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Radiochemical Analyses of Several Spent Fuel Approved Testing Materials

R. J. Guenther
D. E. Blahnik
N. J. Wildung

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Pacific Northwest Laboratory
Richland, Washington 99352

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Abstract

Radiochemical characterization data are described for UO_2 and UO_2 plus 3 wt% Gd_2O_3 commercial spent nuclear fuel taken from a series of Approved Testing Materials (ATMs). These full-length nuclear fuel rods include MLA091 of ATM-103, MKP070 of ATM-104, NBD095 and NBD131 of ATM-106, and ADN0206 of ATM-108. ATMs 103, 104, and 106 were all irradiated in the Calvert Cliffs Nuclear Power Plant (Reactor No.1), a pressurized-water reactor that used fuel fabricated by Combustion Engineering. ATM-108 was part of the same fuel bundle designated as ATM-105 and came from boiling-water reactor fuel fabricated by General Electric and irradiated in the Cooper Nuclear Power Plant. Rod average burnups and expected fission gas releases ranged from 2400 to 3700 GJ/kgM. (25 to 40 Mwd/kgM) and from less than 1% to greater than 10%, respectively, depending on the specific ATM.

The radiochemical analyses included uranium and plutonium isotopes in the fuel, selected fission products in the fuel, fuel burnup, cesium and iodine on the inner surfaces of the cladding, ^{14}C in the fuel and cladding, and analyses of the gases released to the rod plenum. Supporting examinations such as fuel rod design and material descriptions, power histories, and gamma scans used for sectioning diagrams are also included.

These ATMs were examined as part of the Materials Characterization Center Program conducted at Pacific Northwest Laboratory provide a source of well-characterized spent fuel for testing in support of the U.S. Department of Energy Office of Civilian Radioactive Waste Management Program.

Summary

Radiochemical analyses of the fuel, cladding, and samples of gas from the rod plenum are reported for five light-water reactor fuel rods fabricated by Combustion Engineering and General Electric. The fuel contained UO_2 and UO_2 plus 3 wt% Gd_2O_3 taken from a series of ATMs. These full-length nuclear fuel rods include MLA091 of ATM-103, MKP070 of ATM-104, NBD095 and NBD131 of ATM-106, and ADN0206 of ATM-108. Hydrogen in the cladding from Rod G13 of ATM-101 are also reported.

Results of the burnup analyses and apparent fission gas releases are consistent with previous data for Rods MLA091, MKP707, NBD095, and NBD131, all of which were fabricated by C-E. Approximate end-of-life, rod-averaged burnups for these rods were 28, 38, 40, and 46 MWd/kgM, respectively. Apparent fission gas releases to the rod plenum were < 1% for Rods MLA091 and MKP070, about 7% for Rod NBD095, and about 18% for Rod NBD131. Rod ADN0206, (with 3 wt% gadolinia in the as-fabricated fuel rod) had a end-of-life, rod-averaged burnup of about 24 MWd/kgm, and unexpectedly, moderate fission gas release of possibly 9%. Data for hydrogen is the cladding of Rod G13 from ATM-101 indicates hydrogen content increased by about 200% from the bottom to the top of the rod. Except for the fission gas release in Rod ADN0206, the burnups and fission gas releases were consistent with previous results for other fuel rods from these ATMs.

Extensive additional data has been published for these ATMS, including fuel burnup, the isotopes of uranium and plutonium, and specific nuclides such as ^{79}Se, ^{90}Sr, ^{99}Tc, ^{126}Sn, ^{135}Cs, ^{137}Cs, ^{237}Np, ^{241}Am, and ^{243}Cm plus ^{244}Cm. The amount of ^{129}I, ^{14}C, ^{135}Cs, and ^{137}Cs in the fuel was also determined for most of the rods. Data were also provided for cesium on the exterior and interior surfaces of the cladding, iodine on the interior surfaces of the cladding, and total ^{14}C in the cladding. No comparison of these data with previous results for other rods from the same ATMs have been made; however, the data base for these fuels has significantly expanded.

These data were all obtained in accordance with the quality assurance requirements of Impact Level I under PNL-MA-70 and meet the needs of NQA-1 quality assurance. All work was obtained other issuance of statements of work, followed by specific requests for analytical service. The results have been obtained by trained staff with the necessary verifications and recording of the data.

Acknowledgments

Characterization of these additional spent fuel rods was achieved through the efforts of many people. The authors extend their appreciation to the individuals who provided valuable assistance in conducting these analyses, including R. S. Holeman and L. J. Dunn, who conducted the in-cell fuel rod gamma scanning, fission gas sampling, and fuel rod sectioning operations; and W. Y. Matsumoto, D. L. Baldwin, M. W. Goheen, L. S. Kellogg, and many technicians who conducted radiochemical analyses.

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Acronymns

ATM	Approved Testing Material
BG&E	Baltimore Gas and Electric
BOL	beginning of life
BWR	boiling-water reactor
C:	Curie
CC-1	Calvert Cliffs Nuclear Reactor No. 1
C-E	Combustion Engineering
Cooper	Cooper Nuclear Power Plant
$d/m/cm^2$	disintegrations/minute/centimeter squared
DOE	U.S. Department of Energy
EOL	end of life
GE	General Electric
g^{fuel}	1 gram of initial fuel material (VO_2)
gZr	1 gram of Zircalog cladding
LHGRs	linear heat generation rates
MCC	Materials Characterization Center
MWd/kgM	megawatt-day per kilogram of initial heavy metal in the fuel
MWd/mtm	megawatt-day per metric ton of initial heavy metal in the fuel
OCRWM	Office of Civilian Radioactive Waste Management
PNL	Pacific Northwest Laboratory
PWR	pressurized-water reactor

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1.0 Introduction

The Materials Characterization Center (MCC) at Pacific Northwest Laboratory (PNL)[(a)] has provided spent fuel test material and samples for laboratory investigations of nuclear waste forms by the U.S. Department of Energy (DOE) Office of Civilian Radioactive Waste Management (OCRWM) Program. This report provides previously unpublished radiochemical data obtained from characterization conducted for Rod MLA091 of Approved Testing Material-103 (ATM-103), Rod MKP070 of ATM-104, Rods NBD095 and NBD131 of ATM-106, and Rod ADN0206 of ATM-108. These rods came from a series of six spent fuel ATMs characterized to support investigations of spent nuclear fuel disposal. Previously reported data are provided for ATM-101 (Barner 1985), for Rod MLA098 of ATM-103 (Guenther et al. 1988a), for Rod MKP109 of ATM-104 (Guenther et al. 1991a), for Rods ADD2966 and ADD2974 of ATM-105 (Guenther et al. 1990), and for NBD107 of ATM-106 (Guenther et al. 1988b). These characterizations were conducted at the Hanford Site in Richland, Washington. A summary of the general characteristics of the spent fuel ATMs is provided in Table 1.1.

Table 1.1. Summary of Spent Fuel ATMs (Guenther et al. 1991a)

ATM	Fuel Type	Reactor	Burnup Range	Range of	No. of Rods
101	PWR	H. B. Robinson, No. 1	16-32	0.2-0.3	9 as 27 1.2-m (4-ft) segments[(b)]
103	PWR	Calvert Cliffs, No. 1	13-33	0.25	176 full length
104	PWR	Calvert Cliffs, No. 1	26-44	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	29-47	7.8-18	20 full length
108	BWR	Cooper	~15-26	~9	10 full length

(a) Range of rod average values measured in the fuel rods examined.
(b) ATM-101 rods were cut in three sections prior to shipment to Hanford. These sections were denoted as bottom (B), center (C), or top (T).

(a) Operated by Battelle Memorial Institute for the U.S. Department of Energy.

ATM-103 was selected as a representative moderate-burnup UO_2 fuel, averaging about 2600 GJ/kgM (30 MWd/kgM), and was expected to have had only minor fission gas release from the UO_2 fuel during irradiation. This fuel was fabricated by Combustion Engineering (C-E) and irradiated in the Calvert Cliffs Nuclear Reactor No. 1 (CC-1), a pressurized-water reactor (PWR) operated by Baltimore Gas and Electric (BG&E). The 176 full-length fuel rods from Assembly D101 comprised ATM-103. ATM-101 was also a moderate-burnup, low-fission gas release fuel, but was fabricated by Westinghouse (Barner 1985).

ATM-104 has UO_2-fueled rods with a moderately high burnup of about 3700 GJ/kgM (43 MWd/kgM). These rods were also expected to have only minor fission gas release from the UO_2 fuel during irradiation and were fabricated by C-E and irradiated in the CC-1 PWR. ATM-104 consisted of 128 full-length fuel rods from Assembly D047. Of the original 176 rods irradiated in Assembly D047, 41 rods were removed for other uses by BG&E. The remaining 135 rods were received by the MCC, but seven of these rods had insufficient data on fuel fabrication specifications to be included as part of ATM-104. The 128 ATM-104 rods were selected for characterization because they had moderately high burnup and because they were manufactured by the same vendor and irradiated in the same reactor as ATM-103 (moderate burnup, low fission gas release) and ATM-106 (moderately high burnup, high fission gas release).

Fuel rods from ATM-106 had a moderately high burnup of about 3700 GJ/kgM (43 MWd/kgM) and were expected to have fission gas release of about 10% from the UO_2 fuel during irradiation. These fuel rods were fabricated by C-E and irradiated in the CC-1 PWR. Twenty full-length fuel rods from Assembly BT03 comprised ATM-106. The ATM-106 rods were removed from BT03, reinserted into unused locations in the assembly containing the ATM-104 rods, and shipped to the Hanford Site. The remaining fuel rods in Assembly BT03 were removed for other purposes by BG&E. ATM-106 fuel was selected for characterization because it had moderately high burnup and high fission gas release was expected in these rods.

The ATM-108 rods were actually part of two fuel bundles comprising ATM-105 that had UO_2-fueled and UO_2-Gd_2O_3-fueled rods with moderate burnup, estimated to average about 2400 GJ/kgM (28 MWd/kgM). The fuel bundles containing ATM-108 and ATM-105 fuel rods were fabricated by General Electric (GE) and irradiated in the Cooper Nuclear Power Plant (Cooper), a boiling-water reactor (BWR) operated by the Nebraska Public Power District. There were several fuel rod designs in the GE fuel bundles. Five of the fuel rods from each of Bundles CZ346 and CZ348 contained UO_2 and Gd_2O_3 and were designated ATM-108, with the remaining rods comprising ATM-105; the rods were not removed from the bundles unless they were examined. Because of gadolia in the fuel and various designs for rods with gadolinia, no burnup estimates were provided by the vendor for the individual rods. The fuel rods in the two bundles were expected to have low release of the fission gas from the UO_2 fuel during irradiation. Characterization of ATM-105 and ATM-108 was initiated because a significant portion of spent fuel in the U.S. comes from BWRs. The results of the ATM-105 characterization reported by Guenther et al. (1991b) can be compared with the burnup data and limited isotopic analyses available for ATM-108. Only gamma scanning, fuel burnup, and metallography were conducted on Rod ADN0206 of ATM-108.

The MCC spent fuel ATMs were selected to represent typical end-of-life (EOL) fuel conditions for their generation of fuel rods, potential extremes in EOL spent fuel conditions, or differences between PWR and BWR spent fuel from U.S. commercial nuclear reactors. This report presents the results of radiochemical analyses conducted on the fuel, cladding, and the plenum gases of spent fuel rods MLA091, MKP070, NBD095, NBD131, and ADN0206. Section 2.0 provides information on the assembly and fuel rod designs and the power histories for each ATM. Section 3.0 provides a brief description of the gamma scanning and sectioning diagrams. The results of the radiochemical analyses are discussed in Section 4.0, including ^{14}C in the cladding; ^{135}Cs, ^{137}Cs, and ^{129}I on the cladding interior surface; fuel burnup; and radiochemical analyses of selected isotopes in the fuel.

2.0 Design and Power Histories for ATMs 103, 104, 106, and 108

Available design characteristics and power histories are provided for ATMs 103, 104, 106, and 108 in Sections 2.1, 2.2, 2.3, and 2.4, respectively. Details are provided for fuel assembly design, fuel rod and pellet designs, and as-fabricated materials properties. Details on ATM-101 can be found in Barner (1985).

2.1 ATM-103 Design and Power History

ATM-103 consists of one fuel assembly (D101) irradiated for three cycles in the CC-1 PWR operated by BG&E and located outside Lusby, Maryland. The fuel assembly was discharged October 18, 1980 and transported from the reactor cooling basin to PNL in September 1985. Information is provided in Subsections 2.1.1 and 2.1.2 for the assembly and rod design, fuel and pellet initial composition, and power history during irradiation. This information is taken from Guenther et al. (1988a), in which the completed characterization of Rod MLA098 of ATM-103 is described.

2.1.1 Assembly, Fuel Rod, and Pellet Description

Assembly D101 is a standard C-E 14 x 14 fuel assembly. This fuel assembly is constructed with five guide tubes that comprise its main structure. The upper- and lower- end fittings, together with eight spacer grids and the five guide tubes, form a structural cage to support the fuel rods (Figure 2.1). All structural components except the lower Inconel grid and the stainless steel upper- and lower- end fittings are fabricated from Zircaloy-4.

The fuel rod and pellet dimensions for ATM-103 are shown in Figure 2.2. All the fuel pellets were fabricated using a standard cold-pressing and sintering process. Certification data for the fuel pellets used in Assembly D101 are shown in Table 2.1. All ATM-103 fuel rods are clad with Zircaloy-4 tubing fabricated by Sandvik Special Metals, Lot Nos. 5FS72, 5FS73, and 5DM11. Fuel cladding certification data are listed in Table 2.2. Rod MLA091 was located in position D7 of Assembly D101 during irradiation, as shown in Figure 2.3.

2.1.2 Irradiation History

The ATM-103 rods were irradiated in Assembly D101 during Cycles 2, 3, and 4 of operation of CC-1 between March 22, 1977, and October 18, 1980. The core thermal-power rating of CC-1 was 2560 MWt from beginning-of-life (BOL) until midway through Cycle 2 (September 9, 1977) when a new license was issued to increase CC-1's power rating to 2700 MWt. Excluding for a period of about five months at reduced power during reactor Cycle 4, the reactor operated at full power during Cycles 2, 3, and 4.

CC-1 contains 217 fuel assemblies. Linear heat generation rates (LHGRs) for specific fuel rods vary significantly from average LHGRs. For example, the core-average LHGR was relatively constant at about 20.3 kW/m (6.2 kW/ft) during Cycles 2, 3, and 4, while the average LHGR in Rod MLA098 ranged from a high of about 23 kW/m (7.1 kW/ft) at the beginning of Cycle 2 to a low of about

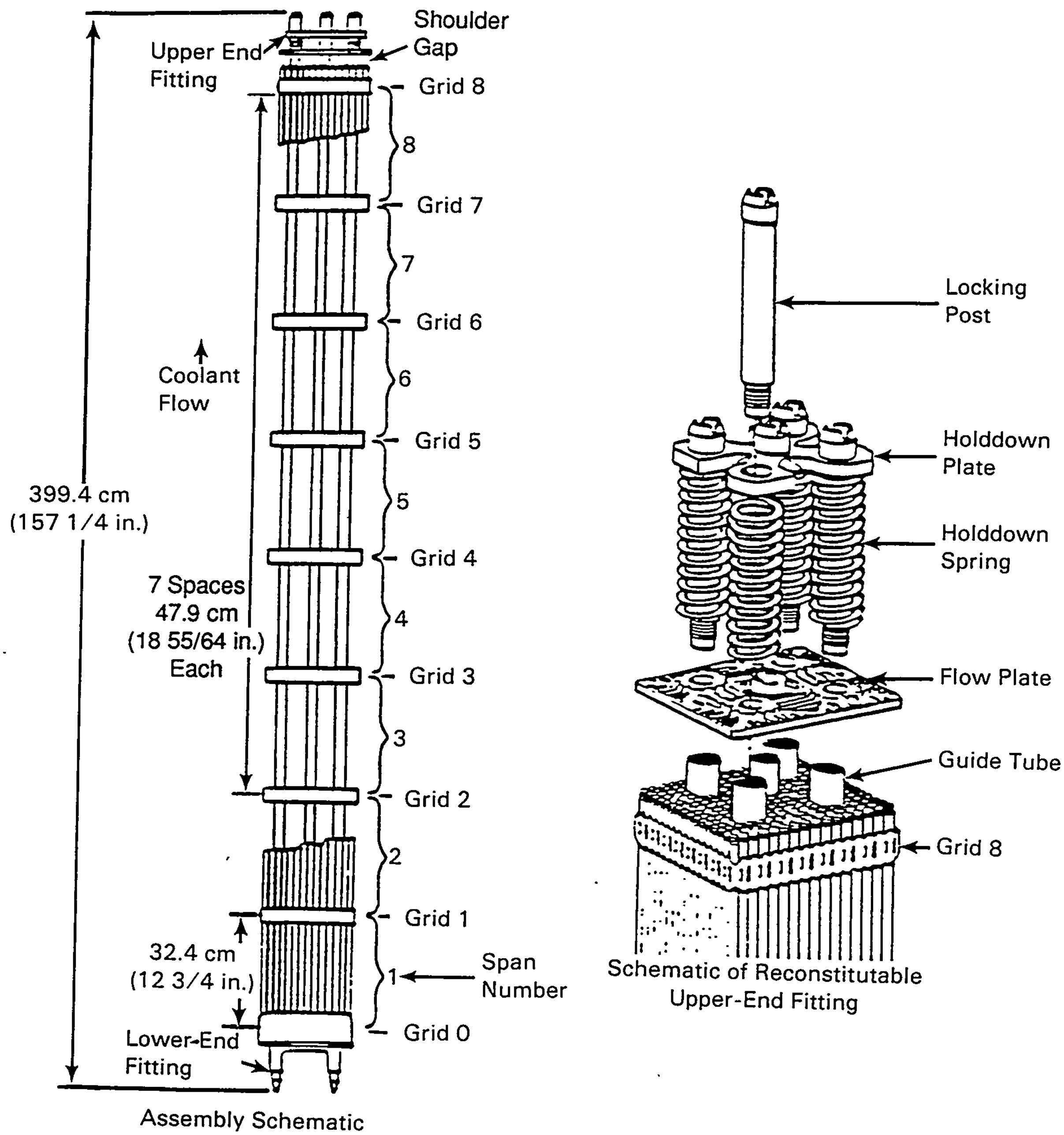

Figure 2.1. Fuel Assembly Schematic for ATMs 103, 104, and 106 (from Guenther et al. 1991a)

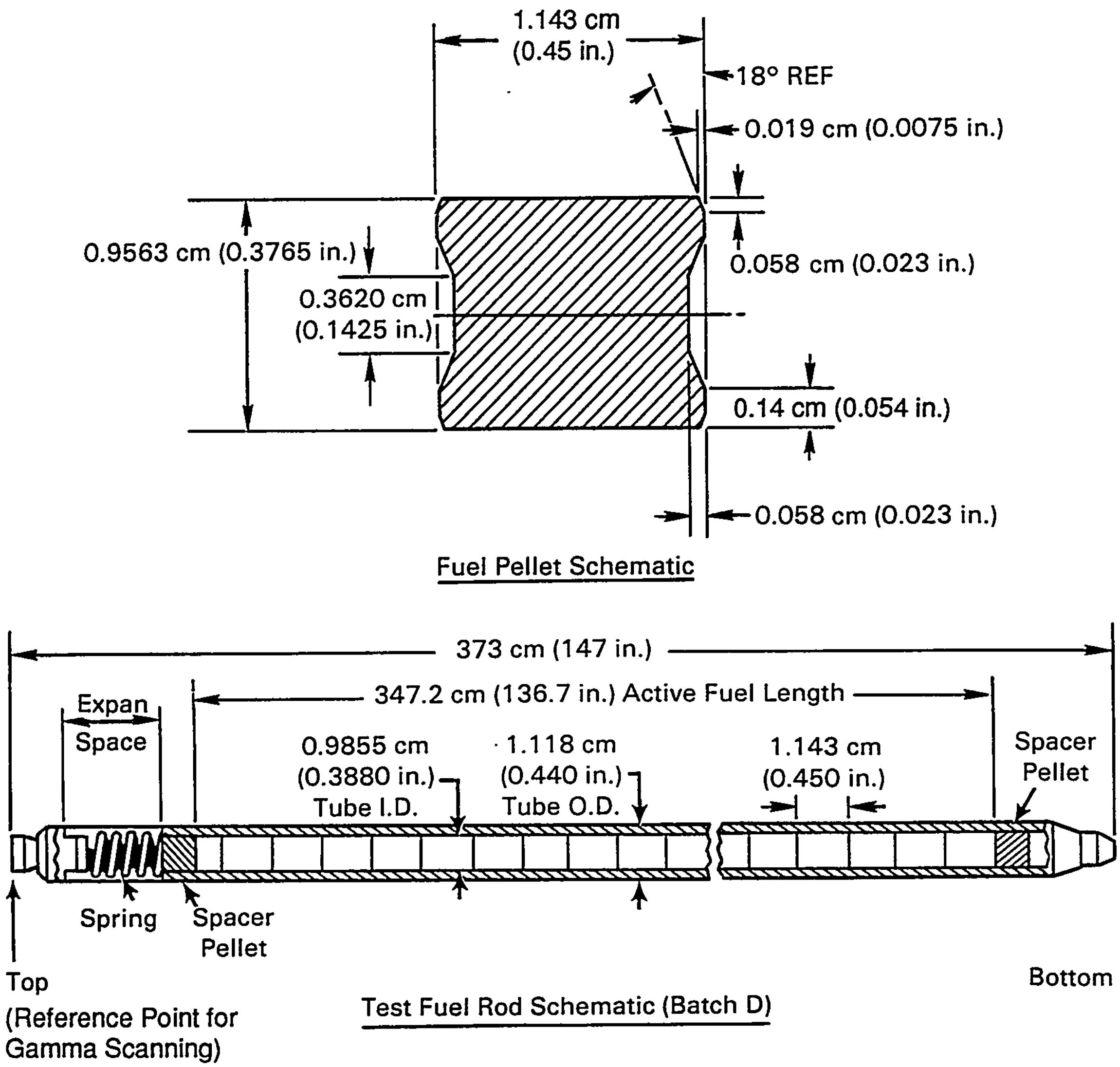

Figure 2.2. ATM-103 and ATM-104 Pellet and Fuel Rod Dimensions (from Guenther et al. 1991a)

Table 2.1. ATM-103 Fuel Pellet Certification Data (Guenther et al. 1988a)

Chemical Attribute	Fuel Lot B-60-EB Analysis Results		
Total uranium wt%	88.149	88.149	88.152
Carbon, ppm	13	12	12
Nitrogen, pp	28	28	17
Fluorine, ppm	<5	<5	<5
Chlorine & fluorine, ppm	<10	<10	<10
Iron, ppm	51	50	55
Silver, ppm	<1	<1	<1
Calcium, ppm Aluminum, ppm Silicon, ppm	<121	<120	<121
O:U ratio	2.000	2.000	2.000
Nickel, ppm	<25	<25	<25
Mass spec. analysis	2.72% ^{235}U		
Density	10.34-10.47 g/cm^3		
Grain size	≥5 μm		

18 kW/m (5.5 kW/ft) at the end of Cycle 4, as approximate for Rod MLA098 in Assembly D101 in Figure 2.4. The power history specific to Rod MLA098 is given in tabular form in Table 2.3. The actual power in other rods in assembly D101 will vary slightly depending on the actual neutron fluence; however, burnups for a given fuel rod or sample may be calculated using the power history for Rod MLA098 appropriately adjusted to yield the desired end of life burnup.

2.2 ATM-104 Design and Power History

ATM-104 consists of a portion of one fuel assembly (D047) fabricated by C-E and irradiated four cycles in CC-1. The assembly was fabricated in the mid-1970s and irradiated from March 1977 to April 1982, when it was discharged from the reactor. The fuel assembly was transported from the reactor cooling basin to PNL in September 1985. Information is provided in Subsections 2.2.1 and 2.2.2 on the assembly and rod design, fuel and pellet initial composition, and power history during irradiation. This information is taken from Guenther et al. (1991a) in which the completed characterization of Rod MKP104 of ATM-104 is described.

Table 2.2. ATM-103 Cladding Certification Data (Guenther et al. 1988a)

Fuel Assembly: D101	ROD LOT: MLA CLAD LOT: 5FS72			ROD LOT: MLA CLAD LOT: 5FS73			ROD LOT: MLA/MLB CLAD LOT: 5DM11		
Tensile Properties									
Room UTS, psi	100900	98600		98500	96800		98800	96000	
0.2% YS, psi	76200	73900		76400	75300		74500	74300	
Elong. 2 in., %	24	24		24	25		23	24	
750°F UTS, psi	54000	51200		51500	49800		53400	50600	
0.2% YS, psi	40700	37200		38900	37600		38500	36700	
Elong. 2 in., %	32	33		33	33		30	32	
Burst Test (closed end with mandrel at room temperature)									
Pressure., psi	17300	16800		17100	17100		17200	17100	
Circ. Elong., %	17	19.7		20.6	23.7		21	21	
Hydride Orientation									
OD	0.04	0.06		0.05	0.08		0.03	0.01	
Fn Mid	0.03	0.02		0.02	0.08		0.02	0.04	
ID	0.05	0.00		0.04	0.04		0.00	0.02	
Corrosion Test (3 day, 750°F steam)									
	Etched			Etched			Etched		
Sample wt/dm^2	12.7	14.4		12.9	13.1		14.6	12.7	
Color	Lustrous Black			Lustrous Black			Lustrous Black		
Std. wt/dm^2	14.7	12.8	11.9	14.7	12.8	11.9	12.5	12.8	15.0
Std. No.	C217(T)	C218(C)	C223(B)	C217(T)	C218(C)	C223(B)	C312(T)	C348(C)	C371(B)
	Unetched			Unetched			Unetched		
Sample wt/dm^2	16.6	17.3		15.6	15.6		17.2	17.1	
Color	Slightly gray			Slightly gray			Slightly gray		
Chemical Analysis, ppm									
Hydrogen	14	15		15	14		9	14	
Nitrogen	33	24		31	24		31	37	
Oxygen	1230	1160		1240	1240		1358	1313	
Carbon	119	113		124	106		178	179	
Grain Size									
Long. ASTM	12.0	11.5		12.0	12.0		12.0	12.0	
Trans. ASTM	11.5	12.0		12.0	12.0		12.0	12.0	
Recrystallization Data	1100°F, 45 min.			1100°F, 45 min.			1100°F, 45 min.		
Surface Roughness									
OD, RMS, microinch	20	20		18	19		18	18	
ID, RMS, microinch	20	20		18	19		18	18	

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	MLB 003	MLA 027	MLA 046	MLA 045	MLA 069	MLA 099	MLA 053	**MLA 098**	MLA 105	MLA 158	MLA 154	MLA 198	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

Figure 2.3. ATM-103 Rod Locations in Assembly D101 (characterized rods denoted in highlighted boxes) (Guenther et al. 1988a)

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)

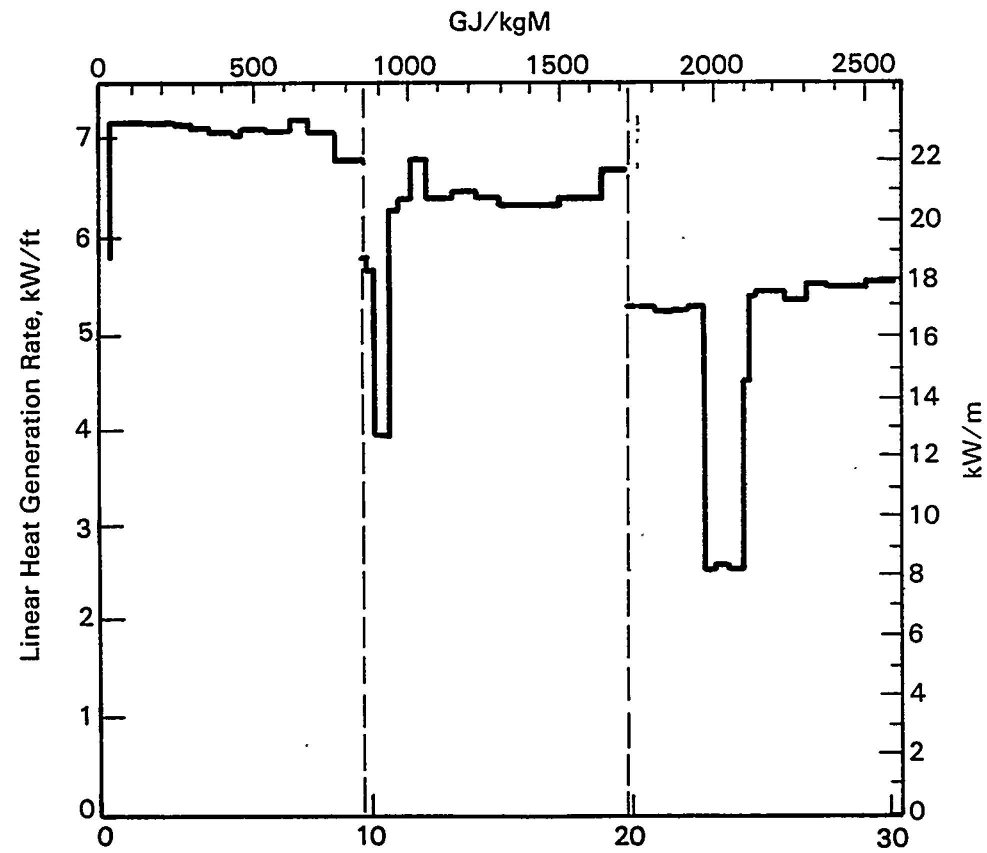

Figure 2.4. Power History for Rod MLA098 from Assembly D101 (from Guenther et al. 1988a)

Table 2.3. ATM-103 Power History, Based on Rod MLA098 (Guenther et al. 1988a)

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.

2.2.1 Assembly, Fuel Rod, and Pellet Description

The assembly, fuel rod, and pellet designs for ATM-104 were identical to those shown previously for ATM-103 in Figures 2.1 and 2.2. All of the fuel pellets were fabricated using a standard cold-pressing and sintering process. The fuel pellet certification data for Assembly D047 are shown in Table 2.4. The 128 ATM-104 rods were fabricated from Fuel Lot B-71-GB; the seven remaining rods (NBD005, NBD067, NBD112, AHS040, AHS044, AHS060, and AHS077) were created from other fuel lots and were not scheduled for testing.

All ATM-104 rods are clad with Zircaloy-4 tubing fabricated by Sandvik Special Metals, Lot Numbers 5GD12, 5GD31, and 5FP65. Cladding certification data are listed in Table 2.5. Rod MKP070 was located in position D7 of Assembly D047, as shown in Figure 2.5.

2.2.2 Irradiation History

Assembly D047 was irradiated in Cycles 2, 3, 4, and 5 of operation of CC-1 between March 22, 1977, and April 17, 1982. The core thermal-power rating at CC-1 was 2560 MWt from BOL until midway through Cycle 2 (September 9, 1977), when a new license was issued to increase CC-1's power rating to 2700 MWt. Like ATM-103 fuel, this assembly operated at reduced power for a period of five months during reactor Cycle 4.

Table 2.4. ATM-104 Fuel Pellet Certification Data (Guenther et al. 1991a)

Chemical Attribute	Fuel Lot B-71-GB Analysis Results			
Total uranium, wt%	88.15	88.148	88.146	88.129
Carbon, ppm	23	22	15	<10
Nitrogen, ppm	21	14	34	24
Fluorine, ppm	<5	<5	<5	<5
Chlorine & fluorine, ppm	<10	<10	<10	<10
Iron, ppm	<45	<45	<45	<45
Silver, ppm	<1	<1	<1	<1
Calcium, ppm Aluminum, ppm Silicon, ppm	<97	<115	<115	<115
0:U ratio	2.000	2.000	2.000	2.003
Nickel, ppm	<25	<25	<25	<25
Mass spec. analysis	3.038 % ^{235}U			
Density	10.36-10.48 g/cm^3			
Grain size	≥5 μm			

The core-average LHGR was relatively constant at about 20.3 kW/m (6.2 kW/ft) during Cycles 2, 3, 4, and 5, while the steady-state average LHGR in Rod MKP104 decreased from a high of about 24.1 kW/m (7.4 kW/ft) at the beginning of Cycle 2 to a low of about 15.4 kW/m (4 kW/ft) at the end of Cycle 5. Rod MKP104 (cell I9 in Figure 2.5) was expected to have an EOL burnup equivalent to the assembly average burnup according to calculations by C-E. The power history specific to Rod MKP104 in Assembly D047 is approximated in Figure 2.6 and is listed in tabular form in Table 2.6.

2.3 ATM-106 Design and Power History

ATM-106 consists of 20 rods from one fuel assembly (BT03) fabricated by C-E and irradiated for four cycles in the CC-1 PWR. The fuel assembly was discharged October 18, 1980. The ATM-106 fuel rods were transported from the reactor cooling basin to PNL in September 1985. Information is provided in Subsections 2.3.1 and 2.3.2 on the assembly and fuel rod design, fuel and pellet initial composition, and power history during irradiation. This information is taken from Guenther et al. (1988b) in which the completed characterization of Rod NBD107 of ATM-106 is described.

