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10 CFR 50.90
L-2010-035

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington D.C. 20555-0001

Re: Turkey Point Units 3 and 4
Docket Nos. 50-250 and 251
License Amendment Request No. 204
Spent Fuel Pool Criticality Analysis Taking Credit for Boraflex

References:

1. Letter from B. L. Mozafari (USNRC) to J. A. Stall (FPL), "Turkey Point Plant Units 3 and 4 - Issuance of Amendments Regarding Spent Fuel Boraflex Remedy (TAC No. MC9740 and MC9741)," July 17, 2007.

2. Letter from Michael Kiley (FPL) to USNRC, "License Amendment 234 for Turkey Point Unit 3, Notice of Inability to Implement", L-2009-268, November 13, 2009.

3. Letter from Michael Kiley (FPL) to USNRC, "Turkey Point Unit 3 – Docket No. 50-250, Spent Fuel Pool Boraflex Actions", L-2009-295, dated December 31, 2009.

Florida Power and Light Company (FPL) submitted an application for license amendments to apply a Boraflex Remedy to the Spent Fuel Pools (SFP) for Turkey Point Units 3 and 4. This application was approved as License Amendment Nos. 234 and 229, respectively, in Reference 1. After approval, FPL informed the NRC of the inability to implement Unit 3 Amendment 234 by the specified implementation date (Reference 2). In Reference 3, FPL informed the NRC of the actions that it would take to address the status of the Boraflex neutron absorber in the Unit 3 SFP until Amendment 234 can be implemented. Among the actions, FPL committed to submit to the NRC a License Amendment Request (LAR) updating the Unit 3 SFP licensing basis by February 28, 2010.

This LAR facilitates the implementation of previously approved Amendment 234 and documents the technical basis and justification to continue to credit Boraflex material in the criticality analysis for the Turkey Point Unit 3 SFP until September 30, 2012. By this date, FPL will have sufficient empty storage cells available by fuel removed from the SFP into dry casks or sufficient Metamic® inserts will be manufactured, such that the storage configurations of Amendment 234 can be fully implemented in the SFP. In addition, since the Turkey Point Technical Specifications (TS) are common to both units, administrative changes are needed regarding Unit 4 to clarify the SFP TS applicable to each unit upon approval.

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FPL has determined that the LAR provided in this application results in a No Significant Hazards Consideration for Turkey Point Units 3 and 4. Attachment 1 is the evaluation of the proposed TS changes. Attachment 2 is the criticality analysis for Unit 3 SFP Region II continued reliance on Boraflex. Attachment 3 contains the marked-up TS pages indicating the proposed changes. Attachment 4 discusses FPL's Boraflex Management Program for Turkey Point.

The Plant Nuclear Safety Committee has reviewed the proposed amendment. In accordance with 10 CFR 50.91(b)(1), copies of the proposed amendment are being forwarded to the State Designee for the State of Florida.

FPL requests approval of this application within 12 months of receipt by the NRC. Implementation by FPL will be within 60 days of license amendment issuance by the NRC.

Please contact Mr. Robert Tomonto at 305-246-7327 if there are any questions about this license amendment application.

I declare under penalty of perjury that the foregoing is true and correct.

Very truly yours,

2/25/10
Executed on

Michael Kiley
Vice President – Turkey Point Nuclear Plant

Attachments:
1) Evaluation of Proposed Technical Specification Changes
2) Unit 3 Spent Fuel Pool Criticality Analysis Crediting Boraflex
3) Marked-up Technical Specification Pages
4) Turkey Point Boraflex Management Program

cc: Regional Administrator, Region II, USNRC
Senior Resident Inspector, USNRC, Turkey Point Nuclear Plant
USNRC Project Manager for Turkey Point
Mr. William Passetti, Florida Department of Health

Attachment 1

Florida Power and Light Company
Turkey Point Units 3 and 4
Renewed Facility Operating License Nos. DPR-31 and DPR-41
Docket Nos. 50-250 and 50-251
License Amendment Request Regarding a Spent Fuel Pool Criticality Analysis for Unit 3 Taking Credit for Boraflex

Evaluation of Proposed Changes

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1.0 BACKGROUND

This License Amendment Request (LAR) documents the technical basis and justification to allow implementation of Unit 3 License Amendment 234 and credit Boraflex as a neutron absorption material as appropriate in Region II of the Turkey Point Unit 3 Spent Fuel Pool (SFP).

The Turkey Point Unit 3 SFP currently uses a "Distinct Zone Two Region" rack design. Region I was designed for storing fresh fuel (i.e., high reactivity fuel), while Region II was designed for storage of irradiated fuel (i.e., low reactivity fuel). The SFP is currently licensed for a storage capacity limited to no more than 1404 assemblies in the two region storage racks and no more than 131 fuel assemblies in the Cask Area Rack. The total SFP storage capacity is limited to no more than 1535 assemblies. The Region I and II racks (not the Cask Area Rack) use Boraflex as the neutron absorber.

Boraflex is a silicone-based polymer material that contains the neutron absorber Boron-10 in the form of small particles of boron carbide. When Boraflex is subjected to the high gamma doses and cooling water flow of a SFP environment, the polymer can degrade and Boron-10 is removed from the rack panel. The reduction in the amount of Boron-10 below the design basis areal density requirement will adversely affect the operability of those storage cells.

In 1999, Florida Power and Light Company (FPL) requested changes to the Technical Specifications (TS) for Turkey Point Units 3 and 4 to allow crediting soluble boron in the SFP criticality analyses (Reference 9.9). These analyses were performed using methodology developed by the Westinghouse Owners Group (WOG) and described in WCAP-14416-NP-A, Rev. 1. The Nuclear Regulatory Commission (NRC) found the criticality aspects of the amendment request acceptable for meeting the requirements of General Design Criterion (GDC) 62 for the prevention of criticality during spent fuel storage and handling (Reference 9.1). The analysis justified credit for soluble boron along with a reduced amount of Boraflex present in the neutron absorber panels in the SFP.

By letter dated July 27, 2001 (Reference 9.10), the NRC staff concluded, regarding identified non-conservatisms in axial burnup biases in the Westinghouse methodology of WCAP-14416, that "Because of the large conservatisms used in other aspects of the methodology, the staff does not view the non-conservatisms in the calculated biases as a safety concern." Additionally, the staff concluded that "as a result of identified non-conservatisms in a Westinghouse topical report (TR) on this subject, future licensing submittals from licensees will no longer be able to reference the methodology in the affected document."

In 2001, FPL evaluated the extent of dissolution of Boraflex panels in the Turkey Point Unit 3 SFP based on Boraflex surveillance results using the Boron-10 Areal Density Gage for Evaluating Racks (BADGER) testing methods, and concluded that the condition of the Unit 3 SFP was degraded and nonconforming.

FPL informed the NRC of FPL's determination that: the Turkey Point Unit 3 SFP was in a degraded and nonconforming condition due to Boraflex panel dissolution, that administrative controls were established to limit the use of the affected SFP rack cells, and that the BADGER testing surveillance interval was reduced from a five-year to a three-year schedule, to monitor more closely the condition of the Boraflex material (Reference 9.2).

The administrative controls included the implementation of compensatory measures to enhance the reactivity control capability of the Unit 3 SFP and satisfy the requirements of TS 5.5.1.1.a and 5.5.1.1.b. The measures resulted in a situation in which the administrative controls employed in the SFP were more restrictive than the TS to ensure that the k_{eff} criteria of TS 5.5.1.1.a and 5.5.1.1.b were satisfied.

NRC Administrative Letter (AL) 98-10 provides NRC staff expectations regarding correction of TS when these are insufficient to assure plant safety. The expectation is that once administrative controls are implemented, a LAR shall be submitted in a timely fashion to correct the TS. FPL recognized the need for this corrective action, and developed a LAR, which was submitted in 2006 to resolve the degraded and nonconforming condition of the SFP, correct the non-conservative TS, and eliminate reliance on the methodology of WCAP-14416 (Reference 9.5).

The 2006 LAR (Boraflex Remedy) revised the SFP storage TS to remove reliance on Boraflex as the neutron absorber material in the analysis. This amendment was approved by the NRC in 2007 (Reference 9.4). The neutron absorbing function, previously performed by Boraflex, was replaced by a combination of inserts (Metamic™ rack inserts within Region II, and rod cluster control assemblies (RCCA) within Region I and II), credit for post-irradiation cooling time, and more restrictive fuel loading patterns. A Metamic™ surveillance program was also developed to replace the Boraflex monitoring program after implementation of the Boraflex Remedy. (See Reference 9.4.)

The LAR was approved by the NRC in 2007 as TS Amendments 234 (Unit 3) and 229 (Unit 4) (Reference 9.4). Unfortunately, late in 2008 and early 2009, it was determined that more than 95% of the 400 Metamic™ inserts produced were out of specifications. At the time of this manufacturing failure, FPL had no alternative but to continue efforts with the insert manufacturer to implement an acceptable panel for insertion in the Turkey Point SFPs. Other alternatives, such as purchasing RCCAs, were not available in 2008, because they required lead times that would delay final implementation of the Boraflex Remedy until 2012.

FPL informed the NRC in 2009 (Reference 9.3) that Amendment 234 could not be implemented by the implementation date stated for Unit 3, according to Reference 9.4, since Metamic™ inserts were not available in sufficient quantity to be installed at the plant. FPL is submitting this LAR to allow use of Amendment 234 with the addition of acceptable 2x2 arrays that credit Boraflex as neutron absorbing material (as appropriate) until September 30th, 2012.

By this date, sufficient empty storage cells will be made available by fuel removed from the SFP into dry casks or sufficient inserts will be manufactured such that the storage configurations of Amendment 234 can be fully implemented in the SFP. It should be noted that the evaluation of the Boraflex allowable arrays uses the same methodology that was approved for use in Amendment 234 and does not rely upon the methodology of WCAP-14416.

The Reference 9.7 letter was issued by FPL to the NRC with a commitment to provide a LAR by February 28, 2010 to update the Unit 3 SFP licensing basis. This LAR satisfies the commitment and the technical basis applies only to the Turkey Point Unit 3 SFP. The TS changes discussed below (with the exception of administrative changes necessary due to the common TS for Units 3 and 4) are applicable to Unit 3.

2.0 PURPOSE

Metamic™ rack inserts are currently not available in sufficient quantity for placement into the SFP due to manufacturing issues. These rack inserts are intended for use only in Region II of the SFP. FPL evaluations suggest that implementation of Amendment 234 for Turkey Point Unit 3 without credit for Boraflex would require placement of approximately 500 inserts in the SFP. Currently, there are a small number of discharged RCCAs in the SFP available for placement, a limited number of Metamic™ inserts, and a limited number of empty storage cells; however, these are insufficient to allow full implementation of Amendment 234. Reliance on a significant number of Metamic™ rack inserts had been a pre-requisite for implementation of the Boraflex Remedy.

Therefore, FPL desires to utilize the methodology approved by Amendment 234 to take credit for the Boraflex currently present in Region II of the SFP in the criticality analysis, as a neutron absorbing material (as appropriate). NRC acceptance is needed, since it was established in both the FPL LAR (Reference 9.5) and the NRC approval (Reference 9.4) that the purpose of the amendment was to replace the neutron absorbing function of

Boraflex, and that Boraflex is not assumed in the criticality analysis that supports Amendment 234. This credit is temporary and will be effective until no later than September 30th, 2012, by which time sufficient empty storage cells will be made available by fuel removed from the SFP into dry casks or sufficient inserts will be manufactured such that the storage configurations of Amendment 234 can be fully implemented in the SFP. The analysis performed to credit Boraflex was performed using the same criticality methodology used in the development of Amendment 234, and does not rely upon WCAP-14416-NP-A, Rev. 1.

NRC Generic Letter 96-04 (Reference 9.6) discusses that, when Boraflex is subjected to gamma radiation in a SFP environment, the silicon polymer matrix becomes degraded and silica filler, boron carbide, along with soluble silica are released. FPL has implemented a comprehensive Boraflex Management Program (BMP) to monitor Boraflex degradation using the Electric Power Research Institute (EPRI) RACKLIFE computer code to model and predict Boraflex degradation and periodic neutron attenuation testing of a sample of SFP Boraflex panels using the EPRI developed BADGER testing technique. As part of the BMP, FPL has implemented administrative controls to restrict the use of any SFP cell that is predicted to have panel dissolution beyond the assumption in the criticality analysis, in order to ensure the criticality design basis requirements continue to be satisfied. These administrative controls prohibit the storage of a fuel assembly in any affected SFP storage cell, unless an alternate storage configuration has been demonstrated to compensate for the loss of Boraflex. Attachment 4 to this LAR provides a discussion on the details of the BMP. The BMP will continue to be maintained for as long as FPL continues to credit Boraflex for criticality control.

This LAR proposes in Attachment 3 a set of marked-up TS pages that incorporate the TS extracted from Amendments 234 and 229 (Reference 9.4), which will be implemented upon approval of this LAR. These proposed changes include:

1. Those TS changes applicable to Unit 3, which implement the requirements of Amendment 234.

2. Changes for Unit 3 providing new allowable storage configurations for arrays crediting Boraflex neutron absorption proposed by this LAR.

3. Those TS changes applicable to both Units (Unit 3 Amendment 234 and Unit 4 Amendment 229), which are considered editorial and administrative in nature.

4. Administrative changes needed to designate the appropriate Unit for these TS; required since currently Units 3 and 4 have a common TS.

Section 4.0 provides a description of each of the proposed changes. No additional technical justification is provided for the TS changes from Amendments 234 and 229, as these have been previously approved by the NRC and may be implemented at any time by FPL. Attachment 2 provides a technical justification for the proposed changes incorporating the storage configurations crediting Boraflex. Upon completion of the Boraflex Remedy for Unit 3, the TS will revert back to those approved changes in Amendment 234 for Unit 3.

3.0 REGULATORY REQUIREMENTS

The following design basis criterion is provided in the Turkey Point UFSAR Section 9.5.2.1, related to the use of neutron absorber materials in the SFP:

> Criticality in the new and spent fuel storage pits shall be prevented by physical systems or processes. Such means as geometrically safe configurations shall be emphasized over procedural controls. (1967 Proposed GDC 66)

Also, according to UFSAR Section 9.5.2.1, the spent fuel storage racks are designed:

a) To maintain subcritical conditions with a k_{eff} of less than 1.0 with unborated water in the spent fuel pit;
b) To maintain subcritical conditions with a k_{eff} of less than or equal to 0.95 with a specified level of soluble boron;
c) To preclude the possibility of storing a fuel assembly in other than prescribed locations;
d) In accordance with the NRC, "OT Position for Review and Acceptance of Spent Fuel Storage and Handling Applications," dated April 14, 1978 (as amended by the NRC letter dated January 18, 1979) and SRP Section 3.8.4[3].

In addition to the above, Turkey Point elected to comply with the requirements of 10 CFR 50.68(b).

The present LAR complies with the above regulatory basis for the SFP criticality analysis, and the BMP currently in place at Turkey Point.

4.0 PROPOSED CHANGES

TS Amendment 234 for Unit 3 and 229 for Unit 4 were previously approved by the NRC, but were not implemented by FPL. FPL plans to incorporate the Amendment 234 changes for Unit 3, as early as feasible.

However, while FPL is working to that end, FPL needs the NRC's approval to incorporate the Amendment 234 changes in the current TS, while taking credit for Boraflex as a neutron absorbing material. Note that, the technical changes corresponding to Unit 4 from Amendment 229 will not be implemented with this review and approval. Since there are also editorial and administrative changes in Amendments 234 and 229, which apply to both units, these will be implemented as part of this LAR. Because the set of TS is provided in a single document (rather than one set of TS for Unit 3 and one set for Unit 4), this section provides an explanation of the Amendment 234 and 229 changes that will be incorporated by this LAR.

Attachment 3 provides the TS mark-ups for the changes that follow. Section 4.1 provides the explanation of the changes being implemented for Unit 3. Section 4.2 provides a description of the additional TS changes resulting from incorporating changes applicable to Unit 4 and TS changes from Amendments 234 and 229 applicable to both units.

4.1 Unit 3 TS Changes

The changes applicable to Unit 3 in this LAR provided below were previously described and approved in Amendment 234, except for one additional change for Figure 5.5-5, which is justified in this LAR. A summary of these changes follows:

Index Section

TS page XIV (Index) was revised to add the titles of the tables being added from Amendment 234 and are applicable to Unit 3 only. This change is editorial.

Limiting Condition for Operation (LCO) 3.9.14.c

Amendments 234 (Unit 3) and 229 (Unit 4) revised this LCO to include all the storage racks in the SFP (including the Cask Area Rack), expanded the list of parameters to include cooling times that constrain fuel storage in Region II, and referred to Section 5.5.1, rather than to Table 3.9-1, since this table was to be deleted. Because only Unit 3 changes are to be implemented from Amendment 234 for this LAR, the LCO from Amendments 234 and 229, which was going to replace LCO 3.9.14c, is applied to Unit 3 only, as follows:

c. The combination of initial enrichment, burnup, and cooling time of each fuel assembly stored in the Spent Fuel Pit shall be in accordance with Specification 5.5.1.(Unit 3 only.)

Surveillance Requirement (SR) 4.9.14

The change to this SR is editorial and consists of renumbering SR 4.9.14 to SR 4.9.14.1 to distinguish it from a new SR added (4.9.14.2) applicable to Unit 3.

SR 4.9.14.2 (New)

This change consists of adding a new requirement to inspect a representative sample of Metamic™ inserts. This item applies to Unit 3 only.

Design Feature 5.5.1.1.f

This item will be added, which will apply to Unit 3 only, as follows:

f. For Unit 3 only, fresh or irradiated fuel assemblies not stored in the cask area rack shall be stored in accordance with Specification 5.5.1.4 or configurations that have been shown to comply with Specification 5.5.1.1.a and 5.5.1.1.b using the NRC approved methodology in UFSAR Chapter 9.

Design Feature 5.5.1.4 (new)

This is a new section which will apply to Unit 3 only, as follows:

This feature is applicable to Unit 3 only. Credit for burnup and cooling time is taken in determining acceptable placement locations for spent fuel in the two-region spent fuel racks. Fresh or irradiated fuel assemblies shall be stored in compliance with the following:

a. Any 2x2 array of Region I storage cells containing fuel shall comply with the storage patterns in Figure 5.5-1 and the requirements of Table 5.5-1 and 5.5-2, as applicable. The reactivity rank of fuel assemblies in the 2x2 array (rank determined using Table 5.5-3) shall be equal to or less than that shown for the 2x2 array.

b. Any 2x2 array of Region II storage cells that does not credit Boraflex and containing fuel shall:

i. Comply with the storage patterns in Figure 5.5-2 and the requirements of Table 5.5-1 and 5.5-2, as applicable. The reactivity rank of fuel assemblies in the 2x2 array (rank determined using Table 5.5-3) shall be equal to or less than that shown for the 2x2 array,

ii Have the same directional orientation for Metamic inserts in a contiguous group of 2x2 arrays where Metamic inserts are required,

iii. Comply with the requirements of 5.5.1.4c for cells adjacent to Region I racks, and

iv. Comply with the requirements of 5.5.1.4d for cells adjacent to the spent fuel pit walls.

c. Any 2x2 array of Region II storage cells that interface with Region I shall comply with the rules of Figure 5.5-3. Arrays II-E and II-F may interface with Region I without special restriction. Arrays II-G and II-H shall not interface with Region I.

d. Any 2x2 array of Region II storage cells that does not credit Boraflex may adjoin a row of assemblies with a reactivity rank of II-2 (or lower) that is located in the outer row adjacent to the spent fuel pit wall. The outer row of reactivity rank II-2 (or lower) fuel assemblies need not contain any Metamic inserts of full length RCCAs, as long as the following additional requirements are met:

i. Fuel is loaded to comply with the allowable storage patterns defined in Figure 5.5-4, and

ii. Arrays II-E and II-F are loaded without any additional restriction on that 2x2 array. Arrays II-E and II-F do not have empty cells, Metamic inserts, or RCCAs that restrict the interface with the adjoining reactivity rank II-2 (or lower) fuel assemblies.

e. Any 2x2 array of Region II that credits Boraflex and containing fuel shall comply with the allowable storage patterns defined in Figure 5.5-5.

Tables 5.5-1 through 5.5-3, and Figures 5.5-1 through 5.5-4

These tables and figures were to be added in Amendments 234 and 229 to reflect the revised spent fuel storage configurations and Region I/II storage arrays already approved by the NRC. These tables will be added to the TS, but applying only to Unit 3.

Figure 5.5-5

This is the only new change provided by this LAR, which has not been previously approved by the NRC. The figure shows the arrays II-G and II-H crediting Boraflex material in the SFP. The acceptability of this change is discussed in Section 5.2 and Attachment 2 of this LAR. This addition to the TS will be in effect no later than 2400 hrs on September 30th, 2012. The added figure applies to Unit 3 only.

4.2 Additional U3/U4 Administrative and Unit 4-specific Changes

The administrative or editorial changes below, which are applicable to both units, were previously approved by the NRC in Amendments 234 and 229. The changes applicable to Unit 4 only are the result of incorporating the Unit 3 changes from Amendment 234, which resulted in necessary conforming changes for Unit 4.

Index

TS page XIV is revised to remove revision bars and modify the amendment numbers. All of these are applicable to both units. Also, a "Unit 4 only" identifier was added to a table title being revised to show that it is only applicable to Unit 4.

SR 4.9.1.4

SR 4.9.1.4 removes the SFP boron concentration surveillance requirement from the Refueling Operations Specifications 3/4.9. This SR is a duplicate to the surveillance requirement in TS Section 4.9.14, Spent Fuel Storage. This change applies to both units and it is administrative.

LCO 3.9.14.a

LCO 3.9.14.a, concerning the maximum enrichment loading of fuel assemblies stored in the SFP, is deleted from the LCOs and takes credit for currently being located in the Design Features section (5.5.1.1.d), consistent with Westinghouse Improved Standard Technical Specifications (ISTS), NUREG-1431, Revision 3. This change applies to both units and it is administrative.

LCO 3.9.14.b

As a result of deleting LCO 3.9.14.a, the other LCOs are renumbered. This change applies to both units and it is an editorial change.

LCO 3.9.14.c

Based on the discussion in the previous section for item LCO 3.9.14.c, there is a need to renumber LCO 3.9.14.c to 3.9.14.b (editorial), and keep it for Unit 4 only.

Action 3.9.14.a

This action was to be deleted by Amendments 234 and 229 since LCO 3.9.14.a was being deleted, and LCO 3.9.14.c was being modified. To comply with the requirement to incorporate Unit 3 TS changes only with this LAR, Action 3.9.14.a will be maintained with minor changes anticipating the changes to LCO 3.9.14(a,b,c). So, TS Action 3.9.14.a will be as follows:

a. With condition b or c not satisfied, suspend movement of additional fuel assemblies into the Spent Fuel Pit of the affected unit and restore the spent fuel storage configurations to within specified conditions. This action applies to each Unit separately, as applicable.

Action 3.9.14.c

A new item Action 3.9.14.c approved for Amendments 234 and 229 was added to segregate spent fuel conditions that are unrelated to reactor operations and prevent them from affecting reactor operations. This change applies to both units and reads as follows:

c. The provisions of Specification 3.0.3 are not applicable.

Table 3.9-1

This table was to be deleted by Amendments 234 and 229 since a set of tables were to be added to Section 5.5.1 applicable to both units to align the revised spent fuel storage configurations with the criticality analyses. Since the addition of these tables to the TS will apply to Unit 3 only, Table 3.9-1 is retained for Unit 4 only, as indicated.

Design Feature 5.5.1.1, a, b, d, e

This item was to be revised by Amendments 234 and 229 for clarification, to note the discussion in UFSAR Chapter 9, and to be consistent with the Westinghouse ISTS. The change applies to both units.

Design Feature 5.5.1.3

Since only the Unit 3 items from Amendments 234 and 229 will be implemented for this LAR, the current Design Feature 5.5.1.3 text will indicate that it applies to Unit 4 only. The corresponding requirements for Unit 3 are provided with the establishment of new Design Feature 5.5.1.4.

Section 5.6 and Table 5.6-1

These items were to be relocated by Amendments 234 and 229 to follow the page numbering for the new tables and figures added to the TS in Section 5.5. This change is editorial, and it applies to both units.

5.0 TECHNICAL JUSTIFICATION

The NRC-approved Amendment 234 contained the following TS requirement in Section 5.5.1.1.f:

> "Fresh or irradiated fuel assemblies not stored in the cask area rack shall be stored in accordance with Specification 5.5.1.3 or configurations that have been shown to comply with Specification 5.5.1.1.a and 5.5.1.1.b using the NRC approved methodology in UFSAR Chapter 9."

The NRC Safety Evaluation Report (SER) for Amendment 234 prohibited taking credit for Boraflex in the SFP, and it was established in both the FPL LAR (Reference 9.5) and the NRC SER that the purpose of the amendment was to replace the neutron absorbing function of Boraflex in Region II. Accordingly, FPL has determined that NRC approval is required to credit Boraflex to comply with TS 5.5.1.1.f.

FPL proposes to credit Boraflex in the criticality analysis at an aerial density of 0.006 gms B-10/cm^2 for cells determined to retain a Boraflex aerial density at or above this value. The criticality analysis employs the methodology used in Amendment 234 as described in Reference 9.5. Attachment 2 provides a description of the criticality analysis performed for the proposed storage arrays crediting Boraflex.

In addition, FPL will maintain the BMP in conjunction with approval of this LAR for as long as Boraflex is credited for neutron absorption in the Turkey Point Unit 3 SFP, but no later than September 30^{th}, 2012. FPL will delay the start of the Metamic^{TM} surveillance program documented in Reference 9.5 until Metamic^{TM} inserts are placed into the SFP. Once this LAR is approved by the NRC accepting FPL's justification for crediting Boraflex, the TS changes in Amendment 234 already approved by the NRC will be fully implemented for Unit 3, as described in this LAR.

