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SUBJECT: Forwards response to GL 96-04, "Boraflax Degradation in Spent Fuel Storage Racks."

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October 22, 1996

U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Document Control Desk

Subject: Generic Letter 96-04, "Boraflex Degradation in Spent Fuel Storage Racks; Duke Power Company Response
Oconee Nuclear Station
Docket Numbers 50-269, -270, and -287
McGuire Nuclear Station
Docket Numbers 50-369 and -370
Catawba Nuclear Station
Docket Numbers 50-413 and -414

By letter dated June 26, 1996, the NRC issued the subject Generic Letter to all holders of nuclear power plant operating licenses, requesting affected licensees to provide an assessment of the physical condition of Boraflex used in spent fuel racks. Attached is Duke Power Company's response for its McGuire and Oconee Nuclear Stations. Note that Catawba Nuclear Station's spent fuel racks do not contain Boraflex; ergo, this Generic Letter is not applicable to Catawba.

If there are any question regarding this response, please call Scott Gewehr at (704) 382-7581.

Very truly yours,

M. S. Tuckman

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RESPONSE TO NRC GENERIC LETTER 96-04

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BACKGROUND

OCONEE

Oconee Nuclear Station utilizes two spent fuel pools with Boraflex neutron absorber material; the shared Unit 1/2 pool which serves both the Unit 1 and Unit 2 reactors, and the Unit 3 pool, which serves only Unit 3.

The spent fuel storage racks in the Oconee Unit 1/2 pool are a high density flux trap design with a 10.65 inch center-to-center cell pitch, designed and fabricated by Westinghouse. Fixed Boraflex neutron absorbing panels surround each storage cell on all four sides, except for peripheral locations in each module where Boraflex is not required on the outboard sides. The Boraflex panels have nominal dimensions of 0.075 x 7.63 x 145.00 inch and a nominal B^{10} areal density of 0.02 grams/cm^2. The Boraflex panels are enclosed in a formed stainless steel wrapper sheet which is spot welded to the storage tube at 2.5 inch intervals along both sides. Stainless steel plates are abutted at the top and bottom ends of the wrapper sheet, completing the enclosure of the Boraflex panel. The storage racks were installed in April 1981.

The spent fuel storage racks in the Oconee Unit 3 pool are a high density flux trap design with a 10.6 inch center-to-center cell pitch, designed and fabricated by Westinghouse. Fixed Boraflex neutron absorbing panels surround each storage cell on all four sides, except for peripheral locations in each module where Boraflex is not required on the outboard sides. The Boraflex panels have nominal dimensions of 0.111 x 7.59 x 138.25 inch and a nominal B^{10} areal density of 0.03 grams/cm^2. The Boraflex panels are enclosed in a formed stainless steel wrapper sheet which is spot welded to the storage tube at 7.0 inch intervals along both sides. The wrapper sheet is bent at each end to complete the enclosure of the Boraflex panel. The storage racks were installed in February 1984.

McGUIRE

McGuire Nuclear Station utilizes two spent fuel pools with Boraflex neutron absorber material; the Unit 1 pool and the Unit 2 pool.

The spent fuel storage racks in both the McGuire Unit 1 and McGuire Unit 2 pools are a two region design, designed and fabricated by Westinghouse. Region 1 is a high density flux trap design for storage of fresh and irradiated fuel and has a 10.4 inch center-to-center cell pitch. Fixed Boraflex neutron absorbing panels surround each storage cell on all four sides, except for peripheral locations in each module where Boraflex is not required on the outboard sides. The Boraflex panels have nominal dimensions of 0.078 x 7.50 x 139.25

inch and a nominal B^{10} areal density of 0.02 grams/cm^2. The Boraflex panels are enclosed in a formed stainless steel wrapper sheet which is spot welded to the storage tube at 7.0 inch intervals along both sides. The wrapper sheet is bent at each end to complete the enclosure of the Boraflex panel.

