4 9 7
BU- 4	0. 6 7 9
BU- 5	0. 3 6 2
BU- 6	0. 4 8 5
BU- 7	0. 4 3 4
BU- 8	0. 5 6 2
BU- 9	0. 4 2 8
BU-1 0	0. 6 8 3
BU-1 1	0. 3 5 3
BU-1 2	0. 5 0 7

Table 3.4.5 The Burnup of BU-1 to BU-12 Samples by Nd-148 Basis.

Sample No.	Burnup(atomic % U-235.)
BU- 1	0. 6 4 1
BU- 2	0. 8 2 5
BU- 3	0. 6 0 9
BU- 4	0. 7 7 5
BU- 5	0. 4 4 2
BU- 6	0. 5 8 2
BU- 7	0. 5 4 7
BU- 8	0. 7 1 5
BU- 9	0. 5 2 5
BU-1 0	0. 7 4 9
BU-1 1	0. 4 3 1
BU-1 2	0. 5 9 9

Table 3.4.6 The Burnup of BU-13 to BU-20 Samples by U,Pu Basis.

Assembly	Fuel Rod	Sample	Burnup(atomic % U-235.)
F 3 A 1	AEAX 2A02M	BU-13	0.931
		BU-14	0.883
	AEAL 2C01M	BU-15	1.10
		BU-16	1.09
	AEE4 4A03M	BU-17	1.04
		BU-18	1.07
	AEAX 4A03M	BU-19	0.924
		BU-20	0.965
F 3 A 6			

Table 3.4.7 The Burnup of BU-13 to BU-20 Samples by Nd-148 Basis.

Assembly	Fuel Rod	Sample	Burnup(atomic % U-235.)
F 3 A 1	AEAX 2A02M	BU-13	2.00
		BU-14	1.64
	AEAL 2C01M	BU-15	1.66
		BU-16	1.53
	AEE4 4A03M	BU-17	1.45
		BU-18	1.52
	AEAX 4A03M	BU-19	1.89
		BU-20	1.83
F 3 A 6			

Table 3.4.8 The Burnup of BU-21 to BU-26 Samples
by Nd-148 Basis.

Assembly	Fuel Rod	Sample	Burnup(atomic % U-235.)
F3A7	AEAX2A05M	BU-21	2.54
		BU-22	2.69
	AEAL2C04M	BU-23	1.93
		BU-24	2.28
	AEE44A10M	BU-25	2.12
		BU-26	2.29

Table 3.4.9 The Burnup of BU-27 to BU-36 Samples
by Nd-148Basis

Assembly	Fuel Rod	Sample	Burnup(atomic % U-235.)
F3A3	AEAX 4A01M (A1)	BU-27	3.50
		BU-28	3.07
	AEE4 7A03M (G7)	BU-29	2.86
		BU-30	2.93
	AEAV 5A02M (H1)	BU-33	3.38
		BU-34	3.22
F3A9	AEAL 2C05M (C3)	BU-31	2.76
		BU-32	2.86
	AEAV 3A11M (H1)	BU-35	3.26
		BU-36	3.28

Table 3.4.10 U Isotopic Ratio of BU-1 to BU-12 Samples

Fuel Rod No.	Sample No.	Isotopic Ratio(atOMIC %)			
		^{234}U	^{235}U	^{236}U	^{238}U
AEAX 2A03M	BU-1	0.009	0.871	0.097	99.023
	BU-2	0.009	0.715	0.127	99.149
AEAL 2C02M	BU-3	0.022	2.443	0.123	97.412
	BU-4	0.023	2.233	0.153	97.591
AEE4 4A05M	BU-5	0.023	2.608	0.111	97.258
	BU-6	0.023	2.468	0.132	97.377
AEAX 4A04M	BU-7	0.009	0.958	0.086	98.947
	BU-8	0.009	0.808	0.108	99.075
AEAL 5D06M	BU-9	0.024	2.528	0.104	97.344
	BU-10	0.023	2.242	0.140	97.595
AEE4 7A09M	BU-11	0.023	2.618	0.109	97.250
	BU-12	0.023	2.443	0.134	97.400

Table 3.4.11 U Isotopic Ratio of BU-13 to BU-20 Samples

Assembly	Fuel Rod No.	Sample No.	Isotopic Ratio(atomic %)			
			^{234}U	^{235}U	^{236}U	^{238}U
F 3 A 1	AEAX-2A02M	BU-13	0.010	0.359	0.187	99.444
		BU-14	0.009	0.421	0.174	99.396
	AEAL-2C01M	BU-15	0.026	1.701	0.265	98.008
		BU-16	0.027	1.720	0.254	97.999
	AEE4-4A03M	BU-17	0.026	1.806	0.247	97.921
		BU-18	0.026	1.763	0.258	97.953
F 3 A 6	AEAX-4A03M	BU-19	0.008	0.382	0.172	99.438
		BU-20	0.008	0.329	0.183	99.480

Table 3.4.12 U Isotopic Ratio of BU-21 to BU-26 Samples

Fuel Rod No.	Sample No.	Isotopic Ratio(atomic %)			
		^{234}U	^{235}U	^{236}U	^{238}U
AEAX-2A05M	BU-21	0.007	0.218	0.201	99.574
	BU-22	0.007	0.127	0.210	99.656
AEAL-2C04M	BU-23	0.019	1.318	0.307	98.356
	BU-24	0.018	1.036	0.282	98.664
AEE4-4A10M	BU-25	0.018	1.385	0.321	98.276
	BU-26	0.018	1.244	0.325	98.413

Table 3.4.13 U Isotopic Ratio of BU-27 to BU-36 Samples

Fuel Rod No.	Sample No.	Isotopic Ratio(atomic %)			
		^{234}U	^{235}U	^{236}U	^{238}U
AEAX4A01M (A 1)	BU-27	0.006	0.080	0.240	99.674
	BU-28	0.006	0.110	0.212	99.672
AEE47A03M (G 7)	BU-29	0.020	1.022	0.340	98.618
	BU-30	0.020	0.987	0.335	98.656
AEAV5A02M (H 1)	BU-33	0.013	0.190	0.260	99.537
	BU-34	0.013	0.211	0.274	99.502

Fuel Rod No.	Sample No.	Isotopic Ratio(atomic %)			
		^{234}U	^{235}U	^{236}U	^{238}U
AEAL2C05M (C 3)	BU-31	0.019	1.001	0.338	98.642
	BU-32	0.020	0.926	0.351	98.703
AEAV3A11M (H 1)	BU-35	0.013	0.202	0.270	99.515
	BU-36	0.014	0.199	0.268	99.519

Table 3.4.14 Pu Isotopic Ratio of Some Samples

Fuel Rod No.	Sample No.	Isotopic Ratio(atomic %)			
		^{239}Pu	^{240}Pu	^{241}Pu	^{242}Pu
AEAX4A01M (A 1)	BU-27	4 3	3 3	1 2	1 2
	BU-28	4 5	3 2	1 3	1 0
AEE47A03M (G 7)	BU-29	5 3	2 9	1 2	6
	BU-30	5 3	2 9	1 2	6
AEAV5A02M (H 1)	BU-33	4 6	3 0	1 3	1 1
	BU-34	4 7	3 0	1 3	1 0

Fuel Rod No.	Sample No.	Isotopic Ratio(atomic %)			
		^{239}Pu	^{240}Pu	^{241}Pu	^{242}Pu
AEAL2C05M (C 3)	BU-31	5 3	2 9	1 2	6
	BU-32	5 3	2 9	1 2	6
AEAV3A11M (H 1)	BU-35	4 7	3 0	1 3	1 0
	BU-36	4 7	3 0	1 3	1 0

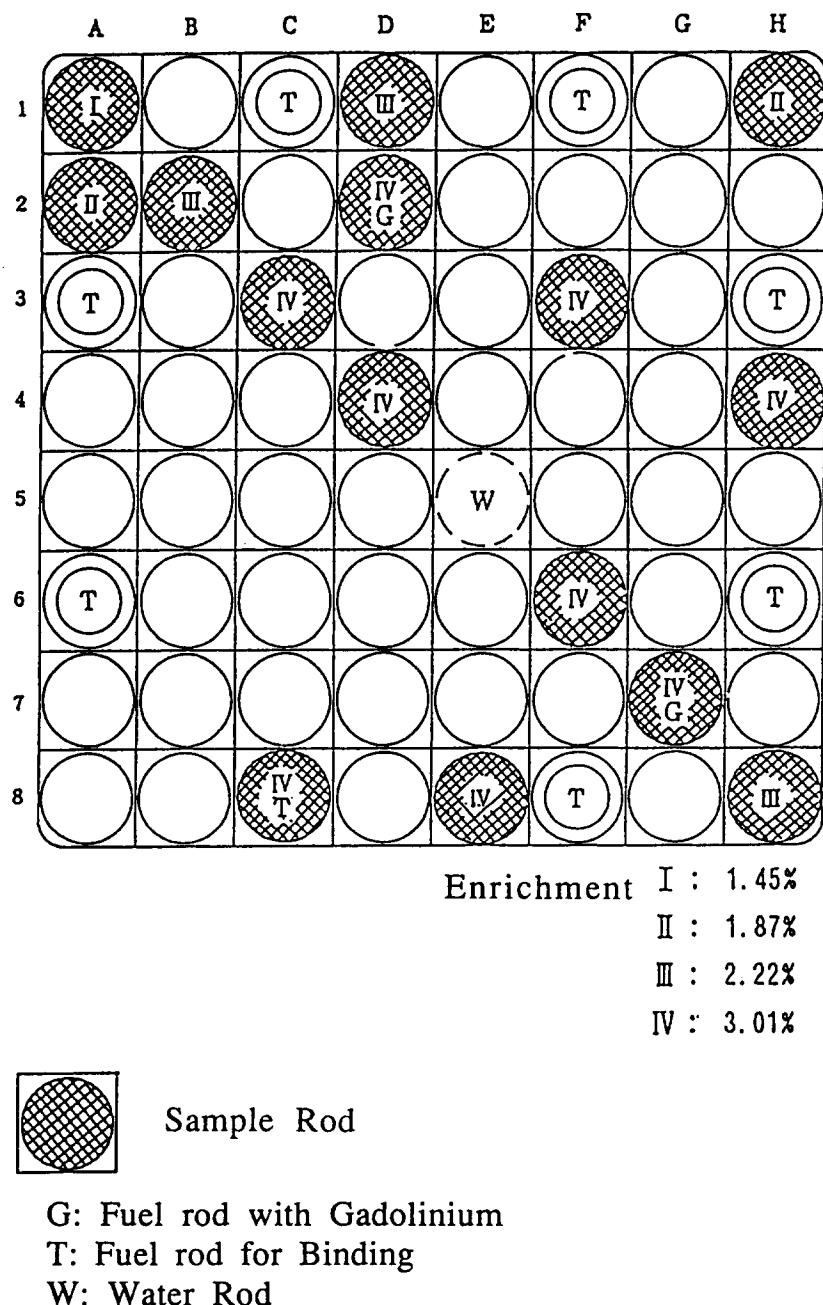


Fig. 3.4.1 The Rod Location of the Sample Assemblies

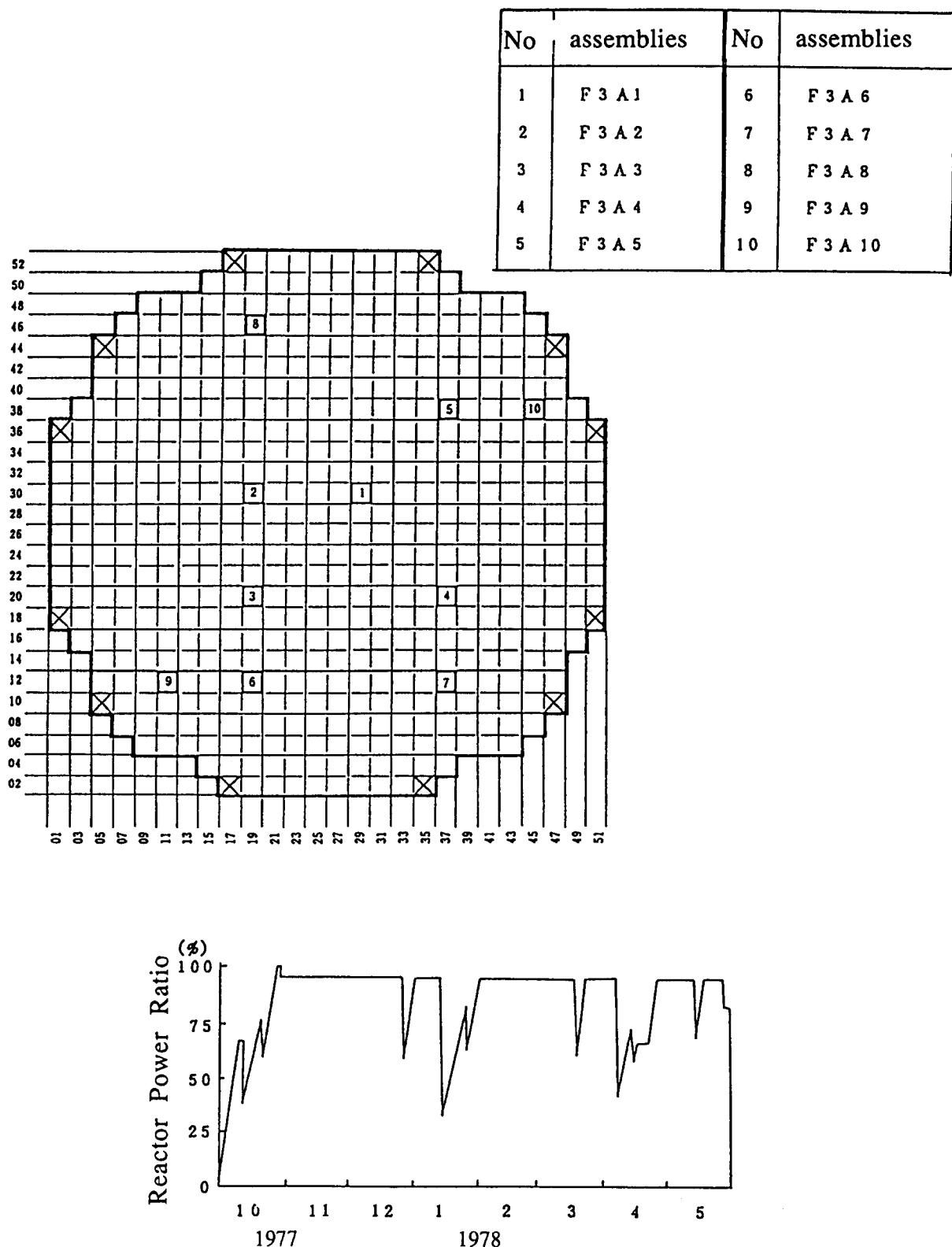


Fig. 3.4.2 The Reactor Power History and the assembly locations (cycle 1)

No	assemblies	No	assemblies
1	F 3 A 1	6	F 3 A 6
2	F 3 A 2	7	F 3 A 7
3	F 3 A 3	9	F 3 A 9
4	F 3 A 4	10	F 3 A 10

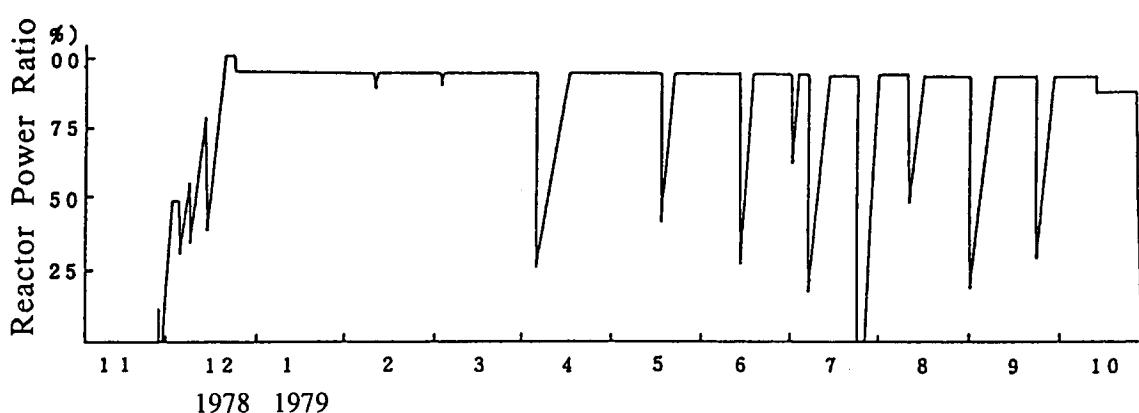
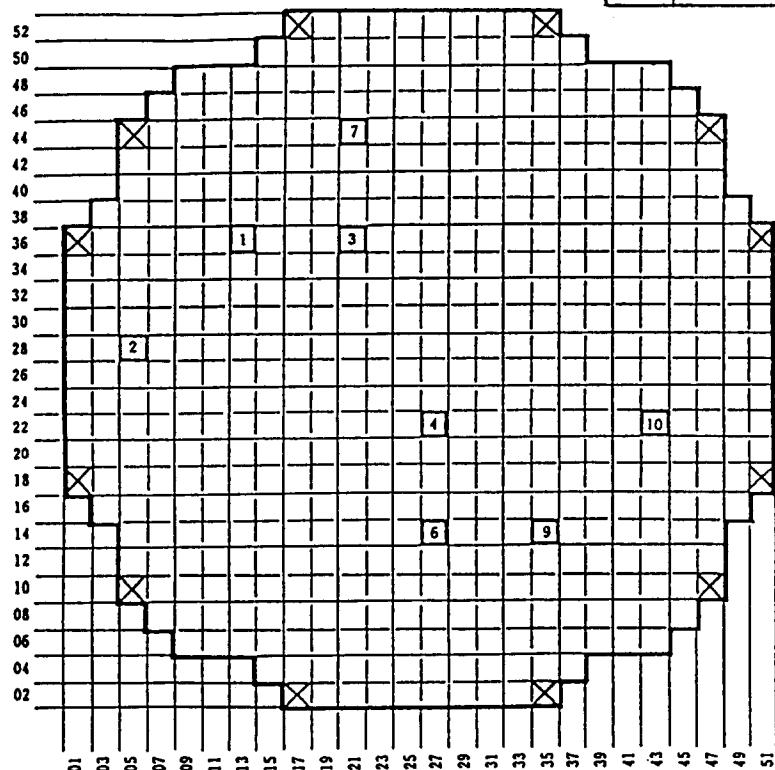


Fig. 3.4.3 The Reactor Power History and the assembly locations (cycle 2)

No	assemblies	No	assemblies
2	F 3 A 2	7	F 3 A 7
3	F 3 A 3	9	F 3 A 9
4	F 3 A 4	10	F 3 A 10