The assumptions in the design basis criticality analysis are intended to provide a conservative representation of the SFP in light of the progressive degradation of the Boraflex panels. The analysis conservatively assumes that all panels have conservative shrinkage, gaps conservatively assumed to be located at the same axial position in each panel, and the design basis dissolution. With respect to dissolution, the actual condition has a variation ranging from panels with as-built B-10 areal density above the minimum design basis assumption to some panels with areal density that has fallen below the design basis dissolution assumption.

Section 5.1 below and Attachment 4 provide descriptions of how these degradation processes are accounted for, monitored, and factored into an overall BMP that assures that the design basis assumptions associated with the SFP criticality analysis that credit Boraflex panels will be met.

5.1 Boraflex Management Program

The Turkey Point BMP described in Attachment 4 to this LAR is based on two industry accepted tools; the RACKLIFE software package for predicting Boraflex degradation and the BADGER in-situ B-10 areal density testing technique for measuring Boraflex degradation. Both were developed under the auspices of EPRI to aid utilities in the management of Boraflex degradation. FPL has been using these tools in the Unit 3 SFP to monitor Boraflex panels as a commitment associated with License Amendments 206 and 200 (Reference 9.1) to credit the use of soluble boron in the SFP.

The RACKLIFE code is routinely used to predict the expected degradation of Boraflex in terms of percent boron carbide (% B_4C) loss in each of the Region II panels prior to and during the core off-loads, reloads and storage throughout the current operating fuel cycle. The storage cell is conservatively declared unusable, unless an alternate storage configuration compensating for the loss of Boraflex is used, if any panel in the storage cell is predicted to fall below the design basis limit of 50% of its minimum certified B-10 areal density of 0.012 gms B-10/cm^2, i.e. 0.006 gms B-10/cm^2.

The continuing ability of the RACKLIFE code to predict Boraflex dissolution in order to effectively manage SFP storage has been periodically evaluated by in-situ Boraflex panel measurements using the BADGER technique. This technique measures the attenuation of thermal neutrons passing through the panel to measure its relative % B-10 areal density remaining and the presence of gaps/shrinkage in a select sample of Region II panels. The measured % B-10 areal density remaining from the BADGER surveillance is then compared with the calculated % B_4C (B-10 areal density) remaining in each of the sampled Boraflex panels from the RACKLIFE model. Comparison of the measured-to-predicted results for each BADGER test demonstrates that RACKLIFE is valid for the conservative prediction of Boraflex degradation at 0.006 gms B-10/cm^2 for Region II.

Based on the statistical analysis of the BADGER test results and the as-built areal density of the Boraflex panels, RACKLIFE conservatively predicts when a panel would reach the areal density of 0.006 gms B-10/cm^2 assumed in the design basis criticality analysis. Requiring action in accordance with the BMP ensures that the design basis k_{eff} criteria are satisfied with a 95/95 basis. Additionally, BADGER testing results indicate that gaps are randomly distributed over panel elevations and the average cumulative gap is well below 11.68 inches, such that the design basis criticality analysis assumptions for panel shrinkage and gapping continue to bound the actual conditions in the SFP.

Additional details regarding the BMP can be found in Attachment 4.

5.2 Criticality Analysis Crediting Boraflex

This criticality evaluation, described in more detail in Attachment 2, discusses and justifies use of two additional storage configurations in Region II racks at Turkey Point Unit 3. Unlike the arrays whose acceptability is documented in Amendment 234 (Reference 9.4), these two storage arrangements, Arrays II-G and II-H, neglect Metamic™ inserts but credit the presence of Boraflex in rack panels at an areal density of 0.006 gm B^{10}/cm^2. Other important characteristics of the Boraflex panels considered are documented in Attachment 2.

Neutron multiplication for storage Arrays II-G and II-H has been evaluated on a comparative basis, using the MCNP4a computer code (Reference 9.8), and considering fuel bundles having identical characteristics to those comprising the corresponding stored fuel arrangement from Amendment 234 where Metamic™ inserts are credited. Attachment 2 discusses details of the comparative criticality analyses, and why it is an appropriate technique for this application. MCNP4a was used to develop the permissible storage arrays documented in Amendment 234. Work discussed in Attachment 2 has credited the same set of code benchmarking studies, and utilized the same isotopic data sets which formed the basis for analyses of storage arrays documented in the Boraflex Remedy LAR (Reference 9.5).

Results of calculations presented in Attachment 2 demonstrate that both Array II-G and Array II-H are typically less than, or at worst comparably reactive to (i.e., yield a lower or statistically equal k_{calc}) the corresponding fuel storage arrays considered in Amendment 234. As effective neutron multiplication of each array included in FPL's Reference 9.5 application was demonstrated to be <1.0, with a 95% probability at a 95% confidence level, for the condition where Turkey Point fuel pool racks were flooded with un-borated water. The k_{eff} for Arrays II-G and II-H will also be <1.0 in the presence of pure water. Examination of these arrays, as well as prior calculations performed in the presence of soluble boron, supports a conclusion that both normal and accident condition soluble boron requirements will not be increased from values previously established as part of FPL's Boraflex Remedy application. At the prescribed soluble boron concentrations, none of the abnormal or accident conditions that have been identified as credible will cause the limiting reactivity to be exceeded (i.e., k_{eff} remains ≤ 0.95).

Arrays II-G and II-H are comprised of only Category II-2 and II-4 fuel, as is defined by TS Amendment 234 and the prior Reference 9.5-related analyses; therefore, loading curves used to select fuel for placement in these arrays are unchanged from those currently approved for use.

Additional details regarding the criticality analysis supporting the proposed additional Region II fuel storage arrays crediting Boraflex can be found in Attachment 2 of this LAR.

6.0 NO SIGNIFICANT HAZARDS DETERMINATION

The proposed license amendment to Renewed Facility Operating Licenses DPR-31 and DPR-41 for Turkey Point Units 3 and 4, respectively, will revise TS to allow implementation of previously approved Amendment 234 (Boraflex Remedy) with the temporary allowance for fuel storage in arrays crediting Boraflex as a neutron absorber in Region II of the Unit 3 SFP. While Boraflex storage configurations are employed under the current TS, this proposed amendment will revise these Boraflex storage configurations to employ the criticality analysis methodology from approved Amendment 234 and add these proposed additional storage configurations crediting Boraflex to those Boraflex free storage configurations previously approved in Amendment 234. The Boraflex free storage requirements of Amendment 234 will be implemented in Region I and in certain Region II arrays not crediting Boraflex. The Cask Area Rack is not affected by the proposed amendment. Administrative changes are also required for Turkey Point Units 3 and 4 due to the common TS, but these changes clarify which TS are applicable to each unit and do not alter the operation of Unit 4.

The current Boraflex Management Program will continue to be maintained for as long as FPL continues to credit Boraflex for criticality control in the Turkey Point Unit 3 SFP, but no later than September 30th, 2012. As part of the BMP, FPL has implemented administrative controls to restrict the use of any SFP cell that is predicted to have panel dissolution that has reduced the B-10 areal density beyond the assumption in the criticality analysis, in order to ensure the criticality design basis requirements continue to be satisfied. These administrative controls prohibit the storage of a fuel assembly in any affected SFP storage cell unless an alternate storage configuration has been demonstrated to compensate for the loss of Boraflex. In the proposed amendment, these alternate storage configurations are the Boraflex free configurations previously approved in Amendment 234.

Pursuant to 10CFR 50.92, a determination may be made that a proposed license amendment involves no significant hazards consideration if operation of the facility in accordance with the proposed amendment would not: (1) involve a significant increase in the probability or consequences of an accident previously evaluated; (2) create the possibility of a new or different kind of accident from any accident previously evaluated; or (3) involve a significant reduction in a margin of safety. Each consideration is discussed below.

6.1 Does operation of the facility in accordance with the proposed amendment involve a significant increase in the probability or consequences of an accident previously evaluated?

No.

The proposed amendment does not change or modify the fuel, any fuel assembly's inventory of fission products, the processes and equipment used to handle fresh or irradiated fuel, spent fuel storage racks, number of fuel assemblies that may be stored in the SFP, decay heat generation rate, or the SFP cooling and cleanup systems. This conclusion is the same as was determined by FPL in justifying, and by the NRC in approving, Amendment 234.

The proposed amendment was evaluated for impact on the following previously evaluated accidents:

a) A fuel handling accident (FHA),
b) A cask drop accident,
c) A fuel mis-positioning event,

d) A spent fuel pool boron dilution event,
e) A seismic event, and
f) A loss of spent fuel pool cooling event.

The probability of a FHA is not significantly increased because implementation of the proposed amendment will employ the same equipment and processes to handle fuel assemblies that are currently used. As was noted, no changes are being made to fuel handling equipment or to an assembly's interface with the fuel handling equipment. The FHA radiological consequences are not increased because the radiological source term of the limiting fuel assembly is not altered by the proposed amendment. Therefore, the proposed amendment does not significantly increase the probability or consequences of a FHA.

The proposed amendment does not increase the probability of dropping a fuel transfer cask because it does not involve or affect the heavy load handling processes. The consequences of the cask drop accident are not increased because the radiological source term of that accident will remain the same. Therefore, the proposed amendment does not significantly increase the probability or consequences of a cask drop accident.

Operation in accordance with the proposed amendment will not increase the probability of a fuel mis-positioning event at Turkey Point Unit 3, because fuel movement will continue to be controlled by approved fuel handling procedures. These procedures will continue to require identification of the initial and target locations for each fuel assembly that is moved. Serial number checks are performed. Additionally, qualifications of the personnel involved in fuel manipulation are not being changed to accommodate this activity. The consequences of a fuel mis-positioning event are not increased or changed because reactivity analyses demonstrate that a worst-case fuel mis-positioning event, evaluated in support of FPL's Amendment 234 application, meets all subcriticality criteria and bounds the reactivity impact of fuel mis-positioning in the proposed storage arrays crediting Boraflex.

The proposed amendment has no impact on the probability of occurrence of an inadvertent fuel pool boron dilution event because the systems and events involved in fuel manipulation are independent from those that could affect or initiate dilution of SFP soluble boron. Methods, techniques and instrumentation available for the detection of inadvertent dilution events are not changed by the proposed storage arrays crediting Boraflex. Adequate time remains available to terminate any inadvertent dilution of the fuel pool boron concentration. Therefore, the proposed amendment does not significantly increase the probability or consequences of a boron dilution event.

Operation in accordance with the proposed amendment will not change the probability of a seismic event. The consequences of a seismic event are not significantly increased because the forcing functions for seismic excitation are not increased and because the mass of the storage racks and the contained fuel is not increased from that previously analyzed.

Operation in accordance with the proposed amendment will not increase the probability of a loss of SFP cooling because the systems and events that could affect SFP cooling are independent of fuel movement and are unchanged. The consequences of a loss of fuel pool cooling are not significantly increased because no changes are being made to the limiting SFP heat load, the fuel pool water inventory or to SFP cooling systems, structures or components. Time to boil, as derived from the limiting heat load present following a loss of fuel pool cooling, is not adversely affected by the proposed fuel handling activity.

Based on the above, it is concluded that the proposed amendment does not involve a significant increase in the probability or consequences of an accident previously evaluated.

6.2 Does operation of the facility in accordance with the proposed amendment create the possibility of a new or different kind of accident from any accident previously evaluated?

No.

The fuel storage configurations crediting Boraflex in this proposed amendment do not change or modify the fuel being added, any fuel bundle's fission product inventory, fuel handling processes, the spent fuel racks, the number of fuel assemblies that may be stored in the pool, decay heat generation rate, or the SFP cooling and cleanup system. Rack storage capacity, for either fresh or irradiated fuel, will not be exceeded. The proposed amendment was evaluated considering the potential for new Boraflex storage patterns in Region II to create the possibility of a new or different kind of accident.

Operation with the Region II proposed fuel storage patterns will not create a new or different kind of accident because fuel movement will continue to be controlled by approved fuel handling procedures. These procedures continue to require identification of the initial and target locations for each fuel assembly that is moved. Assemblies will not be placed in any fuel pool location, device or fixture not designed to accommodate nuclear fuel having the specific characteristics of the bundle(s) being handled. Personnel qualified to manipulate fuel will perform these evolutions. There are no changes in the criteria or design requirements pertaining to spent fuel safety, including sub-criticality requirements, and analyses demonstrate that the proposed Region II storage patterns meet these requirements and criteria with adequate margins.

Based on the above, it is concluded that the proposed amendment does not create the possibility of a new or different kind of accident from any accident previously evaluated.

6.3 Does operation of the facility in accordance with the proposed amendment involve a significant reduction in a margin of safety?

No.

The proposed change was evaluated for its effect on the current margin of safety related to criticality and was shown acceptable. No other aspect of the proposed fuel addition activity has an adverse affect on margin of safety.

The margin of safety for sub-criticality required by 10 CFR 50.68(b)(4) is unchanged. The SFP criticality analysis performed for these proposed fuel storage configurations and in the analysis previously reviewed and approved supporting Amendment 234 confirm that operation in accordance with the proposed amendment will continue to meet the required sub-criticality margins.

Thus, operating the facility with the proposed amendment does not involve a significant reduction in any margin of safety.

6.4 Summary

Based on the above discussion, FPL has determined that the proposed LAR does not: (1) involve a significant increase in the probability or consequences of an accident previously evaluated, (2) create the possibility of a new or different kind of accident from any accident previously evaluated, or (3) involve a significant reduction in a margin of safety; therefore, the proposed change does not involve a significant hazards consideration as defined in 10 CFR 50.92.

7.0 ENVIRONMENTAL IMPACT CONSIDERATIONS

A review has determined that the proposed amendment would not change a requirement with respect to installation or use of a facility component located within the restricted area, as defined in 10 CFR 20, or would not change an inspection or surveillance requirement. Likewise, the proposed amendment does not involve: (i) a significant hazards consideration, (ii) a significant change in the types or significant increase in the amounts of any effluent that may be released offsite, or (iii) a significant increase in individual or cumulative occupational radiation exposure. Accordingly, the proposed amendment meets the eligibility criterion for categorical exclusion set forth in 10 CFR 51.22(c)(9).

Therefore, pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment needs to be prepared in connection with the proposed amendment.

8.0 CONCLUSIONS

Based on the discussion provided in this LAR, it has been demonstrated that Boraflex can be temporarily credited as a neutron absorber material, since it complies with all the regulatory requirements in the SFP criticality analysis. The Boraflex Management Program discussed in this LAR will ensure that the assumptions of the criticality analysis continue to be met. The design basis criticality analysis for Turkey Point Unit 3 taking credit for Boraflex as presented in Attachment 2 of this LAR meets the requirements of 10 CFR 50.68.

9.0 REFERENCES

9.1 NRC Letter from Kahtan N. Jabbour to Mr. T. F. Plunkett (FPL), "Turkey Point Units 3 and 4 – Issuance of Amendments regarding Boron Credit in the Spent Fuel Pool," issuing License Amendments 206 (DPR-31) and 200 (DPR-41), dated July 19, 2000. (TAC Nos. MA7262 and MA7263).

9.2 FPL Letter L-2001-115 from T. F. Plunkett to USNRC: "Soluble Boron Credit for Spent Fuel and Fresh Fuel Rack Criticality Analyses Fuel Rack Surveillance Testing 2001 Report and Commitment Change for Fuel Rack Surveillance Testing Frequency," May 15, 2001.

9.3 FPL Letter to NRC L-2009-268, "License Amendment No. 234 for Turkey Point Unit 3 – Notice of Inability to Implement", dated November 13, 2009.

9.4 NRC Letter from B. L. Mozafari to J. A. Stall (FPL), "Turkey Point Plant Units 3 and 4 - Issuance of Amendments Regarding Spent Fuel Boraflex Remedy (TAC No. MC9740 and MC9741)," issued July 17, 2007, Amendments 234 and 229.

9.5 FPL letter L-2005-247, "Turkey Point Units 3 and 4 – Docket Nos. 50-250 and 50-251, License Amendment Request No. 178 Spent Fuel Pool Boraflex Remedy", dated January 27, 2006.

9.6 NRC Generic Letter 96-04, "Boraflex Degradation in Spent Fuel Pool Storage Racks", dated June 26, 1996.

9.7 FPL Letter L-2009-295, “Turkey Point Unit 3 – Docket No. 50-250, Spent Fuel Pool Boraflex Actions”, dated December 31, 2009.

9.8 J.F. Briesmeister, Editor, “MCNP – A General Monte Carlo N-Particle Transport Code, Version 4A,” LA-12625, Los Alamos National Laboratory (1993).

9.9 FPL Letter L-99-176 from R. J. Hovey to USNRC, "Turkey Point Units 3 and 4 - Docket Nos. 50-250 and 50-251, Proposed License Amendments, Soluble Boron Credit for Spent Fuel Pool and Fresh Fuel Rack Criticality Analyses," dated November 30, 1999.

9.10 NRC Letter from Stephen Dembek to Mr. H. A. Sepp (Westinghouse), "Non-Conservatisms in Axial Burnup Biases For Spent Fuel Rack Criticality Analysis Methodology," dated July 27, 2001.

Attachment 2

Florida Power and Light Company
Turkey Point Units 3 and 4
Renewed Facility Operating License Nos. DPR-31 and DPR-41
Docket Nos. 50-250 and 50-251
License Amendment Request Regarding a Spent Fuel Pool Criticality Analysis for Unit 3 Taking Credit for Boraflex

Spent Fuel Pool Criticality Analysis for Unit 3 Taking Credit for Boraflex

Turkey Point Unit 3
Additional Fuel Storage Patterns that Credit Boraflex™

Introduction:

The license amendment request described here proposes to implement the permissible storage arrays documented in Amendment 234 (Reference 1) and to add two additional arrangements of stored fuel, suitable for use in Region II of the spent fuel pool racks. No changes are being proposed to any of the existing, approved storage arrays, or to any of the polynomial-based functional relationships used to classify fuel based on an assembly's initial U^{235} enrichment, accumulated burnup and its post–irradiation cooling time. However, unlike the arrangements documented in Reference 1, arrays of stored fuel discussed here would credit Boraflex™ (subsequently denoted as Boraflex) as a neutron absorber at an areal density of 0.006 gm B^{10}/cm^2 i.e., at 50 % of the Region II manufacturing minimum certified areal density. Boraflex is present in most Region II storage cells with this B^{10} areal density, or greater, and will be credited for neutron absorption during the interim period until the Boraflex Remedy discussed in Reference 1 can be fully implemented. No credit is taken for B^{10} areal densities above the design basis value, while any cell with a panel below the design basis value must use one of the other permissible storage arrays documented in Amendment 234 that do not credit Boraflex.

Justification of the additional storage arrangements discussed here relies on numerous aspects of the criticality analyses methodology presented in FPL's January 27, 2006 submittal (Reference 2) that was approved via Amendments 234 and 229. Comparative analyses techniques, as discussed in this amendment request, have been used to assess the acceptability of these additional storage arrangements. Results of these comparative analyses demonstrate that each proposed additional array conforms with the requirements of 10CFR 50.68(b)(4) with respect to neutron multiplication, considering credit for the presence of soluble boron, as is permitted by regulations.

Aside from any possible interface effects, the new storage arrays discussed in this license amendment request ignore the presence of Metamic® (subsequently denoted as Metamic) rack inserts. Proposed storage arrangements crediting Boraflex as a neutron absorber are intended as a temporary adjunct to the storage arrays previously reviewed by the NRC and approved via Reference 1.

The proposed additional storage configurations, applicable to Region II, can be characterized as follows:

<u>Array II-G</u> A 2 x 2 array of fuel containing three Category II-2 assemblies and one Category II-4 assembly

<u>Array II-H</u> A 2 x 2 array of fuel containing four Category II-2 assemblies, facing the fuel pool wall, on the periphery of the racks. Thus, this array credits the increased neutron leakage found in this area of the pool.

Finally, the effects of interfaces between these arrays and regions of the pool where Boraflex is not credited, i.e. where a Boraflex Remedy has been implemented, are considered. Guidance has been developed to define and manage these interface regions.

Methodology Utilized:

Criticality analyses described in this license amendment request were performed for FPL by Holtec International, using their approved analytical tool MCNP4a (Reference 4). MCNP4a is a continuous energy three-dimensional Monte Carlo code developed at the Los Alamos National Laboratory. MCNP4a was selected for use because it was previously used to support FPL's Reference 2 license amendment request, and because it has all of the necessary features for this analysis.

Documentation of prior code benchmarking studies, cited as part of the Reference 2 submittal, is relied upon for this application. The MCNP4a calculations used to develop and justify the proposed storage arrays described here used continuous energy cross-section data based on ENDF/B-V and ENDF/B-VI in exactly the same manner as was used to perform the analyses underlying FPL's Reference 2 submittal. As in the Reference 2 submittal, cross sections earlier derived from CASMO-4 (Reference 5) were used for two lumped fission products and one individual fission product that do not have corresponding cross sections in MCNP4a. Earlier validation of this approach by Holtec has shown the same reactivity effect in both CASMO-4 and MCNP4a.

The acceptability of a proposed fuel storage array crediting Boraflex at a B^{10} areal density of 0.006 gm/cm^2 for neutron absorption is established by comparing reactivity (k_{calc}) values from MCNP4a runs modeling that array to limiting values of k_{calc} from prior analyses (i.e., the analyses underlying FPL's Reference 2 submittal) for the same fuel classifications. If an array crediting Boraflex contains multiple fuel types, such as the proposed Array II-G, prior work involving both fuel types is considered in the k_{calc} comparison.

CASMO-4 calculations did not have to be re-performed for this application. The fuel depletions performed in support of Amendment 234 are not affected by assuming Boraflex is the credited neutron absorber. There is no change in the limiting fuel assembly design. CASMO-4 fuel and rack tolerance effects on reactivity, as well as the temperature effects, were conservatively developed for Reference 1 and they remain bounding for this application. The evaluation of Arrays II-G and II-H using MCNP-4a has applied limit values for the key Boraflex inputs; as a result, no tolerances are calculated specifically for the Boraflex cases.

The computer code platform and cross-section libraries applied for this work are unchanged from those used to perform analyses in support of the Reference 2 submittal, or from the benchmarking studies cited in Reference 2. Assumed neutron source distributions and problem initiation and convergence criteria for individual runs are also unchanged from those used for Reference 2.

Acceptance Criteria:

The objective of these analyses is to demonstrate that each proposed fuel storage arrangement crediting the presence of Boraflex, where no Metamic inserts or rod cluster control assemblies (RCCAs) are present, is no more reactive (i.e., has a lower or statistically equivalent k_{calc}) than the corresponding array of stored fuel approved for use at Turkey Point as part of Reference 1. These comparative analyses are based solely on comparisons between MCNP-4a calculations, using mostly nominal inputs (B^{10} areal density and the Boraflex panel gap parameters are treated as limit values). It will be demonstrated that the uncertainty and bias effects on reactivity applied in Reference 1 remain bounding for the arrays developed here that credit Boraflex.

Therefore, since each storage array discussed in Reference 2, and approved via Reference 1, had values of k_{eff} less than the limits of 10CFR 50.68(b)(4) at a temperature corresponding to the highest reactivity, it follows that if the above noted acceptance criteria are met, Arrays II-G and II-H will always yield an effective neutron multiplication <1.0 when the racks are flooded with pure unborated water, and ≤0.95 when racks are flooded with water containing 650 ppm soluble boron.

Assumptions:

To provide a reasonable level of assurance that the actual k_{eff} of the racks are below regulatory limits, a significant number of conservative assumptions were used in Reference 2 analyses. Except for items related to Boraflex panels and Metamic inserts, assumptions embedded in the prior analyses were retained for the analyses of Arrays II-G and II-H. Assumptions specific to this analysis are listed below:

1) Where Boraflex is credited, it is assumed to be present in the racks with a B^{10} areal density of 0.006 gm/cm^2, which is 50% of the manufacturing minimum certified value for Region II.

2) Values for panel gaps, due to shrinkage, and thinning, due to dissolution, are taken as presented in Table 1 and Figure 1. Gaps in Boraflex panels are conservatively considered to be axially aligned throughout the Region II spent fuel storage racks. Alignment of the panel gaps in calculations will yield higher values of neutron multiplication than the actual condition where axial gaps would be randomly dispersed.

3) The limiting manufacturing tolerance effects on reactivity calculated in Reference 2 are assumed to bound the manufacturing tolerance effects for arrays crediting Boraflex. This prior work determined that un-poisoned cells produced the limiting Region II manufacturing tolerance effects. As both Boraflex and Metamic are B^{10}-based thermal absorbers, having similar dimensions, and similarly positioned in a closely spaced array adjacent to irradiated fuel, the effects on reactivity of Boraflex manufacturing uncertainties are expected to approximate the magnitude of the uncertainty effects that have been calculated for Metamic. Note that the tolerances evaluated for Metamic are: *Panel Thickness*; ± 0.01 inch; *Panel Width*; ± 0.25 inch. These values bound the analyzed Boraflex tolerances of: *Thickness*; ± 0.007 inch, and *Panel Width*; ± 0.075 inch (from Reference 6).

4) Assessment of the effects of changes in fuel pool water temperature, and void percentage, on neutron multiplication relies on prior analyses performed in support of FPL's Reference 2 submittal. In support of Reference 2, temperature bias effects were determined for various conditions, e.g. cells with and without inserts, considering a series of representative enrichment, burnup and cooling time combinations. The approach taken in this earlier work was to identify a bounding value for each case, and to subsequently apply that bounding value in all calculations for that case.

5) Reactivity effects of both axial burnup profiles and an axially constant burnup are considered in analyses of fuel storage arrays crediting Boraflex, for both blanketed fuel and fuel without axial blankets. Non-uniform profiles are presented in Table 10. Comparisons to establish the difference in k_{calc} between arrays crediting Boraflex and arrays of the same fuel types from Reference 2 calculations that credit Metamic inserts always utilize the same axial profiles, assembly burnup, initial enrichment, and post-irradiation cooling time.

6) Table 2 documents the fuel loading curves applied to Arrays II-G and II-H.

7) Except for assessment of peripheral and interface effects, the effective neutron multiplication factor of an infinite array of fuel assemblies, or assembly patterns, was used in analyses of the arrays discussed here.