Table 2.5. ATM-104 Cladding Certification Data (Guenther et al. 1991a)

Fuel Assembly: D047	ROD LOT: MKN CLAD LOT: 5GD12		ROD LOT: MKN/MKP CLAD LOT: 5GD31		ROD LOT: MKP CLAD LOT: 5FP65	
Tensile Properties						
Room UTS, psi	101300	102500	100900	102200	102000	98700
0.2% YS, psi	75200	75600	74100	75800	76400	74400
Elong. 2 in., %	24	24	18	24	26	26
750°F UTS, psi	54800	54400	54700	55300	57700	53200
0.2% YS, psi	41100	39200	41100	44500	40600	40200
Elong. 2 in., %	29	28	29	28	26	31
Burst Test (closed end with mandrel at room temperature)						
Pressure., psi	17800	17700	17900	18000	17800	17400
Circ. Elong., %	19	24	15	13	13	22
Hydride Orientation						
Fn OD	0.16	0.05	0.03	0.02	0.06	0.05
Fn Mid	0.01	0.04	0.02	0.05	0.07	0.10
Fn ID	0.02	0.03	0.03	0.01	0.03	0.00
Corrosion Test (3 day, 750°F steam)						
	Etched		Etched		Etched	
Sample wt/dm^2	14.9	15.6	16.6	16	12.9	13.3
Color	Lustrous Black		Lustrous Black		Lustrous Black	
	Unetched		Unetched		Unetched	
Sample wt/dm^2	18.8	17.1	17.6	18.8	17.3	16.7
Color	Slightly gray		Slightly gray		Slightly gray	
Chemical Analysis, ppm						
Hydrogen	13	13	17	16	11	11
Nitrogen	25	22	30	32	20	20
Oxygen	1135	1195	1200	1210	1100	1150
Carbon	102	119	102	102	125	142
Grain Size						
Long. ASTM	12	12	11	12	12.5	12
Trans. ASTM	12	12	11	12	12	12.5
Recrystallization Data	1100°F, 45 min.		1100°F, 45 min.		1100°F, 45 min.	
Surface Roughness						
OD, RMS, microinch	18	18	18	20	18	18
ID, RMS, microinch	16	17	17	22	18	18

Corrosion test standards (etched):

	MKN			MKN/MKP			MKP		
Std. wt/dm^2	15.5	15.8	15.2	14.9	15.2	16.4	15.6	15.9	12.9
Std. No.:	C423(T)	C437(C)	C458(B)	C407(T)	C416(C)	C448(B)	C312(T)	C348(C)	C371(B)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
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	MKP 111	AHS 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	

R9004195.1

Figure 2.5. Locations of 128 ATM-104 Rods in Assembly D047 (characterized rods denoted in highlighted boxes) (Guenther et al. 1991a)

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

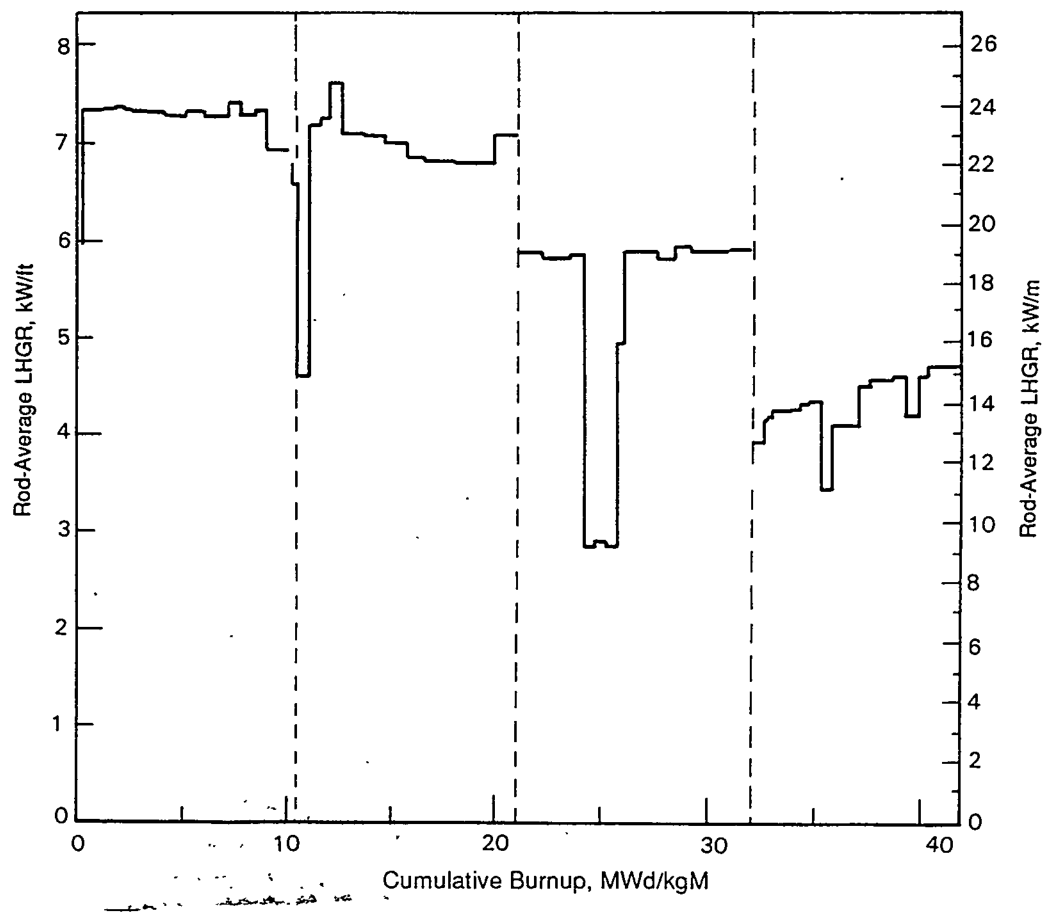

Figure 2.6. Power History for Rod MKP104 from Assembly D047 (Guenther et al. 1991a)

Table 2.6. ATM-104 Power History, Based on Rod MKP104 (Guenther et al. 1991a)

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)	48.2	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)	10.0	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.

2.3.1 Assembly, Fuel Rod, and Pellet Description

Like ATM-103 and ATM-104, the fuel rods in ATM-106 were from a standard C-E 14 x 14 fuel assembly (BT03) comparable to that shown in Figure 2.1. The rod design was the same as for the ATM-103 and ATM-104 fuel rods, but the fuel pellets are approximately one-and-a-half-times longer than the ATM-103 or ATM-104 fuel pellets, and the void volumes of the two dished ends in the pellets are ~38% smaller. A drawing of the ATM-106 fuel pellet is shown in Figure 2.7, and the fuel pellet certification data for Assembly BT03 are shown in Table 2.7.

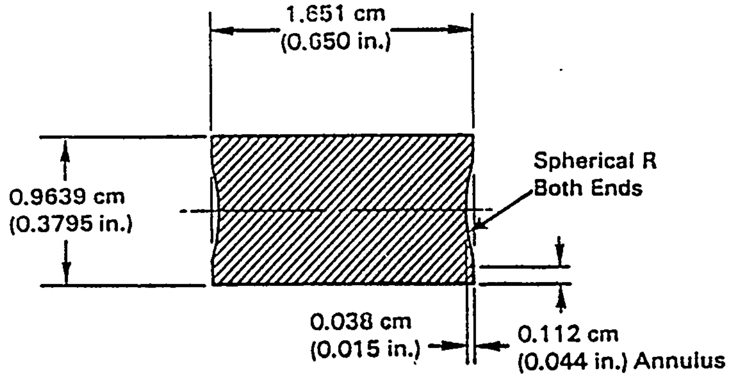

Figure 2.7. Fuel Pellet Design for ATM-106 (Guenther et al. 1988b)

Table 2.7. ATM-106 Fuel Pellet Certification Data (Guenther et al. 1988b)

Chemical Attribute	Fuel Lot B-25-BB Analysis Results				
Total uranium wt%	88.158	88.136	88.136	88.142	88.142
Carbon, ppm	17	23	33	9	15
Nitrogen, ppm	39	41	47	45	48
Fluorine, ppm	<10	<10	<10	<10	<10
Total halides, ppm	<20	<20	<20	<20	<20
Iron, ppm	<45	<45	<45	<45	<45
Silver, ppm	<1	<1	<1	<1	<1
Calcium, ppm; Aluminum, ppm; Silicon, ppm	<115	<115	<115	<117	<132
O:U ratio	2.00	2.00	2.00	2.00	2.00
Mass spec. analysis	2.453% ^{235}U				
Density	10.05-10.30 g/cm^3				
Grain size	$\geq$5 μm				

All ATM-106 fuel rods are clad with Zircaloy-4 tubing fabricated by Sandvik Special Metals, Lot Nos. 54028 and 54027. Cladding certification data are listed in Table 2.8. Rods NBD095 and NBD131 were irradiated in positions G9 and M4, respectively, as shown in Figure 2.8.

2.3.2 Irradiation History

The rods constituting ATM-106 were irradiated in Assembly BT03 in Cycles 1, 2, 3, and 4 of operation of CC-1 between October 7, 1974, and October 18, 1980. The ATM-106 fuel rods were also in the reactor during a five-month period of reduced power during Cycle 4.

To achieve the desired fuel burnup, assembly BT03 was placed in the core's center during Cycles 3 and 4. As a result, LHGRs in Rod NBD107 ranged from a high of about 24 kW/m (7.3 kW/ft) at the beginning of Cycle 1 to a low of about 16 kW/m (4.8 kW/ft) at the end of Cycle 4. The power history specific to Rod NBD107 in Assembly BT03 is approximated in Figure 2.9 and shown in Table 2.9. Power histories for other ATM-106 rods can be determined, as explained above for ATM-103 and ATM-104.

2.4 ATM-108 Design and Power History

ATM-108 consists of the ten fuel rods with both urania (UO_2) and gadolinia (Gd_2O_3) in the CZ346 and CZ348 fuel bundles, which also contained the fuel rods designated as ATM-105. The fuel bundles were fabricated by GE and irradiated in the Cooper BWR (Guenther et al. 1991b). The bundles were fabricated in 1972 and irradiated for five cycles from July 1974 to May 1982, at which time they were discharged. The two fuel bundles were stored wet at the reactor site and subsequently sent to the GE Morris Facility for use in a dry storage test described by McKinnon et al. (1986). The information on the fuel bundle design was reported by Guenther et al. (1991b) in which the completed characterization of Rods ADD2966 and ADD2974 without gadolinia from the same fuel bundle as ADN0206 is described. Information is provided in Subsection 2.4.1 and 2.4.2 on the bundle and rod design and power history during irradiation.

2.4.1 Fuel Bundle and Rod Description

Fuel bundles CZ346 and CZ348 are of the GE 7 x 7 design, as shown in Figure 2.10. Eight tie rods, one segmented rod (spacer capture rod), and 40 standard rods are three fuel rod designs clad with Zircaloy-2 which are used in the fuel bundles. The location of the tie rods, segmented rod, and standard rods are shown in Figure 2.11. There are standard rods with and without gadolinia. The tie rods have threaded-end plugs that thread into the lower-tie-plate casting and extend through the upper-tie-plate casting. The upper ends of the tie rods are secured with lock nuts to hold the bundle together. The central fuel rod in each fuel bundle is segmented, consisting of eight individual tubes of fuel pellets separated by Zircaloy-2 connectors; this rod is one of the ATM-108 rods. Available bundle and fuel rod design parameters are shown in Table 2.10. Additional details on the bundle design are provided in Guenther et al. (1991b).

Table 2.8. ATM-106 Fuel Rod Cladding Certification Data (Guenther et al. 1988b)

Fuel Assembly: BT03	ROD LOT: NBC CLADDING LOT: 54028			ROD LOT: NBC/NBD CLADDING LOT: 54027		
Tensile Properties						
Room UTS, psi	98500	97900		89000	97300	
0.2% YS, psi	74300	73900		64500	69700	
Elong. 2 in., %	23.2	24.4		27.9	24.8	
750°F UTS, psi	52200	50000		48200	52700	
0.2% YS, psi	36600	32600		32000	36500	
Elong. 2 in., %	29.8	34.4		31.8	29.2	
Burst Test (closed end with mandrel at room temperature)						
Pressure, psi	16300	16000		15100	15900	
Circ. elong., %	20.1	34.7		45.3	22	
Hydride Orientation						
OD	0.06	0.07		0.05	0.08	
Fn Mid	0.04	0.06		0.02	0.01	
ID	0.02	0.02		0.03	0.02	
Corrosion Test (3 day, 750°F steam)						
Sample wt/dm^2	17.2	16.7		15.3	17.6	
Color	Slightly Gray			Slightly Gray		
Std. wt/dm^2	12.5	13.5	13.8	12.5	13.5	13.8
Std. No.	41	46	55	41	46	57
Chemical Analysis, ppm						
Hydrogen	12	13		12	10	
Nitrogen	38	45		41	45	
Oxygen	1260	1230		1280	1220	
Carbon	151	160		141	133	
Grain Size						
Long. ASTM	11.5	11.0		11.5	11.5	
Trans. ASTM	12.0	12.0		12.0	12.0	
Recrystallization Data	1100°F, 45 min			1100°F, 45 min		
Surface Roughness						
OD, RMS, microinch	12	10		14	12	
ID, RMS, microinch	12	20		16	16	

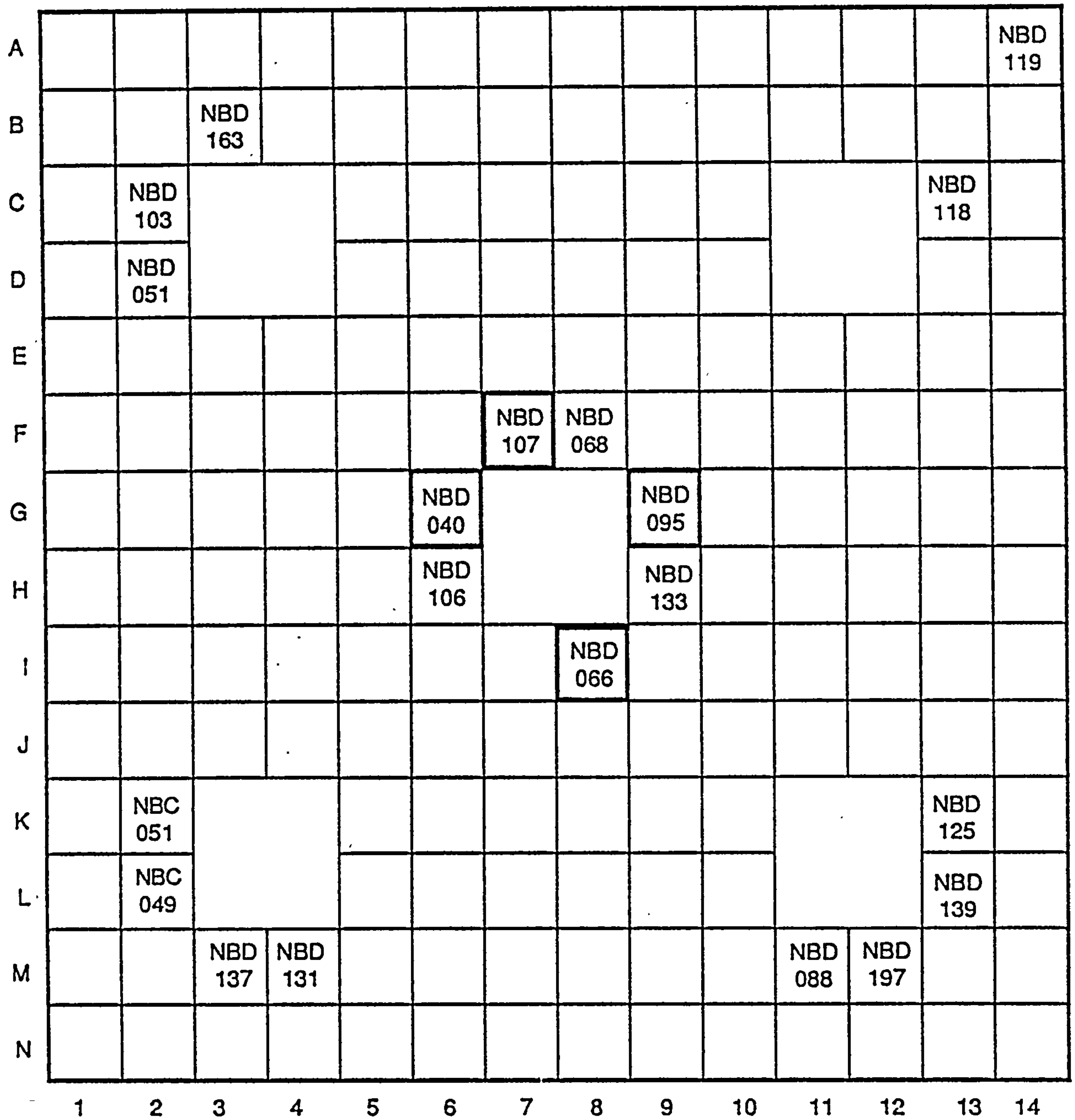

Figure 2.8. Locations of Twenty Rods in Assembly BT03 (characterized rods denoted in highlighted boxes) (Guenther et al. 1988b)

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

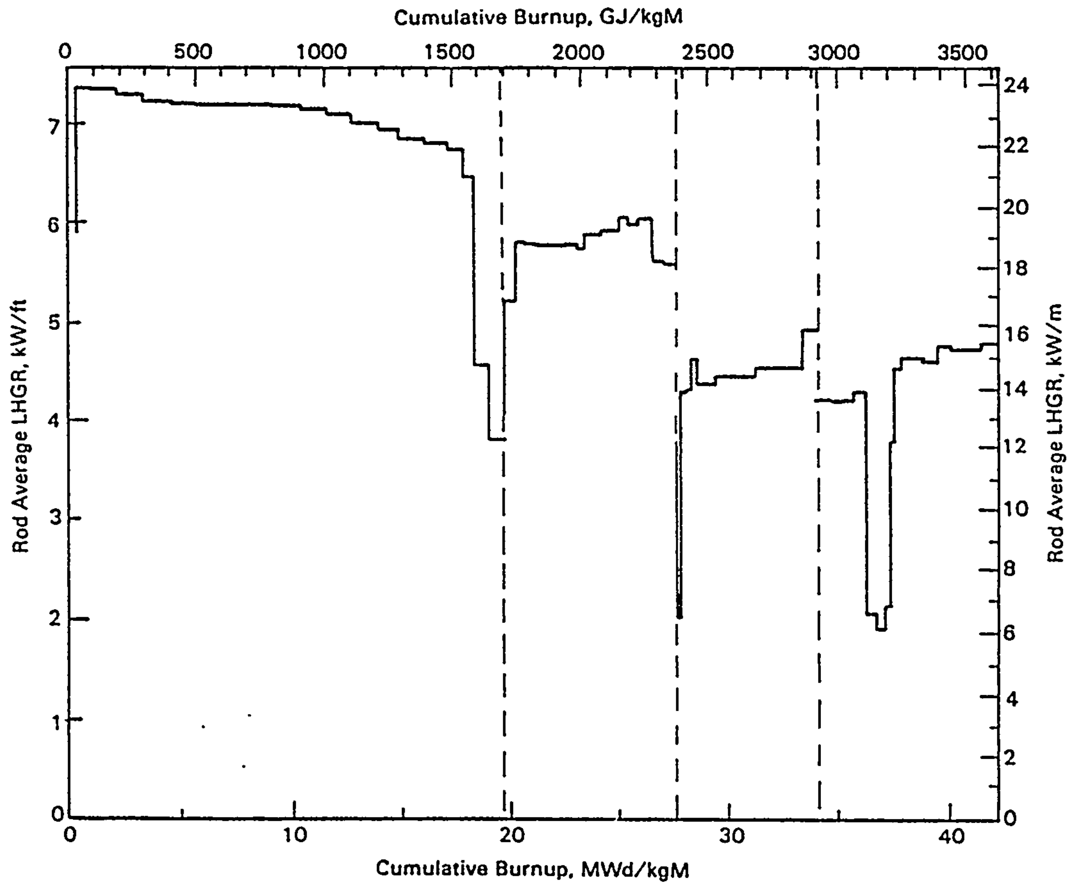

Figure 2.9. Approximate Power History for Rod NBD107 from Assembly BT03 (Guenther et al. 1988b)

Table 2.9. Detailed Power History for Rod NBD107 (Guenther et al. 1988b)

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)
39.4	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)	12.8	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.

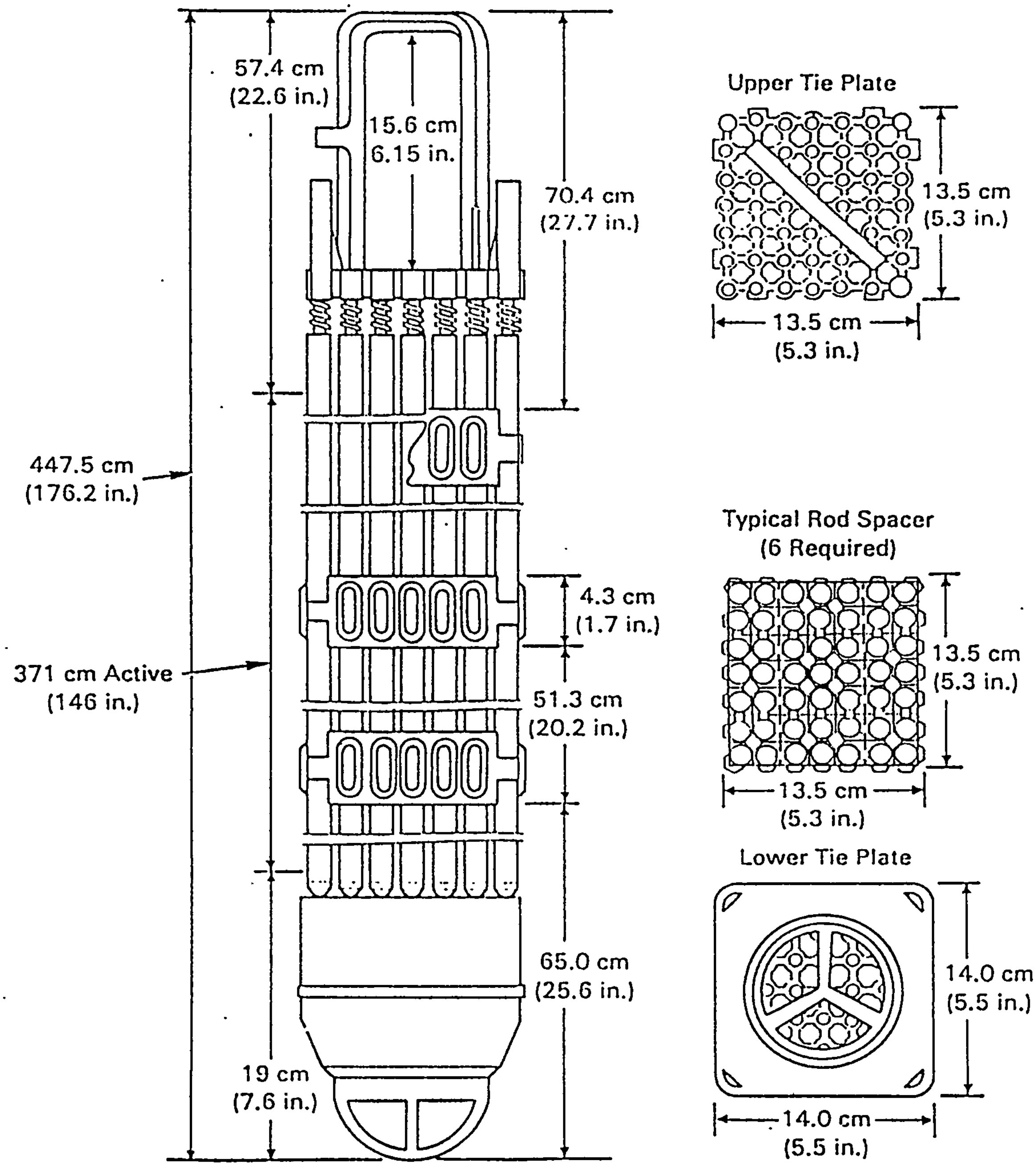

Figure 2.10. General Electric 7 x 7 Fuel Bundle for ATM-108

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	S 5	1	1	1
T 2	1	1	1	1	1	T 1
2	1	5	1	1	6	2
3	2	T 1	1	T 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

Figure 2.11. Location of Different Types of Fuel Rods in Bundles CZ346 and CZ348 (Guenther et al. 1988b)

Table 2.10. ATM-105 Fuel Bundle and Rod Design Parameters (Guenther et al. 1991b)

Design Parameter	Description	
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 UO_2 and Gd_2O_3 have been redesignated as ATM-108; they will be removed from the bundles and characterized.

Considering the fuel enrichment and amount of gadolinia, there are seven fuel rod types in these GE bundles (Figure 2.11). Five of the 49 rods in each bundle had either 3 or 4 wt% gadolinia to act as a burnable poison and comprised the ATM-108 test material. Only the Type 5 fuel rods with 3 wt% gadolinia have burnable poison along the entire fuel column length, as shown in Figure 2.12. Rod ADN0206 was selected for characterization because it was near other characterized rods and had gadolinia along the entire fuel column. Rod ADN0206 was irradiated in position F3 of bundle CZ346, as shown in Figure 2.13.

Only limited data are available for the material properties and design specifications of the fuel and Zircaloy-2 cladding of ATM-105 and ATM-108 fuel rods; most of the information was considered proprietary. As reported in Guenther et al. (1991b), the pellets are flat-ended with chamfered edges and are about 1.3-cm-long based on gamma scan data. Compositions were assumed for the fuel and cladding of the ATM-105 fuel rods without gadolinia and are shown in Tables 2.11 and 2.12. The reader is left to estimate any changes necessary to compensate for the gadolinia content or differences in fuel enrichment. The assumed values are based on nominal values for low-enriched fuel or for typical Zircaloy-2 cladding.

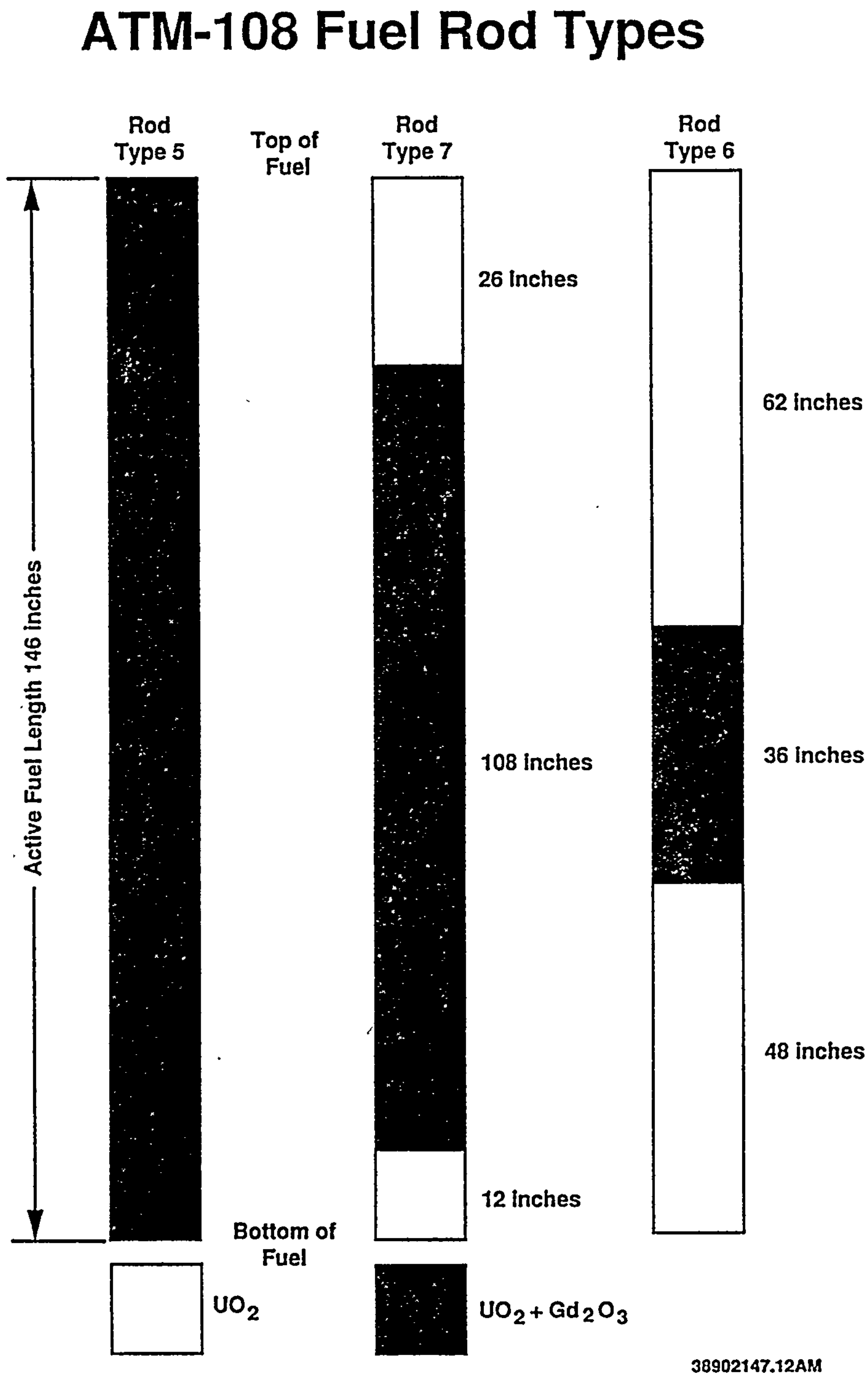

Figure 2.12. Gadolinia Loading in Type 5, Type 6, and Type 7 Rods in ATM-108

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

Bundle CZ346

Figure 2.13. Loading Diagram for Bundle CZ346 (ATM-108 rods are denoted in highlighted boxes)

2.4.2 Irradiation History

Fuel Bundles CZ346 and CZ348 were irradiated in the Cooper BWR during Cycles 1, 2, 3, 6, and 7. Cycle 1 began July 4, 1974, and Cycle 7 ended May 21, 1982. Fuel Bundles CZ346 and CZ348 were not in the reactor during Cycles 4 and 5. The power history for the ATM-105 fuel was based on the history associated with Bundle CZ346. The average burnup for Bundle CZ346 at the end of each cycle was supplied by GE and is shown in Table 2.13. No specific power history for Rod ADN0206 has been provided or determined. Because the gadolinia eventually burns out, the power in the rods would typically start at a low value and increase with time depending on the rate of burnout, the gadolinia content, and the overall power in the assembly; the power history calculations have not been determined.

Table 2.11. Fuel Composition Assumed for ATM-105 Fuel Rods (from Guenther et al. 1991b)

Parameter	Value(a)
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 ATM as minor impurities.

Table 2.12. Cladding Composition Assumed for ATM-105 Fuel Rods (from Guenther et al. 1991b)

Parameter	Value
Zirconium, wt%	98.05
Tin, wt%	1.5
Iron, wt%	0.13
Chromium, wt%	0.11
Nickel, ppm	500
Aluminum, ppm	40
Hafnium, ppm	55
Silicon, ppm	80
Oxygen, ppm	1200
Carbon, ppm	175
Nitrogen, ppm	35
Hydrogen, ppm	12

Table 2.13. Burnup of Bundle CZ346 (Guenther et al. 1991b)

Cycle No.	Startup	Shutdown	Cumulative Bundle-Average Burnup, MWd/kgM
1	07/04/74	09/17/76	13.90
2	11/16/76	09/17/77	19.14
3	10/18/77	03/31/78	21.92
6	06/08/80	04/20/81	25.20
7	08/08/81	05/21/82	28.05

3.0 Gamma Scans and Rod Sectioning

Each fuel rod was gamma scanned to obtain information on the general trend of burnup and to provide a basis for selecting fuel and cladding samples. A brief summary of this process is provided below.

3.1 Gamma Scanning

Axial gamma scan data and measured fuel burnups have been used in the past along with to develop correlations for predicting burnups in the samples of sectioned rods and to estimate burnups in fuel rods that were not destructively analyzed. The gamma scan data also provide valuable information on fission product movement in the rod (such as cesium migration) and on densification or shifts in the fuel column.

Each fuel rod was gamma scanned axially using a germanium-lithium gamma ray detector located in D Cell of the 324 Building in the Hanford Site's 300 Area. Details on the gamma scanning equipment and procedure are provided in all ATM reports previously referenced. The same counting geometry, counting equipment, analyzing equipment, and data storage equipment were used for each measurement. As was done for gamma scans for previously reported MCC spent fuel rods, the gamma scans for the additional rods reported here were preceded and followed by gamma scans of short portions of a reference rod for the appropriate ATM.

Spectral counting for Rods NBD131 of ATM-106 and ADN0206 of ATM-108 indicated significant gamma ray peaks at 605 KeV (^{134}Cs), 662 KeV (^{137}Cs), and 796 KeV (^{134}Cs). The indicated high release in the ATM-106 rod was expected; however, the apparent fission gas release in the ATM-108 rod was not anticipated. Gamma scans for Rods MLA091 and MKP070 were consistent with low fission gas release, while Rod NBD095 appeared to have some cesium migration that indicated fission gas release. Gamma scans for each of the five rods reported are provided in Appendix A. Rod ADN1313 of ATM-108 was also gamma scanned; the plot of that data is also provided in Appendix A.

3.2 Rod Sectioning and Sample Selection

After gamma scanning and fission gas sampling, a sectioning diagram was prepared for each rod being characterizated. The sectioning was based on characterization plans, results of the ^{137}Cs gamma scan of the entire length of the rod, and requests by those conducting the experiments.

The sections used for radiochemical, ceramographic, and metallographic analysis were 0.60 to 2.54 cm (0.25 to 1.0 in.) in length. Each sample was designated with an alphanumeric symbol in order of sectioning from the top of the fuel rod. Details on the sectioning process is provided in each of the previous characterization reports. Sectioning diagrams for each of the rods reported here are provided in Appendix A. The majority of the samples were taken for either radiochemical analyses or ceramographic/metallographic examinations. The estimated burnups determined using gamma scan data and the measured burnups for other samples from the same rod are provided in Tables A.1 through A.4.

4.0 Radiochemical Analyses

Both radiochemical and metallographic examinations were used to characterize many of the rods reported with the intent of determining the amount and distribution of selected elements and isotopes important to the characteristics of spent fuel rods. The radiochemical analyses conducted on the cladding, the fuel, and gas samples from Rods MLA091 (ATM-103), MKP070 (ATM-104), NBD095 and NBD131 (ATM-106), and ADN0206 (ATM-108) are described below. The analyses reported for each rod are summarized in Table 4.1.

4.1 Cladding Analyses

Results of the radiochemical examinations of cladding are reported for analyses to determine the distribution of cesium on the exterior and interior surfaces of the cladding, the distribution of iodine on the interior surfaces of the cladding, and total ^{14}C in the cladding (i.e., in the cladding, as well as any deposits on the surfaces). Brief descriptions of the procedures used to analyze the cladding are provided in Table 4.2. The results of these examinations are shown in tabular form in Appendix B. Hydrogen in cladding samples from the lower third of Rod G13 of ATM-101 (G13B) and the top third (G13T) are reported in Appendix B, but are not listed in Table 4 for simplicity.

4.2 Fuel Analyses

The analyses of the fuel included determining the fuel burnup, the isotopes of uranium and plutonium, and specific nuclides including ^{79}Se, ^{90}Sr, ^{99}Tc, ^{126}Sn, ^{135}Cs, ^{137}Cs, ^{237}Np, ^{241}Am, and ^{243}Cm plus ^{244}Cm. The amount of ^{129}I, ^{14}C, ^{135}Cs, and ^{137}Cs in the fuel was also determined, particularly in fuels with expected fission gas release, but burnup was not directly measured for these types of samples. Procedures used to obtain these data are summarized in Table 4.3. All available results of the fuel analyses and burnup are provided in Appendix B.

