WCAP-10494

Third Cycle Performance
of Beaver Valley Unit 1

by

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1.0 INTRODUCTION

The 17x17 fuel assembly is in extensive operation in recent Westinghouse 3-loop and 4-loop reactors with power up to 3800 MWT and average linear power of approximately 5.3 kw/ft. This design extends fuel capability beyond that of the 15x15 design in use to date in reactors of this size. It was adopted primarily in response to the lowered average kw/ft requirements imposed by the AEC Interim Acceptance Criteria. While the primary intent of the design is to reduce stored energy in fuel rods for LOCA conditions, it is also expected that rod bow will be decreased because of the shorter grid span lengths characteristic of the 17x17 design.

The NRC has required that fuel surveillance inspections be performed on the first several 17x17 plants to go into operation, including Beaver Valley Unit 1, to verify satisfactory fuel performance.

The purpose of the Beaver Valley fuel examination was to evaluate the mechanical integrity of fuel rods and fuel assembly structural components, fuel surface condition, rod-to-nozzle gap and fuel rod bow, and to compare the Beaver Valley fuel performance with that of other 17x17 fuels.

Beaver Valley Unit 1 completed Cycle 1 in November, 1979. Thirty-five fuel assemblies were non-destructively examined with underwater television and a large number of assemblies were binocular examined. The visual examination showed the assemblies to be in excellent mechanical condition.(1)

Cycle 2 of Beaver Valley Unit 1 was completed in December, 1981. One hundred fifty-three (153) fuel assemblies were binocular examined and thirty (30) fuel assemblies were TV visually examined with underwater television consistent with the planned program. Of the thirty fuel assemblies, ten fuel assemblies were selected as representative fuel assemblies from Regions 2 and 3 and the remaining twenty fuel assemblies were examined for possible effects of coolant cross flow through baffle joints. In addition, several assemblies, supplementary to the planned program, were examined due to fuel handling problems.(2)

Cycle 3 of Beaver Valley Unit 1 was initiated on July 8, 1982, and was completed on June 10, 1983. The Beaver Valley End-of-Cycle 3 Fuel Inspection Program was initiated on July 2, 1983, and completed on August 5, 1983. One hundred fifty-seven (157) fuel assemblies were binocular examined during unloading from the core. TV visual examination was performed on twenty (20) standard 17x17 Region 5 fuel assemblies which operated adjacent to the baffle during Cycle 3, five (5) standard 17x17 Region 3 fuel assemblies, two (2) demonstration 17x17 optimized fuel assemblies, and four (4) standard 17x17 Region 4 fuel assemblies. In addition, fuel assembly length measurements were taken on sixty (60) assemblies.

This report presents the results of the examination of standard fuel assemblies at the End-of-Cycle 3. Results of the inspections related to the optimized fuel demonstration assemblies will be reported separately.

2.0 BEAVER VALLEY UNIT 1 FUEL DESIGN

Duquesne Light, Beaver Valley Unit 1 is a 3-loop 17x17 reactor with 2652 MW thermal power rating. The fuel in Beaver Valley Unit 1 is of the low parasitic design. Each of the 157 fuel assemblies in the reactor core contains 264 Zircaloy-4 clad fuel rods. Each rod is approximately thirteen feet long and contains a twelve-foot long column of fuel pellets. Spacing between the fuel rods is maintained by eight Inconel 718 alloy grids nearly equally spaced along the length of the fuel rods. In each fuel assembly, the top and bottom nozzles and the eight grids are attached to twenty-four Zircaloy-4 thimble tubes which extend between the nozzles and through the eight grids. In the Region 5 fuel, pellet density was 95 percent of theoretical density, and the fuel rods were prepressurized with helium to [ ] psig. In Table 2-1, several Beaver Valley Unit 1 core design (a,c) and operating characteristics are compared with those of Salem Unit 1 (Public Service Electric and Gas Co.), and Trojan (Portland General Electric Company) reactors.

While physical dimensions of the Beaver Valley Unit 1 fuel are the same as in the standard 17x17 design in the Salem Unit 1, Salem Unit 2 and Trojan reactors, the nuclear and thermal characteristics are not identical. Core average linear power is lower in Beaver Valley than Trojan and both Salem units.

TABLE 2-1

CORE DESIGN AND OPERATING CHARACTERISTICS

	Beaver Valley Unit 1	Salem Unit 1	Salem Unit 2	Trojan	
UO_2 Enrichment w/o U-235					
Region 1					(a,c)
Region 2					
Region 3					
Region 4					
Region 5					
Coolant Temperature					
Hot Zero Power, °F					
Initial Inlet					
Initial Core Ave. HFP, °F					
Operating Coolant Pressure, psig					
Average Linear Power kw/ft					

3.0 BEAVER VALLEY UNIT 1 THIRD CYCLE OPERATING HISTORY

Beaver Valley Unit 1 achieved criticality in the third cycle in July, 1982 and completed the third cycle in June, 1983 with Cycle 3 average burnup of 10,637 MWD/MTU. A brief summary of region burnup and powers is given in Table 3.1. The Cycle 3 core loading pattern is given in Figure 3-1.

The activity of the fission products I-131 and I-133 in the primary coolant was measured during Cycle 3 to monitor the defect condition of the fuel. Iodine activity is an important indicator of fuel integrity. Although there is no quantitative correlation of activity with the number of fuel rod defects, because large defects release more activity than small defects and because reactor power transients cause sudden transient activity increases or spikes, activity levels in a general sense reflect the condition of the fuel. The I-131/I-133 activity ratio is an indicator of the type of defect. A low I-131/I-133 ratio results from an open fuel rod defect, one which allows rapid release into the coolant of both the longer half life I-131 and the shorter half life I-133. A closed defect restricts release of iodine from the fuel rod and since the short-lived I-133 decays to Xe 133 more rapidly than does the I-131, the ratio of I-131 to I-133 in the coolant is higher. A ratio of 0.1 to 0.3 indicates rapid release through an open defect, and a ratio greater than 0.5 indicates delay of iodine release through a tight defect. Figure 3-2 shows the activity in the coolant during Cycle 3. All iodine measurements reported here were made at or near full power, thus avoiding transients or spikes associated with increasing or decreasing power.

Cycle 3 began with a coolant activity of $\sim 3\times10^{-3}\,\mu$ Ci/g I-131 with an I-131/I-133 ratio of ~ 0.25. The coolant activity level was essentially unchanged from the end of cycle 2; however, the ratio was considerably lower than the EOC 2 Iodine ratio of 0.6. This decrease in ratio indicates removal of some fuel rods with tight defects at EOC 2. The BOC three I-131 level indicates the presence of a few rods with more open defects. Additional rods defected during Cycle 3 indicated by an increasing I-131 activity level to $9\times10^{-3}\,\mu$ Ci/g with a constant Iodine ratio through March. These defects are also of an open type.

TABLE 3-1

Power and Burnup History Summary for Beaver Valley Unit 1

	Cycle 1		Cycle 2		Cycle 3		
Region	Average Power (kw/ft)	Burnup (MWD/MTU)	Average Power (kw/ft)	Burnup (MWD/MTU)	Average Power (kw/ft)	Burnup (MWD/MTU)	
1							(a,c)
2							
3							
4							
4a							
5							

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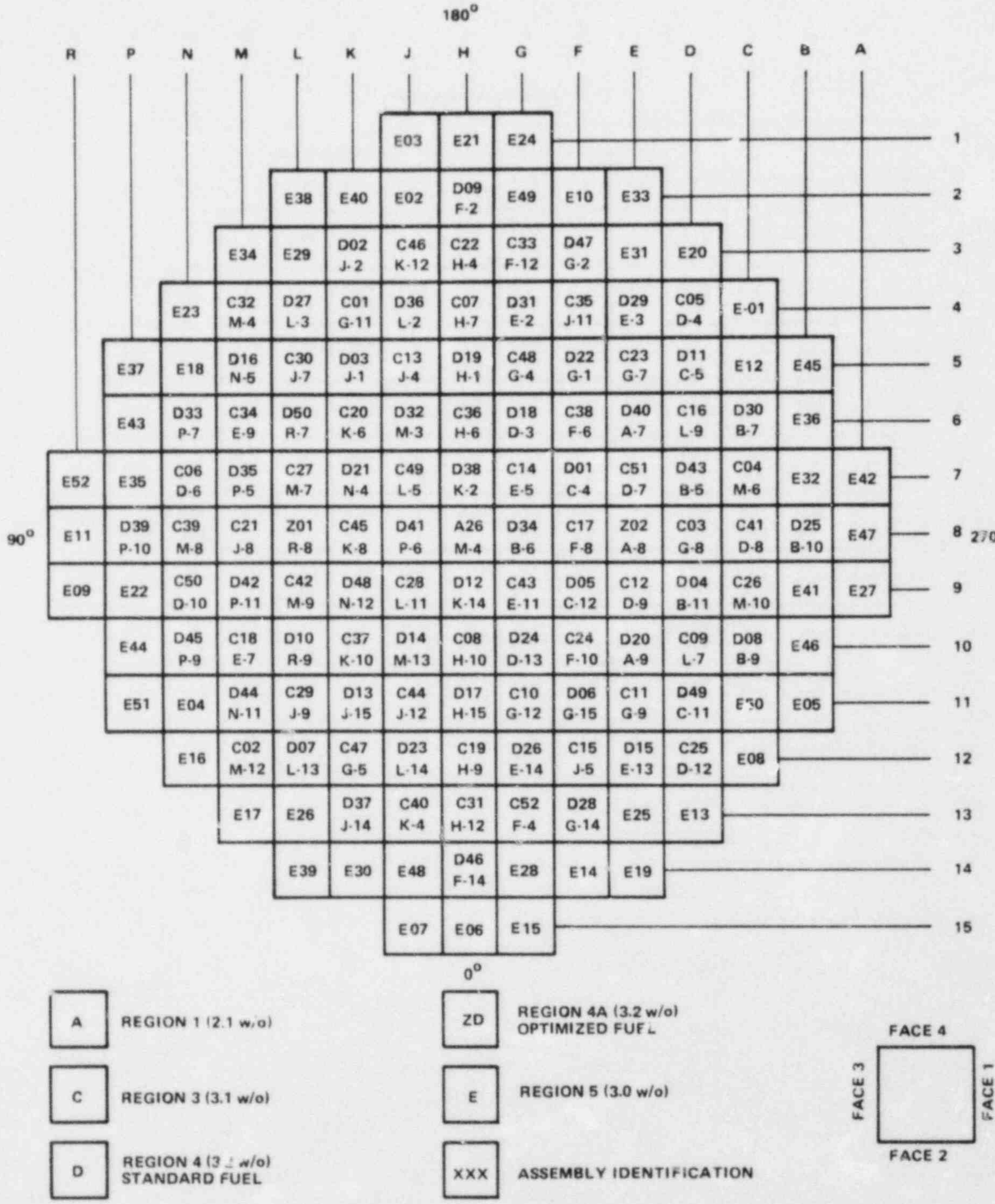

