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Attachment 2 contains proprietary information.

GNRO-2010/00073

November 23, 2010

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

SUBJECT: Supplemental Information
License Amendment Request, Extended Power Uprate
Grand Gulf Nuclear Station, Unit 1
Docket No. 50-416
License No. NPF-29

REFERENCES:
1. Grand Gulf Nuclear Station, Unit 1 – Supplemental Information Needed for Acceptance of License Amendment Request for Extended Power Uprate (TAC No. ME4679) (ADAMS Accession # ML103010200)
2. License Amendment Request, Extended Power Uprate dated September 8, 2010 (GNRO-2010/00056) (ADAMS Accession # ML102660409)
3. Supplemental Information, License Amendment Request, Extended Power Uprate dated November 18, 2010 (GNRO-2010/00071)

Dear Sir or Madam:

By letter dated November 9, 2010 (Reference 1), the Nuclear Regulatory Commission (NRC) requested supplemental information regarding certain aspects of the Grand Gulf Nuclear Station, Unit 1 (GGNS) Extended Power Uprate (EPU) License Amendment Request (LAR) (Reference 2). The response to the request related to the criticality safety analysis is included in Attachments to this letter. Entergy previously responded to other requests for supplemental information by letter dated November 18, 2010 (Reference 3).

GE-Hitachi Nuclear Energy Americas, LLC (GEH) considers portions of the information provided in Attachment 2 to be proprietary and therefore exempt from public disclosure pursuant to 10 CFR 2.390. An affidavit for withholding the subject information, executed by GEH, is provided in Attachment 4. Therefore, on behalf of GEH, Entergy requests to withhold Attachment 2 from public disclosure in accordance with 10 CFR 2.390(b)(1). Proprietary and non-proprietary versions of the report, Grand Gulf Nuclear Station: Fuel Storage Criticality Safety Analysis of Spent and New Fuel Storage Racks, are provided in Attachments 2 and 3, respectively.

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When Attachment 2 is removed, the entire letter is non-proprietary.

No change is needed to the no significant hazards consideration included in the initial LAR (Reference 2) as a result of the supplemental information provided. There are no new commitments included in this letter.

If you have any questions or require additional information, please contact Jerry Burford at 601-368-5755.

I declare under penalty of perjury that the foregoing is true and correct. Executed on November 23, 2010.

Sincerely,

M. A Krupa

MAK/FGB/dm

Attachments:
1. Supplemental Information
2. Grand Gulf Nuclear Station: Fuel Storage Criticality Safety Analysis of Spent and New Fuel Storage Racks (Proprietary)
3. Grand Gulf Nuclear Station: Fuel Storage Criticality Safety Analysis of Spent and New Fuel Storage Racks (Non-Proprietary)
4. GEH Affidavit for Withholding Information from Public Disclosure GGNS Fuel Storage Criticality Safety Analysis of Spent and New Fuel Storage Racks

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Attachment 1

GNRO-2010/00073

Supplemental Information

Supplemental Information

Entergy submitted its license amendment request (LAR) for an extended power uprate for the Grand Gulf Nuclear Station, Unit 1 (GGNS) by letter dated September 8, 2010. Based on its acceptance review, the NRC requested supplemental information in four areas related to the uprate LAR on November 9, 2010. The first three items were addressed by Entergy in a letter dated November 18, 2010; the response to item 4 is provided below.

4. In Sections 2.8.6.1, "New Fuel Storage," and 2.8.6.2, "Spent Fuel Storage," of its submittal, the licensee cities NEDC-33004P-A as the basis for demonstrating compliance with 10 CFR Appendix A General Design Criterion 62, "Prevention of criticality in fuel storage and handling." However, NEDC-33004P-A, Section 6.3.4 addresses the increased decay heat load associated with a constant pressure power uprate and does not address criticality. Therefore, there is no information in the licensee's submittal that addresses criticality in fuel storage and handling and the NRC staff has insufficient information to begin its review. The NRC staff requests the licensee provide the nuclear criticality safety analysis that demonstrates compliance with GDC 62.

