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NRC-FPL
Turkey Point
Units 3 and 4
Continuing Credit for Boraflex in the Spent Fuel Pool

January 21, 2010

Agenda

- Introduction
- Background
- Unit 3 License Amendment Request
  - RACKLIFE and BADGER testing at Turkey Point for Boraflex management
  - Proposed configurations, now evaluated using Amendment 234 method
- Current Situation & Unit-3 Commitment Letter of 12/31/09
- Unit-4 License Amendment Request and Contingency LAR
- Conclusions

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Purpose of Meeting

- Discuss FPL's approach to addressing Boraflex degradation in the Turkey Point Unit 3 and 4 SFPs and licensing compliance, including compensatory action.

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Background

- Actions taken to address Boraflex degradation have ensured the Spent Fuel Pools have remained operable in a controlled safe configuration
  - Commitments regarding Boraflex Management
  - Implementation of conservative compensatory measures
  - Long term program to address Boraflex degradation
  - Additional recent actions taken

Background (con't)

- Credit for 650 ppm soluble boron incorporated in 2000 with Amendments 206 & 200. Established TS requirement for the use of uncertainties in calculating keff.
- In 2000 FPL provided a commitment for Boraflex surveillance program, including in-situ areal density testing (BADGER).
- In 2000 FPL provided NRC with results of first BADGER test:
  - Some Region II Boraflex panels degraded below the minimum analysis areal density of 0.006 gms-B_{10}/cm^2.
  - Degraded and nonconforming condition addressed pursuant to RIS-2005-20 (GL-91-18) .
  - Administrative controls established to limit the use of affected storage cells to assure TS keff requirements remain satisfied. Fundamental treatment of uncertainties consistent with that described in UFSAR.
  - Boraflex degradation projected using RACKLIFE.
  - Commitment for BADGER test frequency reduced from 5 years to 3 years.

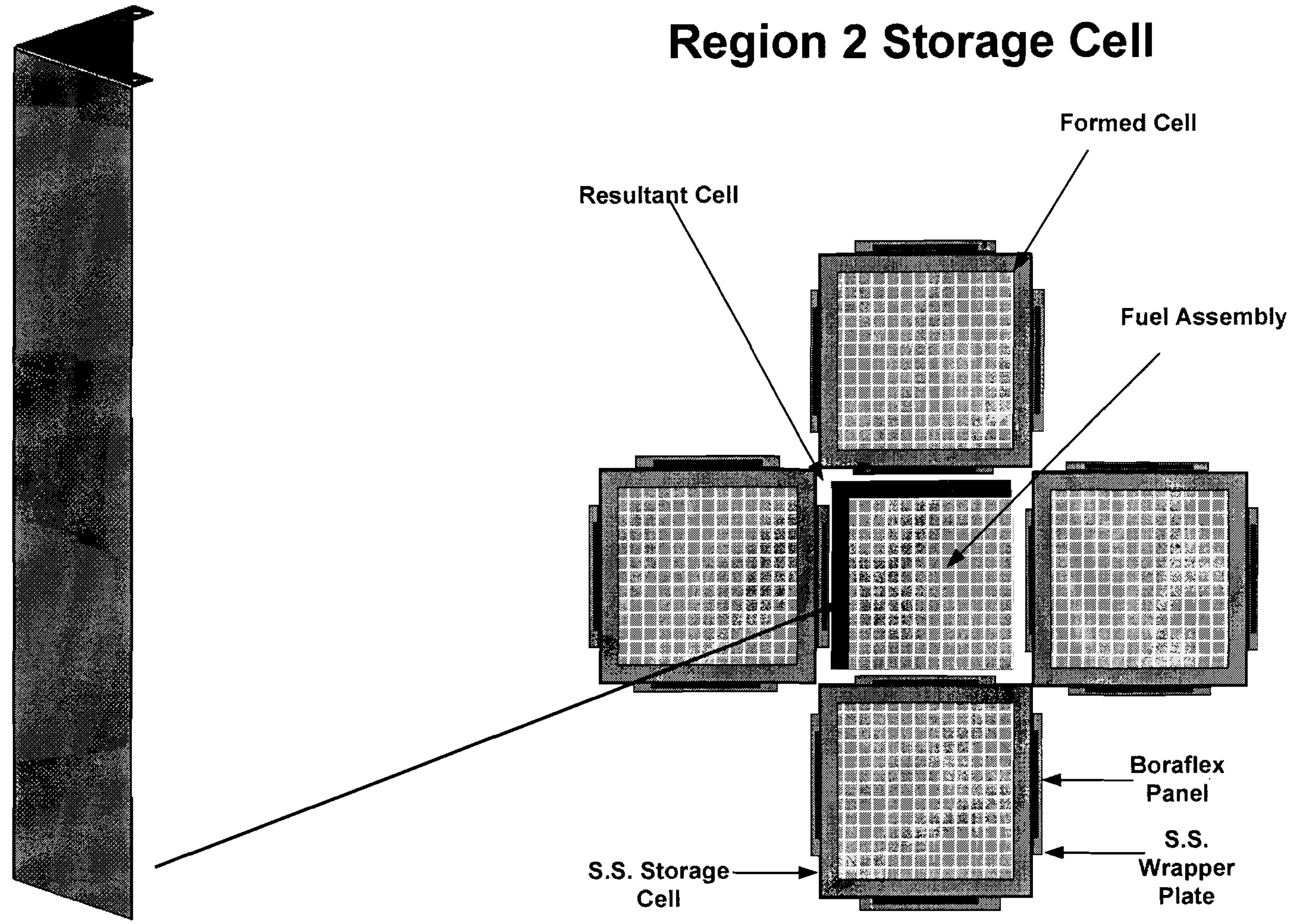
Background (con't)

- In 2001 the Unit 3 high duty Region II SFP storage rack was converted to a configuration that didn't credit Boraflex ("Sacrificial Module").
  - 2-out-of-4 checkerboard with empty storage cells.
  - Predominantly stored freshly offloaded fuel assemblies.
  - Higher dose and higher heat load.
  - After decay fuel moved to other modules to prepare for next refueling.
  - Sacrifice Boraflex in this module and limit duty to remaining modules.
- BADGER tests were performed in 2001, 2004 and 2007 in the Unit 3 SFP.
  - Boraflex racks were installed in the Unit 3 SFP in 1985.
  - Boraflex racks were installed in the Unit 4 SFP in 1989.
  - Tests in Unit 3 have covered a range of predicted Boraflex degradation up through near 50%, covering the service life of Boraflex panels.
- Since 2001, FPL has implemented administrative controls to:
  - Ensure compliance with Technical Specifications and not rely on soluble boron in the pool beyond that allowed by 10 CFR 50.68.
  - 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.
    - Satisfy criticality design basis requirements for keff using NRC approved methods.