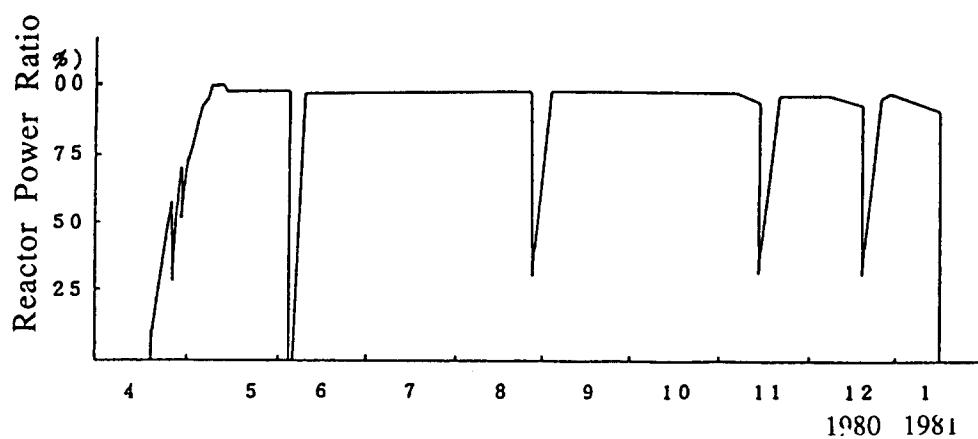
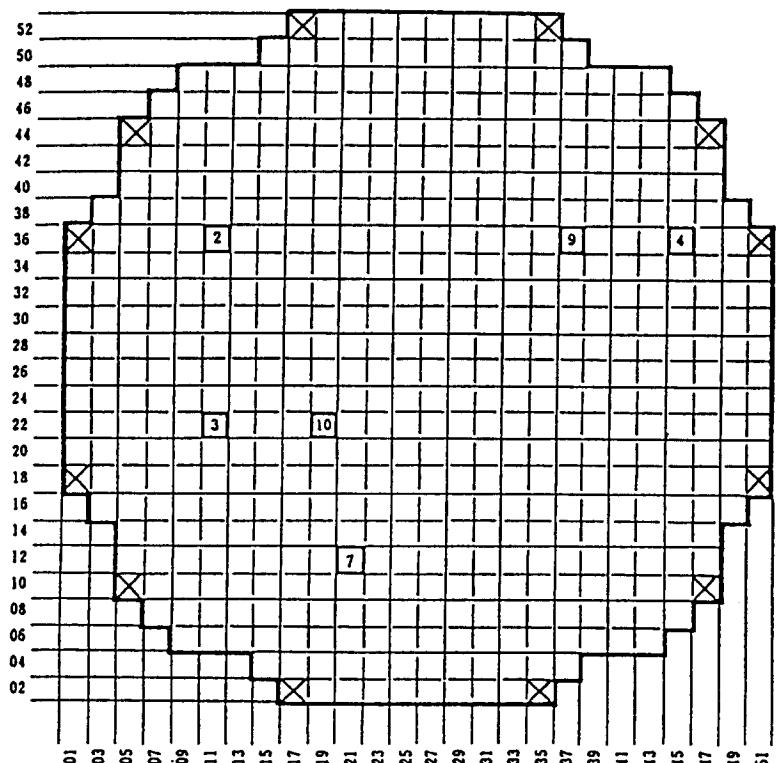


Fig. 3.4.4 The Reactor Power History and the assembly locations
(cycle 3)

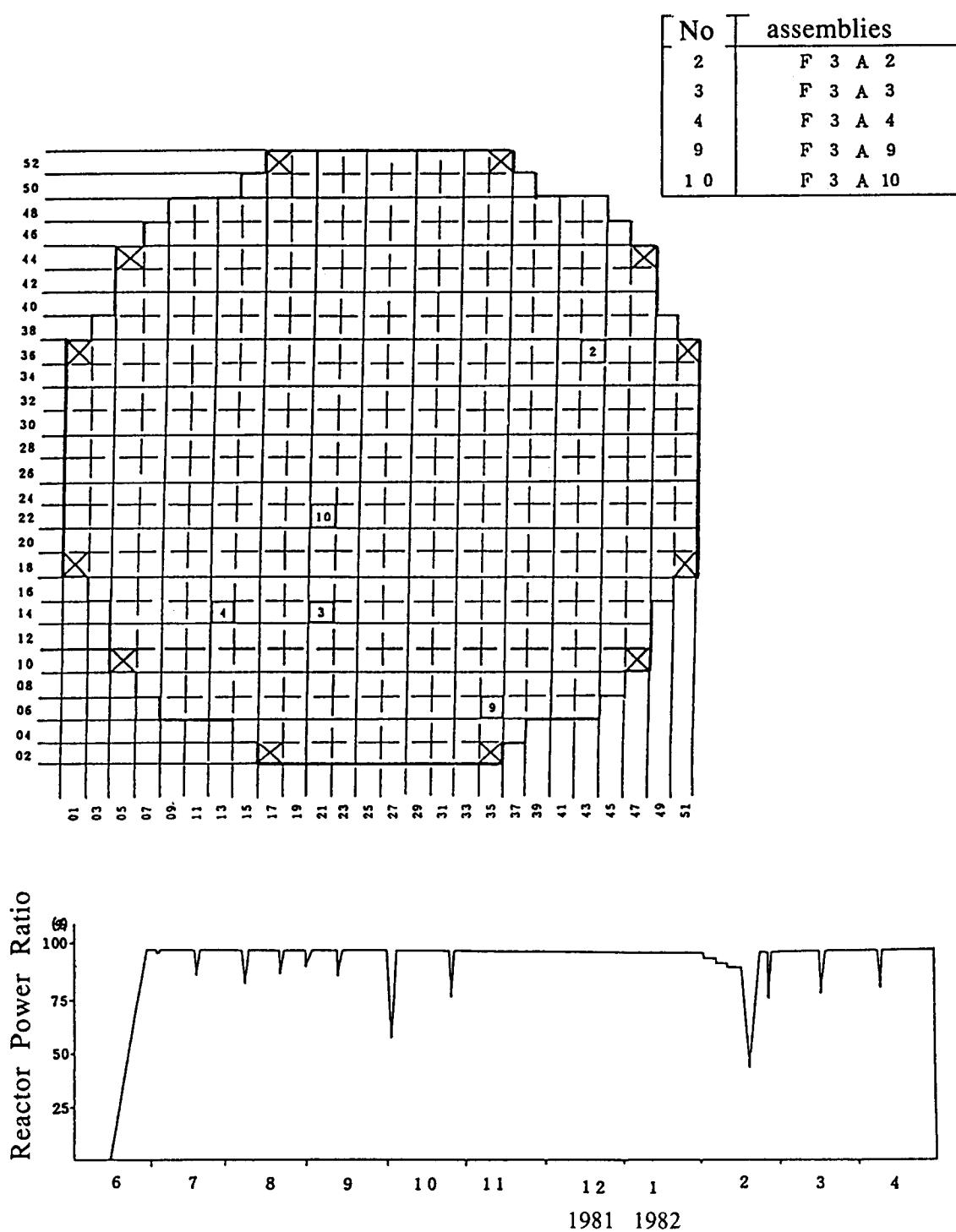


Fig. 3.4.5 The Reactor Power History and the assembly locations
(cycle 4)

4. Burnup Profile Data(axial gamma activity profile data)

In this chapter, the measured axial gamma activity profile data of the spent fuel rods from the following 2 reactors are described.

Tsuruga-1 Reactor(BWR, Japan)

Genkai-1 Reactor(PWR, Japan)

These measurements of axial gamma activity profile were performed as the post-irradiation examinations of BWR Tsuruga-1 fuels conducted by Japan Atomic Power Co., and PWR Genkai-1 fuels conducted by Kyusyu Electric Power Co..

The gamma activity profile strongly depends on the burnup profile of the spent fuel rod. Therefore, we use these data as the index of the burnup profile.

4.1 Core configuration and irradiation history

The Tsuruga-1 reactor is the 357 MWe BWR located at Tsuruga city in Fukui prefecture. The core consists of assemblies of 7 x 7 rods. The Genkai -1 reactor is the PWR with the power of 560 MWe. The fuel assembly consists of 14x14 rods. The details of these core configurations and histories are described in the report of JAERI-M 94-034.

4.2 Burnup(Axial gamma activity) profile data

The Cs-134, Cs-137, Eu-154 gamma and total gamma activity are stored. in two forms of gamma-ray counts/unit length of rod and the relative value in SFCOMPO. SFCOMPO has the function that the burnup profile can be obtained by multiplying the relative values times for the rod average burnup. The stored data contents are shown in Table 4.1.

Table 4.1 The Burnup(Axial Gamma Activity) Profile Data Contents

Reactor Name	Assembly Name	Rod Pos.	Gamma-ray Data
Genkai-1	C33	E11	Cs-134,137,Eu-154,Total
		N1	Cs-137, Total
		N10	Cs-137, Total
Tsuruga-1	JAB-73	A1	Cs-134,137,Eu-154
		C3	C3-134137,EU-154

5. Users Manual of the Database SFCOMPO

5.1 System install and startup

5.1.1 System install

1) System structure

This system consists of the following files.

Startup Command Files	: RBASE.DAT
Application Files	: Identification Index=CMD, APL
Menu Files	: Identification Index=MNU
Database Files	: Identification Index=RBF

These files are contained on a floppy disk to be delivered as the database SFCOMPO, except for the database files. The floppy disk includes a SFCOMPO.UNL instead of the database files. The database files are generated from the SFCOMPO.UNL as described in the Section 5.4.

2) Install the database system

The database SFCOMPO requires the RBASE system ad IBM/PC-AT computer(COMPAC, etc.). First, install the RBASE system in your IBM/PC-AT COMPAC computer. And, install the BASE.DATA in the same directory as that of the RBASE system. hen, generate a SFCOMPO as the just under directory, and install the application files and the menu files. Therefore, after a startup of the SFCOMPO system, the current directory is (RBASE system directory)\$SFCOMPO. In the case of this section, it is named RBFLES\$SFCOMPO.

3) Generations of database files(SFCOMPO*. RBF)

At the DOS prompt in the directory D:\$RBFLES\$SFCOMPO, key in RBASE-C using half characters. After loading the RBASE, a RBASE prompt : R> will be seen. Then, key in RESTORE A:\$SFCOMPO.UNL. In this case, A:\$ indicates FD drive.

By these operations, the database definition and the stored data are read from SFCOMPO.UNL on the FD, and the generations of database files and the installations of data are performed. The generated files are

SFCOMPO1.RBF
SFCOMPO2.RBF
SFCOMPO3.RBF

The searched data under the above operations are to be output in (d:\$outfile=default set). If you want to change this default set, change the characters inside of " " in the following sentence,
SET VAR defdir="d:\$outfile"

on the application file SFCOMPO.APL.

If all operations as described previously are successfully finished, the installation are completed.

5.1.2 Startup and terminating of the database: SFCOMPO

1) Startup

PC and printer : power ON.

Set current directory to D:\$RBFIES.

Key in RBASE(in half size characters) following the DOS prompt.
Then, the following messages appear on the display.

<<SFCOMPO DATABASE SYSTEM>>

- (1) Search and Output
- (2) DB Maintenance
- (3) Terminate

This is a first menu in SFCOMPO database. In this menu, select one out of three by keying in the number, or moving the cursor to the position on the display.

3) System terminating

When number three is selected on the first menu, the database system will be closed. In that time, data rearrangements in the database files are automatically performed to delete vacant space in the database memory.

Finally, switch OFF the PC and printer power.

5.1.3 System flow

The system operation flow is shown in Fig. 5.1.1, Fig. 5.1.2 and Fig. 5.1.3. In the flow chart, the rectangulars show operation menus, each operation menu has a number with (). And the number with () under the flow line end shows the next operation. The rectangulars with curved edges show sub-program modules described in general language. The circles show the sub-program modules using Structured Query Language(SQL) in RBASE soft.

The isotopic composition output and graphic output in the flow are fully explained in the following two sub-flows shown in Figs. 5.1.4 and 5.1.5.

The numbers in { } show the section in which the explanations are described about the operations.

5.2 Fundamental input

5.2.1 Data search operation

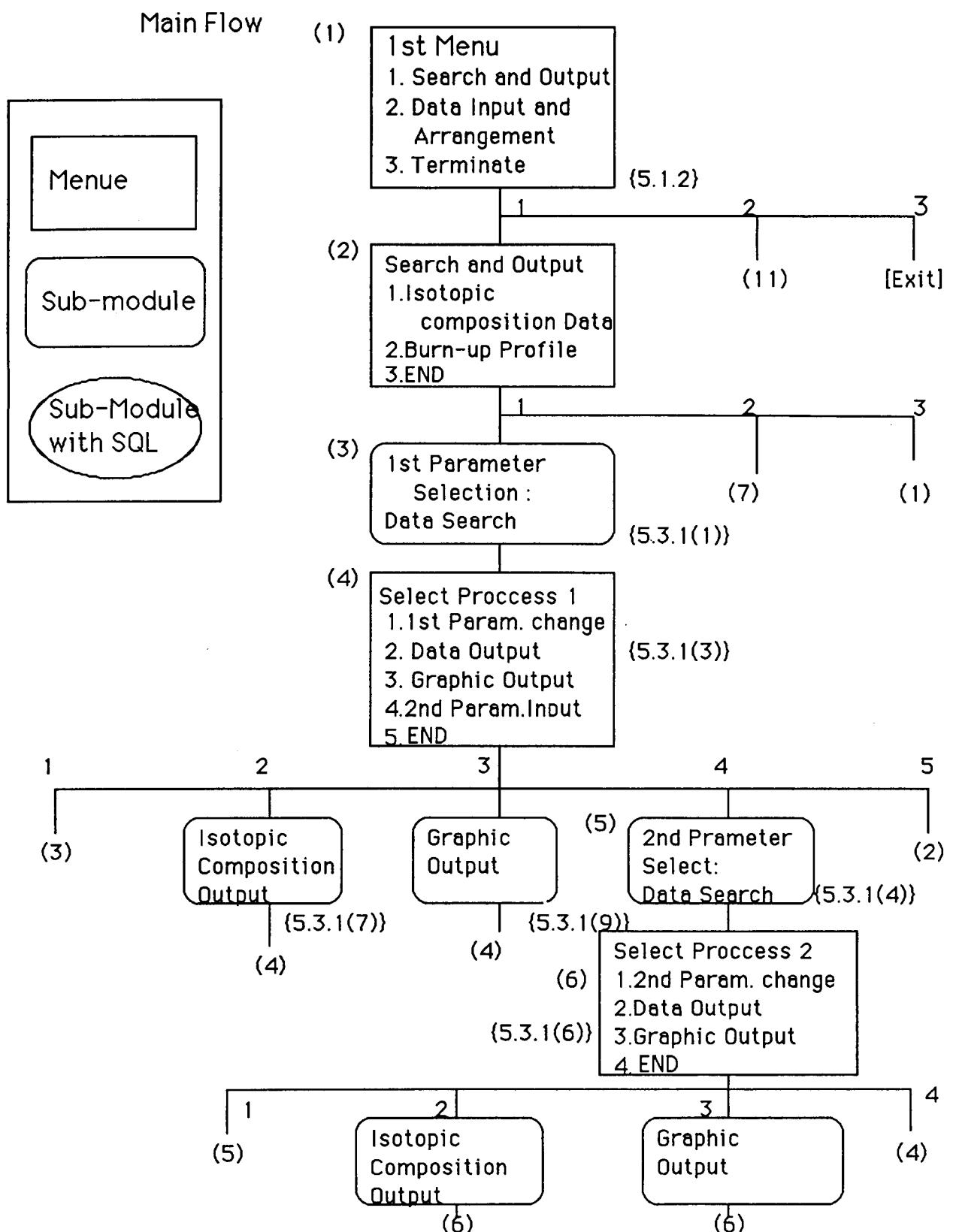


Fig. 5.1.1 System Flow (1) of the Database SFCOMPO

Burn-up Profile Data Search
(Gamma Activity Profile in Fuel Rod)

