Exelon® Generation

Pre-Submittal Meeting – Neutron Absorbing Inserts

Exelon Generation Company, LLC

Peach Bottom Atomic Power Station
Units 2 and 3

May 17, 2011

Agenda

- ✓ Introduction (Tom Loomis (Exelon)) – 10 minutes
- ✓ Discussion of Inserts (Ken Lindquist (Curtiss-Wright Flow Control Service Company)) - 20 minutes
- ✓ Discussion of Criticality Analysis for Inserts (John Hannah (Global Nuclear Fuels)) – 40 minutes
- ✓ Interim Actions / Technical Specifications (TS) (Jeff Dunlap (Exelon)) – 15 minutes
- ✓ Concluding Comments (Tom Loomis (Exelon)) - 5 minutes

Introduction

- ✓ Submitted License Amendment Request (LAR) in June 2008 to address the spent fuel pool issues
- ✓ LAR was withdrawn on June 8, 2010 (15 letters exchanged between NRC and Exelon)
- ✓ Exelon proceeding with NETCO-SNAP-IN® inserts
- ✓ New submittal is intended to follow LaSalle County Station, Unit 2 LAR (submitted October 5, 2009 and approved January 28, 2011)
- ✓ Will be using Global Nuclear Fuel as our criticality analysis vendor
- ✓ Analysis bounds fuel conditions for future plant uprates

Introduction (continued)

- ✓ Intend to submit the LAR in November 2011
- ✓ Insert tests at Penn State July 2011
- ✓ Install and remove 9 test inserts in the spent fuel pool in August 2011
- ✓ Will install inserts first in rack modules with worst degradation
- ✓ Installation schedule still being optimized, based on insert approval and projected degradation. Bounding dates for installation have been established:
  - Unit 2 – 2013 - 2017
  - Unit 3 – 2014 - 2018
- ✓ Estimated cost of installation is approximately $45 million

CURTISS WRIGHT Flow Control Company
NETCO

NETCO-SNAP-IN® Rack Inserts: Neutron Poison Replacement for Fuel Storage Applications

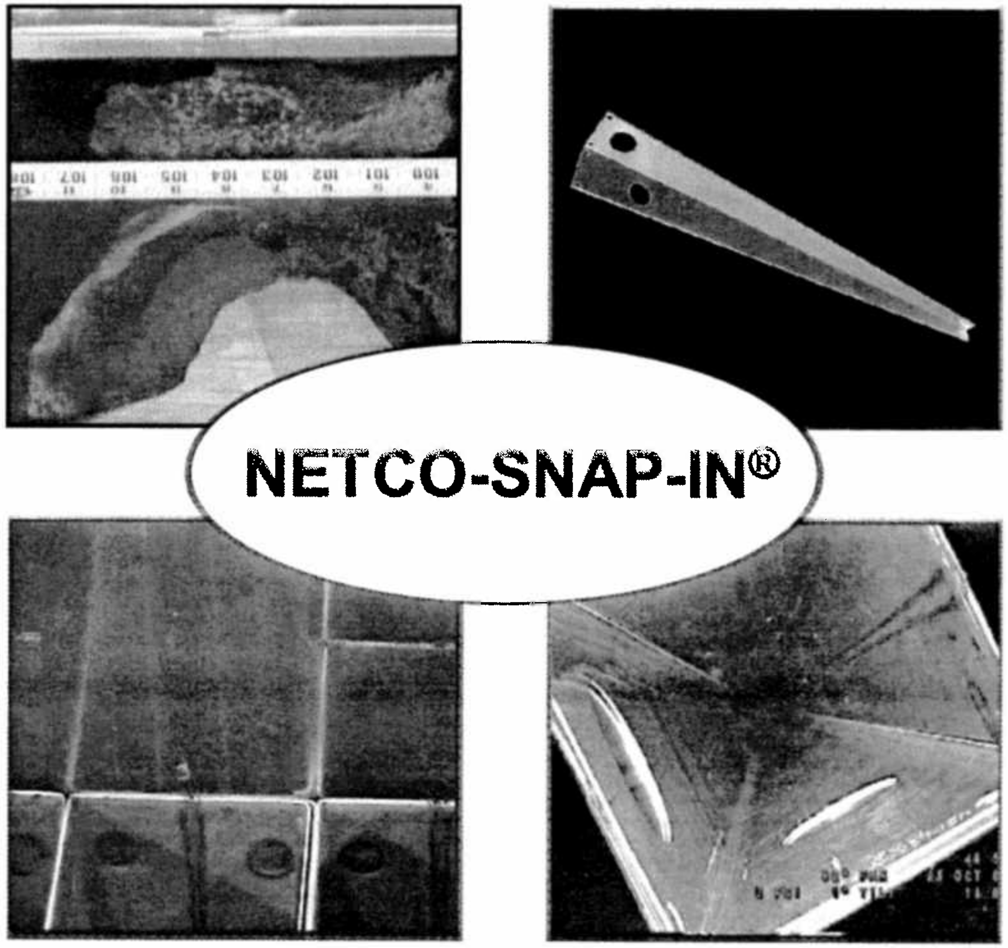
Peach Bottom Pre-Submittal Meeting, 5/17/2011

