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October 16, 1996

Joseph J. Hagan
Vice President
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Grand Gulf Nuclear Station

U.S. Nuclear Regulatory Commission
Mail Station P1-37
Washington, D.C. 20555

Attention: Document Control Desk

Subject: Grand Gulf Nuclear Station
Docket No. 50-416
License No. NPF-29
Response to Generic Letter 96-04, Boraflex Degradation
In Spent Fuel Pool Storage Racks

GNRO-96/00118

Gentlemen:

Pursuant to Generic Letter 96-04, ''Boraflex Degradation In Spent Fuel Pool storage Racks'', Grand Gulf Nuclear Station is submitting the 120 day required response (Attachment 2). The Generic Letter requested all licensees that use Boraflex as a neutron absorber in their spent fuel pool racks to (1) assess the capability of the Boraflex to maintain a 5-percent subcriticality margin and (2) submit a plan describing proposed actions in the event this margin cannot be maintained by the Boraflex material because of current or projected Boraflex degradation.

This letter is submitted under oath under the provisions of Section 182a, Atomic Energy Act of 1954, as amended, and 10 CFR 50.54(f). If additional information is needed, please advise.

Yours truly,

JJH/RR/
attachments: 1. Affirmation per 10CFR50.54(f)
2. Requested Information
cc: Mr. J. E. Tedrow (w/a)
Mr. R. B. McGehee (w/a)
Mr. N. S. Reynolds (w/a)
Mr. H. L. Thomas (w/o)
Mr. J. W. Yelverton (w/a)

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cc: (cont'd)

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BEFORE THE

UNITED STATES NUCLEAR REGULATORY COMMISSION

LICENSE NO. NPF-29

DOCKET NO. 50-416

IN THE MATTER OF

MISSISSIPPI POWER & LIGHT COMPANY
and
SYSTEM ENERGY RESOURCES, INC.
and
SOUTH MISSISSIPPI ELECTRIC POWER ASSOCIATION
and
ENTERGY OPERATIONS, INC.

AFFIRMATION

I, J. J. Hagan, being duly sworn, state that I am Vice President, Operations GGNS of Entergy Operations, Inc.; that on behalf of Entergy Operations, Inc., System Energy Resources, Inc., and South Mississippi Electric Power Association I am authorized by Entergy Operations, Inc. to sign and file with the Nuclear Regulatory Commission, this response to Generic Letter 96-04; that I signed this application as Vice President, Operations GGNS of Entergy Operations, Inc.; and that the statements made and the matters set forth therein are true and correct to the best of my knowledge, information and belief.

J. J. Hagan

STATE OF MISSISSIPPI
COUNTY OF CLAIBORNE

SUBSCRIBED AND SWORN TO before me, a Notary Public, in and for the County and State above named, this 16th day of October, 1996.

(SEAL)

Richard R. Moore III
Notary Public

MISSISSIPPI STATEWIDE NOTARY PUBLIC
MY COMMISSION EXPIRES JUNE 5, 1999
BONDED THRU STEGALL NOTARY SERVICE

Background

The Grand Gulf Nuclear Station spent fuel and upper containment storage racks use Boraflex as a neutron absorber. Both racks were installed during the first fuel cycle (1985) and were exposed to irradiated fuel during the initial refueling outage (September 1986).

Both sets of racks are based on the same Joseph Oat design. This design uses cruciform, ell and tee shaped sub-elements to assemble each fuel storage array. Each sub-element is composed of stainless steel sheets, Boraflex panels and stainless steel edge strips. The Boraflex is enclosed between the stainless steel sheets and the edge strips are welded in place to frame the Boraflex. Two inch welds, spaced approximately every four inches are used to form a stable and relatively "tight" configuration which minimizes the potential for water ingress.

On September 8, 1987, the NRC issued Information Notice No. 87-43 alerting licensees that gaps had been found in the Boraflex panels of the high-density spent fuel storage racks at Quad Cities Unit 1. In light of this information, we initiated blackness tests on the Boraflex panels in the spent fuel storage racks. On November 21, 1988, we reported the results of these measurements which confirmed the presence of gaps. Consequently, a criticality analysis was performed to demonstrate the safety of the storage racks when Boraflex gaps, as large as 6 inches, are present. This analysis was submitted to the NRC by letter dated February 27, 1989.

On April 26 and June 7, 1990, additional criticality analysis was submitted to address the storage of additional fuel types. This analysis included burnup credit based on the maximum reactivity a bundle could obtain over its life when the effects of the integral poison, Gadolinium and fuel depletion were considered. This analysis assumed that 6 inch gaps were present in the Boraflex panels based on specific axial and radial probability distributions. The analysis included a 10 % reduction in the B-10 areal density as an allowance to accommodate potential degradation due to water ingress. This analysis was approved by NRC letter dated July 16, 1990.