Response

Attachment 2 provides a criticality safety analysis (CSA) of the spent fuel pool (SFP) and new fuel storage racks. The CSA demonstrates compliance with 10 CFR 50 Appendix A, General Design Criterion (GDC) 62, "Prevention of criticality in fuel storage and handling." Information supporting the Boraflex assumptions used in the CSA is provided below. In addition, an evaluation of the fuel types currently stored in the GGNS SFP (i.e., legacy fuel) is summarized below.

Boraflex Performance

The spent fuel storage racks at GGNS consist of individual cells with panels of a neutron absorber material (Boraflex) sandwiched between sheets of stainless steel. General degradation of Boraflex gradually reduces the B_{10} areal density. A Boraflex monitoring program, as described in References 1 and 2, has been established at Grand Gulf Nuclear Station, Unit 1 (GGNS) to monitor Boraflex performance. The program includes gap measurements and spent fuel pool (SFP) silica evaluations based on the EPRI RACKLIFE system.

The gap measurements were conducted in a designated test area that accelerated the gamma dose to the Boraflex panels by loading freshly discharged fuel into the test area following a refueling outage. The fuel remained in the test area approximately one year. It was then removed to allow blackness test measurements to be performed.

The results of this process, which has been repeated for seven test campaigns, are illustrated in Figure 1. The total panel gap as a percent of the initial panel length vs. dose follows the EPRI Boraflex shrinkage model until the dose exceeds 2.3E10 rads. The loss accelerates as the panels approach 3.0E10 rads. This performance is consistent with gap edge erosion that occurs as flow increases in the presence of larger gaps.

The RACKLIFE system uses a Boraflex dissolution model, fuel loading history and pool cleanup operation and other inputs to perform a mass balance on each panel in the pool. Predicted SFP water chemistry silica concentrations are provided to benchmark the code against pool chemistry silica measurements. Silica is released from Boraflex panels along with boron, so a comparison to measured water chemistry indicates the accuracy of the RACKLIFE model. The GGNS RACKLIFE model conservatively predicts pool silica levels.

Additionally, a Badger test campaign was conducted at GGNS in December, 2007 to measure the B_{10} areal densities and panel losses from gaps. These gap measurement results for panels with doses below 2.3E10 were consistent with the maximum shrinkage predicted by the EPRI Boraflex shrinkage model. Badger gap measurement results for panels with doses above 2.3E10 are consistent with the results of the seven blackness tests, and show additional losses since the previous blackness test in March, 1999. Thirty-two total panels were measured in Region I and Region II cell locations. The Region I panels that were tested had accumulated doses up to 1.77E10 rads. The Region II panels had accumulated doses as high as 3.83E10 rads. The minimum areal density of a Region I cell is 0.182 gm/cm^2. The minimum areal density of a Region II cell is 0.166 gm/cm^2. The Region I results are well above the criticality safety analysis assumption of 0.0133 gm/cm^2. The Region II analysis does not credit any Boraflex absorption. The difference between the Region I Badger test and RACKLIFE results are bounded by a 95/95 uncertainty of 0.0022 gm/cm^2. A reduction of the RACKLIFE predicted areal density by 0.0022 gm/cm^2 is applied in the Boraflex monitoring program to determine if a panel exceeds the criticality analysis minimum areal density assumption of 0.0133 gm/cm^2. Any cell that contains one or more panels that do not meet these criteria is configured as a Region II cell (see below).

Table 1 provides the results of Blackness and Badger tests with total panel losses that exceed the 4.1% EPRI shrinkage model. The average dose for these panels is 3.24E10 rads. A dose level of 2.3E10 rads was selected to demark the transition in the Boraflex performance since, as observed from Figure 1, the transition to higher panel losses occurs at a significantly higher dose level (around 3.0E10 rads). Additionally, all panel losses greater than the 4.1% EPRI shrinkage model result occur above this dose value (2.3E10 rads).