Region 2 is a high density "egg-crate" design for storage of discharged fuel and has a 9.125 inch center-to-center cell pitch. In this design, storage cells are welded together at the corners to form a module comprised of "cell" and "non-cell" locations in a checkerboard pattern, both of which are acceptable for storage of fuel assemblies. The storage cells have fixed Boraflex neutron absorbing panels on all four sides, except for peripheral locations in each module where Boraflex is not required on the outboard sides. This design results in a Boraflex panel between any adjacent fuel storage locations. The Boraflex panels have nominal dimensions of 0.032 x 7.50 x 141.75 inch and a nominal B^{10} areal density of 0.006 grams/cm^2. The Boraflex panels are enclosed in a formed stainless steel wrapper sheet which is spot welded to the storage tube at 5.50 inch intervals along both sides. The wrapper sheet is bent at each end to complete the enclosure of the Boraflex panel.

The McGuire Unit 2 storage racks were installed in December 1984 and the Unit 1 storage racks were installed in March 1986.

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Information Request 1:

"All licensees of power reactors with installed spent fuel pool storage racks containing the neutron absorber Boraflex are requested to provide an assessment of the physical condition of the Boraflex, including any deterioration, on the basis of current accumulated gamma exposure and possible water ingress to the Boraflex and state whether a subcritical margin of 5 percent can be maintained for the racks in unborated water. Monitoring programs or calculational models in effect or being developed, or an estimation of anticipated concerns based on the specific rack design, are considered an appropriate basis for this response."

Response to Request 1:

<u>Oconee and McGuire</u>

A comprehensive assessment of the Boraflex condition has not been performed at this time for several reasons. First, direct examination of the Boraflex panels in the Oconee and McGuire storage racks is not possible without destruction of the racks since the wrapper sheet enveloping the panels are welded to the storage cell. Additionally, little inference about the rack Boraflex condition can be made by observation of the surveillance coupons originally installed with the racks. This is attributable to the size and configuration of the coupons, as well as their means of encapsulation which virtually precludes interchange with the pool water. Finally, in-situ test equipment capable of quantifying Boraflex thinning does not currently exist for PWR storage racks.

Commercially available Boraflex blackness testing equipment from National Nuclear Corporation (NNC) was utilized in 1991 at both Oconee and McGuire to measure the amount of pullback at the ends of the Boraflex panels caused by shrinkage, as well as the size and frequency of gap formation. (See response to Request 3.) Shrinkage and gap formation was observed in both pools at McGuire and shrinkage without gap formation was observed at Oconee. Both results are consistent with the design and fabrication techniques employed by the manufacture. The data was incorporated into revised criticality analyses for the storage racks and k-eff was verified less than or equal to 0.95.

While the NNC equipment and methods did not permit quantitative assessment of any Boraflex dissolution, qualitative assessments were possible. It was evident to the examiners present during the testing that neutron attenuation in the storage cells was greater than in the benchmark test cell loaded with archive specimens of Boraflex of the same B^{10} loading. This result is consistent with an increase in areal density as the Boraflex shrinks and suggests that any dissolution of the Boraflex had, at that point in time, been offset by this increase in areal density.

An additional factor in the long-term performance of Boraflex is its exposure to the bulk pool water. The Boraflex in the racks at Oconee and McGuire is relatively isolated from the bulk pool as compared to other rack designs. While gamma exposure to some of the Oconee and McGuire Boraflex panels has exceeded 10^{10} rads (the level at which some dissolution could be expected), the wrapper design inhibits free interchange of water within and outside of the wrapper, thus minimizing dissolution.