Input Data:

Specifications of Fuel and Fuel Inserts

Fuel depletion calculations have not been re-performed as part of this analysis; so the design specifications for Turkey Point fuel assemblies, and fuel assembly inserts considered here in the development of Arrays II-G and II-H, are unchanged from those developed in support of the Reference 2 submittal. This is appropriate because characteristics of nuclear fuel, and nuclear fuel inserts used at Turkey Point Unit 3 during power operation, are not being changed by the incorporation of additional storage arrays; fuel continues to be bounded by the specifications utilized in the Reference 2 analyses.

Specifications of the nuclear fuel, fuel inserts and the depletion characteristics utilized in Reference 2 analyses and embedded in the fuel loading curves applied here to Arrays II-G and II-H are reproduced in Tables 3, 4 and 5.

Specification of Fuel Storage Racks

Storage cell characteristics considered in criticality evaluations of Arrays II-G and II-H are summarized in Table 6 for the Region II racks (note that Region I racks are also described in Table 6, although neither storage array is proposed for use in Region I). Aside from the presence of Boraflex absorber material, rack specifications are unchanged from those applied to Reference 2 analyses when considering cases without Metamic inserts. As has been noted, characteristics of the Boraflex panels considered in criticality analyses are presented in Table 1.

Where Boraflex is credited, parameter values, including the dimensions and positioning of gaps assumed to be present in the absorber material, and the assumed B^{10} areal density value of 0.006 gm/cm^2 are treated deterministically as conservative minimum values.

Spent Fuel Pool Specification

Characteristics of the spent fuel pool that were considered as part of the criticality evaluation of Arrays II-G and II-H are presented in Table 7.

Computer Codes:

Analyses of proposed fuel storage arrays II-G and II-H crediting the Boraflex in rack cell panels was performed by Holtec International using MCNP4a. MCNP4a is a three-dimensional continuous energy Monte Carlo code developed at Los Alamos National Laboratory. This code offers the capability of performing full three-dimensional calculations for the loaded storage racks. PCs were used to run MCNP4a at Holtec.

Analysis:

This section describes the methods and calculations that have been used to assess stored fuel, positioned as proposed for Arrays II-G and II-H, and with Boraflex present in rack panels, for compliance with regulatory criteria regarding neutron multiplication. Analysis results are then summarized.

Unless otherwise noted, calculations considered nominal characteristics for the fuel and fuel storage cells. Explicit consideration of manufacturing tolerances did not enter into the comparative analyses performed here. This approach is judged acceptable because characteristics of the irradiated fuel stored in the Region II racks are unchanged and rack dimensions are also unchanged. As was earlier noted, the key parameter values representing Boraflex absorber material are taken as conservative minimum values.

MCNP4a was the primary code used in criticality evaluations of potential Region II storage arrays crediting Boraflex. Where appropriate, boundary conditions are used to create an infinite arrangement of these cells. Analyses performed using MCNP4a in support of one or more of the proposed storage arrays were compared to results developed in Reference 2 supporting analyses for the equivalent burnup, initial enrichment and post-irradiation cooling time.

Figure 2 provides a pictorial representation of Arrays II-G and II-H.

Bounding Fuel Assemblies

Two principal fuel assembly types have been utilized at Turkey Point during prior power operation. Both were examined as a part of Reference 2 supporting calculations to determine the more reactive assembly type. Considering features likely to affect reactivity, the assembly types differ only in the guide and instrument tube dimensions. Comparison of reactivity for these two assembly types performed in support of Reference 2 using CASMO-4 concluded that the designs were practically identical, with differences of less than ± 0.0001 delta-k. Subsequent calculations utilized the OFA/DRFA fuel dimensions shown in Table 3.

Treatment of Fuel Burnable Absorbers

Fuel Assembly depletion calculations performed to justify FPL's Reference 2 submittal considered both the Pyrex and WABA-type burnable absorbers used in prior operating cycles at Turkey Point. As additional assembly depletion calculations have not been performed, and fuel characteristics for the proposed arrays crediting Boraflex are unchanged, the conservative effects of between 0.005 and 0.020 delta-k earlier attributed (in Reference 2) to these burnable absorber assumptions remains embedded in the fuel isotopic inventory.

Pool Water Temperature Effects

Neither of the proposed storage arrays crediting Boraflex will cause a change in the range of pool water temperatures experienced during normal conditions of operation, or to the range of temperatures potentially experienced during off-normal and accident conditions. Table 7 identifies these temperature bands.

Qualification of proposed storage Arrays II-G and II-H relies on CASMO-based sensitivity analyses underlying the Reference 2 submittal, performed to establish the behavior of neutron multiplication following changes in pool temperature. Results of these earlier analyses for

Region II racks are documented in Tables 8a and 8b. CASMO-4 analyses supporting Reference 2 calculated the pool temperature effects at both borated and un-borated conditions, considering racks containing a neutron absorber, i.e. Metamic panels, and also considering un-poisoned Region II racks. For pure water conditions, these results are presented for a number of burnup/enrichment and cooling time combinations, with maximum values posted at the bottom of Table 8. As can be seen, the temperature effect values for racks without inserts are larger than, and opposite in sign to, those developed for conditions where inserts are present. Conservatively, the larger values generated by neglecting inserts were used in all Region II criticality results developed for Reference 2. Thus, un-poisoned Region II racks have a positive temperature coefficient of reactivity, while the presence of a neutron absorber such as Metamic changes the racks' behavior, resulting in a negative temperature coefficient. Basis a 20°C reference temperature, the presence of absorber material corresponds to a smaller bias.

As both Boraflex and Metamic panels are B^{10}-based thermal absorbers, having similar dimensions, and similarly positioned in a closely-spaced array adjacent to irradiated fuel, replacing Metamic inserts with credit for Boraflex panels would yield the same effect, i.e. change the general behavior of Region II racks from a positive temperature coefficient of reactivity (when un-poisoned), to a negative coefficient of reactivity, with a corresponding reduction in the overall temperature bias. Thus, conditions in the pool with Boraflex would also be bounded, in terms of a temperature-induced reactivity effect, by the condition of the rack without poison that was assumed for all k_{eff} calculations documented in analyses supporting FPL's Reference 2 submittal.

Effects of Manufacturing Parameter Tolerances

As for the effects of changes in fuel pool water temperature, qualification of proposed storage Arrays II-G and II-H relies on the reactivity effects of manufacturing tolerances developed by analyses underlying the Reference 2 submittal. Those analyses calculated effects of the fuel and rack tolerances for both poisoned and un-poisoned Region II racks. Table 9 presents these results for pure water conditions, at a series of burnup, initial enrichment and cooling time statepoints. Maximum values for each rack condition are identified. The combined effect on neutron multiplication of tolerances in fuel and rack parameters is shown to be greater for un-poisoned rack conditions than for Region II racks containing poison inserts, even considering the effect of conservative tolerances associated with fabrication of Metamic inserts.

The larger combined tolerance reactivity effects associated with un-poisoned rack conditions were used in Reference 2 analyses to develop maximum k_{eff} values for validation of loading curves, and for comparison to regulatory limits. As there are no changes in either fuel or rack characteristics, aside from the substitution of Boraflex panels for Metamic, from those considered in Reference 2, that philosophy is also applicable here. Thickness and width tolerance effects on reactivity would be of the same order of magnitude for both Boraflex and the Metamic panels. Also, as has been earlier noted, the key Boraflex inputs to analyses (i.e., areal density and gaps) have been considered on a deterministic basis. Thus, conditions in Region II racks where Boraflex replaces any prior-credited Metamic inserts would be bounded with respect to the reactivity effects of manufacturing tolerances and uncertainties, by the condition of the rack without any embedded poison.

Temperature Bias and Uncertainty Effects at Higher Soluble Boron Concentrations

A separate set of uncertainty and bias effects are applied to results derived with soluble boron present in the pool, representative of normal conditions. As part of Reference 2 supporting calculations, temperature bias and parameter tolerance effects were calculated at 800 ppm soluble boron for Region II rack conditions where neutron absorber inserts are present and for un-poisoned rack conditions. The 800 ppm value selected substantially exceeds the soluble boron requirement of 650 ppm documented in Reference 1.

As for the un-borated condition, the 800 ppm CASMO-4 calculations from Reference 2 demonstrated the temperature bias effect on reactivity and the reactivity effects of manufacturing parameter tolerances are greater for the un-poisoned Region II rack condition (0.0109 delta-k temperature effect, 0.0103 delta-k combined tolerance effect) than for a condition where neutron absorber panels are present (0.0017 delta-k temperature effect, 0.0101 delta-k combined tolerance effect). Results from this prior work were considered, and provide a basis for not re-performing these parameter studies with panels of Boraflex credited instead of Metamic. The maximum values of the statistically combined effects were used in the Reference 2 final k_{eff} calculations. For the k_{eff} calculations with soluble boron, the greater uncertainty and bias effect at either pure water or 800 ppm is used.

Depletion Calculation and Burnup Record Uncertainties

Existing fuel classifications and certain of the enrichment/burnup/cooling time-based loading curves developed to accommodate Metamic inserts are being applied to fuel loaded into Region II arrays now crediting Boraflex. This is appropriate because use of a new or different storage arrangement for irradiated fuel has no impact on either the inputs used to establish the fuel depletion or on the depletion's results, unless the fuel itself has changed. Fuel and fuel insert characteristics are not being changed to accommodate storage in Arrays II-G or II-H. As a result, fuel-related isotopic number densities developed by the depletion, and input into MCNP4a, are not affected by placement into a different storage array. In-core fuel and moderator temperatures, specific power and soluble boron values applied during depletions performed in support of the Reference 2 submittal remain bounding for this application.

For these reasons, additional depletion calculations need not be performed as part of the activity to justify Arrays II-G and II-H.

Uncertainties in depletion calculations, and the uncertainty associated with values of recorded burnup, are not re-developed for this application. As it is shown here that Arrays II-G and II-H are in most cases less reactive than, or at worst statistically equivalent to the existing arrays crediting Metamic inserts that utilize the same loading curves (require the same burnup), the depletion and burnup uncertainties previously utilized remain applicable.

Isotopic Compositions

Isotopic compositions are specified as input data in each MCNP4a run. As CASMO-4 runs were not made as part of this activity to justify additional storage arrangements crediting Boraflex, isotopic data sets from the prior Turkey Point work were used.

Eccentric Positioning of Fuel in Region II Racks

Eccentric positioning calculations were not re-performed for fuel stored in Region II rack arrays crediting Boraflex. The use of Boraflex as an absorber material instead of Metamic would have little effect on the results calculated in Reference 2. MCNP4a calculations with and without soluble boron present, performed in support of the Reference 2 submittal, have demonstrated that the reactivity effects of eccentric fuel positioning in Region II racks are substantially negative, i.e., by at least 0.0075 delta-k, irrespective of whether B^{10} absorber material is present. Consistent with Region II design, these MCNP4a calculations focused on irradiated fuel, considered both uniform and non-uniform axial shapes, and produced results showing little sensitivity to initial enrichment. Thus, neglecting the effect of eccentric fuel positioning in Region II racks will not cause an unexpected increase in k_{eff} for any of the proposed arrays of stored fuel.

Reactivity Effect of Axial Burnup and Enrichment Distribution

Spent fuel racks at Turkey Point Unit 3 contain fuel having axial blankets, as well as fuel assemblies without axial blankets. As in Reference 2 analyses, axial burnup effects of assemblies with and without axial blankets are considered, over the range of assembly exposure, for Arrays II-G and II-H. The axial burnup distributions representative of Turkey Point fuel that were developed by FPL prior to beginning the Reference 2 analyses were also utilized here, along with a uniform profile. Of the shapes originally supplied by FPL, profiles having the lowest relative burnup at the upper and lower ends of the rod for twice burned assemblies were conservatively chosen as calculation input, here and in Reference 2, because the lower burnup results in a higher reactivity. Comparisons made to the MCNP-developed k_{calc} values from Reference 2 are always with the higher value produced by considering both the uniform shape and axial profiles.

Tabular versions of the blanketed and non-blanketed axial shapes may be found in Table 10.

Confirmation of Fuel Loading Curves

The general form of the loading curve established for Turkey Point Unit 3 is:

$$Bu = A * En + B * En^2 + C * Ct + D * Ct^2 + E * Ct * En + F * Ct^2 * En + G$$

with:

Bu = Minimum required assembly average burnup (GWD/MTU)
En = Initial Enrichment (w/o U^{235})
Ct = Cooling Time (years)
A,B,C,D,E,F,G as Coefficients

For blanketed assemblies, the enrichment to be used in the loading curve equation is the central zone enrichment, i.e. the enrichment of the axial blankets is excluded from determining the assembly enrichment for the loading curves.

Justifying the fuel loading curves to be applied to Arrays II-G and II-H required that a number of parameter and parameter combinations be considered in analyses, including:

- Fuel initial enrichments between 1.8 and 4.5 weight percent (w/o) U^{235}
- A range of assembly burnup, from once-burned conditions to over 50,000 MWD/MTU
- Assemblies with and without axial blankets
- Post-irradiation cooling times of up to 20 years

Calculations confirming applicability of burnup versus enrichment curves (i.e., loading curves) are all performed in three dimensions, considering axial burnup distributions for each assembly in the model. As reactivity effects of the axial burnup distribution are included in the model, no additional axial burnup penalty need be applied. Examination of Array II-G considered both its constituent assembly types. Array II-H considered the II-2 fuel classification, and conditions at the periphery of the rack facing the pool wall, where neutron leakage is a factor.

Reference 2 analyses, performed in support of the II-2 and II-4 fuel classifications (Arrays II-B and II-D) were used to compare to Array II-G results, and Reference 2 work considering peripheral leakage effects for a variety of fuel classifications, were used as the basis of comparison for Array II-H. In this work, k_{calc} values are compared to a corresponding k_{calc} value from Reference 2.

Reference 2 analyses considered the following enrichment and cooling time combinations, over the full range of assembly burnup, using both a distributed axial profile and a uniform profile:

For non-blanketed fuel:

1.8 w/o: 0, 5 and 20 years
2.5 w/o: 0 and 20 years
3.0 w/o: 0, 2.5, 5, 10, 15 and 20 years
3.5 w/o: 0 and 20 years
4.0 w/o: 0, 5 and 20 years

For blanketed fuel:

2.5 w/o: 0, 5 and 20 years
3.0 w/o: 0 and 20 years
3.3 w/o: 0, 2.5, 5, 10, 15 and 20 years
4.0 w/o: 0 and 20 years
4.5 w/o: 0, 5 and 20 years

Array II-G was evaluated by utilizing the same enrichment/burnup/cooling time combinations as were used in Array II-B and II-D runs from Reference 2 that yielded the highest values of k_{calc}. Array II-G was analyzed with MCNP4a, after removing the Metamic panels, placing Boraflex appropriately in the computer model and replacing the uniform loadings of Array II-B and Array II-D with a mixture of three II-2 and one II-4 fuel assemblies. To establish the reactivity difference (or margin), k_{calc} values for the Array II-G runs were compared to the greater of the limiting Array II-D or II-B k_{calc} value, considering both uniform and distributed axial shapes. Tables 11 and 12 present this comparison for blanketed fuel and non-blanketed fuel.

In most instances the Array II-G fuel, considering the presence of Boraflex at a B^{10} areal density of 0.006 gm/cm^2, was less reactive than Arrays II-D and II-B. Of the sixty-five considered, three combinations of initial enrichment, burnup and post-irradiation cooling time, each analyzed with a non-uniform (segmented) axial profile, produced values of k_{calc} statistically equivalent to the k_{calc} value from the greater of the Array II-B and Array II-D reference cases.

Array II-H considers multiple Category II-2 fuel assemblies to be part of an arrangement positioned on the periphery of Region II racks, adjacent to the pool wall. To qualify Array II-H, comparisons were made with earlier analyses involving cells facing the pool wall. Prior MCNP4a calculations, approved as part of Technical Specification Amendment 234, demonstrated that the outer row of Region II racks, facing the pool wall, is suitable for storage of more reactive assemblies, i.e. Category II-2 fuel without inserts[1].

As Category II-2 fuel produced the minimum delta-k between infinite and finite-sized arrays previously qualified for this special peripheral arrangement, recent work to qualify a storage pattern for the periphery, considering the presence of Boraflex, used this model as a starting point. Cases were modified to replace any inboard, earlier-credited Metamic inserts with water, and to add Boraflex to the interior of the model. As for analyses performed in support of the Reference 2 submittal, a single 11-cell by 13-cell rack module was used here, arranged to face a pool wall on all four sides, and with Category II-2 fuel filling all peripheral locations. No Boraflex is present along the exterior of the racks; elsewhere, Boraflex is present in each cell of the model. Figure 5 shows the arrangement of stored fuel representing this condition.

Table 13 presents results of these comparative analyses with Reference 2. Analyses crediting the presence of Boraflex show no increase in neutron multiplication compared to the earlier analyzed condition. Peripheral Array II-H, analyzed using a non-uniform axial distribution, demonstrates statistical equivalence with prior Array II-B (alternative Metamic positioning) results, whereas analysis performed with a uniform axial profile shows significant margin with Boraflex versus comparable earlier work. As a result, it is acceptable to position fuel, up to and including Category II-2 assemblies, in an array along the interface of Region II racks and the fuel pool wall, when Boraflex having an areal density of 0.006 gm B^{10}/cm^2 is credited.

Interface Considerations

Interfaces between differing local arrangements of stored fuel for the condition where a Boraflex Remedy has been implemented are discussed extensively in FPL's Reference 2 submittal. The work discussed in this license amendment request does not re-examine Region I or the Boraflex Remedy; instead, it presumes a condition where the Boraflex Remedy has been implemented in Region I racks. With this constraint, interface conditions that could result from use of the proposed storage arrays analyzed here are reviewed.

Region II is comprised of nine individual rack modules of varying size. Between adjacent Region II rack modules, the minimum gap is 1.15". Additionally, Region II racks were fabricated such that Boraflex panels are not present on exterior surfaces, e.g. facing the rack-module-to-rack-module gap.

Sometimes, a single array of stored fuel extends beyond the rack module boundary. To assess the implications of a scenario where a storage array crediting Boraflex spans this boundary, comparative analyses were performed, with a goal of demonstrating that the smallest rack-to-rack gap found in Region II is at least equivalent to the reactivity effect of a single rack cell wall and its corresponding Boraflex panel, as comprise the racks' interior.

A specific analysis of this condition, comparing the effects on neutron multiplication of: a) cells with Boraflex panels at an areal density of 0.006 gm B^{10}/cm^2, and; b) crediting the minimum 1.15" un-poisoned gap between adjacent rack modules, is documented in Table 14. As for other aspects of this criticality evaluation, a range of initial fuel enrichments, burnup and post-irradiation cooling times are considered, as well as both uniform and non-uniform axial burnup profiles. Analysis methodology used here involved re-analyzing a subset of the MCNP4a runs used to establish the acceptability of Array II-G, with the array now positioned along the edge of

[1] Details for representative storage arrangements are provided in Technical Specification 234, Figure 5.5-4.

two Region II racks. Instead of Boraflex, this peripheral array has two steel rack cell walls separated by a water gap. Results demonstrate that, for the minimum gap dimension, the two reactivity effects are statistically equivalent.

Arrays II-G and II-H are both qualified for placement on the periphery of Region II racks, facing the pool wall. Array II-H describes the limiting qualified interface between Region II racks crediting Boraflex panels (as described in Table 1) and the fuel pool wall. Considering the results presented in Table 14, both arrays are also qualified for storage arrangements spanning the rack-module-to-rack-module gap. Array II-H was not analyzed for positioning (and is not permitted) in the interior of Region II racks or for cells facing on Region I; of the fuel arrangements crediting Boraflex, only Array II-G was analyzed for interior placement.

Interfaces between fuel stored in Arrays II-G and II-H must conform to the requirements of both arrays; specifically, the interface cells must meet location requirements for Array II-H, and contents of the interface cells must meet the fuel category restrictions of Array II-G. Array II-G permits a maximum of three Category II-2 fuel assemblies in any 2 x 2 array; the 4th assembly can be no more reactive than Category II-4. Thus, for locations near the periphery of the rack, where II-H arrangements could interface with Array II-G, the outer (i.e., nearest the pool wall) two rows may contain only Category II-2 fuel; however, the third row inboard can only contain a maximum of 50% II-2 fuel, which must then be interspersed with assemblies of lower reactivity. Figure 3 is an example of a permissible arrangement involving Arrays II-H and II-G.

Other interfaces within Region II racks between Array II-G and an approved storage array crediting the Boraflex Remedy will continue to require that each overlapping 2 x 2 array of stored fuel match the requirements of at least one of the Arrays II-A through II-H, with the exception of the special requirements associated with the periphery of the rack, adjacent to the pool wall and the Region I/Region II interface. As in Reference 2 analyses, the term "match" means that the configuration has at least the required number of empty cells, Metamic inserts or Boraflex; all assemblies must also have at least the required burnup for the array. For any 2 x 2 arrangement where cells credit Boraflex, panels in those cells must have a B^{10} areal density of at least 0.006 gm/cm^2, and be consistent with the characteristics of Table 1. Requirements defined by the application of the overlapping rules produce locations that are much less reactive due to extra absorber requirements at the buffer between two different arrays. For example, cells on the buffer between a Metamic array and Array II-G would require the interface cells to have Metamic inserts, in addition to Boraflex.

Figure 3a depicts an example Region II interface condition between an array crediting some aspect of the Boraflex Remedy and proposed Arrays II-G or II-H.

Region I racks are separated from Region II by a gap of at least 1 inch. As for racks within Region II near the pool wall, the analyses prepared in support of Reference 2 contain calculations that develop permissible interfaces between Region I and Region II racks, for a condition where both regions have implemented a Boraflex Remedy. For the situation described here, where only Region I has implemented a Boraflex Remedy, interfaces between portions of Region II racks where Boraflex continues to be credited and the Region I racks will be managed in a similar fashion; so that any fuel placed in a cell adjacent to Region I racks will be required to comply with the Array requirements, including any needed inserts, along with the burnup, enrichment and cooling time requirements imposed by the Boraflex Remedy, even though Boraflex may be present. Thus, fuel of Categories II-1 and II-2 may only be stored on this interface as part of an Array II-A. Category II-3 through II-8 fuel may also be stored in Region II racks adjacent to Region I. Figure 4 provides an example of a Region I to Region II interface.

The Region I Cask Area Rack (CAR) utilizes Boral as a neutron absorber. Certain portions of this rack abut Region II. Analyses supporting the CAR (Reference 3) considered conditions where Boraflex was present in Region II racks, along with conditions where Boraflex was assumed absent. No constraints on the positioning of fuel within Region II racks are imposed by the CAR. Additionally, the specifics of Region II storage impose no restrictions on the capability of the CAR.

Soluble Boron Requirements

Calculations to determine the minimum soluble boron concentration in the spent fuel necessary to ensure k_{eff} does not exceed 0.95 were not re-performed for Arrays II-G or II-H. These arrays utilize only Category II-2 and II-4 fuel and apply the previously-qualified loading curves applicable to these fuel types. Analyses discussed here have demonstrated that these arrays, when crediting Boraflex instead of Metamic inserts, are at worst, statistically equivalent to the corresponding arrays i.e., Arrays II-B and II-D developed as part of the Boraflex Remedy for both blanketed and non-blanketed fuel.

Abnormal and Accident Conditions

The effects of adding Arrays II-G and II-H as approved storage arrangements on the credible abnormal and accident conditions have been examined, with individual aspects of this examination presented below. The double contingency principle of ANSI N16.1-1975 (and the NRC letter of April 1978) specifies that it shall require at least two unlikely independent and coincident events to produce a criticality event. This principle precludes the necessity of considering the simultaneous occurrence of multiple accident conditions.

Temperature and Water Density Effects

As was noted, CASMO-4 calculations performed in support of the Reference 2 submittal derived the effect on reactivity of pool water temperature changes for both un-poisoned Region II racks, and Region II racks containing Metamic inserts i.e., a B^{10} absorber. Calculations determined reactivity effects at several specific temperature values between the 4°C minimum and 120°C, considering localized void fractions of up to 20% at the higher pool temperatures. Results demonstrated that for a range of temperatures beyond the normal operating band, the temperature coefficient of reactivity for un-poisoned Region II racks continued to be positive, i.e. neutron multiplication increased as temperature increased, whereas the same reactivity effect is negative for racks containing a B^{10} neutron absorber. The limiting effects of these potential temperature excursions were considered when developing the abnormal condition soluble boron requirements of Reference 2.

No additional calculations to quantify an effect of changes in pool temperature or void fraction on reactivity were performed to qualify Arrays II-G or II-H for fuel storage. Previously developed analyses considered the full range of initial enrichment, burnup and post-irradiation cooling time; these calculations bound all fuel used in Arrays II-G and II-H. Aside from credit for Boraflex in rack panels, instead of a Metamic insert, no aspect of the storage racks is changed.

Horizontal Dropped Assembly

An assumed dropped fuel assembly that comes to rest horizontally on top of the storage racks will continue to have a minimum separation distance of more than 12 inches from the nearest vertically-oriented assembly stored in the racks. A distance of 12 inches between active fuel regions is sufficient to preclude neutron coupling.

Metamic inserts are not considered a structural component of Region II storage racks. Therefore, deformation of Region II racks as a result of postulated seismic or accident conditions where Boraflex is present, instead of one or more Metamic inserts, will not reduce the minimum spacing to less than 12 inches. Consequently, an accident involving the horizontal drop of a fuel assembly onto the racks will not result in a significant increase in reactivity, irrespective of whether Metamic inserts or Boraflex are present.

Dropped Assembly – Vertical Orientation

A dropped assembly could also fall into a rack location occupied by another assembly. The resulting vertical impact could cause a small compression of the stored assembly, reducing its water-to-fuel ratio, thereby reducing reactivity. If this were to occur, the vertical distance between active fuel regions of both assemblies, and their relative orientation, will be sufficient to ensure no significant neutron interaction between the two assemblies.

