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GNRO-2011/00017

March 9, 2011

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

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

REFERENCES:
1. Email from A. Wang to F. Burford dated February 8, 2011, GNS EPU Request for Additional Information Related to Steam Generator Tube Integrity and Chemical Engineering Branch of the Division of Component Integrity Review (ME4679) (ML110390173)
2. License Amendment Request, Extended Power Uprate, dated September 8, 2010 (GNRO-2010/00056, Accession Number ML102660403)

Dear Sir or Madam:

The Nuclear Regulatory Commission (NRC) requested additional information (Reference 1) regarding certain aspects of the Grand Gulf Nuclear Station, Unit 1 (GGNS) Extended Power Uprate (EPU) License Amendment Request (LAR) (Reference 2). Attachment 1 provides responses to the additional information requested by the Steam Generator Tube Integrity and Chemical Engineering Branch.

No change is needed to the no significant hazards consideration included in the initial LAR (Reference 2) as a result of the additional information provided. There are 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 March 9, 2011.

Sincerely,

M. A Krupa

MAK/FGB/dm

Attachments:
1. Response to Request for Additional Information, Steam Generator Tube Integrity and Chemical Engineering Branch
2. List of Regulatory Commitments

cc: Mr. Elmo E. Collins, Jr.
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U. S. Nuclear Regulatory Commission
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U. S. Nuclear Regulatory Commission
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NRC Senior Resident Inspector
Grand Gulf Nuclear Station
Port Gibson, MS 39150

**Attachment 1**

**GNRO-2011/00017**

**Grand Gulf Nuclear Station, Unit 1 Extended Power Uprate**

**Response to Request for Additional Information**

**Steam Generator Tube Integrity and Chemical Engineering Branch**

**Response to Request for Additional Information**
**Steam Generator Tube Integrity and Chemical Engineering Branch**

By letter dated September 8, 2010, Entergy Operations, Inc. (Entergy) submitted a license amendment request (LAR) for an Extended Power Uprate (EPU) for Grand Gulf Nuclear Station, Unit 1 (GGNS). By correspondence dated February 8, 2011 (Accession Number ML110390173), the U.S. Nuclear Regulatory Commission (NRC) staff has determined that the following additional information requested by the Steam Generator Tube Integrity and Chemical Engineering Branch is needed for the NRC staff to complete their review of the amendment. Entergy's response to each item is also provided below.

Please note that the reference to the September 8, 2010 letter in NRC RAIs 2-8 actually relates to the letter from Entergy Operations, Inc. to the NRC dated November 23, 2010 (Accession Number ML103330093).