Duke believes that Oconee and McGuire meet the 5 percent subcriticality requirement for the following reasons:

a) Consideration of gap formation and end pullback has been incorporated into the criticality analyses for the storage racks.

b) Conservatisms in the criticality analyses provide further assurance that the criticality margin is maintained. These include the following: 1) no credit is taken for the increased B^{10} areal density caused by the shrinkage of the Boraflex; 2) minimum B^{10} loadings are assumed in all the analyses; 3) the spent fuel pool is assumed to be an infinite array of storage cells (as opposed to a less reactive finite array with neutron leakage at the edges). Another area of conservatism is that the reactivity of the stored fuel is less than that assumed in the safety analyses.

c) Favorable design of the Boraflex storage racks minimizes Boraflex dissolution.

d) Qualitative assessment of the Boraflex condition in 1991 showed neutron attenuation exceeding that of the benchmark test cell.

e) Since 1991 dissolved silica concentrations in the Oconee and McGuire pools have increased modestly- approximately 3 ppm for Oconee and approximately 2 ppm for McGuire. This implies minimal change in Boraflex condition since the blackness testing was last performed in 1991. (See Response to Request 4 for additional information.)

f) No severe service conditions which might exacerbate Boraflex dissolution (e.g. reverse osmosis for silica removal from the spent fuel pool) have been imposed at either Oconee or McGuire.

Information Request 2:

"All licensees are further requested to submit to the NRC a description of any proposed actions to monitor or confirm that this 5-percent subcriticality margin can be maintained for the lifetime of the storage racks and describe what corrective actions could be taken in the event it cannot be maintained."

Response to Request 2:

Duke Power has recently acquired the RACKLIFE computer code which was developed by EPRI for the purpose of assessing overall Boraflex thinning based upon cumulative gamma exposure, storage rack design parameters, and dissolved silica concentration in the spent fuel pool. A RACKLIFE assessment of all four Oconee and McGuire spent fuel pools will be completed in 1997, and plans for future in-situ testing will be developed based upon those results.

Oconee

The Oconee spent fuel storage racks will be analyzed during 1997, taking reduced or no credit for Boraflex. Future Boraflex verification activities will depend upon the extent to which Boraflex is relied upon in the analysis, as well as the RACKLIFE assessment, and plans for future verification developed accordingly.

McGuire

Demonstration of the EPRI Boraflex Boron Areal Density Gage (BADGER) is currently planned for the Unit 2 spent fuel racks in January 1997. The purpose of this demonstration will be to verify the capability of the equipment to determine Boraflex B^{10} areal density in a borated PWR spent fuel. The results will be compared to the areal density predicted by the RACKLIFE computer code, and the RACKLIFE McGuire model will be adjusted, as required. This effort is expected to increase confidence in the predictive capabilities of the RACKLIFE computer code, thus decreasing reliance upon in-situ testing for Boraflex assessment.

In-situ testing of the Unit 1 racks should not be required since the Unit 1 racks are identical in design to the Unit 2 racks, and the adjusted pool model will be directly applicable to both.

Potential corrective actions in the event that a 5 percent subcriticality margin cannot be maintained are:

a. Reanalysis of the racks, removing analytical conservatisms.
b. De-rating of the racks (e.g. checkerboarding the fuel, requiring higher burnup or lower enrichments, etc.).
c. Re-licensing for dissolved boron credit using the Westinghouse Owners' Group approach.
d. Installation of boron containing inserts into the storage racks (e.g. Racksaver$_{TM}$)

Information Request 3:

"Licensees should describe the results from any previous post operational blackness tests and state whether blackness testing, or other in-situ tests or measurements, will be periodically performed."

Response to Request 3:

Oconee

Blackness testing was performed by National Nuclear Corporation in the Oconee spent fuel pools in September 1991. Both the standard scan and the special test method were employed. The standard scan is used to locate detectable gaps (1/2 inch, and greater), and the special test method is used to determine the elevation of the panel ends for pullback assessment.

In the Unit 1/2 pool, a total of 33 Boraflex panels in 9 storage cells were examined. No detectable gaps were observed from the standard scan. This result is consistent with the design and construction of the Westinghouse storage racks in which the Boraflex was installed, without adhesives, into a formed stainless steel wrapper. The special test method was used to determine the elevation of the top and bottom ends of the Boraflex panels. Average pullback at the panel ends was found to be 1.61 inch at the bottom, and 2.99 inch at the top. Additionally, a comparison was made of neutron attenuation in the test cell versus attenuation in one of the rack cells, to confirm the examiners' qualitative observation of apparently greater attenuation in the racks. A 100 second neutron counting interval in both the test cell and the storage cell showed a greater neutron attenuation in the storage cell. (This result is consistent with an increase in B^{10} areal density caused by shrinkage of the Boraflex.)

