RELOAD SAFETY EVALUATION

BEAVER VALLEY NUCLEAR PLANT

UNIT 1 CYCLE 5

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1.0 INTRODUCTION AND SUMMARY

1.1 INTRODUCTION

This report presents an evaluation for Beaver Valley Unit 1, Cycle 5, which demonstrates that the core reload will not adversely affect the safety of the plant. Both three loop and two loop operation were evaluated. This evaluation was accomplished utilizing the methodology described in WCAP-9272, "Westinghouse Reload Safety Evaluation Methodology" (Reference 1).

Based upon the above referenced methodology, only those incidents analyzed and reported in the FSAR (Reference 2) and N-1 loop safety analyses (References 3-5), which could potentially be affected by this fuel reload, have been reviewed for the Cycle 5 design described herein. The justification for the applicability of previous results is provided.

1.2 GENERAL DESCRIPTION

The Beaver Valley Unit 1 reactor core is comprised of 157 fuel assemblies arranged in the core loading pattern configuration shown in Figure 1. The Cycle 5 core configuration features a low leakage pattern. During the Cycle 4/5 refueling, all fifty (50) of the Region 4 assemblies, two (2) of the region 4a assemblies, and twenty-four (24) of the Region 5 assemblies will be replaced with seventy-six (76) Region 7 assemblies. One Region 1 assembly will be replaced with another Region 1 assembly. A summary of the Cycle 5 fuel inventory is given in Table 1.

A new Wet Annular Burnable Absorber (WABA) rod design will be utilized for Cycle 5. The WABA design provides significantly enhanced nuclear characteristics, when compared with the borosilicate absorber rod design. Use of the WABA rods has been approved by an NRC SER which is incorporated into the approved version of the Westinghouse WABA evaluation topical report (Reference 6).

Nominal core design parameters utilized for Cycle 5 are as follows:

	Three Loop (N)	Two Loop (N-1)
Core Power (MWt)	2652	1724
System Pressure (psia)	2250	2250
Core Inlet Temperature (°F)	542.5	534.4
Core Average Temperature (°F)	579.3	568.5
Thermal Design Flow (gpm)	265,500	187,800
Average Linear Power Density (kw/ft)	5.19	3.38

1.3 CONCLUSIONS

From the evaluation presented in this report, it is concluded that the Cycle 5 design does not cause the previously acceptable safety limits for any incident to be exceeded for three loop or two loop operation. These conclusions are based on the following assumptions:

1. Cycle 4 burnup is between 11100 and 13100 MWD/MTU.

2. Cycle 5 burnup is limited to the end-of-life full power capability* plus a 1000 MWD/MTU power coastdown.

3. There is adherence to plant operating limitations given in the Technical Specifications.

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* Definition: With control rods fully withdrawn and approximately 0-10 ppm residual boron.

2.0 REACTOR DESIGN

2.1 MECHANICAL DESIGN

The mechanical design and fuel rod backfill pressure of the 76 Region 7 fuel assemblies is the same as the Region 6 assemblies, except for the implementation of the IGF/RECON fuel rod end plugs.* Table 1 compares pertinent design parameters of the various fuel regions. The Region 7 fuel has been designed according to the fuel performance model in Reference 7. The fuel is designed to operate so that clad flattening will not occur, as predicted by the Westinghouse model (Reference 8). The fuel rod internal pressure design basis, Reference 9, is satisfied for all fuel regions.

Westinghouse's experience with Zircaloy clad fuel is described in WCAP-8183, "Operational Experience with Westinghouse Cores," Reference 10, which is updated annually.

Wet Annular Burnable Absorber (WABA) rods will be used instead of the standard borosilicate glass absorber rods. The WABA rod design consists of annular pellets of aluminum oxide-boron carbide (Al_2O_3-B_4C) burnable absorber material encapsulated within two concentric Zircaloy tubings. The reactor coolant flows inside the inner tubing and outside the outer tubing of the annular rod. Details of the WABA design are described in Reference 6.