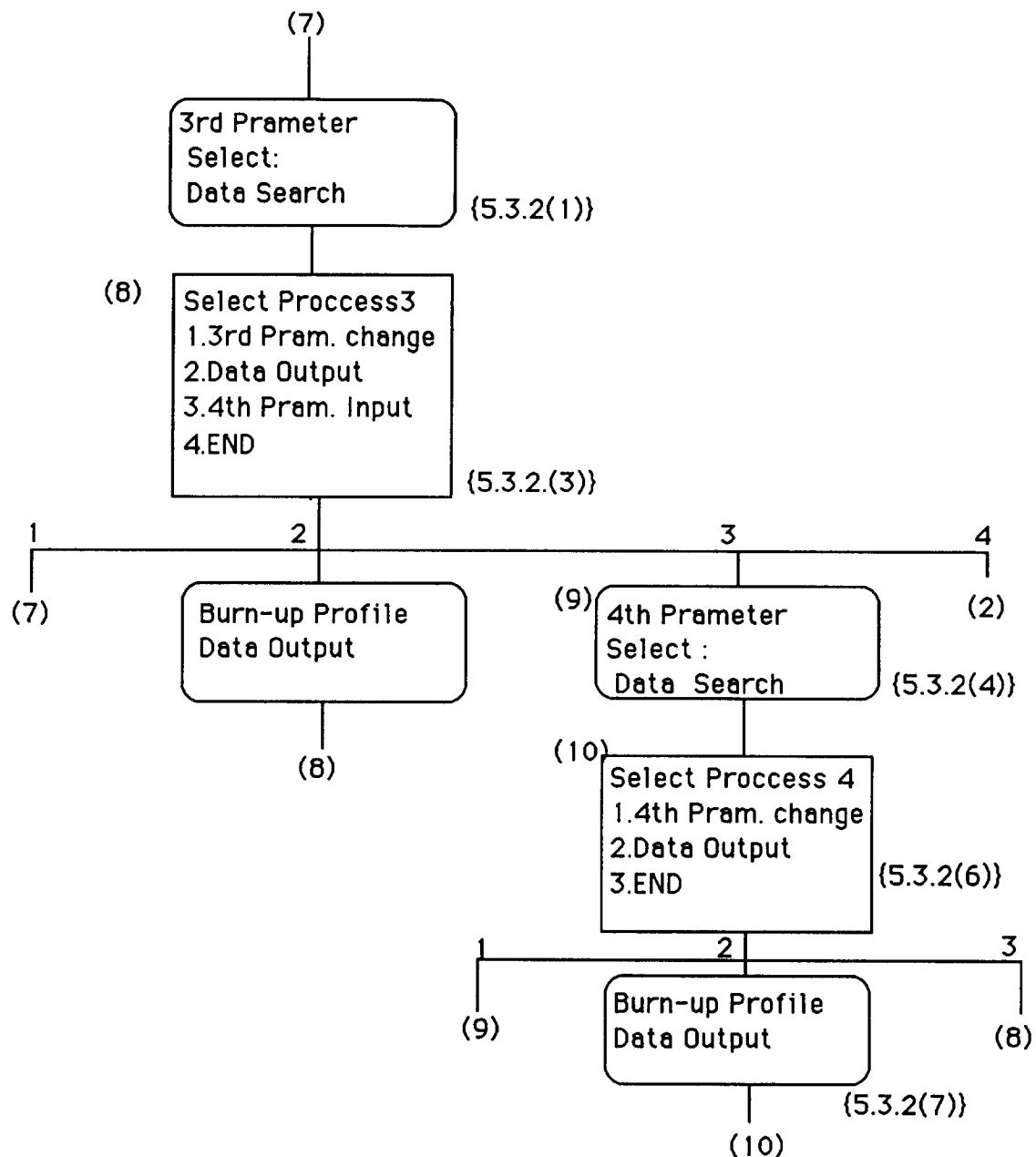


Fig. 5.1.2 System Flow(2) of the Database SFCOMPO

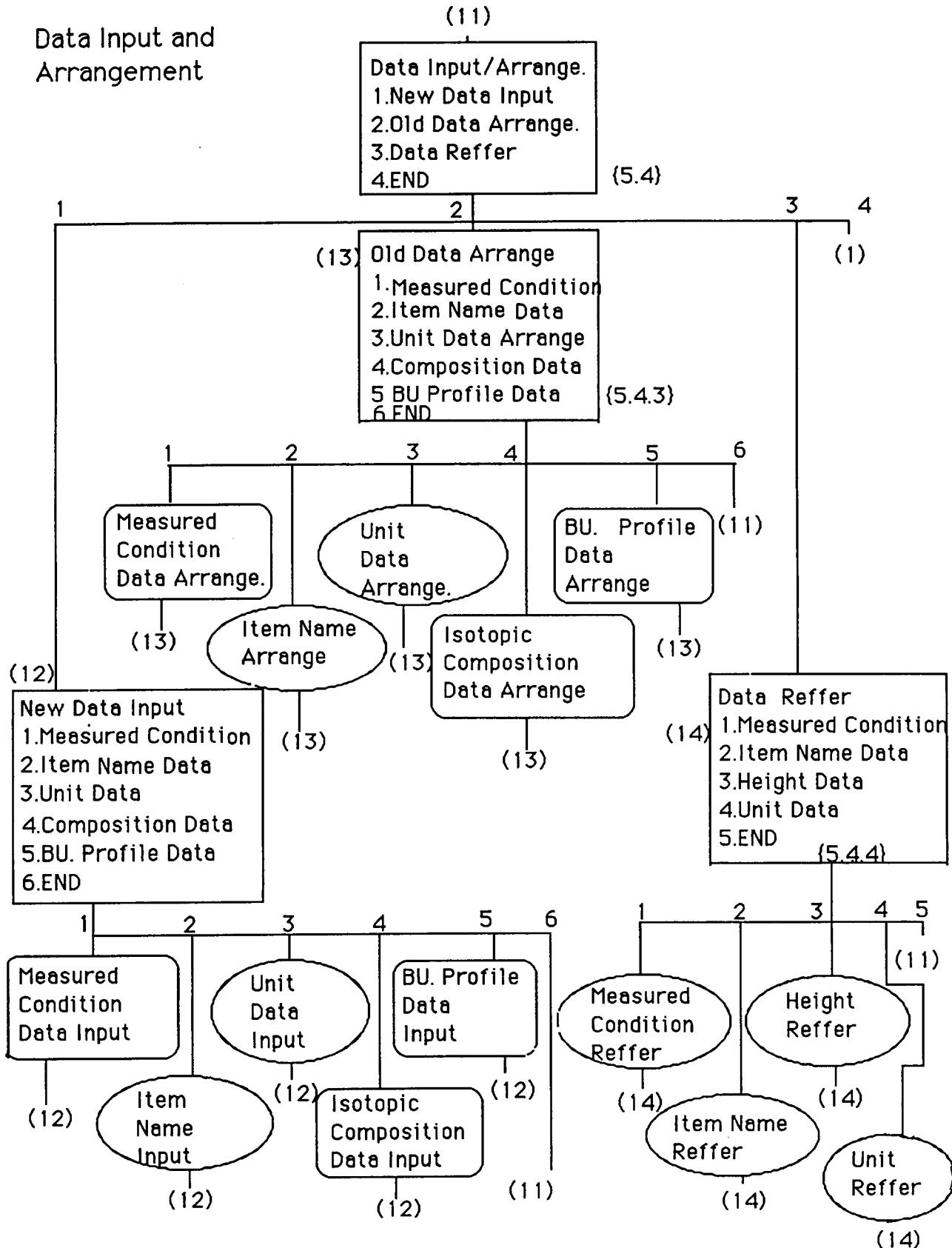


Fig. 5.1.3 System Flow(3) of the Database SFCOMPO

Isotopic Composition Data Output

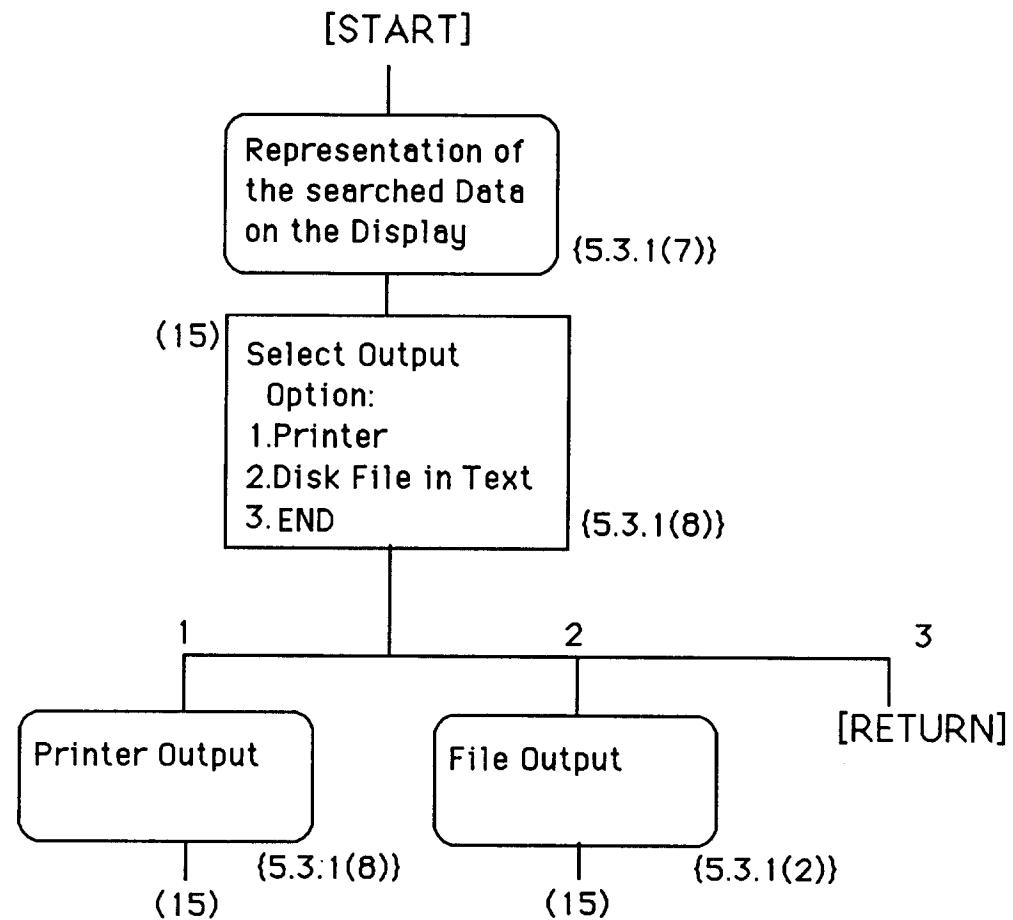


Fig. 5.1.4 System Flow(4) of the Database SFCOMPO

Burn-up Profile Data Output (Gamma Activity Data)

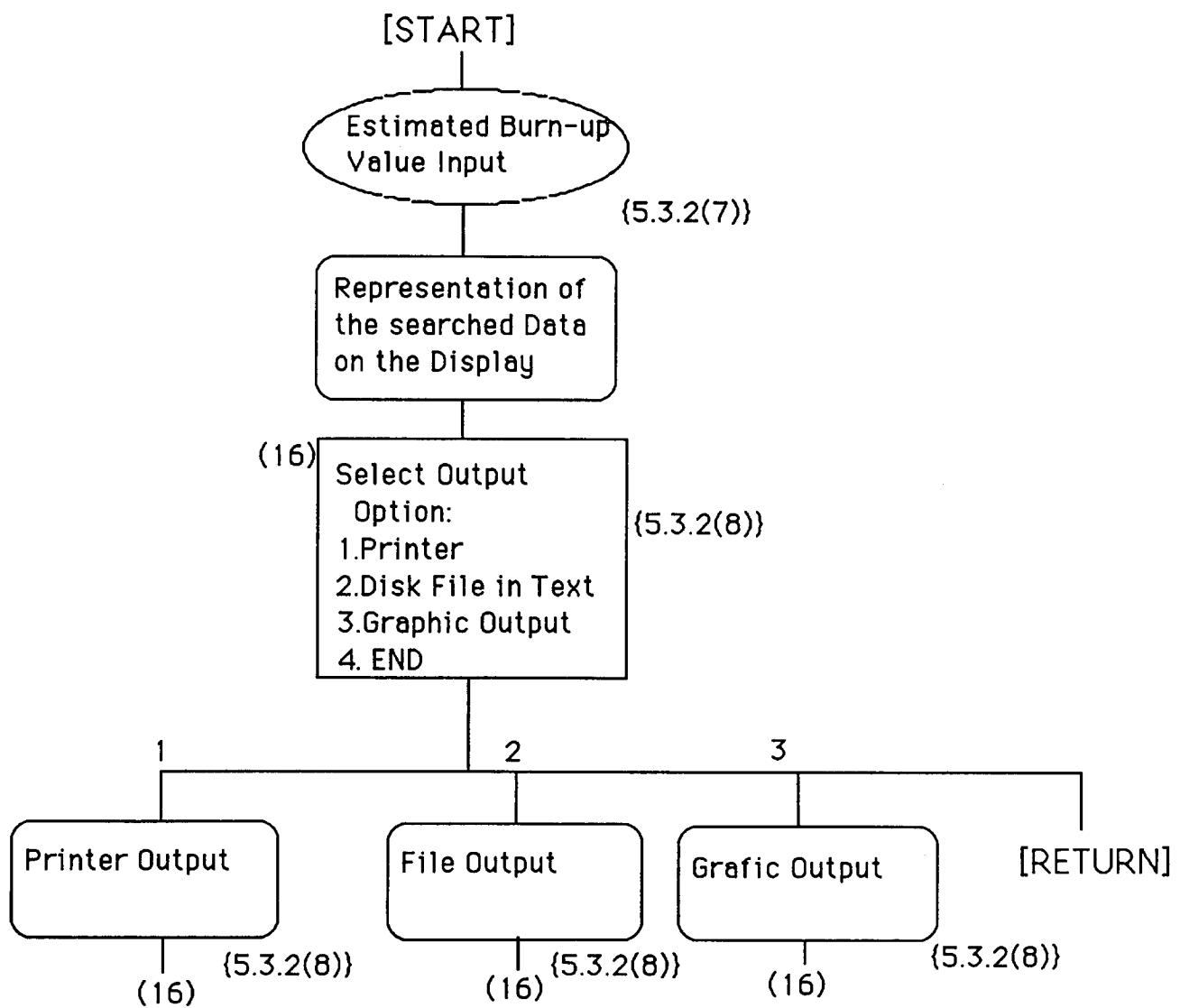


Fig. 5.1.5 System Flow(5) of the Database SFCOMPO

As described in the system flow, there are two kinds of data in the database SFCOMPO, 1)isotopic composition data and 2) Axial burnup profile data.

Data search operation is performed in two steps.

- First step 1) Isotopic composition data search 1st parameters :
 Reactor type, Initial enrichment, Sample burnup,
 Cooling time.
 2) Burnup profile data search 3rd parameters :
 Reactor type, Assembly average burnup.

- Second step 1) Isotopic composition data search 2nd parameters :
 Core name, Assembly name, Fuel rod position,
 Height ID, Measurement laboratory name.
 2) Burnup profile data search 4th parameters :
 Core name, Assembly name, Fuel rod position.

5.2.2 Selection of search area

In the case of all data search, in the first step(1st and 3rd parameters), key in " -1 " in the numeric parameters and key in "D" in the alphabetic parameters.

In the selection of search area on the parameters of initial enrichment, the burnup and cooling time, you can use band specifications indicating the maximum and minimum values with "+-".

5.2.3 Menu after the search parameter selection

After the search parameter selection, press [ESC] key, and the following menu appears at the upper side of the display.

< Edit Go to Exit >

Selection on the term on the menu is performed by moving cursol to the position and pressing [RETURN] key. Each term means the following function.

- 1) Edit: Select one out of two in the following pull down menu
 <Discard row> Go back to the parameter menu without changing parameters.

 <Save changes> Save the selected parameters.

- 2) Go to (no effect)
3) Exit : Go back to the first menu.

5.3 Search and output operations

After starting up the SFCOMPO, the 1st menu appears on the display as shown in Fig. 5.3.1.

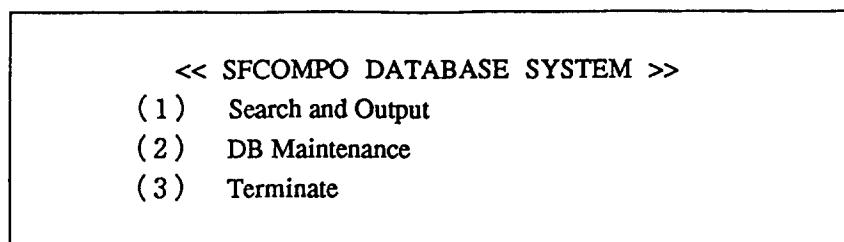


Fig. 5.3.1 The 1st menu of the database SFCOMPO

In this menu, select (1) Search and Output, and the 2nd menu appears as shown in Fig. 5.3.2.

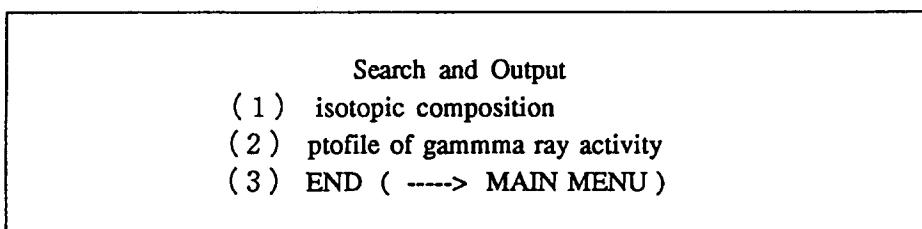


Fig. 5.3.2 Search and Output Menu

In the menu, select the data to be searched, (1)Isotopic composition data or (2)Burnup profile(Gamma activity profile) data. Then, by selecting (3) END, you are able to return to the 1st menu.

5.3.1 Search and output of the isotopic composition data

(1) The 1st search parameter input

By selecting (1) isotopic composition on the menu, the search and output process of the isotopic composition data starts, and the 1st search parameters menu appears as shown in Fig. 5.3.3.

Edit Go to Exit		
<< Please Input First Parameter >>		
Reactor Type	[PWR]	('BWR' or 'PWR')
Initial Enrichment [wt%]	[3.]	+- [0.1]
Burnup [GWd/tU]	[-1.]	+- [-1.]
Cooling Time [y]	[-1.]	+- [-1.]
<small>*Please use vertical cursol key to select the item *Please press [esc] key after input. And then you see the menu panel. Please select the procedure with horizontal cursor key, and press [return] key. *The character 'D' for reactor type means all types(i.e. BWR and PWR). The value '-1' for Initial Enrichment, Burnup and Cooling Time means all values in the data base.</small>		
<small>Form: Parm1 Table: ParameterTable Field: r_type</small>		<small>Page: 1</small>

Fig. 5.3.3 The 1st search parameter menu

Identify the data to be searched by setting the 4 parameters to the appropriate values or characters.

Parameter1: Reactor Type ; PWR or BWR.

Parameter2: Initial Enrichment ;

Set it by a real number. The unit is wt%. The center value of initial enrichment to be searched is set between the left[]. The band width of initial enrichment to be searched is set between the right []. For example, in the case of the parameters, set :[3.0]+-[0.2], the data with the initial enrichment between 2.8 and 3.2 wt% are searched. If you set the center value in the left [] to -1, the data with every initial enrichment are searched.

Parameter3: Burnup ;

Set it by a real number with the unit of GWd/MTU. The parameter setting is performed in the same way as described in the parameter2.

Parameter4: Cooling Time;

Input by a real number. The unit is year. the setting way is the same as in parameter2.

If the parameters are set completely, press the key of [ESC], and the cursor moves to the sub-menu:<Edit Go to Exit> at the left top on the display. If you press [RETURN] setting the cursor at <Edit>, the menu:<Discard row or Save changes> appears. If the parameters set is good for you, select <Save changes>, and the parameters set table is saved and the cursor returns to the sub-menu. Then, select <Exit>, and the search process goes on.

A detailed description of the sub-menu is presented in the Section 5.2.3.

(2) The result searched by the 1st parameter set

The measured condition tables are searched by the 1st parameters set, as a result the following table appears on the display shown in Fig. 5.3.4.

++SFCOMPO Output of Result Query++								
Burnup	CoolingTime	Enrichment	ReacName	Type	Labo	Assembly	RodPosition	
[GWd/tU]	[y]	[wt%]						
21.17	0.	3.	OBR	PWR	KAR	BE124	D1	bottom 150mm
27.91	0.	3.	OBR	PWR	ISP	BE124	D1	bottom 315mm
33.75	0.	3.	OBR	PWR	ISP	BE124	D1	middle 1435mm
20.18	0.	3.	OBR	PWR	ISP	BE124	E3	bottom 150mm
35.1	0.	3.	OBR	PWR	KAR	BE124	E3	bottom 315mm
36.26	0.	3.	OBR	PWR	ISP	BE124	E3	middle 1435mm
30.89	0.	3.	OBR	PWR	ISP	BE124	E3	top 2315mm
30.94	0.	3.	OBR	PWR	KAR	BE124	E3	top 2315mm
22.86	0.	3.	OBR	PWR	ISP	BE124	E3	top 2585mm
17.13	0.	3.	OBR	PWR	ISP	BE124	G7	bottom 150mm
22.7	0.	3.	OBR	PWR	KAR	BE124	G7	bottom 150mm
25.83	0.	3.	OBR	PWR	ISP	BE124	G7	bottom 315mm
31.5	0.	3.	OBR	PWR	ISP	BE124	G7	middle 1435mm
31.14	0.	3.	OBR	PWR	KAR	BE124	G7	middle 1435mm
27.71	0.	3.	OBR	PWR	ISP	BE124	G7	top 2315mm
25.81	0.	3.	OBR	PWR	KAR	BE124	G7	top 2585mm
15.6	0.	3.	OBR	PWR	KAR	BE124	M14	bottom 150mm
29.36	0.	3.	OBR	PWR	ISP	BE124	M14	middle 1435mm
24.9	0.	3.	OBR	PWR	KAR	BE124	M14	top 2315mm
44.34	5.08	3.038	CALV#1	PWR	PNL	D047	C7	middle 163cm
37.12	5.08	3.038	CALV#1	PWR	PNL	D047	C7	bottom 27cm

More output follows. Press Esc to quit, any key to continue.

Fig. 5.3.4 The results of the search performed by the 1st parameter

The all data in the area identified by the 1st parameters are listed in this table. The measured conditions of the searched data are presented in the table, for example, burn-up, cooling time, initial enrichment, reactor name, measurement laboratory, etc..

If there are any following pages, the following message appears at the bottom of the table.

<More output follows. Press Esc to quit, any key to continue>

Press any key, and the next page appears.