Ken Lindquist
Senior Advisor

What are NETCO-SNAP-IN® Inserts?

Replace Lost Reactivity Hold-Down

Made of Al/B_4C Composite Material



Extends Useful Storage Rack Life

Minimal Impact on Fuel Move Operations

Project Overview

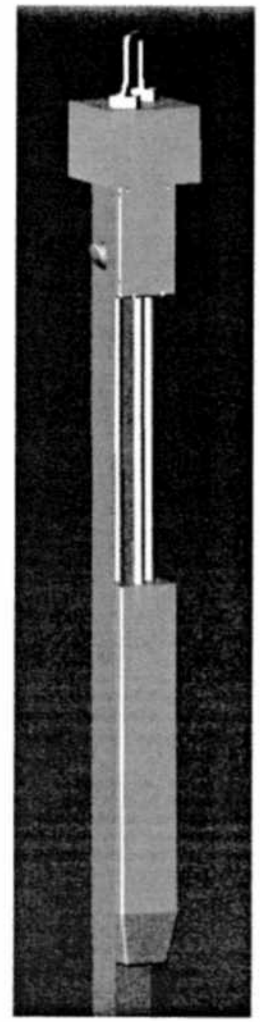
- K. Lindquist Issued U.S. Patent 6,741,669 B2 in 2004 for Absorber Insert Design
- Original Demonstration Program was a Joint Venture Between NETCO and Exelon Corp.
- Clean Pool Prototype Testing Performed at Penn State
- First Installation at Exelon's LaSalle Station in 2007 (Three installed in Demonstration Program)
- Full Scale Installation at LaSalle Initiated in 2010 with 650 Installed to Date
- PWR Demonstration in June 2011

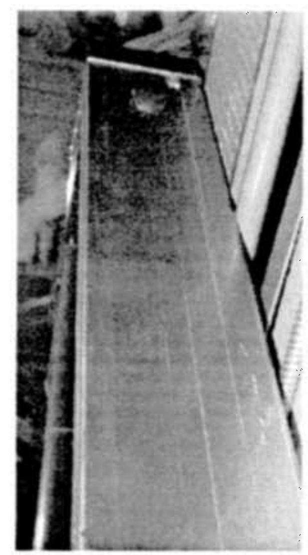
Description

- Al-1100/B_4C Composite, Provided by Rio Tinto Alcan, Formed Into a Chevron Shaped Rack Sleeve; Peach Bottom will use a higher B_4C loading
- Installed via Custom Tool from the Refueling Bridge
- Chevron is Compressed During Installation; Friction and Compression Forces Hold it in Place

Key Features

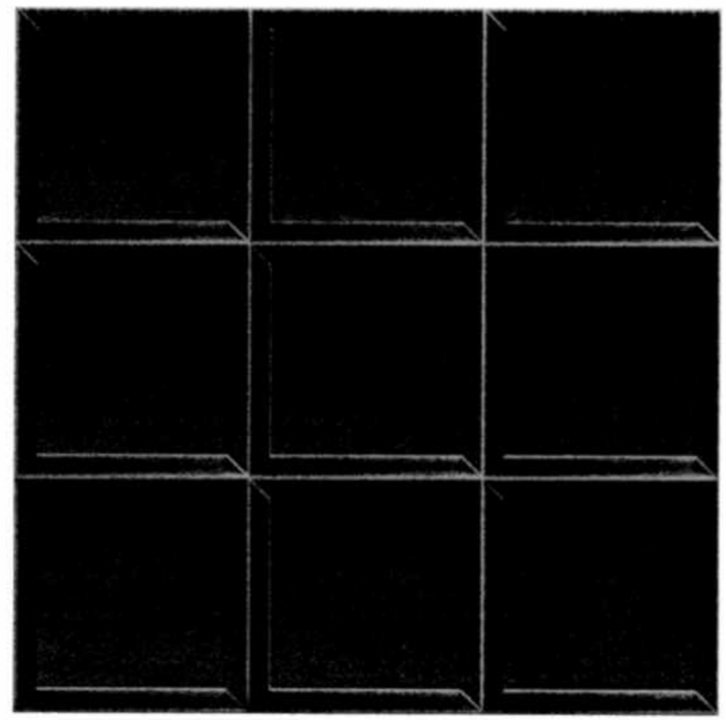
- Simplicity of NETCO-SNAP-IN®
  - Standard Fabrication Methods Used to Form Al/B_4C Composite Material
- Simplicity of Installation Tool
  - Installation force provided by tool weight alone; no Electrical or Hydraulic Systems
- Once Installed, NETCO-SNAP-IN® Inserts are an Integral Part of the Rack Modules