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*IGF/RECON-Internal grip feature pull load (bottom)/reconstitutable (top) end plugs.

2.2 NUCLEAR DESIGN

The Cycle 5 core loading is designed to meet a F_Q x P ECCS limit of $\leq$ 2.32 x K(z)* for three loop operation and $\leq$ 3.03 x K(z) for two loop operation. The two loop (N-1) F_Q is an increase from $\leq$ 2.77 x K(z) specified for Cycle 4 based on an updated LOCA analysis for N-1 loop operation. The flux difference (ΔI) band width during normal operating conditions is $\pm$ 7% for both two and three loop operation.

Table 2 summarizes the current limits for kinetics characteristics which are based on previously submitted accident analyses. None of these limits is exceeded in Cycle 5.

Cycle 5 control rod worths and requirements are compared in Table 3 with those for Cycle 4 at the most limiting condition (end-of-life). The available shutdown margin exceeds the minimum required margin.

The loading pattern for Cycle 5 is shown in Figure 1. It contains 880 WABA rods located in 72 WABA rod assemblies. Two secondary sources, retained from the Cycle 4 core, are located in positions H3 and H13.

2.3 THERMAL AND HYDRAULIC DESIGN

No significant variations in thermal margins will result from the Cycle 5 reload. The DNB core limits and safety analyses used for Cycle 5 are based on the conditions given in Section 1.0.

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*K(z) - See Figures 2 and 3

3.0 POWER CAPABILITY AND ACCIDENT EVALUATION

3.1 POWER CAPABILITY

The plant power capability for two and three loop operation is evaluated considering the consequences of those incidents examined in the FSAR and References 3 - 5 using the previously accepted design basis. It is concluded that the core reload will not adversely affect the ability to safely operate at the two and three loop design power levels (Section 1) during Cycle 5. For the overpower transient, the fuel centerline temperature limit of 4700°F can be accommodated with margin in the Cycle 5 core. The time dependent densification model (Reference 11) was used for fuel temperature evaluations. The LOCA limit at rated power for three and two loop can be met by maintaining F_Q at or below 2.32 and 3.03, respectively, according to their normalized F_Q envelope (Figures 2 & 3).

3.2 ACCIDENT EVALUATION

The effects of the reload on the design basis and postulated incidents analyzed for 3 loop operation in the FSAR (Reference 2), and for two loop operation (References 3 - 5), were examined. In all cases, it was found that the effects were accommodated within the conservatism of the initial assumptions used in the previous applicable safety analysis.

3.2.1 KINETICS PARAMETERS

Table 2 is a summary of the current limits for kinetics parameters. All the Cycle 5 kinetic values fall within the bounds of the current limits.

3.2.2 CONTROL ROD WORTHS

Changes in control rod worths may affect differential rod worths, shutdown margin, ejected rod worths, and trip reactivity. Table 2 shows that the maximum differential rod worth of two RCCA control banks moving together in their highest worth region for Cycle 5 meets the current limit. Table 3 shows that the Cycle 5 shutdown margin requirements are satisfied. Ejected rod worths for the Cycle 5 design are also within the bounds of the current limits.

3.2.3 CORE PEAKING FACTORS

Peaking factors for the dropped RCCA incidents were evaluated based on the NRC approved dropped rod methodology described in Reference 12. Results show that DNB design basis is met for all dropped rod events initiated from full power. Peaking factors following control rod ejection are within the bounds of the current limits. The peaking factors for steamline break have been evaluated and are within the bounds of the previous safety analysis limits.

The F_Q of 3.03 for two loop operation (Reference 5) is an increase from 2.77 in Cycle 4 and results in increased initial fuel temperatures for use in accident analyses. This condition was evaluated and the increased temperatures were confirmed to be acceptable.