If there is no other next page, the message: <Press any key> appears. Press any key, and the search process will continue.

(3) Select process1

After the search by the 1st parameters, the following menu appears shown in Fig. 5.3.5.

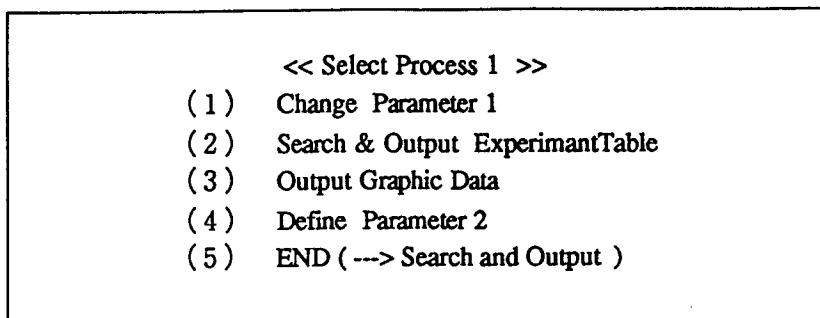


Fig. 5.3.5 The Select Process1 Menu

In this menu, you can select the next search process.

Select1: Change Parameter1;

Return to the 1st search parameter menu. The 1st search is performed again after changing the parameters.(Refer to the Section 5.3.1(1)).

Select2: Search & Output Experiment Table;

The searched isotopic composition data table are presented on the display.(Refer to the Section 5.3.1(7)).

Select3: Output Graphic Data;

The preparation of the input data for the external graphic soft is performed, and the graphic output of the isotopic composition data is obtained by using this input and the external graphic soft, for example, Kaleida Graph(Refer to the Section 5.3.1(9)).

Select4: Define Parameter2;

If you want to minimize the area to be searched after the 1st search, select this option. The 2nd search parameter menu appears as described in the next section.

Select5: END;

This search process is finished, return to the search and output menu.

(4) The 2nd Parameters Input

If you select Select4 in the Select Process1 menu, the 2nd parameter menu appears shown in Fig. 5.3.6.

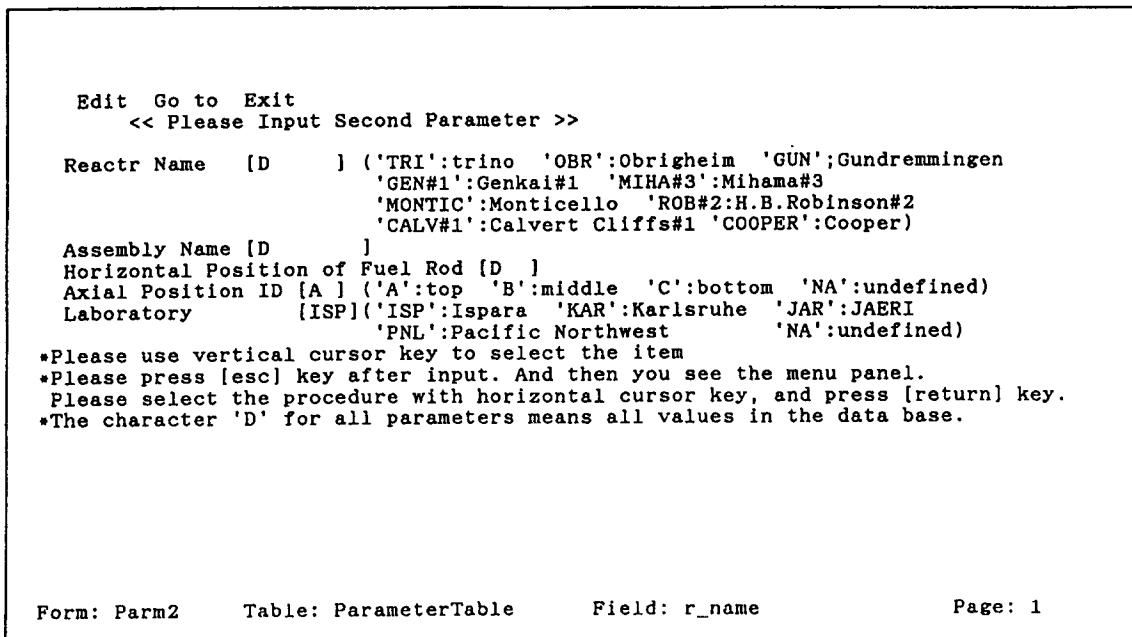


Fig.5.3.6 The 2nd Parameter Menu

You can identify a much smaller search area by selecting the 2nd parameters than the 1st parameters.

Parameter1: Reactor Name;

Input the reactor name in less than 6 half characters. The reactor names and the abbreviations stored in the SFCOMPO are presented below.

TRI	:	Trino Reactor
OBR	:	Obrigheim Reactor
GUN	:	Gundremingen Reactor
MIHA#3	:	Mihama Reactor No.3
GEN#1	:	Genkai Reactor No.1
MONTIC	:	Monticello Reactor
ROB#2	:	H.B.Robinson Reactor No.2
CALV#1	:	Calvert Cliffs No.1
COOPER	:	Cooper Reactor

Parameter2: Assembly Name; Input the name in less than 8 half characters.

Parameter3: Fuel Rod Location; Input the location name in less than 3 half characters.

Parameter3: Core Height ID of the Sample Fuel; Input A or B or C. There are 4 core height IDs in the SFCOMPO, A: Upper part of the

core. B: Center part of the core. C: Lower part of the core. and NA: the core height is not identified.

Parameter4: Measurement Laboratory Name; Input the name in less than 3 half characters.

There are 4 laboratories stored in SFCOMPO.

ISP: ISPRA, KAR: Karlsruhe, JAR: JAERI, PNL: Pacific Northwest Laboratory. As the laboratory name for Monticello data is still not clear, the Lab.ID is NA.

If the parameters set are finished, press the ESC and the cursor moves to the sub-menu on the left top of the display. (Ref.Section 5.2.3)

(5) The result searched by the 2st parameters set

The measured condition tables are searched by the 2nd parameters set, and the same type of search result table appears on the display as shown in Fig. 5.3.7.(Refer to the Section 5.3.1(2))

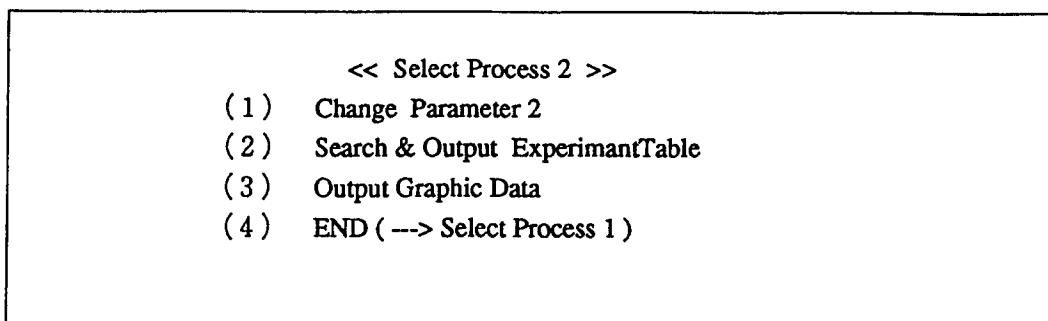


Fig. 5.3.7 The Select Process2 Menu

In this menu, you can select the next search process.

Select1: Change Parameter2;

Return to the 2nd search parameter menu. The 2nd parameter search is performed again after changing the parameters.(Refer to the Section 5.3.1(4)).

Select2: Search & Output Experiment Table;

The searched isotopic composition data table are presented on the display.(Refer to the Section 5.3.1(7)).

Select3: Output Graphic Data;

The preparation of the input data for the external graphic soft is performed, and the graphic output of the isotopic composition data is obtained by using this input and the external graphic soft, for example, Kaleida Graph(Refer to the Section 5.3.1(9)).

Select4: DND;

If you want to perform the 1st parameter search again, select this option. The 1st search parameter menu appears as described in the Section of 5.3.1(1) and Fig. 5.3.3.

(7) The isotopic composition data table output

If the Search and Output option in the Select Process1 and 2, the Section Item Menu is shown in Fig. 5.3.8.

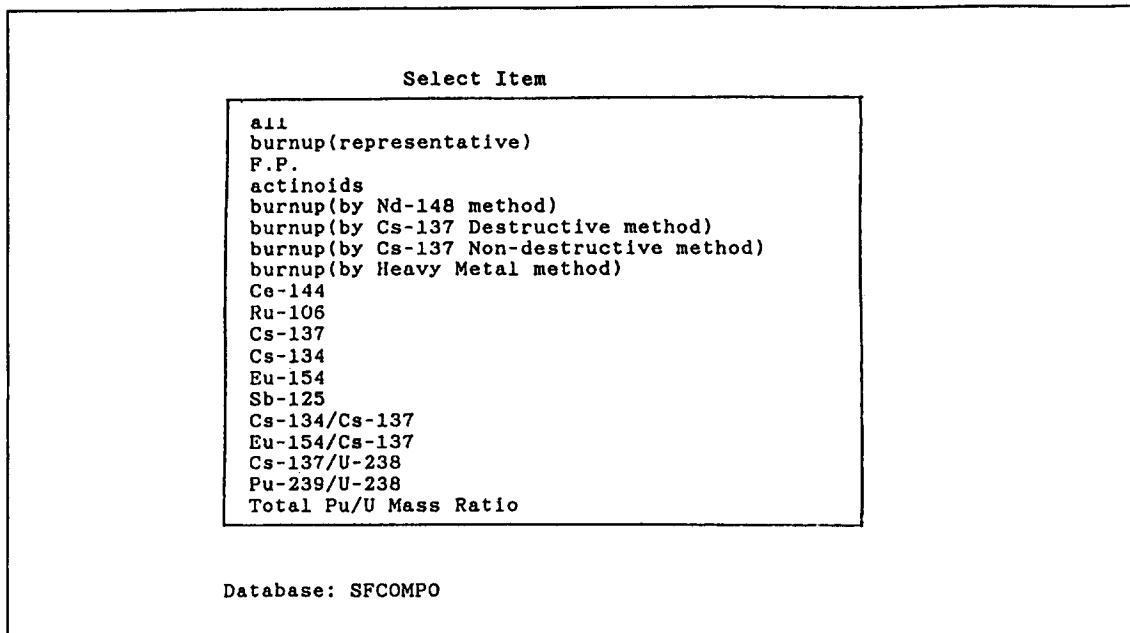


Fig. 5.3.8 The Select Item Menu for Output

Press the RETUN key after setting the cursor at the position of the required item, and the characters of the item change negative from positive representation on the display. By using this menu, you can get the data table about the specified items, as shown in Fig. 5.3.9.

** SF.COMPO : Isotopic Composition **							
Burnup	vs.	Pu-239/U-238					
[GWd/t]		[-----]					
(CoolingTime Enrichment Reac.Name Reac.Type Lab. Ass. Rod Pos.)							
{ [y]		[wt%])
[comment)
30.89		0.00519					
{ 0.		3. OBR	PWR	ISP BE124	E3 top	2315mm)
[)
22.86		0.00486)
{ 0.		3. OBR	PWR	ISP BE124	E3 top	2585mm)
[)
27.71		0.00533)
{ 0.		3. OBR	PWR	ISP BE124	G7 top	2315mm)
[)
Press any key.							

Fig. 5.3.9 The Isotopic Composition Data Table

Generally, a pair of the burnup item and any isotopic composition item is selected from this menu.

(8) Output of the search result Ddata

When the isotopic composition data table is finished, the Select Output Media Menu appears shown in Fig. 5.3.10.

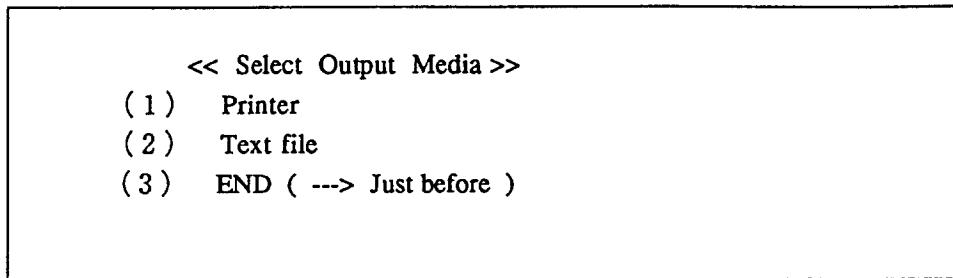


Fig. 5.3.10 The Select Output Media Menu

You can select any output in this menu.

Select1 : Printer Output ; If this option is selected, the following message appears.

<Selected data will be sent to printer. Ready printer>

If the power of printer is OFF at the time, turn on the power.
Then, the next message appears.
<OK? (Y/N)>

If you key in Y, the output process starts, and the following message appears.

< just a moment.....>

Then, the isotopic composition data table is printed as shown in Fig. 5.3.11. When the printing is finished, the above message disappears.

If you select N or any other key in <OK?(Y/N)>, the message;
<Process stops. Key in [RETURN] >
appears, and press the [RETUN] key.

In both cases of Y and N, return to the Select Output Media Menu after the process finished.

Select2 : Text file ; If the option is selected, the following messages appear.

< Selected data will be written to text file. Key in file name >
< (ex. c:\$text\$out.fil Default Directory=d:\$outfile) >

Key in the drive name and file name as shown in the example. If you press the [RETUN] key without keying in the names, the default directory and file name are used.

Then, the message ;

<OK? (Y/N)>

appears.

If you press N, you can input the names again.

If you press Y, the following message appears.

< Process stopped. Key in [RETURN] >

Press the [RETUN] key, and the output process starts and the following message appears.

< just a moment ... >

The output in the form of texts file is carried out and the outputs as shown in Figs. 5.3.12 and 5.3.13 are obtained.

If the process is finished, the message disappears and the Select Output Media Menu appears again.

Select3 : END ; Return to the 1st or 2nd Select Process Menu.

(9) The Output for the graphical output

The SFCOMPO database does not have any graphic soft. Then, this system has the function of making the input for external graphic soft(ex. Kaleida Graph, etc.).

If you select the Select3:Output Graphic Data in the 1st or 2nd Select Process Menu, the Select Item Menu shown in Fig. 5.3.8.

First, select the item on the X-axis by using the cursor. The following unit menu appears.

< Output unit = B dis/sec/g of final Uranium >

< = C dps/g of final Uranium >

When there are several units in the data, the following message appears.

< Key in output unit-id (not change : space)=> >

Press the B or C key in the menu, and the data are generated in the unit of B or C. If you press [space] key, the units are not changed. If the X-axis selection is finished, the Y-axis selection is performed in the same way as the X-axis.

If there are not specified data in this system, the following message appears,
< No data >

The X-axis selection is performed again.

If the X- and Y-axis selections are good, key in the directory and file name in the same way as the text file output in the previous section.

The sample output for the graphical output is shown in Fig.5.3.14(1). The sample figure is shown in Fig. 5.3.14(2) obtained by using the graphic soft:Kaleida Graph.

When the process is finished, return to the 1st or 2nd Select Process Menu.

** SFCOMPO : Isotopic Composition **

page. 1

Burnup vs. Pu-239/U-238

[GWd/t] [-----]

(Cooling Time Enrichment Reactor Name Reactor Type Laboratory Assembly Name Rod Position)

([y] [wt%])

Cooling Time	Enrichment	Reactor Name	Reactor Type	Laboratory	Assembly Name	Rod Position
30.89	0.00519					
0.	3.	OBR	PWR	ISP	BE124	E3 top (2315mm)
22.86	0.00486					
0.	3.	OBR	PWR	ISP	BE124	E3 top (2585mm)
27.71	0.00533					
0.	3.	OBR	PWR	ISP	BE124	G7 top (2315mm)

Fig. 5.3.11 Sample Output for the Printer Output

**SFCOMPO Output of Experimental Data

First Parameter Reactor Type:PWR Initial Enrichment[wt%]: 3. Error of Initial Enrichment[wt%]: 0.1
 Burnup[GDd/tU]: -1. Error of Burnup[GDd/tU]: -1. Cooling Time[y]: -1. Error of Cooling Time[y]: -1.

Item	Burnup	CoolingTime	InitialEnrichment	ReactorName	ReactoeType	ExperimentalValue	Unit
Pu-239/U-238	15.6	0.	3.	OBR	PWR	0.00413(-----)	
Pu-239/U-238	17.13	0.	3.	OBR	PWR	0.00442(-----)	
Pu-239/U-238	20.18	0.	3.	OBR	PWR	0.00445(-----)	
Pu-239/U-238	21.17	0.	3.	OBR	PWR	0.00454(-----)	
Pu-239/U-238	22.7	0.	3.	OBR	PWR	0.00459(-----)	
Pu-239/U-238	22.86	0.	3.	OBR	PWR	0.00486(-----)	
Pu-239/U-238	24.9	0.	3.	OBR	PWR	0.00519(-----)	
Pu-239/U-238	25.81	0.	3.	OBR	PWR	0.00533(-----)	
Pu-239/U-238	25.83	0.	3.	OBR	PWR	0.00492(-----)	
Pu-239/U-238	27.35	0.	3.038	CALV#1	PWR	0.00504(-----)	
Pu-239/U-238	27.35	5.08	3.038	CALV#1	PWR	0.00504(-----)	
Pu-239/U-238	27.71	0.	3.	OBR	PWR	0.00533(-----)	
Pu-239/U-238	29.36	0.	3.	OBR	PWR	0.00527(-----)	
Pu-239/U-238	30.89	0.	3.	OBR	PWR	0.00519(-----)	
Pu-239/U-238	30.94	0.	3.	OBR	PWR	0.00517(-----)	
Pu-239/U-238	31.14	0.	3.	OBR	PWR	0.00531(-----)	
Pu-239/U-238	31.5	0.	3.	OBR	PWR	0.00525(-----)	
Pu-239/U-238	33.75	0.	3.	OBR	PWR	0.00529(-----)	
Pu-239/U-238	35.1	0.	3.	OBR	PWR	0.00488(-----)	
Pu-239/U-238	36.26	0.	3.	OBR	PWR	0.00504(-----)	
Pu-239/U-238	37.12	0.	3.038	CALV#1	PWR	0.00521(-----)	
Pu-239/U-238	37.12	5.08	3.038	CALV#1	PWR	0.00521(-----)	
Pu-239/U-238	44.34	5.08	3.038	CALV#1	PWR	0.00526(-----)	
Pu-239/U-238	44.34	0.	3.038	CALV#1	PWR	0.00526(-----)	

Fig. 5.3.12 Sample Output for the Text File Output1
 (In the case of the Parameter1 Search)

****SFCOMPO Output of Experimental Data**

First Parameter Reactor Type:PWR Initial Enrichment[wt%]: 3. Error of Initial Enrichment[wt%]: 0.1
Burnup[GDD/tU]: -1. Error of Burnup[GDD/tU]: -1. Cooling Time[y]: -1. Error of Cooling Time[y]: -1.
Second Parameter Reactor Name:D Assembly Name:D Horizontal Position of Fuel Rod:D