The difference in Boraflex performance is addressed in the criticality analysis by considering two regions of the pool storage configuration (*i.e.*, Regions I and II) and performing a separate analysis of each region. Region 1 locations continue to credit Boraflex. As shown in Figure 1, blackness tests 1-6 are consistent with expected panel losses from Boraflex shrinkage. For conservatism, the results from test 7 were selected for use in the criticality analysis. Additionally, the criticality analysis input assumptions were selected to provide additional conservatism to the measurements. Figure 2 shows the probability distribution for the number of gaps a given panel may contain. The analysis does not credit the zero gap probability. Additionally, the analysis inputs are biased toward 1 and 2 gaps. This will result in conservatively larger gaps sizes and therefore higher reactivity configurations. Figures 3 and 4 illustrate the total panel losses, from gaps, and the individual gap size distribution. The analysis inputs are biased toward larger gaps for both distributions. Figure 5 shows the axial gap location distribution. The analysis assumption forces all of the gaps into the center 6 feet of the panel which maximizes the reactivity impact. The central 12 inches have a probability assumption greater than any observed value. In net, the Boraflex gap distributions used in the criticality analysis are significantly conservative relative to the GGNS measurements and the measurements are conservative relative to the definition of Region I of the racks.

Region II locations correspond to areas of the SFP where higher panel losses may occur and thus the analysis assumes no Boraflex is present. Any fuel storage location with one or more panels with an accumulated dose greater than 2.3E10 rads or an areal density below the criticality analysis assumption (i.e., 0.0133 gm/cm^2) is considered a Region II cell. Isolated Region II cells have appropriate barriers inserted in the affected locations to preclude fuel storage. Larger areas of Region II cells are configured as described in the criticality safety analysis with appropriate barriers to preclude fuel loading in the required locations. The current Region II cell locations are associated with the Blackness Test area. This area was established in 1999 and has not been expanded since that time. The GGNS Boraflex monitoring program evaluates the dose each cycle, including conservative projections to the next evaluation period to identify any changes in Region II.

Table 1: High Dose Panel (*i.e.*, Region II) Loss

Campaign	Dose	Panel Loss (%)
Blackness – 6	2.97E+10	-5.6
Blackness – 6	2.89E+10	-4.5
Blackness – 6	2.31E+10	-4.2
Blackness – 7	3.52E+10	-9.4
Blackness – 7	3.05E+10	-7.8
Blackness – 7	2.90E+10	-7.0
Blackness – 7	3.29E+10	-6.8
Blackness – 7	3.36E+10	-6.4
Blackness – 7	3.32E+10	-5.4
Blackness – 7	3.27E+10	-5.0
Blackness – 7	2.92E+10	-4.7
Blackness – 7	3.43E+10	-4.7
Blackness – 7	3.32E+10	-4.7
Blackness – 7	3.34E+10	-4.7
Blackness – 7	3.28E+10	-4.2
Badger	2.89E+10	-7.6
Badger	2.97E+10	-5.3
Badger	2.99E+10	-7.3
Badger	3.06E+10	-11.9
Badger	3.33E+10	-5.3
Badger	3.54E+10	-4.4
Badger	3.72E+10	-4.4
Badger	3.83E+10	-13.4