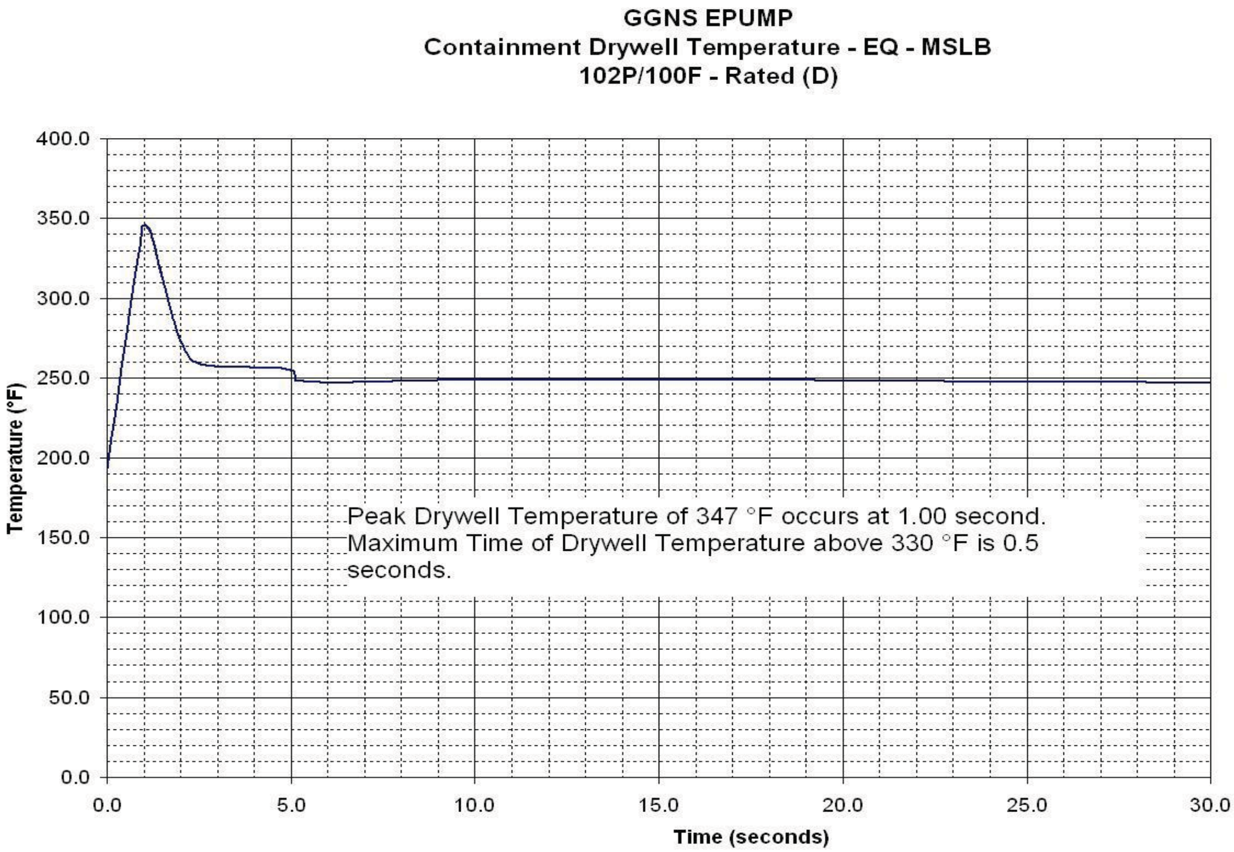
**RAI # 1**

On page 2-10 of attachment 5B of its letter dated September 8, 2010, the licensee states that the qualification level peak temperature for the drywell is 340°F and the peak temperature for the EPU conditions was determined to be <340°F. However, the licensee stated that the EPU peak temperature ignores a short initial one-second transient to 347°F and that this transient would have an insignificant effect on the coating temperatures. Please discuss why the qualification testing remains bounding despite having a containment temperature that exceeds the test temperature profile.

**Response**

The 347°F is a brief spike (or transient) in drywell temperature that happens within the first second of the accident (see Figure 1 - Short Term Temperature Response Main Steam Line Break), then drops below and stays below the 340°F design temperature. In regards to Environmental Qualification, the focus is on the temperature that the components and materials of interest attain. The protective coatings in containment do not instantaneously heat up to the temperature of the drywell environment; rather, the temperature response of the coatings is based on convective heat transfer properties and thermal capacity. Exposure to a very brief spike (one second) of elevated temperature is not nearly long enough to heat up the protective coatings much beyond their initial temperature condition (≤135°F per GGNS Technical Specifications). Rather, the analysis demonstrating that the drywell temperature remains below 340°F confirms that the ultimate peak temperature of the coatings themselves would remain below this qualification temperature, in conformance to design requirement.

**Figure 1 - Short Term Temperature Response - Main Steam Line Break**




**<u>RAI # 2</u>**

In its September 8, 2010 letter, the licensee states that GGNS performed a Blackness campaign in 1999, followed by a BADGER campaign in 2007. It is not clear to the staff what surveillance approach will be implemented going forward and how it will demonstrate that the neutron absorbing material will continue to perform its intended function. As such, please discuss in detail the surveillance approach that will be used in the Boraflex monitoring program, specifically the methods of neutron attenuation testing (i.e., in-situ testing), frequency of inspection, sample size, data collection, and acceptance criteria.