Axial Position of Fuel Rod:top Laboratory:ISP

Item	Burnup	CoolingTime	InitialEnrichment	ReactorName	ReactoType	ExperimentalValue	Unit
Pu-239/U-238	22.86	0.	3.	OBR'	PWR	0.00486(-----)	
Pu-239/U-238	27.71	0.	3.	OBR	PWR	0.00533(-----)	
Pu-239/U-238	30.89	0.	3.	OBR	PWR	0.00519(-----)	

Fig. 5.3.13 Sample Output for the Text File Output2
(In the case of the Parameter2 Search)

condition_id	sample	burnup	X_unit	Ru-106	Y_unit
128		3.435	GWD/MTU		1.092E9 , dis/sec/g of final Uranium
402		6.9	GWD/MTU		1.1E8 , Bq/g
117		7.243	GWD/MTU		3.119E9 , dis/sec/g of final Uranium
129		7.605	GWD/MTU		2.342E9 , dis/sec/g of final Uranium
101		7.822	GWD/MTU		3.848E9 , dis/sec/g of final Uranium
401		8.3	GWD/MTU		1.39E8 , Bq/g
106		8.713	GWD/MTU		4.144E9 , dis/sec/g of final Uranium
112		8.895	GWD/MTU		4.514E9 , dis/sec/g of final Uranium
104		10.478	GWD/MTU		5.513E9 , dis/sec/g of final Uranium
120		11.529	GWD/MTU		5.846E9 , dis/sec/g of final Uranium
126		11.912	GWD/MTU		5.291E9 , dis/sec/g of final Uranium
116		12.053	GWD/MTU		6.549E9 , dis/sec/g of final Uranium
124		12.366	GWD/MTU		6.364E9 , dis/sec/g of final Uranium
102		14.155	GWD/MTU		8.214E9 , dis/sec/g of final Uranium
405		14.6	GWD/MTU		3.08E8 , Bq/g
107		14.77	GWD/MTU		8.769E9 , dis/sec/g of final Uranium
403		15.3	GWD/MTU		3.09E8 , Bq/g
118		15.377	GWD/MTU		8.029E9 , dis/sec/g of final Uranium
119		15.898	GWD/MTU		8.584E9 , dis/sec/g of final Uranium
114		16.146	GWD/MTU		9.842E9 , dis/sec/g of final Uranium
123		17.45	GWD/MTU		9.102E9 , dis/sec/g of final Uranium
125		17.995	GWD/MTU		9.25E9 , dis/sec/g of final Uranium
404		21.2	GWD/MTU		4.2E8 , Bq/g
406		29.44	GWD/MTU		5.88E8 , Bq/g
407		32.3	GWD/MTU		6.83E8 , Bq/g
408		33.7	GWD/MTU		6.61E8 , Bq/g
409		34.1	GWD/MTU		6.85E8 , Bq/g
451		38.7	GWD/MTU		8.07E8 , Bq/g

Fig.5.3.14(1) The sample output for the graphical output

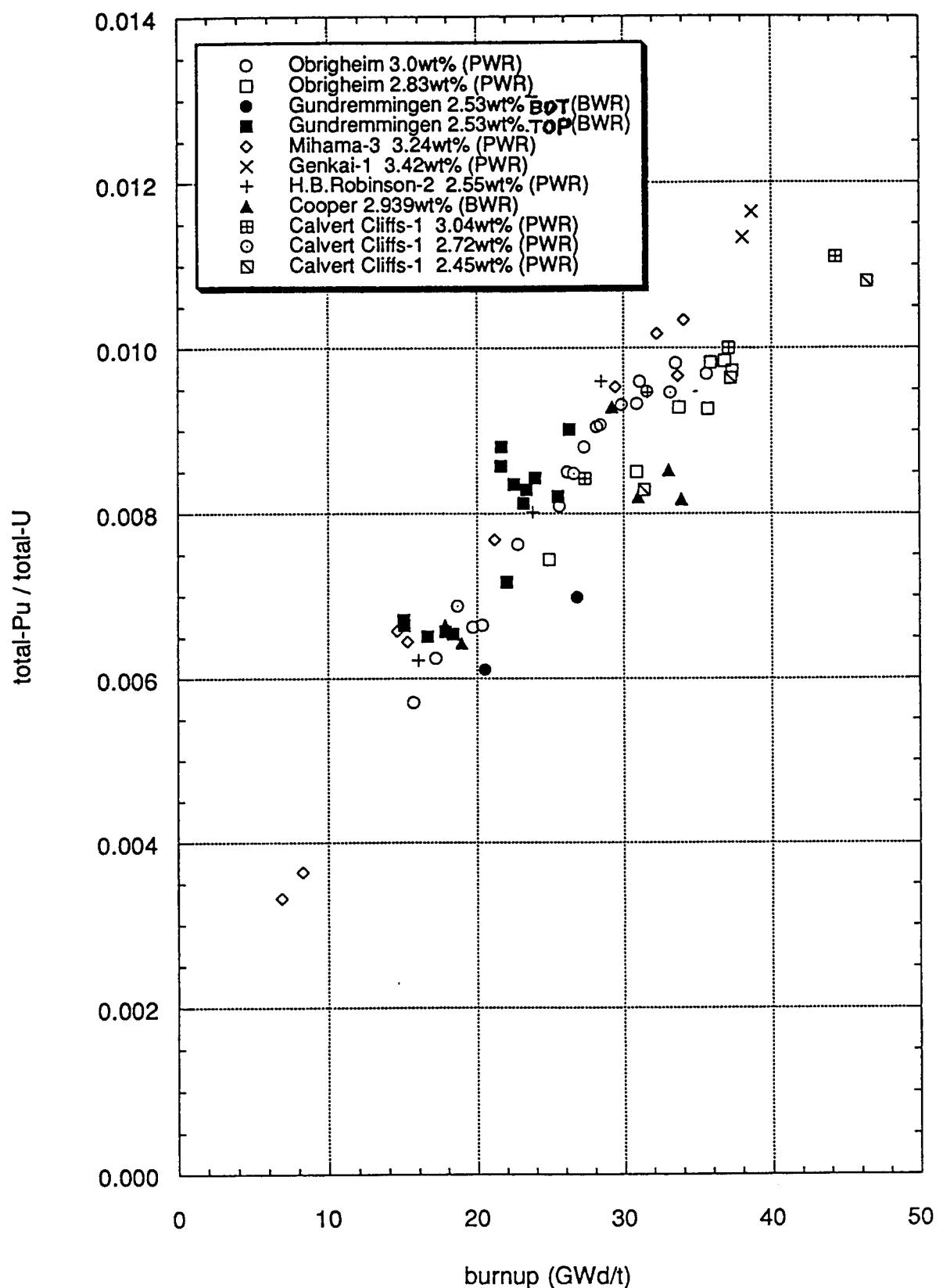


Fig. 5.3.14(2) The sample figure by Kaleida Graph

5.3.2 Search and Output of the Burn-up(Axial Gamma Activity) Profile Data

When the Select2: profile of gamma activity is choosed in the Search and Output Menu, the process of search and output for the burn-up(axial gamma activity) profile data is performed.

(1) The 3rd Parameter Input

If this option is choosed, the 3rd parameter menu appears as shown in Fig.5.3.15.

```

Edit Go to Exit
<< Please Input First Parameter >>

Reacter Type      [D]          ('BWR' or 'PWR')
Burnup [GWd/tU]    [-1.     ]  +- [-1.     ] (average of assembly)

•Please use vertical cursol key to select the item
•Please press [esc] key after input. And then you see the menu panel.
Please select the procedure with horizontal cursor key, and press [return] key.
•The character 'D' for reactor type means all types(i.e. BWR and PWR).
The value '-1' for Initial Enrichment, Burnup and Cooling Time means all values
in the data base.

Form: Parm3      Table: ParameterTable      Field: r_type      Page: 1

```

Fig.5.3.15 The 3rd Search Parameter Menu

Parameter1 : Reactor Type ; PWR or BWR or D,
 D means all reactors.

Parameter2 : Assembly Average Burn-up(MWd/MTU) ;
 Set the center value and the width of burn-up in real numbers
 like other numerical parameters.

If the parameters set is good, press the key of [ESC], and the
 cursor moves to the left top menu of the display. Then, select <Edit>
 and <Exit> as described in the section 5.2.3, and the search process
 starts.

(2) The Results of the 3rd Parameter Search

The search result is presented on the display shown in Fig. 5.3.16.

```

++SFCOMPO Output of Result Query++
Burnup(average) CoolingTime Enrichment ReacName.Type Labo Assembly Rod
 [GWd/tU]      [y]          [wt%]
 36.1           GEN#1   PWR    NA   C33-c   E11
 36.1           GEN#1   PWR    NA   C33-s   E11
 36.1           GEN#1   PWR    NA   C33-c   N1
 36.1           GEN#1   PWR    NA   C33-c   N10
 21.3           TURU#1 BWR    NA   JAB-73a  A1
 21.3           TURU#1 BWR    NA   JAB-73b  A1
 21.3           TURU#1 BWR    NA   JAB-73c  A1
 21.3           TURU#1 BWR    NA   JAB-73   C3

Press any-key.

```

Fig. 5.3.16 The Results of the 3rd Parameter Search

When there are some pages after that, the following message appears.

< More output follows, Press Esc to quit, any key to continue. >

Press any key. If it is the final page, the next message appears.

< Press any key. >

(3) The Select Proces 3

The 3rd parameter search is finished, the following menu appears. in Fig. 5.3.17.

```

<< Select Process 3 >>
(1) Change Parameter 3
(2) Search & Output DistributionTable
(3) Define Parameter 4
(4) END ( ---> Search and Output )

```

Fig 5.3.17 The Select Process 3 Menu

Select1 : Change the 3rd parameters; Return to the 3rd Parameter Search Menu.

Select2 : Search & Output Burn-up Profile Table ; Go to the Estimated Burun-up Value Input Menu shown in Fig.5.3.20. After that, the burn-up profile data will be presented.

Select3 : Define Parameter 4 ; Go to the 4th Parameter Search Menu shown in Fig 5.3.18. Then, you can minimize the search area using with the menu.

Select4 : END ; Return to the Search and Output Menu.

(4) The 4th Parameter Search Menu

If you select the Select3 in the just before menu, the following menu appears in Fig. 5.3.18.

<pre> Edit Go to Exit << Please Input Second Parameter >> Reactor Name [D] ('GEN#1':Genkai#1 'TURU#1':Tsuruga#1) Assembly Name [D] Horizontal Position of Fuel Rod [D] *Please use vertical cursor key to select the item *Please press [esc] key after input. And then you see the menu panel. Please select the procedure with horizontal cursor key, and press [return] key. *The character 'D' for all parameters means all values in the data base. </pre>		
Form: Parm4	Table: ParameterTable	Field: r_name
Page: 1		

Fig. 5.3.18 The 4th Parameter Search Menu

Parameter1 : Reactor Name ; Set it in less than 6 half characters.

In the current burn-up profile database, the following two reactors data are stored.

The Genkai Reactor No.1 : GEN#1

The Tsuruga Reactor No.1 : TURU#1

Parameter2 : Assembly Name ; Set it in less than 8 half characters.

Parameter3 : Fuel Rod Position : Set it in less than 3 half characters.

If the parameters set is finished, press the key of [ESC], and the cursor moves to the sub-menu on the left top of the display. Select <Edit> and <Exit>, the 4th parameter search starts.

(5) Results of the 4th Parameter Search

The data in the area identified by the 3rd parameter and 4th parameter are searched after the 4th parameter input. The resulting data table are represented as well as shown in Fig. 5.3.16.

(6) Select Process 4

When the data table presentation is finished in the former section, the following menu appears shown in Fig. 5.3.19.

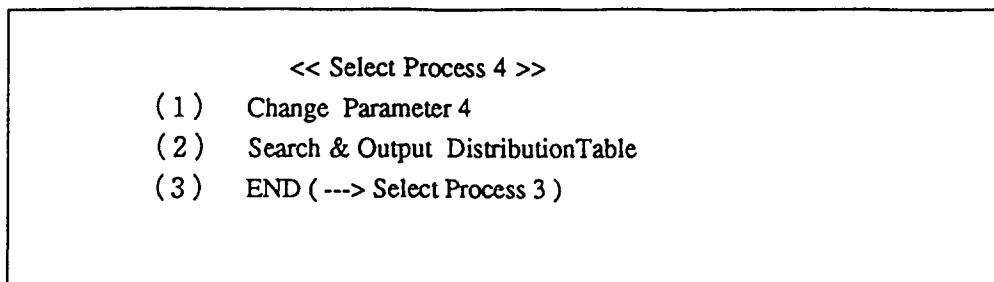


Fig. 5.3.19 Selct Process4 Menu

Select1 : The 4th parameter change. ; Return to the 4th parameter menu.

Select2 : The burn-up profile data representation. ; Go to the estimated burn-up value input menu.

Select3 : END ; Return to the select process3 menu.

(7) The Representation of the Burn-up Proile Data

If the select2 is chosed in the select process3 or select process4, the burn-up profile data search starts. First, the following message is presented on the display.

< Key in assumptive burnup for each fuel rod >

Press the [ENTER] key, and the following menu appears.

		Sort	Edit	Calculate	Layout	Query	Manage views	Print	Exit
reac	reac_name	enrich		cooling		assembly	rod	ave_burn	assum_bu
PWR	GEN#1	-0-		-0-		C33-c	E11	36.1	-0-
PWR	GEN#1	-0-		-0-		C33-s	E11	36.1	-0-
PWR	GEN#1	-0-		-0-		C33-c	N1	36.1	-0-
PWR	GEN#1	-0-		-0-		C33-c	N10	36.1	-0-
BWR	TURU#1	-0-		-0-		JAB-73a	A1	21.3	-0-
BWR	TURU#1	-0-		-0-		JAB-73b	A1	21.3	-0-
BWR	TURU#1	-0-		-0-		JAB-73c	A1	21.3	-0-
BWR	TURU#1	-0-		-0-		JAB-73	C3	21.3	-0-

Database: SFCOMPO Table: TPTBL12 F4 to Browse Edit

Fig. 5.3.20 The Estimated Burnup Value Input Menu

The right end column in the table shown in Fig.5.3.20. should be filld with the estimated average burnup values for each rod. The cursor moves to the right among columns by [TAB] key, and moves to the left by [Shift] key and [TAB] key. If the estimated value input

is finished, press [ESC] key, and the cursor moves to the top menu on the display. When the <Exit> is selected on the menu, the burnup axial profile is calculated using the estimated burnup value on the basis of the Cs-137 gamma activity axial profile stored in the database. Then, the following burnup profile data table is represented on the display shown in Fig.5.3.21.

** SFCOMPO : Axial Gamma Activity Profile **						
Measured Cooling Enrichment	Reac.	Reac.	Lab.	Ass.name	Rod pos.	Assumed
Burnup	Time			name type		Burnup
(Ass.)						(Rod)
[GWd/tU]	[y]	[wt%]				[GWd/tU]
[comment]						
36.1	GEN#1	PWR	NA	C33-c	E11	35.
[Genkai#1 serial scan, deg=0.]						
height	Cs-134	cs-137	Eu-154	Total	Cal.Burnup	
[mm]					[GWd/tU]	
8.5 (abs.)[CPS]	7.8431			127.73	1.289	
(rel.)	0.036			0.052		
26. (abs.)[CPS]	7.9552			142.3	1.307	
(rel.)	0.037			0.058		
43.5 (abs.)[CPS]	8.2913			160.22	1.362	
(rel.)	0.038			0.065		
61. (abs.)[CPS]	8.1793			179.27	1.344	
(rel.)	0.038			0.073		
78.5 (abs.)[CPS]	8.2913			210.64	1.362	
(rel.)	0.038			0.086		
More output follows. Press Esc to quit, any key to continue.						

Fig. 5.3.21 The Axial Gamma Activity and Burnup Profile

(8) Output of the Search Result Data

When the burnup profile data table is finished, the Select Output Media Menu appears shown in Fig. 5.3.22.

<< Select Output Media >>	
(1)	Printer
(2)	Text file
(3)	Graphic data file
(4)	END (---> Just before)

Fig. 5.3.22 The Select Output Media Menu

You can select any output in this menu.

Select1 : Printer Output ; If this option is selected, the following message appears.

<Selected data will be written to printer. Ready printer>

If the power of printer is OFF at the time, switch ON the power. Then, the next message appears.

<OK? (Y/N)>

If you key in Y, the output process starts, and the following message appears.

< just a moment....>

Then, the isotopic composition data table is printed as shown in Fig. 5.3.24. When the printing is finished, the above message disappears.

If you select N or any other key in <OK?(Y/N)>, the message; <Process stopped. Key in [RETURN] > appears, and press the [RETUN] key.

In the both case of Y and N, return to the Select Output Media Menu after the process finished.

Select2 : Text file ;

If the option is selected, the following messages appear.

< Selected data will be written to text file. Key in file name >

<(ex. c:\$text\$out.fil Default Directory=d:\$outfile) >

Key in the drive name and file name as shown in the example. If you press the [RETUN] key without keying in the names, the default directory and file name are used.

Then, the message ;

<OK? (Y/N) >

appears.

If you press N, you can input the names again.

If you press Y, the following message appears.

< Process stopped. Key in [RETURN] >

Press the [RETUN] key, and the output process starts and the following message appears.

< just a moment ... >

The output in the form of texts file is executed and the outputs as shown in Fig. 5.3.25 or Fig. 5.3.26 are obtained.

If the process is finished, the message disappears and the Select Output Media Menu appears again.

Select3 : The Output for the Graphical Output ;

The database SFCOMPO has not any graphic soft. Then, this system has the function of making the input for external graphic soft(ex. Kaleida Graph etc.).

If you select the Select3:Output Graphic Data in the 3rd or 4th Select Process Menu, the following message appears on the display.

< Key in file-name for each assembly >

< ex. A:\$DIRNAME\$FILENAME(without extention)>

< Default Directory + d:\$outfile >

Press [ENTER] key, and the file name input menu is presented on the display shown in Fig. 5.3.23. Then, the directory and file name should be completed by the same way as the text file output in the before section. If the file name input is no good, the following messae appears.

<Re-enter file-name >

Press [Y] key, and the file name input menu appears again.

The sample output for the graphical output are shown in Fig.5.3.27.

. When the output is finished, the output media select menu appears again.

Select4 : END ; Return to the 3rd or 4th Select Process Menu.