Background (con't)

- FPL developed use of alternate poisons (Metamic and RCCAs) and administrative controls (collectively referred to as Boraflex Remedy).
- Boraflex Remedy approved by NRC in Amendments 234 and 229 (2007).
- FPL was not able to implement the 2007 amendments by the implementation date despite significant efforts with FPL's vendor because:
  - Vendor's inability to fabricate Metamic inserts within maximum specified dimensions;
  - Long lead time to procure sufficient RCCAs and/or implement dry cask storage to create empty cells;
  - Amendments preclude reliance on Boraflex.
- FPL incorrectly assumed changes to implementation date would be administrative.
  - Date for implementation was negotiated based on the expected poison fabrication schedule at the time the Boraflex Remedy amendments were issued.

Background (con't)



Metamic Insert

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Unit 3 License Amendment Request (LAR)

- The Unit 3 LAR will:
  - Request NRC approval of a change to the Boraflex Remedy amendment to allow use of Boraflex in Region II until Amendment 234 is implemented.
    - Approach similar to that used by other licensees.
  - Provide information on RACKLIFE and BADGER testing
  - Incorporate methodology, fuel classifications and configurations, already approved by NRC in Amendment 234.
  - Cask Area Rack does not use Boraflex.
  - Region I will not credit Boraflex after June 19, 2010.
  - Temporary credit for Boraflex in Region II until 9/30/12 (Dry Cask storage implemented).
  - Boraflex assumptions consistent with current licensing analysis
    - Conservative shrinkage and gapping.
    - Minimum areal density of 0.006 gms-B_{10}/cm^2.

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Unit 3 LAR
Boraflex Management Program

- Fundamentals of RACKLIFE
- Application of RACKLIFE /BADGER to assure actual varying conditions in the SFP remains bounded by licensing analysis on a 95/95 basis consistent with keff requirements.

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Unit 3 LAR
Boraflex Management Program

- During the November interactions with the NRC staff several questions regarding RACKLIFE were raised.
- 18 PWRs & 7 BWRs are using or have used RACKLIFE to model Boraflex degradation.
- RACKLIFE simulates the dissolution of Boraflex
  - Utilizes a kinetics model based on a mass balance calculation of silica in SFPs to predict B_4C loss from Boraflex.
  - Silica concentration is tracked from its source (solubilization of the Boraflex matrix) through transit into the bulk pool volume and to its final removal via the SFP cleanup system.
  - Kinetics equation parameters, such as silica release rate, were determined over a range of conditions (absorbed dose, temperature, ph) from a series of laboratory experiments.
  - EPRI Topical Report TR-107333 discusses theory and operation of the code.

Unit 3 LAR
Boraflex Management Program

➢ Developed for EPRI by NETCO, RACKLIFE has been successfully utilized to manage Boraflex degradation for over a decade:
  - Several licensees have used RACKLIFE predictions and some have included as a part of NRC accepted submittals involving SFP criticality
    - Mcquire Unit 1 & 2 and Indian Point 2
  - Available data shows good correlation between RACKLIFE predictions and in-situ areal density measurements.

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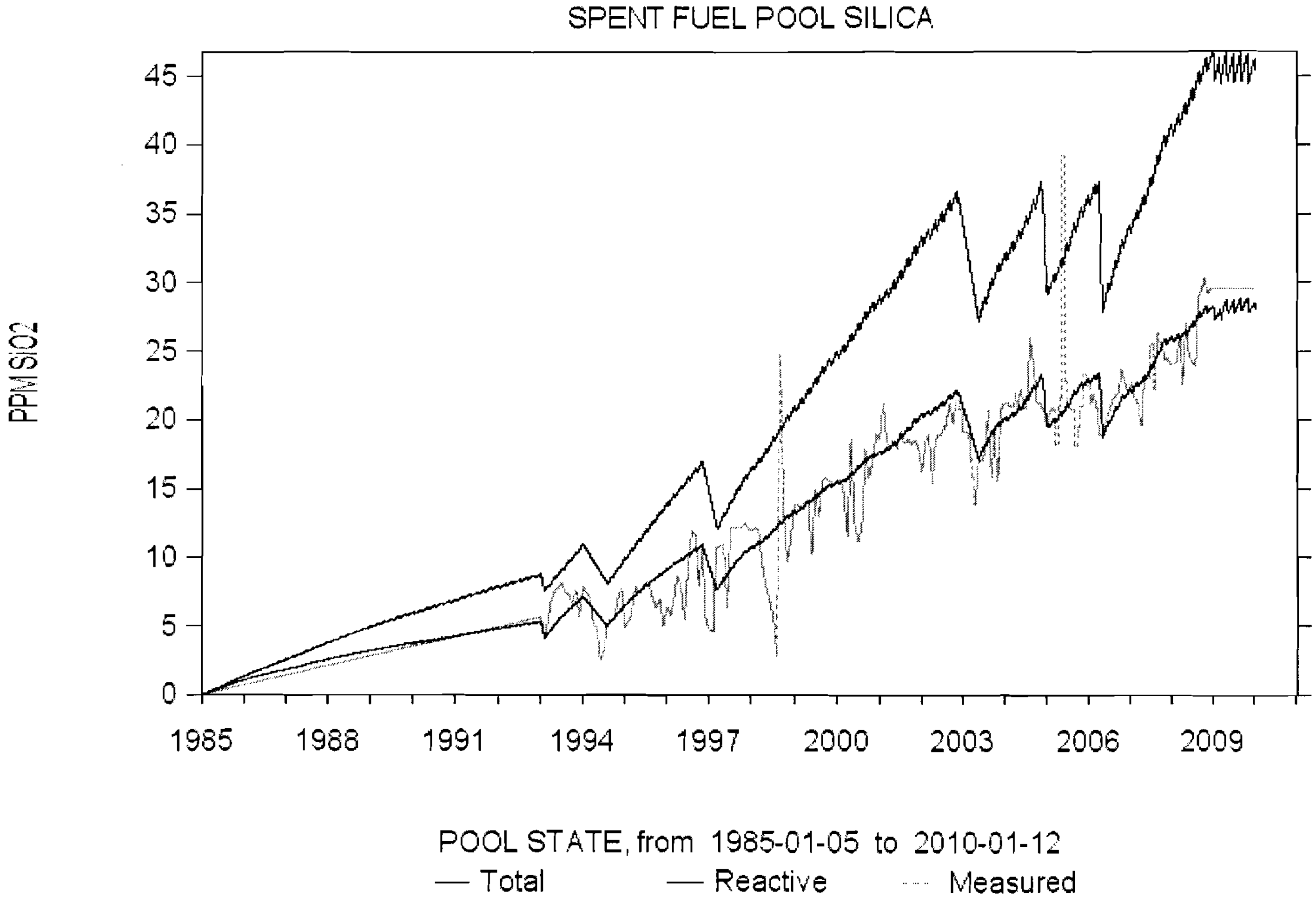
Unit 3 LAR
Boraflex Management Program

- Licensees create RACKLIFE models based upon known SFP parameters (silica history, temperature history, cleanup system efficiency)
- Models are modified to match actual SFP silica history by adjusting escape coefficient values.



