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JCP&L / GPU

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January 4, 1980

Mr. Boyce H. Grier, Director
Office of Inspection and Enforcement
United States Nuclear Regulatory Commission
Region 1
631 Park Avenue
King of Prussia, Pennsylvania 19406

Dear Mr. Grier:

Subject: Oyster Creek Nuclear Generating Station
Docket No. 50-219
IE Bulletin 79-26

The purpose of this letter .. to respond to the directions set forth in IE Bulletin 79-26 which is concerned with the loss of boron from BWR control blades. Our responses to Action Items 1 through 4 are given in Attachment No. 1. Attachment No. 2 is included to provide information in support of the response to Item No. 2b.

Very truly yours,

Donald A. Ross

Donald A. Ross, Manager
Generating Stations-Nuclear

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Attachments (2)

cc: United States Nuclear Regulatory Commission
Office of Inspection and Enforcement
Division of Reactor Operations
Washington, DC 20555

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Q 8002010546

ATTACHMENT NO. 1
OYSTER CREEK NUCLEAR GENERATING STATION
IE BULLETIN 79-26

Item 1: The operating history of the reactor is to be reviewed to establish a record of the current B^{10} depletion averaged over the upper one-fourth of the blade for every control blade; the record is to be maintained on a continuing basis. This action is required on all reactors whether shut down for refueling or operating.

Answer: A computer program has been developed by GPU/JCP&L to track control rod history over the Oyster Creek operating history. The code, RODEX, was modified to calculate exposure over the top quarter of the control blade and to include a correlation factor supplied by the General Electric Company (GE) to relate control blade exposure to %B-10 depletion. The code is being used to track control blade exposure and B-10 depletion for the current cycle. The code was further modified to calculate projected control blade exposures based on exposure data from 3-D reactor simulator model and is used in the determination of requirements for control blade replacement.

Item 2: Identify any control blades predicted to have greater than 34% B^{10} depletion averaged over the upper one-fourth of the blade by next refueling outage.

a. Describe your plans for replacement of identified control blades.

b. Describe measures which you plan to take justifying continued operations until the next refueling specifically addressing (1) any blade with greater than 42% depletion averaged over the upper one-fourth of the blade; and (2) the condition where you find greater than 26% of the control blades calculated to have greater than 34% depletion averaged over the upper one-fourth of the blade.

Answer: 2a. Based upon the analytical approach described in 1, above, it was determined that 81 control blades will require replacement at the end of the current cycle. These 81 control blades include those that have exceeded their end of life criteria and those that are projected to exceed their end of life by the end of next cycle. However, due to storage limitations, only 75 of the 81 blades can be replaced. The six blades that cannot be replaced are projected to have between 34% and 37% B-10 depletion by the end of next cycle. This will result in 4.4% of the control blades exceeding 34% B-10 depletion. GE has indicated that if no more than 26% of the control blades have exceeded 34% B-10 depletion, there is negligible effect on transient CPR reduction and MCPR effects. When the blades exceed 34% B-10 depletion during the cycle, the appropriate shutdown margin (SDM) adder will be calculated and included in the minimum shutdown margin requirements.

2b. The GPU/JCP&L staff has been aware of the B-10 depletion problem in control blades since March 1979 when GE reported the results of its hot cell examination of an Oyster Creek control blade. At that time, a combined analytical and experimental program was established to determine the impact of B-10 depletion on the safety of operation. A report of this evaluation, describing the analyses performed and the results of the shutdown margin testing, was prepared and is included for information purposes (Attachment No. 2).

The analysis considered the impact of B-10 depletion on both shutdown margin and scram reactivity. GE calculated for Oyster Creek a shutdown margin adder to incorporate with minimum shutdown margin requirements. GPUSC also calculated a shutdown margin adder to include control blades which have exceeded 42% B-10 depletion. The assumptions used in the GPUSC calculation were that blades having between 34% and 42% B-10 depletion had no boron in the top six inches and blades having greater than 42% B-10 depletion had no boron in the top three feet. These assumptions were more severe than have been observed in the destructive examination of control blades.

The difference in minimum shutdown margin between calculations with and without degraded control blades was the loss of SDM due to B-10 depletion. This loss of SDM was the SDM adder to be included in minimum shutdown margin requirements. The GE adder was 2.24 mk while the GPUSC adder was 14.24 mk; the primary difference being in the treatment of rods having greater than 42% B-10 depletion.