Sort	Edit	Calculate	Layout	Query	Manage	views	Print	Exit
reac_name	reac type		assembly					
GEN#1	PWR		C33-c	-0-				
GEN#1	PWR		C33-s	-0-				
TURU#1	BWR		JAB-73	-0-				
TURU#1	BWR		JAB-73a	-0-				
TURU#1	BWR		JAB-73b	-0-				
TURU#1	BWR		JAB-73c	-0-				

Database: SFCOMPO Table: TPTBL13 F4 to Browse Edit

Fig. 5.3.23 File name input menu

SFCOMP Output of Experimental Data

Burnup(average)	CoolingTime	Enrichment	ReactorName	ReactorType	Laboratory	Assembly	FuelRod	Burnup(assumptive)	
[Gwd/tU]	[y]	[wt%]						[Gwd/tU]	
36.1			GEN#1	PWR	NA	C33-c	N1	36.1	
			abs[CPS]		rel				
height[mm]	Cs-134	Cs-137	Eu-154	Total	Cs-134	Cs-137	Eu-154	Total	CalculatedBurnup
8.5	9.5238			227.45		0.053		0.116	1.930
26.	9.4117			243.14		0.052		0.124	1.908
43.5	9.7479			257.7		0.054		0.131	1.976
61.	10.42			285.71		0.058		0.145	2.112
78.5	10.532			308.12		0.059		0.157	2.135
96.	10.756			322.69		0.060		0.164	2.180
113.5	10.98			331.65		0.061		0.169	2.226
131.	10.756			342.85		0.060		0.174	2.180
148.5	33.053			553.5		0.185		0.282	6.701
166.	98.936			830.25		0.555		0.423	20.059
183.5	93.893			810.08		0.527		0.413	19.037
201.	95.91			863.86		0.538		0.440	19.446
218.5	103.87			936.69		0.583		0.477	21.060
236.	109.69			1029.7		0.616		0.525	22.240
253.5	116.3			1117.1		0.653		0.569	23.580
271.	124.26			1214.6		0.697		0.619	25.194
288.5	134.9			1302.		0.757		0.664	27.351
306.	139.94			1360.2		0.785		0.693	28.373
323.5	145.32			1448.7		0.816		0.739	29.464
341.	151.6			1520.4		0.851		0.775	30.737
358.5	156.53			1576.5		0.879		0.804	31.737
376.	154.06			1612.3		0.865		0.822	31.236
393.5	162.02			1693.		0.909		0.863	32.850
411.	164.26			1730.		0.922		0.882	33.304
428.5	163.36			1743.4		0.917		0.889	33.122
446.	162.91			1749.		0.914		0.892	33.031
463.5	161.34			1715.4		0.906		0.875	32.712
481.	162.35			1712.		0.911		0.873	32.917
498.5	166.95			1808.4		0.937		0.922	33.850
516.	174.57			1909.2		0.980		0.974	35.395
533.5	186.44			2005.6		1.047		1.023	37.802
551.	183.42			2040.3		1.030		1.040	37.189
568.5	187.79			2065.		1.054		1.053	38.075
586.	189.92			2106.4		1.066		1.074	38.507
603.5	190.92			2100.8		1.072		1.071	38.710
621.	192.72			2151.3		1.082		1.097	39.075
638.5	195.29			2155.7		1.096		1.099	39.596
656.	195.63			2189.3		1.098		1.116	39.665

Fig. 5.3.24 Sample output for print

**SFCONPO Output of Distribution Data

First Parameter	Reactor Type:PWR	Burnup[GDD/tU]:	-1. (average of assembly)	0.						
Burnup(average)	CoolingTime	Enrichment	ReactorName	Type	Assembly	Rod height[mm]	(abs[CPIS])Cs-134	Cs-137	Eu-154	Total (rel)Cs-134
Cs-137	Eu-154	Total Burnup(assumption)	(calculated)							
36.1			GEN#1	PWR C33-c	E11	8.5		7.8431	127.73	
0.036	0.052409	36.1	GEN#1	PWR C33-c	E11	1329		7.9552	142.3	
36.1			GEN#1	PWR C33-c	E11	1348		8.2913	160.22	
0.037	0.058387	36.1	GEN#1	PWR C33-c	E11	43.5		8.1793	179.27	
36.1			GEN#1	PWR C33-c	E11	61.		9.4117	243.14	
0.038	0.06574	36.1	GEN#1	PWR C33-c	E11	78.5		8.2913	210.64	
36.1			GEN#1	PWR C33-c	E11	105		9.972	277.87	
0.038	0.073556	36.1	GEN#1	PWR C33-c	E11	136		10.084	308.12	
36.1			GEN#1	PWR C33-c	E11	166		10.98	339.49	
0.044	0.099763	36.1	GEN#1	PWR C33-c	E11	113.5		80.224	798.88	
36.1			GEN#1	PWR C33-c	E11	169		102.52	891.88	
0.046	0.114013	36.1	GEN#1	PWR C33-c	E11	13601		109.13	931.09	
36.1			GEN#1	PWR C33-c	E11	17381		112.6	1014.	
0.047	0.126425	36.1	GEN#1	PWR C33-c	E11	201		122.13	1109.2	
36.1			GEN#1	PWR C33-c	E11	218.5		131.09	1228.	
0.051	0.139296	36.1	GEN#1	PWR C33-c	E11	22225		141.18	1340.1	
36.1			GEN#1	PWR C33-c	E11	236		146.89	1451.	
0.376	0.327789	36.1	GEN#1	PWR C33-c	E11	23936		159.66	1559.7	
36.1			GEN#1	PWR C33-c	E11	24904		162.46	1637.	
0.481	0.365948	36.1	GEN#1	PWR C33-c	E11	27544		168.96	1736.7	
36.1			GEN#1	PWR C33-c	E11	28646		173.67	1820.7	
0.512	0.382036	36.1	GEN#1	PWR C33-c	E11	306		179.83	1901.4	
36.1			GEN#1	PWR C33-c	E11	3223.5		187.9	1963.	
0.528	0.416055	36.1	GEN#1	PWR C33-c	E11	3271		186.11	2024.6	
36.1			GEN#1	PWR C33-c	E11	3323.5		187.	2076.2	
0.573	0.455116	36.1	GEN#1	PWR C33-c	E11	3369		190.36	2085.1	
36.1			GEN#1	PWR C33-c	E11	341		190.8	2073.9	
0.615	0.503861	36.1	GEN#1	PWR C33-c	E11	358.5		190.59	2096.4	
36.1			GEN#1	PWR C33-c	E11	363.5				
0.663	0.549857	36.1	GEN#1	PWR C33-c	E11	376				
36.1			GEN#1	PWR C33-c	E11	393.5				
0.689	0.595361	36.1	GEN#1	PWR C33-c	E11	411				
36.1			GEN#1	PWR C33-c	E11	428.5				
0.749	0.639961	36.1	GEN#1	PWR C33-c	E11	446				
36.1			GEN#1	PWR C33-c	E11	463.5				
0.763	0.671678	36.1	GEN#1	PWR C33-c	E11	481				
36.1			GEN#1	PWR C33-c	E11					
0.793	0.712586	36.1	GEN#1	PWR C33-c	E11					
36.1			GEN#1	PWR C33-c	E11					
0.815	0.747052	36.1	GEN#1	PWR C33-c	E11					
36.1			GEN#1	PWR C33-c	E11					
0.844	0.780165	36.1	GEN#1	PWR C33-c	E11					
36.1			GEN#1	PWR C33-c	E11					
0.882	0.80544	36.1	GEN#1	PWR C33-c	E11					
36.1			GEN#1	PWR C33-c	E11					
0.874	0.830715	36.1	GEN#1	PWR C33-c	E11					
36.1			GEN#1	PWR C33-c	E11					
0.878	0.851887	36.1	GEN#1	PWR C33-c	E11					
36.1			GEN#1	PWR C33-c	E11					
0.894	0.855539	36.1	GEN#1	PWR C33-c	E11					
36.1			GEN#1	PWR C33-c	E11					
0.891	0.850943	36.1	GEN#1	PWR C33-c	E11					
36.1			GEN#1	PWR C33-c	E11					

Fig. 5.3.25 Sample output for disc file(Parameter3 set only)

**SFCOMPO Output of Distribution Data

```

First Parameter Reactor Type :PWR
Second Parameter Reactor Name :D      Assembly Name :D
Horizontal Position of Fuel rod :N1
Burnup(average) CoolingTime Enrichment ReactorName.Type Assembly Rod height[mm] (abs[CPS])Cs-134 Cs-137 Eu-154 Total (rel)Cs-134
Cs-13 Eu-154 Total Burnup(assumption) (calculated)
  36.1          GEN#1   PWR C33-c N1    8.5           9.5238   227.45
  0.053         0.116   36.1          1.93
  36.1          GEN#1   PWR C33-c N1    26.            9.4117   243.14
  0.052         0.124   36.1          1.908
  36.1          GEN#1   PWR C33-c N1    43.5           9.7479   257.7
  0.054         0.131   36.1          1.976
  36.1          GEN#1   PWR C33-c N1    61.             10.42   285.71
  0.058         0.145   36.1          2.112
  36.1          GEN#1   PWR C33-c N1    78.5           10.532   308.12
  0.059         0.157   36.1          2.135
  36.1          GEN#1   PWR C33-c N1    96.             10.756   322.69
  0.06          0.164   36.1          2.18
  36.1          GEN#1   PWR C33-c N1   113.5           10.98   331.65
  0.061         0.169   36.1          2.226
  36.1          GEN#1   PWR C33-c N1   131.             10.756   342.85
  0.06          0.174   36.1          2.18
  36.1          GEN#1   PWR C33-c N1   148.5           33.053   553.5
  0.185         0.282   36.1          6.701
  36.1          GEN#1   PWR C33-c N1   166.             98.936   830.25
  0.555         0.423   36.1          20.059
  36.1          GEN#1   PWR C33-c N1   183.5           93.893   810.08
  0.527         0.413   36.1          19.037
  36.1          GEN#1   PWR C33-c N1   201.             95.91   863.86
  0.538         0.44    36.1          19.446
  36.1          GEN#1   PWR C33-c N1   218.5           103.87   936.69
  0.583         0.477   36.1          21.06
  36.1          GEN#1   PWR C33-c N1   236.             109.69   1029.7
  0.616         0.525   36.1          22.24
  36.1          GEN#1   PWR C33-c N1   253.5           116.3   1117.1
  0.653         0.569   36.1          23.58
  36.1          GEN#1   PWR C33-c N1   271.             124.26   1214.6
  0.697         0.619   36.1          25.194
  36.1          GEN#1   PWR C33-c N1   288.5           134.9   1302.
  0.757         0.664   36.1          27.351
  36.1          GEN#1   PWR C33-c N1   306.             139.94   1360.2
  0.785         0.693   36.1          28.373
  36.1          GEN#1   PWR C33-c N1   323.5           145.32   1448.7
  0.816         0.739   36.1          29.464
  36.1          GEN#1   PWR C33-c N1   341.             151.6   1520.4
  0.851         0.775   36.1          30.737
  36.1          GEN#1   PWR C33-c N1   358.5           156.53   1576.5
  0.879         0.804   36.1          31.737
  36.1          GEN#1   PWR C33-c N1   376.             154.06   1612.3
  0.865         0.822   36.1          31.236
  36.1          GEN#1   PWR C33-c N1   393.5           162.02   1693.
  0.909         0.863   36.1          32.85
  36.1          GEN#1   PWR C33-c N1   411.             164.26   1730.
  0.922         0.882   36.1          33.304
  36.1          GEN#1   PWR C33-c N1   428.5           163.36   1743.4
  0.917         0.889   36.1          33.122
  36.1          GEN#1   PWR C33-c N1   446.             162.91   1749.
  0.914         0.892   36.1          33.031
  36.1          GEN#1   PWR C33-c N1   463.5           161.34   1715.4

```

Fig. 5.3.26 Sample output for disc file(Parameter3 and 4 set)

reactor:Genkai#1	assembly:C33	rod:E11	0 deg.	step scan	(rel)Cs-134	Cs-137	Eu-154	Total	AssumptiveBurnup
height , (abs)Cs-134	, Cs-137	, Eu-154	, Total						
8.5	, 2.3286,	, 3.2857,	, 1.9143,	,	, 0.	, 0.001,	, 0.033,	,	, 0.038
26.002	, 3.3429,	, 3.2,	, 2.9857,	,	, 0.	, 0.001,	, 0.051,	,	, 0.037
43.501	, 3.5429,	, 4.1429,	, 2.9143,	,	, 0.	, 0.001,	, 0.05,	,	, 0.047
61.001	, 3.8,	, 2.8286,	, 2.9143,	,	, 0.	, 0.	, 0.05,	,	, 0.032
78.501	, 3.7286,	, 2.5143,	, 2.6857,	,	, 0.	, 0.	, 0.046,	,	, 0.029
96.	, 6.4571,	, 4.5714,	, 4.0286,	,	, 0.001,	, 0.001,	, 0.07,	,	, 0.052
113.5	, 4.1571,	, 6.6571,	, 4.6429,	,	, 0.	, 0.002,	, 0.08,	,	, 0.077
131.	, 6.8143,	, 4.7143,	, 4.4286,	,	, 0.001,	, 0.001,	, 0.077,	,	, 0.054
148.5	, 7.4429,	, 4.5143,	, 4.3,	,	, 0.001,	, 0.001,	, 0.074,	,	, 0.052
166.	, 2475.9,	, 628.,	, 11.7,	,	, 0.462,	, 0.201,	, 0.203,	,	, 7.269
183.5	, 2549.3,	, 668.91,	, 13.671,	,	, 0.476,	, 0.214,	, 0.237,	,	, 7.743
201.	, 2613.5,	, 762.51,	, 18.871,	,	, 0.488,	, 0.244,	, 0.328,	,	, 8.827
218.5	, 2809.3,	, 872.71,	, 16.986,	,	, 0.524,	, 0.279,	, 0.295,	,	, 10.102
236.	, 3010.9,	, 1017.7,	, 24.014,	,	, 0.562,	, 0.326,	, 0.417,	,	, 11.781
253.5	, 3250.2,	, 1172.7,	, 24.514,	,	, 0.607,	, 0.376,	, 0.426,	,	, 13.575
271.	, 3476.2,	, 1339.3,	, 25.414,	,	, 0.649,	, 0.429,	, 0.442,	,	, 15.504
288.5	, 3640.2,	, 1475.,	, 28.9,	,	, 0.68,	, 0.473,	, 0.502,	,	, 17.075
306.	, 3850.6,	, 1631.3,	, 34.371,	,	, 0.719,	, 0.523,	, 0.598,	,	, 18.884
323.5	, 3993.2,	, 1776.1,	, 30.971,	,	, 0.745,	, 0.569,	, 0.538,	,	, 20.56
341.	, 4167.3,	, 1908.1,	, 40.043,	,	, 0.778,	, 0.611,	, 0.696,	,	, 22.089
358.5	, 4301.4,	, 2023.9,	, 38.143,	,	, 0.803,	, 0.649,	, 0.663,	,	, 23.429
376.	, 4436.5,	, 2130.7,	, 42.571,	,	, 0.828,	, 0.683,	, 0.74,	,	, 24.665
393.5	, 4584.5,	, 2266.3,	, 45.729,	,	, 0.856,	, 0.726,	, 0.795,	,	, 26.235
411.	, 4650.,	, 2338.3,	, 47.686,	,	, 0.868,	, 0.749,	, 0.829,	,	, 27.069
428.5	, 4756.5,	, 2443.8,	, 47.871,	,	, 0.888,	, 0.783,	, 0.832,	,	, 28.29
446.	, 4746.8,	, 2472.7,	, 45.4,	,	, 0.886,	, 0.792,	, 0.789,	,	, 28.625
463.5	, 4708.1,	, 2455.,	, 46.229,	,	, 0.879,	, 0.787,	, 0.804,	,	, 28.42
481.	, 4726.4,	, 2487.1,	, 51.671,	,	, 0.882,	, 0.797,	, 0.899,	,	, 28.791
498.5	, 4860.2,	, 2606.9,	, 52.6,	,	, 0.907,	, 0.835,	, 0.915,	,	, 30.178
516.	, 5117.1,	, 2815.6,	, 53.986,	,	, 0.955,	, 0.902,	, 0.939,	,	, 32.594
533.5	, 5204.1,	, 2951.,	, 56.329,	,	, 0.972,	, 0.946,	, 0.98,	,	, 34.162
551.	, 5358.2,	, 3038.7,	, 60.386,	,	, 1.	, 0.974,	, 1.05,	,	, 35.177
568.5	, 5472.8,	, 3171.8,	, 54.329,	,	, 1.022,	, 1.017,	, 0.945,	,	, 36.718
586.	, 5526.7,	, 3221.7,	, 57.086,	,	, 1.032,	, 1.033,	, 0.993,	,	, 37.295
603.5	, 5581.5,	, 3274.6,	, 65.386,	,	, 1.042,	, 1.05,	, 1.137,	,	, 37.908
621.	, 5654.,	, 3370.,	, 60.657,	,	, 1.056,	, 1.08,	, 1.055,	,	, 39.012
638.5	, 5714.,	, 3416.2,	, 63.529,	,	, 1.067,	, 1.095,	, 1.105,	,	, 39.547
656.	, 5733.5,	, 3434.5,	, 61.814,	,	, 1.071,	, 1.101,	, 1.075,	,	, 39.759
673.5	, 5828.,	, 3502.1,	, 61.157,	,	, 1.088,	, 1.123,	, 1.064,	,	, 40.541
691.	, 5853.1,	, 3564.,	, 66.543,	,	, 1.093,	, 1.142,	, 1.157,	,	, 41.258
708.5	, 5879.4,	, 3594.4,	, 71.943,	,	, 1.098,	, 1.152,	, 1.251,	,	, 41.61
726.	, 5940.8,	, 3647.,	, 67.243,	,	, 1.109,	, 1.169,	, 1.169,	,	, 42.219
743.5	, 5933.,	, 3670.3,	, 72.829,	,	, 1.108,	, 1.176,	, 1.267,	,	, 42.489
761.	, 5970.1,	, 3674.9,	, 64.014,	,	, 1.115,	, 1.178,	, 1.113,	,	, 42.542
778.5	, 5979.2,	, 3701.4,	, 72.257,	,	, 1.116,	, 1.186,	, 1.257,	,	, 42.849
796.	, 6036.3,	, 3709.,	, 72.729,	,	, 1.127,	, 1.189,	, 1.265,	,	, 42.937
813.5	, 6033.2,	, 3725.9,	, 69.443,	,	, 1.127,	, 1.194,	, 1.208,	,	, 43.132
831.	, 6067.5,	, 3757.6,	, 63.343,	,	, 1.133,	, 1.204,	, 1.102,	,	, 43.499
848.5	, 6073.6,	, 3733.5,	, 69.471,	,	, 1.134,	, 1.197,	, 1.208,	,	, 43.22
866.	, 6079.3,	, 3767.1,	, 70.529,	,	, 1.135,	, 1.208,	, 1.227,	,	, 43.609
883.5	, 6118.,	, 3781.9,	, 63.471,	,	, 1.142,	, 1.212,	, 1.104,	,	, 43.781
901.	, 6057.9,	, 3759.,	, 69.571,	,	, 1.131,	, 1.205,	, 1.21,	,	, 43.515
918.5	, 6105.6,	, 3741.8,	, 66.571,	,	, 1.14,	, 1.199,	, 1.158,	,	, 43.316
936.	, 6110.,	, 3769.9,	, 65.486,	,	, 1.141,	, 1.208,	, 1.139,	,	, 43.642
953.5	, 6072.5,	, 3749.1,	, 64.057,	,	, 1.134,	, 1.202,	, 1.114,	,	, 43.401
971.	, 6079.,	, 3747.5,	, 64.871,	,	, 1.135,	, 1.201,	, 1.128,	,	, 43.382
988.5	, 6098.8,	, 3761.9,	, 69.714,	,	, 1.139,	, 1.206,	, 1.212,	,	, 43.549
1006.	, 6111.3,	, 3759.9,	, 64.414,	,	, 1.141,	, 1.205,	, 1.12,	,	, 43.526
1023.5	, 5970.5,	, 3686.7,	, 68.914,	,	, 1.116,	, 1.182,	, 1.199,	,	, 42.678

Fig. 5.3.27 Sample of input preparation for external graphic soft

5.4 Maintenance of the database

If you chose the Select2:(2)DB Maintenance in the Main Menu shown in Fig. 5.3.1, the following menu appears. Then, you can input of new data and rearrange the stored data, etc.

```
<< MAINTENANCE DATABASE >>
(1) Input New Data
(2) Change & Delete Data
(3) Reference Data
(4) END ( ----> MAIN MENU )
```

Fig. 5.4.1 The Database Maintenance Menu

Select1 : Input of New Data ; Go to the New Data Input Menu shown in Fig. 5.4.3.(Refer to the Section 5.4.2.)