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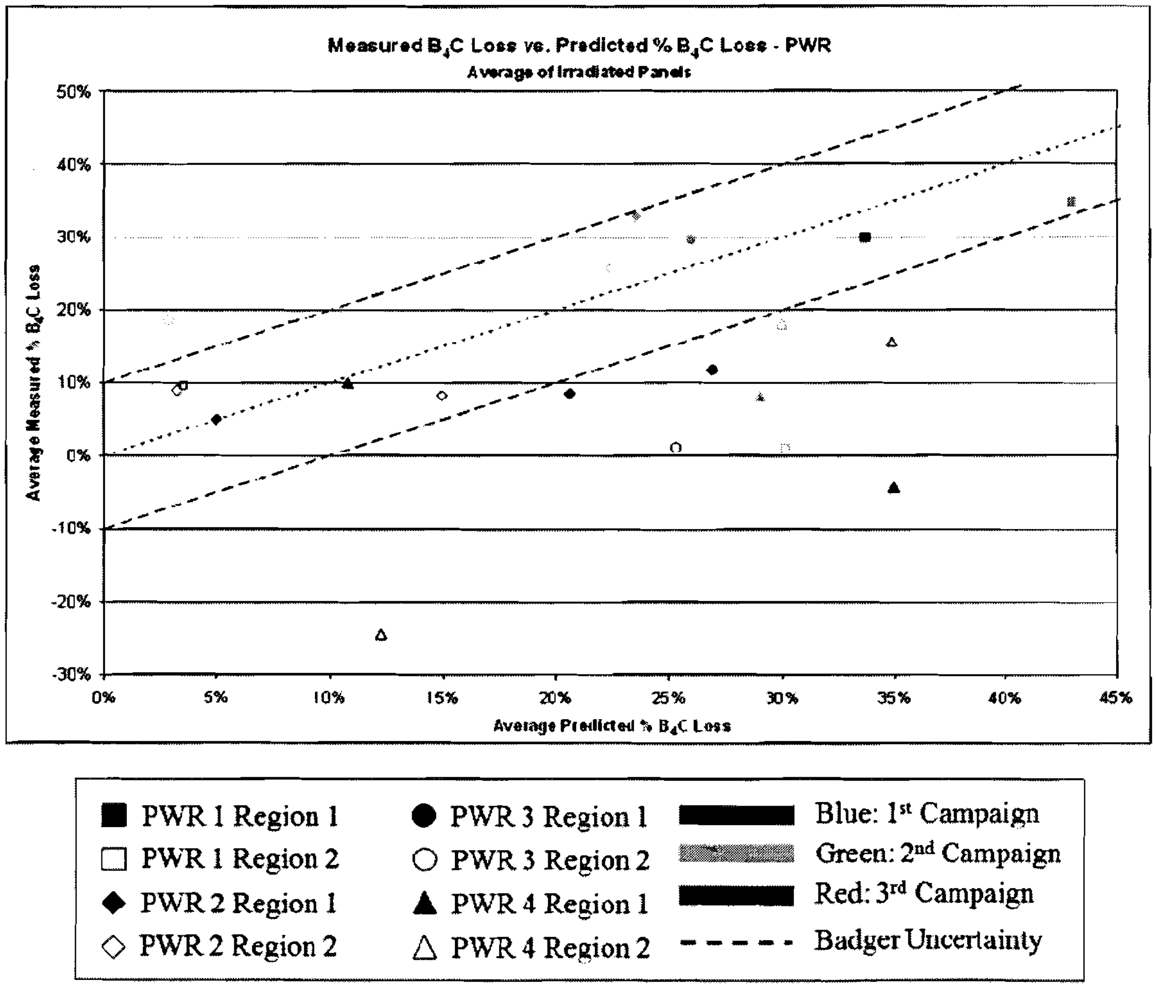
Unit 3 LAR - Boraflex Management Program

- The relative conservatism of these models has been established post BADGER testing by comparing average predicted loss with average measured loss.
- Under-predictions, therefore, are corrected and verified by subsequent BADGER campaigns.