Existing Monitoring Program

During the initial licensing of the Grand Gulf racks a program to monitor Boraflex behavior was proposed based on coupon specimens. These coupon specimens are periodically removed and inspected as described in a letter dated May 6, 1985. The inspections are designed to provide an indication of the general condition of the Boraflex and indicate gross or unusual degradation. The coupons are sent off site to an independent laboratory for testing.

Revisions to this program were proposed on February 27, 1989, December 5, 1989 and April 30, 1990. The changes were approved July 16, 1990. The key elements of these revisions are: comparisons between measured gap distributions and analysis assumptions; dose calculations to confirm the relationship between dose and gap size; and comparisons between the surveillance area dose and the balance of the racks to confirm the measurements will remain bounding through the next test interval.

The program uses neutron blackness testing to determine the size and frequency distribution of gaps in the Boraflex panels. The results of these measurements are compared to the

assumptions used in the current criticality safety analysis to verify that the 0.95 k-effective criticality safety limit is not compromised.

Blackness tests are performed each cycle in the same area of the spent fuel pool. This surveillance area is an 8 x 13 array of spent fuel pool storage locations beginning at cell HH-20 and ending at V-27. During the refueling outage prior to each surveillance, freshly discharged spent fuel is loaded into the surveillance area. Following 10 to 14 months of irradiation the fuel is removed and blackness tests are performed on at least 50 rack cells.

Loading freshly discharged fuel into the surveillance area each cycle induces a significantly higher gamma fluence in the surveillance area than in other areas of the rack. Since gamma fluence has been strongly correlated to gaps in Boraflex, the surveillance area will lead other areas of the racks in the formation of gaps.

The program also contains specific provisions to account for the potential slumping that has been postulated to occur following a seismic event.

In summary, this surveillance program utilizes a surveillance area which leads other areas of the rack in the formation and growth of gaps in Boraflex panels. The results of this program are expected to verify that the criticality analysis assumptions are bounding and to provide a more realistic characterization of Boraflex gap behavior in an in-service rack environment.

Surveillance Coupon Results

The most recent surveillance coupon was removed in September, 1996 and detailed tests are scheduled. Previous coupons were evaluated in December 1991. Two coupons were removed. Both coupons exhibited reductions in length and width consistent with industry data. The coupons' thickness and weight both increased as expected. The neutron attenuation measurements correspond to a B-10 areal density greater than the minimum design value. The corners and edges were sharply defined and no evidence of erosion was present. A dry white residue was present on the surface as expected.

Results Of Blackness Testing

Six blackness test campaigns have been performed at Grand Gulf with the most recent being completed in August, 1996. The results of all six campaigns are summarized on Figure 1. This figure is generated by totaling the size of the gaps in each panel and converting this sum to a percent shrinkage based on the total panel length. The shrinkage is then plotted verses gamma dose accumulated by that panel. The overall trend of the data is consistent with the EPRI model results although shifted to the right and somewhat upward. This is consistent with the tendency of point kernel shielding codes, as the one used in these calculations, to over predict dose. Additionally, some portion of the shrinkage will only increase the strain in the Boraflex and not result in gap formation.

The largest gap size observed during the sixth campaign is 6.7 inches, although most gaps are below 2 inches. Almost 90 % of the panels contain gaps with more that half of the panels containing 2 or more gaps. As illustrated by Table 1, the rate of change in the gap size distribution has slowed significantly since the early campaigns. New gaps are continuing to form and a few large gaps have developed. However, the rate of change seems to be stabilizing which indicates an approach to an equilibrium condition. The gaps tend to be located in the top 75% of the panels with a peak in the central 30 inches and another near the top of the panels.

The sixth campaign reported total shrinkage above the EPRI model in 5 of the 208 panels measured. The specific configurations are provided in Table 2. Two of the panels have multiple gaps totaling 8 inches while the other three are less than or equal to 6.5 inches. The cause for this behavior can not be determined without additional testing. However, one contributing factor is the use of a count rate to gap size correlation that tends to over estimate the size of large gaps.