4.0 TECHNICAL SPECIFICATION CHANGES

No changes to the Beaver Valley Unit 1 Technical Specifications are required for Cycle 5.

5.0 REFERENCES

1. Bordelon, F.M., et. al., "Westinghouse Reload Safety Evaluation Methodology," WCAP-9272, (Proprietary), March 1978.

2. "Beaver Valley Unit No. 1 Final Safety Analysis Report," Docket Number 50-334.

3. Letter from J. D. Woodward (Westinghouse) to J. A. Werling (D. L. Co.), "WRAP N-1 Loop Operation, Non-LOCA Analyses," RPFP-78-34, October 5, 1978.

4. Letter from J. D. Woodward (Westinghouse) to J. A. Werling (D. L. Co.) "WRAP-N-1 Loop Operation [ECCS] Analyses," RPFP-78-16.

5. Letter from J. A. Triggiani (Westinghouse) to J. D. Sieber (D. L. Co.), "N-1 Loop Operation," DLW-83-654, June 30, 1983.

6. Skaritka, J., (et. al.), "Westinghouse Wet Annular Burnable Absorber Evaluation Report," WCAP-10021-P-A, Revision 1, (Proprietary), October, 1983.

7. Miller, J.V., (Ed.), "Improved Analytical Model used in Westinghouse Fuel Rod Design Computations," WCAP-8785, October 1976.

8. George, R.A., (et. al.), "Revised Clad Flattening Model," WCAP-8381, July 1974.

9. Risher, D. H., (et. al.), "Safety Analysis for the Revised Fuel Rod Internal Pressure Design Basis," WCAP-8964, June 1977.

10. Skaritka, J., Iorii, J.A., "Operational Experience with Westinghouse Cores," WCAP-8183, Revision 12, August, 1983.

11. Hellman, J.M. (Ed.), "Fuel Densification Experimental Results and Model for Reactor Operation," WCAP-8219-A, March 1975.

12. Letter from NRC, C. O. Thomas to E. P. Rahe, Jr., Westinghouse, "Acceptance for Referencing of Licensing Topical Report WCAP-10297-(P), WCAP-10298 (NS-EPR-2545) Entitled Dropped Rod Methodology for Negative Flux Rate Trip Plants," March 31, 1983.

TABLE 1

BEAVER VALLEY UNIT 1 - CYCLE 5

FUEL ASSEMBLY DESIGN PARAMETERS

Region	1	5	6	6A*	7
Enrichment (w/o U-235)+	2.107	2.999	3.248	3.114	3.250
Density(% Theoretical)+	94.80	94.34	94.73	94.38	95.0
Number of Assemblies	1	28	51	1	76
Approximate Burnup at++ BOC 5 (MWD/MTU)	13800	21600	13400	7700	0

+ All fuel regions are as-built values except Region 7 which is nominal value.

++Based on EOC4 = 12100 MWD/MTU

* Cycle 4 redesign replacement fuel assembly from Texas Utilities, Comanche Peak Plant.

TABLE 2

KINETICS CHARACTERISTICS

BEAVER VALLEY UNIT 1 - CYCLE 5

	N and N-1 Loop Operation Current Limits	Cycle 5 Changes to Current Limits
Moderator Density** Coefficient ($\Delta\rho$/gm/cc)	0 to 0.43	--
Doppler Temperature Cooefficient (pcm/^oF)*	-2.9 to -1.4	--
Least Negative Doppler - Only Power Coefficient, Zero to Full Power (pcm/% power)*	-6.68	--
Most Negative Doppler - Only Power Coefficient Zero to Full Power (pcm/% power)*	-19.4	--
Delayed Neutron Fraction β_{eff},(%)	0.44 to 0.75	--
Minimum Delayed Neutron Fraction Rod Ejection BOC β_{eff},(%)	0.52 (3 loop)	--
	0.537 (2 loop)	--
Rod Ejection EOC β_{eff},(%)	0.47 (3 loop)	--
	0.44 (2 loop)	--
Maximum Prompt Neutron Lifetime (μ sec)	26	--
Maximum Differential Rod Worth of Two Banks Moving Together (pcm/in.)*	100	--

*pcm = $10^{-5}\Delta\rho$

**The moderator density coefficient for the hot zero power, all rods out physics test condition may be negative at the BOC 5. The coefficient will be kept positive at that zero power by administrative controls (with appropriate D bank position and boron concentration).

