ATTACHMENT 1

ANO-2 SHOULDER GAP INSPECTION PLANS

FOR THE END OF CYCLE 3 REFUELING OUTAGE

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1. Introduction

The distance from the top of a fuel rod to the bottom of the upper flow plate is known as shoulder gap. Measurements of this gap at the end of Cycle 1 were somewhat less than expected and the inspection program for the Cycle 2 refueling outage was accordingly expanded. When the outage occurred in late August 1982, it was discovered that a possibility existed that fuel pin to flow plate contact could occur in Batch C fuel during Cycle 3 unless action was taken. The NRC was notified and the situation, including fuel modification plans and gap acceptance criteria, was presented to the NRC staff in October 1982. The slides used in the presentation were later forwarded to the NRC under separate cover (Reference 1). The measurements and fuel assembly modifications proceeded until all 56 Batch C assemblies had been measured and 30 of these had been modified by shimming. Further details of the procedure and a list of the 30 shimmed Batch C assemblies were forwarded to the NRC in the Cycle 2 Fuel Examination Report (Reference 2).

Although the Batch C assemblies, with one possible exception, are due to be discharged at the end of Cycle 3, the Batch D assemblies are scheduled to receive their third exposure in Cycle 4. While the Batch D assemblies were constructed so that their initial shoulder gaps were 0.3 inch larger than the Batch C's, it will still be necessary to verify that the remaining gaps are adequate to avoid closure during Cycle 4.

In the following sections of this report, the core changes for Cycle 4, a shoulder gap inspection plan, and an analysis approach to determine if the remaining gaps are acceptable will be described. In the event it may become necessary to shim some Batch D assemblies, the modification procedure is discussed.

2. Core Modifications for Cycle 4

A fuel assembly map of the Cycle 3 core is presented in Figure 1. The present plans are to completely off-load the Cycle 3 core to the spent fuel pool so that maintenance can be performed on the service water systems. During refueling, 56 fresh Batch F assemblies will be loaded together with 52 Batch E assemblies, 60 Batch D assemblies, and 8 Batch A assemblies discharged from Cycle 1. The center assembly selection has not been finalized, but will be a Batch C or a Batch A assembly. Further details on the assemblies involved are presented in Table I.

The Cycle 3 termination burnup is anticipated to be about 9,750 MWD/MTU. Cycle 4 is expected to achieve a burnup of about 12,500 MWD/MTU. A Cycle 4 core map by assembly serial number is not yet available. However, a tentative quarter core map by assembly fuel batch is presented in Figure 2. It has been estimated that the Batch C

peak rod fluence received by the end of Cycle 3 will be within 15 percent of the Batch D peak rod fluence projected for the end of Cycle 4.

3. Shoulder Gap Inspection Plan

The following differences exist in the situation during the coming outage from that in the Cycle 2 outage.

a. A full evaluation of the end of Cycle 2 data has shown that a well-behaved bounding function exists for Batch C peripheral gap change as a function of fluence through two cycles. An indication of the shape exhibited by this bounding function is shown in Reference 1, page 7. Furthermore, an analysis of data from interior and peripheral rods indicates that the bounding function based on peripheral rods applies to all Batch C rods.

b. Evaluation of one cycle Batch D data indicates that Batch D falls under the same bounding function, with the possible exception of the behavior of one rod.

c. It will be possible to obtain third cycle shoulder gap change data from measurements on the Batch C assemblies.

The initial plan, then, will be to measure Batch C gap changes. The majority of assemblies selected will be chosen because each had several shoulder gaps that changed at nearly the bounding rate through their two prior cycles. In addition, to cover the possibility that there is a reversal of previous trends, other Batch C assemblies will be selected that exhibited more modest gap change rates through their first two cycles. These measurements will be used to verify that lower change rates early in life are not a forerunner of limiting change rates later in life. Due to the flux gradients in each assembly and the inherent scatter in gap change data, the initial group of Batch C assemblies selected for inspection is expected to cover the full range of third cycle behavior.