The exposures used to determine which rods have exceeded their end of life were end-of-cycle projections; and therefore, the analysis would be valid for the entire cycle. Control blade exposure accumulation is frequently monitored to insure the projected exposures remain valid. Reanalysis would be done for any change in the number or location of blades exceeding 34% or 42% B-10 depletion. Based on beginning-of-cycle (BOC) SDM measurements, there is sufficient margin to include the SDM adder. Further, SDM testing was performed during a forced outage in April 1979 as described in Item 3.

The effect of B-10 depletion on scram activity was analyzed using the end-of-cycle (EOC) scram reactivity. The analysis attempted to bound the consequences by using very conservative assumptions. The calculated EOC scram reactivity was assumed to be delayed by 0.2 of a second as a result of B-10 depletion and taking no credit for the stainless steel worth in the blade. It was shown that while this delay resulted in slightly increased ΔCRP and peak pressure in the transient analysis, it did not result in exceeding the Oyster Creek limiting ΔCPR transient (rod withdrawal error) and that peak pressure limitations were not exceeded. A second calculation was performed to calculate the end-of-cycle scram reactivity in which rods having greater than 42% B-10 depletion were assumed not to scram. There was minimal impact on the scram reactivity, and it remained well within the bounding curve utilized in the transient analyses. It was concluded that there is sufficient safety margin in the Cycle 8 core to operate safely with the assumption of degraded control blades.

Item 3: At the next cold shutdown or refueling outage, conduct shutdown margin tests to verify that:

a. Full withdrawal of any control blade from the cold xenon-free core will not result in criticality; and

b. Compliance with the shutdown margin requirement in a manner that accommodates the boron loss phenomena (i.e., by including a plant specific increment in the shutdown margin that takes the potential loss of boron from control blades identified from evaluation of Item 1 into consideration).

Answer: Oyster Creek shut down on April 2, 1979 due to a leak on a recirculation pump seal. During this outage, shutdown margin testing was performed to insure there was sufficient shutdown margin to include the shutdown margin adder into the minimum shutdown margin requirements. The total required shutdown margin was 18.84 mk (R + 2.5 mk SDM + 0.9 mk for B_4C SETTLING + 14.24 mk SDM adder) with the highest worth rod fully withdrawn. The R value at the time of shutdown was 1.2 mk. Under these conditions, the minimum measured shutdown margin was 20.04 mk.

Further shutdown margin testing was conducted in the vicinity of three control blades having greater than 42% B-10 depletion to further insure that the required margin was attained. Here, the measured SDM was 26.93 mk.

Item 4: Perform a destructive examination of the most highly exposed control blade at the end of the next cycle and provide results of the examination within one calendar year after removal of the blade. The results to be reported should include:

a. Tube number or identification.
b. The evaluation of each crack in the tubing.
c. The calculated B^{10} depletion versus elevation for each tube.
d. The measured B^{10} loss versus elevation for each tube.
e. The maximum local depletion for tubes having no cracks.
f. The maximum local depletion for tubes having no loss of boron.

Alternately, the results of a destructive examination of a blade of similar fabrication and operational history may be provided within one year of the date of issuance of this Bulletin. If the highest local B^{10} depletion is less than 50%, this examination can be deferred until the next fueling.

Answer: A destructive examination of an Oyster Creek control blade has been performed by GE and is the basis for their discussion with the NRC and I&E Bulletin 79-26.

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January 4, 1980

GPU Service TECHNICAL DATA REPORT	TDR NO. 042	REVISION NO. 0
	PROJECT NO. 395IN	PAGE 1 OF 17
PROJECT: OC-1 Control Rod Evaluation	DEPARTMENT/SECTION Systems Engineering/ ~~Nuclear Analysis~~	
	RELEASE DATE 7/20/79	REVISION DATE

DOCUMENT TITLE:

B-10 Depletion in Oyster Creek Control Blades

ORIGINATOR SIGNATURE	DATE	APPROVAL(S) SIGNATURE.	DATE
R. V. Furia R.V. Furia	7/20/79	G. R. Bond G. R. Bond	7-27-79
		APPROVAL FOR EXTERNAL DISTRIBUTION	DATE
		R. F. Wilson RFW	7/27/79

*	DISTRIBUTION
	D. A. Ross J. T. Carroll, Jr. K.O.E.Fickeissen J.Knubel R. B. Lee M. Zukor R. W. Keaten R. L. Williams

It was determined that a number of Oyster Creek control blades have exceeded the end of life criteria for B-10 Depletion.