Burnup is the term used to define the amount of energy obtained from the fuel during irradiation. Because fuel burnup is related to the number of fission events, each of which produces about 200 MeV of energy, the inventory of radionuclides and other fuel characteristics are often expressed as a function of fuel burnup. Burnup samples were taken from three locations in each of the first rods characterized; typically at the middle of the rod and two other locations to get the widest variation possible in burnup.

4.3 Gas Analyses

After the rods were gamma scanned, the rod was punctured with a laser to obtain a gas sample in the rod plenum. The gas sample was analyzed for isotopes of xenon and krypton, ^{14}C, and other possible gases, including the original helium fill gas. Available results from these analyses are provided in Table B.1 following the fuel and cladding radiochemistry results.

Table 4.1. Summary of Section Numbers for Rods Analyzed

Analyses	MLA091	MKP070	NBD095	NBD131	ADN0206
		Fuel			
Burnup	J	J, R	C&D, X&Y	Q, CC	D, M, DD
^{234}U	J	J, R	C&D, X&Y	Q, CC	D, M, DD
^{235}U	J	J, R	C&D, X&Y	Q, CC	D, M, DD
^{236}U	J	J, R	C&D, X&Y	Q, CC	D, M, DD
^{238}U	J	J, R	C&D, X&Y	Q, CC	D, M, DD
^{238}Pu	J	J, R	C&D, X&Y	Q, CC	D, M, DD
^{239}Pu	J	J, R	C&D, X&Y	Q, CC	D, M, DD
^{240}Pu	J	J, R	C&D, X&Y	Q, CC	D, M, DD
^{241}Pu	J	J, R	C&D, X&Y	Q, CC	D, M, DD
^{242}Pu	J	J, R	C&D, X&Y	Q, CC	D, M, DD
^{237}Np	J	J, R	C&D, X&Y	Q, CC	
^{241}Am	J	J, R	C&D, X&Y	Q, CC	
^{243}Am	J	J, R	X&Y	Q, CC	
^{242}Cm	J	J, R	C&D, X&Y	Q, CC	
$^{243+244}Cm$	J	J, R	C&D, X&Y	Q, CC	
^{79}Se	J	J, R	C&D, X&Y	Q, CC	
^{90}Sr	J	J, R	C&D, X&Y	Q, CC	
^{99}Tc	J	J, R	C&D, X&Y	Q, CC	
^{126}Sn	J	J, R	C&D, X&Y	Q, CC	
^{135}Cs	J	J, R	C&D, X&Y, LL	Q, CC	
^{137}Cs	J	J, R	C&D, X&Y, LL	Q, CC	
^{129}I	K, O, R	C, L, S		F, R, W, DD	
^{14}C	D, G, L, P, S	D, G, M, P	H, P, HH, PP, EEE	D, K, S, X, EE	
$^{143}Nd/^{148}Nd$	J	J, R	C&D, X&Y	Q, CC	D, M, DD
$^{144}Nd/^{148}Nd$	J	J, R	C&D, X&Y	Q, CC	D, M, DD
$^{145}Nd/^{148}Nd$	J	J, R	C&D, X&Y	Q, CC	D, M, DD
$^{146}Nd/^{148}Nd$	J	J, R	C&D, X&Y	Q, CC	D, M, DD
^{148}Nd	J	J, R	C&D, X&Y	Q, CC	D, M, DD
$^{150}Nd/^{148}Nd$	J	J, R	C&D, X&Y	Q, CC	D, M, DD

Table 4.1. (contd)

Analyses	MLA091	MKP070	NBD095	NBD131	ADN0206
			Cladding Chemistry		
^{14}C Cladding	D, G, L, P, S	D, G, M, P, T	H, P, HH, PP, EEE	D, K, S, X, EE	
^{137}Cs on cladding interior	C, F, K, O, R	C, F, L, O, S	F, K, N, AA, FF, MM, XX, CCC	C, F, J,N, R, W, Z, DD	
^{135}Cs on cladding interior	C, F, K, O, R	C, F, L, O, S	F, K, N, AA, FF, MM, XX, CCC	C, F, J,N, R, W, Z, DD	
I129 on cladding interior	C, F, K, O, R	C, F, L, O, S	F, K, N, AA, FF, MM, XX, CCC	C, F, J,N, R, W, Z, DD	

Table 4.2. Description of Radiochemical Analysis Procedures for Cladding Samples

Analysis	Description
^{14}C	The carbon in the cladding is evolved by total combustion in pure oxygen, the CO_2 collected, and the ^{14}C measured by liquid scintillation counting. Uncertainty: ±5.6%.
^{135}Cs Interior and Exterior Surfaces	The cesium is leached from (interior or exterior) surface and separated from other elements by chromatographic elution from a cation exchange column. Isotope abundance of cesium isotopes is determined by mass spectrometry. Uncertainty: ±14%.
^{137}Cs Interior and Exterior Surfaces	The cesium is leached from interior or exterior surface and determined by gamma ray spectrometry on an aliquot of the leachate. Uncertainty: ±3.7%.
^{129}I Interior Surface	The cladding interior surface is leached in nitric acid. The iodine is separated from the nitric acid leachate by distillation and precipitation as AgI. Iodine-129 is determined in a GeLi well detector. Uncertainty: ±2.8%.
Hydrogen in Cladding	A weighed cladding sample is melted under a flowing inert cover gas and analyzed by gas chromotography. Uncertainty: ± 10%.

Table 4.3. Description of Radiochemical Analyses Procedures for Fuel Samples

Analysis	Description
Burnup Sample Preparation	Weighed sample is dissolved in heated 12N HNO_3 (+trace HF). Solution is separated from cladding and made up to 100 mL. Aliquots are taken for subsequent analyses. Uncertainty: ±1.0%.[a]
Burnup (including U and Pu isotopes)	Fission product neodymium is chemically separated from irradiated fuel and determined by isotopic dilution mass spectrometry. Enriched ^{150}Nd is used as the Nd isotope diluent, and mass 142 is used to determine natural Nd contamination. Uranium and plutonium are also determined by mass spectrometry. The method uses a calibrated triple spike of ^{150}Nd, ^{233}U, and ^{242}Pu per ANSI/ASTM Standard Test Method E321-79. Uncertainty: Atom % burnup, ±2.5%; Pu, ±1.6%; U, ±1.6%.
^{14}C	The carbon in a specially crushed sample of the fuel is evolved by combustion in pure oxygen. The CO_2 is collected and ^{14}C is measured by liquid scintillation counting. Uncertainty: ±5.6%.
^{79}Se	Selenium-79 is separated from other radioactive species by passing the chemically adjusted solution through a cation plus anion exchange resin column. The selenium in the column effluent is distilled from hydrobromic acid and precipitated as metal by reducing it with hydroxylamine hydrochloride. The reduced metal is dissolved in nitric acid, and the ^{79}Se is measured using liquid scintillation counting. Uncertainty: ±4.9%.
^{90}Sr	The ^{90}Sr is separated from other radioactive species by selective elution from a cation exchange resin using 2-methyllactic acid. Following separation, the growth of ^{90}Y is measured by beta counting. The ^{90}Sr is then calculated based on the growth of the ^{90}Y radioactive decay product over a specific time. Uncertainty: ±5.7%.
^{99}Tc	Technetium is separated from other radioactive species by a process that absorbs most other species on to a cation exchange resin. The technetium is extracted from the effluent into hexone as tetraphenylarsonium pertechnetate. The technetium activity is then measured by beta counting. Uncertainty: ±3.5%.
^{129}I	Iodine is separated by distillation and precipitation as AgI. Iodine-129 is determined in a GeLi well detector. Uncertainty: ±2.2%.
^{126}Sn	Tin is separated by a combination of cation and anion exchange resins. Tin is finally eluted with dilute nitric acid and measured using a GeLi gamma spectrometer. Uncertainty: ±10.2%.

Table 4.3. (contd)

Analysis	Description
^{135}Cs	Cesium is separated from other elements by chromatographic elution from a cation exchange column. Isotopic abundance of the cesium isotope is determined by mass spectrometry. Uncertainty: ±14%.
^{137}Cs	The cesium is determined by gamma ray spectrometry on an aliquot of the aqueous solution. Uncertainty: ±3.5%.
^{237}Np	Neptunium-237 is separated from other radionuclides species by extraction into a mixture of tri-iso-octyl-amine (TiOA) in xylene, stripped from the TiOA phase with HCl and re-extraction into a mixture of thenoyltrifluoracetone (TTA) in xylene for additional separation. Neptunium-237 is measured by alpha counting. A ^{239}Np tracer is added to the sample and gamma-counted to determine a recovery factor. Uncertainty: ±1.9%.
^{241}Am, ^{243}Cm plus ^{244}Cm	Americium and curium are separated using cation and anion exchange and determined by alpha spectrometry. Uncertainty: ^{241}Am, ±4.9%; ^{243}Cm plus ^{244}Cm, ±4.1%.

(a) Uncertainties are one relative standard deviation that is based on experience in the laboratory at PNL.

Previous estimates of the fission gas release were made for the rods based on the gas sample volumes, the approximate rod-average burnup, and assuming 31.0 cm^3 of fission gas was generated for each MWd of fuel at STP (SSA 1982). Examples of these calculations are provided in characterization reports, such as Guenther et al. (1991a). No records were found to verify the calculated fission gas releases for these rods, but nonrecord information provides a valuable reference for the fission gas releases from these rods and is summarized in Table 4.4. All other data were obtained in accordance with Impact Level I of PNL-MA-70 and meet the criteria of NQA-1 quality assurance.

Table 4.4. Estimated Fission Gas Releases from Characterized Rods

Rod Number	Estimated Rod-Average Burnup, MWd/kgM	Estimated Fission Gas Release, %
MLA091	28	< 1
MKP070	38	< 1
NBD095	40	7
NBD131	46	18
ADN0206	24	9

5.0 References

Barner, J. O. 1985. *Characterization of LWR Spent Fuel MCC-Approved Testing Material - ATM-101*. PNL-5109, Rev. 1, Pacific Northwest Laboratory, Richland, Washington.

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SSA (Southern Science Applications, Inc.). 1982. *Background and Derivation of ANS 5.4 Standard Fission Product Release Model*. NUREG/CR-2507, U.S. Nuclear Regulatory Commission, Washington, D.C. NNA.910410.0160.

Appendix A

Gamma Scans and Sectioning Diagrams

Appendix A

Gamma Scans and Sectioning Diagrams

Full-length gamma scans were made of each of the rods receiving examination. The gamma scan was used to determine the location of appropriate samples and for estimating the burnup in samples for which actual measurements were not made. The gamma scans for Rods MLA091, MKP070, NBD095, NBD131, and ADN0206 are provided in Figures A.1 through A.5. A gamma scan of ATM-108 Rod ADN1313 was also made and is shown in Figure A.6. The samples taken from five rods destructively examined are listed in Tables A.1 through A.4 and include the average cesium activity for each sample along with the estimated burnups. The sectioning diagrams for Rods MLA091, MKP070, NBD095, NBD095, NBD131, and ADN0206 are provided in Figures A.7 through A.11, respectively. Not all of the samples taken were analyzed or delivered to those conducting the experiments.

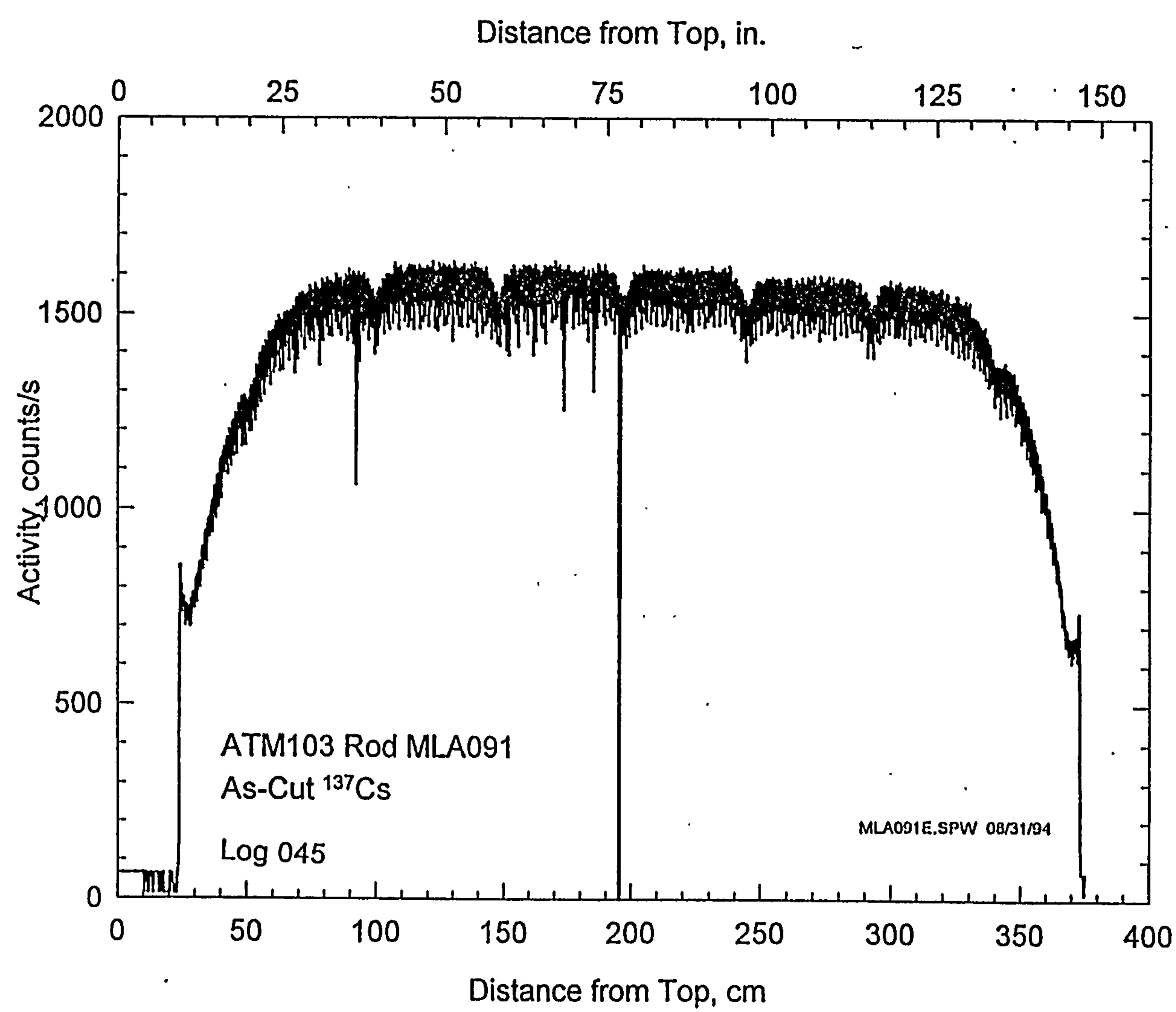


Figure A.1. Gamma Scan of Rod MLA091 of ATM-130

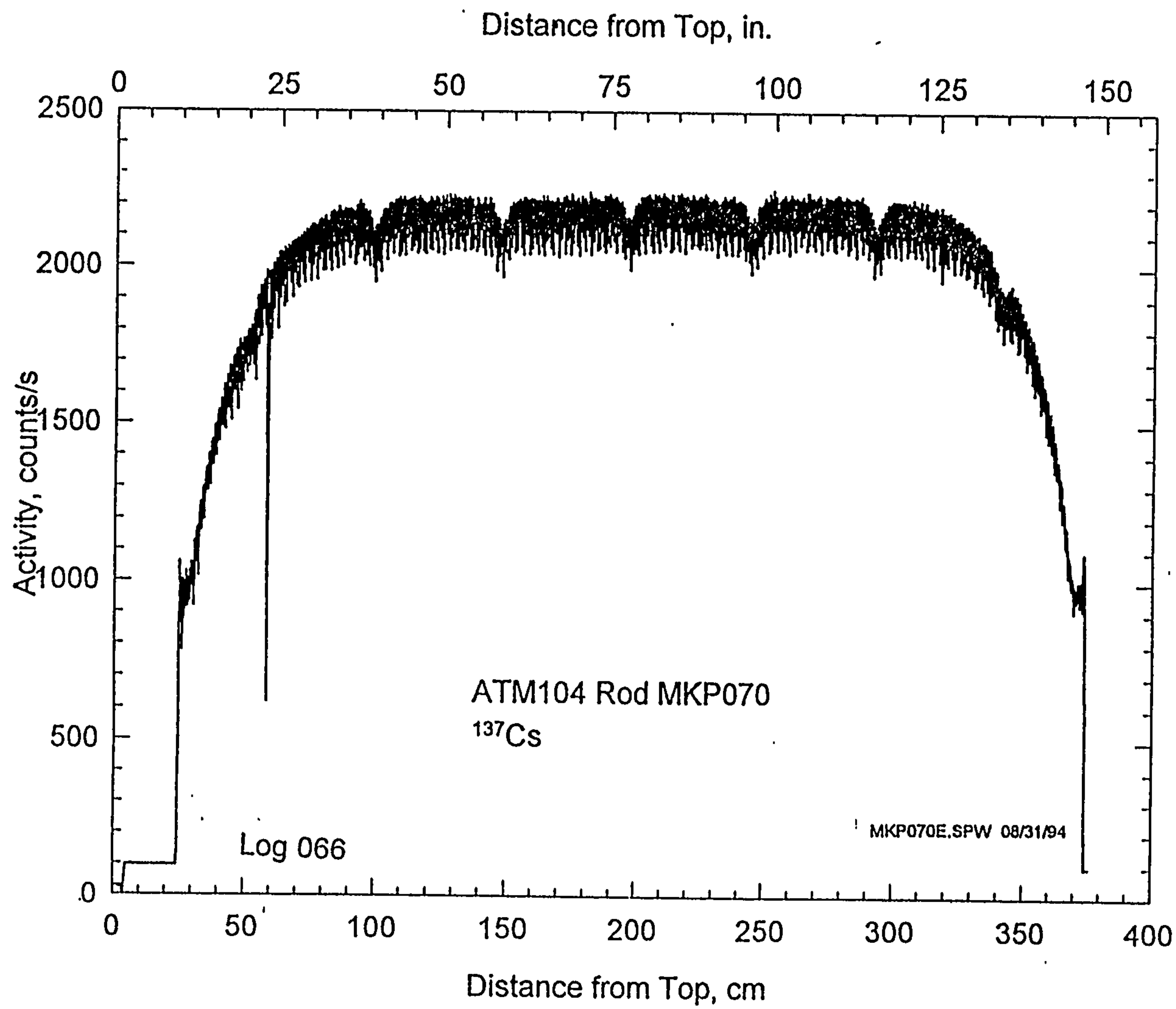


Figure A.2. Gamma Scan of Rod MKP070 of ATM-104

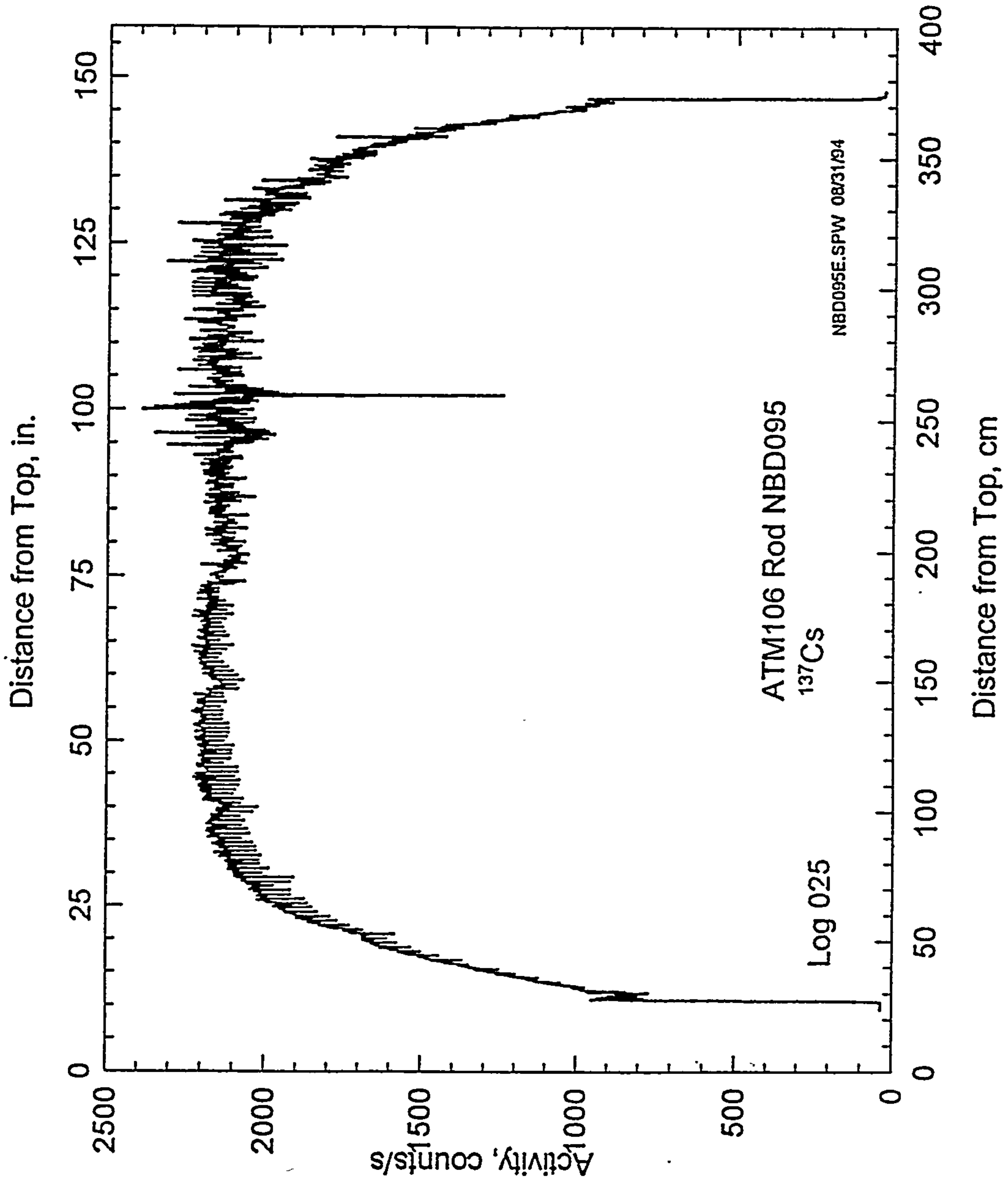


Figure A.3. Gamma Scan of Rod NBD095 of ATM-106

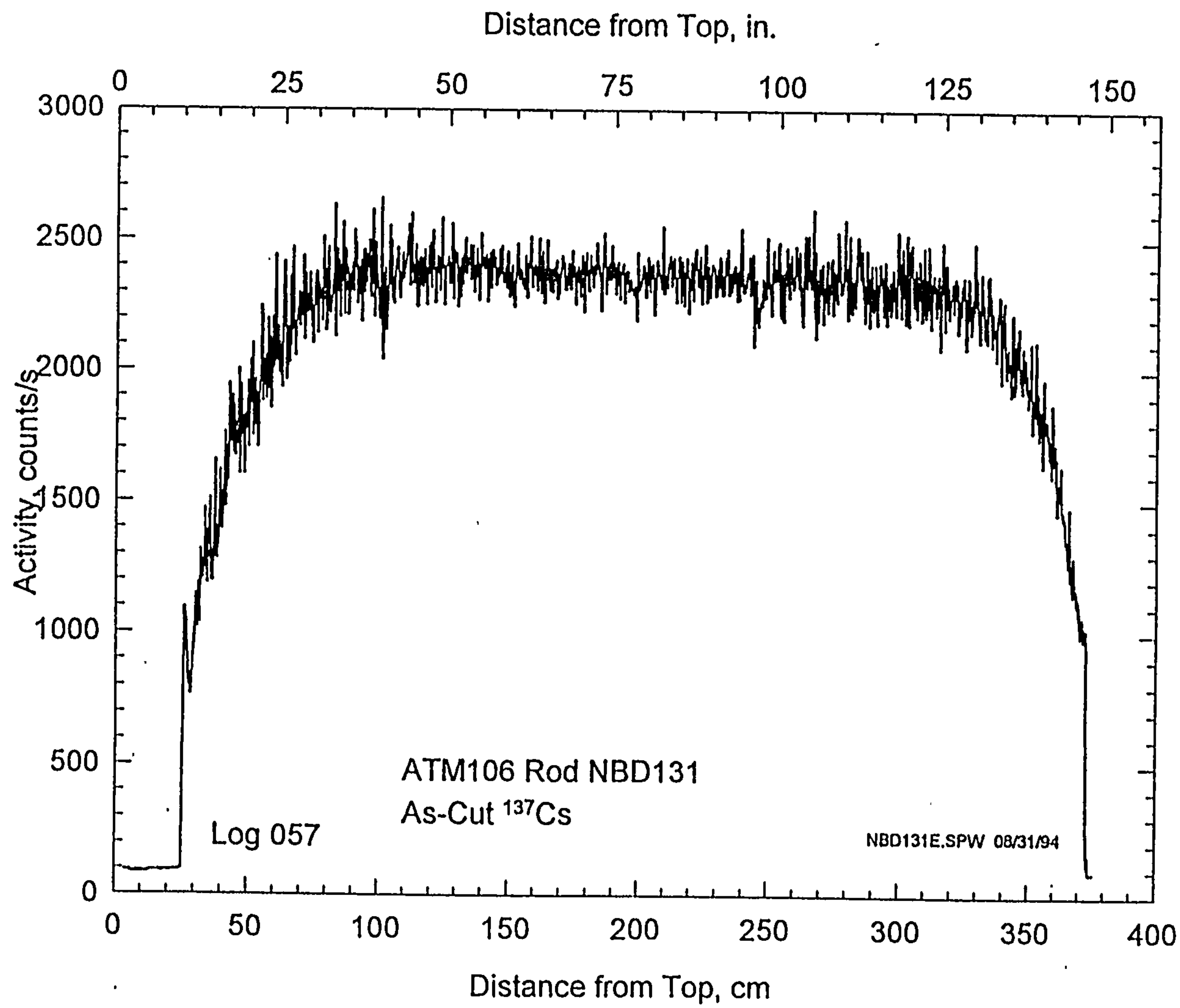


Figure A.4. Gamma Scan of Rod NBD131 of ATM-106

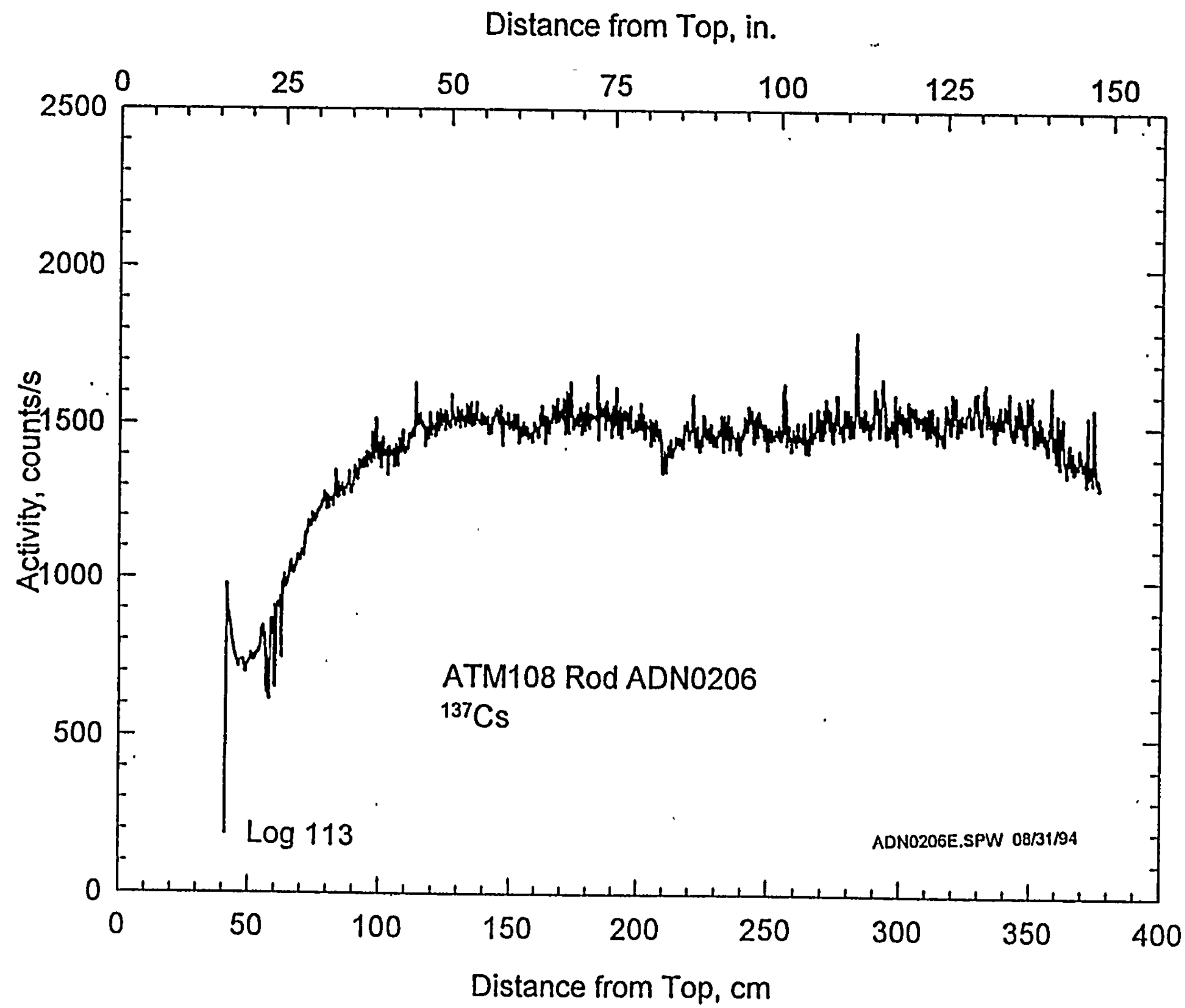


Figure A.5. Gamma Scan of Rod ADN0206 of ATM-108 (Gamma scan for portion of bottom is not available)

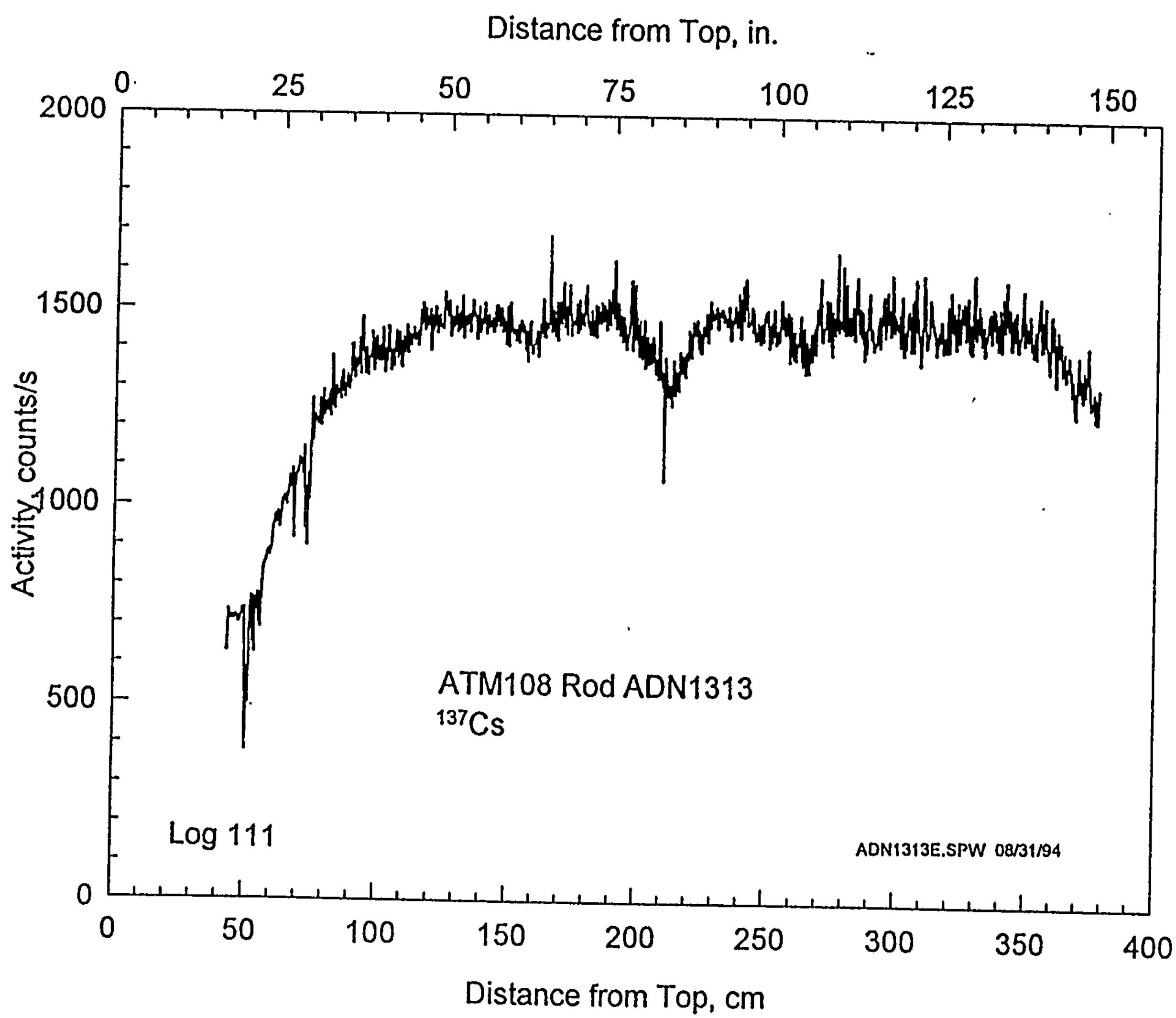


Figure A.6. Gamma Scan of Rod ADN1313 of ATM-108 (Gamma scan for portion of bottom of rod is not available)

Table A.1. Cesium-137 Activities and Estimated Burnups for Rod MLA091

Section Identification	Section Assignment	Original Activity Counts/s	Burnup, MWd/KgM (Measured)
103-MLA091-A	MCC Spare Material	393.3	6.5
103-MLA091-B	MCC Transverse Metallography-Ceramography	1143.6	22.5
103-MLA091-C	MCC ^{129}I on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID	1177.8	23.2
103-MLA091-D	MCC ^{14}C in Fuel and Cladding	1208.9	23.8
103-MLA091-E	MCC Spare and Archive Material	1508.2	30.2
103-MLA091-F	MCC ^{129}I on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID	1590.5	32.0
103-MLA091-G	MCC ^{14}C in Fuel and Cladding	1586.6	31.9
103-MLA091-H	MCC Spare Material	1580.4[(a)]	31.7
103-MLA091-I	MCC Transverse Metallography-Ceramography	1592.9	32.0
103-MLA091-J	MCC Burnup, Isotopes, and Radionuclides	1601.2	32.2(32.91)
103-MLA091-K	MCC ^{129}I in Fuel and on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID	1583.5	31.8
103-MLA091-L	MCC ^{14}C in Fuel and Cladding	1581.7	31.8
103-MLA091-M	MCC Spare and Archive Material	1569.6	31.5
103-MLA091-N	MCC Spare Material	1495.1	29.9
103-MLA091-O	MCC ^{129}I in Fuel and on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID	1285.4	25.5
103-MLA091-P	MCC ^{14}C in Fuel and Cladding	1246.0	24.6
103-MLA091-Q	MCC Spare Material	1095.7	21.4
103-MLA091-R	MCC ^{129}I in Fuel and on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID	863.7	16.5

Table A.1. (contd)

Section Identification	Section Assignment	Original Activity Counts/s	Burnup, MWd/KgM (Measured)
103-MLA091-S	MCC ^{14}C in Fuel and Cladding	761.6	14.3
103-MLA091-T	MCC Spare Material	523.7	9.3

(a) At 76.800, 76.900, and 77.000 in. from the top of the rod, the Cesium-137 activity was an unreasonable 0.0 counts/s. Had the average activity of Cesium-137 been calculated without correcting the 0.0 values to more reasonable numbers, Section H would have shown a lower average Cesium-137 activity than what would have been expected. The 0.0 values were corrected by averaging the counts/s of the data point 0.3 in. above and 0.3 in. below the 76.800-in., 76.900-in., and 77.000-in. points, the corrected averages being 1529.4, 1522.2, and 1558.6, respectively. Then the average Cesium-137 in counts/s was calculated using simple averaging techniques with program AREA.