In the Unit 3 pool, a total of 34 Boraflex panels in 9 storage cells were examined. No detectable gaps were observed from the standard scan. No detectable gaps were observed. Average pullback at the panel ends was found to be 0.93 inch at the bottom, and 1.46 inch at the top. Again, the examiners noted a greater neutron attenuation in the storage cells than in the test cell, although this was not confirmed by attenuation counts.

Future in-situ examinations at Oconee are contingent upon the results of the no-Boraflex analyses to be completed in 1997. If continued operation of the Boraflex is required, the need/schedule for future examinations will be based upon RACKLIFE predictions for the Oconee pools, the results of the BADGER testing at McGuire (see below), and the extent to which Boraflex is relied upon in the analysis.

McGuire

Blackness testing was performed by National Nuclear Corporation in the McGuire Unit 2 spent fuel pool in July 1991 and in the McGuire Unit 1 spent fuel pool in December 1991. Both the standard scan and the special test method were employed. The standard scan is used to locate detectable gaps (1/2 inch, and greater), and the special test method is used to determine the elevation of the panel ends for pullback assessment.

Region 1 cells were examined in both spent fuel pools. Combining the Region 1 examinations, a total of 65 Boraflex panels in 18 storage cells were examined. A total of 61 detectable gaps were observed. Most of the gaps were less than 2 inches, and the largest was less than 3 inches. Smaller gaps, below the threshold for detection (1/2 inch), may also have existed due to the design and fabrication of the racks. (This result is consistent with the design and construction of the Westinghouse storage racks in which the Boraflex was installed into a formed stainless steel wrapper with a few spots of adhesive.) The special test method was used to determine the elevation of the top and bottom ends of the Boraflex panels. Average pullback at the panel ends was found to be 0.26 inch at the bottom, and 0.82 inch at the top. Additionally, a comparison was made of neutron attenuation in the test cell versus attenuation in one of the Unit 2 rack cells, to confirm the examiners' qualitative observation of apparently greater attenuation in the racks. A 100 second neutron counting interval in both the test cell and a selected storage cell showed a greater neutron attenuation in the storage cell. (This result is consistent with an increase in B^{10} areal density caused by shrinkage of the Boraflex.)

Region 2 cells were examined in Unit 1. A total of 36 Boraflex panels in 9 storage cells were examined. A total of 7 detectable gaps were observed, all smaller than 1 inch. Smaller gaps, below the threshold for detection (1/2 inch), may also have existed due to the design and fabrication of the racks. The Boraflex was installed into a formed stainless steel wrapper with sixteen 2-1/2 inch beads of adhesive equally spaced around the panel periphery, creating the potential for multiple crack sites. The special test method was used to determine the elevation of the top and bottom ends of the Boraflex panels. Average pullback at the panel ends was found to be 0.09 inch at the bottom, and 0.57 inch at the top.

Demonstration of the BADGER assay equipment is planned for the McGuire Unit 2 pool in January 1997. The need/schedule for future in-situ examinations at McGuire will be based upon the BADGER test results and RACKLIFE predictions for the McGuire pools.

Information Request 4:

"Chronological trends of pool reactive silica levels, along with the timing of significant events such as refuelings, pools silica cleanups, etc., should be provided. Implications of how these pool silica levels relate to Boraflex performance should be described."