**<u>Response</u>**

Racklife remains a key component of the GGNS Boraflex monitoring program. Racklife calculations will continue to be performed each cycle and include projections of rack performance to the next Racklife calculation. Boraflex panels which have received a gamma dose in excess of 2.3E10 rads or which have an areal density of less than 0.0165 $gm/cm^2$ are treated as Region II panels. Storage cells face-adjacent to Region II panels are either restricted from fuel storage or configured to meet the Region II fuel storage configuration requirements. The dose limit, as described below, ensures the Boraflex gap configurations meet the criticality safety analysis (CSA) assumptions. The areal density criterion has been established by summing the CSA assumed areal density, the Badger / Racklife uncertainty, and the design areal density tolerance. This assures protection of the CSA assumption. Substituting values for these parameters:

Areal Density Criterion = 0.0133 + 0.0022 + 0.001 = 0.0165 gm/cm$^2$

The design areal density tolerance is included since the Racklife and Badger results are expressed relative to the nominal Boraflex design areal density. Credit for Boraflex densification with dose is conservatively not included.

In order to ensure the Badger/Racklife uncertainty remains valid, an additional Badger measurement will be performed prior to the end of 2012. The need for additional tests will be determined following the 2012 test campaign, based on the test results along with projected rack performance. Current Racklife projections show that dose is the dominant factor for panels being classified as Region II; panels which have not crossed the dose threshold are expected to exhibit sufficient margin to the areal density criterion for several years. The results of the projections are summarized in Table 1.

The 2012 test will consist of at least 30 panels. The Badger to Racklife uncertainty will be developed from the test results. This value will be considered acceptable if it is less than the existing Badger/Racklife uncertainty 0.0022 (see above). Additionally, the minimum Badger areal density results will be confirmed to be greater than the CSA assumption of 0.0133 gm/cm$^2$. The gap size and location probability distributions will also be compared to those used in the CSA. The acceptability of these parameters will be based on verifying that all of the CSA distributions bound the corresponding Badger measured distributions. Alternatively, the measured gap distributions are acceptable if the CSA calculations are repeated using the measured gap distributions and the resulting 95/95 k-effective is bounded by the corresponding CSA Region 1 result (see Table 1 of NEDC-33621P, Grand Gulf Nuclear Station Fuel Storage Criticality Safety Analysis of Spent and New Fuel Storage Racks, Attachment 2 to the November 23, 2010 letter).

Additionally, the GGNS Boraflex monitoring program, described in response to Generic Letter (GL) 96-04 dated October 16, 1996, continues to monitor Boraflex performance through the removal and testing of a series of Boraflex coupons. The measurements include areal density measurements.

Table 1: GGNS Expected Boraflex Panel Performance

| Date | Projected Minimum Areal Density | | Percent of Panels above Dose Criterion (2.3E10 rads) |
|---|---|---|---|
| | Min Areal Density gm/cm$^2$ | Margin to Areal Density Criterion (0.0165 gm/cm$^2$) (%) | |
| 1/1/2011 | 0.01836 | 11.27 | 2.1% |
| 1/1/2013 | 0.01806 | 9.45 | 5.1% |
| 1/1/2015 | 0.01773 | 7.45 | 18.9% |

**RAI # 3**

On page 2 of attachment 1 of its September 8, 2010 letter, the licensee states that the minimum areal density of a Region I and II cell is 0.182 gm/cm$^2$ and 0.166 gm/cm$^2$, respectively. In addition, the licensee states that only the Region I minimum areal density is bounded by the uncertainty and is well above the criticality safety analysis minimum areal density assumption of

0.0133 gm/cm$^2$. It appears to the staff that the minimum areal densities stated above for a Region I and II cell may be a typographical error. Please confirm that these values are accurate.

**Response**

The correct minimum areal density of a Region I and II cell is 0.0182 gm/cm$^2$ and 0.0166 gm/cm$^2$, respectively. Note that this data from the November 23, 2010 letter reflects results for the 32 panels tested in the 2007 Badger Test campaign.

**RAI # 4**

In its September 8, 2010 letter, the licensee states that the Boraflex monitoring program utilized at GGNS is described in its response to Generic Letter 96-04 dated October 16, 1996. On page 4 of attachment 2 of its October 16, 1996 letter, the licensee states that, "If gap measurements demonstrate that panels have reached equilibrium, no additional tests will be preformed." It is not clear to the staff as to what is meant by equilibrium and justification for not continuing to perform testing. Please discuss the justification for not continuing to perform testing. In addition, describe how the program acceptance criteria account for potential degradation between surveillance periods.