Figure 1: GGNS Blackness Test Boraflex Panel Gap Loss Data

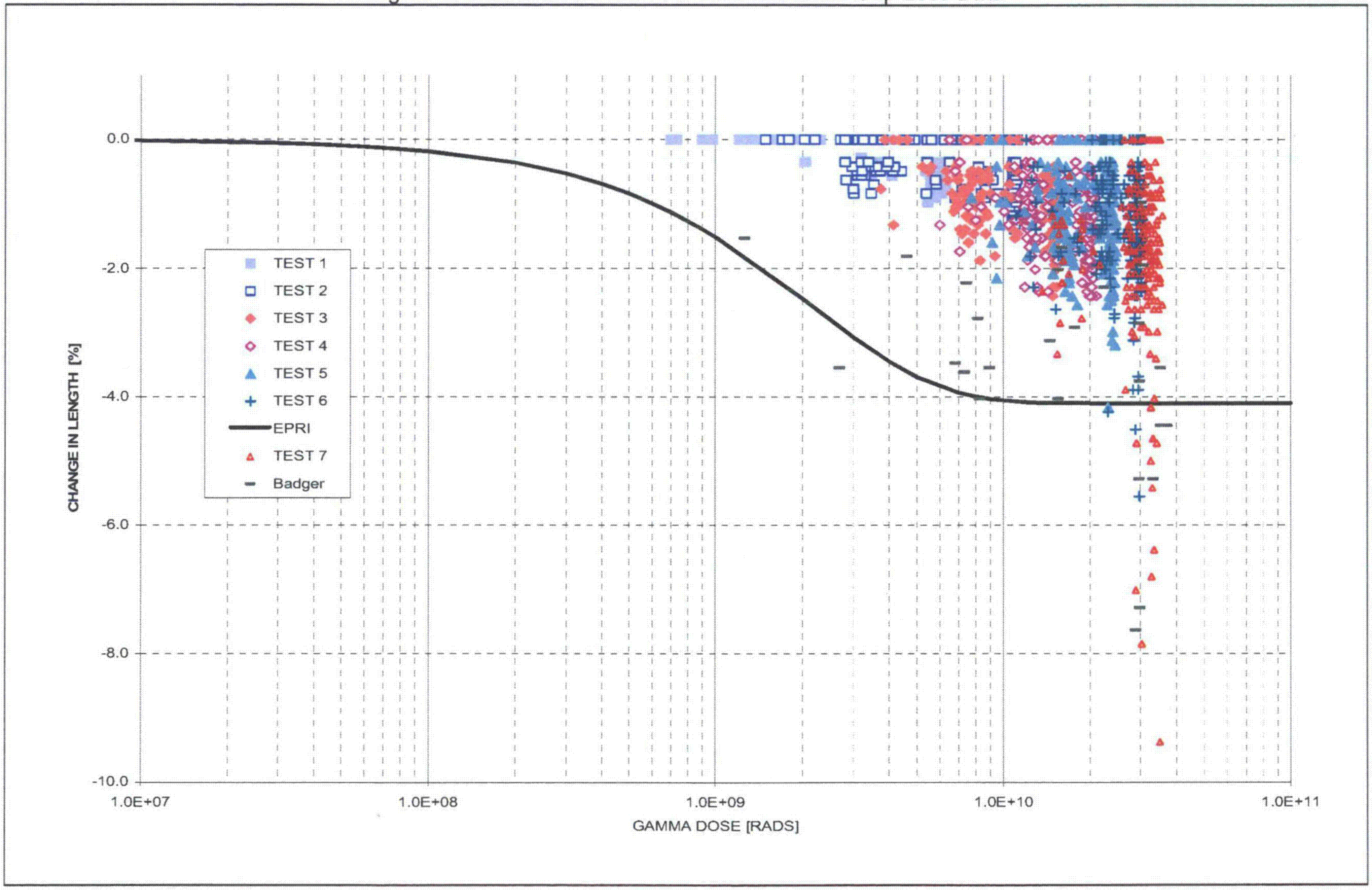


Figure 2: Gaps per Panel Probability Distribution