Response to Request 4:

Oconee and McGuire

In spent fuel pools with Boraflex storage racks, silica concentrations above approximately 0.5 ppm are indicative of Boraflex degradation. Silica is a major constituent of Boraflex, used both as an ingredient in the polymer and as a filler material. Laboratory testing has shown an accompanying loss of B^{10} from the Boraflex as silica is released. The significance of the silica levels present in the Oconee and McGuire spent fuel pools and how it relates to Boraflex performance is currently under evaluation. The relationships between pool silica concentration, B^{10} loss from the Boraflex, and k-eff of the storage racks is complex and depends upon a variety of rack-specific and pool-specific factors such as rack design, pool size, filter design, pool operations, conservatisms in the rack criticality analysis, etc. As described in the responses to Information Request 1 and Information Request 2, Duke believes the required 5% sub-criticality margin is currently being maintained, and has acquired the EPRI RACKLIFE computer code to assess Boraflex condition in the Oconee and McGuire spent fuel pools. This assessment, as well as an assessment of the storage rack reactivity, will be completed in 1997.

Oconee

Measurements of spent fuel pool silica were initiated at Oconee in February 1993. All recorded measurements are presented below.

ONS 1/2 SFP Date	Silica (ppm)	ONS 3 SFP Date	Silica (ppm)
2/2/93	8.1	2/2/93	6.8
3/2/93	9.4	3/2/93	7.4
3/16/93	9.3	3/16/93	7.4
6/17/93	8.3	6/17/93	7.3
7/7/93	9.0	7/7/93	8.0
12/5/94	10.0	12/1/94	8.5
3/13/95	11.7	3/13/95	8.5
5/1/95	11.6	5/1/95	8.5
6/5/95	12.4	6/5/95	8.9
7/3/95	12.0	7/3/95	6.8
9/4/95	12.7	9/4/95	7.8
10/2/95	14.5	10/2/95	9.4
1/8/96	10.4	1/8/96	8.9
4/8/96	10.4	4/8/96	10.0
7/1/96	10.0	7/1/96	9.7

Refueling outages since silica measurements began are as follows:

Unit 1	Unit 2	Unit 3
		EOC13 7/21/92
	EOC12 1/9/92	EOC14 12/28/93
EOC14 12/3/92	EOC13 4/29/93	EOC15 6/6/95
EOC15 4/28/94	EOC14 10/06/94	
EOC16 11/02/95	EOC15 3/28/96	

McGuire

Measurements of silica data since January 1990 are presented below.

MNS 1 SFP Date	Silica	MNS 2 SFP Date	Silica

	(ppm)		(ppm)
1/3/90	1.5	1/2/90	1.2
4/18/90	1.1	4/4/90	1.4
7/4/90	1.2	7/4/90	1.5
10/3/90	1.4	10/3/90	1.4
1/2/91	1.7	1/2/91	1.4
4/3/91	1.9	4/3/91	2.0
7/3/91	1.8	7/3/91	1.9
10/2/91	1.6	10/2/91	1.9
1/1/92	1.5	1/1/92	2.2
4/1/92	1.7	4/1/92	1.9
7/8/92	2.1	7/8/92	2.2
11/4/92	1.4	11/4/92	1.6
1/6/93	1.7	1/6/93	2.0
4/7/93	2.3	4/7/93	2.4
7/7/93	2.2	7/7/93	2.6
10/6/93	2.2	10/6/93	2.7
7/6/94	2.8	1/5/94	3.7
10/5/94	2.5	7/6/94	2.9
1/4/95	2.3	10/5/94	3.1
4/5/95	2.8	1/2/95	2.9
7/5/95	2.8	4/5/95	3.7
10/4/95	3.0	7/5/95	3.5
1/5/96	3.2	10/4/95	3.7
4/3/96	2.8	1/3/96	3.9
7/3/96	3.1	4/1/96	3.8
		7/3/96	3.6

Refueling outages since silica measurements began are as follows:

Unit 1		Unit 2	
EOC6	1/8/90		
EOC7	9/20/91	EOC5	7/5/89
EOC8	3/12/93	EOC6	9/1/90
EOC9	8/19/94	EOC7	1/9/92
EOC10	12/14/95	EOC8	7/1/93
		EOC9	11/24/94
		EOC10	4/5/96