In addition to the Batch C measurements, a sufficient number of Batch D assemblies will be chosen to provide assurance that the bounding function created from three cycles of Batch C data is also applicable to the Batch D fuel.

Based on the preceding considerations, at least eight Batch C assemblies and nine Batch D assemblies will be selected for shoulder gap measurements on at least two opposing faces. As in the Cycle 2 outage, the data will be taken using a periscope optical measuring device.

4. Analysis Procedure

The initial analysis approach will be to use the Batch C data to refine and extend the bounding function. Assuming the Batch D data shows that the bounding function applies, then the Batch D assemblies with their

projected Cycle 4 fluences will be tested for acceptability under the following criterion:

> At a 95% probability, the worst rod in the assembly will not have gap closure at the end of cycle.

The initial analysis approach, however, represents a better than 95% probability situation since the bounding function may represent more rapid gap change rates than those that may exist within individual assemblies. Accordingly, if the bounding function approach produces negative results, it may be desirable to pursue a more assembly specific evaluation of the data, possibly with additional measurements as further support. This more detailed evaluation would employ statistical modeling similar to that used in the Cycle 2 outage evaluation of Batch C assemblies.

5. Modification Procedure

If Batch D assembly modifications to increase the shoulder gap are needed, they will be performed in essentially the same way the Batch C assemblies were modified. The upper end fitting is removed, four shims installed, and the bundle reassembled with new, modified guide posts. Additional details of the process were presented in References 1 and 2. Since the previous outage, some refinements have been added. The shim will be for a 0.4 inch gap increase instead of 0.5, and the replacement guide posts will be for the new shim height. In addition, all of the modified corner posts and the center post will be at the same height. Under the old procedure used on the Batch C's, a different center post height resulted. The 0.4 inch value was selected after consideration of the dimensional requirements imposed by the core alignment plate. The decrease in the working spring length will be the gap change, 0.4 inches.

REFERENCES

1. John R. Marshall to Robert A. Clark, Docket No. 50-368, Letter No. 2CAN128207, dated December 10, 1982.

2. John R. Marshall to Robert A. Clark, Docket No. 50-368, Letter No. 2CAN038307, dated March 30, 1983.

TABLE I

FUEL ASSEMBLY DATA FOR CYCLE 4 REFUELING

a. Cycle 3

Number of Assemblies	Batch and Sub-batch	Number pins/ Wt% U-235/Shims	Previous Cycle Exposures
1	A	236/1.93/0	1, 2 (Center)
8	A	236/1.93/0	1
8	C1	224/2.94/12	1, 2
16	C2	224/2.94/12	1, 2
12	C3	234/2.94/2	1, 2
16	C4	233/2.94/3	1, 2
4	C5	224/2.94/12	1, 2
40	DØ	184/3.48/0 52/3.03/0	2
20	D1	184/3.03/0 52/2.73/0	2
40	EØ	184/3.48/0 52/2.78/0	None
12	E1	224/2.78/0 12/2.28/0	None

TABLE I (Continued)

b. Cycle 4

Number of Assemblies	Batch and Sub-batch	Number pins/ Wt% U-235/Shims	Previous Cycle Exposures
8	A	236/1.93/0	1
40	DØ	184/3.48/0 52/3.03/0	2, 3
20	D1	184/3.48/0 52/3.03/0	2, 3
40	EØ	184/3.48/0 52/2.78/0	3
12	E1	224/2.78/0 12/2.28/0	3
40	FØ	184/4.05/0 52/3.30/0	None
16	F1	224/3.30/0 12/2.78/0	None
1	C or A	--	--

TABLE I (Continued)

c. Principal Batch Differences

Batch	Change in Shoulder Gap From Reference (Inches)	Guide Tubes	Grids
A (Initial Core)	Reference	Annealed[1] (RXA)	Standard
B (Initial Core)	Reference	Annealed (RXA)	Standard
C (Initial Core)	Reference	Annealed (RXA)	Standard
D	+0.300	Annealed (RXA)	Standard
E	+0.150	Cold Worked (SRA)	HID-1[2,3]
F	+0.850[4]	Cold Worked (SRA)	HID-1

[1]Ten Batch A assemblies had cold-worked stress relief annealed (SRA) guide tubes instead of the standard recrystallization annealed (RXA) guide tubes.