Figure 3-1 Cycle 3 Core Loading Pattern

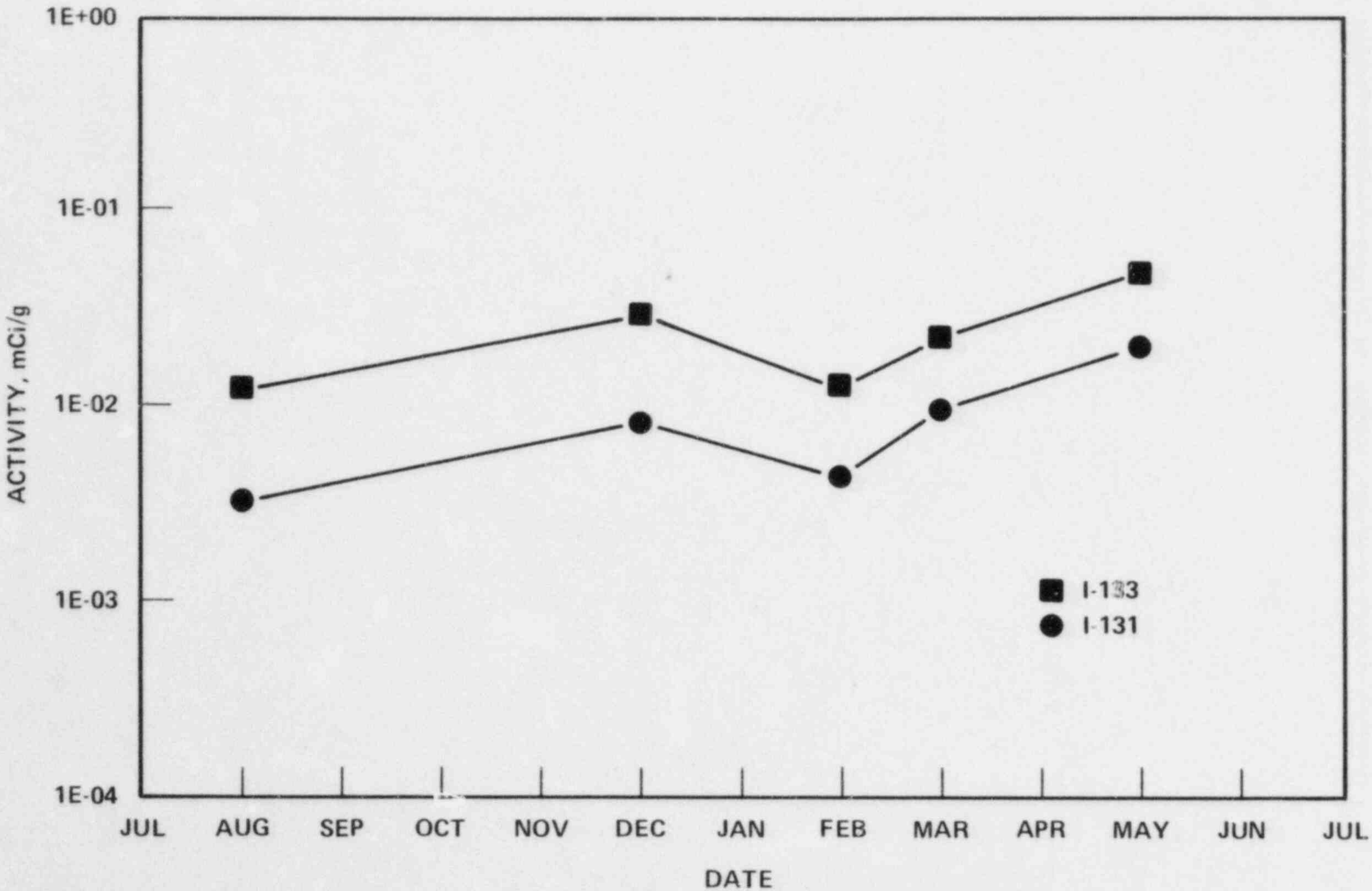

Figure 3-2 Beaver Valley-1 Cycle 3 Coolant Activity

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Further defect formation events occurred in March through May with the I-131 activity level increasing to $2 \times 10^{-2} \mu$ Ci/g and I-131/I-133 ratio of ~ 0.5. The increased Iodine ratio indicates these later defects are of a different nature and are tight defects.

Figure 3-3 shows boron-lithium concentration for Cycles 1, 2, and 3. Beaver Valley operated in a crud dissolving mode for all three cycles. The critical solubility curve of Figure 3-3 represents the dividing line between crud precipitating and crud dissolution based on the crud transportation processes developed by Westinghouse.(3) Below the solubility curve, there is a tendency for magnetite precipitation on hotter surfaces, assuming a saturated solution. Above the curve, the solubility of magnetite increases with temperature; thus there should be a tendency to dissolve the material from the core surface, or at least to retard the precipitation.(4)

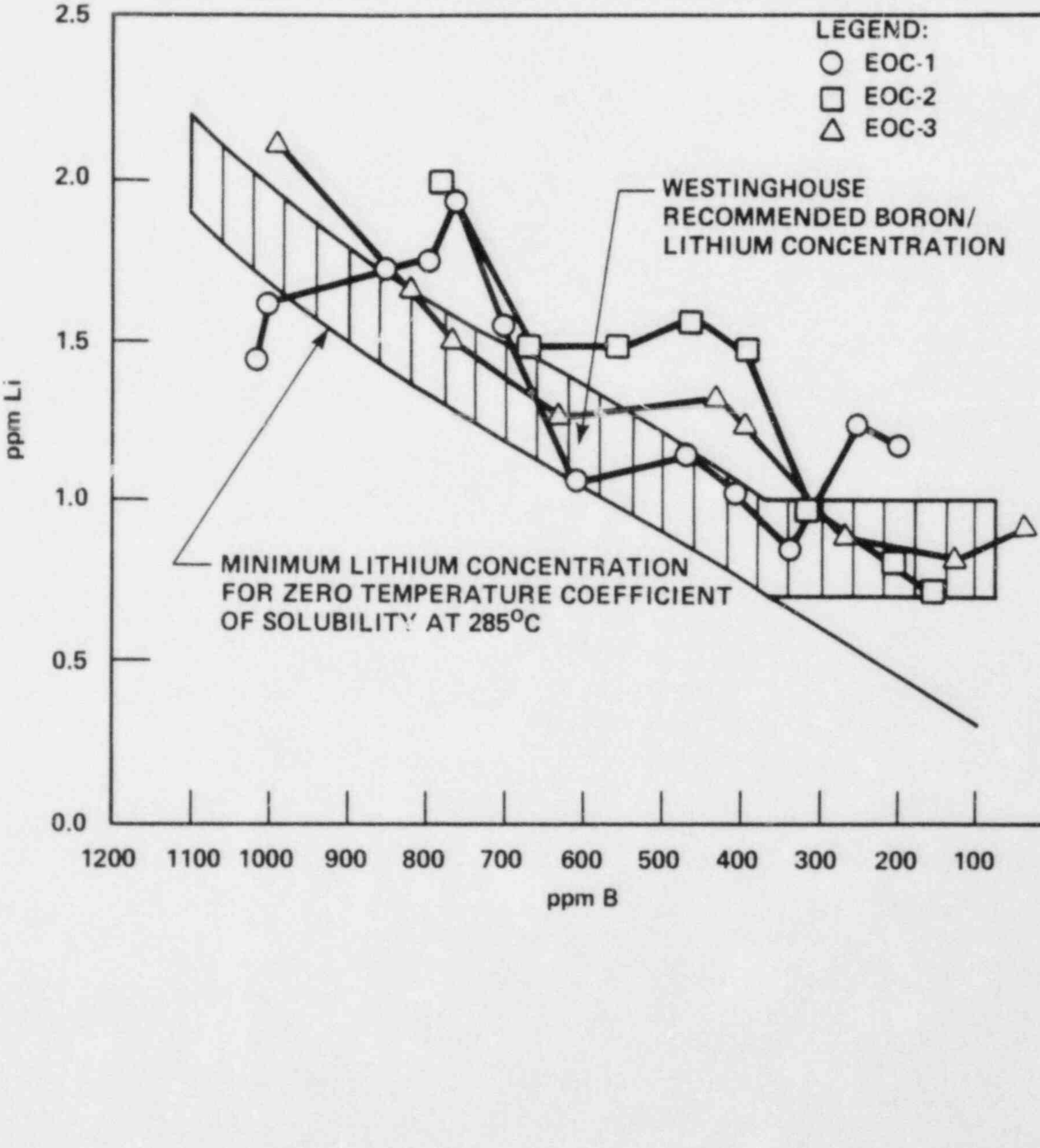

Figure 3-3 Boron Versus Lithium Concentration in DLW's Reactor Coolant During Cycle 1, Cycle 2 and Cycle 3

4.0 FUEL EXAMINATION

At the end of Cycle 3, Duquesne Light Company and Westinghouse performed a Fuel Inspect or Program. The Beaver Valley End-of-Cycle 3 Fuel Inspection Program was initiated on July 2, 1983 and completed on August 5, 1983. This inspection included a binocular visual examination of every fuel assembly which operated in Cycle 3, TV visual exam of twenty (20) standard 17x17 Region 5 fuel assemblies which operated adjacent to the baffle during Cycle 3, TV visual exam of five (5) standard 17x17 Region 3 fuel assemblies, TV visual exam of two (2) demonstration 17x17 optimized fuel assemblies, and TV visual exam of four (4) standard 17x17 Region 4 fuel assemblies. Also included in the program were fuel assembly length measurements on sixty (60) fuel assemblies and fuel rod breakaway withdrawal force measurements on twenty (20) fuel rods from the demonstration assemblies.