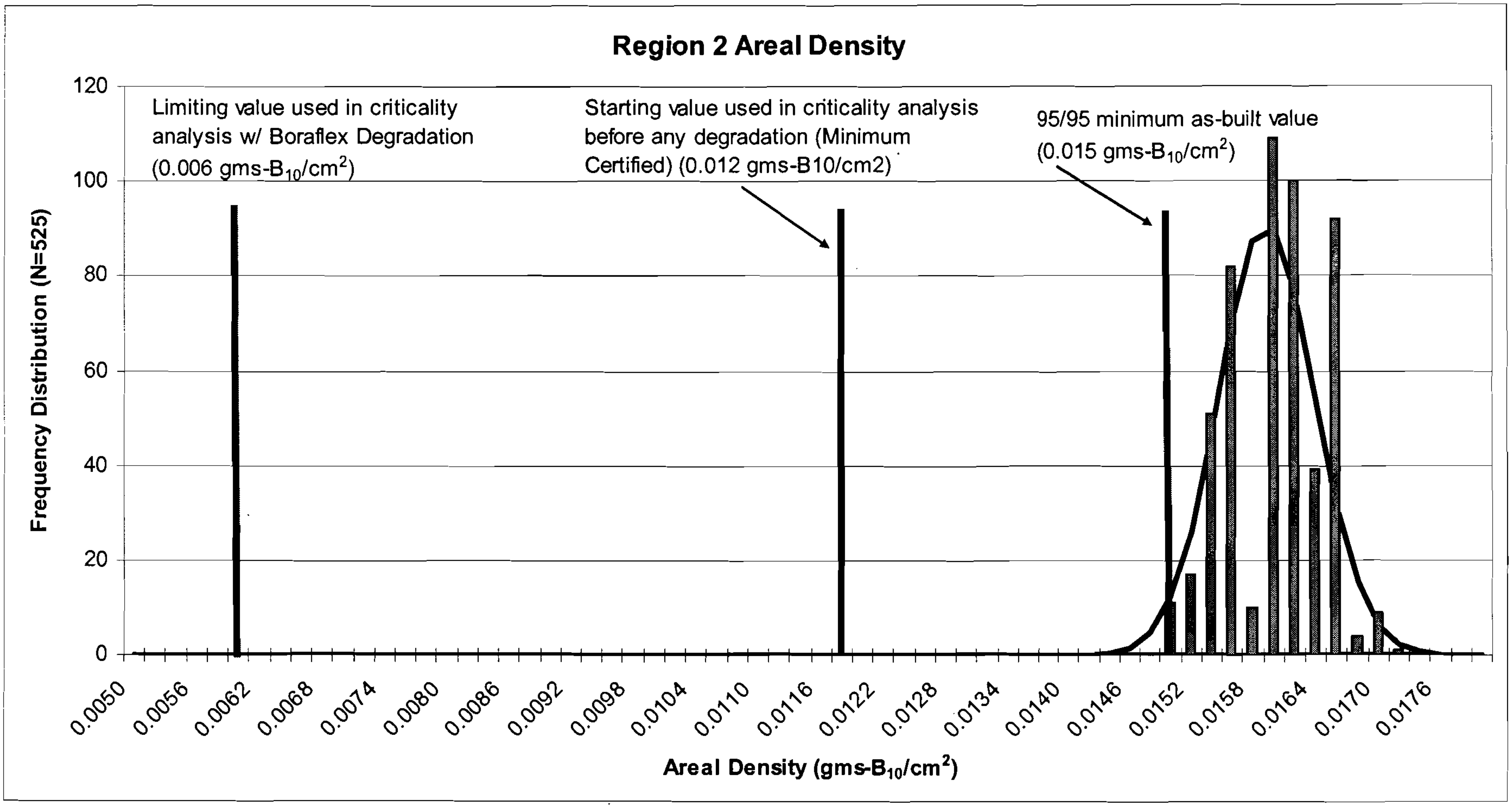


Unit 3 LAR
Boraflex Management Program

- RACKLIFE is conservatively applied to ensure that Keff < 1.0 on a 95/95 basis.
- RACKLIFE is used to predict the varying degraded conditions of the areal density of the Boraflex panels in the SFP
- The statistical analysis of the distribution of the difference between RACKLIFE predicted versus 2001, 2004, and 2007 BADGER test measured degradation shows that:
  - Using the 95/95 minimum initial as-built areal density shows that compensatory action is conservatively taken at an areal density higher than 0.006 gms-B_{10}/cm^2 when RACKLIFE predicts 50% degradation.
  - There is a 95% probability with a 95% confidence that RACKLIFE is over predicting degradation for the four panels in any given storage cell in the SFP.

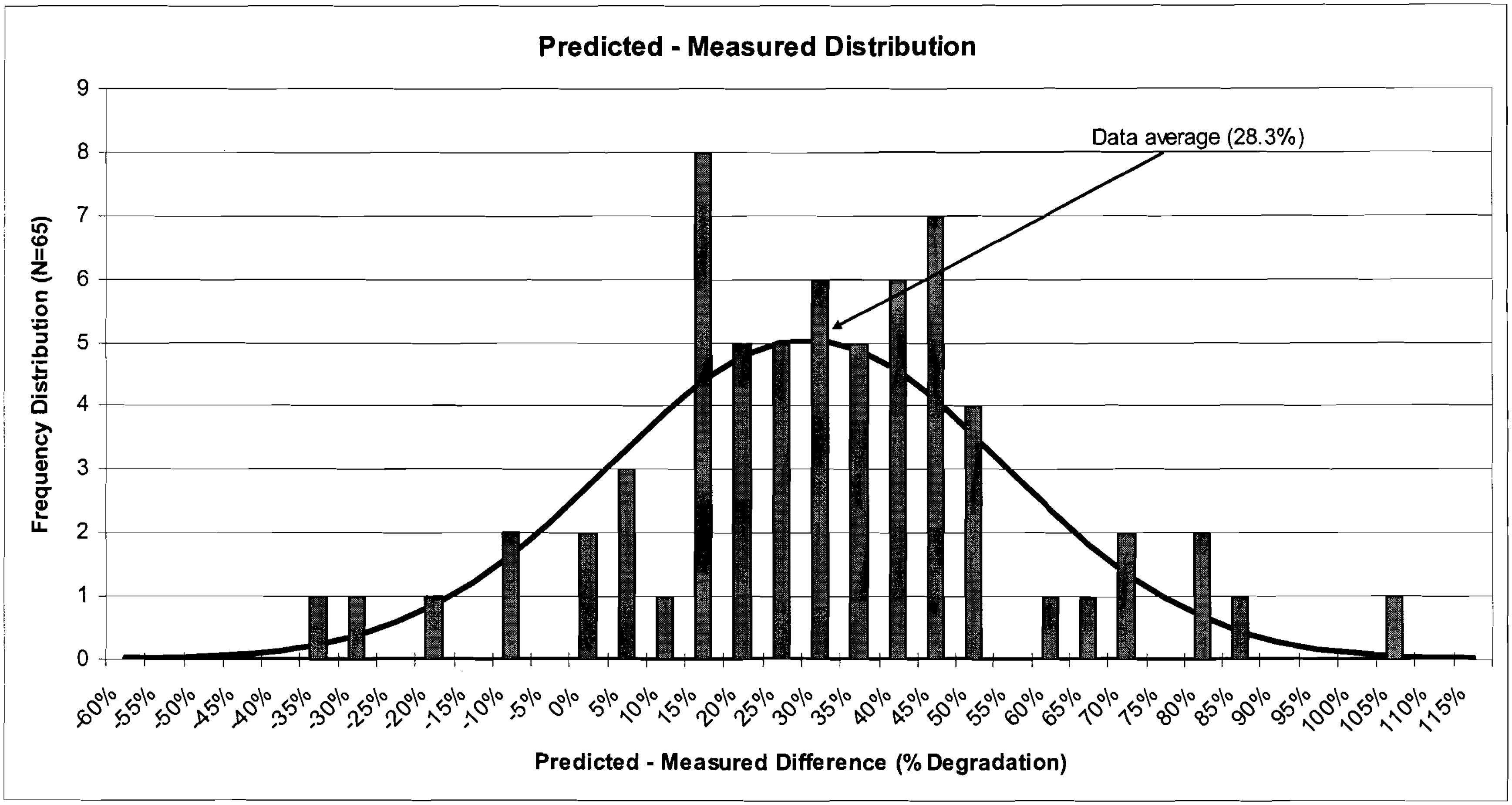
Unit 3 LAR
Boraflex Management Program

As-built areal density of Boraflex panels are higher than the degraded areal density assumed in the criticality analysis.



Unit 3 LAR
Boraflex Management Program

- BADGER testing confirms conservative nature of RACKLIFE compared to SFP conditions.
- This graph shows the distribution of the difference between degradation measured with BADGER and predicted by RACKLIFE for individual panels.



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Unit 3 LAR
Boraflex Management Program

- Based on the as-built areal density data, there is a 95% probability, with 95% confidence, that a given Boraflex panel had an areal density of 0.015 gms-B_{10}/cm^2 or higher.
- Therefore, when RACKLIFE predicts that a panel has 50% degradation, that means there's a 95/95 that the panel will be at 0.0075 gms-B_{10}/cm^2 or higher.
  - Considerable margin to 0.006 gms-B_{10}/cm^2.