Spent Fuel Pool Dose Levels

In addition to the dose assessment of the surveillance area, calculations of the dose in other areas of the racks are also performed. This assessment is used to confirm that the blackness surveillance results will remain applicable to locations outside the surveillance area until the next surveillance is complete. This assessment was performed in conjunction with the campaign six surveillance, considering the dose that will be accumulated through the end of the next cycle (cycle 9). The calculation determined that the dose would be less than 1.4×10^{10} Rads when the expected fuel shuffle plan is assumed. A worst case calculation was also performed in which fuel around the limiting panel is removed and replaced by the limiting bundles from the cycle 8 core. Under these conservative assumptions the dose in areas other than the surveillance area remains below 2.0×10^{10} Rads. The maximum dose in the surveillance area at the time of the fifth campaign was 2.28×10^{10} Rads. The corresponding value for the surveillance area during the sixth campaign is 2.81×10^{10} Rads.

EPRI has established that insignificant Boraflex dissolution occurs below threshold doses of 2 to 3×10^{9} Rads. The bulk of the Grand Gulf Spent fuel storage cells have achieved this dose therefore they are susceptible to degradation due to water ingress.

Trend of Pool Silica Concentrations

The available silica data is provided in Figure 2. Significant reductions in the silica concentration can be observed during outages as expected. The rate of increase in silica concentration following each outage is slightly steeper in the most recent cycle as the number of irradiated storage locations increase. No silica cleanup campaigns have been conducted at Grand Gulf. The silica levels are consistent with levels at other BWR racks reported at the recent EPRI Boraflex workshop. The silica levels indicate that some degradation due to water ingress is occurring. The extent of this effect depends on a detailed evaluation of the fuel pool design and operation. EPRI has developed the RACKLIFE system to perform this evaluation. An initial application has been successfully performed at another site. Model enhancements are currently being incorporated into the system based on initial utility use. A RACKLIFE model for Grand Gulf is currently being developed to perform silica evaluations.

Criticality Analysis Assessment

The existing Grand Gulf criticality analysis provided allowances for both Boraflex gapping and degradation due to water ingress. The existing analysis assumes gaps as large as 6 inches. As previously discussed, the most recent surveillance indicates that gaps totaling more than 6 inches are present in the surveillance area. Because the surveillance area has been loaded with freshly discharged fuel from six different cycles its dose is significantly higher than the bulk of the racks. Due to the higher dose, the campaign six results are overly conservative for the current rack configuration.

The criticality margin for storage outside the surveillance area was evaluated based on a Boraflex configuration consistent with the dose in that area. The dose outside the surveillance area will remain below the dose corresponding to the fifth surveillance campaign through the end of cycle 9. Since criticality analysis assumptions were confirmed to bound the Boraflex configuration from the fifth campaign, criticality margin will be maintained through this interval.

Currently, efforts are in progress to revise the existing criticality analysis. Preliminary results from the revised criticality analysis indicate that the acceptance criteria will be maintained even when gaps which bound the sixth campaign results are assumed. This margin is obtained by including multiple rack storage cells in the model so that gap coupling effects are realistically modeled. The current analysis uses a very conservative single cell model with gaps placed in one of two planes which are separated by 18 inches. This revised analysis will be completed prior to the end of cycle 9.

The criticality margin in the surveillance area has also been evaluated. The reactivity of cells containing panels with gaps totaling more than 6 inches was compared to that obtained from a configuration evaluated during the criticality analysis (approved July 19, 1990). Both configurations were evaluated with the SCALE analysis package, using the same model except for gap assumptions. The campaign six configurations were confirmed to be less reactive than the criticality analysis configuration. The criticality analysis established that an infinite rack containing this configuration had a k-effective, including uncertainties, below the 0.95 acceptance criteria. The remaining panels were confirmed to be bounded by the criticality analysis assumptions. Additionally, the fuel loaded into the surveillance area is highly depleted discharged fuel. While this evaluation confirms that the criticality margin was maintained during the surveillance interval, additional irradiation of this area will be deferred until after the completion of the previously described re-analysis.

Monitoring Program Revisions

In continuing to ensure that the 5 percent sub-criticality margin can be maintained for the life of the spent fuel storage racks the following revisions to the Grand Gulf Monitoring Program are anticipated:

> Grand Gulf will complete a revised criticality analysis for the spent and upper containment storage racks. This analysis will include Boraflex gap assumptions which bound the campaign six gap measurements with an allowance for degradation due to water ingress.
>
> Fuel will be reloaded in the surveillance area during Refueling Outage nine and additional surveillance tests will be performed. The gap measurements will be confirmed to be bounded by the criticality analysis assumptions using the same process described in the existing monitoring program. If gap measurements demonstrate that panels have reached equilibrium, no additional tests will be performed. If not, the test frequency will be extended to once per 36 months, which will continue to ensure that the surveillance area bounds the remainder of the racks.
>
> Grand Gulf will continue to monitor spent fuel pool silica levels and perform silica evaluations prior to receipt of each new fuel batch. This evaluation will be based on the EPRI RACKLIFE system or its equivalent. The initial assessment is scheduled to

be completed prior to the end of cycle 9. This assessment will include projections to confirm acceptable performance through the next evaluation period.