4.1 Binocular Examination

Every fuel assembly which operated in Cycle 3 of Beaver Valley Unit 1 (listed in Table 4-1) was examined with binoculars during unloading from the core. As the assemblies were transferred from the upender to their storage rack locations in the spent fuel pool, each was stopped momentarily and rotated so all four faces could be examined.

The binocular examinations indicated that the assemblies were in good mechanical condition with no visible damage to any fuel rods or structural components. Occasionally, shiny areas on a grid could be seen where the crud was scratched off during removal from the core. However, no damage to a grid was observed on any assembly.

Crud on the assemblies appeared to be very thin and no unusual corrosion was observed. The crud was distributed uniformly on the assemblies and did not appear to vary along its length, or from assembly face to face. Typically, the color of the crud ranged from a medium grayish brown for the one cycle assemblies to a darker gray for the three cycle assemblies.

TABLE 4-1

Beaver Valley EOC-3 Binocular Examination of Assemblies

Region 1	Region 3	Region 4	Region 4a	Region 5
A26	C01	D01	ZD1	E01
	C02	D02	ZD2	E02
	C03	D03		E03
	C04	D04		E04
	C05	D05		E05
	C06	D06		E06
	C07	D07		E07
	C08	D08		E08
	C09	D09		E09
	C10	D10		E10
	C11	D11		E11
	C12	D12		E12
	C13	D13		E13
	C14	D14		E14
	C15	D15		E15
	C16	D16		E16
	C17	D17		E17
	C18	D18		E18
	C19	D19		E19
	C20	D20		E20
	C21	D21		E21
	C22	D22		E22
	C23	D23		E23
	C24	D24		E24
	C25	D25		E25
	C26	D26		E26
	C27	D27		E27
	C28	D28		E28
	C29	D29		E29
	C30	D30		E30
	C31	D31		E31
	C32	D32		E32
	C33	D33		E33
	C34	D34		E34
	C35	D35		E35
	C36	D36		E36
	C37	D37		E37
	C38	D38		E38
	C39	D39		E39
	C40	D40		E40
	C41	D41		E41
	C42	D42		E42
	C43	D43		E43

TABLE 4-1 (cont)

Region 1	Region 3	Region 4	Region 4a	Region 5
	C44	D44		E44
	C45	D45		E45
	C46	D46		E46
	C47	D47		E47
	C48	D48		E48
	C49	D49		E49
	C50	D50		E50
	C51			E51
	C52			E52

Fuel rod bow was observed to be minimal, with only occasional channel closures greater than [ ] observed on an individual assembly. The number of large channel closures [ ] were more numerous on assemblies with three cycles of burnup and decreased progressively for the two and one cycle assemblies, respectively. The large channel closures were located mostly in the bottom three spans of an assembly. There were no cases of complete channel closure. (a,c) (a,c)

4.2 Television Examination: General Fuel Condition

The low magnification television examination was a full face examination of all fuel assembly faces from the bottom nozzle to the top nozzle. Each fuel assembly was positioned in front of the television camera so that the field view covered a 3x4 inch area of the assembly face. The assembly was lowered or raised in front of the television camera, scanning from nozzle to nozzle. The left half of the assembly face was examined in the first scan, and the right half of the face was examined in the second scan. Routinely, each scan was halted, briefly, at the bottom and top nozzle, at each grid and at each mid-span position between grids.[2]

4.2.1 Standard 17x17 Region 3 Fuel Assemblies

Five (5) standard Region 3, 17x17 fuel assemblies (listed in Table 4-2) were examined at low magnification. All of the assemblies were in good condition following three cycles of operation. No unusual fuel performance characteristics or mechanical damage was observed on any of the assemblies. The surface condition of peripheral fuel rods for assembly C49 is shown in figure 4-1.

4.2.2 Standard 17x17 Region 4 Fuel Assemblies

Four (4) Region 4 fuel assemblies (listed in Table 4-3) were examined with TV at low magnification because of handling incidents and possible unusual conditions. It was recommended by Westinghouse that these assemblies be video examined prior to use in subsequent cycles. These assemblies were examined and found to be in good condition.

TABLE 4-2

Beaver Valley Unit 1 EOC-3
TV Visual Examination

Region 3

Fuel Assembly No.	Core Location	Comment
C03	D08	Examined at EOC-1, EOC-2
C06	N07	Examined at EOC-1, EOC-2
C15	F12	Examined at EOC-1, EOC-2
C39	N08	Examined at EOC-1, EOC-2
C49	J07	Examined at EOC-1, EOC-2

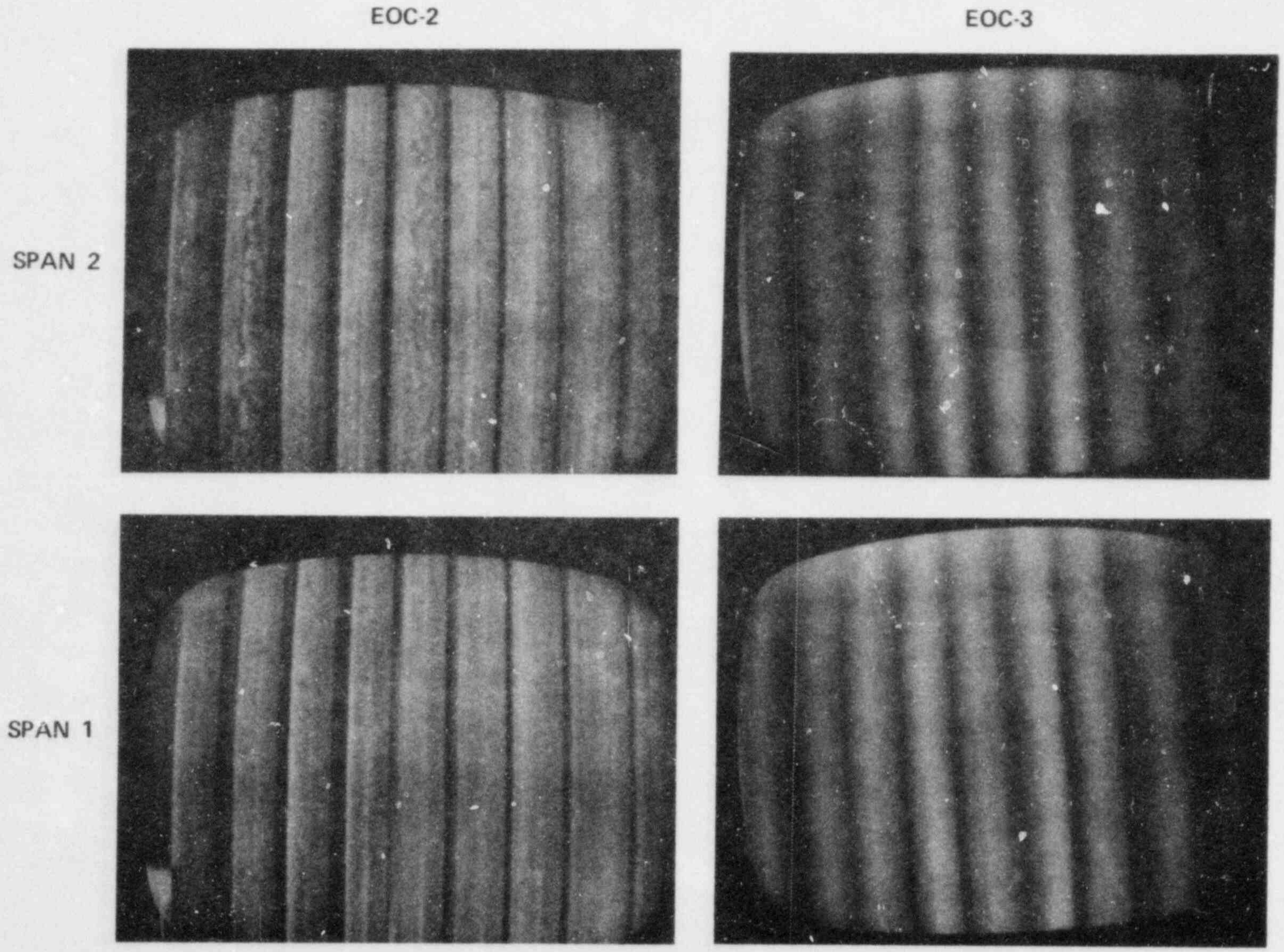

Figure 4-1 Surface Condition of Peripheral Fuel Rods in Beaver Valley Fuel Assembly C49 Face 3 Left Side EOC-2 and EOC-3 (Sheet 1 of 4)