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Unit 3 LAR
Boraflex Management Program

- From the RACKLIFE / BADGER comparison data, there is a 95% probability with 95% confidence that RACKLIFE will under-predict degradation by a maximum of 23.1%.
- That means that if RACKLIFE is predicting 50% degradation for a panel, it could be 73.1% degraded.
- However, the impact on keff must consider the other panels in a SFP storage cell.

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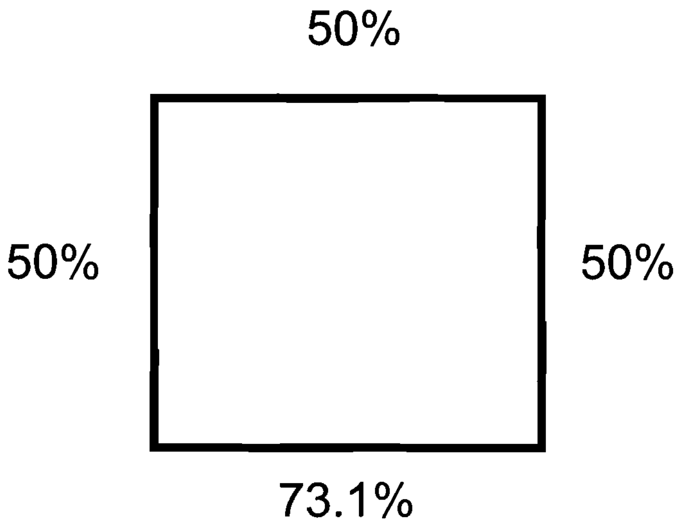
PTN-3 LAR - Managing Boraflex Degradation

- FPL takes action when one panel in a cell is predicted to reach 50% degradation.
- Therefore, the limiting case would be when RACKLIFE predicts that all four panels in one cell reach 50% degradation at once, with one under-predicted (in % degradation)-



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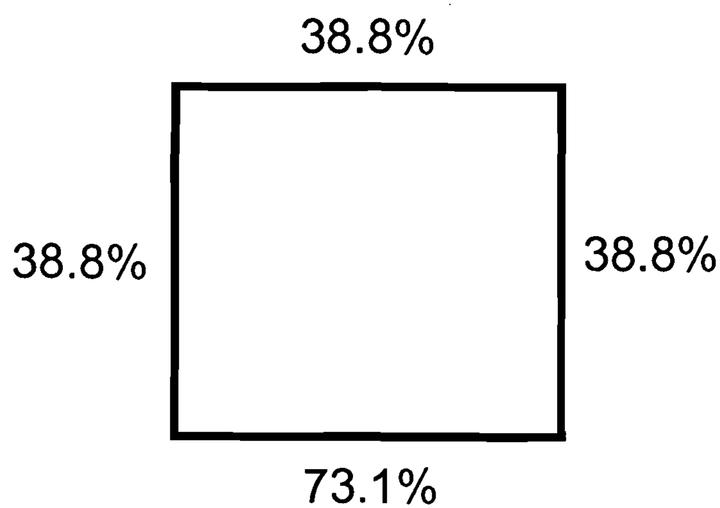
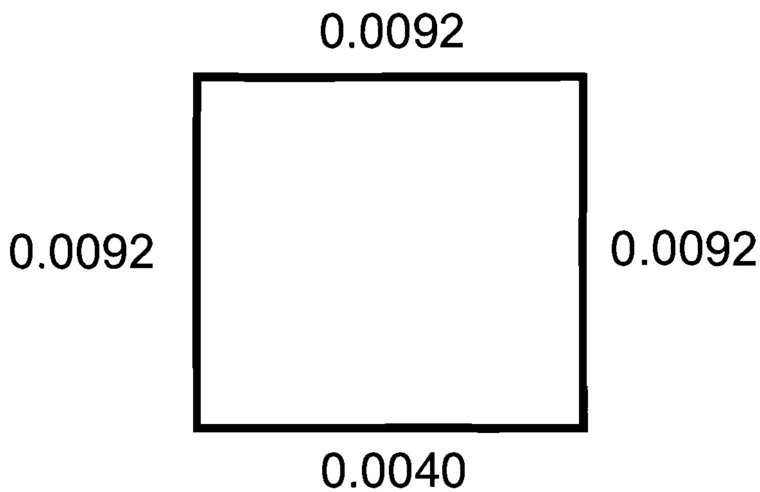
PTN-3 LAR - Managing Boraflex Degradation

- Using the RACKLIFE / BADGER comparison data, there is a 95% probability, with a 95% confidence, that the four panels in one cell will be over-predicted by RACKLIFE by a cumulative total of 10.4%.
- Therefore, if one panel is under-predicted by 23.1%, there's a 95/95 that the other three are over-predicted by 33.5%.



PTN-3 LAR - Managing Boraflex Degradation

- Converted to areal densities (in gms-B_{10}/cm^2), based on the 95/95 minimum value of 0.015 gms-B_{10}/cm^2 -



- This limiting case is bounded by the case with all panels at 0.006 gms-B_{10}/cm^2.

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Unit 3 Commitment Letter of 12/31/09

- Continue to credit Boraflex as a neutron absorber and administratively restrict with compensatory measures the use of storage cells that have Boraflex panels whose B-10 areal density have degraded below 0.006 gms-B_{10}/cm^2.
- Update the UFSAR describe compensating measures.
- Provide additional margin beyond that already afforded by FPL's historical treatment of Boraflex degradation until Amendment 234 is implemented.

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Compensatory Actions for Boraflex Loss

- To ensure margin to criticality is maintained and the keff requirements of the TS are satisfied compensatory actions are taken when a Boraflex panel is predicted to reach 50% degradation.
- Prohibit storage of fuel assembly in any affected SFP storage cell unless an alternate configuration has been demonstrated to compensate for the loss of Boraflex.
- Alternate configurations analyzed using NRC approved methodology.
  - KENO-Va and PHOENIX-P as used in WCAP-14416 for SFP criticality analysis.
  - MCNP4a and CASMO-4 as used in the Turkey Point Cask Area Rack and Boraflex Remedy criticality analysis.

Compensatory Actions for Boraflex Loss

- Alternate configurations accommodate a conservative allowance for uncertainties as described in UFSAR.
  - UFSAR Section 9.5.2.3 describes this methodology for the treatment of uncertainties as:
    - "A final 95/95 Keff was developed by statistically combining the individual tolerance impacts with the calculational and methodological uncertainties and summing this term with the temperature and method biases and the nominal KENOVa [or MCNP4a] reference reactivity [multiplication factor (K)]."
    - "The 95/95 basis is defined as the upper limit, with a 95 percent probability at a 95 percent confidence level, of the effective neutron multiplication factor Keff of the fuel assembly array, including uncertainties and manufacturing tolerances."
  - The analysis of the alternate configurations included an allowance for uncertainties consistent with this fundamental methodology for the treatment of uncertainties described in the UFSAR.