A series of calculations and low power physics testing to evaluate the impact of B-10 depletion on the safety of operation were performed.

It was concluded that the continued operation of Oyster Creek for the remainder of cycle 8 will not compromise the safety of operation.

It is recommended that a program to follow control blade exposure history be implemented to determine annual requirements for control blade replacement.

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CONTENTS

1. INTRODUCTION AND SUMMAR

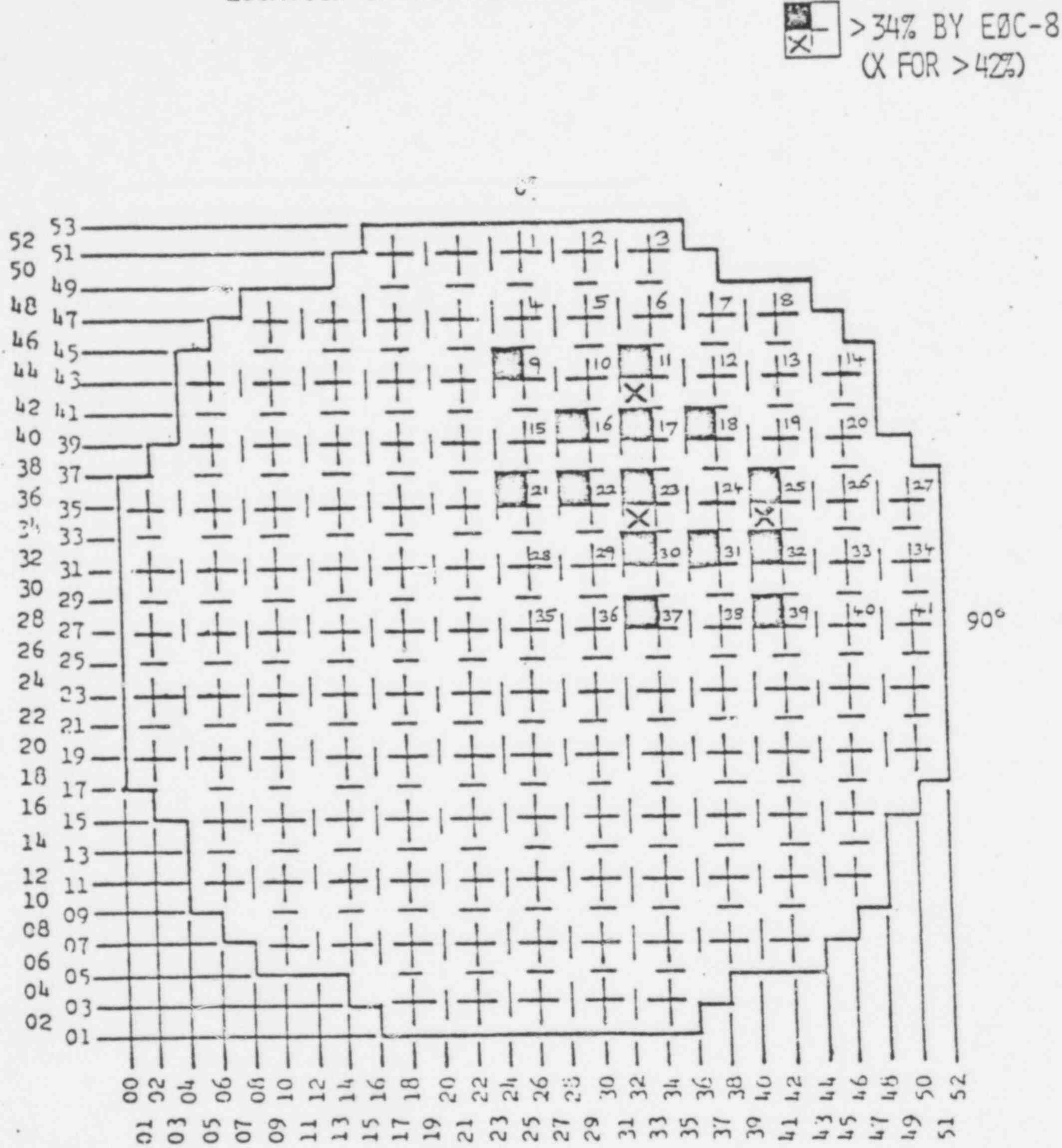
The General Electric Company (GE) had requested and received from Oyster Creek Nuclear Generating Station a control blade which was removed from the core at the end of cycle (EOC) 5 to perform a detailed destructive examination. GPU was notified by GE just prior to cycle 8 startup that cracking was found in the absorber tubes of the control blade, but the extent of B_4C depletion had not been determined. The plant staff, in addition to conducting shutdown margin testing prior to cycle 8 operation, performed low power physics tests to determine if changes in control blade performance due to B_4C depletion was evident. The results of the low power physics tests (reference 1) and the shutdown margin (SDM) measurements (reference 2) presented no evidence of B-10 depletion.