8050-1

EOC-2 EOC-3

SPAN 4

SPAN 3

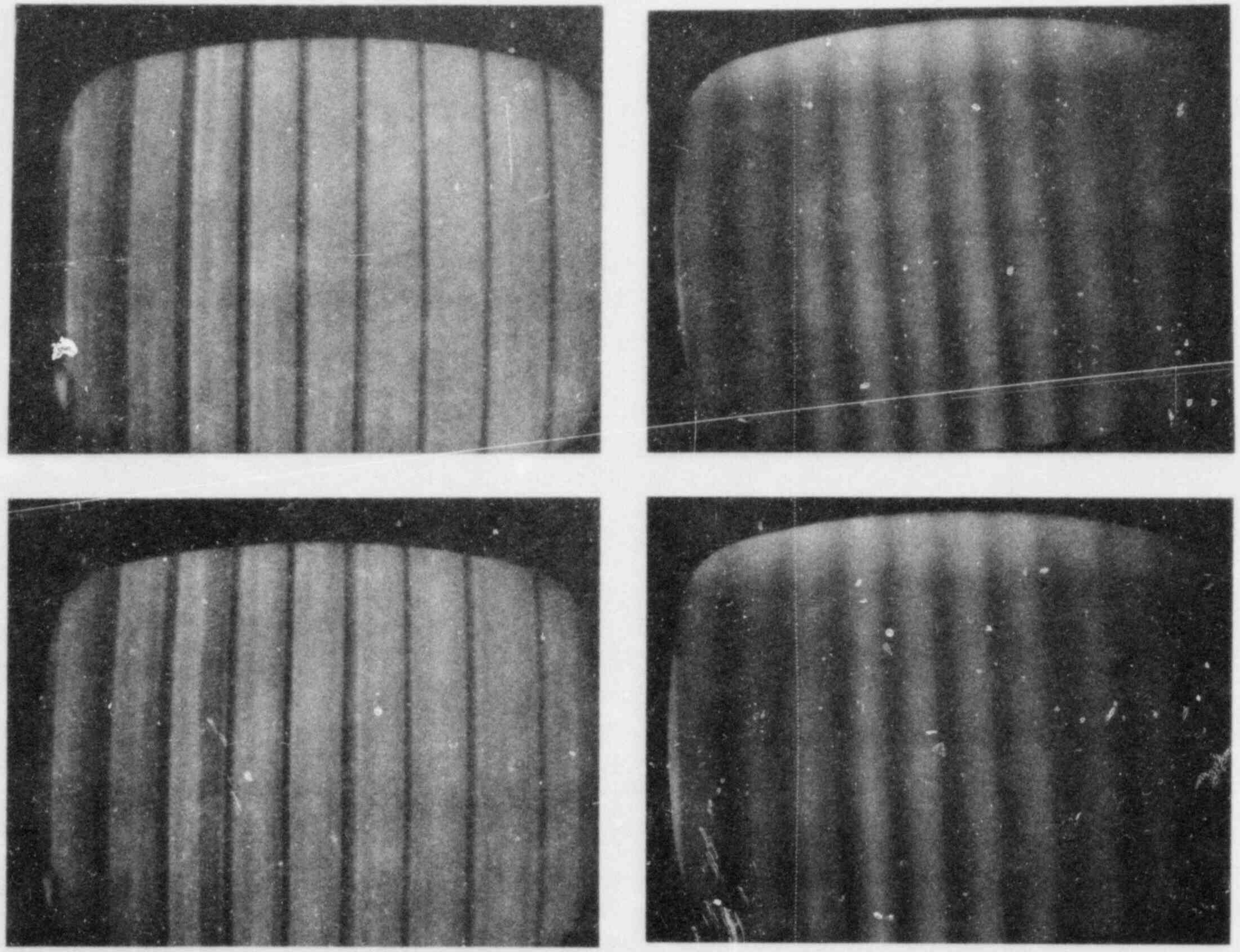

Figure 4-1 Surface Condition of Peripheral Fuel Rods in Beaver Valley Fuel Assembly C49 Face 3 Left Side EOC-2 and EOC-3 (Sheet 2 of 4)

WESTINGHOUSE PROPRIETARY CLASS 3

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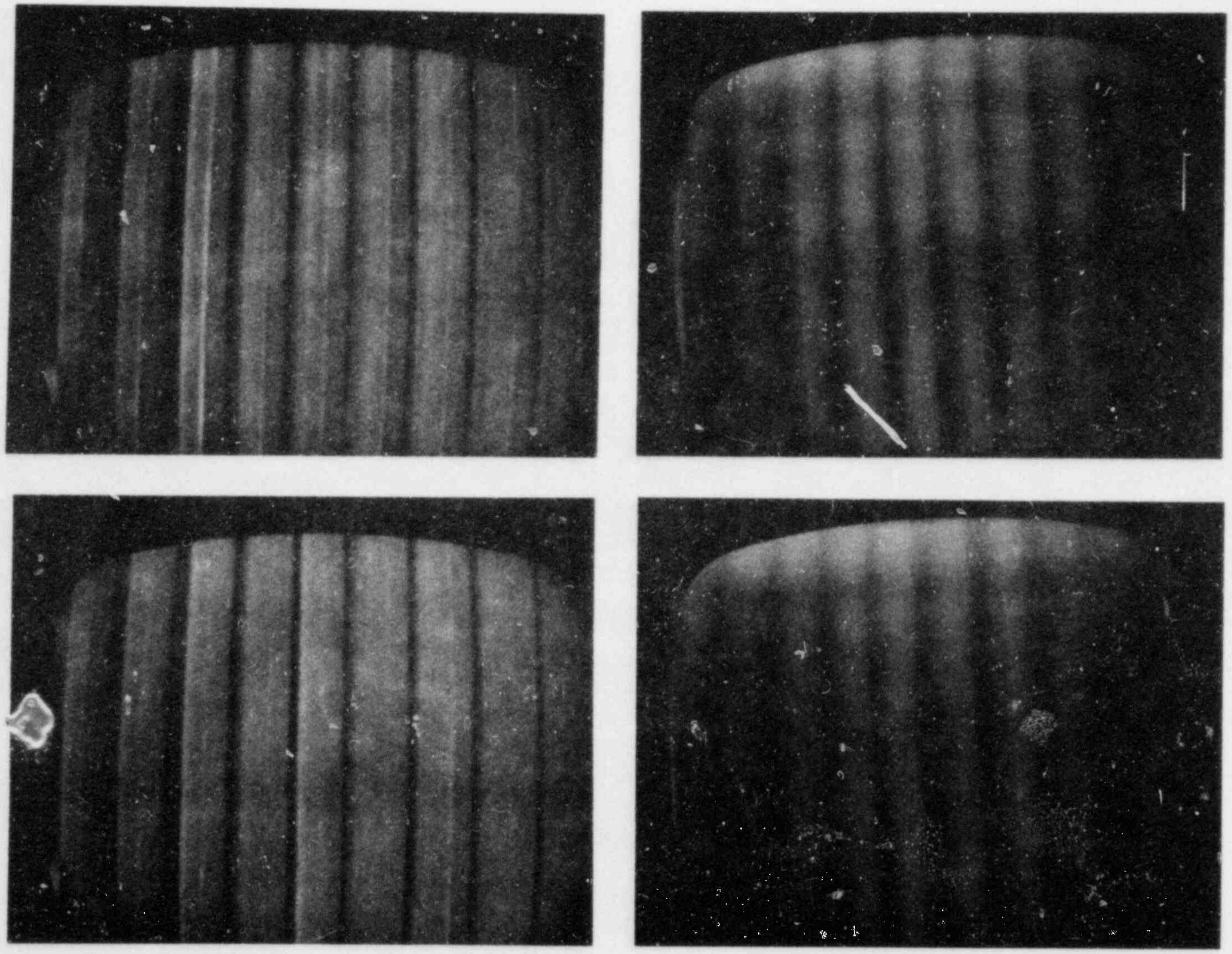

Figure 4-1 Surface Condition of Peripheral Fuel Rods in Beaver Valley Fuel Assembly C49 Face 3 Left Side EOC-2 and EOC-3 (Sheet 3 of 4)

EOC-2 EOC-3

SPAN 7

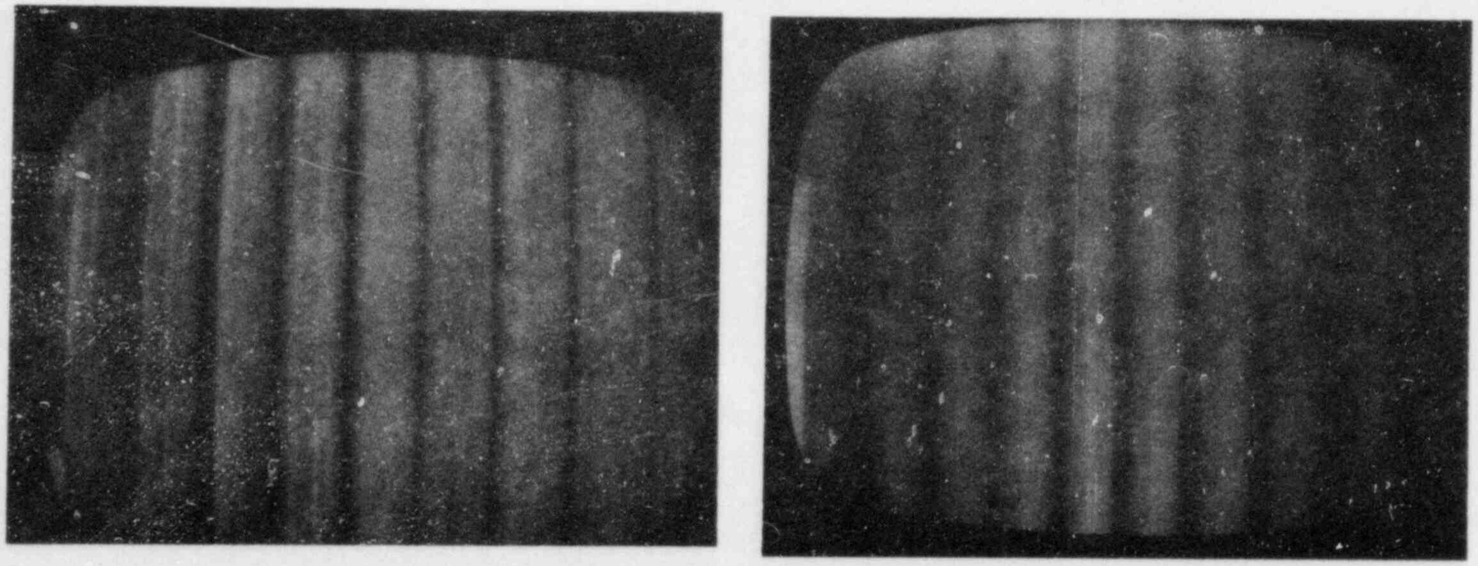

Figure 4-1 Surface Condition of Peripheral Fuel Rods in Beaver Valley Fuel Assembly C49 Face 3 Left Side EOC-2 and EOC-3 (Sheet 4 of 4)