Select2 : Rearrange and Delete the Stored Data ; Go to the Rearrange and Delete Menu shown in Fig. 5.4.10.(Refer to the Section 5.4.3.)

Select3 : Reference of the Data ; Go to the Data Referrence Menu shown in Fig.5.4.16.(Refer to the Section 5.4.4)

Select4 : END ; Go to the Main Menu(Refer to the Section 5.3.1)

5.4.1 Common operations in the database maintenance

The following menu appears just after the term selection in the Database Maintenance Menu.

Add/discard	Edit	Goto	Exit
-------------	------	------	------

Fig. 5.4.2 The Data Input and Arrangement Menu

(1) Termination of Input Operation

[RETURN] key ; If you terminate the input operation by [RETURN] key, the cursor moves to the top of the menu.

[ESC] key ; If you terminate the input operation by [ESC] key, the cursor moves to <Exit> in the menu.

(2) <Exit>

If you press the [RETURN] key after the selection of <Exit>, the following message appears.

< Do you want to save your changes ? Yes No >

If you press [ESC] key after the selection of Yes or No, the menu in Fig. 5.4.2 is presented again.

But, in the case of no input operation or the saving operation already completed, return to the menu just before without representation of this message.

(3) <Add/discard>

If you choose this operation, the following pulldown menu is presented.

Add row : The data on the current display are written into the database, and after the display clear the system is under the input waiting mode.

Add and duplicate row : The data are written into the database, and

the system is under the input waiting mode with keeping the current display.

Discard row : Back to the display under the initial condition.

Add row and exit : The <Add/discard> operation is terminated after the data written on the database.

(4) <Edit>

If you chose this operation, the following pulldown menu is presented.

Add row : The data with the NULL values in every term are written

on the database, and after the display clear the system is under the input waiting mode.

Duplicate row : The current data are written into the database, and the system is under the input waiting mode with keeping the current display.

Delete row : Delete the data on the current display.

Discard changes : Go back to the display under the condition before the data arrangement operation. If you save the current data, the old data before the arrangement are deleted.

Save changes : The current data are written into the database, the next data are presented. If there are no new data, the last data are presented.

(5) <Go to>

If you chose this operation, the following pulldown menu is presented.

Next row : The data just after the current data on the display are

presented.

Previous row : The data just before the current data on the display are presented.

Next section : In the case of the new data input, return to the display just before this menu. If it is the case of stored data rearrangement, this menu has no effect.

5.4.2 The input of new data

If you choose Select1:(1)Input New Data in the DB Maintenance Menu shown in Fig. 5.4.1, the following menu appears.

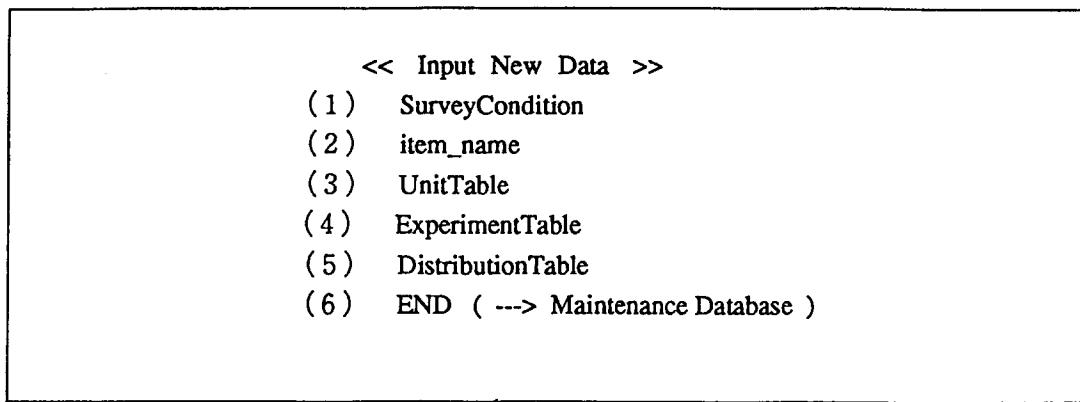


Fig. 5.4.3 New Data Input Menu

You can select the item to be input in this menu.

Select1 : Survey(Measurement) Condition ;

 Go to the Measurement Condition Input Table
 (See Fig. 5.4.4. and Section 5.4.2(1)).

Select2 : Item Name ;

 Go to the Item Name Input Table
 (See Fig. 5.4.5. and Section 5.4.2(2)).

Select3 : Unit Data ;

 Go to the Unit Data Input Table
 (See Fig. 5.4.6. and Section 5.4.2(3)).

Select4 : Experiment(Isotopic Composition) Data ;

 Go to the Isotopic Composition Data Input Table
 (See Fig. 5.4.7. and Section 5.4.2(4)).

Select5 : Distribution(Burnup or Gamma Activity Profile) Data ;

 Go to the Burnup Profile Data Input Table
 (See Fig. 5.4.9. and Section 5.4.2(5))

Select6 : END ; Return to the Database Maintenance Menu

(See Fig. 5.4.1)

(1) Measurement Condition Data

If you chose the Select1: (1)Survey Condition in the New Data Input Menu, the following message appears and you can input any measurement condition.

```
< isotopic composition >
< (TRI:101- OBR:201- GUN:301- MIHA:401- GEN:451- MON:501->
< ROB:601- CALV:621- COOPER:641- ) >
< profile of gamma-ray activity >
< (GEN:11010- TURU:21011- ) >
< Serial number in the reactor >
< Enter Data ID [ESC : END] >
```

Then, you should keyin any serial ID number of the new data to be stored in the database system. You can not use same ID number for the both of isotopic composition data and gamma activity profile data, even if they are the data about same reactor core

If the number already exists in the system, the following message appears at the bottom of the display.

< Already exist >

Then, you should input another number. If you press the [ESC] key without any input, you will return to the New Data Input Menu.

When the ID number input is completed, the following table appears as shown in Fig. 5.4.4.

Add/discard Go to Exit ++ Setting data attribute table ++		
Data ID	990	
Reactor Name	[]	(within 6 characters)
Reactor Type	[]	('BWR' or 'PWR')
Assembly Name	[]	(within 8 characters)
Cooling Time	[]	(unit:year)
Initial Enrichment	[]	(unit:wt%)
Id of Burnup	[]	(representative in some methods)
	method	0:No data - case of distribution data 1:Nd-148 2:Heavy Metal 3:Cs-137 Destructive 4:Cs-137 NonDestructive
Average Burnup	[]	(Average in assembly)
Laboratory	[]	(within 3 characters)
Horizontal Position of Fuel Rod	[]	(address in the core, within 3 characters)
Axial Position ID	[]	('A':top 'B':middle 'C':bottom)
Axial Height	[]	(within 10 characters ex. '100mm' '1.5ft')
Comment	[]	
Form: CondInp Table: SurveyCondition Field: reac_name Page: 1		

Fig. 5.4.4 The Measurement Condition Input Table

Using the cursor key, you should fill in every item [] with characters and numbers for the new data.

When the parameter input is completed, the cursor moves to the menu at the top of the current display. You can store the data in the

database system using the functions in this menu in such a way as described in the Section 5.4.1.

In this case, there is no <Edit> in the menu, and there are <Discard row> and <Add row and exit> only in the pulldown menu of <Add/discard> menu.

If the operation is completed, the data ID input message appears again for the next new data.

If you don't have any more data, you press the [ESC] key, and the New Data Input Menu appears again.

(2) Item Name Data

If you chose Select2:(2) Item name in the New Data Input Table (Fig. 5.4.3), the Item Name Input Menu appears as shown in Fig. 5.4.5.

Add/discard	Go to	Exit
++ Input Item ++		
Serial Number [95]]	
Item []	
(within 45 characters, ex. U-235 Depletion, Pu-239/Total Pu)		
Table Number []	(1:AttributeTable 2:ExperimentTable)	
Output Flag []	(1:include in printing and file out, 0:not include)	
Graph Flag []	(1:include in file out for graph, 0:not include)	
Atomic Number []	(for only nuclide)	
Form: ItemInp Table: SelectionTable Field: selection_name Page: 1		

Fig. 5.4.5 The Item Name Input Table

Using the cursor key, you should fill each item [] with characters and numbers for new data, for example, U-235 depletion for item name, etc. But, the serial number of this table is automatically set and the user can not input the parameter..

If the parameter input is completed, you should store the data in the database system using the top menu(See Section 5.4.1) of the display.

In this case, there is no <Edit> in the menu.

When the operation is completed, the New Data Input Menu will return back to the display.

(3) Unit Data

If you chose Select3:(3) Item name in the New Data Input Menu(Fig. 5.4.3), the Unit Data Input Table appears as shown in Fig. 5.4.6.

Fig. 5.4.6 The Unit Data Input Table

You should input the unit ID with 1 character and the unit with less than 30 characters, for example, unit ID:A and the unit:MWd/MTU, etc. If the parameter input is completed, you should store the data in the database system using the top menu(See Section 5.4.1) of the display. In this case, there is no <Edit> in the menu.

When the operation is completed, the New Data Input Menu will return back to the display(See Fig. 5.4.3).

(4) Isotopic Composition Data

If you chose Select4:(4) Experiment Table in the New Data Input Menu(Fig. 5.4.3), the Data ID and Item Name Input Table appears as shown in Fig. 5.4.7.

You should input the new data ID and the item name in this table. In this case, the ID and the item name must be presented already in the system, but a pair of the ID and the item must not be presented in the system. If the pair already exists, the following message appears, and it requires another input..

< Already exist >

If you input the data ID only and press the [SPACE] key, the Item Selection Menu appears(See Section 5.3.1(7)). Then, you can select the item name in the menu.

If you press the [ESC] key without any input, the New Data Input Menu(Fig.5.4.3) will be back to the current display.

```

++ Input Key ++
;
Data ID [0      ] (TRI:101-, OBR:201-, GUN:301-, MIHA#3:401-, GEN#1:451-
    MONTIC:501-, ROB#2:601-, CALV#1:621-, COOPER:641-
        serial number in the reactor)
    (no-input ===> end)
Item   [
        ]
    (within 45 characters, ex. U-235 Deplation, Pu-239/Total Pu)
    (no-input ===> select Item-name by menu)

```

Fig. 5.4.7 Data ID and Item Name Input Table

When you finished to input a pair of data ID and item successfully, the following table appears(See Fig. 5.4.8).

```

Add/discard Go to Exit
++ Setting a experimental value table ++
Data ID      998
Item         Am-241
Value          [      ] (numerical data)
Unit ID       [ ] (within 1character , see UnitTable)
Nuclide Group ID [ ] ('A':burnup 'B':actinide 'C':F.P.)
Comment        [      ]
                ]

*Data ID, Item and Unit ID respectively correspond to the data attributie
table, the item table and the unit table. You can get these ID and item by
using 'Reference Data' in main menu.

```

Form: SurvInp Table: ExperimentTable Field: exp_value Page: 1

Fig. 5.4.8 The Isotopic Composition Data Input Table

You should fill every item's [] with characters or numbers in the table using the cursor key.

Press the [ESC] key after the input, and the cursor moves to the top menu of the display. You should store the data in the database system using the menu(See Section 5.4.1).

In this case, there is no <Edit> in the menu, and there are <Discard row> and <Add row and exit> only in the pulldown menu of <Add/discard> menu.

When you finished this operation, the Data ID and Item Name Input Table appears again. Then, if you have more data to be stored, you can continue the data storage operation.

(5) Burnup (Gamma Activity) Profile Data

If you chose Select5:(5) Distribution Table in the New Data Input Menu(Fig. 5.4.3), the following message appears.

```
< (GEN:11xxx TURU:21xxx-          >
<           Serial number in the reactor    )   >
<           Enter Data ID [ESC:END]        >
```

Then, you should keyin the data ID of the new data to be stored.

If you press the [ESC] key without any input, the New Data Input Menu(Fig.5.4.3) will return back to the display.

When the data ID input is completed, the following table appears.

Add/discard Go to Exit ++ Setting Distribution Table data ++		
Data ID	11010	(GEN#1:11xxx, TURU#1:21xxx serial number in the reactor)
height	[mm]	(height in the rod)
Cs-134(abs)	[CPS]	(absolute value of gamma-ray distribution)
Cs-137(abs)	[CPS]	
Eu-154(abs)	[CPS]	
Total (abs)	[CPS]	
Form: DstInp Table: DistributionTable Field: height_numeric Page: 1		

Fig. 5.4.9 Burnup Profile Data Input Table

You should fill in every item in [] with real numbers in the table using the cursor key.

Press the [ESC] key after the input, and the cursor moves to the top menu of the display. In this case, there is no <Edit> in the menu. You should store the data in the database system using the menu(See Section 5.4.1). Even if you do storage operation without any input in the table, the message to ask which you store it or not appears. Then, you have to press <No>. If you press <Yes>, null data is stored.

When you finished this operation, the data ID input message appears again. Then, if you have more data to be stored, you can continue the data storage operation.

5.4.3 Change and delete the stored data

When you chose SELECT2:(2)Change & Delete Data in the Database Maintenance Menu shown in Fig. 5.4.1, the following menu appears, and you can arrange and delete the already stored data.

```
<< Change & Delete Data >>
(1) SurveyCondition
(2) item_name
(3) UnitTable
(4) ExperimentTable
(5) DistributionTable
(6) END ( ----> Maintenance Database )
```

Fig. 5.4.10 The Stored Data Change and Delete Menu

You can chose the following function in the menu and execute it.
 Select1: Change and Delete the Measurement Condition Data ; See
 Section 5.4.1(1).

Select2: Change and Delete the Item Name ; See Section 5.4.1(2).

Select3: Change and Delete the Unit Data ; See Section 5.4.1(3)

Select4: Change and Delete the Isotopic Composition Data ; See
 Section 5.4.1(4).

Select5: Change and Delete the Burnup Profile Data ; See Section
 5.4.1(5).

Select6: END ; Return to the Database Maintenance Menu(Fig.5.4.1).

(1) Change and delete the measurement condition data

When you chose Select1:(1) Survey condition in the menu shown in Fig.5.4.10, the following message appears and you can start the data change and delete operations by some input.

```
< isotopic composition >
< ( TRI:101- OBR:201- GUN:301- MIHA:- 401- GEN:451-
  < MON:501- ROB:601- CALV:621- COOPER:641- ) >
< profile of gamma-ray activity >
< (GEN:11010- TURU:21011- ) >
```

< Serial number in the reactor >
 < Enter Data ID [ESC:END] >
 Then, keyin the data ID number stored already. If it is still not stored, the following message appears at the bottom of the display.
 < Not exist >
 You have to keyin another ID again. (If you press the [ESC] key without any input, return to the Change and Delete Data Menu.)
 If it is already stored, the following table appears(See Fig. 5.4.11.)

Edit Go to Exit ++ Setting a data attribute table ++	
Data ID	[101]
Reacter Name	[TRI] (within 6 characters)
Reactr Type	[PWR] ('BWR' or 'PWR')
Assembly Name	[509-049](within 8 characters)
Cooling Time	[0.](unit:year)
Initial Enrichment	[2.719](unit:wtt%)
Burnup ID	[3] (representative in some methods.) method 0:No data - case of distribution data) 1:Nd-148 2:HeavyMetal 3:Cs-137 Destructive 4:Cs-137 Non Destructive
Average Burnup	[-0-] (Average Burnup of assembly.unit:GED/tU)
Laboratory	[ISP] (within 3 characters)
Horizontal Position of Rod	[L5](the adress in the core, within 3 characters)
Axial Position ID	[A] ('A':top 'B':middle 'C':bottom)
Axial Height	[POS.1] (within 10 characters ex. '100mm' '1.5ft')
comment	{ -0- }
]
Form:	CondEdt
Table:	SurveyCondition
Field:	reac_name
Page:	1

Fig. 5.4.11 The Measurement Condition Data Change Table

You can identified the data to be changed or deleted with some input of the items using the cursor key.

In the case of isotopic composition data, the burnup ID is 1,2,3,4. In the case of burnup profile data, the burnup ID is 0.

Press [ESC] key after the input, and the cursor moves to the top menu of the display. You should save the change in the database system using the menu(See Section 5.4.1).

In this case, there is no <Add/discard> in the menu, and there are <Delete row>, <Discard row> and <Save changes> only in the pulldown menu of <Edit> menu.

When you finished this operation, the Data ID input message appears again. Then, if you have more data to be change or deleted, you can continue these operations.

(2) Change and delete the item name

When you choose Select2:(2) Item Name in the menu shown in Fig.5.4.10, the following table appears(See Fig. 5.4.12).

Edit	Go to	Exit
++ Input Item ++		
Serial Number [1]		
Item [all]		
Table Number [2] (1:AttributeTable 2:ExperimentTable)		
Output Flag [1] (1:include in printing and file out, 0:not include)		
Graph Flag [0] (1:include in file out for graph, 0:not include)		
Atomic Number [-0-] (for only nuclide)		
Form: ItemEdt	Table: SelectionTable	Field: SEQNO
		Page: 1

Fig. 5.4.12 Item Name Selection Table

In this item name selection table, the item name already stored appears subsequently by using < Go to > in the menu at the top of the display.

If you find the item name to be changed or deleted, you can change or delete the data in the table. Press the [ESC] key after the input, and the cursor moves to the top menu of the display. You should save the changes in the database system using the menu(See Section 5.4.1).

In this case, there is not <Add/discard> in the menu, and there are <Delete row>, <Discard row> and <Save changes> only in the pulldown menu of <Edit> menu.

When you finished this operation, the Stored Data Change and Delete Menu appears again.

(3) Change and delete the unit data

When you chose Select3: (3) Unit Table in the Stored Data Change and Delete Menu, the following table appears(See Fig. 5.4.13).

```
Edit Go to Exit
++ Setting and Editing the Unit ID table ++
Unit ID      [A]                                (within 1 character)
Value        [GWD/MTU]                          ] (within 30 characters)
```

Fig. 5.4.13 The Unit Data Change and Delete Table

The stored unit data are presented subsequently by using <Go to> in the top menu of the display. If you find the data to be changed or deleted, you can change or delete the data on the display.

After the input operation the cursor moves to the top menu of the display. You should save the changes in the database system using the menu(See section 5.4.1).

In this case, there is not <Add/discard> in the menu, and there are <Delete row>, <Discard row> and <Save changes> only in the pulldown menu of <Edit> menu.

When you finished this operation, the Stored Data Change and Delete Menu appears again.

(4) Change and delete the isotopic composition data

If you chose Select4:(4) Experiment Table in the Stored Data Change and Delete Menu(Fig. 5.4.10), the Data ID and Item Name Input Table appears as shown in Fig. 5.4.7.