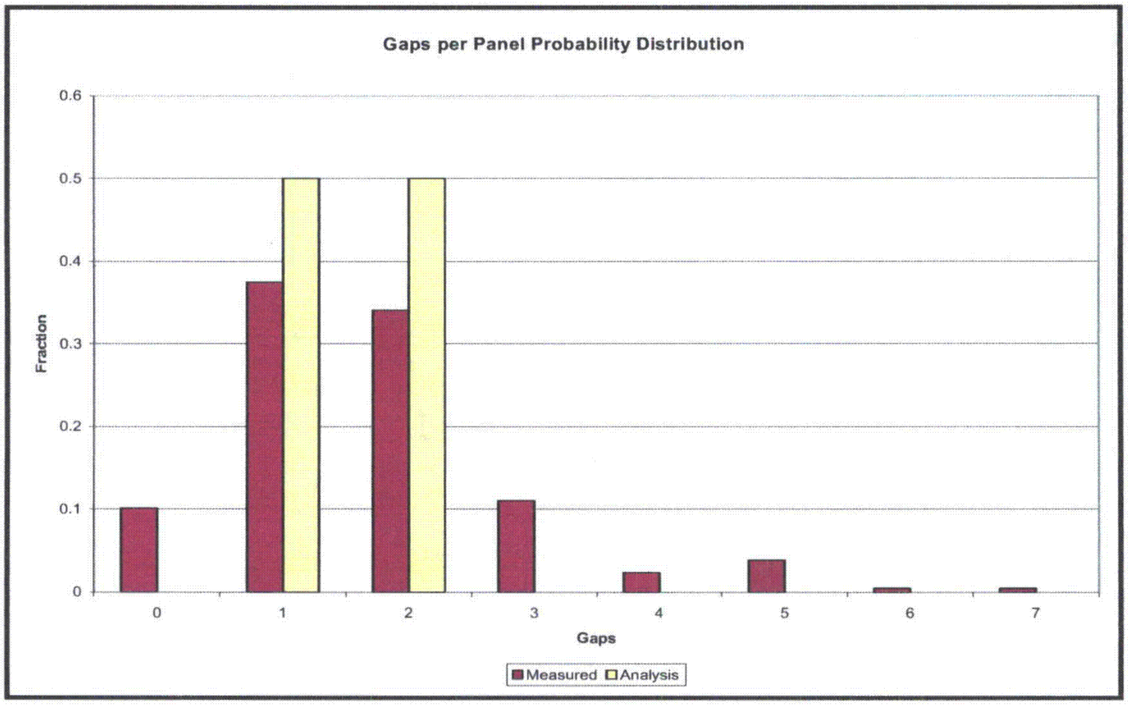


Figure 3: Total Panel Loss Probability Distribution

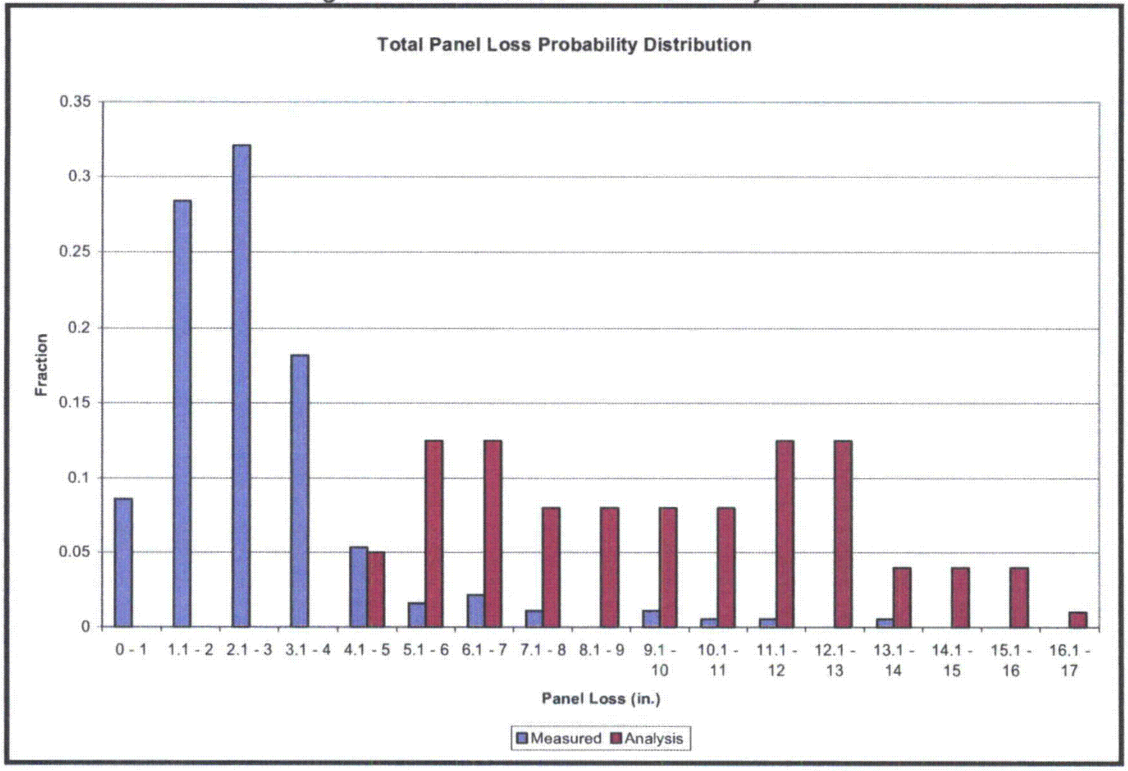