8050-4

TABLE 4-3

Beaver Valley Unit 1 EOC-3
TV Visual Examination

Region 4

Fuel Assembly No.	Core Location	Comment
D17	H11	Examined at EOC-2
D18	G06	Examined because of handling concerns
D26	G12	Examined because of handling concerns
D43	D07	Examined because of handling concerns

4.2.3 Baffle Joint Fuel Assemblies

Recent fuel inspections at several reactors reveal that when coolant cross flow through leaking baffle joints impinges against peripheral fuel rods, fuel rod vibration and resultant fretting wear in the grids may occur. Since Beaver Valley has similar baffle joint geometries (center injection joints) to plants where damage has been observed, assemblies in Beaver Valley adjacent to these joint types were examined. Twenty (20) fuel assemblies (listed in Table 4-4) were inspected to determine the condition of the fuel rods and of corresponding grid cells located adjacent to the baffle joints. The assemblies listed in Table 4-4 were examined by high magnification TV (4 vertical scans per face) on the critical faces located directly next to the baffle joint and by low magnification (2 vertical scans per face) on the non-critical faces. The core locations of the assemblies examined are shown in Figure 4-2.

None of the assemblies examined exhibited obvious baffle flow induced damage. All fuel rods and grids were structurally sound. Minor baffle joint cross flow was evident on the six assemblies listed in Table 4-5. Very faint clean white marks approximately 1/10 inch wide, running the length of the grid, were observed on some of the grids on these assemblies. A typical example of the clean white mark is shown in figure 4-2. These same markings were present on the assemblies which occupied the same baffle joint locations in Cycle 2. In addition, non-uniform darker cladding surfaces were observed on fuel rods 2-3, face 4, fuel assembly E40 at the baffle joint location on the critical face.

4.2.4 Fuel Rod Channel Closure

Five (5) fuel assemblies from Region 3 were evaluated to determine the peripheral rod channel closure with a low magnification TV. The EOC-3 closures greater than [ ] are listed in Table 4.6. Each closure was (a,c) calculated from the expression:

$$\text{Closure} = \left[1 - \frac{M}{\frac{T + B}{2}}\right] \times 100 \text{ where}$$

TABLE 4-4

Beaver Valley Unit 1 Cycle 3

Baffle-Joint Assemblies Examined

Assembly No.	Core Position	Critical Faces	Non-Critical Faces
E10	F-2	3/4	1/2
E20	D-3	3/4	1/2
E40	K-2	1/4	2/3
E38	L-2	2/3	1/4
E34	M-3	2/3	1/4
E23	N-4	2/3	1/4
E43	P-6	2/3	1/4
E44	P-10	3/4	1/2
E51	P-11	1/2	3/4
E16	N-12	1/2	3/4
E17	M-13	1/2	3/4
E30	K-14	1/2	3/4
E14	F-14	2/3	1/4
E19	E-14	1/4	2/3
E13	D-13	1/4	2/3
E08	C-12	1/4	2/3
E46	B-10	1/4	2/3
E36	B-6	1/2	3/4
E45	B-5	3/4	1/2
E01	C-4	3/4	1/2

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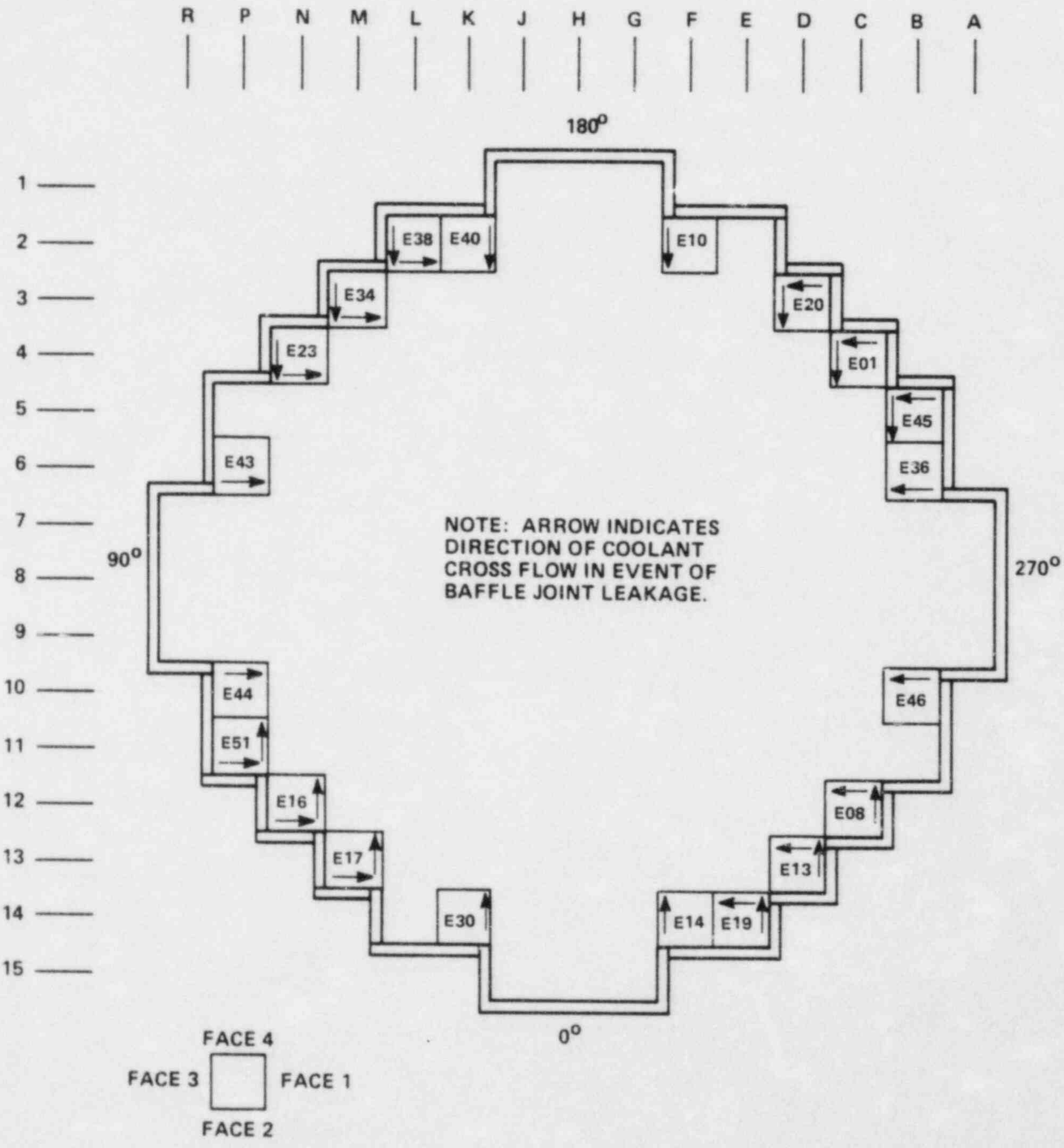

Figure 4-2 Location of Fuel Assemblies Examined for Effects of Coolant Cross Flow Through Baffle Joints

TABLE 4-5

Beaver Valley Unit 1 Cycle 3 Baffle-Joint Assemblies
Exhibiting Minor Baffle-Joint Cross Flow Spraying

Fuel Assembly No.	Core Location
E40	K02
E34	M03
E43	P06
E14	F14
E46	B10
E36	B06

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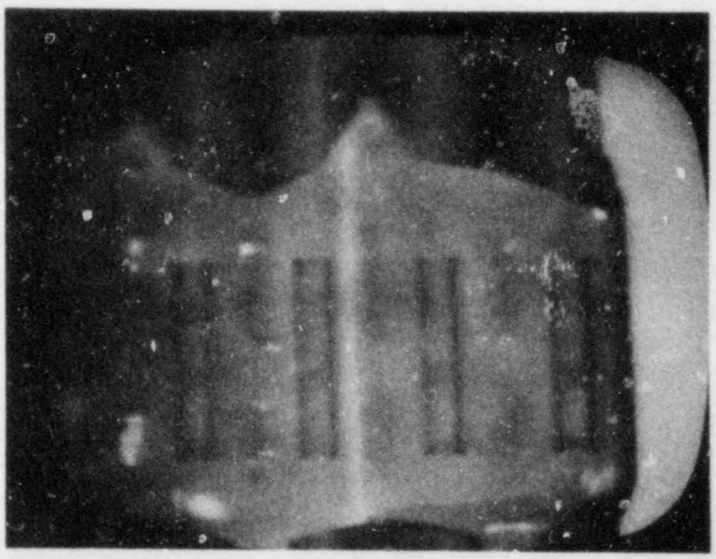

Figure 4-3 Example of White Clean Mark on Grid 6 on Face 3 of Assembly E43

TABLE 4-6

Fuel Rod Channel Closures [ ] Percent in (a,c)
Beaver Valley Unit 1 Fuel at EOC-3

Fuel Assembly No.	Face	Span	Rod	EOC-1	EOC-2	EOC-3
C15						
C39						
C49						
C03						
C06						

(b,c)

[ ] (a,c)

M = spacing between two adjacent fuel rods at mid-span location between grids

T = spacing between two adjacent fuel rods at the top of the grid span

B = spacing between two adjacent fuel rods at the bottom of the grid span

The largest closure observed at the end-of-cycle 3 was [ ] (b,c)
[ ] percent. This was the channel closure between rods 5 and 6, span 3, (b,c)
face 4, of fuel assembly C06. The closure is shown in Figure 4-4. This channel was [ ] percent closed at EOC-1, and [ ] percent closed at EOC-2. (b,c)

The axial variation of channel closure in each region is shown in Figure 4-5. The span 1 closure in Figure 4-5 has been normalized to compensate for the longer length of the first span (24 inches in span 1 and 20 inches in the upper span). The closure in span 1 was normalized by the ratio $(\frac{20}{24})^2$. (This is derived from the ratio of flexural rigidity $(I/1)^2$ between 24-inch-span and 20-inch-span). The worst span closure occurred in span 1 for the Region 3 assemblies measured as can be seen in Figure 4-5. Figure 4-6 shows the 95th-percentile closure in the worst-axial grid span of Beaver Valley Unit 1 at EOC-1, EOC-2 and EOC-3 as well as Surry 7-grid 17x17 assemblies, Trojan 8-grid 17x17 assemblies and Salem 8-grid 17x17 assemblies. The rod bow design limit curve approved by the NRC is also shown. The Surry data (7-grid) have been normalized to the same length as the 8-grid standard 17x17 fuel in other reactors. As seen in Figure 4-6, Beaver Valley Unit 1 closures are well below the design curve for the 8-grid 17x17 design and consistent with other data.