Note: All activities obtained from AREA for each section have been corrected by the multiplier 1.0094 for this table and then used to find the burnups shown in this table. Since Section J was the only section where the burnup was measured, the known burnup over Section J of Rod MLA091 (32.91) and the burnup equation, BU=0.02126 A-1.855, were used to calculate and activity over Section J which was 1635.2. This was done by inserting the measured burnup into the equation and solving for the activity (A).

Then an average activity of 1620 was found graphically over Section J and divided into 1635.2. This determined the multiplier (1.0094) that would correct the activity of the scan of Rod MLA091, which was scanned December 11, 1987, to what it should have been had Rod MLA091 been scanned the same time Rod MLA098 had been scanned (i.e., March 5, 1987).

Table A.2. Cesium-137 Activities and Estimated Burnups for Rod MK070

Section Identification	Section Assignment	Original Activity Counts/s	Burnup, MWd/KgM (Measured)
104-MKP070-A	MCC Spare Material	526.5	4.9
104-MKP070-B	MCC Transverse Metallography-Ceramography	1574.5	29.0
104-MKP070-C	MCC ^{129}I in Fuel and on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID	1622.1	30.0
104-MKP070-D	MCC ^{14}C in Fuel and Cladding	1670.7	31.2
104-MKP070-E	MCC Spare and Archive Material	2053.0[(a)]	39.9
104-MKP070-F	MCC ^{129}I on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID	2170.3	42.6
104-MKP070-G	MCC ^{14}C in Fuel and Cladding	2166.1	42.5
104-MKP070-H	MCC Spare Material	2163.8	42.5
104-MKP070-I	MCC Transverse Metallography-Ceramography	2176.4	42.8
104-MKP070-J	MCC Burnup, Isotopes, and Radionuclides	2175.3	42.7 (43.75)
104-MKP070-K1	ORNL Comparative Analysis	2162.2	42.4
104-MKP070-K2	ORNL Comparative Analysis	2167.9	42.6
104-MKP070-K3	ORNL Comparative Analysis	2179.3	42.8
104-MKP070-K4	ORNL Comparative Analysis	2202.6	43.4
104-MKP070-L	MCC ^{129}I in Fuel and on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID	2188.1	43.0
104-MKP070-M	MCC ^{14}C in Fuel and Cladding	2173.4	42.7
104-MKP070-N	MCC Spare and Archive Material	2170.8	42.6
104-MKP070-O	MCC ^{129}I on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID	2173.1	42.7
104-MKP070-P	MCC ^{14}C in Fuel and Cladding	2180.8	42.9
104-MKP070-Q	MCC Spare Material	2002.9	38.9

Table A.2. (contd)

Section Identification	Section Assignment	Original Activity Counts/s	Burnup, MWd/KgM (Measured)
104-MKP070-R	MCC Burnup, Isotopes, and Radionuclides	1366.5	24.2 (24.96)
104-MKP070-S	MCC ^{129}I in Fuel and on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID	1256.3	21.7
104-MKP070-T	MCC ^{14}C in Fuel and Cladding	1117.5	18.5
104-MKP070-U	MCC Spare Material	816.2	11.6

(a) In the data file MKP070.2ND, at 23.050 in. from the top of the rod, the Cesium-137 activity drops to an unreasonable 620.2 counts/s. The 620.2 was replaced with 1978.2, which was an average of the measured Cesium-137 activity at 23.250 in. (1984.0) and 22.850 in. (1972.5) in the data file. Then the average activity over the entire section was calculated using the program AREA (code custodian NJ Wildung) with the corrected value 1978.2 in place of 620.2 counts/s at 23.050 in. from the top of the rod.

Note: The burnups were calculated using the burnup equation BU=0.02294 A-7.16. The burnup equation was formulated by plotting the known burnups of Sections J and R against the measured Cesium-137 activity over the two sections which were found graphically (2219.1 counts/s over Section J and 1400.0 over Section R). Then the linear burnup equation was found that related the burnup as a function of Cesium-137 activity so that the burnup over any section of the rod could be estimated by knowing the Cesium-137 activity over the section.

Table A.3. Cesium-137 Activities and Estimated Burnups for Rod NBD095

Section Identification	Section Assignment	Original Activity Counts/s	Burnup, MWd/KgM (Measured)
106-NBD095-A	MCC Spare Material	706.6	12.5
106-NBD095-B	ORNL Spark Source and Mass Spectrometry	1236.1	24.6
106-NBD095-C	ORNL Spark Source and Mass Spectrometry[(a)]	1307.3	26.2
106-NBD095-D	MCC Burnup, Isotopes, and Radionuclides[(a)]	1359.0	27.4 (27.42)
106-NBD095-E	MCC ^{3}H in Cladding	1398.8	28.3
106-NBD095-F	MCC ^{129}I in Fuel and on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID; Hydrogen in Cladding	1470.3	30.0
106-NBD095-G	MCC Transverse Metallography-Ceramography	1551.1	31.8
106-NBD095-H	MCC ^{14}C in Fuel and Cladding	1566.9	32.2
106-NBD095-I	MCC Spare and Archive Material	1763.2	36.7
106-NBD095-J	MCC ^{3}H in Cladding	1920.8	40.3
106-NBD095-K	MCC ^{129}I in Fuel and on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID; Hydrogen in Cladding	1976.4	41.5
106-NBD095-L	MCC Spare Material	2055.8	43.3
106-NBD095-M	MCC ^{3}H in Cladding	2125.5	44.9
106-NBD095-N	MCC ^{129}I in Fuel and on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID; Hydrogen in Cladding	2117.5	44.7
106-NBD095-O	MCC Transverse Metallography-Ceramography	2122.6	44.9
106-NBD095-P	MCC ^{14}C in Fuel and Cladding	2133.5	45.1
106-NBD095-Q	MCC Spare and Archive Material	2161.5	45.7
106-NBD095-R	MCC Acid Etch Assay	2190.8	46.6
106-NBD095-S	MCC Acid Etch Assay	2169.4	45.9

Table A.3. (contd)

Section Identification	Section Assignment	Original Activity Counts/s	Burnup, MWd/KgM (Measured)
106-NBD095-T	MCC Acid Etch Assay	2176.0	46.1
106-NBD095-U	MCC Acid Etch Assay	2193.5	46.5
106-NBD095-V	MCC Acid Etch Assay	2197.7	46.6
106-NBD095-W	ORNL Spark Source and Mass Spectrometry	2183.0	46.2
106-NBD095-X	ORNL Spark Source and Mass Spectrometry[(a)]	2177.1	46.1
106-NBD095-Y	MCC Burnup, Isotopes, and Radionuclides[(a)]	2205.3	46.7 (46.75)
106-NBD095-Z	MCC ^{3}H in Cladding	2205.5	46.8
106-NBD095-AA	MCC ^{129}I in Fuel and on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID; Hydrogen in Cladding	2184.3	46.3
106-NBD095-BB	MCC Transverse Metallography-Ceramography	2205.2	46.7
106-NBD095-CC	MCC GGBI Sample	2207.0	46.8
106-NBD095-CC-2	MCC GGBI Sample	2186.6	46.3
106-NBD095-DD	MCC Spare Material	2162.2	45.8
106-NBD095-EE	MCC ^{3}H in Cladding	2156.6	45.6
106-NBD095-FF	MCC ^{129}I in Fuel and on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID; Hydrogen in Cladding	2145.4	45.4
106-NBD095-GG	MCC Transverse Metallography-Ceramography	2133.5	45.1
106-NBD095-HH	MCC ^{14}C in Fuel and Cladding	2112.2	44.6
106-NBD095-II	MCC Spare and Archive Material	2132.0	45.1
106-NBD095-JJ	MCC GGBI Sample	2134.3	45.1
106-NBD095-KK	MCC ^{3}H in Cladding	2152.0	45.5
106-NBD095-LL	MCC ^{135}Cs and ^{137}Cs in Fuel	2135.8	45.2

Table A.3. (contd)

Section Identification	Section Assignment	Original Activity Counts/s	Burnup, MWd/KgM (Measured)
106-NBD095-MM	MCC ^{129}I in Fuel and on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID; Hydrogen in Cladding	2156.9	45.6
106-NBD095-NN	MCC Transverse Metallography-Ceramography	2134.8	45.1
106-NBD095-OO	MCC Longitudinal Metallography-Ceramography	2175.3	46.1
106-NBD095-PP	MCC ^{14}C in Fuel and Cladding	2121.8	44.8
106-NBD095-QQ	MCC Acid Etch Assay	2097.2	44.3
106-NBD095-RR	MCC Acid Etch Assay	2155.5	45.6
106-NBD095-SS	MCC Acid Etch Assay	2187.6	46.3
106-NBD095-TT	MCC Acid Etch Assay	2177.7	46.1
106-NBD095-UU	MCC Acid Etch Assay	2113.4	44.6
106-NBD095-VV	MCC Spare Material	2132.6	45.1
106-NBD095-WW	MCC ^{3}H in Cladding	2117.1	44.7
106-NBD095-XX	MCC ^{129}I in Fuel and on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID; Hydrogen in Cladding	2108.7	44.5
106-NBD095-YY	MCC Transverse Metallography-Ceramography	2111.9	44.6
106-NBD095-ZZ	MCC Spare Material	1900.8	39.8
106-NBD095-AAA	MCC GGBI Sample	1562.4	32.1
106-NBD095-BBB	MCC ^{3}H in Cladding	1501.1	30.7
106-NBD095-CCC	MCC ^{129}I in Fuel and on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID; Hydrogen in Cladding	1432.2	29.1
106-NBD095-DDD	MCC Transverse Metallography-Ceramography	1338.8	27.0

Table A.3. (contd)

Section Identification	Section Assignment	Original Activity Counts/s	Burnup, MWd/KgM (Measured)
106-NBD095-EEE	MCC ^{14}C in Fuel and Cladding	1269.2	25.4
106-NBD095-FFF	MCC Spare Material	802.7	14.7

(a) Samples C and D and Samples X and Y from Rod NBD095 were combined to provide a blended fuel sample for SSMS and burnup analyses.

Note: To determine the burnups in this table, the two known burnups from Sections C/D and X/Y were plotted against the average Cesium-137 activity found over sections by the program AREA (code custodian NJ Wildung). A linear equation was found that related the burnup as a function of Cesium-137 activity so that the burnup over any section of the rod could be estimated by knowing the Cesium-137 activity over the section. The equation created and used was BU=0.02284 A-3.620 where BU is burnup in MWd/KgM and A is Cesium-137 activity in counts/s.

Table A.4. Cesium-137 Activities and Estimated Burnups for Rod NBD131

Section Identification	Section Assignment	Original Activity Counts/s	Burnup, MWd/KgM (Measured)
106-NBD131-A	MCC Spare Material	429.2	5.7
106-NBD131-B	MCC Transverse Metallography-Ceramography	1351.1	25.8
106-NBD131-B(lost)	Lost Sample	1332.5	25.4
106-NBD131-C	MCC ^{129}I on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID	1533.7	29.8
106-NBD131-D	MCC ^{14}C in Fuel and Cladding	1689.3	33.2
106-NBD131-E	MCC Spare and Archive Material	1932.6	38.6
106-NBD131-F	MCC ^{129}I in Fuel and on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID	2147.1	43.2
106-NBD131-G	MCC Spare Material	2283.3	46.2
106-NBD131-H	MCC Longitudinal Metallography-Ceramography	2386.5	48.5
106-NBD131-I	MCC Transverse Metallography-Ceramography	2364.4	48.0
106-NBD131-J	MCC ^{129}I on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID	2323.1	47.1
106-NBD131-K	MCC ^{14}C in Fuel and Cladding	2447.6	49.8
106-NBD131-L	MCC Spare and Archive Material	2384.0	48.4
106-NBD131-M	MCC Transverse Metallography-Ceramography	2358.6	47.9
106-NBD131-N	MCC ^{129}I on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID	2406.5	48.9
106-NBD131-O	MCC Spare Material	2368.6	48.1
106-NBD131-P	MCC Transverse Metallography-Ceramography	2376.7	48.3
106-NBD131-Q	MCC Burnup, Isotopes, and Radionuclides	2404.6	48.9 (49.65)

Table A.4. (contd)

Section Identification	Section Assignment	Original Activity Counts/s	Burnup, MWd/KgM (Measured)
106-NBD131-R	MCC ^{129}I in Fuel and on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID	2374.1	48.2
106-NBD131-S	MCC ^{14}C in Fuel and Cladding	2367.0	48.1
106-NBD131-T	MCC Spare and Archive Material	2352.7	47.7
106-NBD131-U	MCC Longitudinal Metallography-Ceramography	2338.7	47.4
106-NBD131-V	MCC Transverse Metallography-Ceramography	2459.7	50.1
106-NBD131-W	MCC ^{129}I in Fuel and on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID	2393.9	48.6
106-NBD131-X	MCC ^{14}C in Fuel and Cladding	2252.1	45.5
106-NBD131-Y	MCC Spare Material	2340.8	47.5
106-NBD131-Z	MCC ^{129}I on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID	2292.5	46.4
106-NBD131-AA	MCC Spare Material	2104.9	42.3
106-NBD131-BB	MCC Transverse Metallography-Ceramography	1699.6	33.5
106-NBD131-CC	MCC Burnup, Isotopes, and Radionuclides	1544.4	30.3 (31.28)
106-NBD131-DD	MCC ^{129}I in Fuel and on Cladding ID, MCC ^{135}Cs and ^{137}Cs on Cladding ID	1505.8	29.2
106-NBD131-EE	MCC ^{14}C in Fuel and Cladding	1342.6	25.7
106-NBD131-FF	MCC Spare Material	842.9	14.7

Note: The burnups were calculated using the burnup equation BU=0.02187 A-3.71. The burnup equation was formulated by plotting the known burnups of Sections Q and CC against the measured Cesium-137 activity over the two sections which were found graphically. Then the linear burnup equation was found that related the burnup as a function of Cesium-137 activity so that the burnup over any section of the rod could be estimated by knowing the Cesium-137 activity over the section.