You should input the data ID and the item name to be change or deleted in this table. In this case, the pair of the ID and the item name must be stored already in the system. If the pair is still not stored, the following message appears, and it requires another input..

< Not exist >

If you input the data ID only and press the [SPACE] key, the Item Selection Menu appears(See Section 5.3.1(7)). Then, you can select the item name in the menu.

If you press the [ESC] key without any input, the Stored Data Change and Delete Menu(Fig. 5.4.10) will be back to the current display.

When you finished to input a pair of data ID and item successfully, the following table appears(See Fig. 5.4.14).

Edit Go to Exit	
++ Setting a experimental value table ++	
Data ID	[101]
Item	[Total Pu]
Value	[4.327](numerical data)
Unit ID	[D] (within 1 character, see unit table)
Nuclide Groupe ID	[B] ('A':burnup 'B':actinide 'C':F.P.)
comment	[-0-]
*Data ID, Item and Unit ID respectively correspond to the data attribute table, the item table and the unit table. You can get these ID and item by using 'Data Reference' in main menu.	
Form: SurvEdt Table: ExperimentTable Field: exp_value Page: 1	

Fig. 5.4.14 The Isotopic Composition Data Change and Delete Table

After the input operation the cursor moves to the top menu of the display. You should save the changes in the database system using the menu(See section 5.4.1).

In this case, there is not <Add/discard> in the menu, and there are <Delete row>, <Discard row> and <Save changes> only in the pulldown menu of <Edit> menu.

After the input operation, the cursor moves to the top menu of the display. You should save the changes in the database system using the menu(See Section 5.4.1).

In this case, there is not <Edit> in the menu, and there are <Discard row> and <Add row and exit> only in the pulldown menu of <Add/discard> menu.

When you finished this operation, the Data ID and Item Name Input Table appears again. Then, if you have more data to be changed or deleted, you can continue the data change operation.

(5) Change and delete the burnup(Gamma activity) profile data

When you chose Select5:(5) Distribution Table in the Stored Data Change and Delete Menu shown in Fig. 5.4.10, the following message appears.

```
< ( GEN:11xxx TURU:21xxx- >
< Serial number in the reactor ) >
< Enter Data ID [ESC:END] >
```

If you press the [ESC] key without any input, you will return to the Stored Data Change and Delete Menu.

If the data ID entered is still not stored, the following message appears at the bottom of the display.

```
< Not exist >
```

You should enter any other data ID again.

When the data ID input is completed, the following table appears(See Fig. 5.4.15).

Edit Go to Exit ++ Editting Distribution Table data ++			
Data ID	11010	(GEN#1:11xxx, TURU#1:21xxx serial number in the reactor)	
height	[mm]	8.5	(height in the rod)
Cs-134(abs)	[CPS]		(absolute value of gamma-ray distribution)
Cs-137(abs)	[CPS]	7.8431	
Eu-154(abs)	[CPS]		
Total (abs)	[CPS]	127.73	

Form: DstEdt Table: DistributionTable Field: height_numeric Page: 1

Fig. 5.4.15 The Burnup (Gamma activity) Profile Data Change and Delete Table

You can change or delete the data in this table using the cursor key. After the change operation you should stored the change using the top menu in the display. In this case, there is not <Add/Discard> in the menu, and there are <Delete row>, <Discard row> and <Save changes> only in the pulldown menu of <Edit> menu.

When you finished this operation, the data ID input message appears again. Then, if you have more data to be changed or deleted, you can continue the data change operation.

5.4.4 Stored data refer

When you chose Select3:(3) Reference Data in the Database Maintenance Menu shown in Fig. 5.4.1, the Data Reference Menu appears as follows(See Fig. 5.4.16).

```
<< Reference Data >>
(1) SurveyCondition
(2) item_name
(3) HeightTable
(4) UnitTable
(5) END ( ---> Maintenance Database )
```

Fig. 5.4.16 The Data Reference Menu

If you miss the relationship between the data content and each ID, for example, data ID, item name, height ID and unit ID, under the database maintenance operation, you can confirm it using this menu.

You choose the item to be confirmed in the following items.

Select1: Survey Condition Data ID; See Fig. 5.4.17.

Select2: Item Name; See Fig 5.4.18.

Select3: Height ID ; See Fig. 5.4.19.

Select4: Unit ID ; See Fig. 5.4.20.

Select5: END; Return to the Database Maintenance Menu.

(1) Survey condition data ID

When you choose Select1:(1) Survey condition at the before menu, the following data table appears(See Fig. 5.4.17).

Sort	Edit	Calculate	Layout	Query	Manage views	Print	Exit
condition_id		reac_name	reac_type	assembly	enrich	id	sam_burnup
101		TRI	PWR	509-049	2.719	3	7.82200003
	102	TRI	PWR	509-049	2.719	1	14.1549997
	103	TRI	PWR	509-049	2.719	1	14.4899998
	104	TRI	PWR	509-049	2.719	3	10.4779997
	105	TRI	PWR	509-049	2.719	1	10.1870003
	106	TRI	PWR	509-049	2.719	1	8.7130003
	107	TRI	PWR	509-049	2.719	1	14.7700005
	108	TRI	PWR	509-049	2.719	4	15.4420004
	109	TRI	PWR	509-049	2.719	1	15.1929998
	110	TRI	PWR	509-049	2.719	4	10.7060003
	111	TRI	PWR	509-049	2.719	1	11.1269999
	112	TRI	PWR	509-049	2.719	1	8.89500046
	113	TRI	PWR	509-049	2.719	1	7.81400013
	114	TRI	PWR	509-049	2.719	3	16.1459999
	115	TRI	PWR	509-049	2.719	1	15.5059996
	116	TRI	PWR	509-049	2.719	1	12.0530005
	117	TRI	PWR	509-032	3.13	1	7.2430003
	118	TRI	PWR	509-032	3.13	1	15.3769999
	119	TRI	PWR	509-032	3.13	1	15.8979998
	120	TRI	PWR	509-032	3.13	1	11.5290003

Database: SFCOMPO Table: SurveyCondition Read F4 to Edit Browse

Fig. 5.4.17 The Survey Condition Data Table

If there are more data behind the table, the following message appears at the bottom of this table.

< More output follows. Press Esc to quit, or any key to continue. >
You can choose <quit> or <continue>.

The following message appears in the last page of the table.
< press any key >. When you press any key, the data table disappears and the Data Reference Menu appears again.

(2) The item name refer

The following table appears when you choose Select2:(2) Item name in the Data Reference Menu(See Fig. 5.4.18).

SEQ selection_name	output	graph	atomic_wei
1 all	1	0	-0-
2 burnup(representative)	1	0	-0-
3 F.P.	1	0	-0-
4 actinoids	1	0	-0-
6 burnup(by Nd-148 method)	1	1	-0-
7 burnup(by Cs-137 Destructive method)	1	1	-0-
8 burnup(by Cs-137 Non-destructive method)	1	1	-0-
9 burnup(by Heavy Metal method)	1	1	-0-
10 Ce-144	1	1	-0-
11 Ru-106	1	1	-0-
12 Cs-137	1	1	-0-
13 Cs-134	1	1	-0-
14 Eu-154	1	1	-0-
15 Sb-125	1	1	-0-
16 Cs-134/Cs-137	1	1	-0-
17 Eu-154/Cs-137	1	1	-0-
18 Cs-137/U-238	1	1	-0-
19 Pu-239/U-238	1	1	-0-

More output follows. Press Esc to quit, any key to continue.

Fig. 5.4.18 The Item Name Reference Table

You can confirm the item name with the same key operations as described in the former section.

The Data Reference Menu appears again after the data confirmation operation.

(3) The height ID refer

The following table appears when you choose Select3:(3) Height Table in the Data Reference Menu(See Fig. 5.4.19).

height	height_e
A	top
B	middle
C	bottom
D	
X	

Fig. 5.4.19 The Height Data Reference Table

You can confirm the height ID with the same key operations as described in the former section.

The Data Reference Menu appears again after the data confirmation operation.

(4) The Unit Data Refer

The following table appears when you choose Select4:(4) Unit table in the Data Reference Menu(See Fig. 5.4.20).

unit_i	unit_express
A	GWD/MTU
B	dis/sec/g of final Uranium
C	dps/g of final Uranium
D	kg/MTU initial
E	atoms/100 initial heavy atoms
F	atoms/1000 initial heavy atoms
G	atoms/10E6 initial heavy atoms
H	-----
I	MCRG/g of Uranium
J	Bq/g
K	CPS
X	wt%
Y	year

Fig. 5.4.20 The Unit Data Reference Table

You can confirm the unit ID with the same key operations as described in the former section.

The Data Reference Menu appears again after the data confirmation operation.

5.5 Fundamental limitations in the database

In the database SFCOMPO, there are five fundamental restrictions as follows.

- (1) The items which you must keyin some input.

Survey Condition Data ID, Unit ID, Height ID, Item Name,
Reactor Type, Core Name, Assembly Name.

- (2) The items which you can not use same name in the table.

Data ID(in the Survey Condition Table)
Unit ID(in the Unit Table)
Height ID(in the Height Table)
Item Name(in the Item Selection Table)
A pair of Item Name and Data ID
(in the Distribution Table; the Burnup Profile Data Table)

- (3) The items which must be already stored in the right-side table before the items will be stored in the table.

Data ID(in the Data Table; Isotopic Composition Data or Burnup Profile Data Table)	Survey Condition Table
Unit ID (in the Survey Condition Table)	Unit Table
Height ID (in the Survey Condition Table)	Height Table
Item Name(in the Data Table)	Item Selection Table
Sample Burnup ID (Survey Condition Table)	Burnup Measurement Method Table

- (4) The items which you can not be deleted

when it is used in the other table

Data ID(in the Survey Condition Table)
Unit ID(in the Unit Table)
Height ID(in the Height Table)
Item Name(in the Item Selection Table)

- (5) The items whose values are limited in some area.

The flag for the general output selection (in the Item Selection Table)	0 or 1
The flag for the graphic output selection (in the Item Selection Table)	0 or 1
The kind of table (in the Item Selection Table)	1 or 2

6. Conclusions

The LWR spent fuel isotopic composition SFCOMPO database was prepared for researchers and engineers engaged in the study of burnup calculation and burnup credit, etc. on the nuclear fuel cycle safety. The data in the database will be used as benchmark data for the verification of burnup calculation codes.

The database SFCOMPO has the isotopic composition data from the 10 LWRs'(6 PWRs' and 4 BWRs'), and some axial burnup profile data collected from the Japanese nuclear reactors. But the details of the history data of the reactors and fuels are not included in the database. Therefore, the users of the database should refer to this report and the report of JAERI-M 94-034. There are many functions in the database system; the new data storage, the stored data change, the data search, etc. The users can easily use the database for many types of studies.

We are going to collect more assay data of LWR spent fuel, and we will collect assay data of MOX spent fuel in near future. And, we will revise this database by including the new data.

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国際単位系(SI)と換算表

表1 SI基本単位および補助単位

量	名称	記号
長さ	メートル	m
質量	キログラム	kg
時間	秒	s
電流	アンペア	A
熱力学温度	ケルビン	K
物質量	モル	mol
光强度	カンデラ	cd
平面角	ラジアン	rad
立体角	ステラジアン	sr

表3 固有の名称をもつSI組立単位

量	名称	記号	他のSI単位による表現
周波数	ヘルツ	Hz	s ⁻¹
力	ニュートン	N	m·kg/s ²
圧力、応力	パスカル	Pa	N/m ²
エネルギー、仕事、熱量	ジュール	J	N·m
功率、放射束	ワット	W	J/s
電気量、電荷	クーロン	C	A·s
電位、電圧、起電力	ボルト	V	W/A
静電容量	ファラード	F	C/V
電気抵抗	オーム	Ω	V/A
コンダクタンス	ジーメンス	S	A/V
磁束密度	ウェーバ	Wb	V·s
磁束密度	テスラ	T	Wb/m ²
インダクタンス	ヘンリー	H	Wb/A
セルシウス温度	セルシウス度	°C	
光束度	ルーメン	lm	cd·sr
照度	ルクス	lx	lm/m ²
放射能	ベクレル	Bq	s ⁻¹
吸収線量	グレイ	Gy	J/kg
線量当量	シーベルト	Sv	J/kg

表2 SIと併用される単位

名称	記号
分、時、日	min, h, d
度、分、秒	°, ′, ″
リットル	l, L
トントン	t
電子ボルト	eV
原子質量単位	u

$$1 \text{ eV} = 1.60218 \times 10^{-19} \text{ J}$$

$$1 \text{ u} = 1.66054 \times 10^{-27} \text{ kg}$$

表4 SIと共に暫定的に維持される単位

名称	記号
オングストローム	Å
バーン	b
バール	bar
ガル	Gal
キュリ	Ci
レンントゲン	R
ラド	rad
レム	rem

$$1 \text{ Å} = 0.1 \text{ nm} = 10^{-10} \text{ m}$$

$$1 \text{ b} = 100 \text{ fm}^2 = 10^{-28} \text{ m}^2$$

$$1 \text{ bar} = 0.1 \text{ MPa} = 10^5 \text{ Pa}$$

$$1 \text{ Gal} = 1 \text{ cm/s}^2 = 10^{-2} \text{ m/s}^2$$

$$1 \text{ Ci} = 3.7 \times 10^{10} \text{ Bq}$$

$$1 \text{ R} = 2.58 \times 10^{-4} \text{ C/kg}$$

$$1 \text{ rad} = 1 \text{ cGy} = 10^{-2} \text{ Gy}$$

$$1 \text{ rem} = 1 \text{ cSv} = 10^{-2} \text{ Sv}$$

表5 SI接頭語

倍数	接頭語	記号
10^{18}	エクサ	E
10^{15}	ペタ	P
10^{12}	テラ	T
10^9	ギガ	G
10^6	メガ	M
10^3	キロ	k
10^2	ヘクト	h
10^1	デカ	da
10^{-1}	デシ	d
10^{-2}	センチ	c
10^{-3}	ミリ	m
10^{-6}	マイクロ	μ
10^{-9}	ナノ	n
10^{-12}	ピコ	p
10^{-15}	フェムト	f
10^{-18}	アト	a

(注)

- 表1～5は「国際単位系」第5版、国際度量衡局1985年刊行による。ただし、1eVおよび1uの値はCODATAの1986年推奨値によった。
- 表4には海里、ノット、アール、ヘクタールも含まれているが日常の単位なのでここでは省略した。
- barは、JISでは流体の圧力を表わす場合に限り表2のカテゴリーに分類されている。
- EC閣僚理事会指令ではbar、barnおよび「血圧の単位」mmHgを表2のカテゴリーに入れている。

換算表

力	N(=10 ⁵ dyn)	kgf	lbf
1	0.101972	0.224809	
9.80665	1	2.20462	
4.44822	0.453592	1	

$$\text{粘度 } 1 \text{ Pa}\cdot\text{s} (\text{N}\cdot\text{s}/\text{m}^2) = 10 \text{ P(ボアズ)} (\text{g}/(\text{cm}\cdot\text{s}))$$

$$\text{動粘度 } 1 \text{ m}^2/\text{s} = 10^4 \text{ St(ストークス)} (\text{cm}^2/\text{s})$$

圧	MPa(=10 bar)	kgf/cm ²	atm	mmHg(Torr)	lbf/in ² (psi)
力	1	10.1972	9.86923	7.50062×10^3	145.038
0.0980665	0.0980665	1	0.967841	735.559	14.2233
0.101325	0.101325	1.03323	1	760	14.6959
1.33322×10^{-4}	1.33322×10^{-4}	1.35951×10^{-3}	1.31579×10^{-3}	1	1.93368×10^{-2}
6.89476×10^{-3}	6.89476×10^{-3}	7.03070×10^{-2}	6.80460×10^{-2}	51.7149	1

エネルギー・仕事・熱量	J(=10 ⁷ erg)	kgf·m		kW·h		cal(計量法)	Btu	ft · lbf	eV	1 cal = 4.18605 J(計量法)	
		1	0.101972	2.77778×10^{-7}	0.238889					= 4.184 J(熱化学)	
9.80665	1	2.72407	2.72407×10^{-6}	2.34270	9.29487×10^{-3}	7.23301	6.12082×10^{19}			= 4.1855 J(15 °C)	
3.6×10^6	3.67098×10^5	1	8.59999×10^5	3412.13	2.65522×10^6	2.24694×10^{25}				= 4.1868 J(国際蒸気表)	
4.18605	0.426858	1.16279×10^{-6}	1	3.96759×10^{-3}	3.08747	2.61272×10^{19}				仕事率 1 PS(仏馬力)	
1055.06	107.586	2.93072×10^{-4}	252.042	1	778.172	6.58515×10^{21}				= 75 kgf·m/s	
1.35582	0.138255	3.76616×10^{-7}	0.323890	1.28506×10^{-3}	1	8.46233×10^{18}				= 735.499 W	
1.60218×10^{-19}	1.63377×10^{-20}	4.45050×10^{-26}	3.82743×10^{-20}	1.51857×10^{-22}	1.18171×10^{-19}	1					

放射能	Bq	Ci	吸収線量	Gy	rad
	1	2.70270×10^{-11}		1	100
	3.7×10^{10}	1	0.01	1	

照 射 線 量	C/kg	R
	1	3876
	2.58×10^{-4}	1

線 量 当 量	Sv	rem
	1	100
	0.01	1

(86年12月26日現在)

THE ISOTOPIC COMPOSITIONS DATABASE SYSTEM ON SPENT FUELS IN LIGHT WATER REACTORS(SFCOMPO)

The Isotopic Compositions Database System on Spent Fuels in Light Water Reactors (SFCOMPO) is a comprehensive database system designed to store and manage data related to the isotopic compositions of spent nuclear fuel from light water reactors. The system is intended to support various applications, such as reactor physics calculations, waste management, and nuclear non-proliferation efforts. The database includes information on the chemical composition of the fuel rods, the distribution of various isotopes (e.g., U-235, U-238, Pu-239, etc.) within the rods, and the resulting gamma-ray spectra. The system also provides tools for data analysis, visualization, and reporting.

The SFCOMPO system consists of several interconnected components. At its core is a relational database management system (RDBMS) that stores the primary data. This database is populated through various input sources, including experimental measurements, theoretical calculations, and data from other databases. The RDBMS is connected to a web-based user interface, which allows users to search for specific data, view detailed reports, and generate plots. The user interface is designed to be intuitive and accessible, even for users without extensive technical knowledge. In addition to the main database and user interface, the system includes a set of analytical tools. These tools are used to perform complex calculations, such as neutron transport simulations, and to validate the data stored in the database. They also provide statistical analysis and data mining capabilities to help identify trends and patterns in the isotopic data.

The development of the SFCOMPO system has been a collaborative effort involving researchers from multiple institutions. The team includes experts in nuclear engineering, computer science, and data analysis. The project has received funding from several sources, including the National Nuclear Security Administration (NNSA) and the Department of Energy (DOE). The system is currently in the final stages of development and is expected to be fully operational by early 2024. Once it is live, it will be available to researchers and analysts around the world who need access to accurate and up-to-date data on spent fuel isotopic compositions. The hope is that this tool will contribute to the advancement of nuclear energy and the safe management of radioactive waste.