8050-6

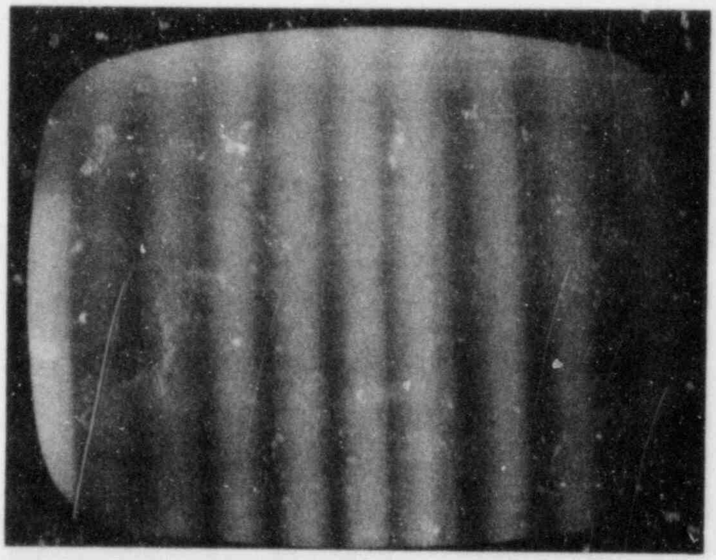

Figure 4-4 Maximum Channel Closure [ ] Percent, Assembly C06, Face 4 Span 3 between Rods 5 and 6 (b,c)

3760

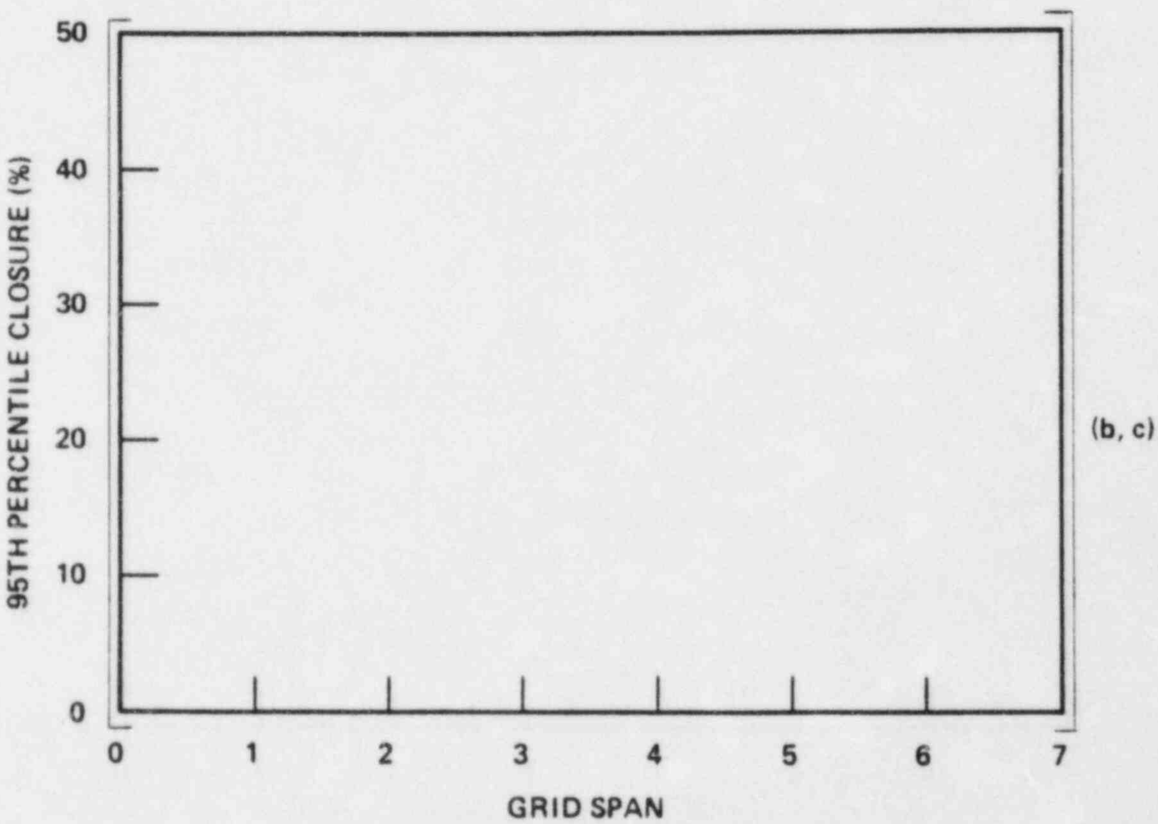

Figure 4-5 EOC-2 Axial Variation in 95th Percentile Peripheral Fuel Rod Channel Closure in Beaver Valley Unit 1

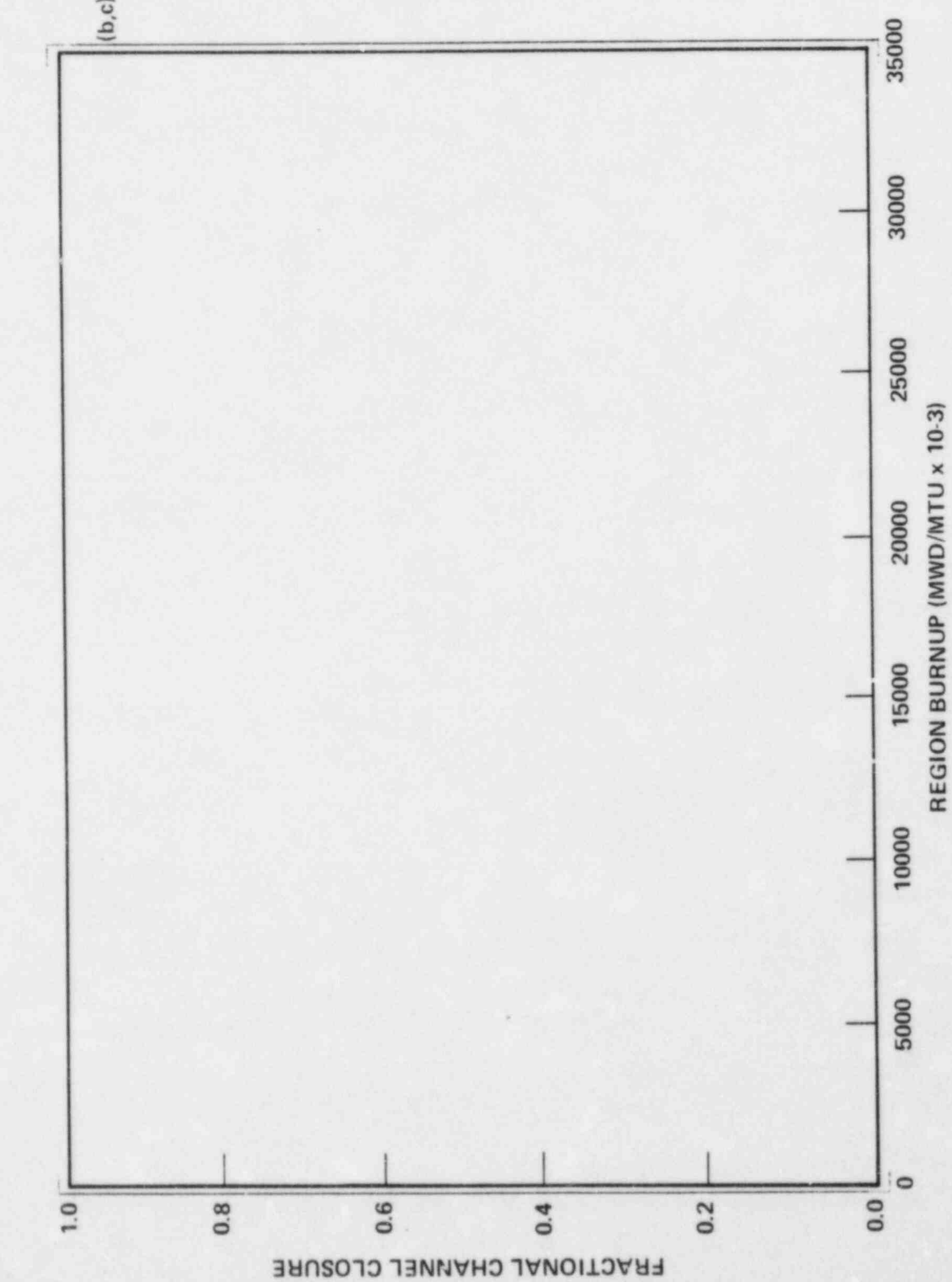

Figure 4-6 Worst-Span Channel Closure Behavior at the 95th Percentile Level

4.2.5 Peripheral Fuel Rod-To-Nozzle Gap and Rod Growth

The axial gap between peripheral rod and assembly nozzle for five (5) assemblies, C03, C06, C15, C39, and C49 was measured from the low magnification image on the television video tapes.