--Indicates no change.

TABLE 3

END-OF-CYCLE SHUTDOWN REQUIREMENTS AND MARGINS

BEAVER VALLEY UNIT 1 - CYCLE 5

	3 Loop (N)		2 Loop (N-1)
Control Rod Worth (%Δρ)	Cycle 4	Cycle 5	Cycle 5
All Rods Inserted	8.48	8.19	8.19
All Rods Inserted Less Worst Stuck Rod	7.54	7.32	7.32
(1) Less 10%	6.79	6.59	6.59
Control Rod Requirements			
Reactivity Defects (Combined Doppler, T_{avg}, Void and Redistribution Effects)	2.94	2.91	2.26
Rod Insertion Allowance	0.50	0.50	0.50
(2) Total Requirements	3.44	3.41	2.76
Shutdown Margin [(1) - (2)] (%Δρ)	3.35	3.18	3.83
Required Shutdown Margin (%Δρ)	1.77	1.77	2.40

Note: Cycle 4 has standard BPs
Cycle 5 has Wet Annular Burnable Absorbers (WABAs)

FIGURE 1

CORE LOADING PATTERN

BEAVER VALLEY UNIT 1 CYCLE 5

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1							6	7	6						
2					5	7	7 (8)	6	7 (8)	7	5				
3				5	7 (4)	7 (12)	6	6 SS	6	7 (12)	7 (4)	5			
4			5	7	7 (16)	6	7 (20)	5	7 (20)	6	7 (16)	7	5		
5		5	7 (4)	7 (16)	5	7 (16)	6 (4)	7 (20)	6 (4)	7 (16)	5	7 (16)	7 (4)	5	
6		7	7 (12)	6	7 (16)	5	7 (16)	6	7 (16)	5	7 (16)	6	7 (12)	7	
7	6	7 (8)	6	7 (20)	6 (4)	7 (16)	6	6 (8)	6	7 (16)	6 (4)	7 (20)	6	7 (8)	6
8	7	6	6	5	7 (20)	6	6 (8)	1	6A (8)	6	7 (20)	5	6	6	7
9	6	7 (8)	6	7 (20)	6 (4)	7 (16)	6	6 (8)	6	7 (16)	6 (4)	7 (20)	6	7 (8)	6
10		7	7 (12)	6	7 (16)	5	7 (16)	6	7 (16)	5	7 (16)	6	7 (12)	7	
11		5	7 (4)	7 (16)	5	7 (16)	6 (4)	7 (20)	6 (4)	7 (16)	5	7 (16)	7 (4)	5	
12			5	7	7 (16)	6	7 (20)	5	7 (20)	6	7 (16)	7	5		
13				5	7 (4)	7 (12)	6	6 SS	6	7 (12)	7 (4)	5			
14					5	[illegible]	7 (8)	6	7 (8)	7	5				
15							6	7	6						