**Response**

The Boraflex measurements described in the response to GL 96-04 are based on blackness tests which measure gaps and end-shrinkage in the Boraflex. Blackness tests do not provide an indication of areal density. At that time, Boraflex shrinkage was considered to be the dominate mechanism for gap formation and was predicted to saturate at 4.1 % of the panel length (i.e., the EPRI shrinkage model). "Equilibrium" gap conditions would exist if similar gap distributions were obtained over at least two campaigns, consistent with the EPRI shrinkage assumption reflected in Figure 1 of the November 23, 2010 letter.

At the time of the GL response, a few panels had reached the shrinkage model condition and were expected to exhibit equilibrium. The seventh Blackness test campaign was conducted in March, 1999. Twelve of the 208 panels tested contained gaps that exceeded the expected shrinkage values. This indicated that edge erosion was a larger factor than previously considered.

On the basis of those test results, a dose threshold was established which bounded the large gaps observed in the seventh campaign. A revised criticality analysis was performed that eliminated credit for Boraflex in those cells which had experienced radiation in excess of the threshold (Region II). With the decision to not credit the Boraflex in that region, further blackness testing was of little value; thus, the accelerated irradiation and corresponding blackness tests were eliminated.

In summary, the use of a gamma dose limit, based on the blackness test data, along with an areal density limit was implemented to identify cells for which Boraflex will not be credited. This limit is monitored by periodic Racklife calculations. As the Region I areal density and gamma dose approached the threshold values, a Badger test campaign was scheduled and completed in 2007. The response to RAI #2 above describes plans for future testing.

**RAI # 5**

On page 1 of attachment 1 of its September 8, 2010 letter, the licensee states that, "the total panel gap as a percent of the initial panel length vs. dose follows the [4.1 percent] EPRI [Electric Power Research Institute] Boraflex shrinkage model until the dose exceeds 2.3E10 rads." Further, on page 2 the licensee states that all panel losses greater than the 4.1 percent EPRI shrinkage model result occur above this dose value. Please discuss the 4.1 percent EPRI shrinkage model dose as it relates to your acceptance criteria analysis for continued operation.

**Response**

The EPRI shrinkage model has no direct impact on the criticality safety analysis. However, as shown in Figure 1 of the November 23, 2010 letter, GGNS observed that a change in the Boraflex gap performance can occur at doses above that value.

GGNS uses that dose threshold as one criterion to conservatively designate each storage cell in the SFP as either a Region I or a Region II cell. The criticality safety analysis does not credit Boraflex for panels in Region II. Note that while the CSA does credit Boraflex for panels in Region I, these panels are conservatively modeled using gap configurations that bound the gap distributions measured in the seventh blackness campaign, which occurred well above the 2.3E10 rad dose level.

The CSA includes configurations with (Region I) and without (Region II) credit for Boraflex panels. As described in response to RAI #2, criteria are identified to determine when a storage cell classification moves from Region I to Region II. The acceptability of the racks for continued use is maintained as long as these criteria remain applicable as described in the Badger test acceptance criteria in response to RAI #2.

**RAI # 6**

Please discuss the extent to the Region II expansion as it relates to the degradation in the Boraflex panels in the spent fuel pool. In other words, discuss how the new Region II locations are determined and added after each Blackness and BADGER test campaign. Please provide a spent fuel pool map illustrating the current Region I and II locations.

**Response**

As described in response to RAI # 2, new Region II locations are established based on Racklife calculations. If either the Region I Racklife areal density or dose criteria are not met for a given Boraflex panel, the two fuel storage cells face-adjacent to that panel are classified as Region II storage locations. Region II storage locations are controlled in one of two ways:

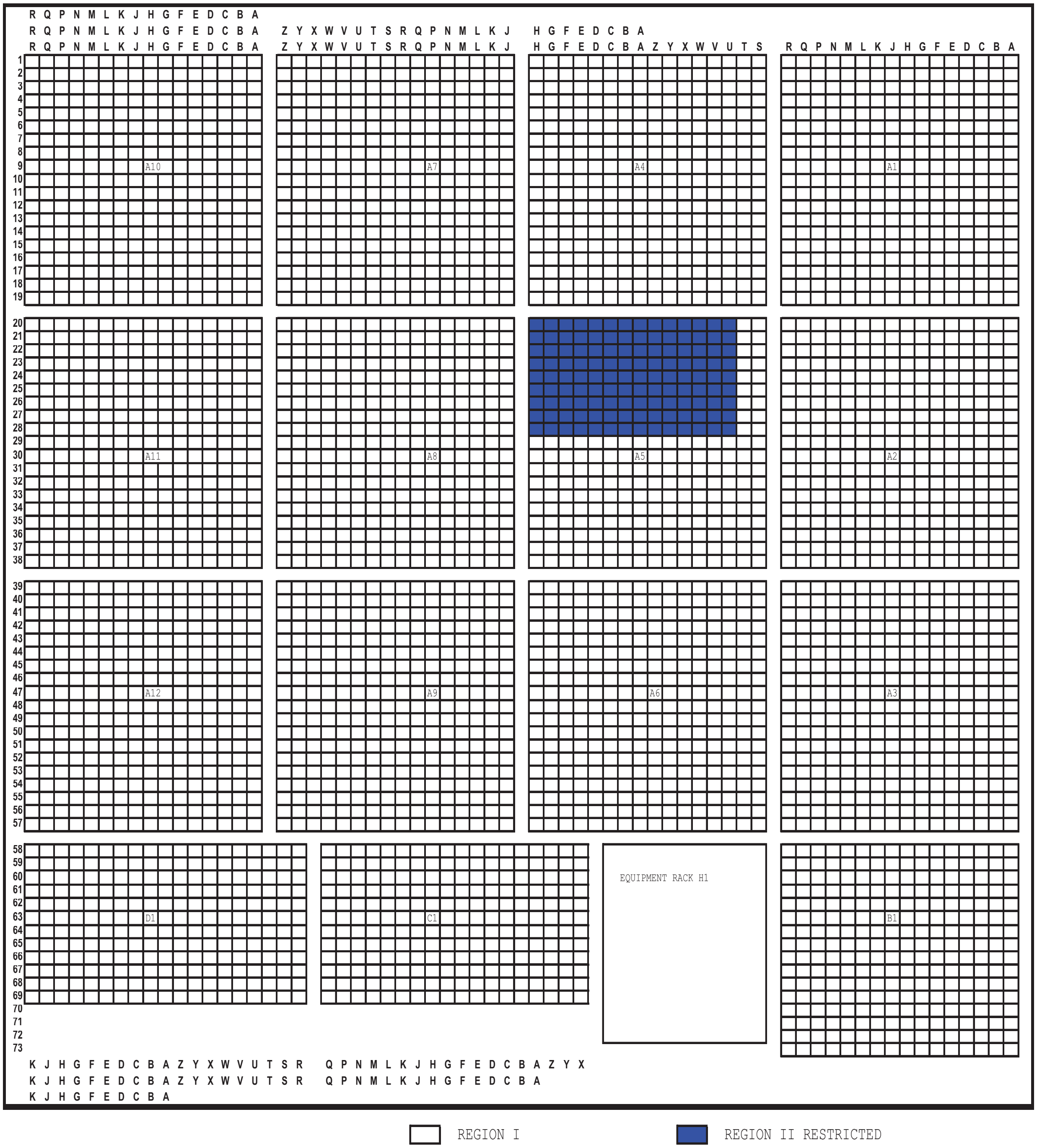
- Fuel is restricted from being loaded into applicable cells;

- Once a minimum contiguous area is configured as a Region II area, an acceptable configuration as demonstrated in the CSA is established. Cells that still meet Region I criteria may be conservatively declared as Region II cells in order to establish a minimum contiguous area and implement the Region II storage configuration.

The Racklife calculations include extrapolated rack performance to project which panels will reach the Region II criteria before the next Racklife calculation.

The spent fuel map, illustrating the current region designations of the storage cells, is provided in Figure 1. Note that the current Region II area has not been expanded since its initial creation in 2000.

Figure 1: GGNS SFP Map



**RAI # 7**

Please discuss the calibration technique and reference panel used for the Blackness and BADGER campaigns. In particular, discuss the reference panel's areal density (i.e., nominal areal density, minimum design measurement areal density).

**Response**

The seventh GGNS Blackness test was performed with a calibration cell that included known gaps of various sizes to determine detector response.