Figure 4: Gap Size (individual gaps) Probability Distribution

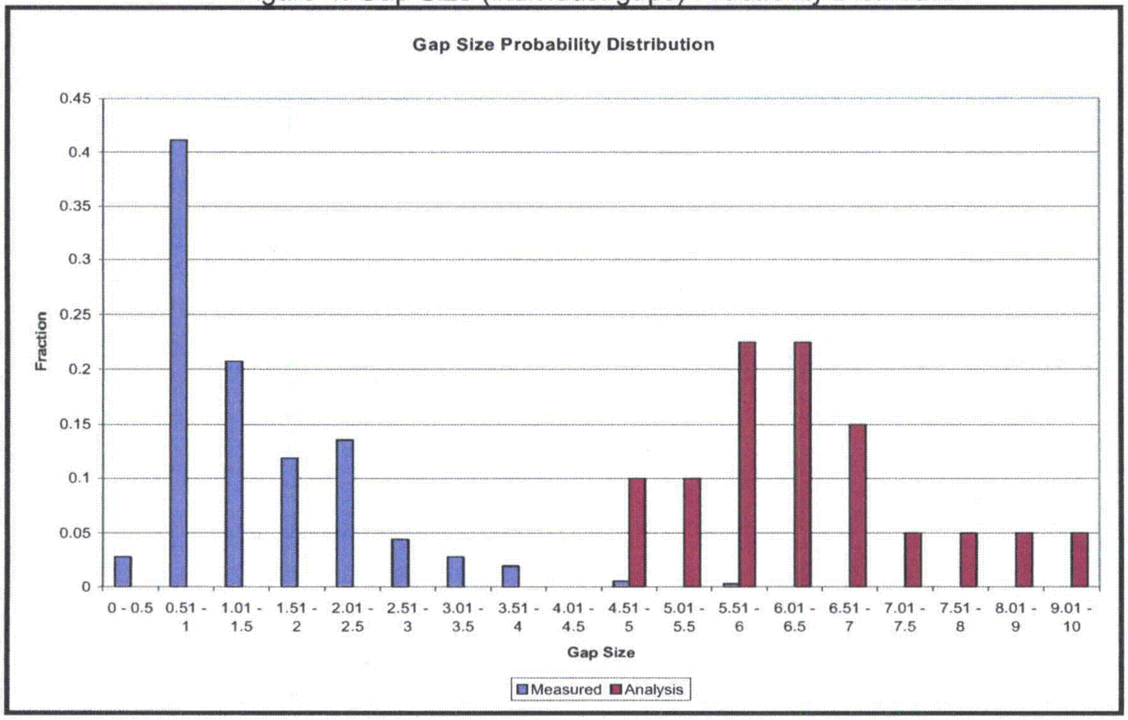
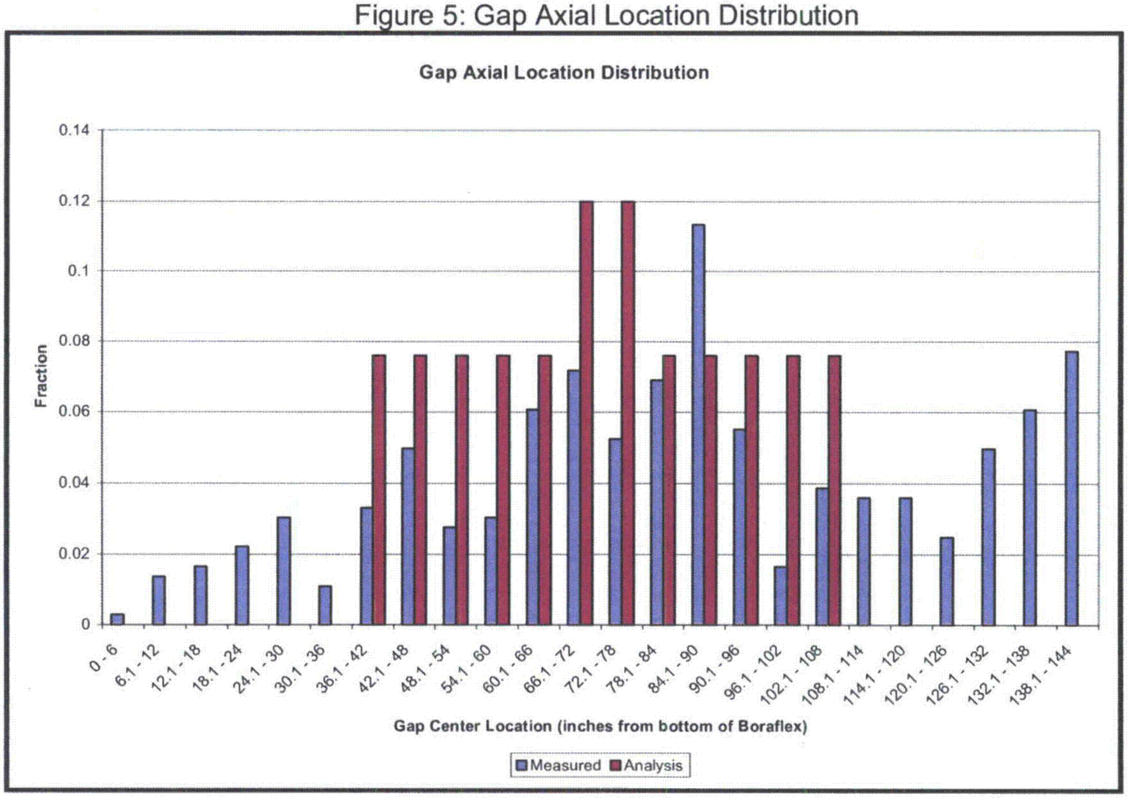