A vertically dropped fuel assembly could also impact the racks, possibly damaging one or more Boraflex panels, or the wrapper plates holding such panels in place. Similarly, an evaluation of a fuel assembly dropped onto the periphery of a fuel rack, with the storage location adjacent to the impact area containing a fuel assembly and a neutron absorber insert, predicts damage to the rack extending approximately 24" down from the top of the rack. Such damage would uncover at least a portion of the top of the active fuel length. The reactivity effect of this condition is less than the reactivity effect of either an accidental removal of an insert or a mis-located fresh fuel assembly.

Incorrectly Loaded Fuel Assembly

In the absence of fuel pool soluble boron, mis-positioning a fresh unburned Turkey Point fuel assembly of the highest permissible enrichment (4.5 w/o U^{235}) could produce a condition where k_{eff} exceeds the 0.95 regulatory limit. This condition could occur irrespective of whether Metamic inserts or Boraflex panels are present in the racks and credited for neutron absorption, if the fresh assembly were to be inadvertently placed into a storage location intended to remain empty. Array I-A (Region I) or Array II-A (Region II) include (require) the presence of at least one water-filled cell.

Reference 2 analyses concluded a bounding condition is represented by the mis-loading of a fresh assembly into an Array II-A cell intended to remain empty (i.e., water-filled), and that a minimum of 1462 ppm soluble boron is required to maintain neutron multiplication within limits. This soluble boron concentration is less than the Technical Specification 3.9.14 requirement.

As Arrays II-G and II-H are full-density arrangements of fuel assemblies, without embedded water hole cells, including these configurations as qualified storage arrays does not affect the limiting array from the perspective of an abnormally located fuel assembly, or soluble boron requirements established by the limiting array.

Mis-located Fuel Assembly

Accidental placement of an assembly outside of the storage racks, but adjacent to other assemblies, has also been considered. In such a location, an assembly can be face-adjacent to no more than two rack walls, with water on the other two sides. The neutron leakage pathway provided by the two sides of water ensures this condition is bounded by the mis-loading accident discussed previously, because the mis-loading event within the racks has a fresh assembly surrounded by four other assemblies.

Mis-positioned RCCA or absorber insert

Boraflex panels are an integral part of Region II storage racks. Accidental removal of one or more panels, through mechanical means while the racks are in the pool is implausible. However, the accidental removal of an installed insert from a cell or of an RCCA from a stored assembly is possible, although either of these possibilities is bounded by the assembly mis-load event previously discussed. This is because the reactivity effect of removing an insert or an RCCA is less than the reactivity effect that results from inserting a fresh assembly into a cell intended to be empty.

Conclusions:

This criticality evaluation discusses and justifies use of two additional storage configurations in Region II racks at Turkey Point Unit 3. Unlike the arrays whose acceptability is documented in Reference 1, these two storage arrangements, Arrays II-G and II-H, neglect Metamic inserts but credit the presence of Boraflex in rack panels at an areal density of 0.006 gm B^{10}/cm^2. Other important characteristics of the Boraflex panels considered are documented in this evaluation.

Neutron multiplication for storage Arrays II-G and II-H has been evaluated on a comparative basis, using the MCNP4a computer code, and considering fuel bundles having identical characteristics[2] to those comprising the corresponding stored fuel arrangement from Reference 2, where Metamic inserts are credited. This evaluation discusses details of the comparative criticality analyses, and why it is an appropriate technique for this application. MCNP4a was used to develop the permissible storage arrays documented in Reference 2; work discussed here has credited the same set of code benchmarking studies, and utilized the same isotopic data sets as formed the basis for analyses of storage arrays documented in Reference 2.

Results of calculations presented here demonstrate that both Array II-G and Array II-H are typically less than, or at worst comparably reactive to (i.e., yield a lower or statistically equal k_{calc}) the corresponding fuel storage arrays considered in Reference 2. As effective neutron multiplication of each array included in FPL's Reference 2 submittal was demonstrated to be <1.0, with a 95% probability at a 95% confidence level, for the condition where Turkey Point fuel pool racks were flooded with un-borated water, k_{eff} for Arrays II-G and II-H will also be <1.0 in the presence of pure water. Examination of these arrays, as well as prior calculations performed in the presence of soluble boron, supports a conclusion that both normal and accident condition soluble boron requirements will not be increased from values previously established as part of FPL's Boraflex Remedy submittal. At the prescribed soluble boron concentrations, none of the abnormal or accident conditions that have been identified as credible will cause the limiting reactivity to be exceeded (i.e., k_{eff} remains $\leq$0.95).

Arrays II-G and II-H are comprised of only Category II-2 and II-4 fuel, as is defined by Technical Specification Amendment 234 and the prior Reference 2-related analyses; therefore, loading

[2]Considering items such as initial enrichment, accumulated burnup, post irradiation cooling time and axial profile as were used in establishing suitability for storage in Arrays II-A through II-F.

curves used to select fuel for placement in these arrays are unchanged from those currently approved for use.

Special positioning requirements involving the interface between Arrays II-G and II-H have been defined, as well as any requirements applicable to interfaces between these arrays and other permissible storage arrangements. For purposes of this Region II criticality evaluation, it is assumed that a Boraflex Remedy has been implemented in Region I racks at Turkey Point Unit 3. As a result, controls on positioning fuel at the interface between Region I and Region II racks are conservatively established based on a presumption of no creditable Boraflex in the Region II cells adjacent to Region I, irrespective of whether Boraflex is actually present.

References:

1. Attachments and Enclosures to NRC letter dated July 17, 2007, Turkey Point Plant, *Units 3 and 4 – Issuance of Amendments Regarding Spent Fuel Pool Boraflex Remedy (TAC No. MC9740 and MC9741)*

2. Attachments and Enclosures to FPL letter L-2005-247, dated January 27, 2006, *Turkey Point Units 3 and 4 – Docket Nos. 50-250 and 50-251, License Amendment Request No. 178 Spent Fuel Pool Boraflex Remedy*

3. Attachments and Enclosures to FPL letter L-2002-214, dated November 26, 2002, Turkey Point Units 3 and 4 – Docket Nos. 50-250 and 50-251, *Proposed License Amendments Addition of Cask Area Spent Fuel Storage Racks*

4. J.F. Briesmeister, Editor, "MCNP – A General Monte Carlo N-Particle Transport Code, Version 4A," LA-12625, Los Alamos National Laboratory (1993)

5. M. Edenius, K. Ekberg, B.H. Forssen, and D. Knott, "CASMO-4 A Fuel Assembly Burnup Program User's Manual," Studsvik/SOA-95/1, Studsvik of America, Inc. and Studsvik Core Analysis AB (proprietary)

6. Turkey Point Updated FSAR, Table 9.5-13, *Region II – No Soluble Boron (Reduced Areal Density)*, Revised 09/29/2005

Table 1

Assumed Characteristics of Boraflex in Region II at Turkey Point Unit 3

Parameter	**Value**
Boraflex Panel Thickness	0.051 inches
Boraflex Loading	0.006 gm B^{10}/cm^2
Boraflex Width	7.5 inches
Boraflex Axial Dimensions	see Figure 1
Bottom of Boraflex above Rack Base Plate	6.16 inches
Initial Panel Length	139.4 inches
Top Shrinkage	4.182 inches
Width of Gaps in Boraflex Panels	1.5 inches
Number of Gaps / Center-to-Center Spacing	5 / 7.5 inches

Fuel Specification

Array II-G	Any Category II-2 and II-4
Array II-H	Any Category II-2

Table 2

Loading Curves Applicable to Arrays II-G and II-H

Coefficients for Non-Blanketed Assemblies

Fuel Category	**Coefficients**†						
	A	B	C	D	E	F	G
II-2	11.8419	0.287918	0.113820	-0.00527641	-0.175033	0.00507248	-9.9305
II-4	12.6130	0.436168	-0.128105	0.00275389	-0.151579	0.00377707	-7.0392

Coefficients for Blanketed Assemblies

Fuel Category	**Coefficients**†						
	A	B	C	D	E	F	G
II-2	14.4600	-0.372732	0.132275	-0.00617104	-0.187813	0.00526411	-12.8293
II-4	15.3172	-0.444842	-0.114363	0.00273060	-0.162664	0.00344467	-9.1868

†Text denotes the polynomial function

Table 3

Turkey Point Fuel Characteristics

Parameter	Value	
Assembly type	OFA / DRFA	LOPAR
Rod Array Size	15x15	
Rod Pitch, inches	0.563 ± _*	
Active Fuel Length, inches	144	
Stack Density (g/cm^3)	10.45 ± _*	
Maximum Nominal Enrichment, wt%	4.5	
Total Number of Fuel Rods	204	
Fuel Cladding Outer Diameter, inches	0.422 ± _*	
Fuel Cladding Inner Diameter, inches	0.3734 ± _*	
Fuel Cladding Thickness, inches	0.0225*	
Pellet Diameter, inches	0.3659‡ ± _*	
Number of Guide/Instrument Tubes	20 / 1	
Guide / Instrument Tube Outer Diameter, inches	0.533 ± _*	0.546 ± _*
Guide / Instrument Tube Inner Diameter, inches	0.499 ± _*	0.512 ± _*
Guide / Instrument Tube Thickness, inches	0.0147*	

*Tolerances on these parameters, and the characterization of fuel cladding and Guide / Instrument tube thickness, are unchanged from those in Attachment 9 to Reference 1, Table 4.4.1.

‡Most fuel rods have a nominal pellet OD of 0.3659 inches, and this is the value used in analyses. However, there are some assemblies with a slightly smaller pellet diameter of 0.3649 inches, and there are four rods with a slightly larger pellet OD of 0.3671 inches. The smaller pellet diameter is conservatively bounded by the value used in analyses, because a larger pellet diameter generally results in a higher reactivity. Effects of the rods with the larger pellet OD are negligible, as there are only four rods with pellets of this diameter.

Table 4

Characteristics of Turkey Point Fuel (Burnable Absorber) Inserts[††]

Parameter	**Value**
Wet Annular Burnable Absorber (WABA)	
Absorber Material	$Al_2O_3 - B_4C$
B_4C Theoretical Density (Fraction)	0.7
B-10 in B, Atom Percent	19.9
B-10 Loading, g/cm	0.0060
Poison ID, inches	0.2780
Poison OD, inches	0.3180
Inner Clad Thickness, inches	0.0210
Inner Clad OD, inches	0.2670
Outer Clad Thickness, inches	0.0260
Outer Clad OD, inches	0.3810
Clad Material	Zr
Assembly Burnup when Absorber is removed, GWD/MTU	22
Pyrex Burnable Absorber	
Boric Oxide Content, wt%	12.5
B-10 in B, Atom Percent	19.9
Poison ID, inches	0.2430
Poison OD, inches	0.3960
Inner Clad ID, inches	0.2235
Inner Clad OD, inches	0.2365
Outer Clad ID, inches	0.4005
Outer Clad OD, inches	0.4390
Clad Material	SS-304
Assembly burnup when Absorber is removed, GWD/MTU	16

[††]As the text notes, fuel depletion calculations were not re-performed when developing Arrays II-G and II-H. Effects of values noted here for the WABA and Pyrex absorbers are embedded in the existing depletion analyses, performed in support of License Amendment 234 (Reference 1), and re-used for this application.

Table 5

Core Operating Parameters Utilized in Depletion Analyses†††

Parameter	**Value**
Soluble Boron Concentration, ppm	780
Reactor Specific Power, MW/MTU	31.7
Cycle Average Fuel Temperature, °F	1280
Moderator Temperature, °F	611.3
In-Core Assembly Pitch, inches	8.465 (21.5 cm)

†††see note at the bottom of Table 4

Table 6

Fuel Rack Dimensions

Parameter	**Value**	
	Region I	Region II
Cell ID, inches	8.75 +_*/–_*	8.80 ± _* & 8.882
Wall Thickness, inches	0.075 ± _*	0.075 ± _*
Cell Pitch, inches	10.60 ± _*	9.0 +_*/-_*
Poison Cavity Thickness, inches	0.090 ± _*	0.064 ± _*
Sheathing Thickness, inches	0.02 ± _*	0.02 ± _*
Sheathing Width, inches	7.5 ± _*	7.5 ± _*
Minimum Gap between Rack Modules, inches	1.15	1.15

*Tolerances on these parameters are unchanged from those in Attachment 9 to Reference 2, Table 4.4.5.

Table 7

Spent Fuel Pool Specifications used in the Analyses

Parameter	**Value**
Thickness of SS Liner on Pool Walls, inches	0.25
Normal Condition Pool Water Temperature Range, °C	4 - 85
Off-Normal Temperature Range, °C	>85 - 120

Table 8a

Temperature Effects on Neutron Multiplication (in Δk) – Turkey Point Region II Racks

Enrichment (w/o U^{235})	Cooling (yrs)	Burnup (GWD/MTU)	Ref 68F (20 °C)	Rack 39.2 F (4 °C)	Rack 80.3 F (27 °C)	Rack 185 F	Rack 248 F (120 °C)	Rack 248 F (120 °C) 10% Void	Rack 248 F (120 °C) 20% Void
1.8	0	4	1.14647	-0.00016	0.00008	0.00086	0.00142	0.00133	-0.00178
1.8	0	10	1.09002	-0.00060	0.00025	0.00229	0.00360	0.00145	-0.00388
1.8	0	20	0.99988	-0.00123	0.00052	0.00467	0.00731	0.00405	-0.00240
1.8	0	25	0.95851	-0.00150	0.00063	0.00576	0.00903	0.00562	-0.00093
1.8	20	4	1.14198	-0.00001	0.00002	0.00038	0.00075	0.00071	-0.00231
1.8	20	10	1.06457	-0.00040	0.00017	0.00163	0.00267	0.00071	-0.00431
1.8	20	20	0.93650	-0.00109	0.00046	0.00431	0.00690	0.00429	-0.00125
1.8	20	25	0.88009	-0.00141	0.00060	0.00569	0.00910	0.00659	0.00127
3.3	0	20	1.16424	-0.00029	0.00007	-0.00031	-0.00113	-0.00857	-0.01972
3.3	0	30	1.07710	-0.00067	0.00024	0.00133	0.00153	-0.00593	-0.01702
3.3	0	40	0.99861	-0.00110	0.00042	0.00318	0.00454	-0.00259	-0.01323
3.3	0	50	0.93148	-0.00150	0.00060	0.00493	0.00738	0.00070	-0.00933
3.3	20	20	1.12948	-0.00013	0.00001	-0.00076	-0.00176	-0.00882	-0.01947
3.3	20	30	1.01693	-0.00057	0.00020	0.00115	0.00137	-0.00533	-0.01542
3.3	20	40	0.91633	-0.00110	0.00043	0.00350	0.00521	-0.00072	-0.00977
3.3	20	50	0.83264	-0.00160	0.00066	0.00574	0.00886	0.00381	-0.00413
4.5	0	30	1.17261	-0.00020	0.00001	-0.00127	-0.00289	-0.01284	-0.02667
4.5	0	40	1.09713	-0.00050	0.00014	0.00004	-0.00075	-0.01053	-0.02415
4.5	0	50	1.02506	-0.00085	0.00030	0.00162	0.00183	-0.00747	-0.02049
4.5	0	60	0.95936	-0.00121	0.00045	0.00326	0.00451	-0.00414	-0.01634
4.5	20	30	1.13059	-0.00008	-0.00003	-0.00157	-0.00328	-0.01273	-0.02590
4.5	20	40	1.03481	-0.00044	0.00013	0.00007	-0.00059	-0.00950	-0.02198
4.5	20	50	0.94453	-0.00089	0.00032	0.00207	0.00270	-0.00530	-0.01665
4.5	20	60	0.86400	-0.00133	0.00052	0.00416	0.00612	-0.00084	-0.01089
			Max	-0.00001	0.00066	0.00576	0.00910	0.00659	0.00127

Table 8b

Temperature Effects on Neutron Multiplication (in Δk) – Turkey Point Region II Racks w/ Inserts

Enrichment (w/o U^{235})	Cooling (yrs)	Burnup (GWD/MTU)	Ref 68F (20 °C)	Rack 39.2 F (4 °C)	Rack 80.3 F (27 °C)	Rack 185F	Rack 248 F (120 °C)	Rack 248 F (120 °C) 10% Void	Rack 248 F (120 °C) 20% Void
1.8	0	4	0.92500	0.00256	-0.00117	-0.01265	-0.02058	-0.03708	-0.05746
1.8	0	10	0.88387	0.00192	-0.00091	-0.01007	-0.01649	-0.03300	-0.05324
1.8	0	20	0.81213	0.00119	-0.00059	-0.00698	-0.01155	-0.02725	-0.04644
1.8	0	30	0.75024	0.00062	-0.00033	-0.00455	-0.00771	-0.02239	-0.04032
1.8	20	4	0.92214	0.00263	-0.00120	-0.01281	-0.02076	-0.03706	-0.05720
1.8	20	10	0.86373	0.00201	-0.00094	-0.01025	-0.01666	-0.03261	-0.05217
1.8	20	20	0.76118	0.00117	-0.00057	-0.00657	-0.01078	-0.02508	-0.04258
1.8	20	30	0.67774	0.00045	-0.00026	-0.00345	-0.00578	-0.01829	-0.03364
3.3	0	20	0.95861	0.00176	-0.00089	-0.01054	-0.01772	-0.03726	-0.06063
3.3	0	30	0.88487	0.00138	-0.00070	-0.00866	-0.01463	-0.03313	-0.05527
3.3	0	40	0.81878	0.00096	-0.00051	-0.00672	-0.01143	-0.02875	-0.04954
3.3	0	50	0.76267	0.00057	-0.00034	-0.00488	-0.00846	-0.02466	-0.04411
3.3	20	20	0.92993	0.00184	-0.00091	-0.01062	-0.01774	-0.03655	-0.05905
3.3	20	30	0.83538	0.00136	-0.00069	-0.00831	-0.01395	-0.03111	-0.05166
3.3	20	40	0.75165	0.00082	-0.00045	-0.00578	-0.00979	-0.02512	-0.04356
3.3	20	50	0.68268	0.00032	-0.00022	-0.00338	-0.00591	-0.01957	-0.03605
4.5	0	30	0.97230	0.00163	-0.00084	-0.01031	-0.01752	-0.03805	-0.06232
4.5	0	40	0.90729	0.00134	-0.00071	-0.00892	-0.01522	-0.03488	-0.05819
4.5	0	50	0.84549	0.00101	-0.00055	-0.00733	-0.01261	-0.03122	-0.05329
4.5	0	60	0.78962	0.00068	-0.00040	-0.00573	-0.00998	-0.02742	-0.04818
4.5	20	30	0.93710	0.00166	-0.00084	-0.01026	-0.01735	-0.03701	-0.06024
4.5	20	40	0.85547	0.00130	-0.00068	-0.00846	-0.01437	-0.03263	-0.05428
4.5	20	50	0.77911	0.00087	-0.00049	-0.00638	-0.01095	-0.02758	-0.04733
4.5	20	60	0.71169	0.00044	-0.00029	-0.00428	-0.00750	-0.02247	-0.04033
			Max	0.00263	-0.00022	-0.00338	-0.00578	-0.01829	-0.03364

Table 9
Effects (in Δk) of Manufacturing Tolerances at Turkey Point

			Region II	No Inserts		Region II	Inserts	
Enrichment (w/o U^{235})	Cooling (yrs)	Burnup (GWD/MTU)	Rack	Fuel	Combined	Rack	Fuel	Combined
1.8	0	4	0.00533	0.00809	0.0097	0.00564	0.00774	0.0096
1.8	0	10	0.00485	0.00750	0.0089	0.00556	0.00718	0.0091
1.8	0	20	0.00435	0.00713	0.0084	0.00544	0.00691	0.0088
1.8	0	30	0.00402	0.00668	0.0078	0.00534	0.00660	0.0085
1.8	20	4	0.00528	0.00826	0.0098	0.00563	0.00783	0.0096
1.8	20	10	0.00472	0.00824	0.0095	0.00552	0.00768	0.0095
1.8	20	20	0.00410	0.00822	0.0092	0.00536	0.00759	0.0093
1.8	20	30	0.00365	0.00749	0.0083	0.00522	0.00700	0.0087
3.3	0	20	0.00432	0.00451	0.0062	0.00574	0.00486	0.0075
3.3	0	30	0.00406	0.00505	0.0065	0.00559	0.00535	0.0077
3.3	0	40	0.00384	0.00553	0.0067	0.00544	0.00578	0.0079
3.3	0	50	0.00364	0.00591	0.0069	0.00536	0.00615	0.0082
3.3	20	20	0.00420	0.00514	0.0066	0.00569	0.00524	0.0077
3.3	20	30	0.00387	0.00585	0.0070	0.00550	0.00581	0.0080
3.3	20	40	0.00355	0.00632	0.0072	0.00533	0.00620	0.0082
3.3	20	50	0.00328	0.00655	0.0073	0.00523	0.00640	0.0083
4.5	0	30	0.00397	0.00355	0.0053	0.00577	0.00408	0.0071
4.5	0	40	0.00380	0.00403	0.0055	0.00562	0.00455	0.0072
4.5	0	50	0.00365	0.00464	0.0059	0.00550	0.00513	0.0075
4.5	0	60	0.00348	0.00528	0.0063	0.00540	0.00571	0.0079
4.5	20	30	0.00386	0.00412	0.0056	0.00571	0.00440	0.0072
4.5	20	40	0.00362	0.00472	0.0059	0.00553	0.00492	0.0074
4.5	20	50	0.00339	0.00534	0.0063	0.00539	0.00549	0.0077
4.5	20	60	0.00318	0.00594	0.0067	0.00528	0.00599	0.0080
				Max	0.0098		Max	0.0096
				Temperature	0.0058		Temperature	0.0026

Table 10

Non-Uniform Axial-Profiles used in Turkey Point Depletion

Axial Section (1 = Bottom)	Profile for Blanketed Assemblies	Profile for Non-Blanketed Assemblies
1	0.1580	0.5485
2	0.7525	0.8477
3	0.9952	1.077
4	1.1093	1.077
5	1.1536	1.105
6	1.1629	1.105
7	1.1541	1.105
8	1.1454	1.105
9	1.1394	1.098
10	1.1353	1.098
11	1.1337	1.098
12	1.1373	1.098
13	1.1467	1.079
14	1.1510	1.079
15	1.1504	1.079
16	1.1471	1.079
17	1.1413	1.05
18	1.1319	1.05
19	1.1154	1.05
20	1.0845	1.05
21	1.0236	0.9604
22	0.9016	0.9604
23	0.6778	0.7338
24	0.1517	0.467

Table 11

Region II, 3 Category II-2 FA, 1 Category II-4 FA, 2x2 Model, No Inserts, w/Boraflex @ 0.006 gm B^{10}/cm^2, Blanketed Fuel

Category II-2 FA (3 of 4)				Category II-4 FA (1 of 4)				- Reference -			
								Array II-G	Array II-D	Array II-B	
Enr (w/o)	Burnup (GWD/MTU)	CT (years)	Axial Profile	Enr (w/o)	Burnup (GWD/MTU)	CT (years)	Axial Profile	k_{calc}	k_{calc}	k_{calc}	Delta k_{calc}
4.5	44.69	0	uniform	4.5	50.73	0	uniform	0.9364	0.9798	0.9772	-0.0434
4.5	44.69	0	uniform	4.0	44.96	0	uniform	0.9376	0.9798	0.9772	-0.0422
4.5	44.69	0	uniform	3.3	36.52	0	uniform	0.9365	0.9808	0.9772	-0.0443
4.5	44.69	0	uniform	2.5	26.33	0	uniform	0.9363	0.9801	0.9772	-0.0438
4.5	44.69	0	uniform	3.3	29.92	15	uniform	0.9361	0.9780	0.9772	-0.0419
4.5	44.69	0	uniform	4.5	41.10	20	segmented	0.9274	0.9785	0.9772	-0.0511
4	39.05	0	uniform	4.5	50.73	0	uniform	0.9374	0.9798	0.9786	-0.0424
4	39.05	0	uniform	4	44.96	0	uniform	0.9372	0.9798	0.9786	-0.0426
4	39.05	0	uniform	3.3	36.52	0	uniform	0.9374	0.9808	0.9786	-0.0434
4	39.05	0	uniform	2.5	26.33	0	uniform	0.9365	0.9801	0.9786	-0.0436
4	39.05	0	uniform	3.3	29.92	15	uniform	0.9364	0.9780	0.9786	-0.0422
4	39.05	0	uniform	4.5	41.1	20	segmented	0.9280	0.9785	0.9786	-0.0506
3.3	30.83	0	uniform	4.5	50.73	0	uniform	0.9380	0.9798	0.9798	-0.0418
3.3	30.83	0	uniform	4	44.96	0	uniform	0.9370	0.9798	0.9798	-0.0428
3.3	30.83	0	uniform	3.3	36.52	0	uniform	0.9366	0.9808	0.9798	-0.0442
3.3	30.83	0	uniform	2.5	26.33	0	uniform	0.9364	0.9801	0.9798	-0.0437
3.3	30.83	0	uniform	3.3	29.92	15	uniform	0.9364	0.9780	0.9798	-0.0434
3.3	30.83	0	uniform	4.5	41.1	20	segmented	0.9266	0.9785	0.9798	-0.0532
3	27.2	0	uniform	4.5	50.73	0	uniform	0.9277	0.9798	0.9809	-0.0532
3	27.2	0	uniform	4	44.96	0	uniform	0.9374	0.9798	0.9809	-0.0435
3	27.2	0	uniform	3.3	36.52	0	uniform	0.9370	0.9808	0.9809	-0.0439
3	27.2	0	uniform	2.5	26.33	0	uniform	0.9370	0.9801	0.9809	-0.0439
3	27.2	0	uniform	3.3	29.92	15	uniform	0.9351	0.9780	0.9809	-0.0458
3	27.2	0	uniform	4.5	41.1	20	segmented	0.9370	0.9785	0.9809	-0.0439
2.5	20.99	0	uniform	4.5	50.73	0	uniform	0.9268	0.9798	0.9811	-0.0543
2.5	20.99	0	uniform	4	44.96	0	uniform	0.9359	0.9798	0.9811	-0.0452
2.5	20.99	0	uniform	3.3	36.52	0	uniform	0.9367	0.9808	0.9811	-0.0444
2.5	20.99	0	uniform	2.5	26.33	0	uniform	0.9357	0.9801	0.9811	-0.0454
2.5	20.99	0	uniform	3.3	29.92	15	uniform	0.9354	0.9780	0.9811	-0.0457
2.5	20.99	0	uniform	4.5	41.1	20	segmented	0.9362	0.9785	0.9811	-0.0449