If gap measurements or silica evaluations indicate that the criticality analysis is not conservative, an evaluation of the racks will be performed to confirm criticality margin can be maintained. Consistent with the existing program, during the interim period while this criticality evaluation is in progress, loading fuel into the surveillance area will be restricted to a checkerboard configuration.

Additionally, alternatives exist to maintain use of the racks if the monitoring program indicates margin may not be maintained at some future date. These alternatives include, among others, credit for burnup beyond peak reactivity, alternate rack loading plans and the use of neutron absorbing inserts.

Table 1: Comparison of Gap Sizes for Six Campaigns

Campaign	1	2	3	4	5	6
Number of Gaps	65	120	192	239	260	276
Maximum Gap Size (in.)	1.4	2.0	3.5	4.1	4.6	6.7
Number of Gaps, By Inch						
05-1.0	48	80	104	122	133	141
1.1-2.0	17	40	61	77	80	87
2.1-3.0			24	28	33	34
3.1-4.0			3	11	11	10
4.1-5.0				1	3	2
5.1-6.0						1
6.1-7.0						1

Table 2: Gap Distribution for Maximum Shrinkage Panels

Panel	Elevation	Gap Size (in.)
Y-21 E	24	0.6
	77	2.9
	86	3.0
V-24 S	33	0.6
	54	1.5
	135	4.1
CC-27 E	88	2.9
	96	1.1
	117	1.8
	137	2.2
DD-22 E	89	6.0
HH-24 E	57	1.3
	91	6.7

Figure 1

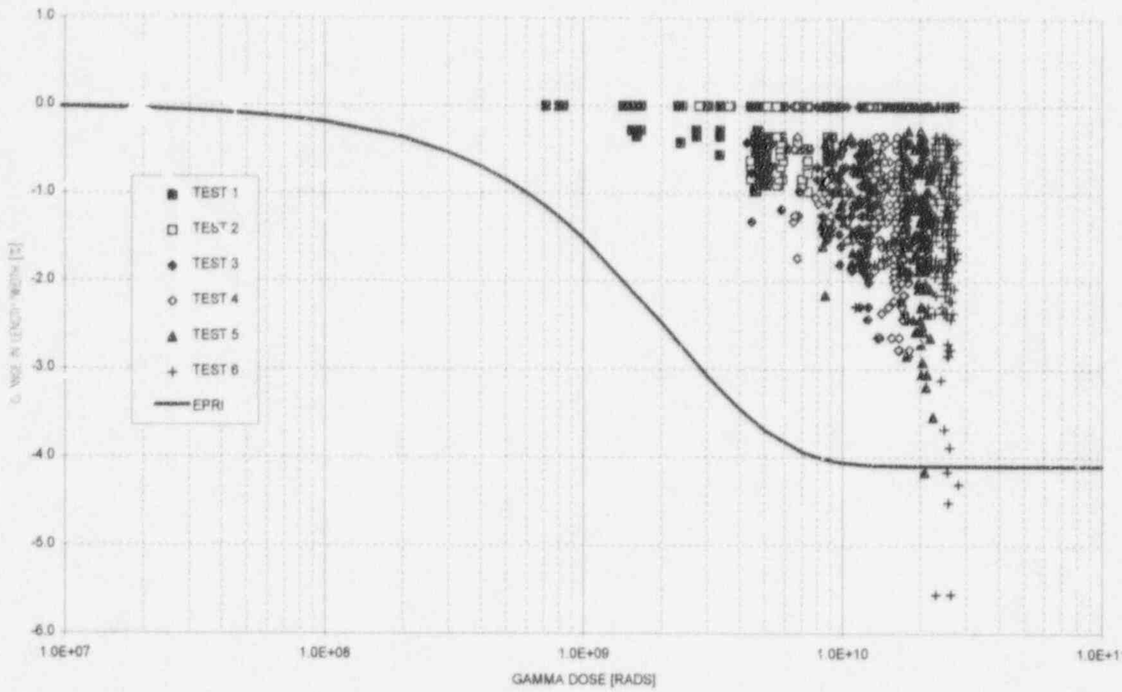

Figure 2
Grand Gulf Spent Fuel Pool Silica