Compensatory Actions for Boraflex Loss

- In 2001 the high duty Region II SFP storage rack was converted to a configuration that didn't credit Boraflex ("Sacrificial Module").
- Additional alternate configurations use RCCAs to compensate for Boraflex degradation.
- Other alternate configurations use higher burnup requirements and empty cells.
- In addition, going forward the configurations of Amendment 234 (Boraflex Remedy) will be used to compensate for the loss of Boraflex.
  - Consistent with commitments in 12/31/09 letter.
    - Region I of the Unit 3 SFP to comply with Amendment 234 by June 19, 2010.
    - One storage rack in Region II to comply with Amendment 234 by June 19, 2010.
    - Additional storage racks will be configured to comply with Amendment 234 as Metamic inserts, RCCAs or empty storage cells become available.

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Summary Compensatory Actions for Boraflex Loss

- Compensatory actions taken in response to the degraded and nonconforming condition of some of the Boraflex panels in the Unit 3 SFP.
  - Actions taken use administrative controls and configurations similar to those approved in Amendment 234.
    - Empty storage cells.
    - RCCAs.
    - Higher fuel assembly burnup configurations.
  - Actions taken enhance the reactivity control capability of the SFP and satisfy the requirements of TS 5.5.1.1.a and 5.5.1.1.b.
    - The compensatory measures were analyzed using NRC-approved methodology and are conservative to accommodate a conservative allowance for uncertainties as described in the UFSAR.
  - Implementation of the Boraflex Remedy Amendment intended to be final corrective action for the degraded and nonconforming condition.
- Given length of time compensatory actions in place, UFSAR should have been updated.
- Compensatory measures taken are more conservative than TS requirements and require action to bring TS into conformance per NRC Administrative Letter 98-10.
  - Implementation of the Boraflex Remedy Amendment intended to address this issue.

Unit 4 LAR

- NRC approved Unit 4 Boraflex remedy extension to 2/28/11 with license conditions (BADGER test by 5/1/10, 2100 ppm SFP boron, 10% burnup penalty and no additional fuel to SFP).
- License conditions have been implemented providing additional margin.
- BADGER testing to start in 3/10/10.
- Based on BADGER test results FPL will subsequently submit a LAR to NRC requesting Boraflex Remedy extension to 2012.
  - Similar to the Unit 3 LAR, the Unit 4 LAR is to be based on the Boraflex Remedy amendment methodology.
- FPL is preparing a contingency LAR for Unit 4 to have available to submit in the unlikely event we have to offload the core prior to the next refueling outage.

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Conclusions

- The Turkey Point SFPs remain operable in a controlled safe configuration.
  - Actions taken and going forward conservatively manage Boraflex degradation to assure adequate reactivity margin in the SFP.
- Actions taken in SFPs are in compliance with TS.
- FPL will update Turkey Point UFSAR to include compensatory measures by 3/15/10.
- The proposed Unit 3 LAR will address SFP conditions until the Boraflex Remedy Amendment can be implemented.

APPENDIX

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Definitions

- Resultant cells: Region II storage cell that contains Boraflex panels.
- 95/95 lower tolerance limit: The value in a statistical population which has a 95 percent probability that the population is greater than at a 95 percent confidence level.
- Metamic Insert: A chevron shaped SFP storage cell insert composed of an aluminum and B_4C metal matrix composite.
- Administrative controls: Those actions established to restrict storage of fuel assemblies and the placement of neutron absorbers in the SFP to assure that the SFP keff requirements are satisfied.
- Boraflex Remedy: License Amendments 234 and 229.