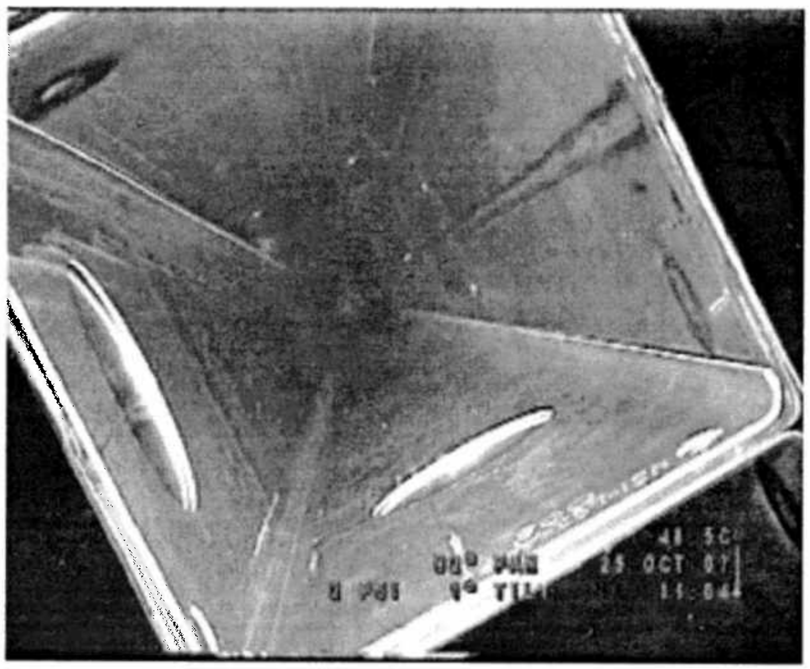
Application

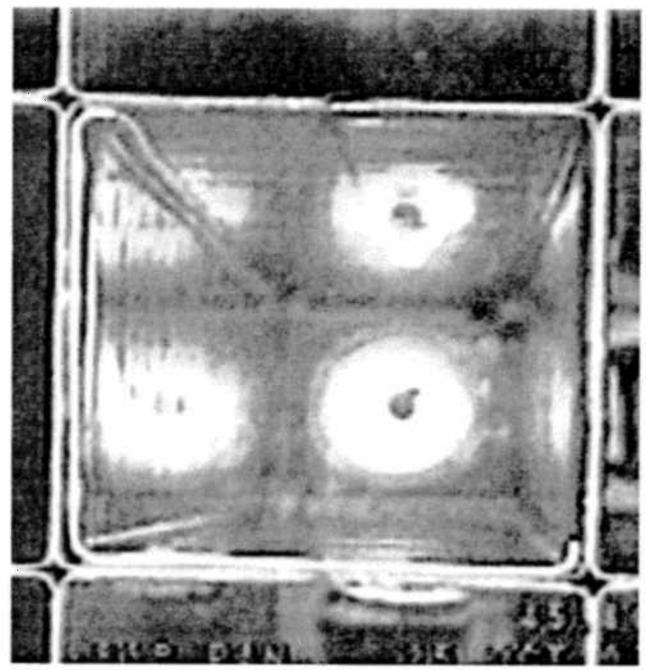
- When Placed in Each Storage Location, the NETCO-SNAP-IN® Inserts Supplement the Neutron Poison in the Existing Racks
- Once Installed, Fuel Can Be Moved In and Out of the Storage Locations as Usual
- 650 Inserts Installed To-Date at LaSalle
- LaSalle Installation Experience and Lessons Learned will Be Applied at Peach Bottom