[2]HID-1 zircaloy grids have a 2-mil thicker and ½ inch wider perimeter strip.

[3]Eight Batch E bundles each have three anti-bow demonstration grids.

[4]Guide tubes are 0.7-inch longer than Batch E; but, with upper end fitting and post adjustments, the assembly length and holddown force are unchanged from Batch E.

FIGURE 1

Cycle 3

FINAL REACTOR CORE LOADING PLAN

	A	B	C	D	E	F	G	H	J	K	L	M	N	P	R
1						E038	E039 67	E032	E014 68	E024					
2				E027	E017	C409 57	D031	C311 52	D005	C411 56	E037	E036			
3			E020 66	D028	C413 45	D016	C308 33	D103	C307 34	D033	C412 46	D037	E029 69		
4		E002	D034	D115 39	D026	A041 25	E110	C102 C	E111	A102 26	D011	D104 40	D006	E018	
5		E006	C408 44	D019	C101 F	D119	C212 17	D015	C209 18	D110	C108 G	D010	C410 27	E040	
6	E023	C407 56	D039	A021 24	D120	D024 11	C214	D102 8	C213	D035 12	D107	A043 27	D029	C404 59	E008
7	E012 65	D030	C306 32	E103	C210 16	C206	E112 3	C504	E104 4	C201	C205 19	E109	C310 35	D004	E016 70
8	E034 501	C303 51	D108	C105 B	D021	D114 7	C501	A105 1	C502	D101 9	D007	C104 D	D113	C305 53	E033 502
9	E010 64	D012	C312 31	E108	C203 15	C215	E107 2	C503	E102 5	C204	C216 20	E105	C304 36	D001	E011 71
10	E005	C414 55	D017	A026 23	D118	D003 10	C208	D116 6	C207	D023 13	D117	A051 28	D040	C401 60	E030
11		E013	C416 43	D032	C107 E	D105	C211 14	D008	C202 21	D106	C106 H	D025	C402 48	E019	
12		E028	D027	D111 38	D022	A029 22	E106	C103 A	E101	A045 29	D009	D112 41	D036	E004	
13			E026 63	D014	C415 42	D018	C302 30	D109	C301 37	D038	C403 49	D002	E025 72		
14				E035	E003	C405 54	D013	C309 50	D020	C406 61	E001	E022			
15						E021	E015 62	E031	E009 73	E007					

North

FIGURE 2

Preliminary Cycle 4
Quarter Core Batch Loading

					1 F	2 F	3 F
			4 F	5 F	6 26 D1 1	7 18 D 3	8 3/45 E 0
		9 F	10 4 E 2	11 2 E 3	12 31 D 0	13 F1	14 508 A 0
	15 F	16 15 E 2	17 17 D1 0	18 1 E 2	19 22 E 0	20 16 D 1	21 14/47 D1 0
	22 F	23 37 E 1	24 29 E 2	25 36/50 D1 3	26 7 D 3	27 F1	28 521 A 2
29 F	30 33 D1 3	31 12 D 0	32 5 E 0	33 38 D 1	34 34 D 0	35 20 E1 1	36 28/49 D 0
37 F	38 24 D 1	39 F1	40 10 D 3	41 F1	42 40 E1 3	43 9 E 2	44 43 E1 1
45 F	46 3/45 E 3	47 546 A 0	48 14/47 D1 3	49 548 A 2	50 28/49 D 3	51 43 E1 0	52 35 C2* 0

*AKC201, AKC107, or AKA040 Under Consideration