Table 12

Region II, 3 Category II-2 FA, 1 Category II-4 FA, 2x2 Model, No Inserts, w/Boraflex @ 0.006 gm B^{10}/cm^2, Non-Blanketed Fuel

Category II-2 FA (3 of 4)				Category II-4 FA (1 of 4)				- Reference -			
								Array II-G	Array II-D	Array II-B	
Enr (w/o)	Burnup (gwd/mtu)	CT (years)	Axial Profile	Enr (w/o)	Burnup (gwd/mtu)	CT (years)	Axial Profile	k_{calc}	k_{calc}	k_{calc}	Delta k_{calc}
4	42.04	0	segmented	4.0	50.39	0	segmented	0.9797	0.9771	0.9793	0.0004
4	42.04	0	segmented	3.5	42.45	0	segmented	0.9800	0.9802	0.9793	-0.0002
4	42.04	0	segmented	3.0	34.73	0	segmented	0.9774	0.9802	0.9793	-0.0028
4	42.04	0	segmented	2.5	27.22	0	segmented	0.9757	0.9785	0.9793	-0.0036
4	42.04	0	segmented	1.8	17.08	0	uniform	0.9599	0.9768	0.9793	-0.0194
4	42.04	0	segmented	3.0	30.31	10	segmented	0.9774	0.9764	0.9793	-0.0019
4	42.04	0	segmented	3	28.7	20	segmented	0.9787	0.9730	0.9793	-0.0006
3.5	35.04	0	segmented	4	50.39	0	segmented	0.9765	0.9771	0.9795	-0.0030
3.5	35.04	0	segmented	3.5	42.45	0	segmented	0.9756	0.9802	0.9795	-0.0046
3.5	35.04	0	segmented	3	34.73	0	segmented	0.9748	0.9802	0.9795	-0.0054
3.5	35.04	0	segmented	2.5	27.22	0	segmented	0.9711	0.9785	0.9795	-0.0084
3.5	35.04	0	segmented	1.8	17.08	0	uniform	0.9567	0.9768	0.9795	-0.0228
3.5	35.04	0	segmented	3	30.31	10	segmented	0.9751	0.9764	0.9795	-0.0044
3.5	35.04	0	segmented	3	28.7	20	segmented	0.9741	0.9730	0.9795	-0.0054
3	28.19	0	segmented	4	50.39	0	segmented	0.9715	0.9771	0.9777	-0.0062
3	28.19	0	segmented	3.5	42.45	0	segmented	0.9696	0.9802	0.9777	-0.0106
3	28.19	0	segmented	3	34.73	0	segmented	0.9690	0.9802	0.9777	-0.0112
3	28.19	0	segmented	2.5	27.22	0	segmented	0.9670	0.9785	0.9777	-0.0115
3	28.19	0	segmented	1.8	17.08	0	uniform	0.9513	0.9768	0.9777	-0.0264
3	28.19	0	segmented	3	30.31	10	segmented	0.9689	0.9764	0.9777	-0.0088
3	28.19	0	segmented	3	28.7	20	segmented	0.9678	0.9730	0.9777	-0.0099
2.5	21.47	0	uniform	4	50.39	0	segmented	0.9251	0.9771	0.9767	-0.0520
2.5	21.47	0	uniform	3.5	42.45	0	segmented	0.9263	0.9802	0.9767	-0.0539
2.5	21.47	0	uniform	3	34.73	0	segmented	0.9270	0.9802	0.9767	-0.0532
2.5	21.47	0	uniform	2.5	27.22	0	segmented	0.9272	0.9785	0.9767	-0.0513
2.5	21.47	0	uniform	1.8	17.08	0	uniform	0.9294	0.9768	0.9767	-0.0474
2.5	21.47	0	uniform	3	30.31	10	segmented	0.9243	0.9764	0.9767	-0.0524
2.5	21.47	0	uniform	3	28.7	20	segmented	0.9239	0.9730	0.9767	-0.0528
1.8	12.32	0	uniform	4	50.39	0	segmented	0.9198	0.9771	0.9702	-0.0573
1.8	12.32	0	uniform	3.5	42.45	0	segmented	0.9187	0.9802	0.9702	-0.0615
1.8	12.32	0	uniform	3	34.73	0	segmented	0.9212	0.9802	0.9702	-0.0590
1.8	12.32	0	uniform	2.5	27.22	0	segmented	0.9208	0.9785	0.9702	-0.0577
1.8	12.32	0	uniform	1.8	17.08	0	uniform	0.9234	0.9768	0.9702	-0.0534
1.8	12.32	0	uniform	3	30.31	10	segmented	0.9182	0.9764	0.9702	-0.0582
1.8	12.32	0	uniform	3	28.7	20	segmented	0.9179	0.9730	0.9702	-0.0551

Table 13

Category II-2 Fuel

Comparison of Rack-to-Wall Interface Calculations with Boraflex present @ 0.006 gm B^{10}/cm^2 and with no Boraflex

Case	Description	Enrichment	Burnup	Cooling Time (yrs)	Axial Profile	k_{calc}	Delta k_{calc}
Peripheral Array II-B (alternative)	Reference⁺	1.8	12.32	0	uniform	0.9681	
Array II-H	w/Boraflex	1.8	12.32	0	uniform	0.9158	-0.0523
Peripheral Array II-B (alternative)	Reference⁺	4	36.32	20	segmented	0.9668	
Array II-H	w/Boraflex	4	36.32	20	segmented	0.9671	0.0003

⁺No Boraflex present. Refer also to Technical Specification Amendment 234 Figure 5.5-4

Table 14

Rack Minimum Gap Analysis - II-4 Fuel @1.15" across Gap

Case	Enr (w/o)	FA Type	Burnup (gwd/mtu)	Cooling Time (years)	Axial Profile	k_{calc}	*Delta* k_{calc}
Gap - No Boraflex+	2.5	blanketed	26.33	0	uniform	0.9021	
Boraflex w/No Gap	2.5	blanketed	26.33	0	uniform	0.9024	-0.0003
Gap - No Boraflex	4.5	blanketed	50.73	0	uniform	0.9074	
Boraflex w/No Gap	4.5	blanketed	50.73	0	uniform	0.9064	0.0010
Gap - No Boraflex	4.5	blanketed	41.1	20	segmented	0.9088	
Boraflex w/No Gap	4.5	blanketed	41.1	20	segmented	0.9099	-0.0011
Gap - No Boraflex	2.5	non-blanketed	27.22	0	segmented	0.9312	
Boraflex w/No Gap	2.5	non-blanketed	27.22	0	segmented	0.9355	-0.0043
Gap - No Boraflex	4	non-blanketed	50.39	0	segmented	0.9485	
Boraflex w/No Gap	4	non-blanketed	50.39	0	segmented	0.9529	-0.0044
Gap - No Boraflex	4	non-blanketed	42.85	20	segmented	0.9418	
Boraflex w/No Gap	4	non-blanketed	42.85	20	segmented	0.9465	-0.0047

+Analyses denoted as *Gap – No Boraflex* mean that a 1.15" gap between adjacent rack modules is modeled, with no Boraflex present on the exterior face of the rack module. Other faces of peripheral cells, and faces of interior cells, are modeled as having Boraflex present @ the 0.006 gm B^{10}/cm^2 areal density.

Figure 1

Degraded Boraflex Panel

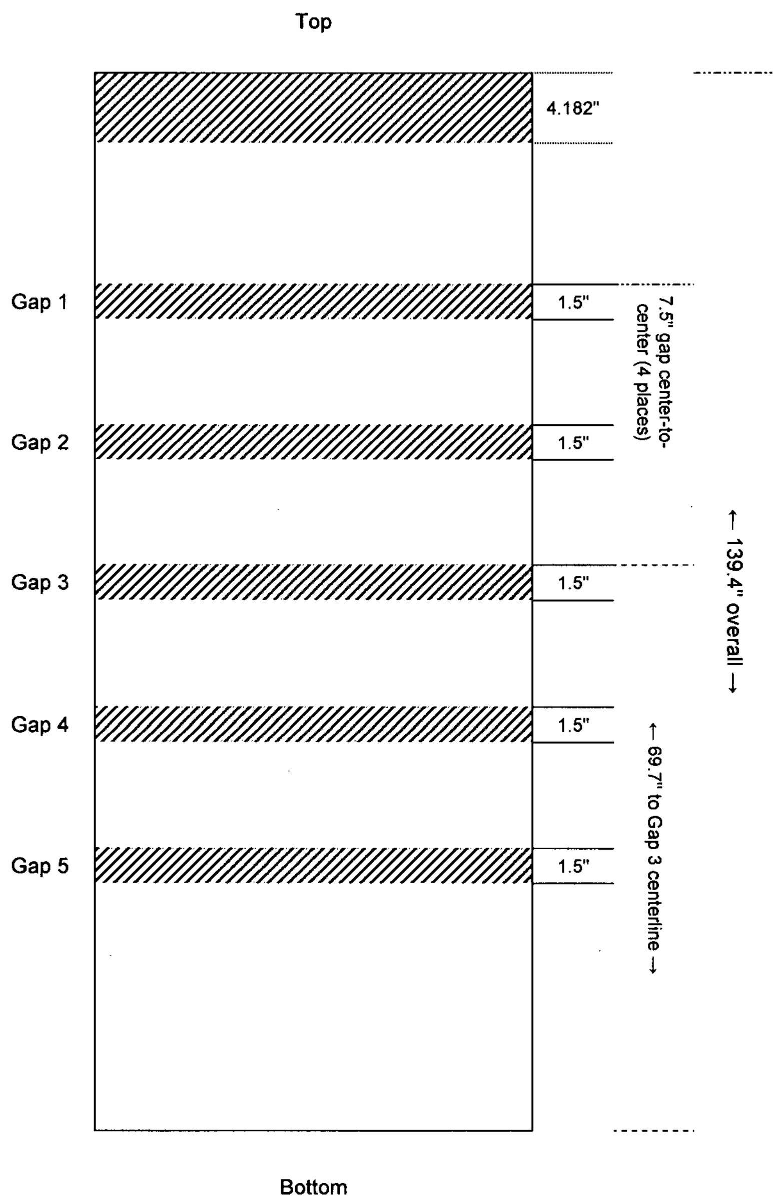
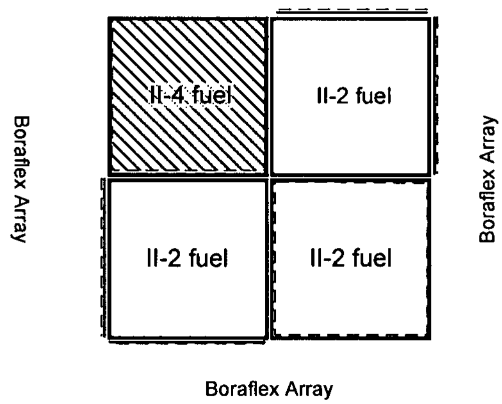


Figure 2

Turkey Point Unit 3

Arrays of Stored Fuel Crediting Boraflex[R]

Array II-G



Array II-H

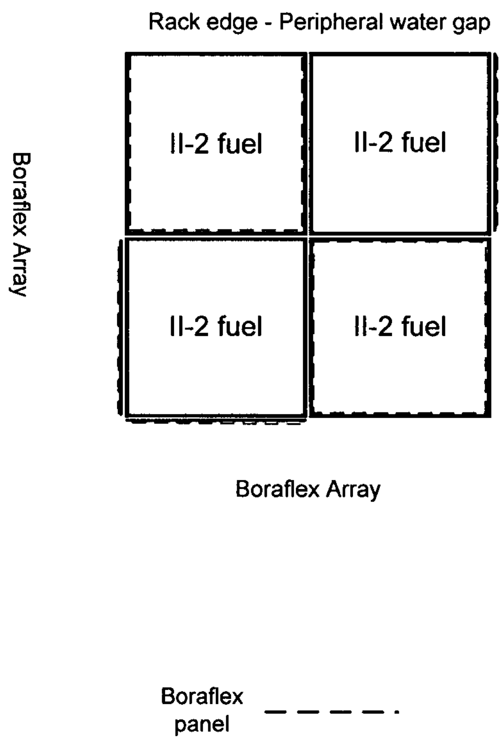
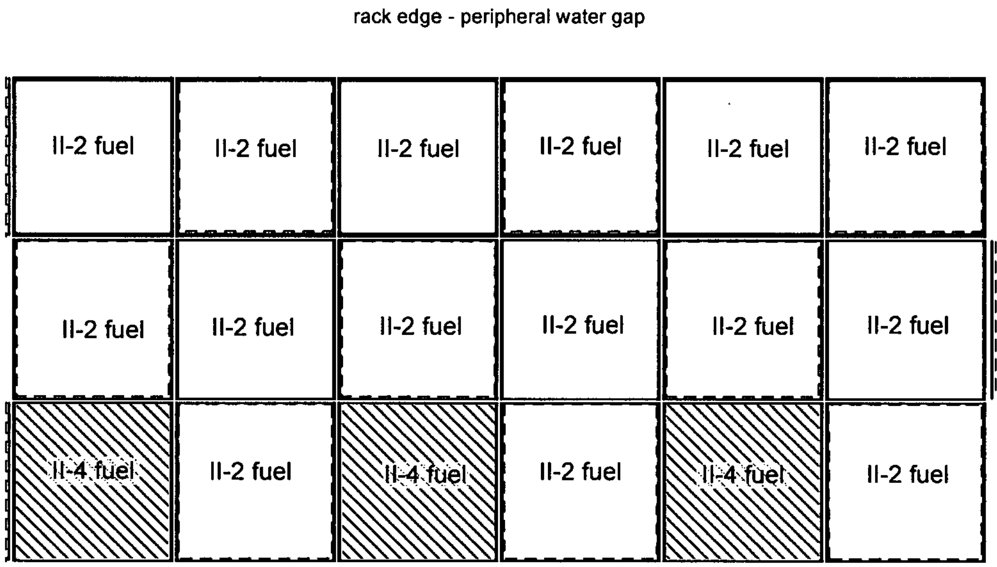


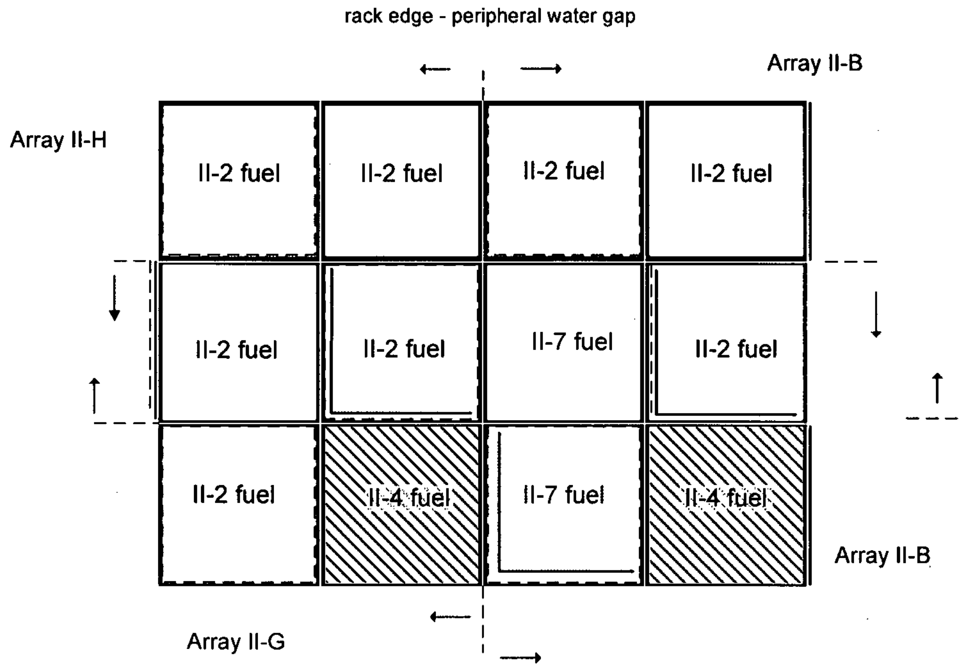
Figure 3



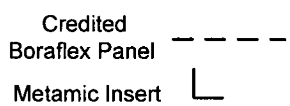
Interface of Arrays II-G and II-H

Boraflex Panel — — — —

Figure 3a



Example Interface of Arrays II-G, II-H and II-B



Note that Boraflex may still be present in rack locations where it is not credited

Figure 4

Turkey Point Unit 3
Example Region II to Region I Interface
Corner Configured as Array II-A

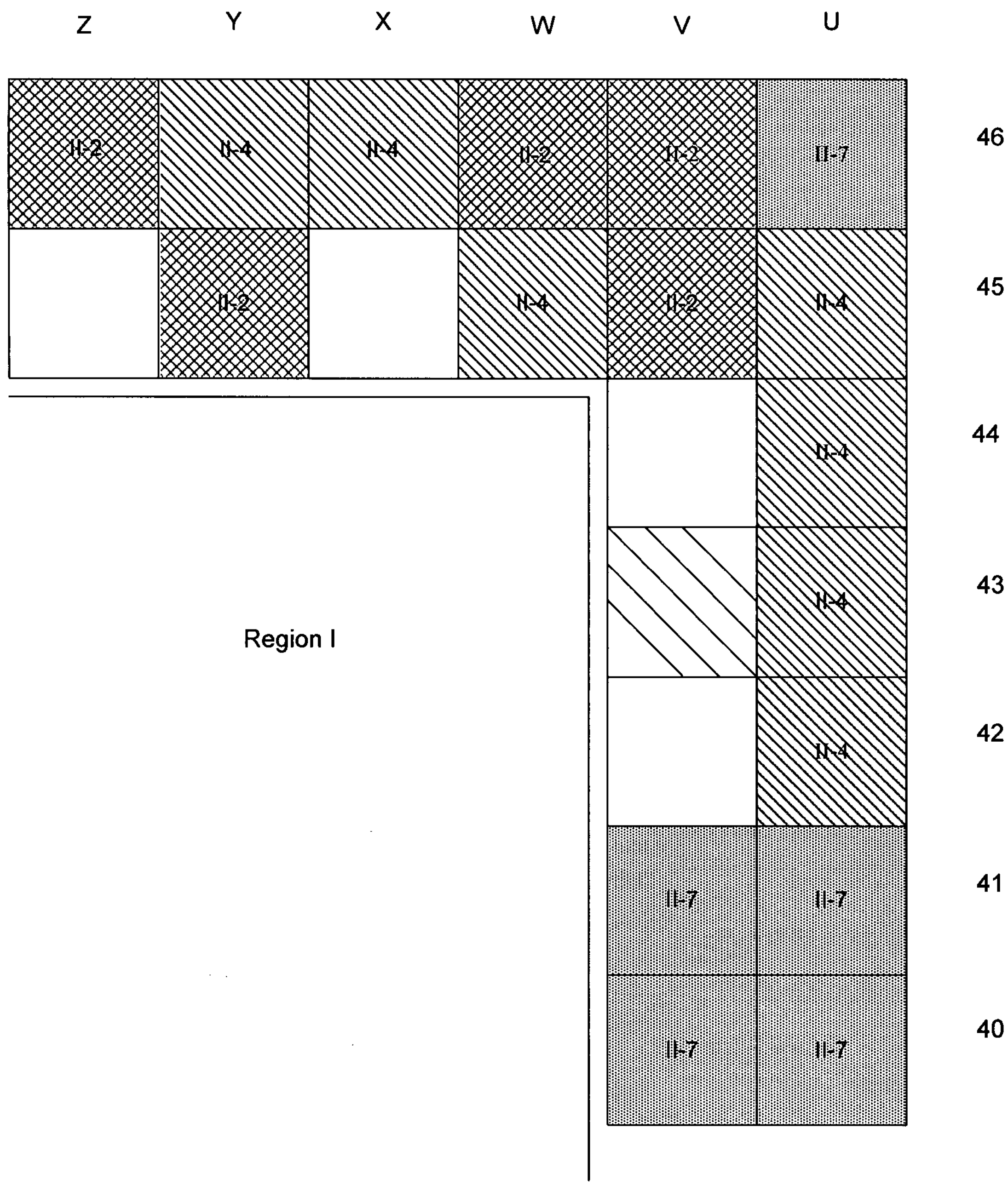


Figure 5
Modeling of Array II-H

concrete

SS liner

water gap

no Boraflex along edge

Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex
Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex
Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-4 Boraflex	Cat. II-2 Boraflex	Cat. II-4 Boraflex	Cat. II-2 Boraflex	Cat. II-4 Boraflex	Cat. II-2 Boraflex	Cat. II-4 Boraflex	Cat. II-2 Boraflex	Cat. II-4 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex
Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex
Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-4 Boraflex	Cat. II-2 Boraflex	Cat. II-4 Boraflex	Cat. II-2 Boraflex	Cat. II-4 Boraflex	Cat. II-2 Boraflex	Cat. II-4 Boraflex	Cat. II-2 Boraflex	Cat. II-4 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex
Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex
Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-4 Boraflex	Cat. II-2 Boraflex	Cat. II-4 Boraflex	Cat. II-2 Boraflex	Cat. II-4 Boraflex	Cat. II-2 Boraflex	Cat. II-4 Boraflex	Cat. II-2 Boraflex	Cat. II-4 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex
Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex
Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-4 Boraflex	Cat. II-2 Boraflex	Cat. II-4 Boraflex	Cat. II-2 Boraflex	Cat. II-4 Boraflex	Cat. II-2 Boraflex	Cat. II-4 Boraflex	Cat. II-2 Boraflex	Cat II-4 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex
Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex
Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex	Cat. II-2 Boraflex

no Boraflex along edge

water gap

liner

concrete

Left side (outer to inner): concrete, liner, water gap, no Boraflex along edge

Right side (inner to outer): no Boraflex along edge, water gap, liner, concrete

Attachment 3

Florida Power and Light Company
Turkey Point Units 3 and 4
Renewed Facility Operating License Nos. DPR-31 and DPR-41
Docket Nos. 50-250 and 50-251
License Amendment Request Regarding a Spent Fuel Pool Criticality Analysis for Unit 3 Taking Credit for Boraflex

Marked-up Technical Specification Pages

LIMITING CONDITIONS FOR OPERATION AND SURVEILLANCE REQUIREMENTS

INDEX

DESIGN FEATURES

3/4.9 REFUELING OPERATIONS

3/4.9.1 BORON CONCENTRATION

LIMITING CONDITION FOR OPERATION

3.9.1 The boron concentration of all filled portions of the Reactor Coolant System and the refueling canal shall be maintained uniform and sufficient to ensure that the more restrictive of the following reactivity conditions is met; either:

a. A K_{eff} of 0.95 or less, or

b. A boron concentration of greater than or equal to 1950 ppm.

APPLICABILITY: MODE 6.*

ACTION:

With the requirements of the above specification not satisfied, immediately suspend all operations involving CORE ALTERATIONS or positive reactivity changes and initiate and continue boration at greater than or equal to 16 gpm of a solution containing greater than or equal to 3.0 wt% (5245 ppm) boron or its equivalent until K_{eff} is reduced to less than or equal to 0.95 or the boron concentration is restored to greater than or equal to 1950 ppm, whichever is the more restrictive.

SURVEILLANCE REQUIREMENTS

4.9.1.1 The more restrictive of the above two reactivity conditions shall be determined prior to:

a. Removing or unbolting the reactor vessel head, and

b. Withdrawal of any full-length control rod in excess of 3 feet from its fully inserted position within the reactor vessel.

4.9.1.2 The boron concentration of the Reactor Coolant System and the refueling canal shall be determined by chemical analysis at least once per 72 hours.

4.9.1.3 Valves isolating unborated water sources** shall be verified closed and secured in position by mechanical stops or by removal of air or electrical power at least once per 31 days.

~~4.9.1.4 The spent fuel pit boron concentration shall be determined at least once per 31 days.~~

* The reactor shall be maintained in MODE 6 whenever fuel is in the reactor vessel with the vessel head closure bolts less than fully tensioned or with the head removed.

** The primary water supply to the boric acid blender may be opened under administrative controls for makeup.

REFUELING OPERATIONS

3/4.9.14 SPENT FUEL STORAGE

LIMITING CONDITION FOR OPERATION

3.9.14 The following conditions shall apply to spent fuel storage:

~~a. The maximum enrichment loading for the fuel assemblies in the spent fuel racks shall not exceed 4.5 weight percent of U-235.~~

a. ~~b.~~ The minimum boron concentration in the Spent Fuel Pit shall be 1950 ppm.

b. ~~c.~~ Storage in Region II of the Spent Fuel Pit shall be further restricted by burnup and enrichment limits specified in Table 3.9-1. (Unit 4 Only.)

INSERT #1 →

APPLICABILITY: At all times when fuel is stored in the Spent Fuel Pit.

ACTION:

a. With ~~either condition a, or c~~ condition b or c not satisfied, suspend movement of additional fuel assemblies into the Spent Fuel Pit of the affected unit and restore the spent fuel storage configuration to within the specified conditions.

b. With boron concentration in the Spent Fuel Pit less than 1950 ppm, suspend movement of spent fuel in the Spent Fuel Pit and initiate action to restore boron concentration to 1950 ppm or greater.

INSERT #2 →

SURVEILLANCE REQUIREMENTS

4.9.14.1 The boron concentration of the Spent Fuel Pit shall be verified to be 1950 ppm or greater at least once per month.

INSERT #2a →

This action applies to each Unit separately, as applicable.