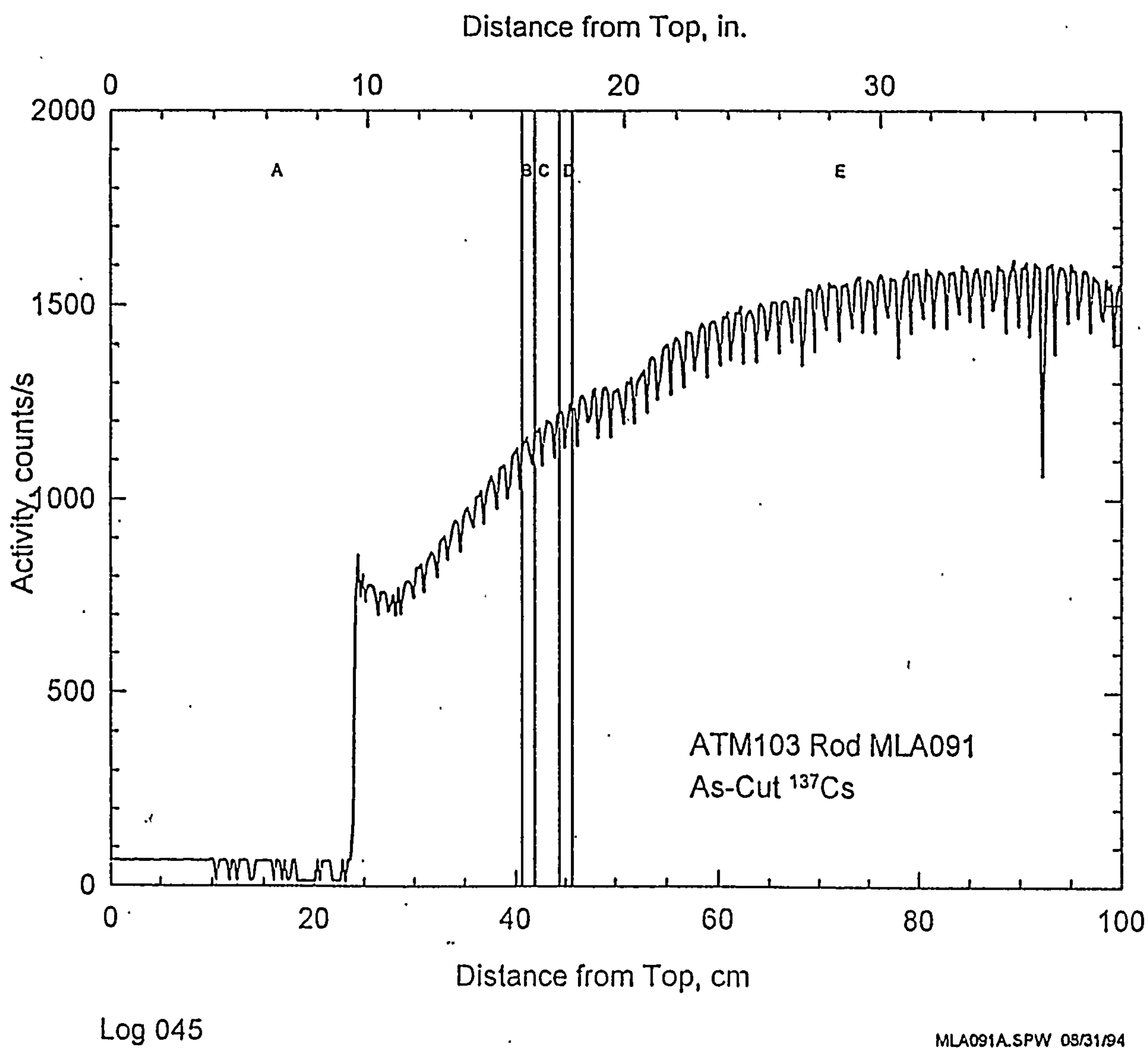


Figure A.7.a. Sectioning Diagram for Rod MLA091 of ATM-103

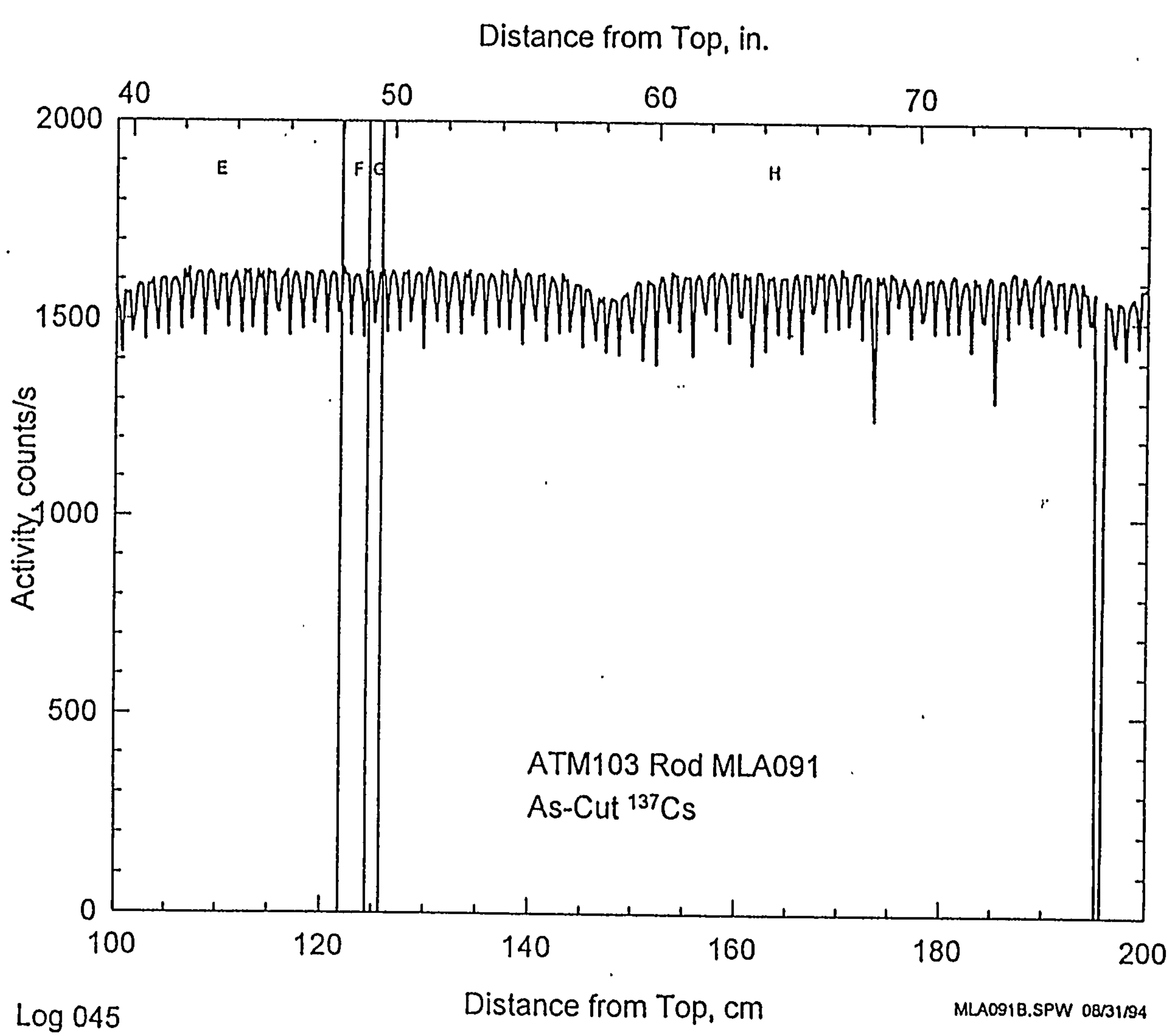


Figure A.7.b. Sectioning Diagram for Rod MLA091 of ATM-103

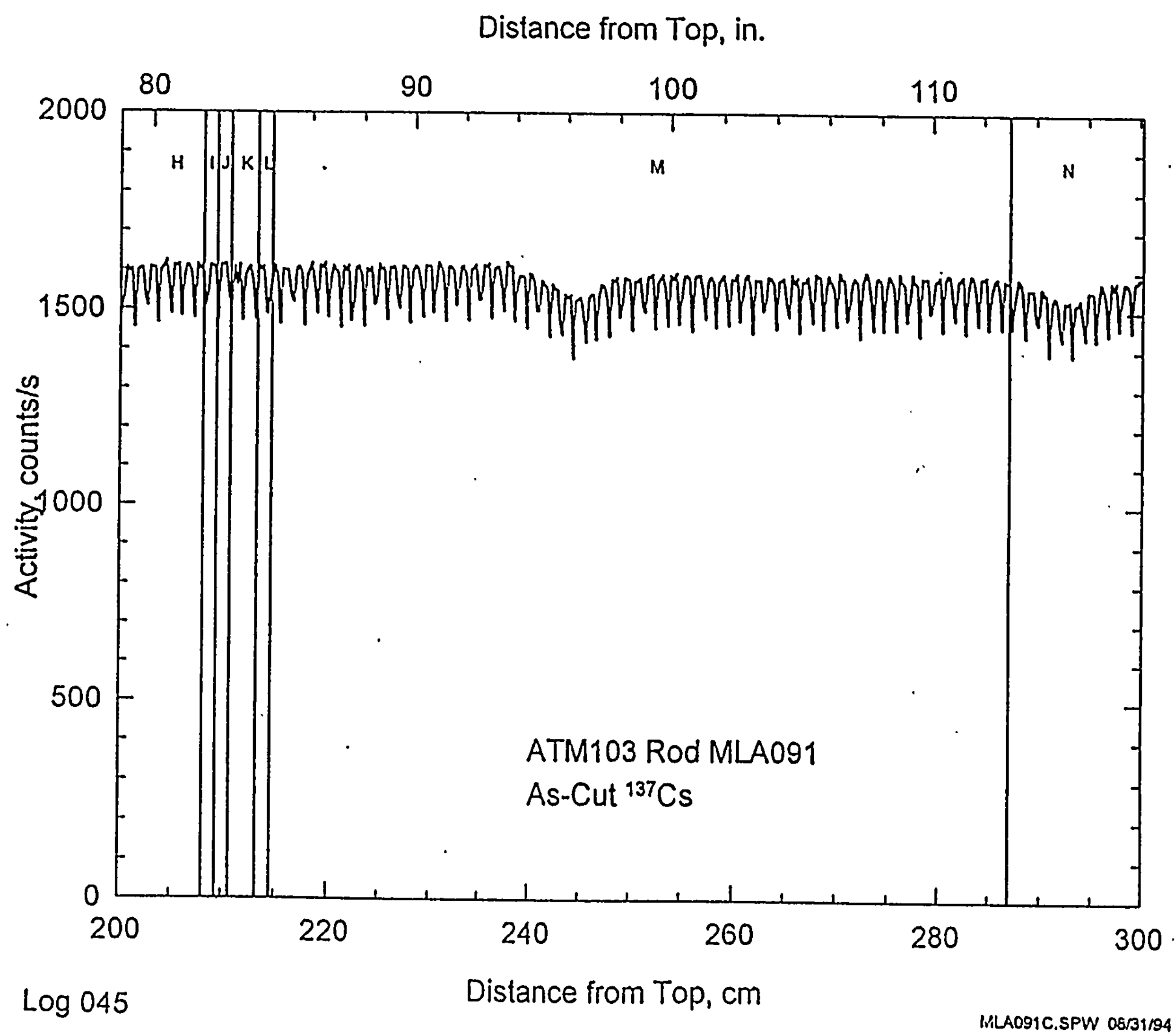


Figure A.7.c. Sectioning Diagram for Rod MLA091 of ATM-103

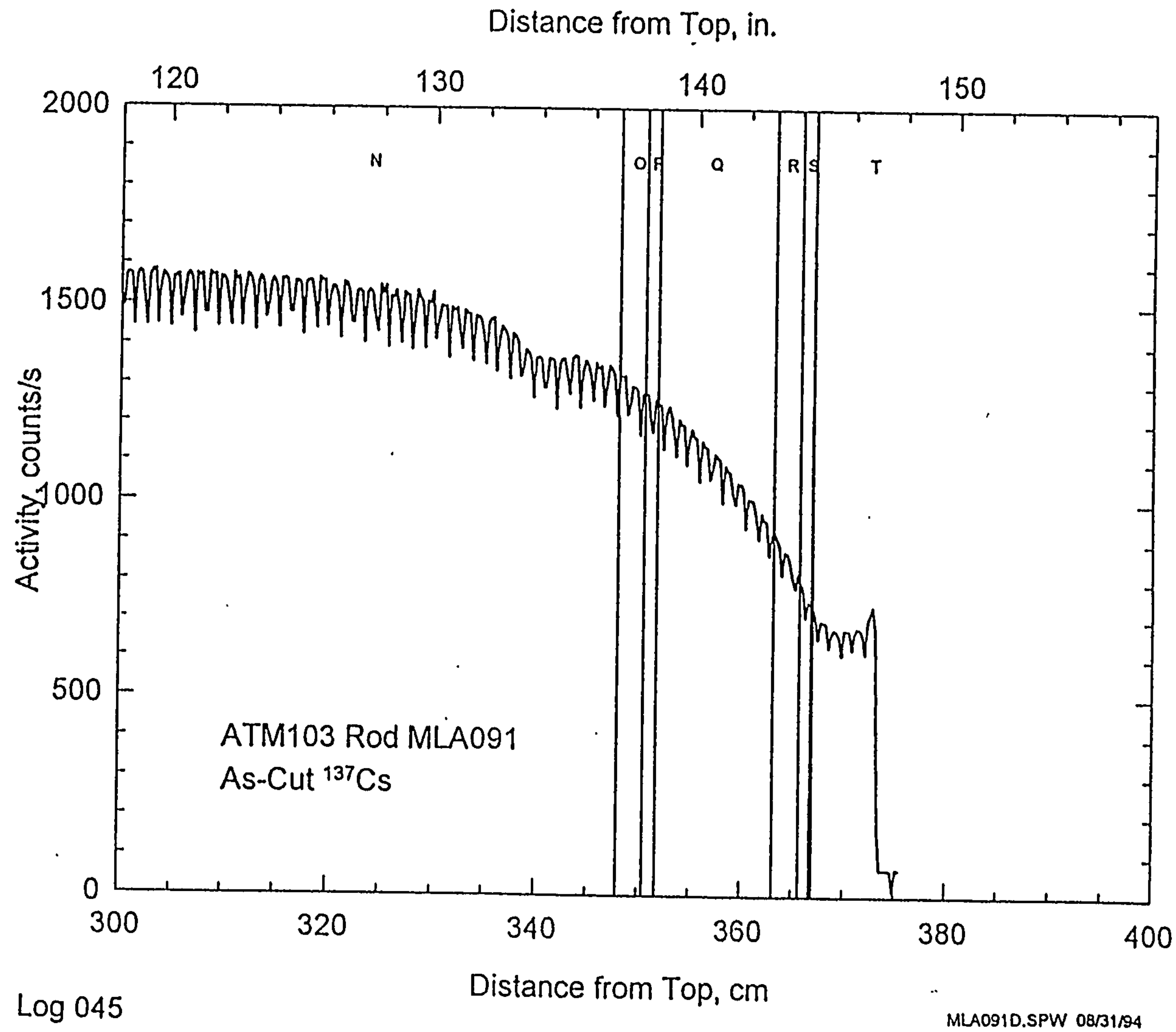


Figure A.7.d. Sectioning Diagram for Rod MLA091 of ATM-103

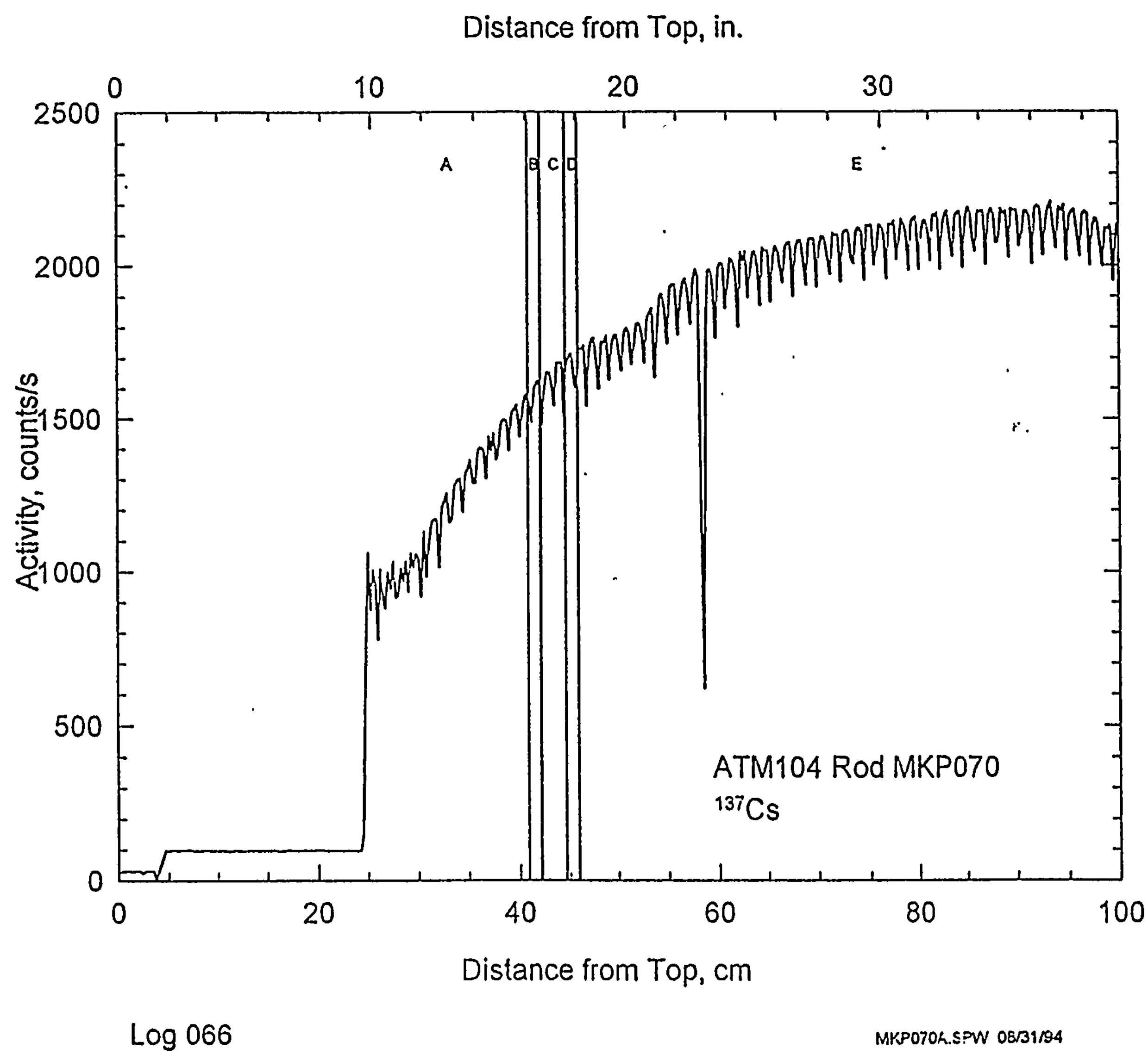


Figure A.8.a. Sectioning Diagram for Rod MKP070 of ATM-104

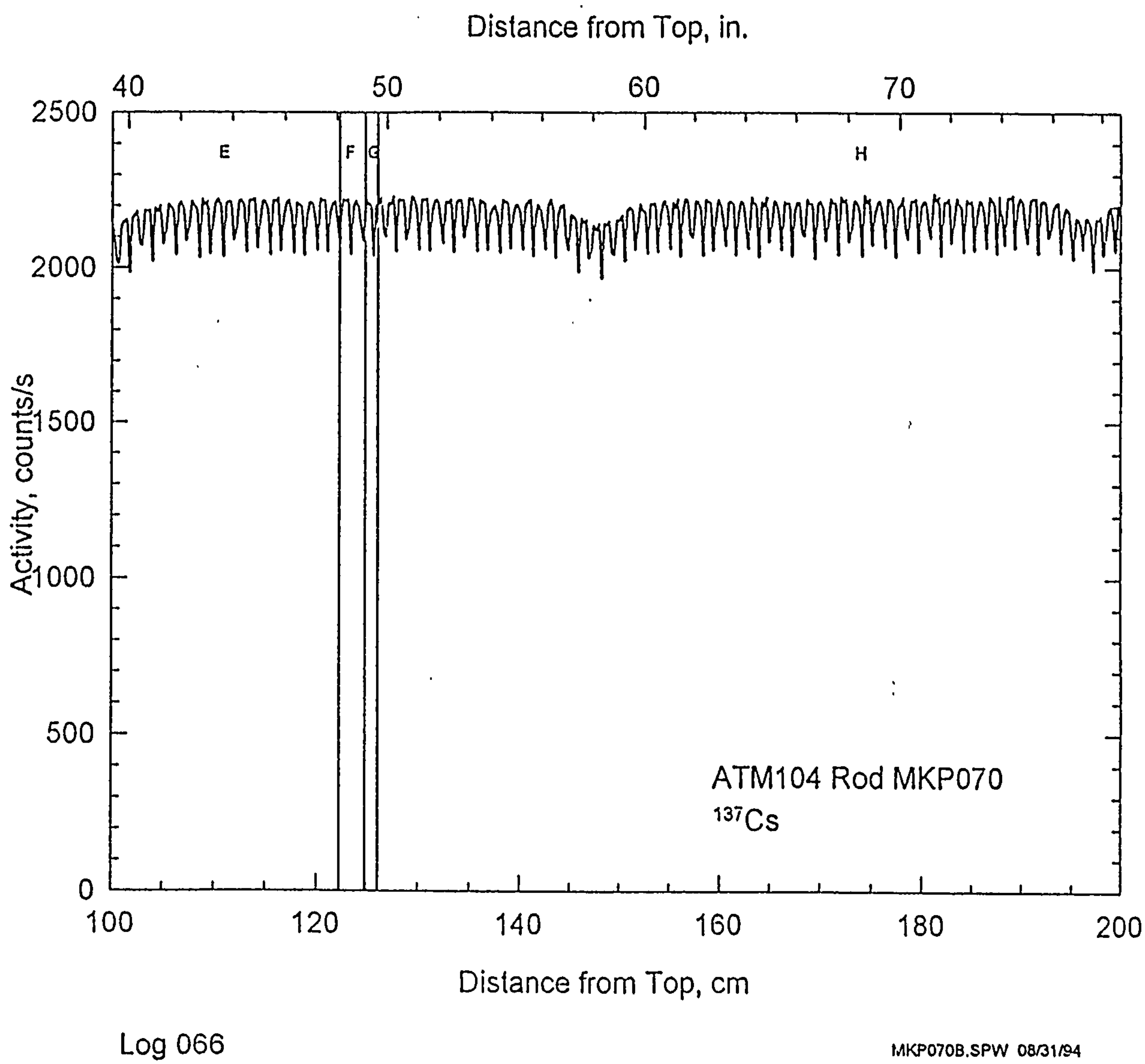


Figure A.8.b. Sectioning Diagram for Rod MKP070 of ATM-104

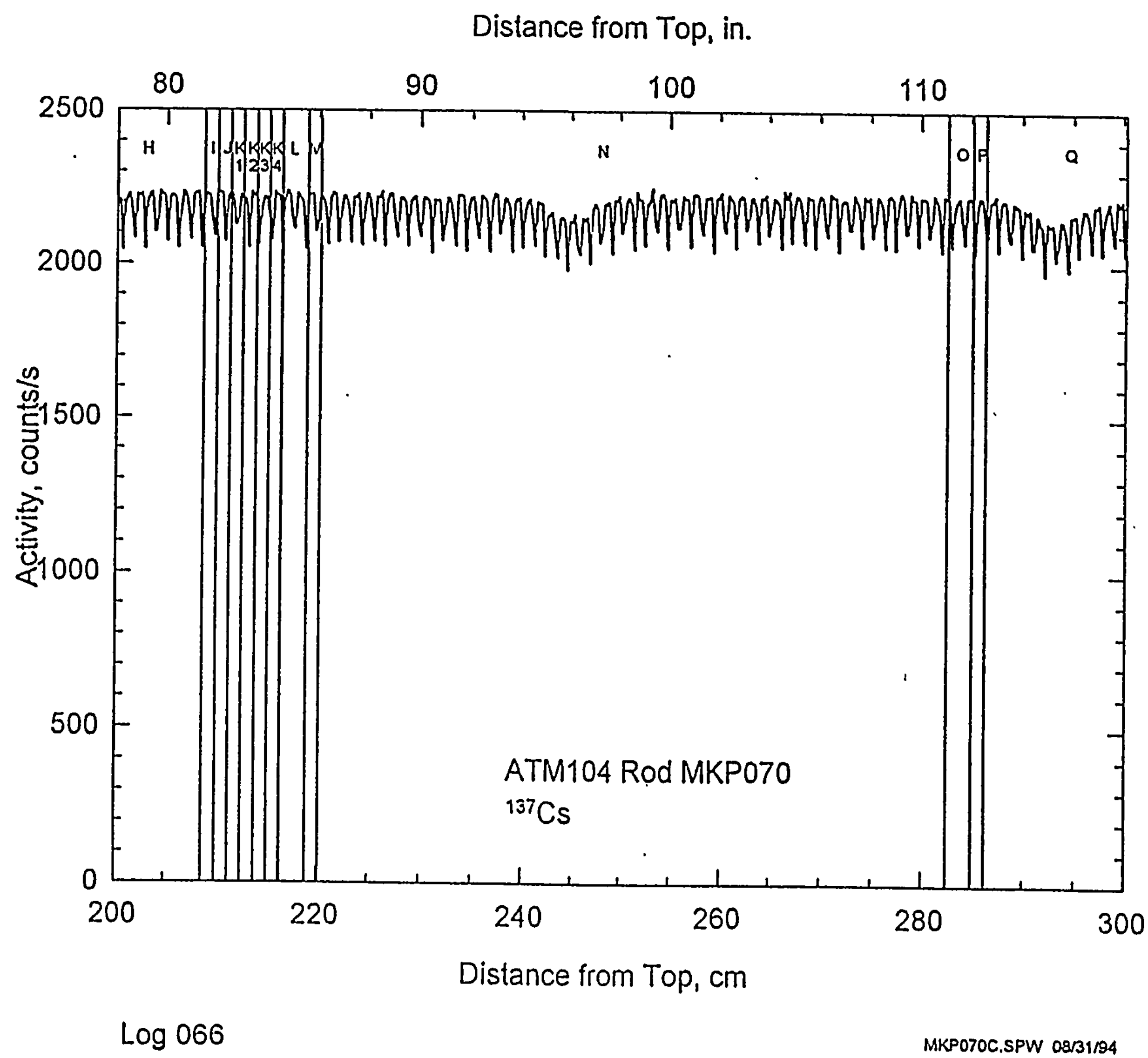


Figure A.8.c. Sectioning Diagram for Rod MKP070 of ATM-104

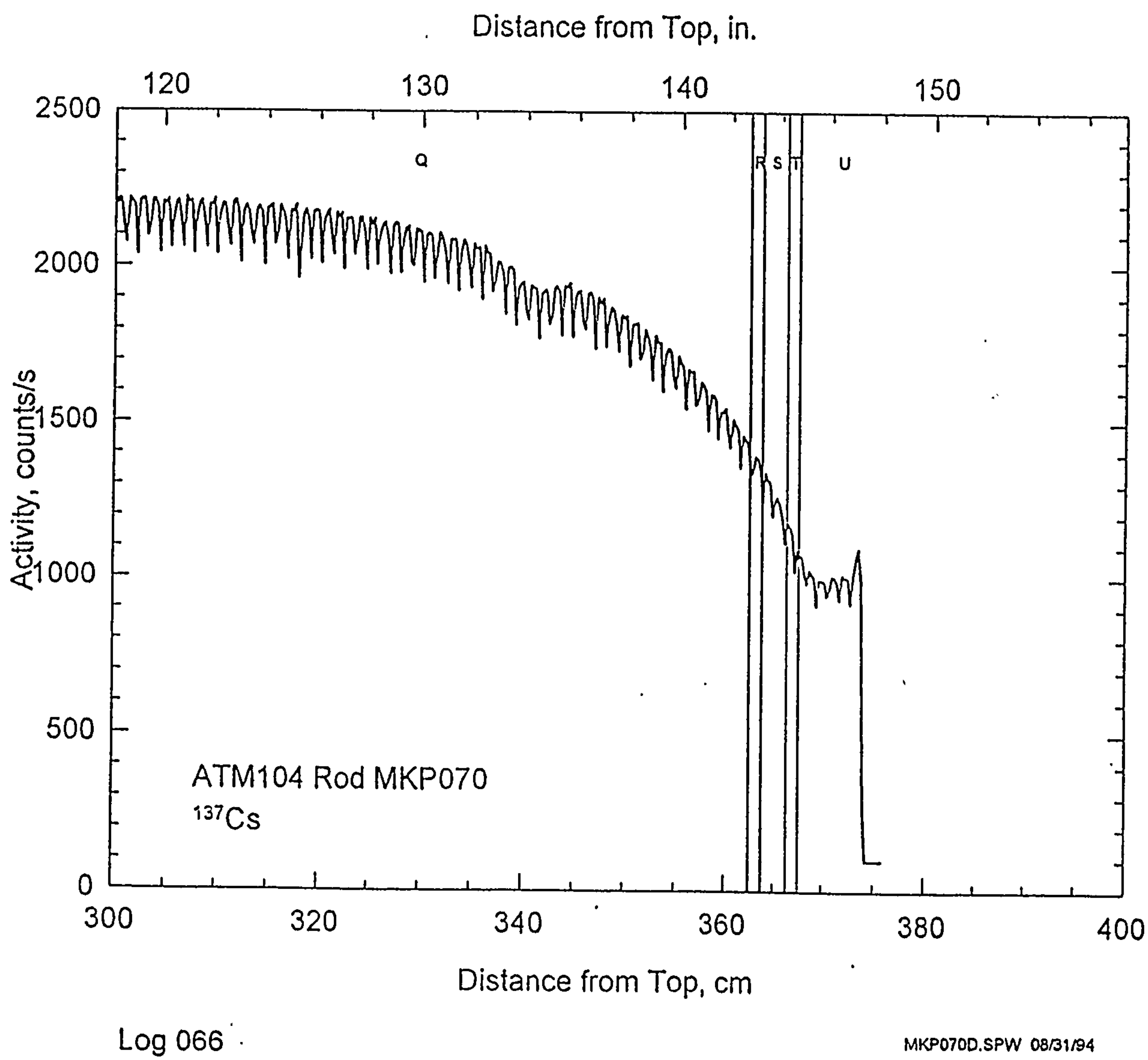


Figure A.8.d. Sectioning Diagram for Rod MKP070 of ATM-104

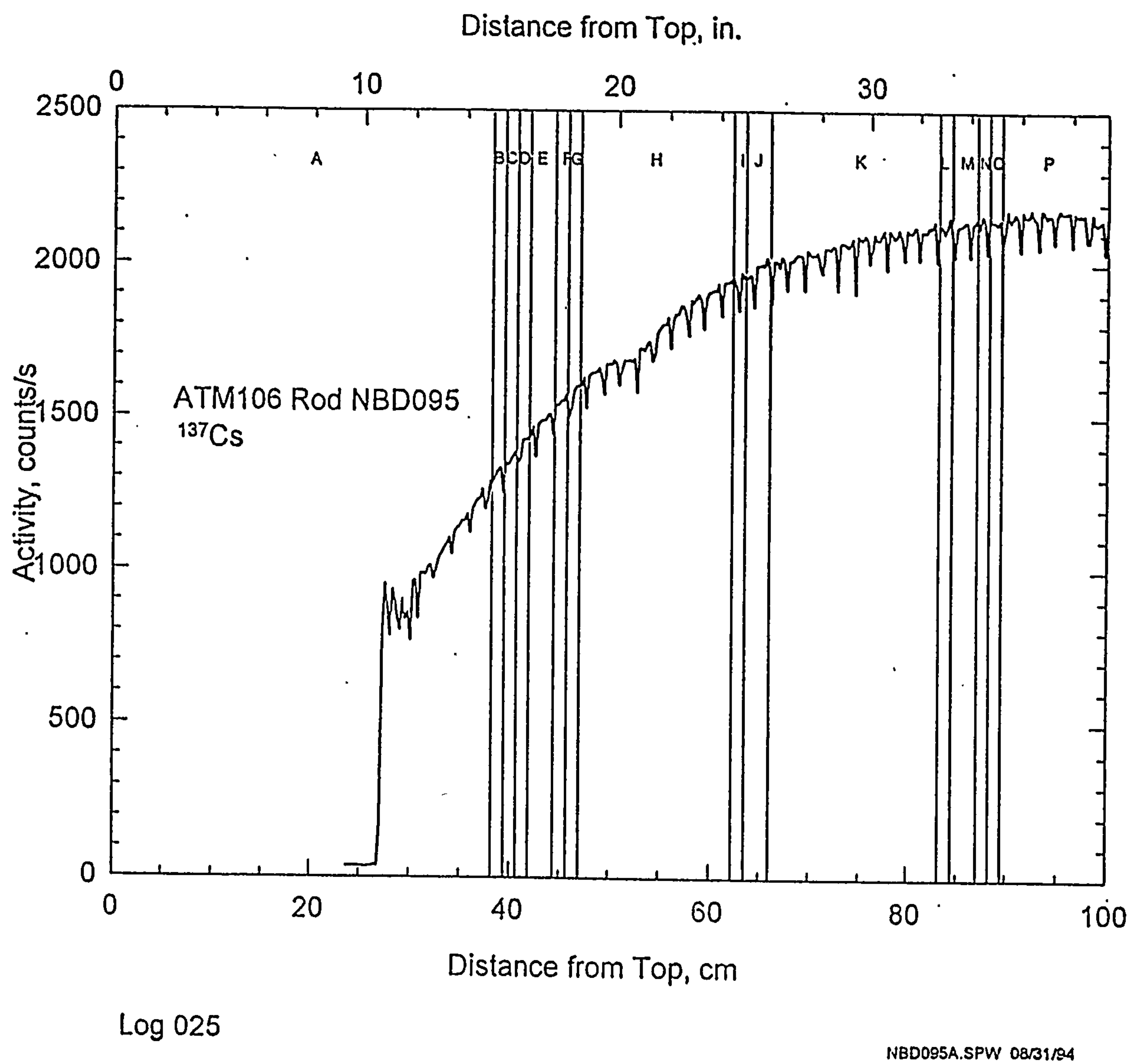
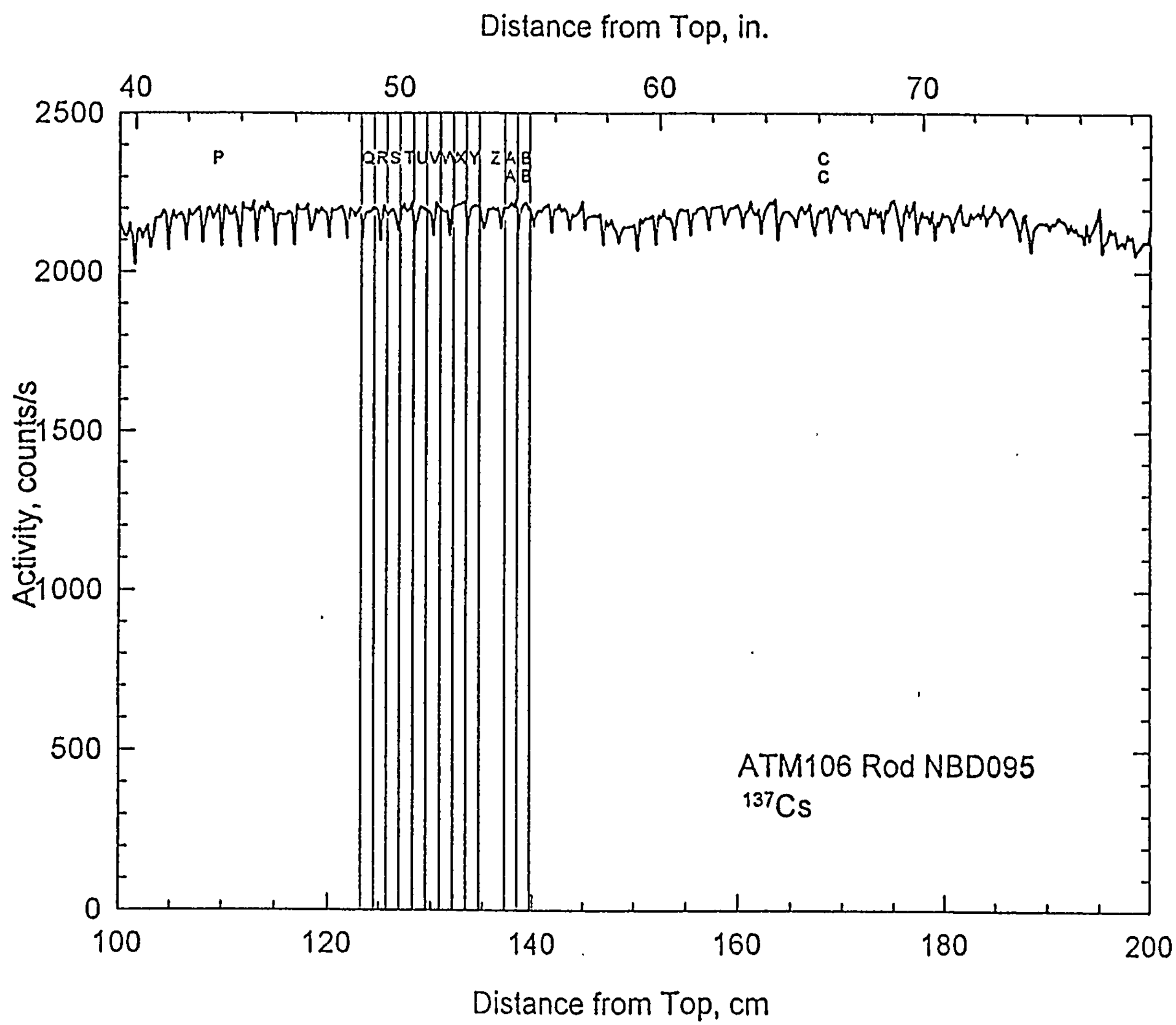