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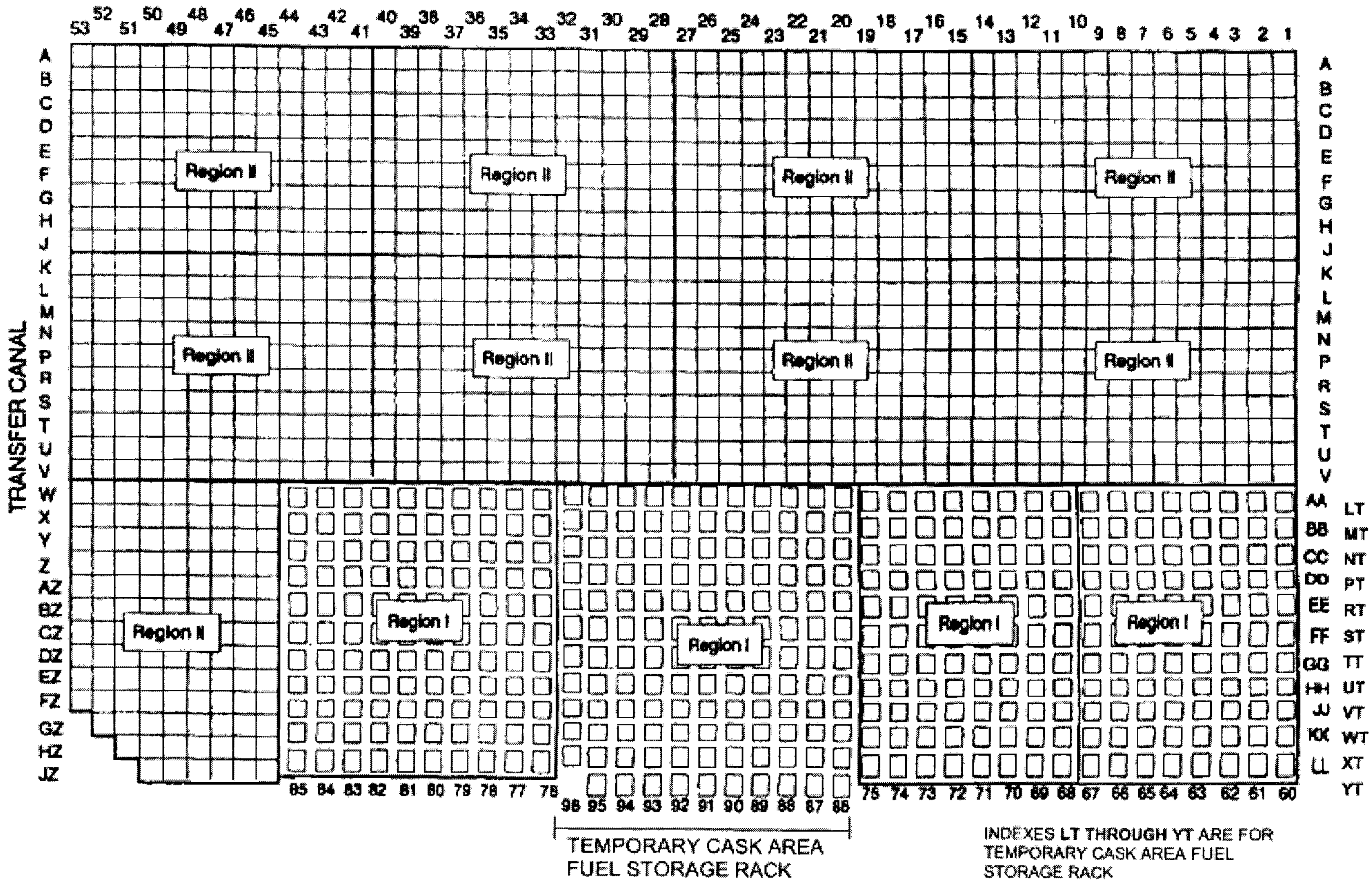
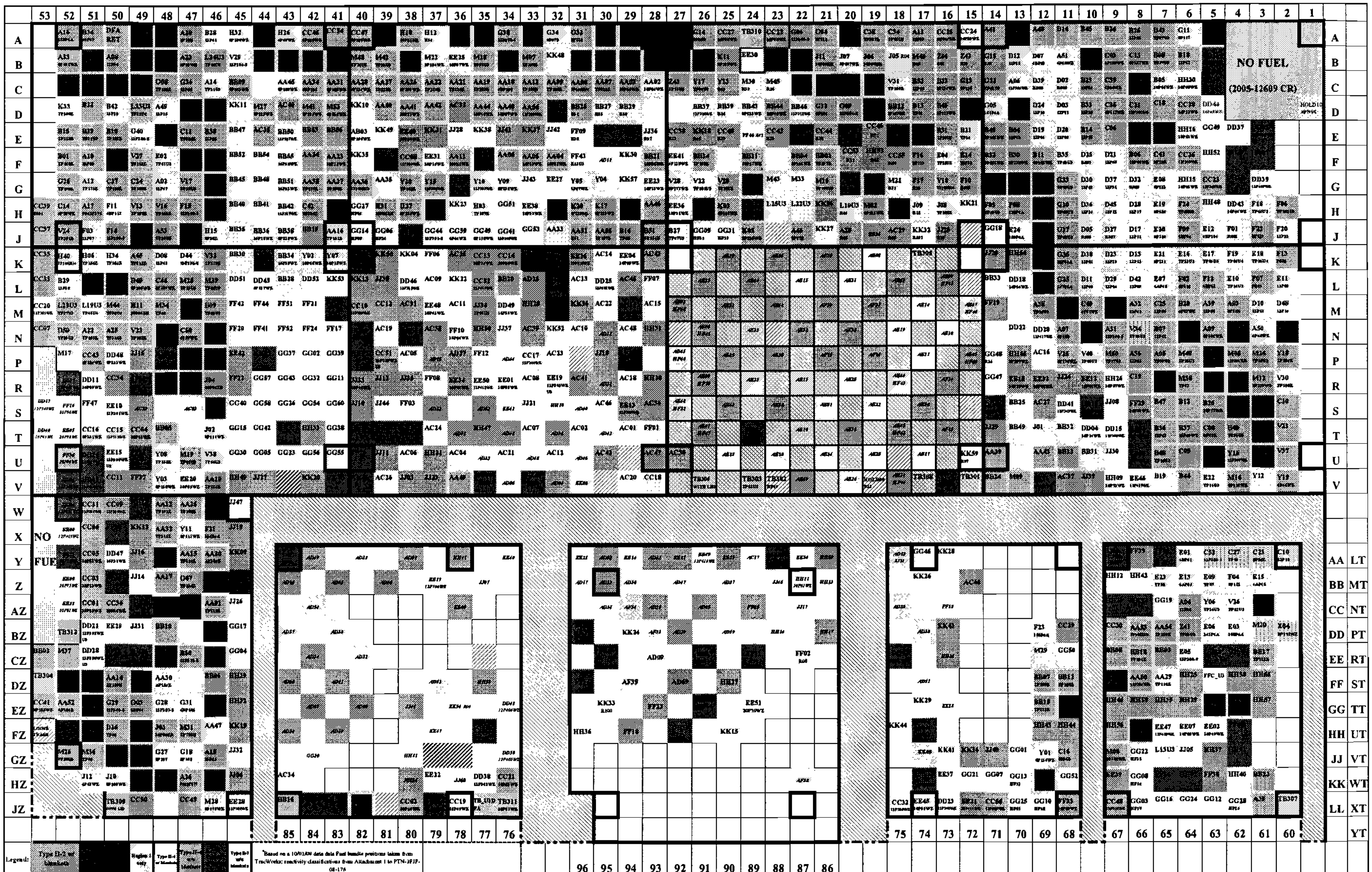
Background (con't)