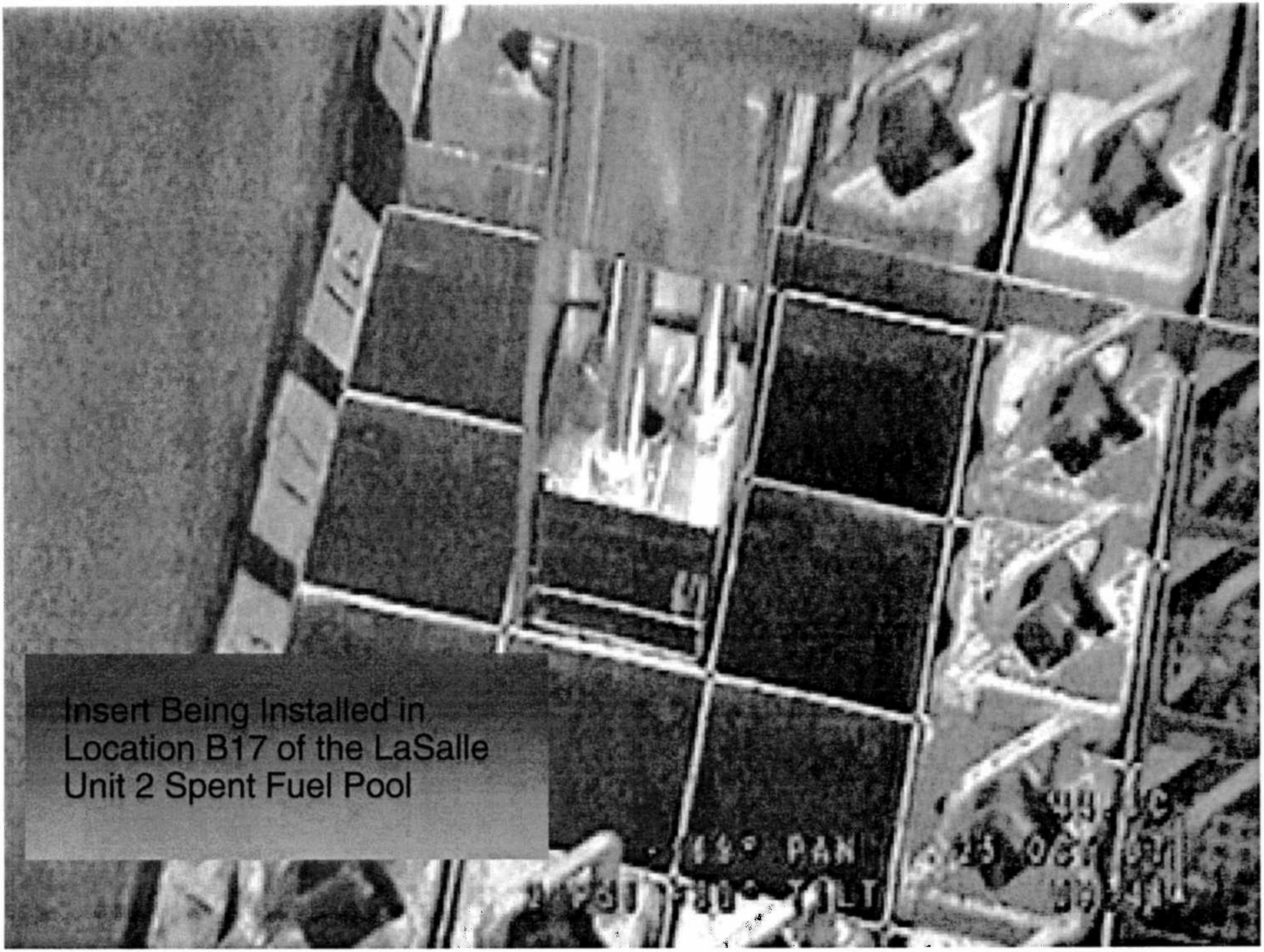


LaSalle Installation

- No Clearance Issues were Encountered During Installation; Further Testing has Validated Acceptable Clearance with Irradiated Fuel
- Peach Bottom has additional Margin in their Rack Dimensions