GE, based upon the analysis of the Oyster Creek Control blade examination data and one done by Kernkraftwerk RWE-Bayernwerk GmbH (KRB), revised its end of life (EOL) criteria for control blades from 42% to 34% B-10 depletion. The B-10 depletion is estimated in the top three feet of the control blade. They also calculated, as a result of the analysis, a conversion factor to relate Oyster Creek control rod exposure to B-10 depletion. It was then determined that a number of Oyster Creek control blades have exceeded the EOL criteria (Figure 1). This determination was made following the cycle 8 startup when the analysis was completed.

GE has visited with GPU (March 15, 1979) and other Utilities that were affected by the results of the examinations and to discuss their recommendations prior to issuing a Service Information

OYSTER CREEK

LOCATION OF DEGRADED CONTROL RODS



CONTROL ROD ARRAY DEFINITION

BASED ON OYSTER CREEK RODEX EDITS OF EØC-7

Letter (reference 3) on the subject. It was then determined by GE that B-10 depletion will have its largest impact on SDM and a lessor impact on scram reactivity. Although control blades have exceeded EOL criteria, GE has recommended to Utilities to continue operations until replacement of control rods could take place during routine maintenance/refueling outages, provided the affected core has adequate SDM. This would also allow time for the manufacture of control blades.

This report describes the analysis and testing performed to assure the safe operation of Oyster Creek for the remainder of cycle 8.

For control blades that have exceeded 34% B-10 depletion, GE has recommended using an SDM adder to account for the control rod worth. The adder would be incorporated in the minimum SDM requirement for cycle operation. The adder extends only to control blades which have greater than 34% but less than 42% B-10 depletion. The Oyster Creek plant has 10 control blades that have exceeded 42% B-10 depletion. GPU requested GE to perform an SDM adder calculation (reference 4) and performed an inhouse calculation (reference 5) similar to GE's to include control blades that have exceeded 42% B-10 depletion. Additional calculations (reference 6) to review the impact on scram reactivity were also performed.

Soon after the discussions with GE, Oyster Creek was required to shutdown due to a recirculation pump seal leak. The opportunity was utilized to perform a series of criticals (references 7 and 8) to determine if B-10 depletion was present and what effects

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it had on SDM. With the information obtained from GE, a more thorough set of criticals was proposed (reference 8) specifically aimed at blades which exceeded 42% B-10 depletion.

It was concluded from the analysis and testing that no safety aspect of Oyster Creek operation will be compromised by continued operation of the cycle 8 core.