The GGNS Badger campaign used the standard Badger calibration process. A calibration cell with neutron absorber material of varying areal densities was used to determine the detector response to changes in areal density. A reference panel in the spent fuel pool was used to determine the baseline detector response. The reference panel was selected based on its relatively low gamma dose. Irradiated fuel had not been loaded into the storage cells face-adjacent to the reference panel. The panel dose from fuel in nearby storage cells is estimated at ~8E8 rads based on Badger measured shrinkage results.

The GGNS Boraflex design areal density is 0.0204 +/- 0.001 $gm/cm^2$. The Badger results are expressed using values relative to the nominal design value.

**RAI # 8**

On pages 5 and 6 of attachment 1 of its September 8, 2010 letter, it is unclear to the staff how the fractions of panels and gap sizes in figures 2, 3, 4 and 5 correlate to the total number of panels tested and gap sizes observed and what tests (e.g., Blackness, BADGER) they came from. Please discuss the type of testing performed and total number of panels and gap sizes that correlate to these fractions in these figures.

**Response**

The measured results presented in the referenced figures of the November 23, 2010 letter are derived from the seventh blackness test campaign, conducted in 1999. Blackness tests measure gaps in Boraflex but do not measure areal density. That campaign measured 208 panels that were subject to accelerated irradiation, as described in the November 23, 2010 letter. A total of 362 gaps were identified. Typically 1 to 2 gaps per panel were observed; a single panel exhibited the maximum of 7 gaps. Tests results were converted to the probability distributions (see the November 23, 2010 letter, Figures 3 and 4), which are bounded by the criticality analysis assumptions.

For example, Figure 2 illustrates that of the 208 panels tested, 10% exhibited no gaps; approximately 38% exhibited 1 gap, etc. The figure also identifies that the CSA assumption was 50% of the panels have 1 gap and 50% have 2 gaps.

Figure 3 shows the summation of the individual gaps measured for each panel to give the total panel loss due to gaps. Of the 208 panels measured in campaign 7, 21 did not exhibit gaps. Figure 3 is conservatively based on the remaining 187 panels. For example, approximately 32% of the 187 panels tested show a total panel loss due to gaps of 2.1 to 3 inches. The analysis conservatively assumed that total panel loss due to gaps was larger than the measured losses.

Figure 4 reflects the gap size (in inches) of individual gaps. In other words, of the 362 gaps measured, approximately 41% of the gaps measured 0.51 to 1 inch. The analysis conservatively assumed the majority of the gap sizes were larger than what was measured.

Figure 5 reflects the axial locations of the 362 gaps measured during the test campaign.

**Attachment 2**

**GNRO-2011/00017**

**Grand Gulf Nuclear Station, Unit 1 Extended Power Uprate**

**List of Regulatory Commitments**

**List of Regulatory Commitments**

The following table identifies those actions committed to by Entergy in this document. Any other statements in this submittal are provided for information purposes and are not considered to be regulatory commitments.

| COMMITMENT | TYPE (Check one) | | SCHEDULED COMPLETION DATE (If Required) |
|---|---|---|---|
| | ONE-TIME ACTION | CONTINUING COMPLIANCE | |
| 1. In order to ensure the Badger/Racklife uncertainty remains valid, an additional Badger measurement will be performed prior to the end of 2012.<br>The 2012 test will consist of at least 30 panels. The Badger to Racklife uncertainty will be developed from the test results. This value will be considered acceptable if it is less than the existing Badger/Racklife uncertainty 0.0022 (see above). Additionally, the minimum Badger areal density results will be confirmed to be greater than the CSA assumption of 0.0133 $gm/cm^2$. The gap size and location probability distributions will also be compared to those used in the CSA. The acceptability of these parameters will be based on verifying that all of the CSA distributions bound the corresponding Badger measured distributions. Alternatively, the measured gap distributions are acceptable if the CSA calculations are repeated using the measured gap distributions and the resulting 95/95 k-effective is bounded by the corresponding CSA Region 1 result (see Table 1 of NEDC-33621P, Grand Gulf Nuclear Station Fuel Storage Criticality Safety Analysis of Spent and New Fuel Storage Racks, Attachment 2 to the November 23, 2010 letter). | x | | **12/31/2012** |
| 2. The need for additional tests will be determined following the 2012 test campaign, based on the test results along with projected rack performance. | x | | **12/31/2013** |