TABLE 3.9-1 - (Unit 4 Only)

SPENT FUEL BURNUP REQUIREMENTS FOR STORAGE
IN REGION II OF THE SPENT FUEL PIT

Initial w/o	Discharge Burnup MWD/MTU
1.6	0.0
1.80	3706
2.00	7459
2.20	9724
2.40	12582
2.60	15338
2.63	15914
2.80	17994
3.00	20548
3.25	23312
3.40	25354
3.60	27605
3.88	30256
4.00	31804
4.20	33752
4.40	35599
4.50	36746

Linear interpolation between values may be used for intermediate points.

5.5 FUEL STORAGE

5.5.1 CRITICALITY

5.5.1.1 The spent fuel storage racks are designed ~~to provide safe subcritical storage of fuel assemblies by providing sufficient center-to-center spacing or a combination of spacing and poison~~ and shall be maintained with:

a. A k_{eff} ~~equivalent to~~ less than 1.0 when flooded with unborated water, which includes an ~~conservative~~ allowance for biases and uncertainties as described in UFSAR ~~Appendix 14D~~. Chapter 9.

b. A k_{eff} ~~equivalent to~~ less than or equal to 0.95 when flooded with water borated to 650 ppm ~~water~~, which includes an ~~conservative~~ allowance for biases and uncertainties as described in UFSAR ~~Appendix 14D~~. Chapter 9.

c. A nominal 10.6 inch center-to-center distance for Region I and 9.0 inch center-to-center distance for Region II for the two region spent fuel pool storage racks. A nominal 10.1 inch center-to-center distance in the east-west direction and a nominal 10.7 inch center-to-center distance in the north-south direction for the Region I cask area storage rack.

INSERT #3 →

d. A ~~The~~ maximum enrichment loading for fuel assemblies of ~~is~~ 4.5 weight percent of U-235.

5.5.1.2 The racks for new fuel storage are designed to store fuel in a safe subcritical array and shall be maintained with:

a. A nominal 21 inch center-to-center spacing to assure k_{eff} equal to or less than 0.98 for optimum moderation conditions and equal to or less than 0.95 for fully flooded conditions.

b. Fuel assemblies placed in the New Fuel Storage Area shall contain no more than 4.5 weight percent of U-235.

This feature is applicable to Unit 4 only.

DESIGN FEATURES

5.5.1.3 Credit for burnup is taken in determining placement locations for spent fuel in the two-region spent fuel racks. Administrative controls are employed to evaluate the burnup of each spent fuel assembly stored in areas where credit for burnup is taken. The burnup of spent fuel is ascertained by careful analysis of burnup history, prior to placement into the storage locations. Procedures shall require an independent check of the analysis of suitability for storage. A complete record of such analysis is kept for the time period that the spent fuel assembly remains in storage onsite.

INSERT #4

DRAINAGE

5.5.2 The spent fuel storage pit is designed and shall be maintained to prevent inadvertent draining of the pool below a level of 6 feet above the fuel assemblies in the storage racks.

CAPACITY

5.5.3 The spent fuel pool storage racks are designed and shall be maintained with a storage capacity limited to no more than 1404 fuel assemblies in two region storage racks, and the cask area storage rack is designed and shall be maintained with a storage capacity limited to no more than 131 fuel assemblies. The total spent fuel pool storage capacity is limited to no more than 1535 fuel assemblies.

5.6 COMPONENT CYCLIC OR TRANSIENT LIMIT

5.6.1 The components identified in Table 5.6-1 are designed and shall be maintained within the cyclic or transient limits of Table 5.6-1.

(Move to page 5-19)

INSERT #1

c. The combination of initial enrichment, burnup, and cooling time of each fuel assembly stored in the Spent Fuel Pit shall be in accordance with Specification 5.5.1. (Unit 3 only.)

INSERT #2

c. The provisions of Specification 3.0.3 are not applicable.

INSERT #2a:

4.9.14.2 A representative sample of inservice Metamic inserts shall be visually inspected in accordance with the Metamic Surveillance Program described in UFSAR Section 16.2. The surveillance program ensures that the performance requirements of Metamic are met over the surveillance interval. (Unit 3 only.)

INSERT #3

e. No restriction on storage of fresh or irradiated fuel assemblies in the cask area storage rack.

f. For Unit 3 only, fresh or irradiated fuel assemblies not stored in the cask area rack shall be stored in accordance with Specification 5.5.1.4 or configurations that have been shown to comply with Specification 5.5.1.1.a and 5.5.1.1.b using the NRC approved methodology in UFSAR Chapter 9.

INSERT #4

5.5.1.4. This feature is applicable to Unit 3 only. Credit for burnup and cooling time is taken in determining acceptable placement locations for spent fuel in the two-region spent fuel racks. Fresh or irradiated fuel assemblies shall be stored in compliance with the following:

a. Any 2x2 array of Region I storage cells containing fuel shall comply with the storage patterns in Figure 5.5-1 and the requirements of Table 5.5-1 and 5.5-2, as applicable. The reactivity rank of fuel assemblies in the 2x2 array (rank determined using Table 5.5-3) shall be equal to or less than that shown for the 2x2 array.

b. Any 2x2 array of Region II storage cells that does not credit Boraflex and containing fuel shall:

i. Comply with the storage patterns in Figure 5.5-2 and the requirements of Table 5.5-1 and 5.5-2, as applicable. The reactivity rank of fuel assemblies in the 2x2 array (rank determined using Table 5.5-3) shall be equal to or less than that shown for the 2x2 array,

ii Have the same directional orientation for Metamic inserts in a contiguous group of 2x2 arrays where Metamic inserts are required,

iii. Comply with the requirements of 5.5.1.4c for cells adjacent to Region I racks, and

iv. Comply with the requirements of 5.5.1.4d for cells adjacent to the spent fuel pit walls.

c. Any 2x2 array of Region II storage cells that interfaces with Region I shall comply with the rules of Figure 5.5-3. Arrays II-E and II-F may interface with Region I without special restriction. Arrays II-G and II-H shall not interface with Region I.

d. Any 2x2 array of Region II storage cells that does not credit Boraflex may adjoin a row of assemblies with a reactivity rank of II-2 (or lower) that is located in the outer row adjacent to the spent fuel pit wall. The outer row of reactivity rank II-2 (or lower) fuel assemblies need not contain any Metamic inserts or full length RCCAs, as long as the following additional requirements are met:

   i. Fuel is loaded to comply with the allowable storage patterns defined in Figure 5.5-4, and

   ii. Arrays II-E and II-F are loaded without any additional restriction on that 2x2 array. Arrays II-E and II-F do not have empty cells, Metamic inserts, or RCCAs that restrict the interface with the adjoining reactivity rank II-2 (or lower) fuel assemblies.

e. Any 2x2 array in Region II that credits Boraflex and containing fuel shall comply with the allowable storage patterns defined in Figure 5.5-5.

Insert the following tables and figures to follow page 5-6:

Table 5.5-1	3 pages
Table 5.5-2	3 pages
Table 5.5-3	1 page
Figure 5.5-1	1 page
Figure 5.5-2	1 page
Figure 5.5-3	1 page
Figure 5.5-4	1 page
Figure 5.5-5	1 page

These tables/figures are provided on the following pages:

Table 5.5-1 (Unit 3 only)

Blanketed Fuel - Minimum Required Fuel Assembly Burnup (Bu) as a Function of Enrichment (En) and Cooling Time (Ct)

See note 1 for use of Table 5.5-1

Fuel Category	Blanketed Fuel Storage Curve Coefficients[1]							Blanketed Fuel Minimum Burnup[1] (GWd/MTU) for Initial Enrichment[2]					
	A	B	C	D	E	F	G	Cooling Time[3]	2.5 w%	3.0 w%	3.3 w%	4.0 w%	4.5 w%
I-1[4]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
I-2	18.8602	-1.090486	0.266387	-0.00474496	-0.158563	0.00314739	-30.1637	0	10.17	16.60	20.20	27.83	32.62
								2.5	9.87	16.11	19.59	26.96	31.57
								5	9.60	15.67	19.06	26.19	30.62
								10	9.18	14.98	18.20	24.94	29.10
								15	8.92	14.52	17.62	24.08	28.04
								20	8.82	14.30	17.32	23.61	27.45
II-1	16.2639	-0.712257	0.175883	-0.00399237	-0.166686	0.00370969	-19.5118	0	16.70	22.87	26.40	34.15	39.25
								2.5	16.13	22.10	25.52	32.99	37.90
								5	15.62	21.43	24.74	31.96	36.70
								10	14.82	20.34	23.49	30.32	34.78
								15	14.27	19.61	22.65	29.23	33.50
								20	13.99	19.24	22.22	28.67	32.85
II-2	14.4600	-0.372732	0.132275	-0.00617104	-0.187813	0.00526411	-12.8293	0	20.99	27.20	30.83	39.05	44.69
								2.5	20.19	26.18	29.68	37.59	43.02
								5	19.48	25.28	28.67	36.32	41.57
								10	18.32	23.85	27.07	34.35	39.32
								15	17.50	22.89	26.04	33.11	37.94
								20	17.04	22.42	25.56	32.62	37.44
II-3	15.4624	-0.501267	-0.06553	0.00160009	-0.161078	0.00340497	-11.2483	0	24.27	30.63	34.32	42.58	48.18
								2.5	23.17	29.33	32.91	40.90	46.31
								5	22.19	28.18	31.65	39.41	44.65
								10	20.60	26.32	29.63	37.00	41.97
								15	19.53	25.05	28.25	35.36	40.13
								20	18.96	24.38	27.51	34.47	39.14

Table 5.5-1 (continued)

Blanketed Fuel - Minimum Required Fuel Assembly Burnup (Bu) as a Function of Enrichment (En) and Cooling Time (Ct)

See note 1 for use of Table 5.5-1

Fuel Category	Blanketed Fuel Storage Curve Coefficients[1]							Blanketed Fuel Minimum Burnup[1] (GWd/MTU) for Initial Enrichment[2]					
	A	B	C	D	E	F	G	Cooling Time[3]	2.5 w%	3.0 w%	3.3 w%	4.0 w%	4.5 w%
II-4	15.3172	-0.444842	-0.114363	0.00273060	-0.162664	0.00344467	-9.1868	0	26.33	32.76	36.52	44.96	50.73
								2.5	25.09	31.34	34.98	43.16	48.73
								5	24.00	30.08	33.61	41.55	46.96
								10	22.25	28.04	31.41	38.97	44.09
								15	21.06	26.67	29.92	37.20	42.14
								20	20.44	25.94	29.13	36.27	41.10
II-5	15.1701	-0.387768	-0.163521	0.00394514	-0.164014	0.00345174	-7.1273	0	28.37	34.89	38.71	47.35	53.29
								2.5	27.02	33.34	37.05	45.41	51.15
								5	25.82	31.97	35.57	43.69	49.26
								10	23.90	29.77	33.20	40.93	46.22
								15	22.60	28.28	31.59	39.05	44.14
								20	21.93	27.50	30.75	38.06	43.05
II-6	13.4516	-0.078364	-0.266734	0.00288411	-0.147006	0.00446530	-3.3460	0	29.79	36.30	40.19	49.21	55.60
								2.5	28.30	34.64	38.42	47.20	53.42
								5	26.97	33.17	36.87	45.45	51.53
								10	24.86	30.85	34.43	42.73	48.61
								15	23.44	29.35	32.88	41.05	46.85
								20	22.73	28.66	32.20	40.41	46.23
II-7	13.7900	-0.086680	-0.355570	0.00574698	-0.145745	0.00426994	-2.0705	0	31.86	38.52	42.49	51.70	58.23
								2.5	30.17	36.65	40.53	49.50	55.86
								5	28.67	35.02	38.81	47.58	53.80
								10	26.31	32.45	36.11	44.60	50.61
								15	24.76	30.80	34.41	42.76	48.67
								20	24.03	30.09	33.70	42.06	47.99

Table 5.5-1 (continued)

Blanketed Fuel - Minimum Required Fuel Assembly Burnup (Bu) as a Function of Enrichment (En) and Cooling Time (Ct)

See note 1 for use of Table 5.5-1

Fuel Category	Blanketed Fuel Storage Curve Coefficients[1]							Blanketed Fuel Minimum Burnup[1] (GWd/MTU) for Initial Enrichment[2]					
	A	B	C	D	E	F	G	Cooling Time[3]	2.5 w%	3.0 w%	3.3 w%	4.0 w%	4.5 w%
II-8	14.1212	-0.094016	-0.448138	0.00877894	-0.143511	0.00402944	-0.7808	0	33.93	40.74	44.80	54.20	60.86
								2.5	32.04	38.67	42.63	51.80	58.29
								5	30.37	36.86	40.74	49.71	56.06
								10	27.75	34.04	37.79	46.47	52.61
								15	26.07	32.25	35.94	44.47	50.51
								20	25.34	31.51	35.19	43.71	49.75

Notes

1. All relevant uncertainties are explicitly included in the criticality analysis. For instance, no additional allowance for burnup uncertainty is required. For a fuel assembly to meet the requirements of a Fuel Category, the assembly burnup must exceed the "minimum burnup" given in the table for the assembly "cooling time" and "initial enrichment." Alternatively, the specific minimum burnup required for each fuel assembly may be calculated from the following equation: $Bu = A \times En + B \times En^2 + C \times Ct + D \times Ct^2 + E \times Ct \times En + F \times Ct^2 \times En + G$. Only cooling times of 0, 2.5, 5, 10, 15 and 20 years may be used in this equation. Actual cooling time (Ct) is rounded down to the nearest value.
2. Nominal central zone U-235 enrichment: Axial blanket material is not considered when determining enrichment.
3. Cooling time in years.
4. Fresh unburned fuel up to 4.5 w% U-235 enrichment: No burnup is required.

Table 5.5-2 (Unit 3 only)

Non-Blanketed Fuel - Minimum Required Fuel Assembly Burnup (Bu) as a Function of Enrichment (En) and Cooling Time (Ct)

See note 1 for use of Table 5.5-2

Fuel Category	Non-Blanketed Fuel Storage Curve Coefficients[1]							Non-Blanketed Fuel Minimum Burnup[1] (GWd/MTU) for Initial Enrichment[2]					
	A	B	C	D	E	F	G	Cooling Time[3]	1.8 w%	2.5 w%	3.0 w%	3.5 w%	4.0 w%
I-1[4]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
I-2	18.1371	-0.944126	0.253120	-0.00553408	-0.151450	0.00334051	-29.3574	0	0.23	10.08	16.56	22.56	28.08
								2.5	0.18	9.79	16.08	21.90	27.25
								5	0.14	9.53	15.66	21.33	26.52
								10	0.08	9.11	14.99	20.40	25.34
								15	0.05	8.84	14.55	19.79	24.56
								20	0.03	8.70	14.33	19.48	24.16
II-1	11.9800	0.158287	0.237665	-0.00688305	-0.192273	0.00492032	-14.2029	0	7.87	16.74	23.16	29.67	36.25
								2.5	7.62	16.16	22.36	28.64	35.00
								5	7.38	15.66	21.66	27.75	33.91
								10	6.99	14.85	20.56	26.35	32.22
								15	6.69	14.31	19.85	25.46	31.16
								20	6.49	14.04	19.53	25.10	30.74
II-2	11.8419	0.287918	0.113820	-0.00527641	-0.175033	0.00507248	-9.9305	0	12.32	21.47	28.19	35.04	42.04
								2.5	11.84	20.71	27.22	33.87	40.67
								5	11.41	20.04	26.38	32.86	39.49
								10	10.69	18.98	25.07	31.30	37.68
								15	10.17	18.28	24.25	30.37	36.63
								20	9.83	17.96	23.94	30.06	36.32
II-3	12.6055	0.361578	-0.075193	0.00118870	-0.152297	0.00386780	-8.6212	0	15.24	25.15	32.45	39.93	47.59
								2.5	14.42	24.08	31.20	38.50	45.98
								5	13.70	23.14	30.11	37.25	44.58
								10	12.56	21.68	28.41	35.32	42.41
								15	11.83	20.76	27.35	34.12	41.07
								20	11.51	20.38	26.92	33.65	40.56

Table 5.5-2 (continued)

Non-Blanketed Fuel - Minimum Required Fuel Assembly Burnup (Bu) as a Function of Enrichment (En) and Cooling Time (Ct)

See note 1 for use of Table 5.5-2

Fuel Category	Non-Blanketed Fuel Storage Curve Coefficients[1]							Non-Blanketed Fuel Minimum Burnup[1] (GWd/MTU) for Initial Enrichment[2]					
	A	B	C	D	E	F	G	Cooling Time[3]	1.8 w%	2.5 w%	3.0 w%	3.5 w%	4.0 w%
II-4	12.6130	0.436168	-0.128105	0.00275389	-0.151579	0.00377707	-7.0392	0	17.08	27.22	34.73	42.45	50.39
								2.5	16.13	26.03	33.36	40.90	48.67
								5	15.31	24.99	32.16	39.56	47.17
								10	14.02	23.37	30.31	37.46	44.83
								15	13.21	22.36	29.15	36.16	43.39
								20	12.88	21.96	28.70	35.67	42.85
II-5	12.6086	0.517311	-0.185177	0.00442008	-0.150482	0.00367344	-5.3438	0	19.03	29.41	37.14	45.12	53.37
								2.5	17.96	28.09	35.64	43.45	51.52
								5	17.02	26.94	34.34	42.00	49.91
								10	15.57	25.16	32.32	39.73	47.41
								15	14.67	24.05	31.06	38.33	45.86
								20	14.32	23.62	30.58	37.80	45.27
II-6	17.1055	-0.116940	0.024104	-0.00410005	-0.262366	0.00761230	-10.7361	0	19.67	31.30	39.53	47.70	55.81
								2.5	18.61	29.81	37.74	45.61	53.42
								5	17.67	28.51	36.18	43.79	51.35
								10	16.15	26.47	33.77	41.01	48.20
								15	15.11	25.18	32.30	39.36	46.36
								20	14.55	24.63	31.76	38.83	45.85
II-7	17.5099	-0.130912	-0.143634	0.00199657	-0.235656	0.00625103	-9.1041	0	21.99	33.85	42.25	50.58	58.84
								2.5	20.65	32.13	40.25	48.31	56.29
								5	19.48	30.63	38.51	46.33	54.08
								10	17.64	28.29	35.82	43.28	50.68
								15	16.45	26.83	34.16	41.42	48.62
								20	15.93	26.25	33.54	40.76	47.92

Table 5.5-2 (continued)

Non-Blanketed Fuel - Minimum Required Fuel Assembly Burnup (Bu) as a Function of Enrichment (En) and Cooling Time (Ct)

See note 1 for use of Table 5.5-2

Fuel Category	Non-Blanketed Fuel Storage Curve Coefficients[1]							Non-Blanketed Fuel Minimum Burnup[1] (GWd/MTU) for Initial Enrichment[2]					
	A	B	C	D	E	F	G	Cooling Time[3]	1.8 w%	2.5 w%	3.0 w%	3.5 w%	4.0 w%
II-8	17.9109	-0.143928	-0.308137	0.00796481	-0.209912	0.00492410	-7.4704	0	24.30	36.41	44.97	53.45	61.87
								2.5	22.69	34.45	42.76	51.01	59.17
								5	21.29	32.75	40.85	48.87	56.82
								10	19.13	30.11	37.86	45.55	53.16
								15	17.80	28.48	36.01	43.48	50.88
								20	17.31	27.86	35.30	42.68	49.98

Notes

1. All relevant uncertainties are explicitly included in the criticality analysis. For instance, no additional allowance for burnup uncertainty is required. For a fuel assembly to meet the requirements of a Fuel Category, the assembly burnup must exceed the "minimum burnup" given in the table for the assembly "cooling time" and "initial enrichment." Alternatively, the specific minimum burnup required for each fuel assembly may be calculated from the following equation: $Bu = A \times En + B \times En^2 + C \times Ct + D \times Ct^2 + E \times Ct \times En + F \times Ct^2 \times En + G$. Only cooling times of 0, 2.5, 5, 10, 15 and 20 years may be used in this equation. Actual cooling time (Ct) is rounded down to the nearest value.
2. Nominal U-235 enrichment.
3. Cooling time in years.
4. Fresh unirradiated fuel up to 4.5 w% U-235 enrichment: No burnup is required.

Table 5.5-3 (Unit 3 only)

Fuel Categories Ranked by Reactivity[1]

Fuel Category	
Region I	Region II
I-1	II-1
I-2	II-2
	II-3
	II-4
	II-5
	II-6
	II-7
	II-8

Notes

1. Reactivity Rank: Fuel Category is ranked in decreasing order of reactivity, ~~e.g.~~ e.g., II-2 is less reactive than II-1, etc.

FIGURE 5.5-1 (Unit 3 only)

ALLOWABLE REGION I STORAGE ARRAYS

DEFINITION[1,4] | **ILLUSTRATION[1,2,3,4]**

Array I-A

Checkerboard pattern of Category I-1 assemblies and empty (water filled) cells.

I-1	E
E	I-1

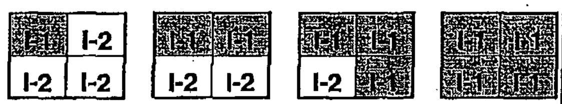
Array I-B

Category I-2 assembly in every cell.

I-2	I-2
I-2	I-2

Array I-C

Category I-1 assemblies and Category I-2 assemblies: Each Category I-1 assembly shall have a full length RCCA in the assembly. The number of Category I-1 assemblies with RCCAs in the assemblies is unrestricted.



Notes:

1. Fuel Categories are determined from Tables 5.5-1 and 5.5-2.
2. Shaded cells indicate the fuel assembly contains a full length RCCA.
3. E indicates an empty (water filled) cell.
4. Attributes for each 2x2 array are as stated in the definition. Diagram is for illustrative purposes only.

FIGURE 5.5-2 (Unit 3 only)

ALLOWABLE REGION II STORAGE ARRAYS

DEFINITION[1,4] — **ILLUSTRATION[1,2,3,4]**

Array II-A
Category II-1 assembly in three of every four cells: One of every four cells is empty (water-filled).

II-1	II-1
II-1	E

Array II-B
Category II-2 assembly in every cell: Two of every four cells contain a Metamic insert (or full length RCCA in the assembly).

II-2	II-2
II-2	II-2

II-2	II-2
II-2	II-2

II-2	II-2
II-2	II-2

Array II-C
Checkerboard pattern of Category II-3 and II-5 assemblies: One of every four cells contains a Metamic insert (or full length RCCA in the assembly). Metamic inserts (or RCCAs) may be in either II-3 or II-5 cells.

II-3	II-5
II-5	II-3

II-5	II-3
II-3	II-5

Array II-D
Category II-4 assembly in every cell: One of every four cells contains a Metamic insert (or full length RCCA in the assembly).

II-4	II-4
II-4	II-4

Array II-E
Checkerboard pattern of Category II-6 and II-8 assemblies.

II-8	II-6
II-6	II-8

Array II-F
Category II-7 assembly in every cell.

II-7	II-7
II-7	II-7

Notes:

1. Fuel Categories are determined from Tables 5.5-1 and 5.5-2.
2. Shaded cells indicate either a Metamic insert in the cell or the fuel assembly contains a full length RCCA.
3. E indicates an empty (water filled) cell.
4. Attributes for each 2x2 array are as stated in the definition. Diagram is for illustrative purposes only.

FIGURE 5.5-3 (Unit 3 only)

ALLOWABLE INTERFACES BETWEEN REGION II – REGION I ARRAYS

DEFINITION[1,4] — **ILLUSTRATION[1,2,3,4,5]**

For Array II-A, the empty cell shall be in the row adjacent to the Region I Rack.

Region I Rack

I-2	I-2	I-2	I-2
I-2	I-2	I-2	I-2

II-1	E	II-1	E
II-1	II-1	II-1	II-1

Array II-A

For Array II-B, the reactivity rank of assemblies adjacent to the Region I rack shall be reduced from a rank of II-2 to a reactivity rank of II-4 or lower. The Array II-B pattern shall have the required Metamic insert (or full length RCCA in the assembly) placed in the row adjacent to the Region I rack.

Region I Rack

I-2	I-2	I-2	I-2
I-2	I-2	I-2	I-2

II-4	II-4	II-4	II-4
II-2	II-2	II-2	II-2

Array II-B

Region I Rack

I-2	I-2	I-2	I-2
I-2	I-2	I-2	I-2

II-4	II-4	II-4	II-4
II-2	II-2	II-2	II-2

Array II-B

Region I Rack

I-2	I-2	I-2	I-2
I-2	I-2	I-2	I-2

II-4	II-4	II-4	II-4
II-2	II-2	II-2	II-2

Array II-B

For Arrays II-C and II-D, the Metamic insert (or full length RCCA in the assembly) shall be placed in the row adjacent to the Region I rack.

Region I Rack

I-2	I-2	I-2	I-2
I-2	I-2	I-2	I-2

II-3	II-5	II-3	II-5
II-5	II-3	II-5	II-3

Array II-C

Region I Rack

I-2	I-2	I-2	I-2
I-2	I-2	I-2	I-2

II-5	II-3	II-5	II-3
II-3	II-5	II-3	II-5

Array II-C

Region I Rack

I-2	I-2	I-2	I-2
I-2	I-2	I-2	I-2

II-4	II-4	II-4	II-4
II-4	II-4	II-4	II-4

Array II-D

Notes:

1. Fuel Categories are determined from Tables 5.5-1 and 5.5-2.
2. Shaded cells indicate either a Metamic insert in the cell or the fuel assembly contains a full length RCCA.
3. E indicates an empty (water filled) cell.
4. Attributes for each 2x2 array are as stated in the definition. Diagram is for illustrative purposes only.
5. Region I Array I-2 is depicted as the example; however, any Region I array is equally representative.

FIGURE 5.5-4 (Unit 3 only)

ALLOWABLE REGION II STORAGE ADJACENT TO SPENT FUEL PIT WALLS

DEFINITION[1,4]

ILLUSTRATION[1,2,3,4]

An assembly of rank II-2 placed in the peripheral row of a Region II storage rack shall not be adjacent to a Region I storage rack.