2. METHODS

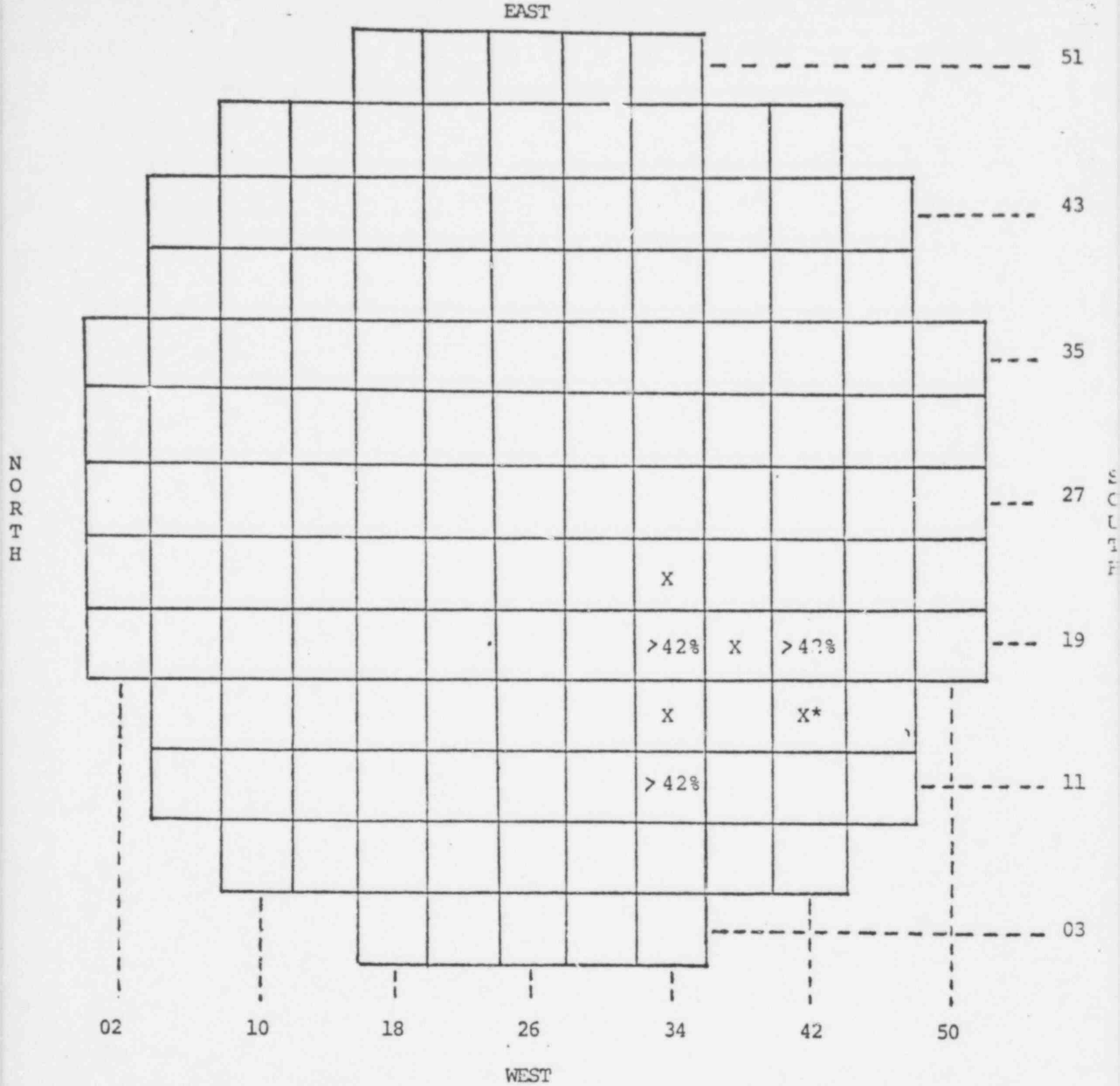
2.1 Low Power Physics Testing

The series of criticals performed during the Oyster Creek shutdown (reference 7) were designed to measure minimum SDM and detect signs of B-10 depletion.

There have been five control blades replaced (reference 9) at Oyster Creek. One control blade is in a four rod group in which the others have exceeded 42% B-10 depletion. The blade that was replaced has 30% B-10 depletion which is still below the EOL criteria. A method to detect boron depletion was to have a series of symmetric criticals set up such that the control blade of interest would be the one with which criticality was achieved. It was proposed that any difference in the critical position of the control blade would be due to boron depletion.

Another method was to pull criticals in areas where three control rods have B-10 depletion greater than 42%. These blades remained inserted and the control blades adjacent to these were withdrawn (figure 2). It was assumed that a change in bias for this critical from one in which the blades having greater than 42% were withdrawn would be attributable to boron depletion. These criticals were to determine an accumulative effect of boron depletion. The SDM for this area of the core was also calculated.