Figure A.9.a. Sectioning Diagram for Rod NBD095 of ATM-106



Log 025

NBD095B.SPW 08/31/94

Figure A.9.b. Sectioning Diagram for Rod NBD095 of ATM-106

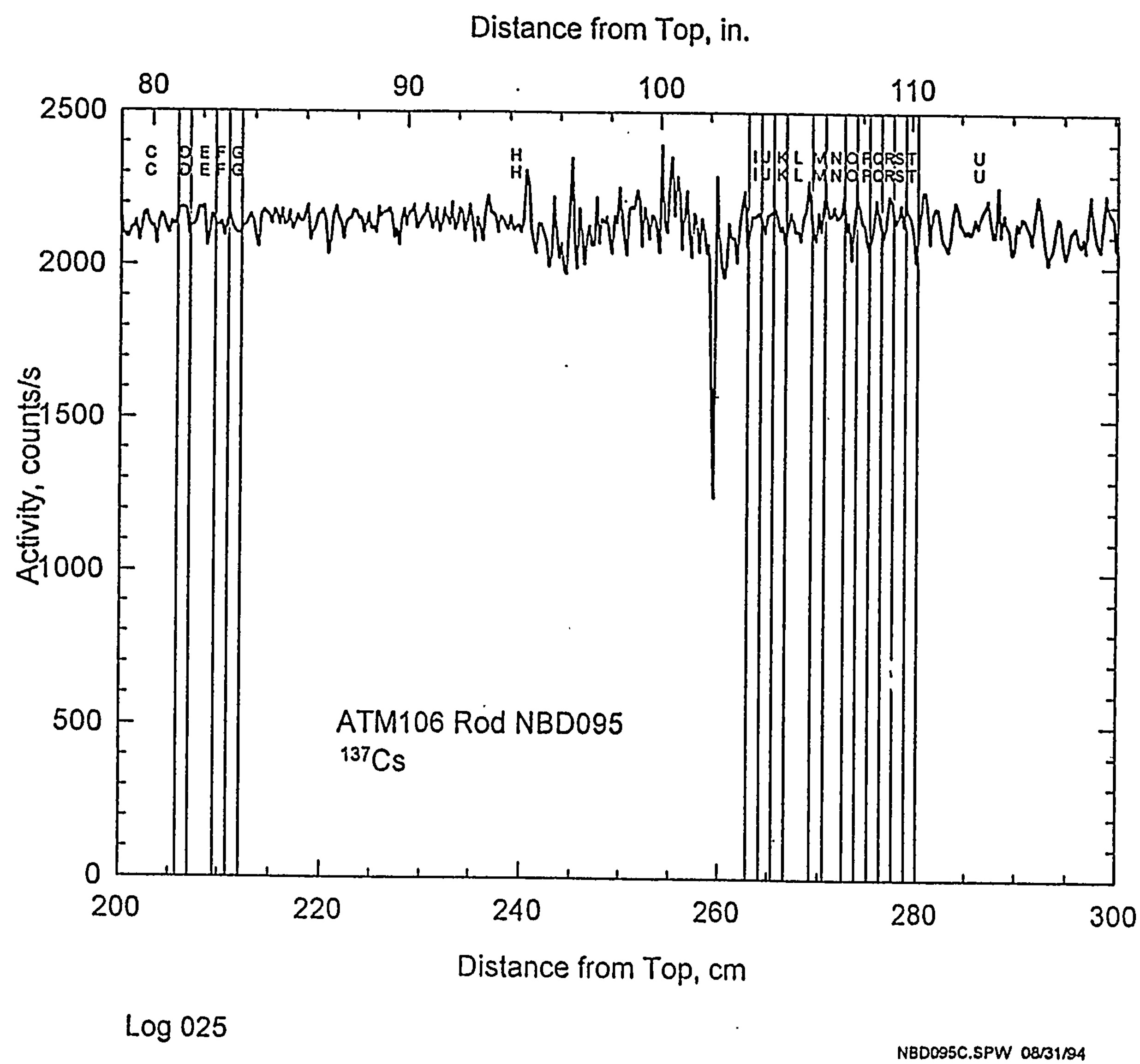


Figure A.9.c. Sectioning Diagram for Rod NBD095 of ATM-106

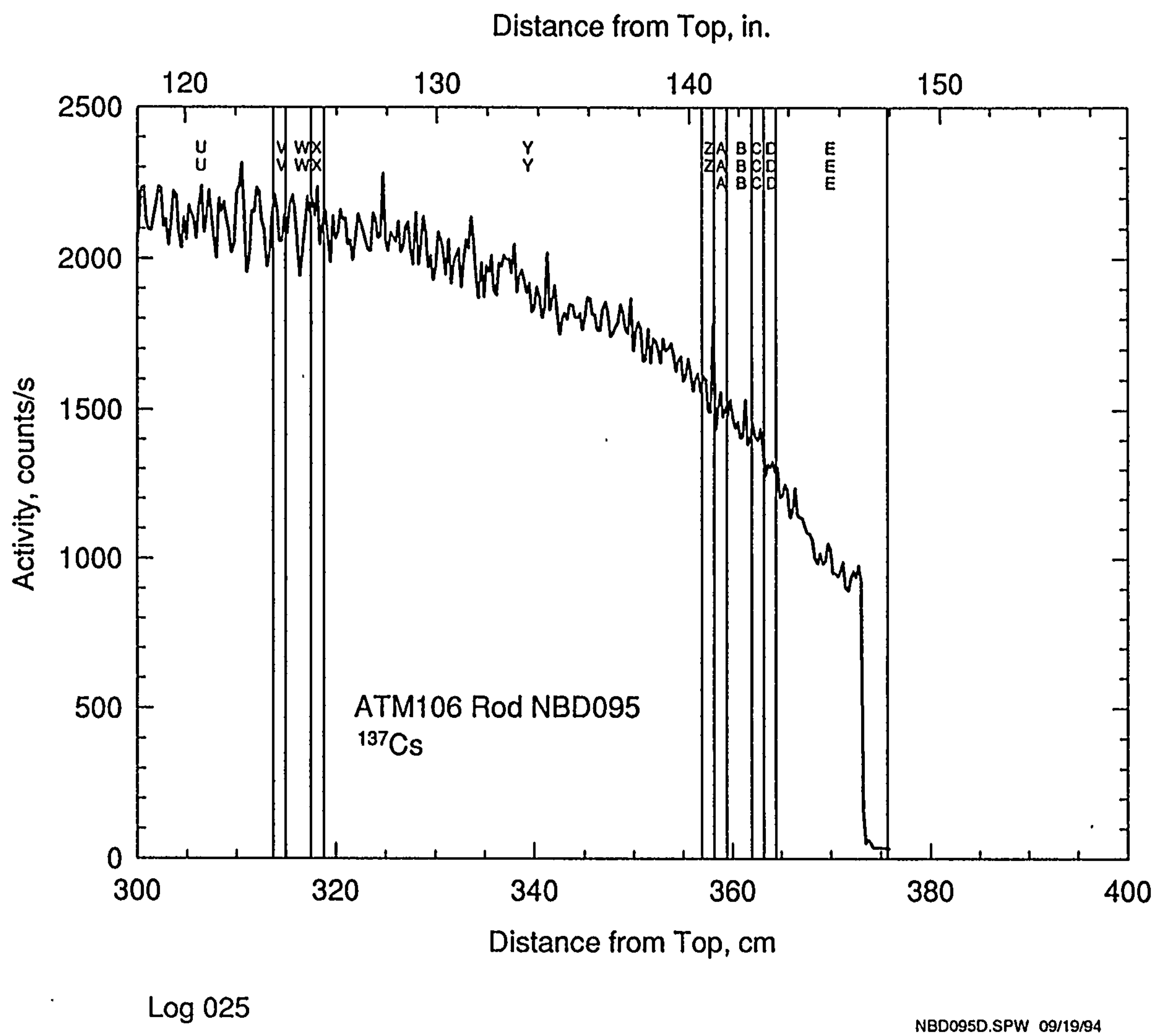


Figure A.9.d. Sectioning Diagram for Rod NBD095 of ATM-106

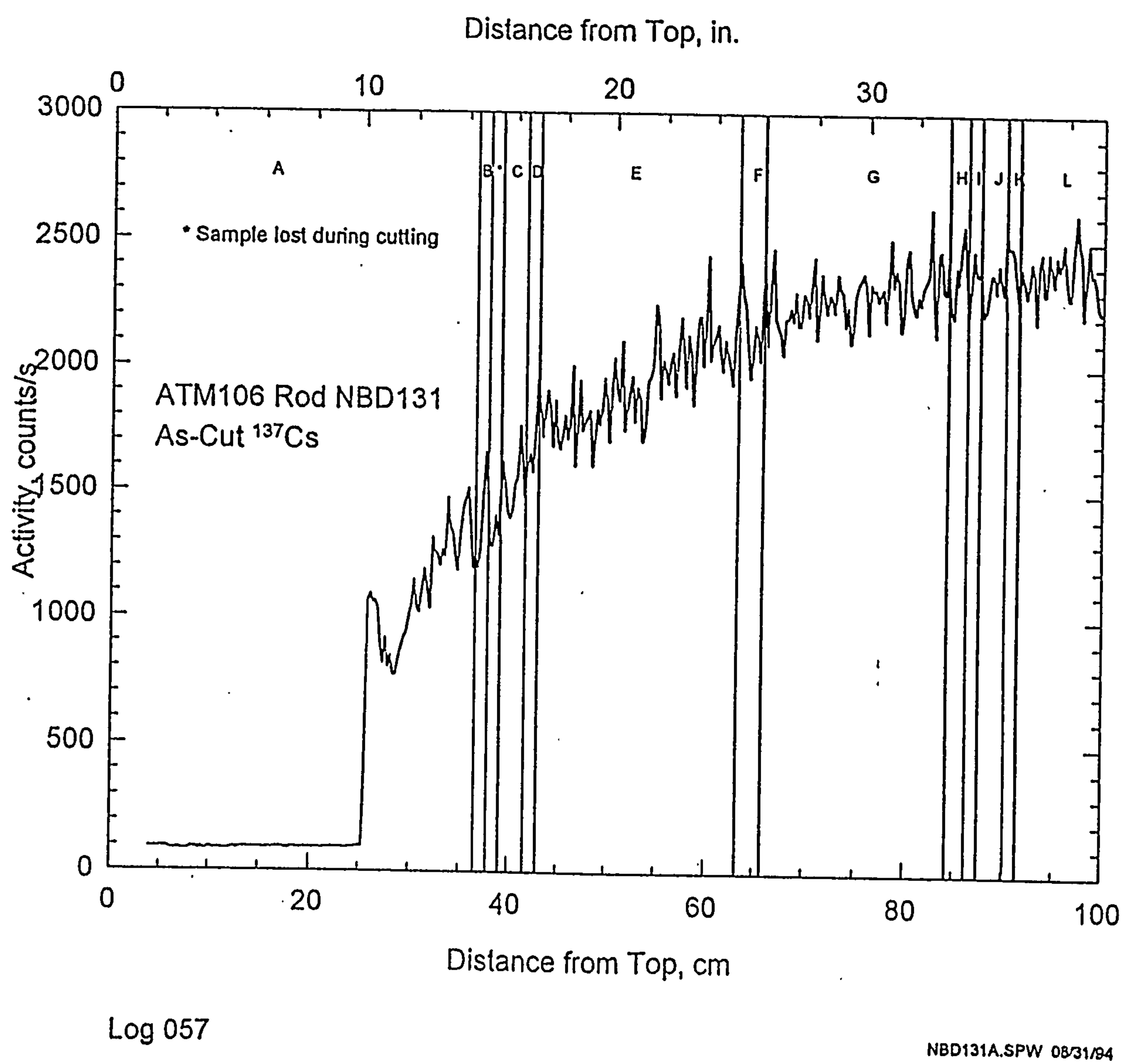


Figure A.10.a. Sectioning Diagram for Rod NBD131 of ATM-106

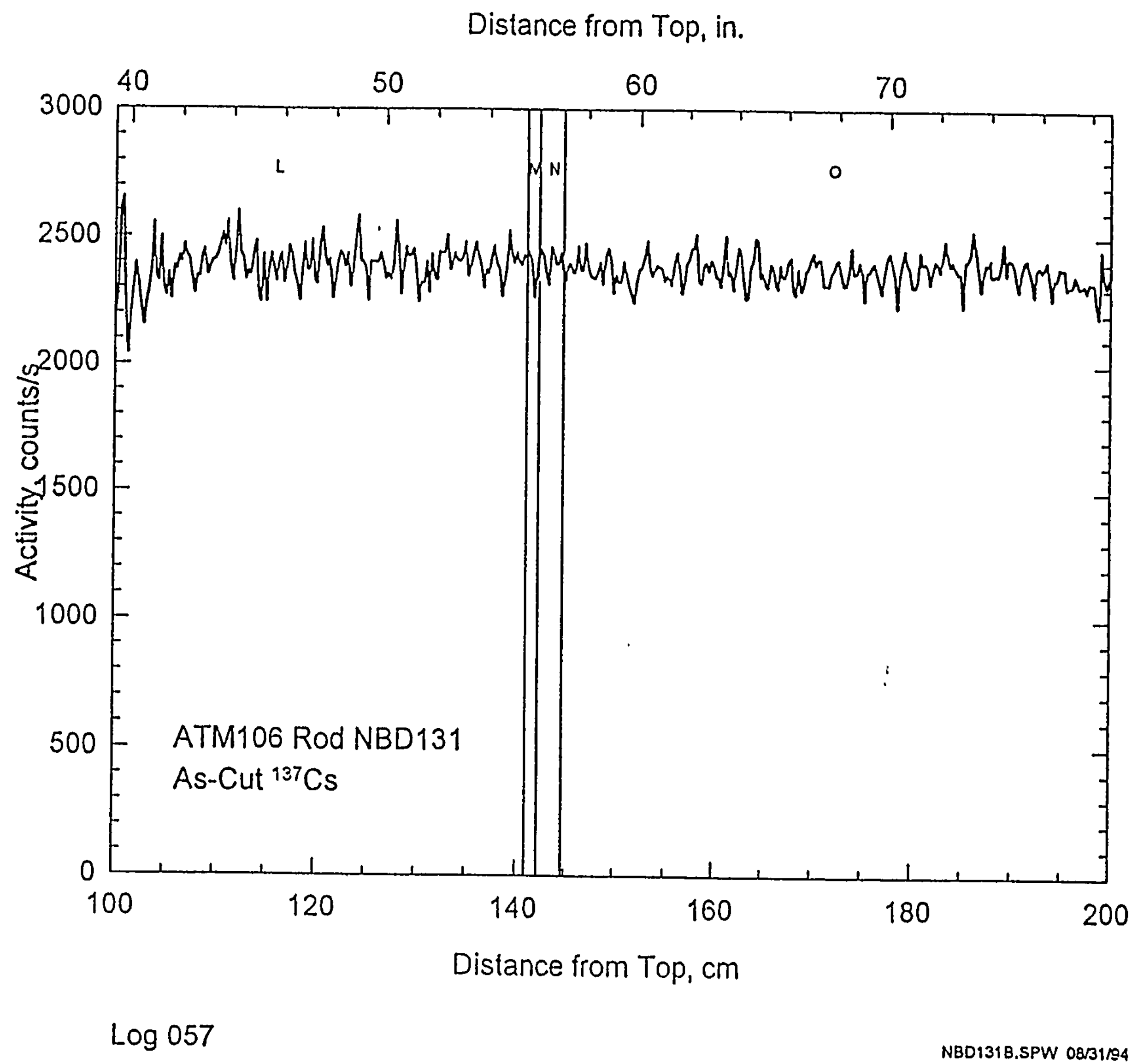


Figure A.10.b. Sectioning Diagram for Rod NBD131 of ATM-106

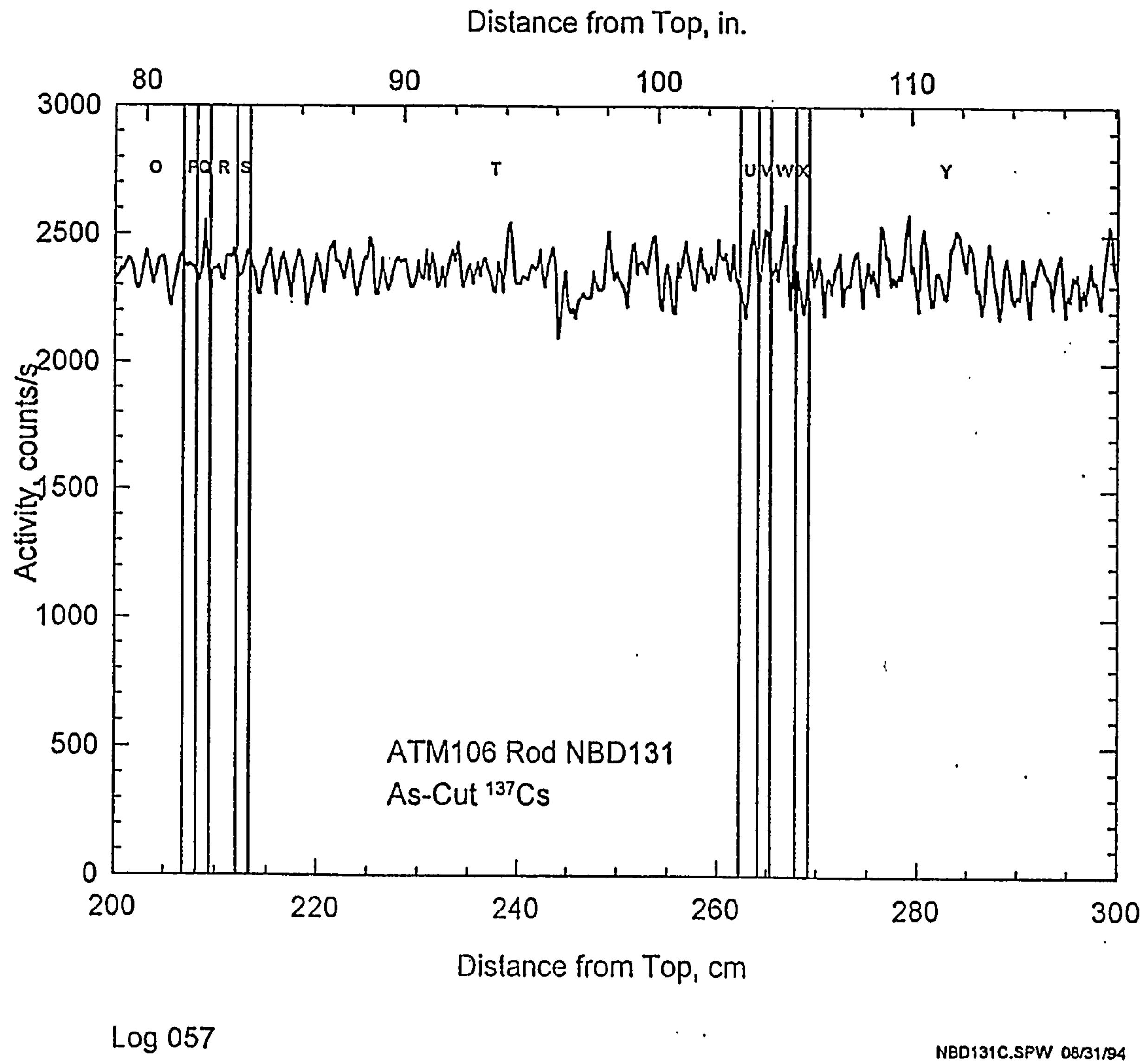
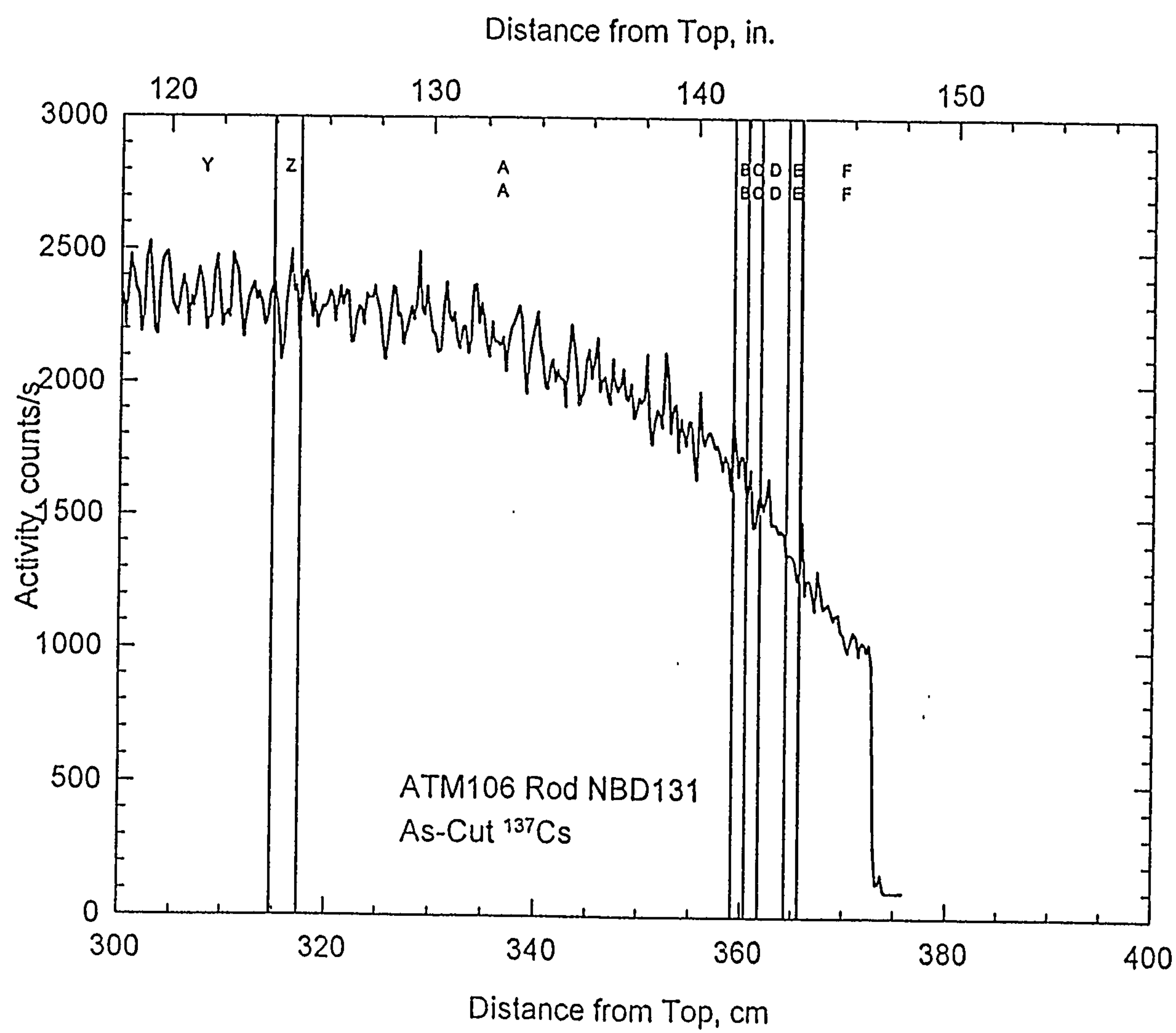


Figure A.10.c. Sectioning Diagram for Rod NBD131 of ATM-106



Log 057

NBD131D.SPW 08/31/94

Figure A.10.d. Sectioning Diagram for Rod NBD131 of ATM-106

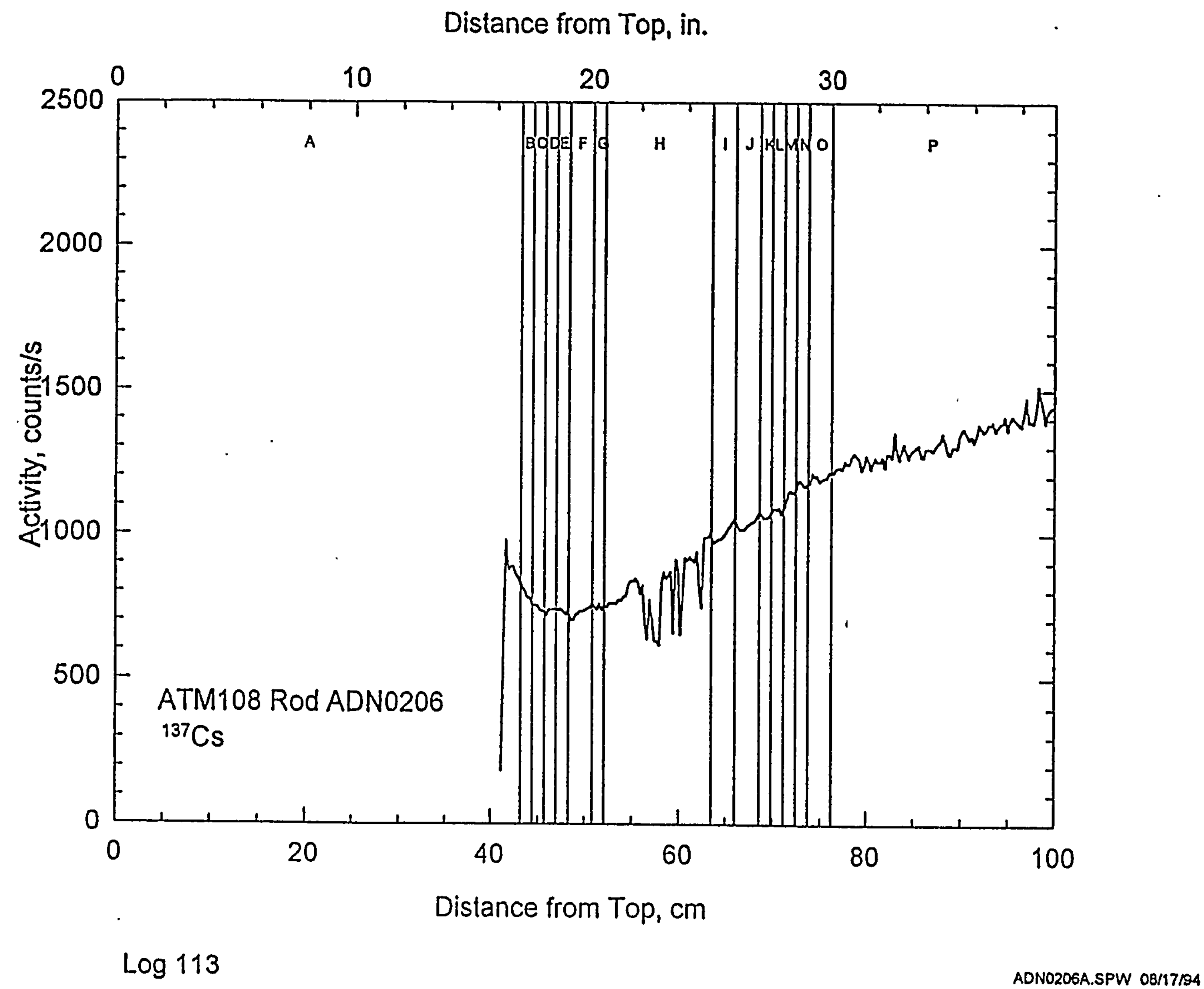


Figure A.11.a. Sectioning Diagram for Rod ADN0206 of ATM-108

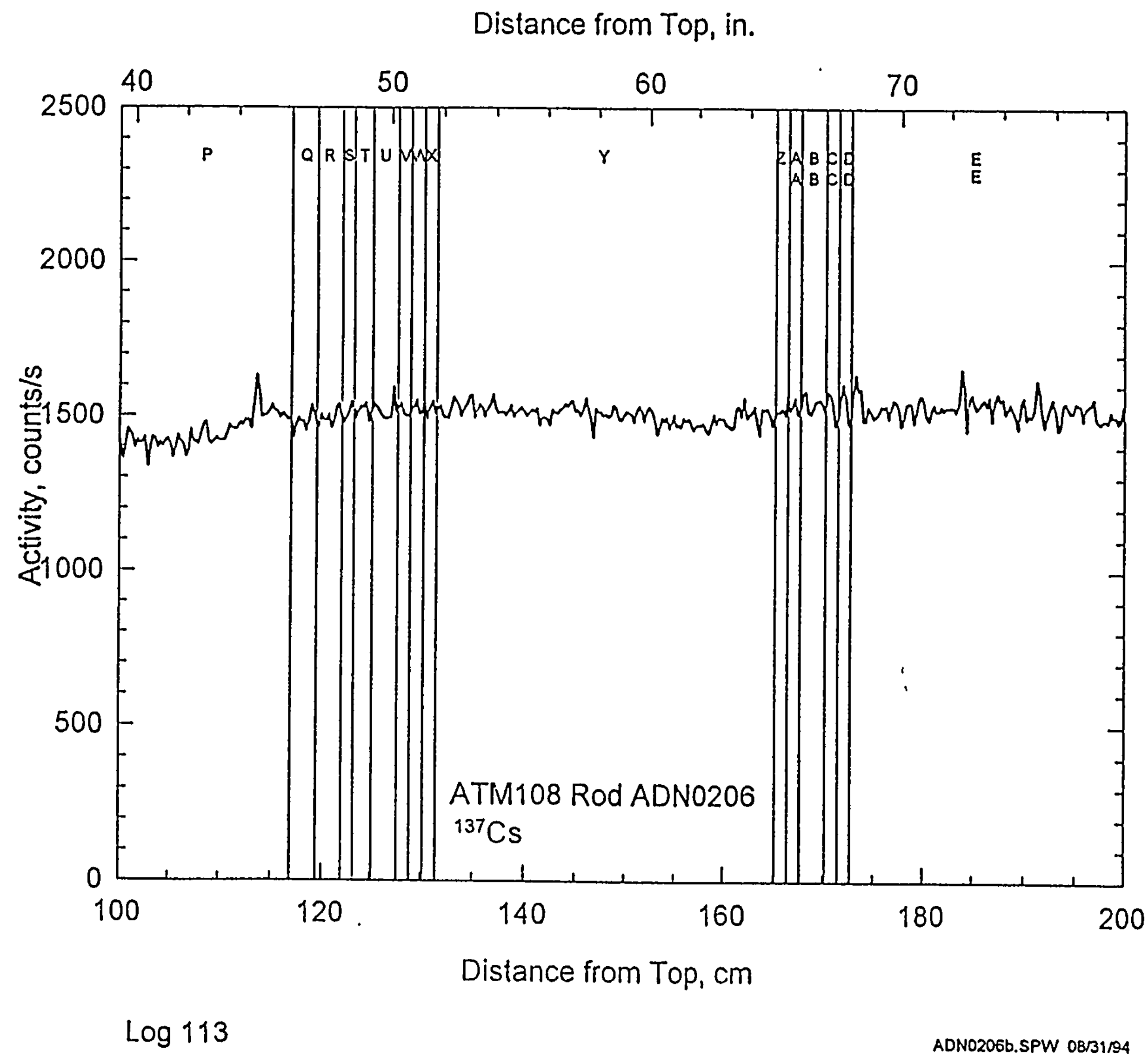


Figure A.11.b. Sectioning Diagram for Rod ADN0206 of ATM-108

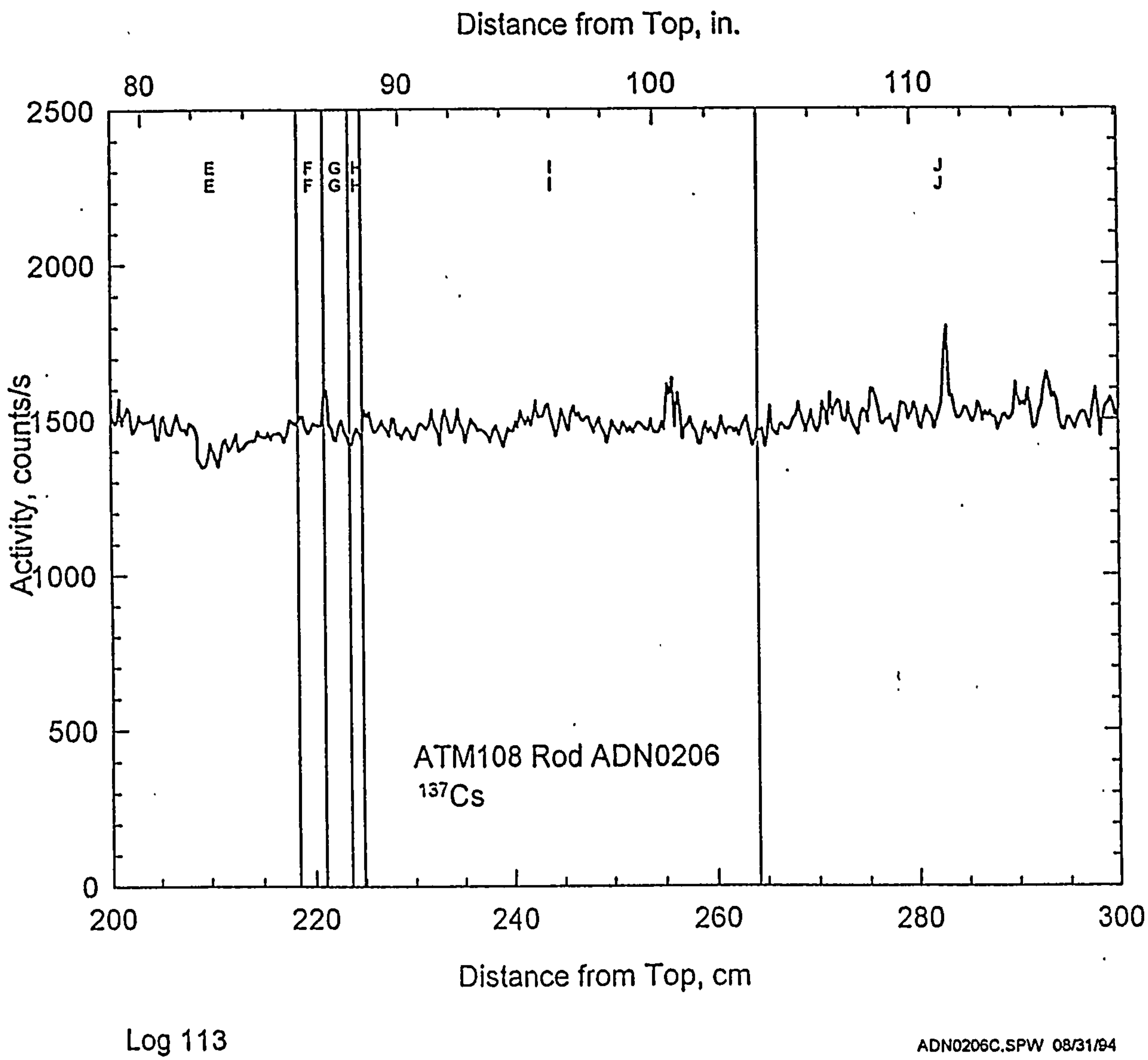


Figure A.11.c. Sectioning Diagram for Rod ADN0206 of ATM-108

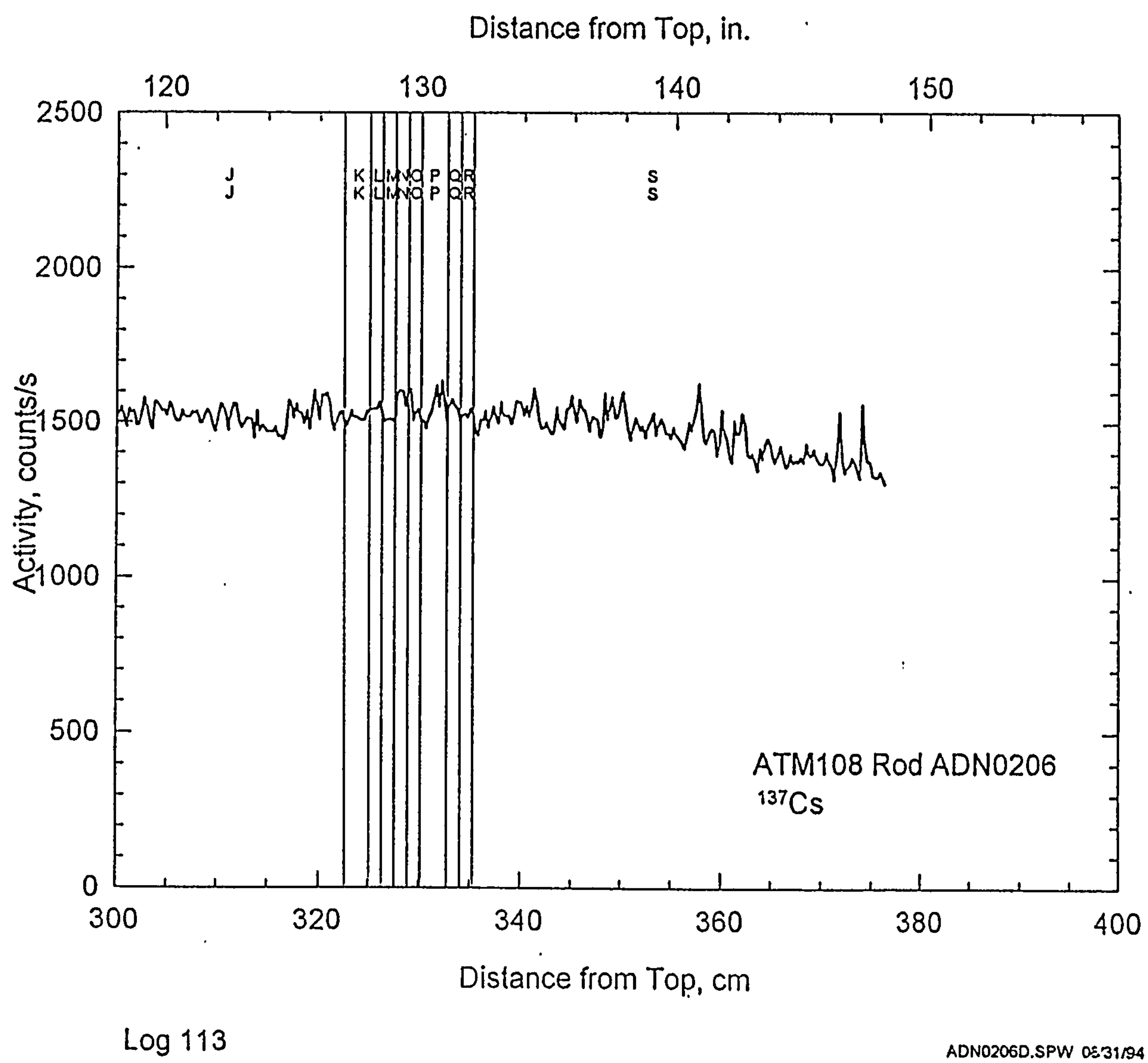


Figure A.11.d. Sectioning Diagram for Rod ADN0206 of ATM-108

Appendix B

Radiochemical Analyses

Appendix B

Radiochemical Analyses

Available radiochemical analyses for Rods MLA091, MKP070, NBD095, NBD131, and ADN0206 are provided in Table B.1. The hydrogen content in the cladding of samples from the lower third of Rod G13 of ATM-101 (G13B) and from the upper third of this rod (G13T) are also reported. Design and power history data are provided in Barner (1985). Information in the table includes the ATM rod number, section number as identified in the sectioning diagrams of Appendix A, the sample number used to mark transfer containers and maintain identity of the samples during radiochemical analyses, the number of the analytical request, the type of analyses, the measured values, uncertainties assigned to the measured value according to the completed analytical requests, and the date the measurement was made. The number of analyses reported varies because some of the rods were not examined as extensively and multiple analyses are reported for some samples. Only the analyses for burnup and a few isotopes were completed from three samples of Rod ADN0206. Analytical results for the fuel and cladding are presented first, followed by the gas analyses where available. All of the data in this appendix meet the Impact Level I requirements of PNL-MA-70, which is consistent with NQA-1 quality assurance.

Table B.1. Results of Radiochemical Analyses of Fuel, Cladding, and Fission Gases in Rods MLA091 (ATM-103), MKP070 (ATM-104), NBD095 and NBD131 (ATM-106), and ADN0206 (ATM-108)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
101	G137	A1		B71989-J-2	H is Cladding	149	7.45	ppm	9/21/89
101	G137	C1		B71989-J-2	H is Cladding	164.9	8.25	ppm	9/21/89
101	G137	E1		B71989-J-2	H is Cladding	166.7	8.34	ppm	9/21/89
101	G137	G1		B71989-J-2	H is Cladding	177.9	8.90	ppm	9/21/89
101	G137	I1		B71989-J-2	H is Cladding	167.0	8.35	ppm	9/21/89
101	G137	K1		B71989-J-2	H is Cladding	183.3	9.17	ppm	9/21/89
101	G13B	A1		B71989-J-2	H is Cladding	49.5	0.495	ppm	9/21/89
101	G13B	C1		B71989-J-2	H is Cladding	59.9	0.569	ppm	9/21/89
101	G13B	E1		B71989-J-2	H is Cladding	53.4	0.534	ppm	9/21/89
101	G13B	G1		B71989-J-2	H is Cladding	65.2	0.652	ppm	9/21/89
101	G13B	I1		B71989-J-2	H is Cladding	51.4	0.514	ppm	9/21/89
101	G13B	K1		B71989-J-2	H is Cladding	56.7	0.557	ppm	9/21/89
103	MLA091	C	88-5	B71989-F-6	^{137}Cs on Cladding Interior	1.453e+07	5.40e+05	d/m/cm2	04/18/88
103	MLA091	C	88-5	B71989-F-6	^{135}Cs on Cladding Interior	8.000e+01	1.10e+01	d/m/cm2	05/09/88
103	MLA091	C	88-5	B71989-G-6	^{129}I on Cladding Interior	1.610e+01	4.80e-01	d/m/cm2	04/21/88
103	MLA091	D	88-6	B71989-D-6	^{14}C in Fuel	5.620e-07	5.60e-08	Ci/g Fuel	
103	MLA091	D	88-6	B71989-D-6	^{14}C in Fuel	5.750e-07	5.80e-08	Ci/g Fuel	

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
103	MLA091	D	88-6	B71989-E-6	^{14}C in Cladding	1.560e-07	1.60e-08	Ci/g Zr	
103	MLA091	D	88-6	B71989-E-6	^{14}C in Cladding	4.360e-07	4.40e-08	Ci/g Zr	
103	MLA091	F	88-7	B71989-F-6	^{137}Cs on Cladding Interior	2.492e+07	9.20e+05	d/m/cm2	04/18/88
103	MLA091	F	88-7	B71989-F-6	^{135}Cs on Cladding Interior	1.100e+02	1.50e+01	d/m/cm2	05/09/88
103	MLA091	F	88-7	B71989-G-6	^{129}I on Cladding Interior	6.360e+01	1.90e+00	d/m/cm2	04/21/88
103	MLA091	G	88-8	B71989-D-6	^{14}C in Fuel	7.320e-07	7.30e-08	Ci/g Fuel	
103	MLA091	G	88-8	B71989-D-6	^{14}C in Fuel	7.320e-07	7.30e-08	Ci/g fuel	
103	MLA091	G	88-8	B71989-E-6	^{14}C in Cladding	5.290e-07	5.30e-08	Ci/g Zr	
103	MLA091	G	88-8	B71989-E-6	^{14}C in Cladding	6.860e-07	6.90e-08	Ci/g Zr	
103	MLA091	J	88-10	B71989-B-6	Measured Fuel Burnup	3.291e+01		MWd/kgM	
103	MLA091	J	88-10	B71989-B-6	^{234}U	1.400e-02	1.00e-03	^{234}U wt%	
103	MLA091	J	88-10	B71989-B-6	^{235}U	6.090e-01	7.00e-03	^{235}U wt%	
103	MLA091	J	88-10	B71989-B-6	^{236}U	3.800e-01	4.00e-03	^{236}U wt%	
103	MLA091	J	88-10	B71989-B-6	^{238}U	9.900e+01	2.00e-02	^{238}U wt%	
103	MLA091	J	88-10	B71989-B-6	^{238}Pu	2.273e+00	6.90e-02	^{238}Pu wt%	
103	MLA091	J	88-10	B71989-B-6	^{239}Pu	5.472e+01	1.60e-01	^{239}Pu wt%	
103	MLA091	J	88-10	B71989-B-6	^{240}Pu	2.700e+01	1.60e-01	^{240}Pu wt%	
103	MLA091	J	88-10	B71989-B-6	^{241}Pu	9.600e+00	7.70e-02	^{241}Pu wt%	
103	MLA091	J	88-10	B71989-B-6	^{242}Pu	6.415e+00	1.00e-01	^{242}Pu wt%	

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
103	MLA091	J	88-10	B71989-B-6	^{79}Se	1.30 E+05	4.30e+03	d/m/g fuel	07/15/88
103	MLA091	J	88-10	B71989-B-6	^{90}Sr	1.15E+11	3.70e+09	d/m/g fuel	07/06/88
103	MLA091	J	88-10	B71989-B-6	^{99}Tc	2.62E+07	8.90e+05	d/m/g fuel	06/27/87
103	MLA091	J	88-10	B71989-B-6	^{126}Sn	3.52E+05	3.50e+04	d/m/g fuel	06/29/88
103	MLA091	J	88-10	B71989-B-6	^{135}Cs	7.3E+05	9.50e+04	d/m/g fuel	07/22/88
103	MLA091	J	88-10	B71989-B-6	^{137}Cs	1.67E+11	3.30e+09	d/m/g fuel	06/29/88
103	MLA091	J	88-10	B71989-B-6	^{237}Np	5.59E+05	1.70e+04	d/m/g fuel	09/20/88
103	MLA091	J	88-10	B71989-B-6	^{241}Am	2.81E+09	4.20e+07	d/m/g fuel	07/14/88
103	MLA091	J	88-10	B71989-B-6	$^{243 \& 244}Cm$	4.12E+09	6.20e+07	d/m/g fuel	07/14/88
103	MLA091	J	88-10	B71989-B-6	^{243}Am	9.300e+07	1.10e+07	d/m/g fuel	07/14/88
103	MLA091	J	88-10	B71989-B-6	^{242}Cm	1.600e+07	9.00e+05	d/m/g fuel	7/14/88
103	MLA091	J	88-10	B71989-B-6	Measured Fuel Burnup	3.291e+04		MWd/MTM	
103	MLA091	J	88-10	B71989-B-6	$^{143/148}Nd$	2.094e+00		$^{143/148}Nd$	
103	MLA091	J	88-10	B71989-B-6	$^{144/148}Nd$	3.703e+00		$^{144/148}Nd$	
103	MLA091	J	88-10	B71989-B-6	$^{145/148}Nd$	1.837e+00		$^{145/148}Nd$	
103	MLA091	J	88-10	B71989-B-6	$^{146/148}Nd$	1.874e+00		$^{146/148}Nd$	
103	MLA091	J	88-10	B71989-B-6	^{148}Nd in Fuel	1.284e+18		Atoms/g fuel	
103	MLA091	J	88-10	B71989-B-6	$^{150/148}Nd$	4.747e-01		$^{150/148}Nd$	09/07/88
103	MLA091	K	88-11	B71989-C-6	^{129}I in Fuel	6.750e+04	1.50e+03	d/m/g Fuel	05/02/88
103	MLA091	K	88-11	B71989-F-6	^{137}Cs on Cladding Interior	3.653e+07	1.30e-06	d/m/cm2	04/18/88

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
103	MLA091	K	88-11	B71989-F-6	^{135}Cs on Cladding Interior	1.590e+02	2.20e+01	d/m/cm2	05/09/88
103	MLA091	K	88-11	B71989-G-6	^{129}I on Cladding Interior	5.840e+01	1.80e+00	d/m/cm2	04/20/88
103	MLA091	L	88-12	B71989-D-6	^{14}C in Fuel	7.640e-07	7.60e-08	Ci/g Fuel	
103	MLA091	L	88-12	B71989-D-6	^{14}C in Fuel	7.720e-07	7.70e-08	Ci/g Fuel	
103	MLA091	L	88-12	B71989-E-6	^{14}C in Cladding	5.160e-07	5.20e-08	Ci/g Zr	
103	MLA091	L	88-12	B71989-E-6	^{14}C in Cladding	8.460e-07	8.50e-08	Ci/g Zr	
103	MLA091	O	88-13	B71989-C-6	^{129}I in Fuel	5.000e+04	1.10e+03	d/m/g Fuel	05/02/88
103	MLA091	O	88-13	B71989-F-6	^{137}Cs on Cladding Interior	1.667e+07	6.20e+05	d/m/cm2	04/18/88
103	MLA091	O	88-13	B71989-F-6	^{135}Cs on Cladding Interior	8.500e+01	1.20e+01	d/m/cm2	05/09/88
103	MLA091	O	88-13	B71989-G-6	^{129}I on Cladding Interior	2.020e+01	6.10e-01	d/m/cm2	05/02/88
103	MLA091	P	88-14	B71989-D-6	^{14}C in Fuel	5.580e-07	5.60e-08	Ci/g Fuel	
103	MLA091	P	88-14	B71989-D-6	^{14}C in Fuel	5.630e-07	5.60e-08	Ci/g Fuel	
103	MLA091	P	88-14	B71989-E-6	^{14}C in Cladding	5.960e-07	6.00e-08	Ci/g Zr	
103	MLA091	P	88-14	B71989-E-6	^{14}C in Cladding	2.250e-07	2.30e-08	Ci/g Zr	
103	MLA091	R	88-15	B71989-C-6	^{129}I in Fuel	2.960e+04	6.50e+02	d/m/g Fuel	05/02/88
103	MLA091	R	88-15	B71989-F-6	^{137}Cs on Cladding Interior	1.124e+07	4.20e+05	d/m/cm2	04/18/88
103	MLA091	R	88-15	B71989-F-6	^{135}Cs on Cladding Interior	7.800e+01	1.10e+01	d/m/cm2	05/09/88