Figure 5: Gap Axial Location Distribution



Legacy Fuel

The criticality analysis is based on a design basis assembly which bounds all fuel designs existing in the GGNS SFP (including GE14 and GNF2). The design basis fuel design for SFP storage is a GE14 assembly described in the criticality safety analysis. Legacy fuel is not evaluated for the New Fuel Storage rack since only fresh fuel can be stored in the new fuel racks. The legacy fuel was evaluated by comparing the peak reactivity of the design basis assembly with the peak reactivity of all fuel segments of all fuel designs used at GGNS. These designs include 8x8, 9x9, and 10x10 fuel assemblies. The comparison was performed using the integral transport theory code, CASMO-4. Each fuel segment was depleted in reactor geometry assuming zero void fraction coolant conditions to maximize reactivity. The depletion results were reanalyzed in rack geometry to determine the peak reactivity of each fuel segment. The rack geometry included cases with and without Boraflex. The results for the most reactive fuel segments for each class of fuel are shown in Table 2.

The design basis assembly is limiting at peak reactivity for all fuel segments except one: a 6-inch segment of ANF 9x9 fuel just below the natural blanket at the top of some Cycle 5 reload assemblies. This location is subject to very high leakage so it contributes little to overall reactivity. The segment is less reactive than the design basis assembly once it has achieved 11.0 GWD/MTU burnup. The minimum burnup achieved in this segment for all assemblies of this type is 14.3 GWD/MTU; at this burnup, the segment is 3.6% less reactive than the design basis assembly. The design basis assembly is thus more reactive than all of the legacy fuel designs in the GGNS SFP.

Table 2: Legacy Fuel and Design Basis (DB) Assembly Reactivity Comparison

Fuel Type	Margin to the DB Assembly
GE14	Design Basis Assembly
ANF8x8	6.46%
ANF9x9*	3.92%
ATRIUM10	1.47%
GE11	4.61%
GE14**	5.57%
GNF2**	3.39%

* Reactivity margin for ANF 9x9 fuel segments except as described above.
** The GE14 value represents the margin of the limiting lattice used at GGNS to the design basis GE14 assembly considered by the analysis.

References

1) Grand Gulf Nuclear Station letter, "Response to Generic Letter 96-04, Boraflex Degradation in Spent Fuel Pool Storage Racks", dated October 16, 1996.

2) NRC letter, "Completion of Licensing Action Review for Generic Letter 96-04, "Boraflex Degradation in Spent Fuel Pool Storage Racks," for Grand Gulf Nuclear Station, Unit 1 (TAC NO. M95952)", dated May 14, 1997.