FIGURE 2



X - Indicates control blades withdrawn for critical

*Blade was at Notch Six

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CORE ARRANGEMENT
CONTROL CELLS
TOP VIEW

2.2 Calculations

Calculations were performed to evaluate the impact on SDM and scram reactivity of continued operation of Oyster Creek with control blades that have lost boron.

The method used to determine the loss of SDM is similar to the calculation performed by GE to determine SDM adder, but makes additional assumptions to include rods with greater than 42% B-10 depletion. The calculation described in reference 5 used the 3-D XTRA code. Code inputs were adjusted to simulate loss of all B_4C from the top six inches of a control blade with greater than 34% and less than 42% B_4C depletion. Control blades with greater than 42% B_4C depletion were simulated to lose all B_4C in the top 3 feet of the blade.

The difference in K_{eff} between the minimum SDM calculated with depleted control blades and the minimum SDM calculated with non-depleted control blades was the loss of SDM. This loss then becomes the adder to minimum SDM requirements.

The method to estimate the effect on scram reactivity was to delay scram by 0.2 seconds. This was to simulate a complete loss of B_4C (and stainless steel) in the top six inches of all control blades and thereby delay the insertion of negative reactivity. Another calculation was to have 12 blades, having greater than 42% B-10 depletion, fail to scram. In both cases the method used was to bound the problem and be able to assure safe operation rather than calculate a more realistic loss of reactivity.

3. EVALUATION

The low power physics testing performed in April during the recirc pump maintenance outage and at the BOC 8 indicates the considerable SDM present in the Oyster Creek cycle 8 loading. The testing further indicates that GE calculated SDM adder (reference 10) is sufficient to cover any loss of SDM attributed to B_4C loss including control blades exceeding 42% B-10 depletion. The calculation performed by GE and the one by GPU used EOC 8 exposures projected for the control blades to determine how many blades exceeded 34% B-10 depletion. The control blades which have exceeded 42% B-10 depletion have already experienced the majority of exposure they will receive in cycle 8 prior to the April SDM measurement in the A1 sequence. The remaining control blade patterns (reference 11) will have these rods out of core (B1 and B2 requences) and as shallow rods (A2 requence) at the end of cycle. Since GE has established a direct correlation between exposure and B_4C depletion the likelihood for a reduction in SDM beyond the R value and the GE SDM adder is small.

The GPU calculation (reference 5) resulted in a 14.24 mk SDM adder as opposed to the GE result of 2.24 mk. In the GE calculation all rods exceeding 34% B-10 depletion were treated as being at 42% B-10 depletion (including rods that have exceeded 42% B-10 depletion). As indicated above, the GE adder is sufficient to cover any expected loss of B_4C. The GPU calculation attempts to treat rods with greater than 42% as having a worse case of B-10 depletion and thereby bound the consequences for B-10 depletion. The complete loss of B_4C in the top three feet of any rod that exceeded 42% B-10 depletion is taken as the worse case. This would be supported by the control blade exposure profiles. After the first 3 feet the control blade exposures are below the 34% B-10 depletion value. If the B_4C loss extends below 3 ft in the outer boron pins, the total B_4C loss would still be (using average exposure values across the blade) less than losing the top 3 ft. completely.

The SDM adder calculated by GPU when added to other tech spec SDM requirements is within the measured minimum SDM. A comparison in the calculated loss of Δ K due to B-10 depletion between GE and GPU for various control rods is presented in table 1.

TABLE 1

CALCULATED Δ K DUE TO B-10 DEPLETION

Control Rod Location	GE Δ K*	GPU Δ K*
06-35	-0.00224	-0.010956
10-39	-0.00316	-0.014018
10-35	-0.00317	-0.004754
14-31	-0.00827	-0.011884
22-43	-0.00777	-0.016883
14-35	-0.01148	-0.024325
22-31	-0.01014	-0.015243
14-27	-0.01639	-0.019295

GE Δ SDM = -0.00224

GPU Δ SDM = -0.01424

*Difference in K_{eff} Between the Cycle 8 Core with No Boron Depleted Rods and the Cycle 8 Core with Depleted Rods

4. RESULTS

4.1 Low Power Physics Testing

The results of the low power physics tests are as follows:

a) Minimum SDM based on XTRA code normalization to measurements is 20.04 mk for rod 34-07

b) The measured differences between a control rod with 30% B-10 depletion and one with 42% is approximately 0.63 mk.

c) The accumulative effect of B-10 depletion on shutdown margin is approximately 1.2 mk. The SDM in the area of the 3 control rods with greater than 42% B-10 depletion is 26.93 mk.

d) Control rods with less than 30% B-10 depletion do not appear to show any signs of B_4C loss.