X REGION NUMBER
(Y) NUMBER OF ABSORBERS
SS SECONDARY SOURCE RODS

FIGURE 2

K(Z) - NORMALIZED $F_Q(Z)$

AS A FUNCTION OF CORE HEIGHT

N-LOOP

BEAVER VALLEY - UNIT 1

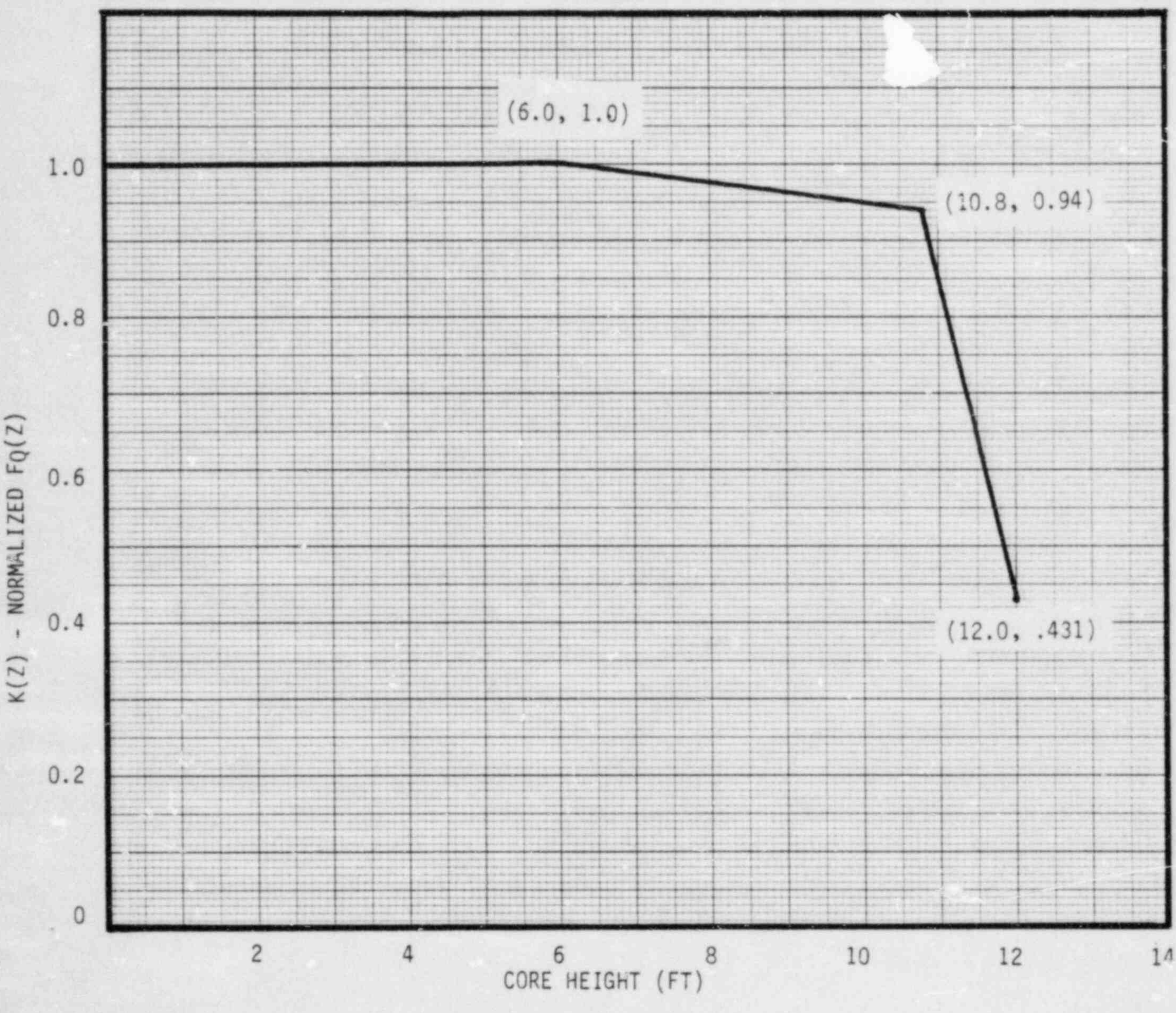

FIGURE 3

K(Z) - NORMALIZED $F_Q(Z)$

AS A FUNCTION OF CORE HEIGHT

N-1 LOOP

BEAVER VALLEY UNIT 1