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
103	MLA091	R	88-15	B71989-G-6	^{129}I on Cladding Interior	7.100e+00	2.10e-01	d/m/cm2	05/03/88
103	MLA091	S	88-16	B71989-D-6	^{14}C in Fuel	3.110e-07	3.10e-08	Ci/g Fuel	
103	MLA091	S	88-16	B71989-D-6	^{14}C in Fuel	2.960e-07	3.00e-08	Ci/g Fuel	
103	MLA091	S	88-16	B71989-E-6	^{14}C in Cladding	2.720e-07	2.70e-08	Ci/g Zr	
103	MLA091	S	88-16	B71989-E-6	^{14}C in Cladding	1.530e-07	1.50e-08	Ci/g Zr	
104	MKP070	C	88-48	B71989-C-8	^{129}I in Fuel	6.610e+04	1.90e+03	d/m/g Fuel	09/14/88
104	MKP070	C	88-48	B71989-F-8	^{137}Cs on Cladding Interior	2.000e+07	7.60e+05	d/m/cm2	09/28/88
104	MKP070	C	88-48	B71989-F-8	^{135}Cs on Cladding Interior	1.150e+02	1.60e+01	d/m/cm2	09/28/88
104	MKP070	C	88-48	B71989-G-8	^{129}I on Cladding Interior	1.620e+01	4.90e-01	d/m/cm2	09/15/88
104	MKP070	D	88-49	B71989-D-8	^{14}C in Fuel	7.140e-07	7.10e-08	Ci/g Fuel	
104	MKP070	D	88-49	B71989-D-8	^{14}C in Fuel	6.650e-07	6.70e-08	Ci/g Fuel	
104	MKP070	D	88-49	B71989-E-8	^{14}C in Cladding	2.230e-07	2.20e-08	Ci/g Zr	
104	MKP070	D	88-49	B71989-E-8	^{14}C in Cladding	3.140e-07	3.10e-08	Ci/g Zr	
104	MKP070	F	88-50	B71989-F-8	^{137}Cs on Cladding Interior	2.080e+08	7.90e+06	d/m/cm2	09/28/88
104	MKP070	F	88-50	B71989-F-8	^{135}Cs on Cladding Interior	9.520e+03	1.30e+03	d/m/cm2	09/28/88
104	MKP070	F	88-50	B71989-G-8	^{129}I on Cladding Interior	1.260e+02	3.70e+00	d/m/cm2	09/15/88
104	MKP070	G	88-51	B71989-D-8	^{14}C in Fuel	9.980e-07	1.00e-07	Ci/g Fuel	

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
104	MKP070	G	88-51	B71989-D-8	^{14}C in Fuel	1.003e-06	1.00e-07	Ci/g Fuel	
104	MKP070	G	88-51	B71989-E-8	^{14}C in Cladding	9.470e-07	9.50e-08	Ci/g Zr	
104	MKP070	G	88-51	B71989-E-8	^{14}C in Cladding	9.700e-07	9.70e-08	Ci/g Zr	
104	MKP070	J	88-53	B71989-B-8	Measured Fuel Burnup	4.375e+01		MWd/kgM	
104	MKP070	J	88-53	B71989-B-8	^{234}U	1.500e-02	2.00e-03	^{234}U wt%	
104	MKP070	J	88-53	B71989-B-8	^{235}U	4.140e-01	6.00e-03	^{235}U wt%	
104	MKP070	J	88-53	B71989-B-8	^{236}U	4.460e-01	6.00e-03	^{236}U wt%	
104	MKP070	J	88-53	B71989-B-8	^{238}U	9.912e+01	1.20e-02	^{238}U wt%	
104	MKP070	J	88-53	B71989-B-8	^{238}Pu	2.937e+00	2.00e-02	^{238}Pu wt%	
104	MKP070	J	88-53	B71989-B-8	^{239}Pu	4.842e+01	1.50e-01	^{239}Pu wt%	
104	MKP070	J	88-53	B71989-B-8	^{240}Pu	2.861e+01	1.50e-01	^{240}Pu wt%	
104	MKP070	J	88-53	B71989-B-8	^{241}Pu	1.060e+01	1.00e-01	^{241}Pu wt%	
104	MKP070	J	88-53	B71989-B-8	^{242}Pu	9.445e+00	9.00e-02	^{242}Pu wt%	
104	MKP070	J	88-53	B71989-B-8	^{79}Se	1.400e+05	7.40e+03	d/m/g fuel	09/23/88
104	MKP070	J	88-53	B71989-B-8	^{90}Sr	8.760e+10	6.00e+09	d/m/g fuel	09/21/88
104	MKP070	J	88-53	B71989-B-8	^{99}Tc	3.770e+07	1.70e+06	d/m/g fuel	09/21/88
104	MKP070	J	88-53	B71989-B-8	^{126}Sn	5.260e+05	5.50e+04	d/m/g fuel	09/20/88
104	MKP070	J	88-53	B71989-B-8	^{135}Cs	1.090e+06	1.50e+05	d/m/g fuel	10/03/88
104	MKP070	J	88-53	B71989-B-8	^{137}Cs	2.320e+11	8.60e+09	d/m/g fuel	10/03/88
104	MKP070	J	88-53	B71989-B-8	^{237}Np	5.610e+05	1.08e+05	d/m/g fuel	09/20/88

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
104	MKP070	J	88-53	B71989-B-8	^{237}Np	7.370e+05	1.43e+05	d/m/g fuel	09/20/88
104	MKP070	J	88-53	B71989-B-8	^{241}Am	3.020e+09	4.80e+07	d/m/g fuel	09/15/88
104	MKP070	J	88-53	B71989-B-8	$^{243 \& 244}Cm$	1.250e+10	6.50e+07	d/m/g fuel	09/15/88
104	MKP070	J	88-53	B71989-B-8	^{243}Am in Fuel	1.540e+08	2.10e+07	d/m/g Fuel	09/15/88
104	MKP070	J	88-53	B71989-B-8	^{242}Cm in Fuel	3.450e+07	7.00e+06	d/m/g Fuel	09/15/88
104	MKP070	J	88-53	B71989-B-8	Measured Fuel Burnup	4.375e+04		MWd/MTM	12/09/88
104	MKP070	J	88-53	B71989-B-8	$^{143/148}Nd$	1.795e+00		$^{143/148}Nd$	12/09/88
104	MKP070	J	88-53	B71989-B-8	$^{144/148}Nd$	3.898e+00		$^{144/148}Nd$	12/09/88
104	MKP070	J	88-53	B71989-B-8	$^{145/148}Nd$	1.742e+00		$^{145/148}Nd$	12/09/88
104	MKP070	J	88-53	B71989-B-8	$^{146/148}Nd$	1.939e+00		$^{146/148}Nd$	12/09/88
104	MKP070	J	88-53	B71989-B-8	^{148}Nd in Fuel	1.738e+18		Atoms/g Fuel	12/09/88
104	MKP070	J	88-53	B71989-B-8	$^{150/148}Nd$	4.833e-01		$^{150/148}Nd$	12/09/88
104	MKP070	L	88-55	B71989-C-8	^{129}I in Fuel	1.030e+05	3.00e+03	d/m/g Fuel	09/14/88
104	MKP070	L	88-55	B71989-F-8	^{137}Cs on Cladding Interior	2.960e+08	1.10e+07	d/m/cm2	09/28/88
104	MKP070	L	88-55	B71989-F-8	^{135}Cs on Cladding Interior	1.370e+03	1.90e+02	d/m/cm2	09/28/88
104	MKP070	L	88-55	B71989-G-8	^{129}I on Cladding Interior	1.260e+02	3.70e+00	d/m/cm2	09/15/88
104	MKP070	M	88-56	B71989-D-8	^{14}C in Fuel	1.080e-06	1.10e-07	Ci/g Fuel	
104	MKP070	M	88-56	B71989-D-8	^{14}C in Fuel	1.051e-06	1.10e-07	Ci/g Fuel	
104	MKP070	M	88-56	B71989-E-8	^{14}C in Cladding	3.960e-07	4.00e-08	Ci/g Zr	

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
104	MKP070	M	88-56	B71989-E-8	^{14}C in Cladding	9.400e-07	9.40e-08	Ci/g Zr	
104	MKP070	O	88-57	B71989-F-8	^{137}Cs on Cladding Interior	3.300e+08	1.30e+07	d/m/cm2	09/28/88
104	MKP070	O	88-57	B71989-F-8	^{135}Cs on Cladding Interior	1.500e+03	2.10e+02	d/m/cm2	09/28/88
104	MKP070	O	88-57	B71989-G-8	^{129}I on Cladding Interior	1.390e+02	4.00e+00	d/m/cm2	09/15/88
104	MKP070	P	88-58	B71989-D-8	^{14}C in Fuel	1.076e-06	1.10e-07	Ci/g Fuel	
104	MKP070	P	88-58	B71989-D-8	^{14}C in Fuel	1.163e-06	1.20e-07	Ci/g Fuel	
104	MKP070	P	88-58	B71989-E-8	^{14}C in Cladding	1.006e-06	1.00e-07	Ci/g Zr	
104	MKP070	P	88-58	B71989-E-8	^{14}C in Cladding	9.520e-07	9.50e-08	Ci/g Zr	
104	MKP070	R	88-59	B71989-B-8	Measured Fuel Burnup	2.496e+01		MWd/kgM	
104	MKP070	R	88-59	B71989-B-8	^{234}U	1.900e-02	2.00e-03	^{234}U wt%	
104	MKP070	R	88-59	B71989-B-8	^{235}U	1.088e+00	8.00e-03	^{235}U wt%	
104	MKP070	R	88-59	B71989-B-8	^{236}U	3.540e-01	6.00e-03	^{236}U wt%	
104	MKP070	R	88-59	B71989-B-8	^{238}U	9.854e+01	2.00e-02	^{238}U wt%	
104	MKP070	R	88-59	B71989-B-8	^{238}Pu	1.239e+00	2.00e-02	^{238}Pu wt%	
104	MKP070	R	88-59	B71989-B-8	^{239}Pu	6.290e+01	1.50e-01	^{239}Pu wt%	
104	MKP070	R	88-59	B71989-B-8	^{240}Pu	2.363e+01	1.50e-01	^{240}Pu wt%	
104	MKP070	R	88-59	B71989-B-8	^{241}Pu	8.709e+00	8.00e-02	^{241}Pu wt%	
104	MKP070	R	88-59	B71989-B-8	^{242}Pu	3.521e+00	3.00e-02	^{242}Pu wt%	
104	MKP070	R	88-59	B71989-B-8	^{79}Se	9.300e+04	4.90e+03	d/m/g fuel	9/23/88

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
104	MKP070	R	88-59	B71989-B-8	^{90}Sr	5.730e+10	3.90e+09	d/m/g fuel	09/21/88
104	MKP070	R	88-59	B71989-B-8	^{99}Tc	2.050e+02	9.60e+00	d/m/g fuel	09/21/88
104	MKP070	R	88-59	B71989-B-8	^{126}Sn	1.950e+05	2.05e+04	d/m/g fuel	09/20/88
104	MKP070	R	88-59	B71989-B-8	^{135}Cs	8.740e+05	1.20e+05	d/m/g fuel	09/29/88
104	MKP070	R	88-59	B71989-B-8	^{137}Cs	1.300e+11	4.80e+09	d/m/g fuel	09/29/88
104	MKP070	R	88-59	B71989-B-8	^{237}Np	3.760e+05	1.10e+04	d/m/g fuel	09/20/88
104	MKP070	R	88-59	B71989-B-8	^{241}Am	1.830e+09	2.20e+07	d/m/g fuel	09/15/88
104	MKP070	R	88-59	B71989-B-8	$^{243 \& 244}Cm$	9.850e+08	1.70e+07	d/m/g fuel	09/15/88
104	MKP070	R	88-59		^{243}Am in Fuel	5.140e+07	1.90e+07	d/m/g Fuel	09/15/88
104	MKP070	R	88-59		^{242}Cm in Fuel	1.980e+07	1.05e+06	d/m/g Fuel	09/15/88
104	MKP070	R	88-59		Measured Fuel Burnup	2.496e+04		MWd/MTM	
104	MKP070	R	88-59		$^{143/148}Nd$	2.437e+00		$^{143/148}Nd$	
104	MKP070	R	88-59		$^{144/148}Nd$	3.586e+00		$^{144/148}Nd$	
104	MKP070	R	88-59		$^{145/148}Nd$	1.964e+00		$^{145/148}Nd$	
104	MKP070	R	88-59		$^{146/148}Nd$	1.847e+00		$^{146/148}Nd$	
104	MKP070	R	88-59		^{148}Nd in Fuel	9.919e+17		Atoms/g Fuel	
104	MKP070	R	88-59		$^{150/148}Nd$	4.596e-01		$^{150/148}Nd$	
104	MKP070	S	88-60	B71989-C-8	^{129}I in Fuel	4.900e+04	1.40e+03	d/m/g Fuel	09/14/88
104	MKP070	S	88-60	B71989-F-8	^{137}Cs on Cladding Interior	1.170e+07	4.40e+05	d/m/cm2	09/28/88

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
104	MKP070	S	88-60	B71989-F-8	^{135}Cs on Cladding Interior	7.860e+01	1.30e+01	d/m/cm2	09/28/88
104	MKP070	S	88-60	B71989-G-8	^{129}I on Cladding Interior	7.800e+00	2.70e-01	d/m/cm2	09/15/88
104	MKP070	T	88-61	B71989-D-8	^{14}C in Fuel	4.850e-07	4.90e-08	Ci/g Fuel	
104	MKP070	T	88-61	B71989-D-8	^{14}C in Fuel	4.470e-07	4.50e-08	Ci/g Fuel	
104	MKP070	T	88-61	B71989-E-8	^{14}C in Cladding	3.470e-07	3.50e-08	Ci/g Zr	
104	MKP070	T	88-61	B71989-E-8	^{14}C in Cladding	3.180e-07	3.20e-08	Ci/g Zr	
106	NBD095	C & D	88-67/68	B71989-B-9	Measured Fuel Burnup	2.742e+01		MWd/kgM	
106	NBD095	C & D	88-67/68	B71989-B-9	^{234}U	1.200e-02	1.00e-03	^{234}U wt%	
106	NBD095	C & D	88-67/68	B71989-B-9	^{235}U	6.050e-01	6.00e-03	^{235}U wt%	
106	NBD095	C & D	88-67/68	B71989-B-9	^{236}U	3.240e-01	3.00e-03	^{236}U wt%	
106	NBD095	C & D	88-67/68	B71989-B-9	^{238}U	9.906e+01	9.00e-02	^{238}U wt%	
106	NBD095	C & D	88-67/68	B71989-B-9	^{238}Pu	1.644e+00	2.00e-02	^{238}Pu wt%	
106	NBD095	C & D	88-67/68	B71989-B-9	^{239}Pu	5.726e+01	1.00e-01	^{239}Pu wt%	
106	NBD095	C & D	88-67/68	B71989-B-9	^{240}Pu	2.662e+01	1.00e-01	^{240}Pu wt%	
106	NBD095	C & D	88-67/68	B71989-B-9	^{241}Pu	8.815e+00	5.00e-02	^{241}Pu wt%	
106	NBD095	C & D	88-67/68	B71989-B-9	^{242}Pu	5.665e+00	3.00e-02	^{242}Pu wt%	
106	NBD095	C & D	88-67/68	B71989-B-9	^{79}Se	1.080e+05	8.50e+03	d/m/g fuel	09/29/89
106	NBD095	C & D	88-67/68	B71989-B-9	^{90}Sr	9.170e+10	4.20e+09	d/m/g fuel	04/06/89
106	NBD095	C & D	88-67/68	B71989-B-9	^{99}Tc	2.040e+07	7.80e+05	d/m/g fuel	04/03/89

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
106	NBD095	C & D	88-67/68	B71989-B-9	^{126}Sn	7.900e+05	4.00e+04	d/m/g fuel	04/04/89
106	NBD095	C & D	88-67/68	B71989-B-9	^{135}Cs	8.820e+05	1.30e+05	d/m/g fuel	04/10/89
106	NBD095	C & D	88-67/68	B71989-B-9	^{137}Cs	1.420e+11	6.00e+09	d/m/g fuel	04/10/89
106	NBD095	C & D	88-67/68	B71989-B-9	^{237}Np	4.460e+05	3.20e+04	d/m/g fuel	09/19/89
106	NBD095	C & D	88-67/68	B71989-B-9	^{241}Am	2.790e+09	1.70e+08	d/m/g fuel	04/27/89
106	NBD095	C & D	88-67/68	B71989-B-9	$^{243 \& 244}Cm$	2.470e+09	1.50e+08	d/m/g fuel	04/27/89
106	NBD095	C & D	88-67/68	B71989-B-9	^{242}Cm in Fuel	2.400e+07	1.90e+06	d/m/g Fuel	08/27/89
106	NBD095	C & D	88-67/68	B71989-B-9	Measured Fuel Burnup	2.742e+04		MWd/MTM	04/15/89
106	NBD095	C & D	88-67/68	B71989-B-9	$^{143/148}Nd$	2.169e+00		$^{143/148}Nd$	04/15/89
106	NBD095	C & D	88-67/68	B71989-B-9	$^{144/148}Nd$	3.723e+00		$^{144/148}Nd$	04/15/89
106	NBD095	C & D	88-67/68	B71989-B-9	$^{145/148}Nd$	1.891e+00		$^{145/148}Nd$	04/15/89
106	NBD095	C & D	88-67/68	B71989-B-9	$^{146/148}Nd$	1.863e+00		$^{146/148}Nd$	04/15/89
106	NBD095	C & D	88-67/68	B71989-B-9	^{148}Nd in Fuel	1.093e+18		Atoms/g Fuel	04/15/89
106	NBD095	C & D	88-67/68	B71989-B-9	$^{150/148}Nd$	4.734e-01		$^{150/148}Nd$	04/15/89
106	NBD095	F	88-70	B71989-F-9	^{137}Cs on Cladding Interior	2.120e+07	8.70e+05	d/m/cm2	04/25/89
106	NBD095	F	88-70	B71989-F-9	^{135}Cs on Cladding Interior	1.180e+02	1.69e+01	d/m/cm2	04/25/89
106	NBD095	F	88-70	B71989-G-9	^{129}I on Cladding Interior	2.990e+02	1.40e+01	d/m/cm2	08/31/89
106	NBD095	H	88-72	B71989-D-9	^{14}C in Fuel	8.690e-07	8.70e-08	Ci/g fuel	
106	NBD095	H	88-72	B71989-D-9	^{14}C in Fuel	7.400e-07	7.40e-08	Ci/g fuel	

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
106	NBD095	H	88-72	B71989-E-9	^{14}C in Cladding	1.080e-06	1.10e-07	Ci/g Zr	
106	NBD095	H	88-72	B71989-E-9	^{14}C in Cladding	9.830e-07	9.80e-07	Ci/g Zr	
106	NBD095	K	88-74	B71989-F-9	^{137}Cs on Cladding Interior	6.610e+07	2.64e+06	d/m/cm2	04/25/89
106	NBD095	K	88-74	B71989-F-9	^{135}Cs on Cladding Interior	3.050e+02	4.39e+01	d/m/cm2	04/25/89
106	NBD095	K	88-74	B71989-G-9	^{129}I on Cladding Interior	1.010e+03	5.10e+01	d/m/cm2	08/31/89
106	NBD095	N	88-76	B71989-F-9	^{137}Cs on Cladding Interior	2.890e+08	1.10e+07	d/m/cm2	04/25/89
106	NBD095	N	88-76	B71989-F-9	^{135}Cs on Cladding Interior	1.310e+03	1.82e+02	d/m/cm2	04/25/89
106	NBD095	N	88-76	B71989-G-9	^{129}I on Cladding Interior	1.300e+03	5.20e+01	d/m/cm2	09/07/89
106	NBD095	P	88-78	B71989-D-9	^{14}C in fuel	1.400e-06	1.40e-07	Ci/g Fuel	
106	NBD095	P	88-78	B71989-D-9	^{14}C in Fuel	1.420e-06	1.40e-07	Ci/g fuel	
106	NBD095	P	88-78	B71989-E-9	^{14}C in Cladding	1.560e-06	1.60e-07	Ci/g fuel	
106	NBD095	P	88-78	B71989-E-9	^{14}C in cladding	1.480e-06	1.50e-07	Ci/g Zr	
106	NBD095	X & Y	88-85/86	B71989-B-9	Measured Fuel Burnup	4.675e+01		MWd/kgM	
106	NBD095	X & Y	88-85/86	B71989-B-9	^{234}U	1.000e-02	1.00e-03	^{234}U wt%	
106	NBD095	X & Y	88-85/86	B71989-B-9	^{235}U	1.540e-01	2.00e-03	^{235}U wt%	
106	NBD095	X & Y	88-85/86	B71989-B-9	^{236}U	3.660e-01	4.00e-03	^{236}U wt%	
106	NBD095	X & Y	88-85/86	B71989-B-9	^{238}U	9.947e+01	9.00e-02	^{238}U wt%	

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
106	NBD095	X & Y	88-85/86	B71989-B-9	^{238}Pu	3.290e+00	2.00e-02	^{238}Pu wt%	
106	NBD095	X & Y	88-85/86	B71989-B-9	^{239}Pu	4.331e+01	1.00e-01	^{239}Pu wt%	
106	NBD095	X & Y	88-85/86	B71989-B-9	^{240}Pu	3.021e+01	1.00e-01	^{240}Pu wt%	
106	NBD095	X & Y	88-85/86	B71989-B-9	^{241}Pu	9.388e+00	5.00e-02	^{241}Pu wt%	
106	NBD095	X & Y	88-85/86	B71989-B-9	^{242}Pu	1.380e+01	7.00e-02	^{242}Pu wt%	
106	NBD095	X & Y	88-85/86	B71989-B-9	^{79}Se	1.720e+05	1.20e+04	d/m/g fuel	09/29/89
106	NBD095	X & Y	88-85/86	B71989-B-9	^{90}Sr	1.310e+11	5.80e+09	d/m/g fuel	04/06/89
106	NBD095	X & Y	88-85/86	B71989-B-9	^{99}Tc	3.080e+07	9.90e+05	d/m/g fuel	04/03/89
106	NBD095	X & Y	88-85/86	B71989-B-9	^{126}Sn	7.660e+05	4.10e+04	d/m/g fuel	04/04/89
106	NBD095	X & Y	88-85/86	B71989-B-9	^{135}Cs	1.060e+06	1.45e+05	d/m/g fuel	04/10/89
106	NBD095	X & Y	88-85/86	B71989-B-9	^{137}Cs	2.450e+11	1.10e+10	d/m/g fuel	04/10/89
106	NBD095	X & Y	88-85/86	B71989-B-9	^{237}Np	7.100e+05	3.30e+04	d/m/g fuel	09/18/89
106	NBD095	X & Y	88-85/86	B71989-B-9	^{241}Am	3.640e+09		d/m/g fuel	04/27/89
106	NBD095	X & Y	88-85/86	B71989-B-9	^{243}Am	2.4E+08	5.28E+107	d/m/g fuel	04/27/89
106	NBD095	X & Y	88-85/86	B71989-B-9	$^{243\ \&\ 244}Cm$	2.210e+10	1.30e+09	d/m/g fuel	04/27/89
106	NBD095	X & Y	88-85/86	B71989-B-9	^{242}Cm in Fuel	3.100e+08	2.70e+06	d/m/g Fuel	08/27/89
106	NBD095	X & Y	88-85/86	B71989-B-9	Measured Fuel Burnup	4.675e+04		MWd/MTM	04/15/89
106	NBD095	X & Y	88-85/86	B71989-B-9	$^{143/148}Nd$	1.428e+00		$^{143/148}Nd$	04/15/89
106	NBD095	X & Y	88-85/86	B71989-B-9	$^{144/148}Nd$	4.112e+00		$^{144/148}Nd$	04/15/89
106	NBD095	X & Y	88-85/86	B71989-B-9	$^{145/148}Nd$	1.646e+00		$^{145/148}Nd$	04/15/89

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
106	NBD095	X & Y	88-85/86	B71989-B-9	$^{146/148}Nd$	1.971e+00		$^{146/148}Nd$	04/15/89
106	NBD095	X & Y	88-85/86	B71989-B-9	^{148}Nd in Fuel	1.849e+18		Atoms/g Fuel	04/15/89
106	NBD095	X & Y	88-85/86	B71989-B-9	$^{150/148}Nd$	4.953e-01		$^{150/148}Nd$	04/15/89
106	NBD095	AA	88-88	B71989-F-9	^{137}Cs on Cladding Interior	8.570e+08	3.30e+07	d/m/cm2	04/24/89
106	NBD095	AA	88-88	B71989-F-9	^{135}Cs on Cladding Interior	3.830e+03	5.44e+02	d/m/cm2	04/24/89
106	NBD095	AA	88-88	B71989-G-9	^{129}I on Cladding Interior	2.500e+03	1.20e+02	d/m/cm2	09/07/89
106	NBD095	FF	88-92	B71989-F-9	^{137}Cs on Cladding Interior	2.480e+09	1.00e+08	d/m/cm2	04/24/89
106	NBD095	FF	88-92	B71989-F-9	^{135}Cs on Cladding Interior	1.180e+04	1.68e+03	d/m/cm2	04/24/89
106	NBD095	FF	88-92	B71989-G-9	^{129}I on Cladding Interior	3.230e+04	1.40e+03	d/m/cm2	09/07/89
106	NBD095	HH	88-94	B71989-D-9	^{14}C in Fuel	1.440e-06	1.40e-07	Ci/g fuel	
106	NBD095	HH	88-94	B71989-D-9	^{14}C in Fuel	1.640e-06	1.60e-07	Ci/g fuel	
106	NBD095	HH	88-94	B71989-E-9	^{14}C in Cladding	2.080e-06	2.10e-07	Ci/g Zr	
106	NBD095	HH	88-94	B71989-E-9	^{14}C in Cladding	2.300e-06	2.30e-07	Ci/g fuel	
106	NBD095	LL	88-97	B71989-B-9A	^{135}Cs in Fuel	9.800e+05	1.39e+05	d/m/g fuel	04/11/89
106	NBD095	LL	88-97	B71989-B-9A	^{137}Cs in Fuel	2.270e+11	8.90e+09	d/m/g fuel	04/11/89
106	NBD095	MM	88-98	B71989-F-9	^{137}Cs on Cladding Interior	6.310e+09	2.70e+08	d/m/cm2	04/24/89

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
106	NBD095	MM	88-98	B71989-F-9	^{135}Cs on Cladding Interior	2.950e+04	4.07e+03	d/m/cm2	04/24/89
106	NBD095	MM	88-98	B71989-G-9	^{129}I on Cladding Interior	5.820e+04	3.80e+03	d/m/cm2	09/08/89
106	NBD095	PP	88-101	B71989-D-9	^{14}C in Fuel	1.150e-06	1.20e-07	Ci/g fuel	
106	NBD095	PP	88-101	B71989-D-9	^{14}C in Fuel	1.420e-06	1.40e-07	Ci/g fuel	
106	NBD095	PP	88-101	B71989-E-9	^{14}C in Cladding	1.820e-06	1.80e-07	Ci/g Zr	
106	NBD095	PP	88-101	B71989-E-9	^{14}C in Cladding	2.100e-06	2.10e-07	Ci/g Zr	
106	NBD095	XX	88-108	B71989-F-9	^{137}Cs on Cladding Interior	1.050e+10	4.00e+08	d/m/cm2	04/24/89
106	NBD095	XX	88-108	B71989-F-9	^{135}Cs on Cladding Interior	5.030e+04	6.89e+03	d/m/cm2	04/24/89
106	NBD095	XX	88-108	B71989-G-9	^{129}I on Cladding Interior	8.530e+04	4.60e+03	d/m/cm2	09/08/89
106	NBD095	CCC	88-112	B71989-F-9	^{137}Cs on Cladding Interior	1.150e+10	4.90e+08	d/m/cm2	04/24/89
106	NBD095	CCC	88-112	B71989-F-9	^{135}Cs on Cladding Interior	7.270e+04	1.05e+04	d/m/cm2	04/24/89
106	NBD095	CCC	88-112	B71989-G-9	^{129}I on Cladding Interior	1.870e+04	1.10e+03	d/m/cm2	09/08/89
106	NBD095	EEE	88-114	B71989-D-9	^{14}C in Fuel	5.550e-07	5.60e-08	Ci/g fuel	
106	NBD095	EEE	88-114	B71989-D-9	^{14}C in Fuel	5.740e-07	5.70e-08	Ci/g fuel	
106	NBD095	EEE	88-114	B71989-E-9	^{14}C in Cladding	8.280e-07	8.30e-08	Ci/g fuel	
106	NBD095	EEE	88-114	B71989-E-9	^{14}C in Cladding	1.150e-06	1.20e-07	Ci/g Zr	

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
106	NBD131	C	88-18	B71989-F-7	^{137}Cs on Cladding Interior	2.190e+10	8.10e+08	d/m/cm2	08/12/88
106	NBD131	C	88-18	B71989-F-7	^{135}Cs on Cladding Interior	1.220e+05	1.70e+04	d/m/cm2	08/12/88
106	NBD131	C	88-18	B71989-G-7	^{129}I on Cladding Interior	3.510e+04	1.10e+03	d/m/cm2	08/15/88
106	NBD131	D	88-19	B71989-D-7	^{14}C in Fuel	8.320e-07	8.30e-08	Ci/g fuel	
106	NBD131	D	88-19	B71989-D-7	^{14}C in Fuel	9.170e-07	9.20e-08	Ci/g fuel	
106	NBD131	D	88-19	B71989-E-7	^{14}C in Cladding	2.390e-06	2.40e-07	Ci/g Zr	
106	NBD131	D	88-19	B71989-E-7	^{14}C in Cladding	2.540e-06	2.50e-07	Ci/g Zr	
106	NBD131	F	88-20	B71989-C-7	^{129}I in Fuel	7.540e+04	5.70e+03	d/m/g fuel	08/19/88
106	NBD131	F	88-20	B71989-F-7	^{137}Cs on Cladding Interior	1.840e+10	6.80e+08	d/m/cm2	08/12/88
106	NBD131	F	88-20	B71989-F-7	^{135}Cs on Cladding Interior	8.360e+04	1.20e+04	d/m/cm2	08/12/88
106	NBD131	F	88-20	B71989-G-7	^{129}I on Cladding Interior	2.980e+04	8.90e+02	d/m/cm2	08/15/88
106	NBD131	J	88-23	B71989-F-7	^{137}Cs on Cladding Interior	1.510e+10	5.60e+08	d/m/cm2	08/12/88
106	NBD131	J	88-23	B71989-F-7	^{135}Cs on Cladding Interior	6.670e+04	9.30e+03	d/m/cm2	08/12/88
106	NBD131	J	88-23	B71989-G-7	^{129}I on Cladding Interior	2.060e+04	6.20e+02	d/m/cm2	08/15/88
106	NBD131	K	88-24	B71989-D-7	^{14}C in Fuel	1.620e-06	1.60e-07	Ci/g fuel	
106	NBD131	K	88-24	B71989-D-7	^{14}C in Fuel	1.650e-06	1.70e-07	Ci/g fuel	

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
106	NBD131	K	88-24	B71989-E-7	^{14}C in Cladding	3.270e-06	3.30e-07	Ci/g Zr	
106	NBD131	K	88-24	B71989-E-7	^{14}C in Cladding	3.450e-06	3.50e-07	Ci/g Zr	
106	NBD131	N	88-26	B71989-F-7	^{137}Cs on Cladding Interior	4.860e+09	1.80e+08	d/m/cm2	08/12/88
106	NBD131	N	88-26	B71989-F-7	^{135}Cs on Cladding Interior	2.200e+04	3.10e+03	d/m/cm2	08/12/88
106	NBD131	N	88-26	B71989-G-7	^{129}I on Cladding Interior	5.980e+03	1.80e+02	d/m/cm2	08/15/88
106	NBD131	Q	88-28	B71989-B-7	Measured Fuel Burnup	4.965e+01		MWd/kgM	
106	NBD131	Q	88-28	B71989-B-7	^{234}U	1.000e-02	2.00e-03	^{234}U wt%	
106	NBD131	Q	88-28	B71989-B-7	^{235}U	1.180e-01	5.00e-03	^{235}U wt%	
106	NBD131	Q	88-28	B71989-B-7	^{236}U	3.660e-01	5.00e-03	^{236}U wt%	
106	NBD131	Q	88-28	B71989-B-7	^{238}U	9.951e+01	1.00e-02	^{238}U wt%	
106	NBD131	Q	88-28	B71989-B-7	^{238}Pu	3.381e+00	3.10e-02	^{238}Pu wt%	
106	NBD131	Q	88-28	B71989-B-7	^{239}Pu	4.190e+01	2.06e-01	^{239}Pu wt%	
106	NBD131	Q	88-28	B71989-B-7	^{240}Pu	3.017e+01	2.06e-01	^{240}Pu wt%	
106	NBD131	Q	88-28	B71989-B-7	^{241}Pu	9.588e+00	6.90e-02	^{241}Pu wt%	
106	NBD131	Q	88-28	B71989-B-7	^{242}Pu	1.497e+01	1.11e-01	^{242}Pu wt%	
106	NBD131	Q	88-28	B71989-B-7	^{79}Se	1.720e+05	4.10e+03	d/m/g fuel	07/07/88
106	NBD131	Q	88-28	B71989-B-7	^{90}Sr	1.460e+11	4.70e+09	d/m/g fuel	07/06/88
106	NBD131	Q	88-28	B71989-B-7	^{99}Tc	3.460e+07	1.00e+06	d/m/g fuel	06/27/88
106	NBD131	Q	88-28	B71989-B-7	^{126}Sn	5.990e+05	6.00e+04	d/m/g fuel	06/24/88