4.2 Calculations

The SDM adder calculated by GE is 2.24 mk and the one calculated by GPU is 14.24 mk. The total SDM required to operate safely is 6.84 using the GE adder and 18.84 mk using the GPU adder (R + 2.5 mk SDM + 0.9 mk for B_4C settling + SDM adder). The minimum SDM required is determined from core exposure data at the time of shutdown (182 GWD) for the recirc pump maintenance outage with an R value of 1.2 mk occurring at 250 GWD.

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The bounding calculations for the effect of B_4C depletion on scram reactivity resulted in a maximum Δ CPR of 0.1392 and peak pressure of 1202 psia in the turbine trip without bypass transient. These values are within the technical specifications for Oyster Creek.

5. CONCLUSIONS

There is evidence of B-10 depletion from the Oyster Creek Control blades. However, the current level of B-10 depletion in the control blades has a minimal effect on shutdown margin and there is sufficient shutdown margin to insure that any further B-10 depletion will not exceed minimum shutdown margin requirements for the remainder of cycle 8.

The operation of the Oyster Creek plant 'ith control blades exceeding their EOL criteria will not compromise the safety of operation for the remainder of cycle 8.

6. RECOMMENDATIONS

6.1 The following recommended actions from reference 3 should be implemented:

a) Maintain records on individual blade exposures using the RODEX code to allow a blade management program.

b) In the future if it is expected that control blades will exceed 34% B-10 depletion before the completion of the next cycle, plans should be made to repl-ce control blades at the upcoming refueling/maintenance outage.

c) As an interim measure for cycle 8 use the shutdown margin adder.

6.2 The control blade replacement schedule presented in reference 12 should be met which will satisfy (b) above.

6.3 The control blade exposure history should be followed closely for the remainder of cycle 8 to insure the projected blades exposure used in the analysis are correct. If any other blades than the ones projected exeed either 34% or 42% B-10 depletion the analysis should be redone with the new data.

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7. REFERENCES

1. Memorandum to G. R. Bond from R. V. Furia, NF-496, "Oyster Creek Control Rod Depletion", January 24, 1979

2. JCP&L memorandum to G. R. Bond, K.O.E. Fickeissen from R. V. Furia, "Oyster Creek BOC 8 Shutdown Margin Calculation and XTRA Cold Bias Results," November 30, 1978.

3. General Electric BWR SErvices Information Letter #157 supplement 1, "Control Blade Lifetime," March 1979.

4. Letter to G. C. Nelson (GE) from G. R. Bond (GPU), NF-573, "Calculation of Shutdown Margin Adder," March 21, 1979

5. Calculation C-395IN-321-001, "The effect on Shutdown Margin of B_4C depletion in Oyster Creek Control Rods," April 5, 1979.

6) Calculation C-395IN-321-002, "The Effect on Transient Analysis of B_4C Depletion in Oyster Creek Control Rods," April 4, 1979

7) Calculation C-395IN-321-003, "Low Power Physics Testing to determine the Effect of B_4C Depletion in Oyster Creek Control Rods," April 4, 1979

8) Memorandum to K.O.E.Fickeisen from R. V. Furia, NF-579, "Criticals for Control Rod Evaluation" March 30, 1979.

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9. Memorandum to G. R. Bond from R. V. Furia, NF-479, "Oyster Creek Control Blade Replacement," January 4, 1979.

10. Letter to G. R. Bond (GPU) from G. C. Nelson, (GE) "Oyster Creek Cycle 8 Shutdown Margin Analysis at 250 GWD", April 17, 1979

11. JCP&L Memorandum to A. H. Rone from R. J. Thompson, Jr. and F. A. Saksa, "Cycle 8 Exposure Predictions" October 15, 1978.

12. Memorandum to G. R. Bond from R. B. Lee, NF-579, "OC-1 Determination of % B-10 Depletion" April 4, 1979