Spent Fuel Pit Wall

II-2	II-2	II-2	II-3
II-3	II-5	II-3	II-5
II-5	II-3	II-5	II-3

Region 2 (Array II-C)

I-2	I-2	I-2	I-2	I-2	I-2	I-2	I-2
I-2	I-2	I-2	I-2	I-2	I-2	I-2	I-2
I-2	I-2	I-2	I-2	I-2	I-2	I-2	I-2

Region I (Array I-B)

For Array II-A, the empty cell in the 2x2 II-A array shall be adjacent to the peripheral row that contains the category II-2 assembly(s). For Array II-A only, the peripheral row may contain category II-1 assemblies as the outer two rows will comply with Array II-A requirements.

Spent Fuel Pit Wall

II-2	II-2	II-2	II-2
II-1	E	II-1	E
II-1	II-1	II-1	II-1

Array II-A

II-1	II-1	II-1	II-1
II-1	E	II-1	E
II-1	II-1	II-1	II-1

Array II-A

For Array II-B, the Metamic insert (or full length RCCA in the assembly) shall be adjacent to the peripheral row that contains the category II-2 assembly(s).

Spent Fuel Pit Wall

II-2	II-2	II-2	II-2
II-2	II-2	II-2	II-2
II-2	II-2	II-2	II-2

Array II-B

II-2	II-2	II-2	II-2
II-2	II-2	II-2	II-2
II-2	II-2	II-2	II-2

Array II-B

II-2	II-2	II-2	II-2
II-2	II-2	II-2	II-2
II-2	II-2	II-2	II-2

Array II-B

For Arrays II-C and II-D, the Metamic insert (or full length RCCA in the assembly) shall be adjacent to the peripheral row that contains the category II-2 assembly(s).

Spent Fuel Pit Wall

II-2	II-2	II-2	II-2
II-5	II-3	II-5	II-3
II-3	II-5	II-3	II-5

Array II-C

II-2	II-2	II-2	II-2
II-5	II-3	II-5	II-3
II-3	II-5	II-3	II-5

Array II-C

II-2	II-2	II-2	II-2
II-4	II-4	II-4	II-4
II-4	II-4	II-4	II-4

Array II-D

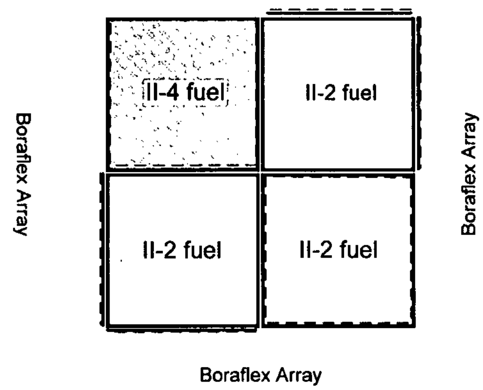
Notes:

1. Fuel Categories are determined from Tables 5.5-1 and 5.5-2.
2. Shaded cells indicate either a Metamic insert in the cell or the fuel assembly contains a full length RCCA.
3. E indicates an empty (water filled) cell.
4. Attributes for each 2x2 array are as stated in the definition. Diagram is for illustrative purposes only.

Figure 5.5-5
Boraflex Cell Arrays (Unit 3 only)

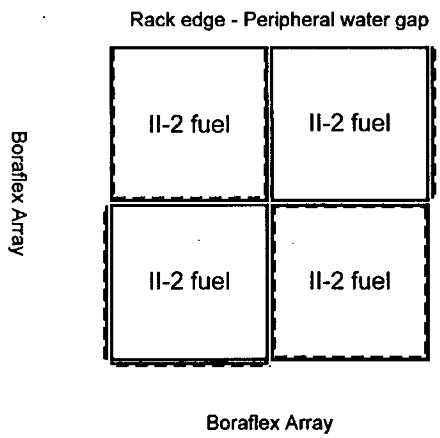
Array II-G Definition:	A 2 x 2 array of fuel containing three Category II-2 assemblies and one Category II-4 assembly.

Array II-G



Array II-G Definition:	A 2 x 2 array of fuel containing four Category II-2 assemblies, facing the fuel pool wall, on the periphery of the racks.

Array II-H



Note: These arrangements will be available until 2400 hrs September 30th, 2012.

5.6 Component Cyclic or Transient Limit

5.6.1 The components identified in Table 5.6-1 are designed and shall be maintained within the cyclic or transient limits of Table 5.6-1.

(Relocated from page 5-6)

TABLE 5.6-1

COMPONENT CYCLIC OR TRANSIENT LIMITS

COMPONENT	CYCLIC OR TRANSIENT LIMIT	DESIGN CYCLE OR TRANSIENT
Reactor Coolant System	200 heatup cycles at ≤ 100°F/h and 200 cooldown cycles at ≤ 100°F/h.	Heatup cycle - T_{avg} from ≤ 200°F to ≥ 550°F. Cooldown cycle - T_{avg} from ≥ 550°F to ≤ 200°F.
	200 pressurizer cooldown cycles at ≤ 200°F/h.	Pressurizer cooldown cycle temperatures from ≥ 650°F to ≤ 200°F.
	80 loss of load cycles, without immediate Turbine or Reactor trip.	≥ 15% of RATED THERMAL POWER to 0% of RATED THERMAL POWER.
	40 cycles of loss-of-offsite A.C. electrical power.	Loss-of-offsite A.C. electrical ESF Electrical System.
	80 cycles of loss of flow in one reactor coolant loop.	Loss of only one reactor coolant pump.
	400 Reactor trip cycles.	100% to 0% of RATED THERMAL POWER.
	150 leak tests.	Pressurized to ≥ 2435 psig.
	5 hydrostatic pressure tests.	Pressurized to ≥ 3100 psig.
Secondary Coolant System	6 loss of secondary pressure	Loss of Secondary pressure
	50 leak tests	Pressurized to ≥ 1085 psig
	35 hydrostatic pressure tests.	Pressurized to ≥ 1356 psig.

Attachment 4

Florida Power and Light Company
Turkey Point Units 3 and 4
Renewed Facility Operating License Nos. DPR-31 and DPR-41
Docket Nos. 50-250 and 50-251
License Amendment Request Regarding a Spent Fuel Pool Criticality Analysis for Unit 3 Taking Credit for Boraflex

Boraflex Management Program

1.0 Boraflex Management Program

The assumptions in the design basis criticality analysis are intended to provide a conservative representation of the SFP in light of the progressive degradation of the Boraflex panels. The analysis conservatively assumes that all panels have conservative shrinkage, gaps conservatively assumed to be located at the same axial position in each panel, and the design basis dissolution while the actual condition has a variation ranging from panels with as-built B-10 areal density above the minimum design basis assumption to some panels with areal density that has fallen below the design basis dissolution assumption.

The Turkey Point Management Program tracks Boraflex degradation and is used to conservatively predict when Boraflex panel degradation will result in a B-10 areal density that has fallen below the design basis dissolution assumption. Action is taken prior to reaching this level of degradation to assure the actual varying conditions in the SFP remains bounded by the design basis analysis keff requirements with a 95% probability and 95% confidence basis consistent with design requirements.

The Turkey Point Boraflex Management Program is based on two industry accepted tools; the RACKLIFE software package for predicting Boraflex degradation and the BADGER (**B**oron-10 **A**real **D**ensity **G**age for **E**valuating **R**acks) instrumentation for measuring Boraflex degradation. Both were developed under the auspices of EPRI to aid utilities in the management of Boraflex degradation. FPL has been using these tools in the Unit 3 SFP to monitor Boraflex panels as a commitment associated with License Amendments 206 and 200 (Reference 4.1) to credit the use of soluble boron in the SFP.

The RACKLIFE code is routinely used to predict the expected degradation of Boraflex in terms of percent boron carbide (% B_4C) loss in each of the Region II panels prior to and during the core off-loads, reloads and storage throughout the current operating fuel cycle. The storage cell is conservatively declared unusable, unless an alternate storage configuration compensating for the loss of Boraflex is used, if any panel in the storage cell is predicted to fall below the design basis limit of 50% of its minimum certified B-10 areal density of 0.012 gms B-10/cm^2 (i.e. 0.006 gms B-10/cm^2).

The identification of affected cells is controlled administratively via the implementation restrictions in the core reload control process and controlled transmittal of the information to the operator's Plant Curve Book. Fuel movement and storage of fuel in the SFP is controlled by Plant operating procedures.

The continuing ability of the RACKLIFE code to predict Boraflex dissolution in order to effectively manage SFP storage has been periodically evaluated by in-situ Boraflex panel measurements using the BADGER technique. This technique measures the attenuation of thermal neutrons passing through the panel to measure its % B-10 remaining and the presence of gaps/shrinkage in a select sample of is then compared with the calculated % B_4C remaining in each of the sampled Boraflex panels from the RACKLIFE model. Comparison of the measured to predicted results for each BADGER test demonstrates that RACKLIFE is valid for the conservative prediction of Boraflex degradation at 50% for Region II.

The following sections provide additional information on each aspect of FPL's Boraflex Management Program at Turkey Point that are related to the RACKLIFE code method, the BADGER surveillance program, and the methods used to evaluate the ability of the RACKLIFE code to predict Boraflex dissolution in order to effectively manage fuel storage in the SFP.

2.0 RACKLIFE Code

RACKLIFE is an industry standard that has been used by several utilities, both PWR and BWR, over many years to both monitor and manage Boraflex degradation in the SFP. RACKLIFE models the key Boraflex dissolution mechanisms in the SFP, modeling and tracking the irradiation history and silica transport of each Boraflex panel in the SFP. The methodology uses essentially a zero dimensional code representing the Boraflex panel, the poison cavity bounded by the surface of the panel and the wrapper plate (that mechanically holds the panel in place), and the bulk water as separate compartments. The transport of silica to and from each compartment is represented by a set of rate equations with experimentally established transport coefficients for the dissolution of silica. Given the initial silica and boron carbide concentration in the panel, the rate equations are simultaneously solved for each panel in the pool until the process comes into equilibrium with the silica concentration in the bulk pool water. The final result is the predicted silica concentration remaining in the Boraflex panel which is correlated to the percentage of boron carbide loss from the panel.

In its unirradiated state, the Boraflex panels are made up of fine particles of the neutron poison B_4C that are uniformly distributed and entrained in a flexible rectangular strips (*139.6" x 7.5" x .051"*) of a silicone polymer matrix of polydimethyl siloxane (PDMS). The panel itself is retained against the metal wall of the storage cell by a thin metal wrapper plate. Each wrapper plate forms a poison cavity which contains the Boraflex panel and surrounding borated water. A representative illustration of a Region II storage cell and its Boraflex panels are provided in Figure 1.

Once a Boraflex panel has absorbed a critical gamma dose (~ 5 E+08 Rads) from the surrounding fuel, the panel becomes susceptible to the loss of B_4C in an aqueous environment. The physical mechanism that drives this loss is through dissolution of the polymer when portions of its silica backbone go into solution within the poison cavity as a soluble chemical species of reactive and polymerized silica. The insoluble B_4C particles and crystalline silica filler being heavier than the surrounding water are no longer entrained in the polymer strands and are washed away or otherwise relocated. The removal of silica from the Boraflex panel can be directly related to the % B_4C from the panel, if its initial material composition is known.

The function of the wrapper plate was to hold the flexible Boraflex panel in position against the storage wall. It is not intended to be water tight and is secured to the storage cell wall by several resistance welds. This provides an opportunity for the ingress and egress of bulk SFP water to and from the poison cavity containing the Boraflex panel. This provides several paths by which the reactive silica can diffuse from the poison cavity and into the bulk SFP water, which would normally be at a lower silica concentration than in the poison cavity. The exchange of silica from the Boraflex panel to the poison cavity and ultimately to the bulk pool water continues until a chemical balance between the two is achieved. Factors which can disturb this balance are activities such as pool dilution, refueling evolutions, cleanup operations, and temperature changes.

As discussed previously, the presence of reactive silica in the bulk SFP water is indicative of Boraflex degradation. Unless the reactive silica is removed from the pool, its concentration is the integral of the degradation of each Boraflex panel in the pool. The essential function of the RACKLIFE model is to track the loss of reactive silica from each panel in the pool and produces two basic outputs: the % B_4C loss from each panel and the bulk pool silica concentration by which the user can manage the loss of Boraflex.

The formation of reactive silica is tracked from its source in the Boraflex panel to the bulk SFP water using a series of chemical kinetic equations. RACKLIFE performs a mass balance of SiO_2 in the pool and within the wrapper plate plenum that encapsulates the Boraflex panels. The total SiO_2 released by the Boraflex panels, in aggregate, is affected by the amount of SiO_2 in solution in the pool water and the amount removed over time by the clean-up system. The contribution of each panel to the bulk SiO_2 quantity is determined, based on the irradiation-time history of the panel.

RACKLIFE utilizes a set of initial conditions and a series of chemical kinetic equations to establish a relationship between the reactive silica concentration in the pool to the % B_4C lost from each Boraflex panel as a function of time. The following is a brief summary that will provide a fuller appreciation of the analytical method.

The RACKLIFE code accomplishes this by solving the following set of coupled ordinary differential equations:

- Time rate of change of silica concentration in a particular the poison cavity:

$$\frac{dR_i}{dt} = S_i(t) - R_i(t) - P_i(t) - D_i(t) \qquad \text{Eqn. 1.1}$$

where $$S_i(t) = \lambda_i \left(1 - \frac{R_i(t)}{R_{eq,i}}\right)$$ Eqn. 1.2

- Time rate of change of reactive silica concentration in the bulk pool water:

$$\frac{dR}{dt} = \sum_{i=1}^{N} R_i(t) - P(t) - D(t) - F_R$$ Eqn. 1.3

Note: The subscripted terms refer to individual panels and the non subscripted terms refer to the bulk pool concentrations. The definition of each term above is provided in the table below.

Symbol		Definition
N	=	Total number of Boraflex panels.
$R_i(t)$	=	Poison cavity net leakage of reactive silica.
$S_i(t)$	=	Reactive silica source term.
$R(t)$	=	Bulk pool reactive silica concentration.
R_{eq}	=	Equilibrium silica concentration.
$P_i(t)$	=	Net polymerization of reactive silica.
$D_i(t)$	=	Net deposition of reactive silica on structural surfaces.
F_R	=	Bulk pool silica removal by filters and the demineralizer.
λ_i	=	Silica release rate from the Boraflex panel: A function of the Boraflex panel dose, water temperature, and the surface area of the panel (mg SiO_2/day).

Other aspects of Boraflex dissolution such as polymerization of reactive silica are accounted for, but the above set of equations is sufficient to illustrate the analytical method. A conceptual representation of the kinetic model in RACKLIFE is provided in Figure 2. This figure illustrates the various volume exchange relationships associated with the dissolution of silica from a Boraflex panel.

The net leakage of reactive silica $R_i(t)$ from the Boraflex panel's poison cavity in the above equations contains an escape coefficient factor (ε) that can be adjusted by the RACKLIFE user to account for the uncertainty in the water tightness of the Boraflex panel's wrapper plate. The value of the escape coefficient is determined by the desired degree of conservatism in modeling Boraflex dissolution. This adjustment is made by controlling the degree of bias between the bulk pool silica concentration calculated by RACKLIFE and that measured in the pool.

3.0 BADGER Testing

3.1 Purpose

The BADGER test measures the degree of Boraflex panel degradation; viz. shrinkage of the panel, formation of gaps, and % B_4C loss from the Boraflex panel. This is accomplished by measuring the amount of thermal neutron attenuation through a Boraflex panel at axial intervals over the entire vertical length of the panel. The result of this scan is a normalized average signal that is compared to the normalized average signal of a "reference panel", where no degradation is expected to occur.

The data obtained for each Boraflex panel tested provides information on the:

- Number, size, and locations of gaps,
- Location of areas of dissolution,
- Average % B_4C lost.

3.2 Panel Selection

The Boraflex panels to be tested are selected using criteria to identify a sample of Boraflex panels that could be expected to represent the population of all panels in the pool over the range of panel dose. This approach provides BADGER test results that can be reasonably expected to bound the results expected for any panel in the SFP. Repeat measurements of a few of the same panels from one campaign to the next can permit trending. However, data over a varying range of predicted degradation from the three testing campaigns provides a better statistical assessment of RACKLIFE vs. BADGER test results. This approach is more indicative of RACKLIFE performance throughout the SFP rather than a relatively few repeat test panels.

3.3 Measurement of Degradation

What is measured during the BADGER test is the percent deviation $(\%D_M)$ between the areal density of the panel being measured (ρ) and that of an unirradiated reference panel (ρ_r) which is given by:

$$\%D_M = \left(\frac{\rho - \rho_r}{\rho_r}\right)100\% \qquad \text{Eqn. 3.3.1}$$

The measured areal densities of each Boraflex panel in the Turkey Point Unit 3 SFP must be indirectly estimated from Eqn. 3.3.1 since the as-built values for the individual Boraflex panels are unknown. The conservative determination of the as-built areal density of the reference panel (ρ_r) is based on the Boraflex panel production batch data. The results of an analysis of this data are shown in Figure 3. The analysis determined that the minimum produced areal density for all production batches at a 95% confidence level with a 95% probability was 0.015 gms-B_{10}/cm^2.

3.4 Evaluation of BADGER Test Results

The BADGER test results are compared to the RACKLIFE predictions to validate the RACKLIFE model. The evaluation of the BADGER test results specific to Region II of the SFP is performed by:

- Comparison between the measured dissolution based on the reference panel having a conservative initial as-built areal density of 0.015 gms-B_{10}/cm^2 as discussed in Section 3.3, above and the RACKLIFE prediction based on the initial manufacturing minimum certified areal density of 0.012 gms-B_{10}/cm^2, and

- Analysis of the differences in percent Boraflex panel degradation from BADGER measurements from RACKLIFE predicted for individual panels, and

- Analysis of the RACKLIFE / BADGER comparison data to demonstrate that when action is taken to administratively limit the use of the affected storage cell prior to when the Unit 3 RACKLIFE model predicts 50% B-10 areal density loss in any Boraflex panel in that storage cell, the design basis criticality analysis assumptions for B-10 areal density for the four panels in that storage cell bounds the actual conditions such that the keff criteria are satisfied with a 95% probability and 95% confidence consistent with design basis requirements.

3.4.1 Boraflex Panel Areal Density

Figure 3 shows that when action is taken on panels predicted to have 50% degradation there is a 95% probability with a 95% confidence that the actual areal density of that panel is 0.0075 gms-B_{10}/cm^2 (50% of 0.015 gms-B_{10}/cm^2). As a result there is considerable margin to the design basis assumption of 0.006 gms-B_{10}/cm^2. This margin is available when comparing the remaining areal density in the BADGER measured panels to the remaining areal density in those panels predicted by RACKLIFE.

The measured Boraflex panel degradation values from all three campaigns converted to remaining areal density and compared the RACKLIFE predicted remaining areal density for each measured panel is shown in Figure 4. The values on the x-axis are the RACKLIFE predicted areal densities based on an initial areal density at the manufacturing minimum areal density of 0.012 gms-B_{10}/cm^2. The values on the y-axis are measured areal densities obtained by multiplying the measured degradation values by the 95/95 lower tolerance value (0.015 gms-B_{10}/cm^2) discussed in Section 3.3. Figure 4 shows that the BADGER measured areal density of most of the panels is above that predicted by RACKLIFE and the average measured areal density is well above the predicted. There are a few random and isolated panels from the three campaigns have a measured areal density below that predicted by RACKLIFE. The impact to keff of an under-prediction of panel degradation must consider the other three panels in the storage cell. This is discussed in section 3.4.2 below.

3.4.2 Measured vs. Predicted Deviation in % B_4C Loss

The graph in Figure 5 shows the distribution of the differences between percent degradation measured with BADGER and that predicted by RACKLIFE for individual panels.

Using the data points for (%predicted – %measured) degradation shown in Figure 5, calculations are performed to compute the average difference, standard deviation, and the 95/95 single-sided lower tolerance limit for a single panel.

Single Panel

N	65
Average (%)	28.3
Standard Deviation (%)	25.7
K (95/95)	2.000
95/95 Lower Tolerance Limit (%)	-23.1

This distribution is representative of RACKLIFE prediction of the degradation of any single Boraflex panel in Region II. On the average RACKLIFE will over-predict a single panel's degradation by 28.3%. There is a 95% probability with 95% confidence that RACKLIFE will under-predict degradation by a maximum of 23.1%. In the worst case, when RACKLIFE is used to predict 50% degradation there is a 95% probability with 95% confidence that the panel is degraded to 73.1%. The impact to keff must consider the remaining B-10 neutron absorber in all four panels of a storage cell.

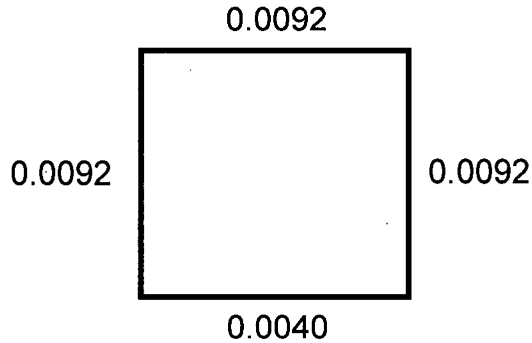
The degradation of each of the four panels in a storage cell is independent of each other. There is no mechanism that would cause the degradation in one panel to affect the degradation in an adjacent panel. Accordingly, the RACKLIFE/BADGER benchmark distribution is independently representative of the RACKLIFE prediction of degradation of each panel in a storage cell. The average difference, standard deviation, and the 95/95 single-sided lower tolerance limit for the sum of the degradation of the four panels in a storage cell can be determined from the sum of the individual means and the sum of the individual variances. The results for all four panels are shown in the following table.

Four Panels

N	65
Average (%)	113.2
Standard Deviation (%)	56.6
K (95/95)	2.000
95/95 Lower Tolerance Limit (%)	+10.4

This means that on a 95/95 basis, four panels in one cell will be over-predicted by RACKLIFE by a cumulative sum of at least 10.4%. The limiting case for determining the impact to keff would be when, hypothetically, RACKLIFE predicted that all four panels in a storage cell would reach 50% degradation at the same time. Based on the 10.4% over-prediction of the sum of the four panels, a cell that has all four panels predicted to be at 50% would be, on a 95/95 basis, have all four panels at 47.4% (this assumes that the over-prediction of 10.4% is shared equally among the four panels, 50-10.4/4=47.4). For a case in which one panel is under-predicted by 23.1%, that means that the remaining three panels are over-predicted by 33.5% (so that overall, the cell is over-predicted by 10.4%, -23.1+33.5=10.4). Again, assuming that all four panels are predicted to be at 50% degraded, that case would have one panel at 73.1%, and the other three at 38.8% degradation (compensating over-prediction of 33.5% is shared equally among the three panels, 50-33.5/3=38.8).

The remaining areal density in this storage cell on 95/95 basis is determined using the conservative 95/95 lower confidence limit initial as-built areal density of 0.015 gms-B_{10}/cm^2. This remaining areal density of the four panels in this storage cell is shown below.



The remaining B-10 neutron poison in this limiting storage cell is greater than a storage cell with all the panels at the design basis analysis assumption of 0.006 gms-B_{10}/cm^2. Therefore keff for this limiting case is bounded by the design basis analysis keff requirements with a 95% probability and 95% confidence basis consistent with design requirements.

3.4.3 Gaps/Shrinkage

The occurrence of gaps in Unit 3, as shown in Figure 6 for all three tests, are randomly distributed along the panel with no preferential elevation for gap formation i.e. they are uniformly distributed over the length of the panel. As a result, alignment of gaps at any axial location for two or more panels is very small. For example, if the fraction of panels with a gap at any given location is 0.2, then the probability that any two panels having a gap at the same location is $(0.2)^2$ = 0.04. The probability that all the panels (N) in a 3x3 Region II storage array would be aligned is $(0.2)^N$ which would be insignificantly small.

The gap width is random and independent of axial location as indicated for all three tests in Figure 7. Using 0.05 inches/gap as a baseline it can be recognized that the number of points relative to this baseline is increasing with each successive test. The increase in the average gap size is due to significant dissolution along the edges of a few of the gaps where significant water ingress has taken place. This trend can also be seen in the cumulative gap length of the average panel.

Turkey Point's design basis assumes that every Boraflex panel has five 1.5 inch gaps near the center of the Boraflex panel and another 4.18 inch gap at the top of the panel to account for top panel shrinkage. This yields a cumulative length of 11.68 inches for each panel which is well above the average cumulative length of all gaps measured in Unit 3. In addition, the analysis conservatively assumes no credit for the densification of Boraflex due to shrinkage. Even though the measured cumulative gap length of the average panel exceeds that assumed in the criticality analysis, its impact is taken into account during the BADGER test in which the measured areal density accounts for gaps, shrinkage, dissolution, and densification.

Comparative evaluation of the gap measurements in Unit 3 demonstrate that any alignment of gaps is highly unlikely to occur and that the average cumulative gap is well below the 11.68 inches assumed in the criticality analysis. Thus the Unit 3 criticality analysis conservatively accounts for the number of gaps, gap size, and panel shrinkage.

3.5 Conclusion

The Turkey Point Boraflex Management Program ensures that the actual conditions of the Boraflex panels in the SFP are conservatively predicted such that credit for Boraflex neutron absorption can be assured to satisfy the keff criteria of the SFP with a 95% probability and 95% confidence. BADGER testing at Turkey Point Unit 3 has validated the conservative nature of RACKLIFE predictions through predicted degradation of up to 0.006 gms B-10/cm^2.

Based on the statistical analysis of the BADGER test results and the as-built areal density of the Boraflex panels, RACKLIFE conservatively predicts when a panel would reach the areal density of 0.006 gms B-10/cm^2 assumed in the design basis criticality analysis, such that action taken in accordance with the Boraflex Management Program, ensures that the design basis keff criteria are satisfied with a 95% probability and 95% confidence. Additionally, BADGER testing results indicate that gaps are randomly distributed over panel elevations and the average cumulative gap is well below 11.68 inches, such that the design basis criticality analysis assumptions for panel shrinkage and gapping will remain bounding of actual conditions in the SFP.