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
106	NBD131	Q	88-28	B71989-B-7	^{135}Cs	9.600e+05	1.20e+05	d/m/g fuel	07/05/88
106	NBD131	Q	88-28	B71989-B-7	^{137}Cs	2.330e+11	4.70e+09	d/m/g fuel	07/05/88
106	NBD131	Q	88-28	B71989-B-7	^{237}Np	5.560e+05	1.70e+04	d/m/g fuel	09/20/88
106	NBD131	Q	88-28	B71989-B-7	^{241}Am	3.400e+09	1.60e+08	d/m/g fuel	07/14/88
106	NBD131	Q	88-28	B71989-B-7	$^{243\ \&\ 244}Cm$	2.640e+10	6.10e+08	d/m/g fuel	07/14/88
106	NBD131	Q	88-28	B71989-B-7	^{243}Am in Fuel	3.490e+08	6.60e+07	d/m/g fuel	07/14/88
106	NBD131	Q	88-28	B71989-B-7	^{242}Cm in Fuel	2.240e+07	1.00e+06	d/m/g fuel	07/14/88
106	NBD131	Q	88-28	B71989-B-7	Measured Fuel Burnup	4.965e+04		MWd/MTM	
106	NBD131	Q	88-28	B71989-B-7	$^{143/148}Nd$	1.341e+00		$^{143/148}Nd$	
106	NBD131	Q	88-28	B71989-B-7	$^{144/148}Nd$	4.216e+00		$^{144/148}Nd$	
106	NBD131	Q	88-28	B71989-B-7	$^{145/148}Nd$	1.628e+00		$^{145/148}Nd$	
106	NBD131	Q	88-28	B71989-B-7	$^{146/148}Nd$	1.995e+00		$^{146/148}Nd$	
106	NBD131	Q	88-28	B71989-B-7	^{148}Nd in Fuel	1.973e+18		Atoms/g Fuel	
106	NBD131	Q	88-28	B71989-B-7	$^{150/148}Nd$	4.954e-01		$^{150/148}Nd$	
106	NBD131	R	88-29	B71989-C-7	^{129}I in Fuel	1.110e+05	2.40e+03	d/m/g fuel	08/03/88
106	NBD131	R	88-29	B71989-F-7	^{137}Cs on Cladding Interior	5.090e+09	1.90e+08	d/m/cm2	08/12/88
106	NBD131	R	88-29	B71989-F-7	^{135}Cs on Cladding Interior	2.300e+04	3.20e+03	d/m/cm2	08/12/88
106	NBD131	R	88-29	B71989-G-7	^{129}I on Cladding Interior	4.190e+03	1.30e+02	d/m/cm2	08/15/88
106	NBD131	S	88-30	B71989-D-7	^{14}C in Fuel	1.910e-06	1.90e-07	Ci/g fuel	

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
106	NBD131	S	88-30	B71989-D-7	^{14}C in Fuel	1.890e-06	1.90e-07	Ci/g fuel	
106	NBD131	S	88-30	B71989-E-7	^{14}C in Cladding	1.030e-06	1.00e-07	Ci/g Zr	
106	NBD131	S	88-30	B71989-E-7	^{14}C in Cladding	2.470e-06	2.50e-07	Ci/g Zr	
106	NBD131	W	88-33	B71989-C-7	^{129}I in Fuel	1.070e+05	2.40e+03	d/m/g fuel	08/19/88
106	NBD131	W	88-33	B71989-F-7	^{137}Cs on Cladding Interior	2.270e+10	8.40e+08	d/m/cm2	08/12/88
106	NBD131	W	88-33	B71989-F-7	^{135}Cs on Cladding Interior	9.900e+04	1.40e+04	d/m/cm2	08/12/88
106	NBD131	W	88-33	B71989-G-7	^{129}I on Cladding Interior	2.480e+04	7.40e+02	d/m/cm2	08/15/88
106	NBD131	X	88-34	B71989-D-7	^{14}C in Fuel	1.400e-06	1.40e-07	Ci/g Fuel	
106	NBD131	X	88-34	B71989-D-7	^{14}C in Fuel	1.470e-06	1.50e-07	Ci/g Fuel	
106	NBD131	X	88-34	B71989-E-7	^{14}C in Cladding	3.240e-06	3.20e-07	Ci/g Zr	
106	NBD131	X	88-34	B71989-E-7	^{14}C in Cladding	3.390e-06	3.40e-07	Ci/g Zr	
106	NBD131	Z	88-35	B71989-F-7	^{137}Cs on Cladding Interior	1.160e+10	4.30e+08	d/m/cm2	08/12/88
106	NBD131	Z	88-35	B71989-F-7	^{135}Cs on Cladding Interior	5.220e+04	7.30e+03	d/m/cm2	08/12/88
106	NBD131	Z	88-35	B71989-G-7	^{129}I on Cladding Interior	1.340e+04	4.00e+02	d/m/cm2	08/15/88
106	NBD131	CC	88-37	B71989-B-7	Measured Fuel Burnup	3.128e+01		MWD/kgM	
106	NBD131	CC	88-37	B71989-B-7	^{234}U	1.200e-02	2.00e-03	^{234}U wt%	
106	NBD131	CC	88-37	B71989-B-7	^{235}U	4.360e-01	9.00e-03	^{235}U wt%	

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
106	NBD131	CC	88-37	B71989-B-7	^{236}U	3.390e-01	5.00e-03	^{236}U wt%	
106	NBD131	CC	88-37	B71989-B-7	^{238}U	9.921e+01	1.00e-02	^{238}U wt%	
106	NBD131	CC	88-37	B71989-B-7	^{238}Pu	2.176e+00	3.76e-01	^{238}Pu wt%	
106	NBD131	CC	88-37	B71989-B-7	^{239}Pu	5.226e+01	3.28e-01	^{239}Pu wt%	
106	NBD131	CC	88-37	B71989-B-7	^{240}Pu	2.846e+01	1.79e-01	^{240}Pu wt%	
106	NBD131	CC	88-37	B71989-B-7	^{241}Pu	9.502e+00	6.60e-02	^{241}Pu wt%	
106	NBD131	CC	88-37	B71989-B-7	^{242}Pu	7.604e+00	8.40e-02	^{242}Pu wt%	
106	NBD131	CC	88-37	B71989-B-7	^{243}Cm & ^{244}Cm in Fuel	3.790e+09	6.10e+07	d/m/g fuel	07/14/88
106	NBD131	CC	88-37	B71989-B-7	^{79}Se	1.220e+05	2.90e+03	d/m/g fuel	07/07/88
106	NBD131	CC	88-37	B71989-B-7	^{90}Sr	1.050e+11	3.40e+09	d/m/g fuel	07/06/88
106	NBD131	CC	88-37	B71989-B-7	^{99}Tc	2.370e+07	8.10e+05	d/m/g fuel	06/27/88
106	NBD131	CC	88-37	B71989-B-7	^{126}Sn	3.700e+05	3.70e+04	d/m/g fuel	06/24/88
106	NBD131	CC	88-37	B71989-B-7	^{135}Cs	8.800e+05	1.10e+05	d/m/g fuel	07/05/88
106	NBD131	CC	88-37	B71989-B-7	^{137}Cs	1.630e+11	3.30e+09	d/m/g fuel	07/05/88
106	NBD131	CC	88-37	B71989-B-7	^{237}Np	4.180e+05	1.30e+04	d/m/g fuel	09/20/88
106	NBD131	CC	88-37	B71989-B-7	^{241}Am	2.600e+09	4.20e+07	d/m/g fuel	07/14/88
106	NBD131	CC	88-37	B71989-B-7	^{243}Am in Fuel	7.670e+07	1.20e+07	d/m/g fuel	07/14/88
106	NBD131	CC	88-37	B71989-B-7	^{242}Cm in Fuel	1.870e+07	8.00e+05	d/m/g fuel	07/14/88
106	NBD131	CC	88-37	B71989-B-7	Measured Fuel Burnup	3.128e+04		MWd/MTM	
106	NBD131	CC	88-37	B71989-B-7	$^{143/148}Nd$	1.941e+00		$^{143/148}Nd$	

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
106	NBD131	CC	88-37	B71989-B-7	$^{144/148}Nd$	3.828e+00		$^{144/148}Nd$	
106	NBD131	CC	88-37	B71989-B-7	$^{145/148}Nd$	1.836e+00		$^{145/148}Nd$	
106	NBD131	CC	88-37	B71989-B-7	$^{146/148}Nd$	1.870e+00		$^{146/148}Nd$	
106	NBD131	CC	88-37	B71989-B-7	^{148}Nd in Fuel	1.238e+18		Atoms/g Fuel	
106	NBD131	CC	88-37	B71989-B-7	$^{150/148}Nd$	4.787e-01		$^{150/148}Nd$	
106	NBD131	DD	88-38	B71989-C-7	^{129}I in Fuel	5.930e+04	1.20e+03	d/m/g fuel	08/19/88
106	NBD131	DD	88-38	B71989-F-7	^{137}Cs on Cladding Interior	8.220e+09	3.00e+08	d/m/cm2	08/12/88
106	NBD131	DD	88-38	B71989-F-7	^{135}Cs on Cladding Interior	5.010e+04	7.00e+03	d/m/cm2	08/12/88
106	NBD131	DD	88-38	B71989-G-7	^{129}I on Cladding Interior	1.080e+04	3.20e+02	d/m/cm2	08/15/88
106	NBD131	EE	88-39	B71989-D-7	^{14}C in Fuel	4.870e-07	4.90e-08	Ci/g Fuel	
106	NBD131	EE	88-39	B71989-D-7	^{14}C in Fuel	4.560e-07	4.60e-08	Ci/g Fuel	
106	NBD131	EE	88-39	B71989-E-7	^{14}C in Cladding	1.050e-06	1.10e-07	Ci/g Zr	
106	NBD131	EE	88-39	B71989-E-7	^{14}C in Cladding	1.050e-06	1.10e-07	Ci/g Zr	
108	ADN0206	D	89-37	B71989-B-10	Measured Fuel Burnup	1.221e+01		MWd/KgM	
108	ADN0206	D	89-37	B71989-B-10	^{234}U in Fuel	2.000e-02	1.00e-03	^{234}U wt%	
108	ADN0206	D	89-37	B71989-B-10	^{235}U	1.816e+00	2.00e-02	^{235}U wt%	
108	ADN0206	D	89-37	B71989-B-10	^{236}U	2.180e-01	2.00e-03	^{236}U wt%	
108	ADN0206	D	89-37	B71989-B-10	^{238}U	9.795e+01	2.00e-02	^{238}U wt%	
108	ADN0206	D	89-37	B71989-B-10	^{238}Pu	4.600e-01	5.00e-03	^{238}Pu wt%	

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
108	ADN0206	D	89-37	B71989-B-10	^{239}Pu	7.507e+01	1.00e-01	^{239}Pu wt%	
108	ADN0206	D	89-37	B71989-B-10	^{240}Pu	1.963e+01	1.00e-01	^{240}Pu wt%	
108	ADN0206	D	89-37	B71989-B-10	^{241}Pu	3.963e+00	3.00e-02	^{241}Pu wt%	
108	ADN0206	D	89-37	B71989-B-10	^{242}Pu	8.800e-01	5.00e-03	^{242}Pu wt%	
108	ADN0206	D	89-37	B71989-B-10	$^{143/148}Nd$	2.890e+00		$^{143/148}Nd$	
108	ADN0206	D	89-37	B71989-B-10	$^{144/148}Nd$	3.383e+00		$^{144/148}Nd$	
108	ADN0206	D	89-37	B71989-B-10	$^{145/148}Nd$	2.128e+00		$^{145/148}Nd$	
108	ADN0206	D	89-37	B71989-B-10	$^{146/148}Nd$	1.791e+00		$^{146/148}Nd$	
108	ADN0206	D	89-37	B71989-B-10	^{148}Nd in Fuel	3.890e+17		Atoms/g Fuel	
108	ADN0206	D	89-37	B71989-B-10	$^{150/148}Nd$	4.427e-01		$^{150/148}Nd$	
108	ADN0206	M	89-45	B71989-B-10	Measured Fuel Burnup	1.958e+01		MWd/kgM	
108	ADN0206	M	89-45	B71989-B-10	^{234}U	1.700e-02	1.00e-03	^{234}U wt%	
108	ADN0206	M	89-45	B71989-B-10	^{235}U	1.413e+00	1.00e-02	^{235}U wt%	
108	ADN0206	M	89-45	B71989-B-10	^{236}U	3.080e-01	3.00e-03	^{236}U wt%	
108	ADN0206	M	89-45	B71989-B-10	^{238}U	9.826e+01	1.00e-02	^{238}U wt%	
108	ADN0206	M	89-45	B71989-B-10	^{238}Pu	1.114e+00	2.00e-02	^{238}Pu wt%	
108	ADN0206	M	89-45	B71989-B-10	^{239}Pu	6.708e+01	1.00e-01	^{239}Pu wt%	
108	ADN0206	M	89-45	B71989-B-10	^{240}Pu	2.334e+01	1.00e-01	^{240}Pu wt%	
108	ADN0206	M	89-45	B71989-B-10	^{241}Pu	6.287e+00	4.00e-02	^{241}Pu wt%	
108	ADN0206	M	89-45	B71989-B-10	^{242}Pu	2.189e+00	2.00e-02	^{242}Pu wt%	

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
108	ADN0206	M	89-45	B71989-B-10	$^{143/148}Nd$	2.665e+00		$^{143/148}Nd$	
108	ADN0206	M	89-45	B71989-B-10	$^{144/148}Nd$	3.441e+00		$^{144/148}Nd$	
108	ADN0206	M	89-45	B71989-B-10	$^{145/148}Nd$	2.018e+00		$^{145/148}Nd$	
108	ADN0206	M	89-45	B71989-B-10	$^{146/148}Nd$	1.826e+00		$^{146/148}Nd$	
108	ADN0206	M	89-45	B71989-B-10	^{148}Nd in Fuel	6.360e+17		Atoms/g Fuel	
108	ADN0206	M	89-45	B71989-B-10	$^{150/148}Nd$	4.617e-01		$^{150/148}Nd$	
108	ADN0206	DD	89-60	B71989-B-10	Measured Fuel Burnup	2.767e+01		MWd/kgM	
108	ADN0206	DD	89-60	B71989-B-10	^{234}U	1.600e-02	1.00e-03	^{234}U wt%	
108	ADN0206	DD	89-60	B71989-B-10	^{235}U	9.890e-01	9.00e-03	^{235}U wt%	
108	ADN0206	DD	89-60	B71989-B-10	^{236}U	3.800e-01	4.00e-03	^{236}U wt%	
108	ADN0206	DD	89-60	B71989-B-10	^{238}U	9.862e+01	1.00e-02	^{238}U wt%	
108	ADN0206	DD	89-60	B71989-B-10	^{238}Pu	1.907e+00	2.00e-02	^{238}Pu wt%	
108	ADN0206	DD	89-60	B71989-B-10	^{239}Pu	5.811e+01	2.00e-01	^{239}Pu wt%	
108	ADN0206	DD	89-60	B71989-B-10	^{240}Pu	2.784e+01	2.00e-01	^{240}Pu wt%	
108	ADN0206	DD	89-60	B71989-B-10	^{241}Pu	7.897e+00	5.00e-02	^{241}Pu wt%	
108	ADN0206	DD	89-60	B71989-B-10	^{242}Pu	4.253e+00	4.00e-02	^{242}Pu wt%	
108	ADN0206	DD	89-60	B71989-B-10	$^{143/148}Nd$	2.376e+00		$^{143/148}Nd$	
108	ADN0206	DD	89-60	B71989-B-10	$^{144/148}Nd$	3.601e+00		$^{144/148}Nd$	
108	ADN0206	DD	89-60	B71989-B-10	$^{145/148}Nd$	1.931e+00		$^{145/148}Nd$	
108	ADN0206	DD	89-60	B71989-B-10	$^{146/148}Nd$	1.861e+00		$^{146/148}Nd$	

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
108	ADN0206	DD	89-60	B71989-B-10	^{148}Nd in Fuel	8.927e+17		Atoms/g Fuel	
108	ADN0206	DD	89-60	B71989-B-10	$^{150/148}Nd$	4.722e-01		$^{150/148}Nd$	
103	MLA091		10A	B71989-A-13	He in Gas	9.940e+01	1.00e+00	Mole %	03/25/88
103	MLA091		10A	B71989-A-13	Xe in Gas	5.100e-01		Mole %	03/25/88
103	MLA091		10A	B71989-A-13	Xe-124 in Gas	<1E-02		Mole %	03/25/88
103	MLA091		10A	B71989-A-13	Xe-126 in Gas	<1E-02		Mole %	03/25/88
103	MLA091		10A	B71989-A-13	Xe-128 in Gas	<1E-02		Mole %	03/25/88
103	MLA091		10A	B71989-A-13	Xe-129 in Gas	<1E-02		Mole %	03/25/88
103	MLA091		10A	B71989-A-13	Xe-130 in Gas	<1E-02		Mole %	03/25/88
103	MLA091		10A	B71989-A-13	Xe-131 in Gas	4.000e-02	4.00e-04	Mole %	03/25/88
103	MLA091		10A	B71989-A-13	Xe-132 in Gas	1.100e-01	1.00e-03	Mole %	03/25/88
103	MLA091		10A	B71989-A-13	Xe-134 in Gas	1.400e-01	1.00e-03	Mole %	03/25/88
103	MLA091		10A	B71989-A-13	Xe-136 in Gas	2.200e-01	2.00e-03	Mole %	03/25/88
103	MLA091		10A	B71989-A-13	Kr in Gas	6.000e-02		Mole %	03/25/88
103	MLA091		10A	B71989-A-13	Kr-78 in Gas	<1E-02		Mole %	03/25/88
103	MLA091		10A	B71989-A-13	Kr-80 in Gas	<1E-02		Mole %	03/25/88
103	MLA091		10A	B71989-A-13	Kr-82 in Gas	<1E-02		Mole %	03/25/88
103	MLA091		10A	B71989-A-13	Kr-83 in Gas	1.000e-02	1.00e-04	Mole %	03/25/88
103	MLA091		10A	B71989-A-13	Kr-84 in Gas	2.000e-02	2.00e-04	Mole %	03/25/88
103	MLA091		10A	B71989-A-13	Kr-86 in Gas	3.000e-02	3.00e-04	Mole %	03/25/88
103	MLA091		10A	B71989-A-13	Xe/Kr ratio	8.500e+00			03/25/88

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
103	MLA091		10A	B71989-A-13	Ar in Gas	<1E-02		Mole %	03/25/88
103	MLA091		10A	B71989-A-13	H2 in Gas	<1E-02		Mole %	03/25/88
103	MLA091		10A	B71989-A-13	CO2 in Gas	<1E-02		Mole %	03/25/88
103	MLA091		10A	B71989-A-13	CO in Gas	<3E-02		Mole %	03/25/88
103	MLA091		10A	B71989-A-13	N2 in Gas	3.000e-02	3.00e-04	Mole %	03/25/88
103	MLA091		10A	B71989-A-13	O2 in Gas	<1E-02		Mole %	03/25/88
103	MLA091		10A	B71989-A-13	Organics in Gas	<1E-02		Mole %	03/25/88
103	MLA091		10A	B71989-A-14	^{14}C in Gas	5.060e-13		Ci/cc	04/05/88
104	MKP063		10A		Xe-in Gas	9.850e+01		Mole %	12/06/88
104	MKP063		10A		Xe-124 in Gas	1.400e+00		Mole %	12/06/88
104	MKP063		10A		Xe-126 in Gas	<1E-02		Mole %	12/06/88
104	MKP063		10A		Xe-128 in Gas	<1E-02		Mole %	12/06/88
104	MKP063		10A		Xe-129 in Gas	<1E-02		Mole %	12/06/88
104	MKP063		10A		Xe-130 in Gas	<1E-02		Mole %	12/06/88
104	MKP063		10A		Xe-131 in Gas	<1E-02		Mole %	12/06/88
104	MKP063		10A		Xe-132 in Gas	1.000e-01	1.00e-03	Mole %	12/06/88
104	MKP063		10A		Xe-134 in Gas	3.100e-01	3.00e-03	Mole %	12/06/88
104	MKP063		10A		Xe-136 in Gas	4.000e-01	4.00e-03	Mole %	12/06/88
104	MKP063		10A		Kr in Gas	5.900e-01	6.00e-03	Mole %	12/06/88
104	MKP063		10A		Kr-78 in Gas	1.300e-01		Mole %	12/06/88
104	MKP063		10A		Kr-80 in Gas	<1E-02		Mole %	12/06/88

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
104	MKP063		10A		Kr-82 in Gas	<1E-02		Mole %	12/06/88
104	MKP063		10A		Kr-83 in Gas	<1E-02		Mole %	12/06/88
104	MKP063		10A		Kr-84 in Gas	2.000e-02	2.00e-04	Mole %	12/06/88
104	MKP063		10A		Kr-85 in Gas	4.000e-02	4.00e-04	Mole %	12/06/88
104	MKP063		10A		Kr-86 in Gas	<1E-02		Mole %	12/06/88
104	MKP063		10A		Xe/Kr ratio	7.000e-02	7.00e-04		12/06/88
104	MKP063		10A		Kr-86	<8E-02			12/06/88
104	MKP063		10A		H_2 in Gas	<1E-02		Mole %	12/06/88
104	MKP063		10A		CO_2 in Gas	<1E-02		Mole %	12/06/88
104	MKP063		10A		CO in Gas	<1E-02		Mole %	12/06/88
104	MKP063		10A		N_2 in Gas	<1E-02		Mole %	12/06/88
104	MKP063		10A		O_2 in Gas	<1E-02		Mole %	12/06/88
104	MKP063		10A		Organics in Gas	<1E-02		Mole %	12/06/88
104	MKP063		10A		^{14}C in Gas	<1E-02		Mole %	12/06/88
104	MKP063		10A		He in Gas	<6.00E-14	<1.2E-14	Ci/cc	12/29/88
104	MKP070		10A	B71989-A-16	He- in Gas	9.860e+01	1.00e+00	Mole %	07/13/88
104	MKP070		10A	B71989-A-16	Xe-124 in Gas	<1E-02		Mole %	07/13/88
104	MKP070		10A	B71989-A-16	Xe-126 in Gas	<1E-02		Mole %	07/13/88
104	MKP070		10A	B71989-A-16	Xe-128 in Gas	<1E-02		Mole %	07/13/88
104	MKP070		10A	B71989-A-16	Xe-129 in Gas	<1E-02		Mole %	07/13/88
104	MKP070		10A	B71989-A-16	Xe-130 in Gas	<1E-02		Mole %	07/13/88

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
104	MKP070		10A	B71989-A-16	Xe-131 in Gas	1.000e-01	1.00e-03	Mole %	07/13/88
104	MKP070		10A	B71989-A-16	Xe-132 in Gas	2.900e-01	3.00e-03	Mole %	07/13/88
104	MKP070		10A	B71989-A-16	Xe-134 in Gas	3.800e-01	4.00e-03	Mole %	07/13/88
104	MKP070		10A	B71989-A-16	Xe-136 in Gas	5.700e-01	6.00e-03	Mole %	07/13/88
104	MKP070		10A	B71989-A-16	Kr in Gas	1.100e-01		Mole %	07/13/88
104	MKP070		10A	B71989-A-16	Kr-78 in Gas	<1E-02		Mole %	07/13/88
104	MKP070		10A	B71989-A-16	Kr-80 in Gas	<1E-02		Mole %	07/13/88
104	MKP070		10A	B71989-A-16	Kr-82 in Gas	<1E-02		Mole %	07/13/88
104	MKP070		10A	B71989-A-16	Kr-83 in Gas	1.000e-02	1.00e-04	Mole %	07/13/88
104	MKP070		10A	B71989-A-16	Kr-84 in Gas	4.000e-02	4.00e-04	Mole %	07/13/88
104	MKP070		10A	B71989-A-16	Kr-85 in Gas	<1E-02		Mole %	07/13/88
104	MKP070		10A	B71989-A-16	Kr-86 in Gas	6.000e-02	6.00e-04	Mole %	07/13/88
104	MKP070		10A	B71989-A-16	Xe/Kr ratio	1.220e+01			07/13/88
104	MKP070		10A	B71989-A-16	Ar in Gas	<1E-02		Mole %	07/13/88
104	MKP070		10A	B71989-A-16	H2 in Gas	<1E-02		Mole %	07/13/88
104	MKP070		10A	B71989-A-16	CO2 in Gas	<1E-02		Mole %	07/13/88
104	MKP070		10A	B71989-A-16	CO in Gas	<1E-02		Mole %	07/13/88
104	MKP070		10A	B71989-A-16	N2 in Gas	<1E-02		Mole %	07/13/88
104	MKP070		10A	B71989-A-16	O2 in Gas	<1E-02		Mole %	07/13/88
104	MKP070		10A	B71989-A-16	Organics in Gas	<1E-02		Mole %	07/13/88
104	MKP070		10A	B71989-A-16	^{14}C in Gas	9.730e-13		Ci/g	08/03/88

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
104	MKP081		10A	B71989-A-18	Fission Gas				
104	MKP081		10B	B71989-A-19	Fission Gas				
104	MKP087		10A	B71989-A-20	Fission Gas				
106	NBD066		10A						
106	NBD095		10A	B71989-A-8	He in Gas	7.680e+01	7.70e-01	Mole %	06/11/87
106	NBD095		10A	B71989-A-8	Xe- in Gas	1.797e+01	2.00e-01	Mole %	06/11/87
106	NBD095		10A	B71989-A-8	Xe-124 in Gas	<1E-02		Mole %	06/11/87
106	NBD095		10A	B71989-A-8	Xe-126 in Gas	<1E-02		Mole %	06/11/87
106	NBD095		10A	B71989-A-8	Xe-128 in Gas	1.000e-02	1.00e-04	Mole %	06/11/87
106	NBD095		10A	B71989-A-8	Xe-129 in Gas	<1E-02		Mole %	06/11/87
106	NBD095		10A	B71989-A-8	Xe-130 in Gas	7.000e-02	7.00e-04	Mole %	06/11/87
106	NBD095		10A	B71989-A-8	Xe-131 in Gas	8.600e-01	8.60e-03	Mole %	06/11/87
106	NBD095		10A	B71989-A-8	Xe-132 in Gas	4.260e+00	4.30e-02	Mole %	06/11/87
106	NBD095		10A	B71989-A-8	Xe-134 in Gas	5.030e+00	5.00e-02	Mole %	06/11/87
106	NBD095		10A	B71989-A-8	Xe-136 in Gas	7.740e+00	7.70e-02	Mole %	06/11/87
106	NBD095		10A	B71989-A-8	Kr in Gas	1.840e+00		Mole %	06/11/87
106	NBD095		10A	B71989-A-8	Kr-78 in Gas	<1E-02		Mole %	06/11/87
106	NBD095		10A	B71989-A-8	Kr-80 in Gas	<1E-02		Mole %	06/11/87
106	NBD095		10A	B71989-A-8	Kr-82 in Gas	<1E-02		Mole %	06/11/87
106	NBD095		10A	B71989-A-8	Kr-83 in Gas	1.600e-01	1.60e-03	Mole %	06/11/87
106	NBD095		10A	B71989-A-8	Kr-84 in Gas	6.500e-01	6.50e-03	Mole %	06/11/87

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
106	NBD095		10A	B71989-A-8	Kr-85 in Gas	7.000e-02	7.00e-04	Mole %	06/11/87
106	NBD095		10A	B71989-A-8	Kr-86 in Gas	9.600e-01	1.00e-02	Mole %	06/11/87
106	NBD095		10A	B71989-A-8	Xe/Kr ratio	9.770e+00			06/11/87
106	NBD095		10A	B71989-A-8	Ar in Gas	3.380e+00	3.40e-02	Mole %	06/11/87
106	NBD095		10A	B71989-A-8	H2 in Gas	<1E-02		Mole %	06/11/87
106	NBD095		10A	B71989-A-8	CO2 in Gas	<1E-02		Mole %	06/11/87
106	NBD095		10A	B71989-A-8	CO in Gas	<1E-02		Mole %	06/11/87
106	NBD095		10A	B71989-A-8	N2 in Gas	<1E-02		Mole %	06/11/87
106	NBD095		10A	B71989-A-8	O2 in Gas	<1E-02		Mole %	06/11/87
106	NBD095		10A	B71989-A-8	Organics in Gas	<1E-02		Mole %	06/11/87
106	NBD095		10A	B71989-A-8	^{14}C in Gas	3.800e-12		Ci/cc	06/11/87
106	NBD131		10A	B71989-A-15	He in Gas	6.080e+01	6.00e-01	Mole %	04/11/88
106	NBD131		10A		Xe-in Gas	3.304e+01		Mole %	04/11/88
106	NBD131		10A	B71989-A-15	Xe-124 in Gas	<1E-02		Mole %	04/11/88
106	NBD131		10A	B71989-A-15	Xe-126 in Gas	<1E-02		Mole %	04/11/88
106	NBD131		10A	B71989-A-15	Xe-128 in Gas	3.000e-02	3.00e-04	Mole %	04/11/88
106	NBD131		10A	B71989-A-15	Xe-129 in Gas	<1E-02		Mole %	04/11/88
106	NBD131		10A	B71989-A-15	Xe-130 in Gas	1.500e-01	1.50e-03	Mole %	04/11/88
106	NBD131		10A	B71989-A-15	Xe-131 in Gas	1.810e+00	1.80e-02	Mole %	04/11/88
106	NBD131		10A	B71989-A-15	Xe-132 in Gas	7.570e+00	8.00e-02	Mole %	04/11/88
106	NBD131		10A	B71989-A-15	Xe-134 in Gas	9.280e+00	9.00e-02	Mole %	04/11/88

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
106	NBD131		10A	B71989-A-15	Xe-136 in Gas	1.420e+01	1.40e-01	Mole %	04/11/88
106	NBD131		10A		Kr in Gas	3.670e+00		Mole %	04/11/88
106	NBD131		10A	B71989-A-15	Kr-78 in Gas	<1E-02		Mole %	04/11/88
106	NBD131		10A	B71989-A-15	Kr-80 in Gas	<1E-02		Mole %	04/11/88
106	NBD131		10A	B71989-A-15	Kr-82 in Gas	1.000e-02	1.00e-04	Mole %	04/11/88
106	NBD131		10A	B71989-A-15	Kr-83 in Gas	3.900e-01	4.00e-03	Mole %	04/11/88
106	NBD131		10A	B71989-A-15	Kr-84 in Gas	1.220e+00	1.20e-02	Mole %	04/11/88
106	NBD131		10A	B71989-A-15	Kr-85 in Gas	1.400e-01	1.40e-03	Mole %	04/11/88
106	NBD131		10A	B71989-A-15	Kr-86 in Gas	1.910e+00	2.00e-02	Mole %	04/11/88
106	NBD131		10A		Xe/Kr ratio	9.000e+00			04/11/88
106	NBD131		10A	B71989-A-15	Ar in Gas	2.510e+00	2.50e-02	Mole %	04/11/88
106	NBD131		10A	B71989-A-15	H2 in Gas	<1E-02		Mole %	04/11/88
106	NBD131		10A	B71989-A-15	CO2 in Gas	<1E-02		Mole %	04/11/88
106	NBD131		10A	B71989-A-15	CO in Gas	<1E-02		Mole %	04/11/88
106	NBD131		10A	B71989-A-15	N2 in Gas	<1E-02		Mole %	04/11/88
106	NBD131		10A	B71989-A-15	O2 in Gas	<1E-02		Mole %	04/11/88
106	NBD131		10A	B71989-A-15	Organics in Gas	<1E-02		Mole %	04/11/88
106	NBD131		10A	B71989-A-15	^{14}C in Gas	1.100e-11		Ci/cc	04/25/88
108	ADN0206		10A	B71989-A-25	He in Gas	2.540e+01	3.00e-01	Mole %	06/26/89
108	ADN0206		10A		Xe- in Gas	6.551e+01		Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	Xe-124 in Gas	<1E-02		Mole %	06/26/89

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
108	ADN0206		10A	B71989-A-25	Xe-126 in Gas	<1E-02		Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	Xe-128 in Gas	2.000e-02	2.00e-04	Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	Xe-129 in Gas	<1E-02		Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	Xe-130 in Gas	1.000e-01	1.00e-03	Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	Xe-131 in Gas	6.090e+00	6.10e-02	Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	Xe-132 in Gas	1.370e+01	1.40e-01	Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	Xe-134 in Gas	1.980e+01	2.00e-01	Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	Xe-136 in Gas	2.580e+01	2.60e-01	Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	Kr in Gas	8.160e+00		Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	Kr-78 in Gas	<1E-02		Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	Kr-80 in Gas	<1E-02		Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	Kr-82 in Gas	1.000e-02	1.00e-04	Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	Kr-83 in Gas	9.900e-01	1.00e-03	Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	Kr-84 in Gas	2.570e+00	2.60e-02	Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	Kr-85 in Gas	2.800e-01	2.80e-03	Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	Kr-86 in Gas	4.310e+00	4.30e-02	Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	Xe/Kr ratio	8.028e+00			06/26/89
108	ADN0206		10A	B71989-A-25	Ar in Gas	1.000e-02	1.00e-04	Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	H2 in Gas	<1E-02		Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	CO2 in Gas	<1E-02		Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	CO in Gas	<1E-01		Mole %	06/26/89

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
108	ADN0206		10A	B71989-A-25	N2 in Gas	7.200e-01	7.20e-03	Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	O2 in Gas	1.800e-01	1.80e-03	Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	Organics in Gas	<1E-02		Mole %	06/26/89
108	ADN0206		10A	B71989-A-25	^{14}C in Gas	<5.6E-12	<1E-12	Ci/cc	07/13/89
108	ADN0206		10B	B71989-A-26	He in Gas	2.570e+01	2.60e-01	Mole %	06/28/89
108	ADN0206		10B		Xe- in Gas	6.599e+01		Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	Xe-124 in Gas	<1E-02		Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	Xe-126 in Gas	<1E-02		Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	Xe-128 in Gas	2.000e-02	2.00e-04	Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	Xe-129 in Gas	<1E-02		Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	Xe-130 in Gas	1.100e-01	1.10e-03	Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	Xe-131 in Gas	6.160e+00	6.20e-02	Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	Xe-132 in Gas	1.380e+01	1.40e-01	Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	Xe-134 in Gas	2.000e+01	2.00e-01	Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	Xe-136 in Gas	2.590e+01	2.60e-01	Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	Kr in Gas	8.230e+00		Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	Kr-78 in Gas	<1E-02		Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	Kr-80 in Gas	<1E-02		Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	Kr-82 in Gas	1.000e-02	1.00e-04	Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	Kr-83 in Gas	9.900e-01	1.00e-02	Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	Kr-84 in Gas	2.600e+00	2.60e-02	Mole %	06/28/89

Table B.1. (contd)

ATM	Rod	Section	Sample Number	Analytical Request	Type of Analysis	Measured Value	Uncertainties	Measured Value Units	Date Measured
108	ADN0206		10B	B71989-A-26	Kr-85 in Gas	2.800e-01	2.80e-03	Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	Kr-86 in Gas	4.350e+00	4.40e-02	Mole %	06/28/89
108	ADN0206		10B		Xe/Kr ratio	8.020e+00	8.00e-02		06/28/89
108	ADN0206		10B	B71989-A-26	Ar in Gas	<1E-02		Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	H2 in Gas	<1E-02		Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	CO2 in Gas	<1E-02		Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	CO in Gas	<1E-02		Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	N2 in Gas	<1E-02		Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	O2 in Gas	<1E-02		Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	Organics in Gas	<1E-02		Mole %	06/28/89
108	ADN0206		10B	B71989-A-26	^{14}C in Gas	<2.5E-10	<5.0E-11	Ci/cc	07/13/89
108	ADN0206			B71989-A-25	Fission Gas				
108	ADN1313			B71989-A-24	Fission Gas				
108	ADD4347			B71989-A-23	Fission Gas				

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