The low magnification television measurements of rod-to-nozzle gaps were calibrated for each fuel assembly face by measuring the video tape image of several grid springs on the outside straps in the top grid and bottom grid. The spring slot lengths on the top grid, on each individual face, were averaged and used as the standard for the top rod-to-nozzle gap measurements on that face. Similarly, the spring slot lengths from each bottom grid were averaged and used as a standard for the bottom rod-to-nozzle gap measurements on that face.

Appendix B contains the fuel rod-to-nozzle data for each of the five (5) assemblies that had measurements taken. A summary of these results is found in Table 4-7. The average bottom gap for Region 3 was [ ] inches, and (b,c)
the average top gap for Region 3 was [ ] inches. The average total gap (b,c)
for Region 3 was [ ] inches. (b,c)

The average percent change in bottom gap for Region 3 was [ ] percent, (b,c)
with a minimum of [ ] percent and a maximum of [ ] percent. (b,c)
Figure 4-7 shows percent change in bottom gap as a function of burnup for the five (5) Region 3 fuel assemblies from which data were obtained. Figure 4-7 also includes data from other plants as well as the data from Beaver Valley Unit 1, end-of-cycle 2. It can be seen from Figure 4-7 that the bottom gap decreases continuously with burnup.

The average percent change in top gap for Region 3 was [ ] percent, with (b,c)
a minimum of [ ] percent and a maximum of [ ] percent. Figure 4-8 (b,c)
shows percent change in top gap as a function of burnup for the five(5) Region 3 fuel assemblies from which data were obtained. Figure 4-8 also includes data

Table 4-7

Summary of Fuel Rod-To-Nozzle Gap Data

	Bottom Gap	Top Gap	Total Gap	Rod Growth	Percent Change Bottom Gap	Percent Change Top Gap	Percent Change Total Gap
Average Region 3							
Minimum							
Maximum							

(b,c)

3760

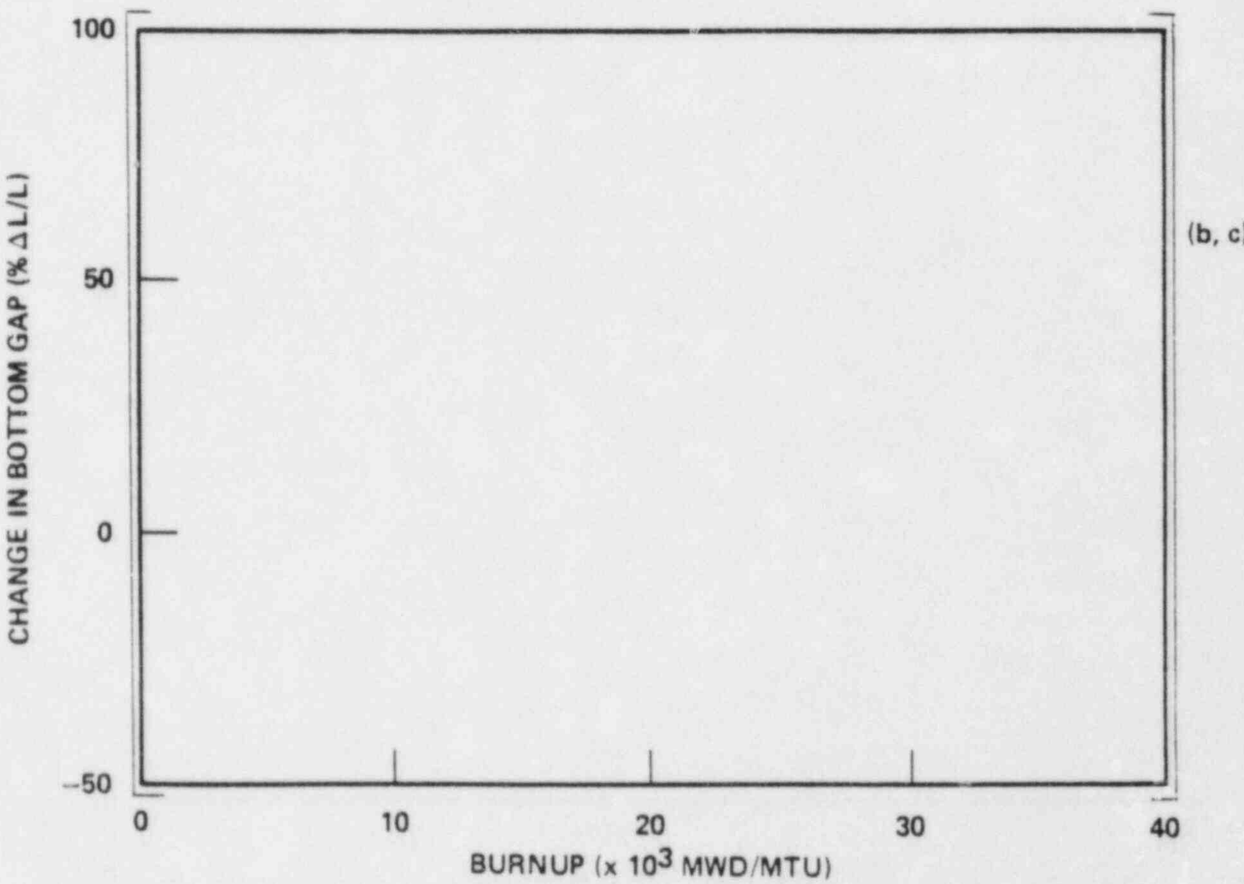

Figure 4-7 Bottom Gap Change Versus Burnup

3760

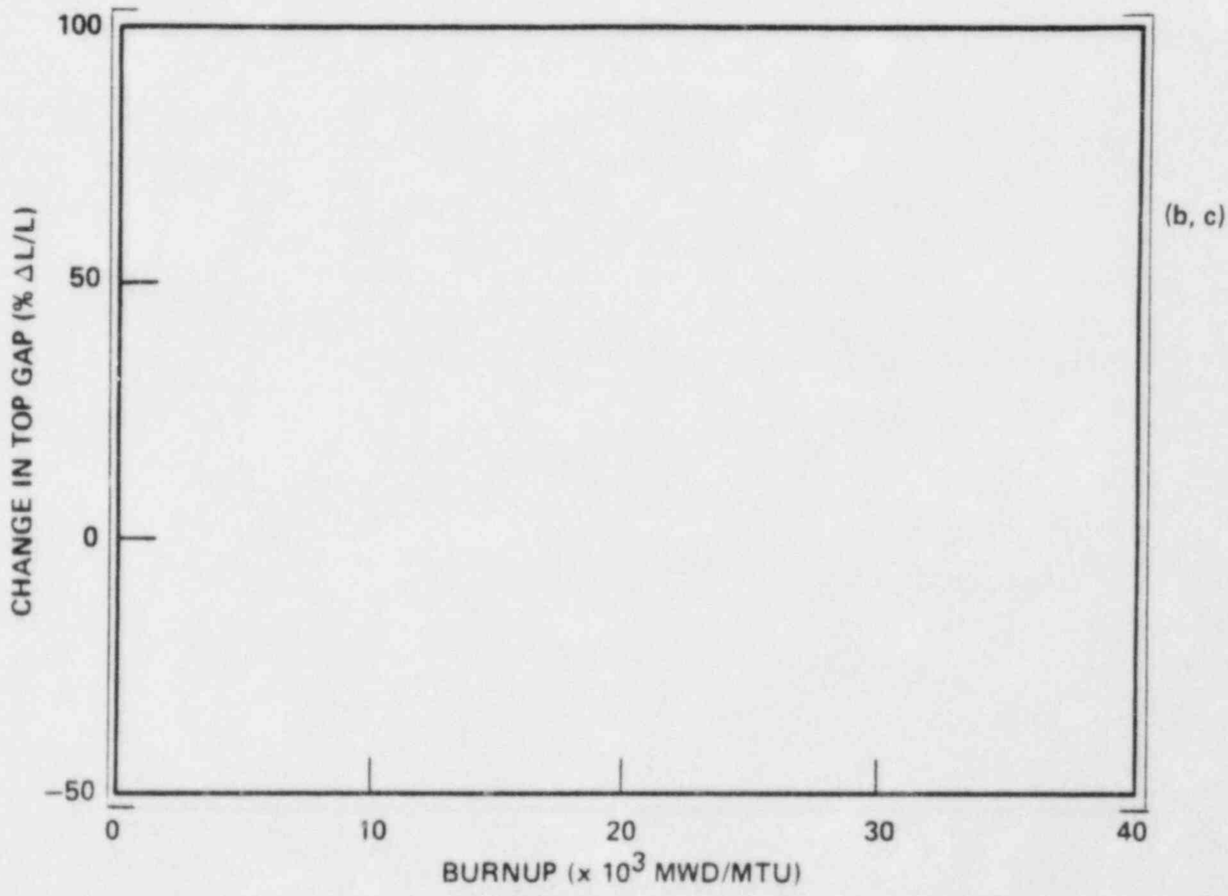

Figure 4-8 Top Gap Change Versus Burnup

from other plants as well as the data from Beaver Valley Unit 1, end-of-cycle 2. It can be concluded from Figure 4-8 that the top gap changes little with burnup through this level of exposure.

The observation of burnup dependent bottom gap, and burnup independent top gap, supports the interpretation that the fuel rods grow predominantly downward until the bottom gap is fully closed. There are occurrences, however, of occasional fuel rod slippage downward through the grids as evidenced by the negative values recorded for the percent change in top gap. The gap data obtained for the Beaver Valley Unit 1, 3-cycle assemblies indicate that an adequate rod-to-nozzle gap exists to accommodate continued rod growth for further cycles of irradiation.

Fuel rod growth for each rod examined was derived from the rod-to-nozzle gap data and the predicted fuel assembly growth based upon data from other es.