4.0 REFERENCES

4.1 NRC Letter from Kahtan N. Jabbour to Mr. T. F. Plunkett (FPL), "Turkey Point Units 3 and 4 – Issuance of Amendments regarding Boron Credit in the Spent Fuel Pool," issuing License Amendments 206 (DPR-31) and 200 (DPR-41), dated July 19, 2000. (TAC Nos. MA7262 and MA7263).

Figure 1

Illustrative Representation of a Region II SFP Storage Cell

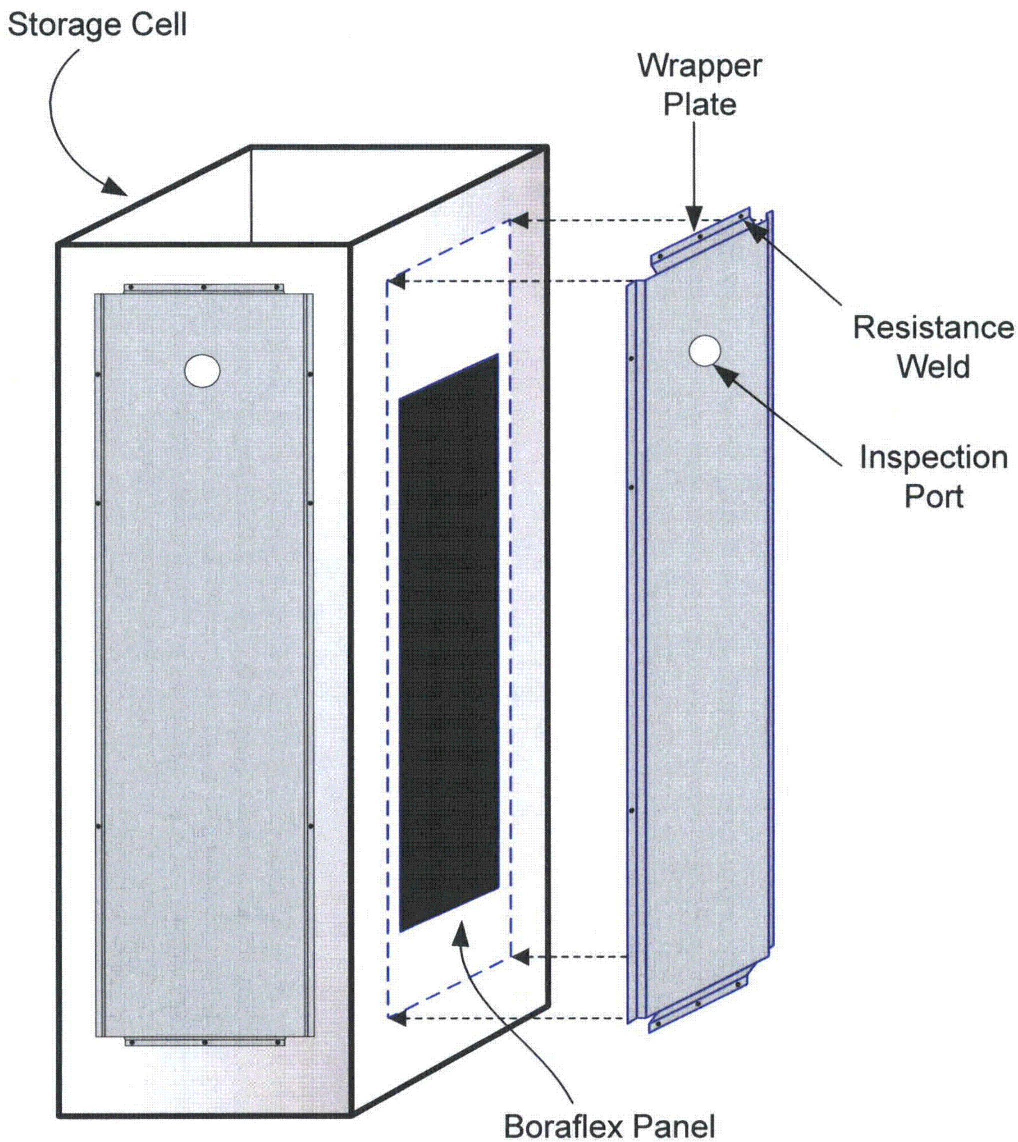


Figure 2

Illustrative Representation of the Kinetic Model of Silica Dissolution From Boraflex Panels in the SFP

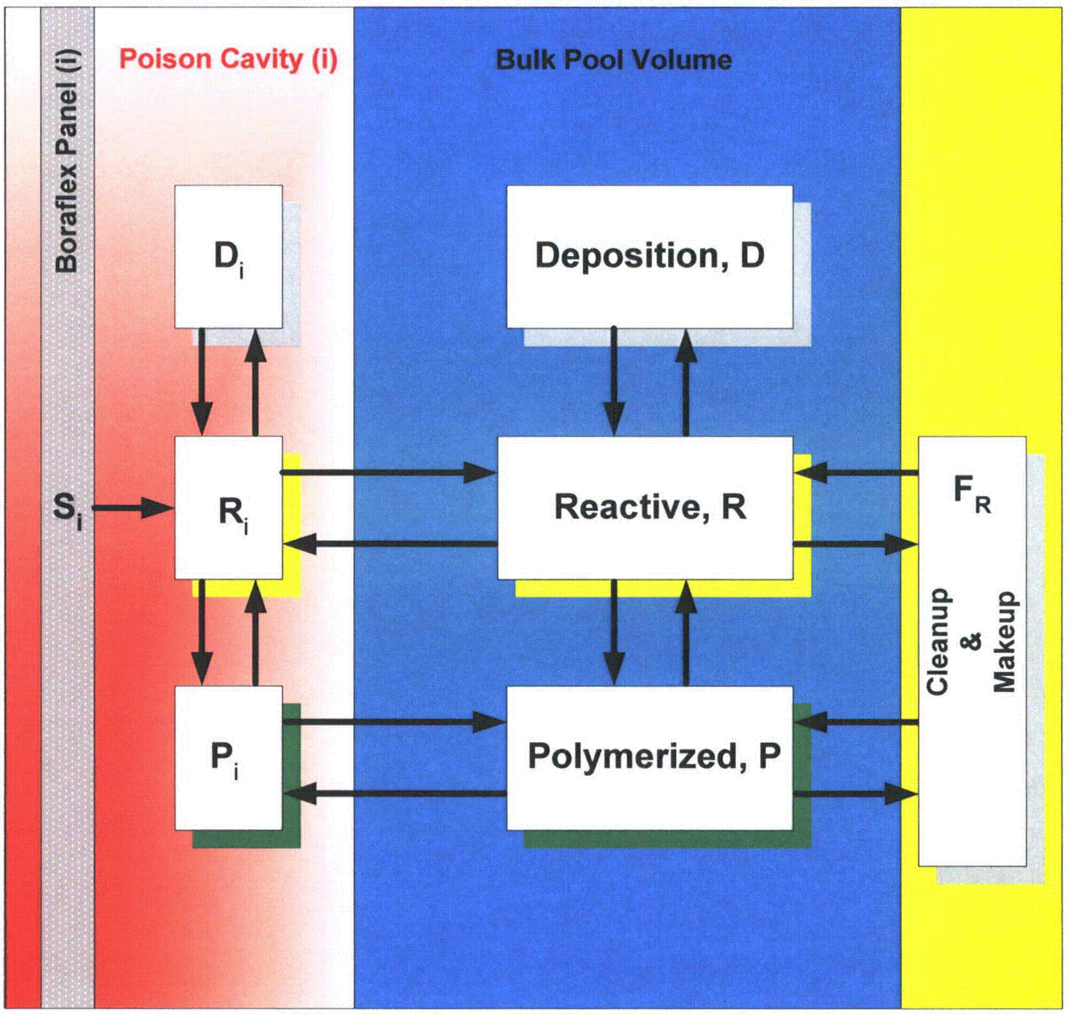


Figure 3

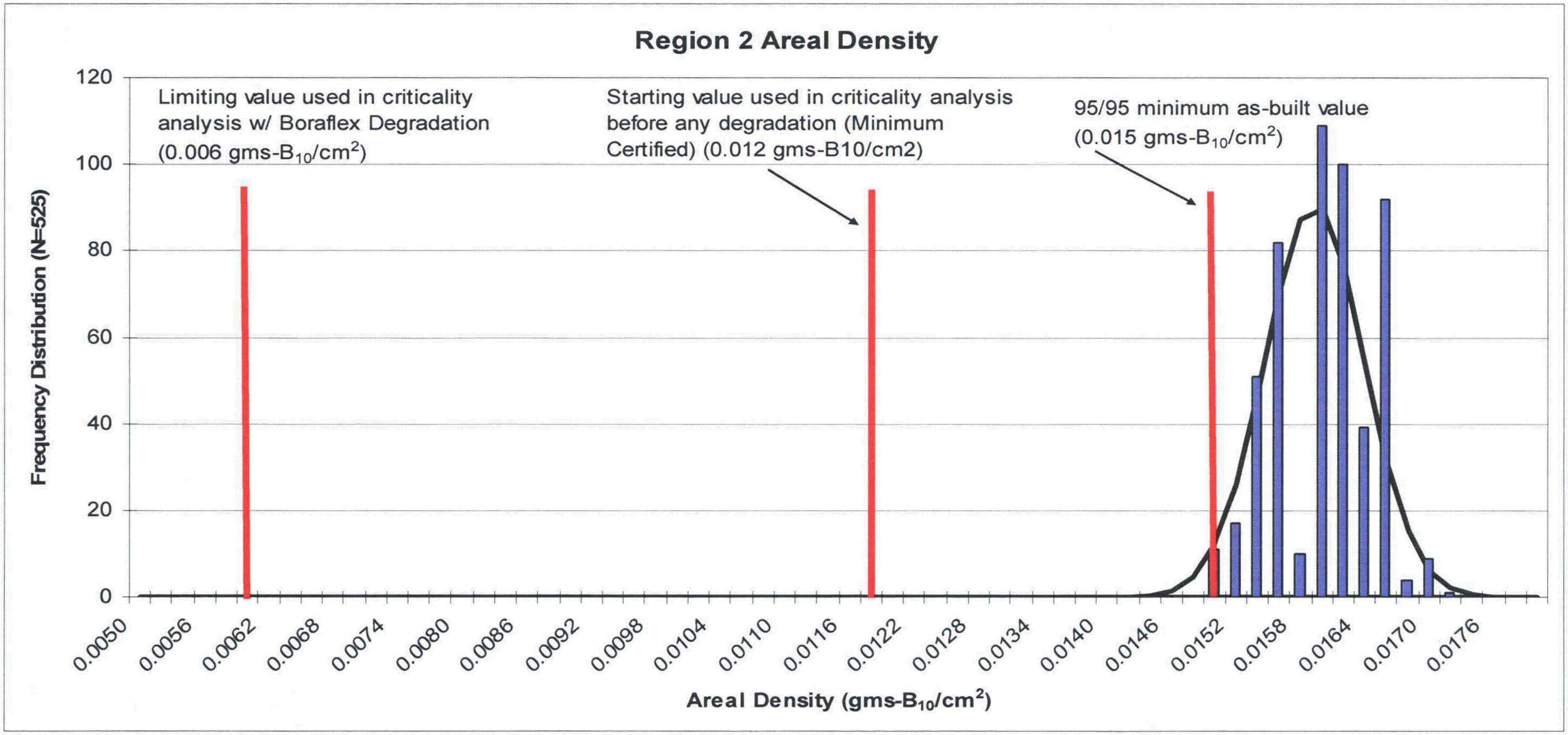

Region 2 Areal Density
Limiting value used in criticality analysis w/ Boraflex Degradation (0.006 gms-B10/cm2)
Starting value used in criticality analysis before any degradation (Minimum Certified) (0.012 gms-B10/cm2)
95/95 minimum as-built value (0.015 gms-B10/cm2)
Frequency Distribution (N=525)
Areal Density (gms-B10/cm2)
120
100
80
60
40
20
0
0.0050
0.0056
0.0062
0.0068
0.0074
0.0080
0.0086
0.0092
0.0098
0.0104
0.0110
0.0116
0.0122
0.0128
0.0134
0.0140
0.0146
0.0152
0.0158
0.0164
0.0170
0.0176

Figure 4
Measured vs. Calculated Deviation

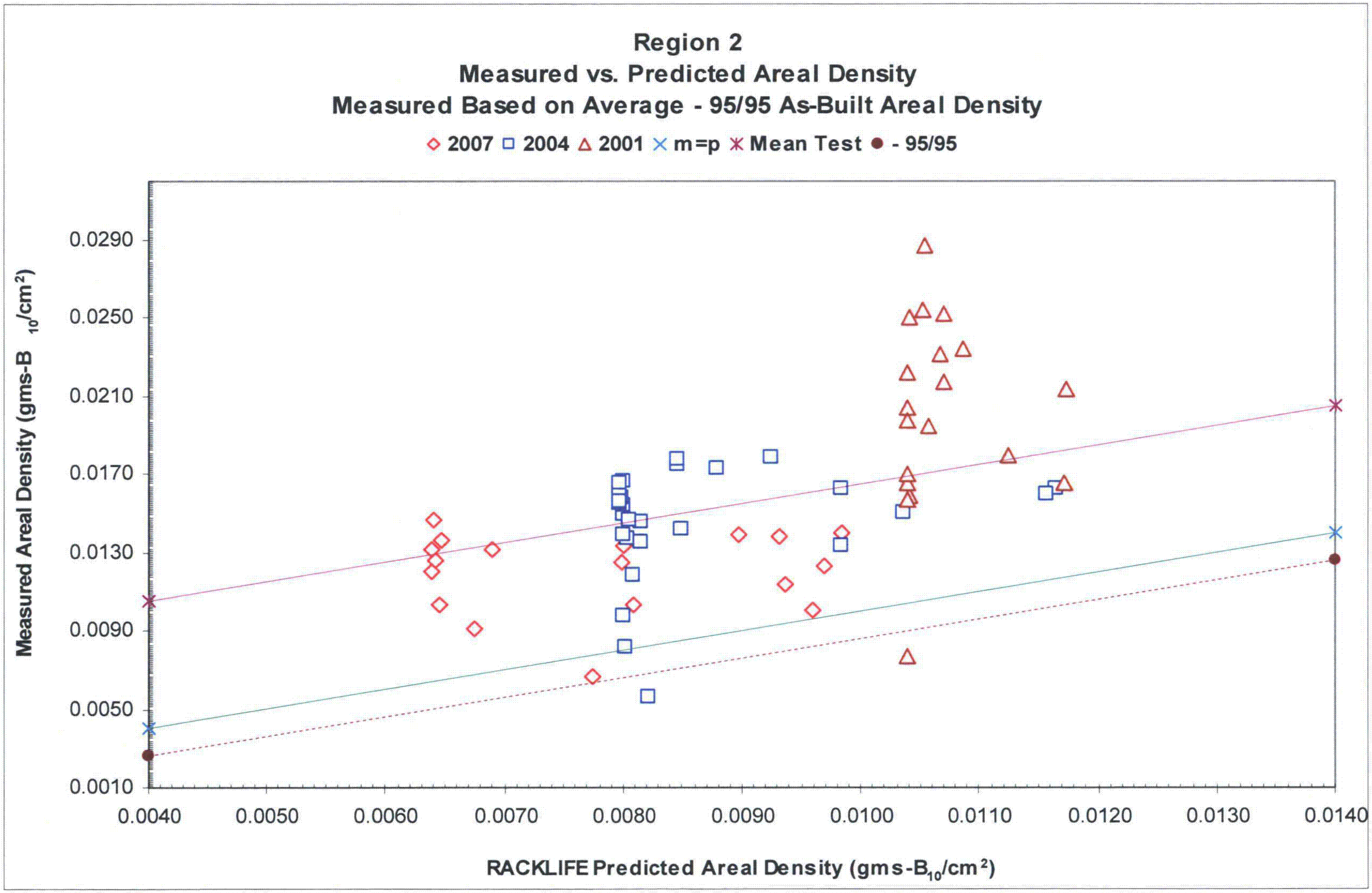


Figure 5

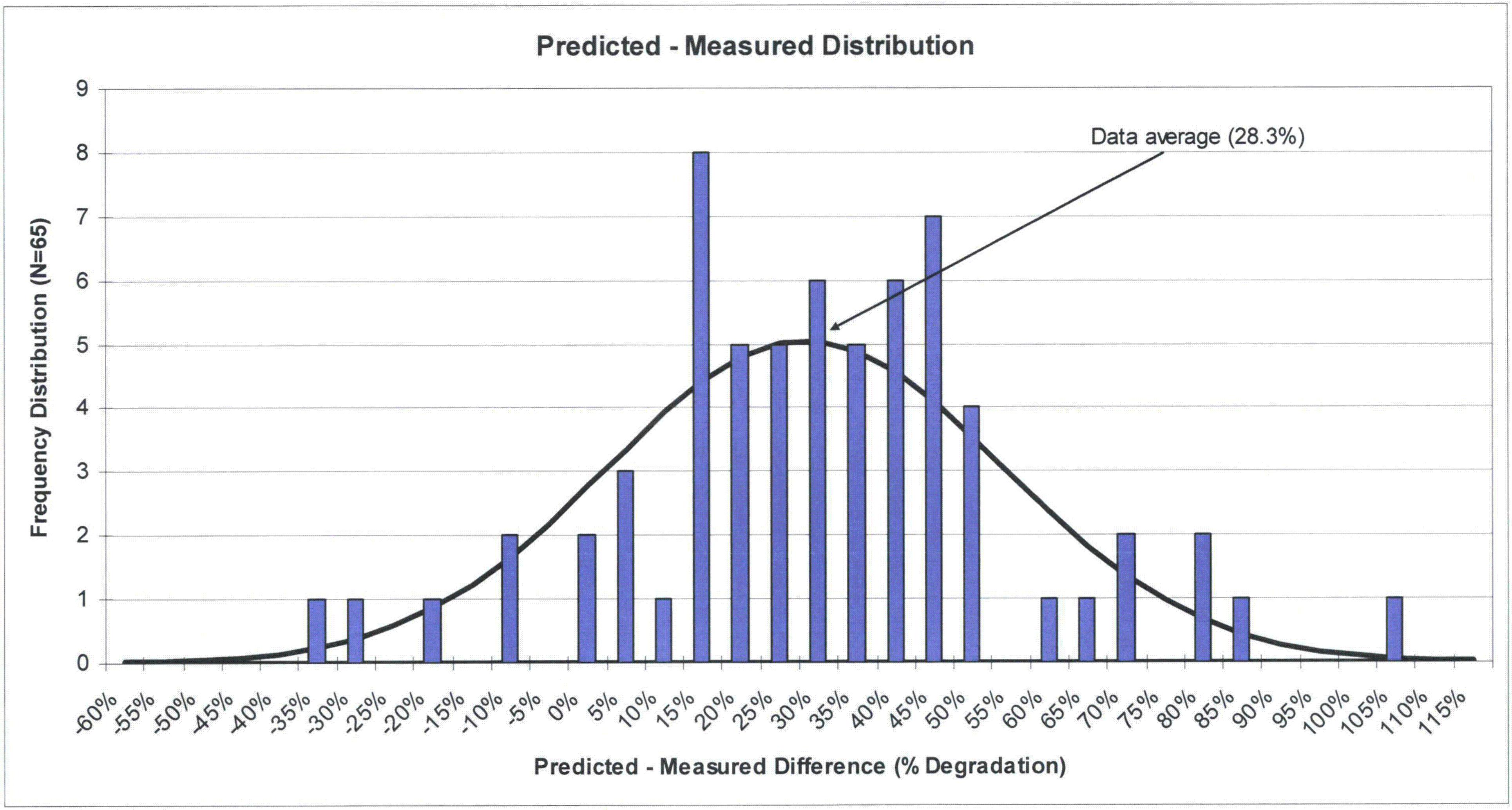

Predicted - Measured Distribution
Data average (28.3%)
Frequency Distribution (N=65)
0
1
2
3
4
5
6
7
8
9
-60%
-55%
-50%
-45%
-40%
-35%
-30%
-25%
-20%
-15%
-10%
-5%
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
55%
60%
65%
70%
75%
80%
85%
90%
95%
100%
105%
110%
115%
Predicted - Measured Difference (% Degradation)

Figure 6

Axial Distribution of Gaps

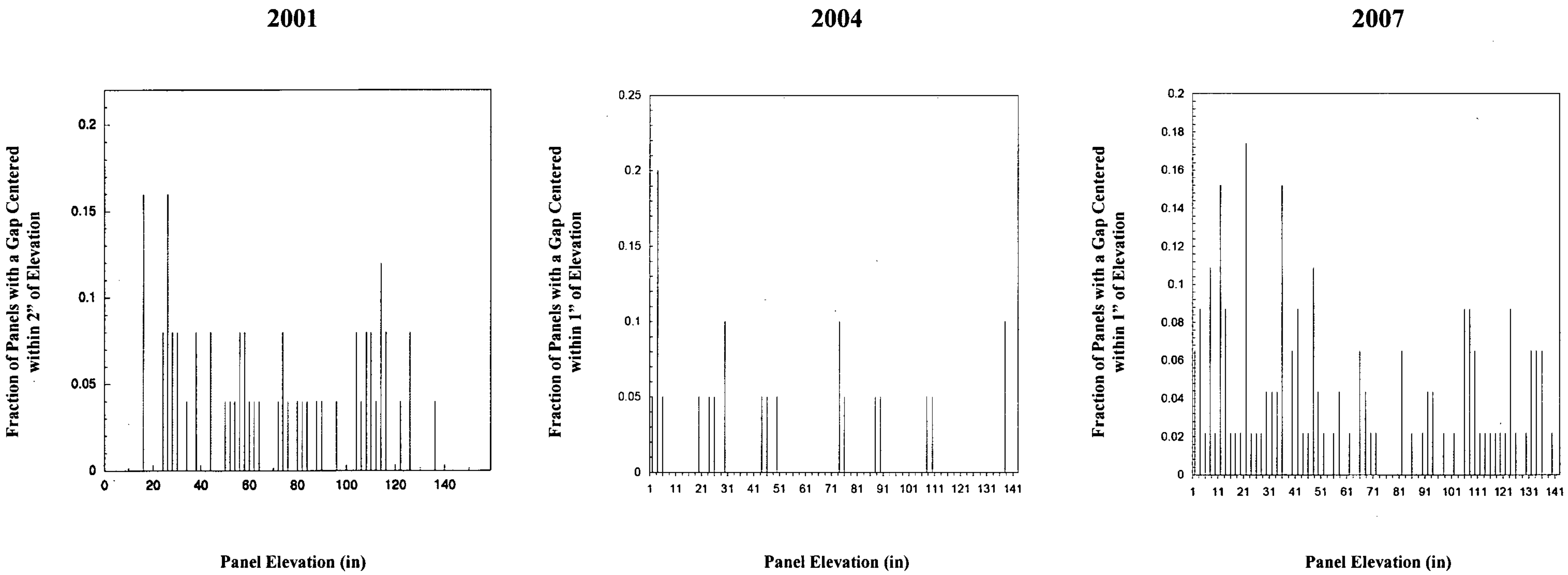
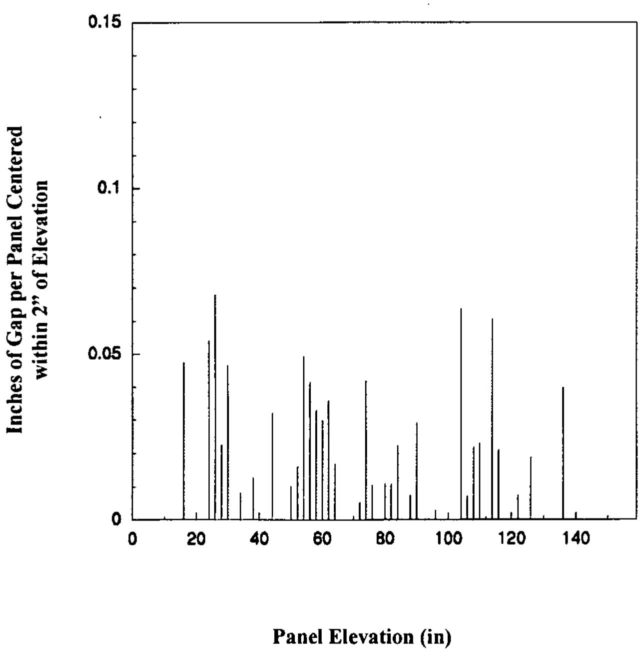


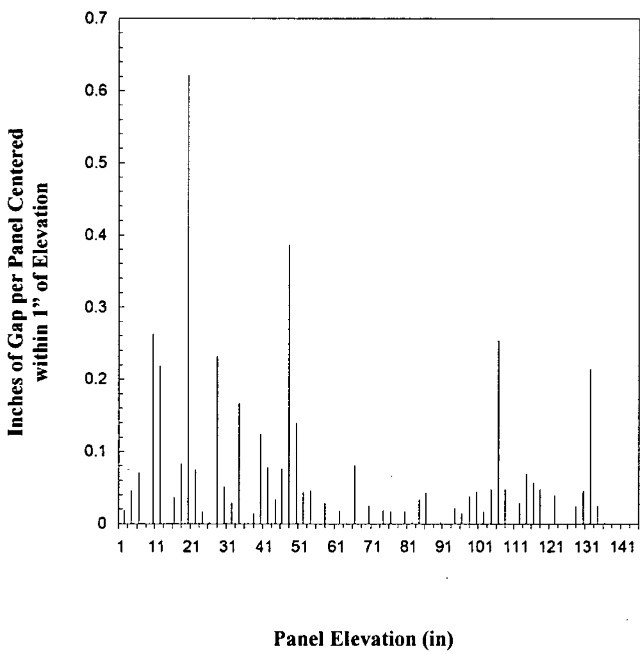
Figure 7

Axial Distribution of Inches of Gap along Panel Length

2001



2004



2007