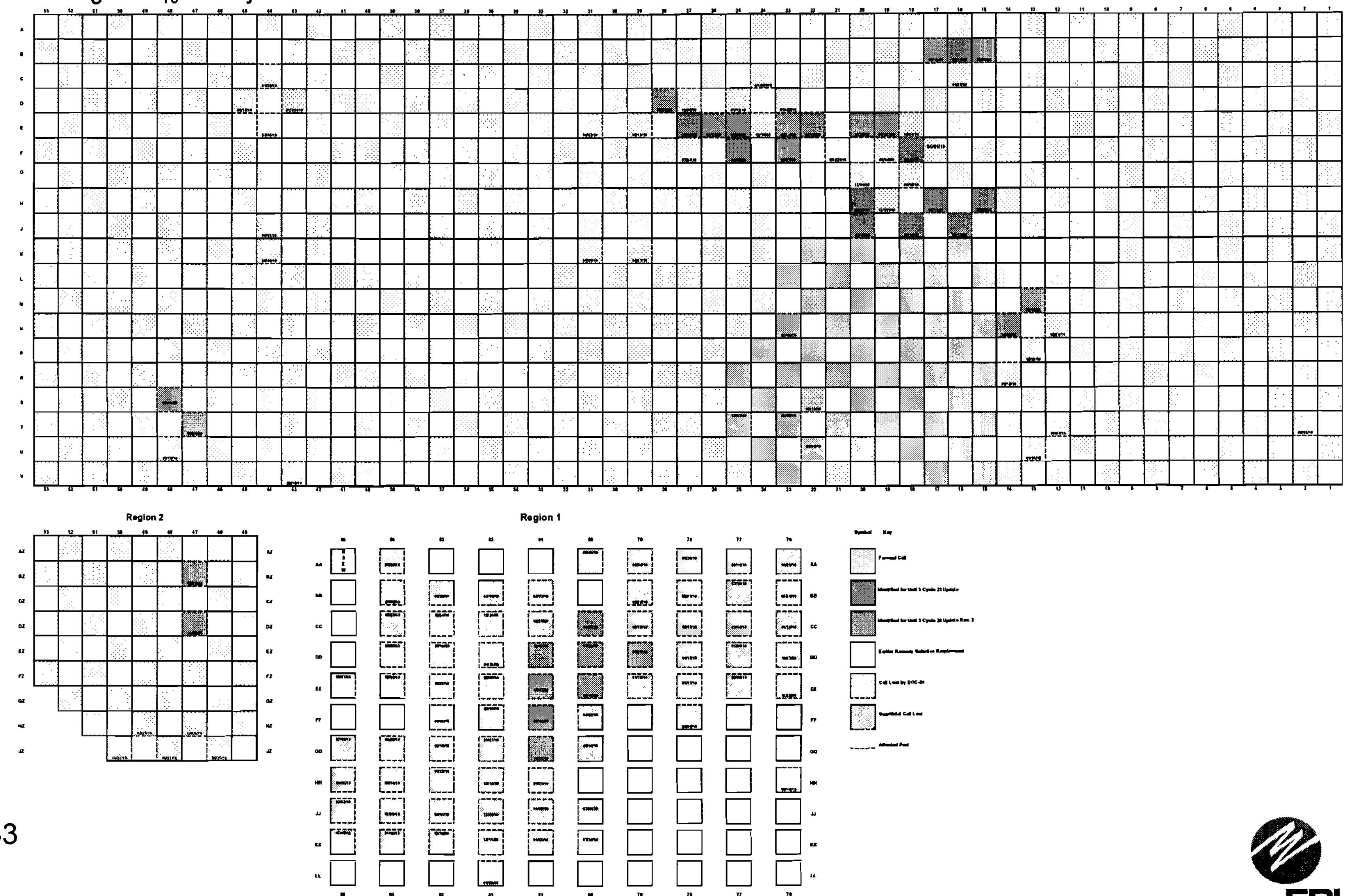
Unit 3 SFP Layout

Unit 3 SFP



U3 SFP Projected Degradation

- Status of the Boraflex in the Unit 3 SFP
  - 10% of the Region II Boraflex panels conservatively projected to be below the minimum analysis areal density of 0.006 gms-B_{10}/cm^2 by 9/27/10.

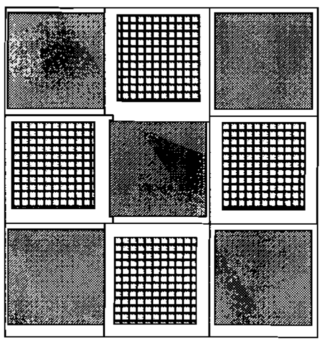


Current TS Requirements

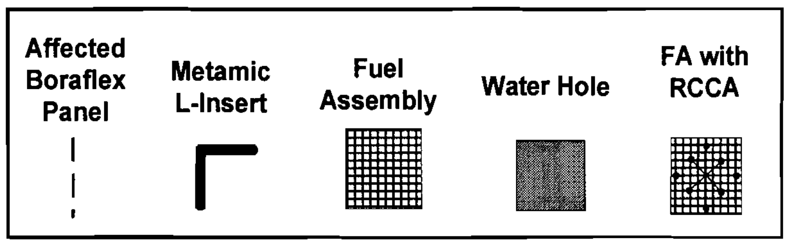
- **<u>TS 3.9.14 SPENT FUEL STORAGE</u> The following conditions shall apply to spent fuel storage:**
  - The maximum enrichment loading for the fuel assemblies in the spent fuel racks shall not exceed 4.5 weight percent of U-235.
  - The minimum boron concentration in the Spent Fuel Pit shall be 1950 ppm.
  - Storage in Region II of the Spent Fuel Pit shall be further restricted by burnup and enrichment limits specified in Table 3.9-1.
- **<u>TS 5.5.1.1 DESIGN FEATURES – FUEL STORAGE – CRITICALITY</u> 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:**
  - Keff equivalent to less than 1.0 when flooded with unborated water, which includes a conservative allowance for uncertainties as described in UFSAR Appendix 14D.
  - A Keff equivalent to less than or equal to 0.95 when flooded with water borated to 650 ppm water, which includes a conservative allowance for uncertainties as described in UFSAR Appendix 14D.
  - 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.
  - The maximum enrichment loading for fuel assemblies is 4.5 weight percent of U-235.

Compensatory Actions for Boraflex Loss

- 2001: 2-out-of-4 checkerboard with empty storage cells (Sacrificial Module).
  - NRC approved methods
  - Codes: KENO-Va
  - Unborated keff < 0.80 vs. the keff requirement of < 1.0
  - Uncertainties: Accommodates conservatively applied biases & uncertainties
    - Calculational bias and uncertainty appropriate for the 44-energy group KENO-Va model
    - Remaining biases and uncertainties are those used in the licensing basis analysis in the UFSAR



No Boraflex in any cells



Compensatory Actions for Boraflex Loss

- 2008: Location specific (SFP Location H15) use of Amendment 234 (Boraflex Remedy) configurations.
  - NRC approved methods
  - Codes: MCNP4a and CASMO-4
  - Unborated keff consistent with Amendment 234 licensing basis analysis.
  - Uncertainties: Biases & uncertainties conservatively applied consistent the UFSAR methodology for the treatment of uncertainties.
- 2009: Location specific (SFP Location L38) use of specific higher burnup fuel assemblies.
  - NRC approved methods
  - Codes: PHOENIX-P
    - Use consistent with WCAP-14416 defined the use of PHOENIX-P for SFP criticality analysis
    - Target multiplication factor (K) was established (base case) using this model with the limiting fuel assembly allowed by Technical Specification (TS)
    - Analysis performed assuming Boraflex neutron absorber removed from one SFP storage cell and the actual enrichment / burnup characteristics of the fuel stored in and around L38 to compensate for the K impact of the loss of the Boraflex
    - Analysis determined the no Boraflex case K was less than base case K.
  - Unborated keff < Amendments 206 & 200 licensing basis analysis (UFSAR)
  - Uncertainties: Biases & uncertainties conservatively applied
    - Comparative analysis inherently applies the calculated biases and uncertainties from the licensing basis analysis.
    - Increased axial burnup shape bias appropriate for the higher burnup fuel assemblies used in the compensatory measure configuration consistent with the licensing basis analysis methodology.

Compensatory Actions for Boraflex Loss

- 2003: RCCAs used to compensate for the loss of Boraflex.
  - NRC approved methods
  - Codes: PHOENIX-P
    - Use consistent with WCAP-14416 defined the use of PHOENIX-P for SFP criticality analysis
    - Target multiplication factor (K) was established (base case) using this model with the limiting fuel assembly allowed by Technical Specification (TS)
    - Analysis performed assuming Boraflex neutron absorber removed from one SFP storage cell and used RCCAs to compensate for the K impact of the loss of the Boraflex.
    - Analysis determined the no Boraflex case K was less than base case K.
  - Unborated keff < 0.95 vs. the keff limit of <1.0
  - Uncertainties: Accommodates conservatively applied biases & uncertainties
    - Comparative analysis inherently applies the calculated biases and uncertainties from the licensing basis analysis.
    - Uncertainty associated with RCCA easily accommodated by conservative results.