Fuel rod growth was derived from the gap measurements using the equation:

$$\text{Rod Growth} = 100 \times \frac{A+B-C}{D}$$

A= Preirradiation nominal total gap

B= Irradiation change in nozzle-to-nozzle length (Measured preirradiation nozzle-to-nozzle length times the EOC-3 assembly growth)

C= EOC-3 rod-to-nozzle gap

D= Preirradiation nominal rod length

Fuel rod growth after three cycles of irradiation ranged from [ ] (b,c)
percent to [ ] percent with a mean of [ ] percent for Region 3. (b,c)
Individual assembly data is in Appendix B. A summary of the fuel rod growth data is found in Table 4-7.

Figure 4-9 plots the combined rod growth data for the five (5) Beaver Valley Unit 1 assemblies as a function of fast fluence, together with data from several other plants. The Beaver Valley Unit 1, end-of-cycle 3 data are consistent with the data obtained from other plants.

4.3 Fuel Assembly Length Measurements

Fuel Assembly length measurements were performed on sixty (60) fuel assemblies (listed in Appendix A) from Regions 1, 2, 3, 4 and 5. The results of the assembly length measurements are also given in Appendix A. A summary of the assembly length data is given in Table 4-8.

The assemblies were found to have grown from [ ] percent to [ ] (b,c) percent larger than their unirradiated nominal fuel assembly length. This is typical for fuel with one to three cycles of irradiation.

3760

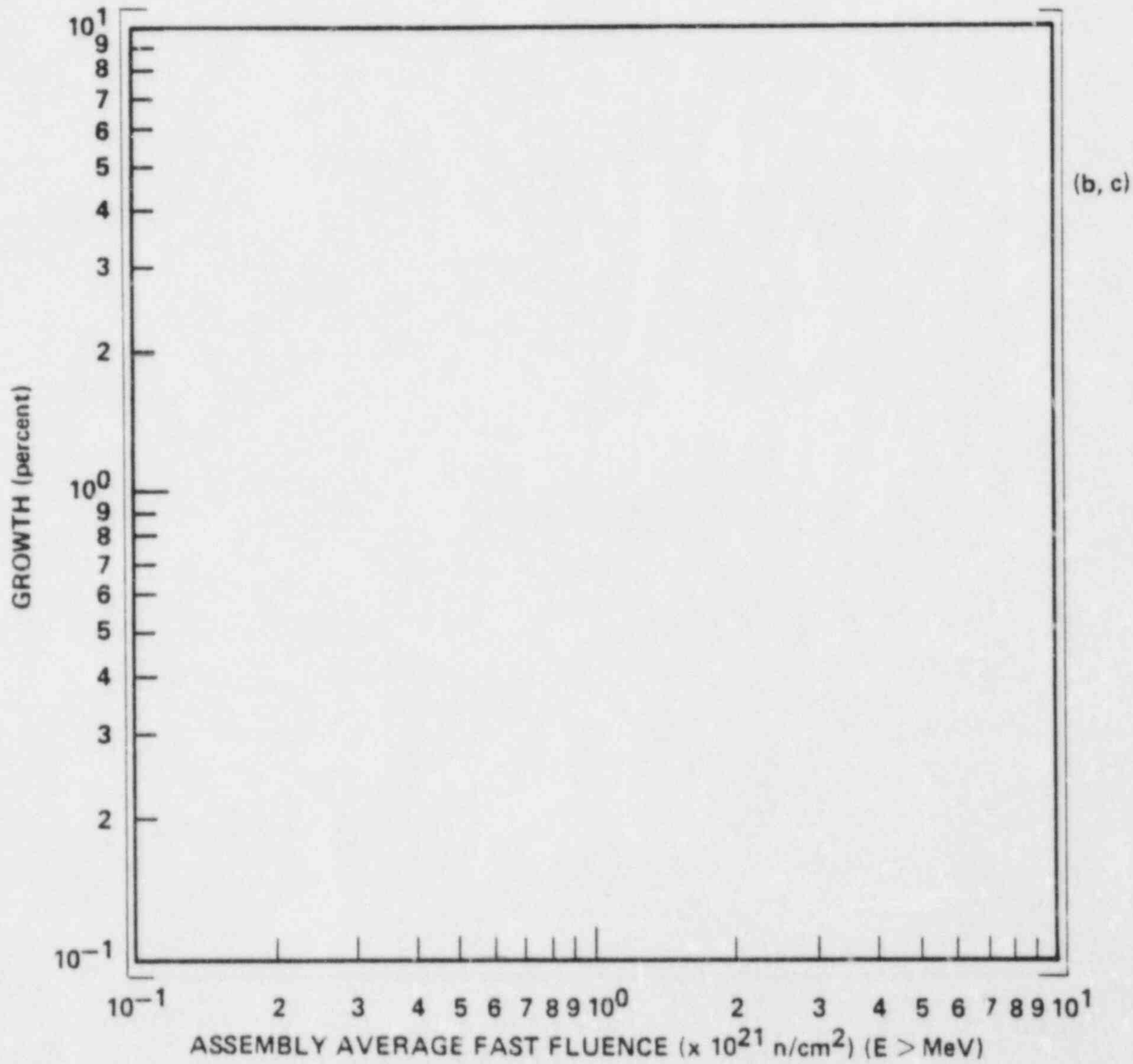

Figure 4-9 Fuel Rod Growth Variation With Fluence

TABLE 4-8

Summary of Beaver Valley Unit 1 Cycle 3 Assembly Growth Data

Region	Fuel Assembly No.	Burnup	Average Growth (%)	Growth (%) Maximum	Growth (%) Minimum
1	Average				
2	Average				
3	Average				
4	Average				
5	Average				

(b,c)

5.0 CONCLUSIONS

The overall condition of fuel assemblies examined during the Beaver Valley Unit 1, End-of-Cycle 3 Fuel Inspection Program was excellent. Binocular examinations indicated the assemblies were in good mechanical condition with no anomalies observed on any of the fuel rods, grids, nozzles, or holddown springs. TV visual examination of the detected anomalies confirmed these observations. Rod bow for the 1-, 2-, and 3-cycle fuel was typical and minimal. No occurrence of complete channel closure was observed. Crud deposits were thin with no unusual cladding or grid material degradation. Length measurements indicated fuel rod and fuel assembly growth to be normal.

No obvious baffle joint related damage was observed on the twenty (20) assemblies examined. However, six assemblies showed evidence of slight baffle joint spraying, all of these assemblies appeared to be structurally sound.

Based on the examination performed and the preliminary evaluation of the data, all of the assemblies examined are acceptable for further irradiation.

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4. Sweeton, F.H. and C. F. Baes, Jr., The Solubility of Magnetite and Hydrolysis of Ferrous Ion in Aqueous Solutions at Elevated Temperatures, J. Chem Thermodyn 2, pp. 479-500 (1970).

APPENDIX A

Beaver Valley Unit 1 Cycle 3
Fuel Assembly Growth

Beaver Valley Unit 1 Cycle 3 Fuel Assemblies
Length Measured

1)	E21	31)	C32
2)	E47	32)	D28
3)	E10	33)	D37
4)	E30	34)	D47
5)	E37	35)	D02
6)	E05	36)	B43
7)	ZD1	37)	B30
8)	ZD2	38)	B14
9)	D12	39)	B35
10)	D46	40)	B51
11)	D25	41)	B32
12)	D39	42)	B13
13)	D08	43)	B26
14)	D45	44)	B25
15)	D30	45)	B38
16)	D33	46)	A11
17)	A26	47)	B20
18)	C17	48)	B31
19)	C45	49)	B07
20)	C09	50)	B04
21)	C21	51)	C49
22)	C41	52)	C15
23)	C39	53)	A01
24)	C26	54)	A14
25)	C03	55)	A25
26)	C06	56)	A36
27)	C50	57)	A10
28)	C25	58)	A05
29)	C02	59)	A20
30)	C05	60)	A15

Beaver Valley Unit 1 Cycle 3
Fuel Assembly Growth

Region	Fuel Assembly No.	Burnup	Growth (%)
1	A01		
	A05		
	A10		
	A11		
	A14		
	A15		
	A20		
	A25		
	A26		
	A36		
2	B04		
	B07		
	B13		
	B14		
	B20		
	B25		
	B26		
	B30		
	B31		
	B32		
	B35		
	B38		
	B43		
	B51		

(b,c)

Region	Fuel Assembly No.	Burnup	Growth (%)
3	C02		
	C03		
	C05		
	C06		
	C09		
	C15		
	C17		
	C21		
	C25		
	C26		
	C32		
	C39		
	C41		
	C45		
	C49		
	C50		
4	D02		
	D08		
	D12		
	D25		
	D28		
	D30		
	D33		
	D37		
	D39		
	D45		
	D46		
	D47		

(b,c)

Region	Fuel Assembly No.	Burnup	Growth (%)	
5	E05			(b,c)
	E10			
	E21			
	E30			
	E37			
	E47			

APPENDIX B

Fuel Rod-To-Nozzle Gap Data

Fuel Assembly C03

	Average	Minimum	Maximum	
Bottom Gap				(b,c)
Top Gap				
Total Gap				
Rod Growth				
Percent Change Bottom Gap				
Percent Change Top Gap				
Percent Change Total Gap				

Fuel Assembly C06

	Average	Minimum	Maximum	
Bottom Gap				(b,c)
Top Gap				
Total Gap				
Rod Growth				
Percent Change Bottom Gap				
Percent Change Top Gap				
Percent Change Total Gap				

Fuel Assembly C15

	Average	Minimum	Maximum	
Bottom Gap				(b,c)
Top Gap				
Total Gap				
Rod Growth				
Percent Change Bottom Gap				
Percent Change Top Gap				
Percent Change Total Gap				

Fuel Assembly C39

	Average	Minimum	Maximum	
Bottom Gap				(b,c)
Top Gap				
Total Gap				
Rod Growth				
Percent Change Bottom Gap				
Percent Change Top Gap				
Percent Change Total Gap				

Fuel Assembly C49

	Average	Minimum	Maximum	
Bottom Gap				(b,c)
Top Gap				
Total Gap				
Rod Growth				
Percent Change Bottom Gap				
Percent Change Top Gap				
Percent Change Total Gap				