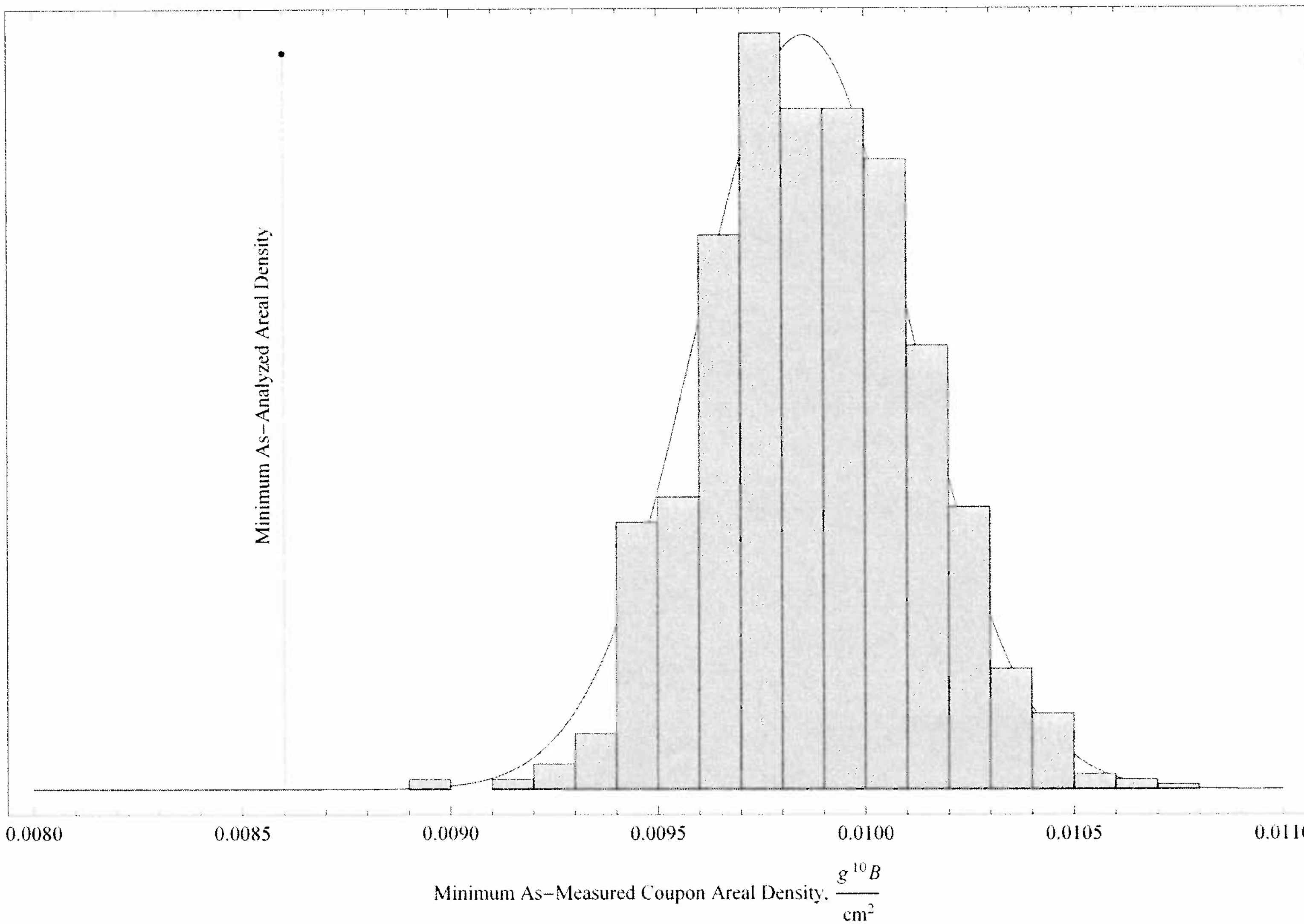
Insert Being Installed in
Location B17 of the LaSalle
Unit 2 Spent Fuel Pool

Borated Aluminum Material

- Material Qualification of Alcan Through Accelerated Corrosion Testing
  - Pre-test characterization
  - Post-test characterization
  - Accelerated corrosion environment
  - 2000, 4000, 6000 & 8000-hour test results
- Results Show Corrosion Rates Within Measurement Uncertainty of Zero for 8000-hr Tests
- Stability of Areal Density Values Throughout Test
- Fast-Start Results (6 Pulled So Far) Show Consistency with Accelerated Test Predictions, Showing No Negative Change in Areal Density

Material Performance (LaSalle)

Alcan Material Shows Consistent Performance in Neutron Attenuation Tests



Material Surveillance

- Coupon Surveillance program will be similar to LaSalle
- Inspection Frequency and Coupon Tests will be similar to LaSalle

CURTISS WRIGHT
Flow Control Company
NETCO

Questions?

GE Hitachi Nuclear Energy

Peach Bottom Spent Fuel Pool Criticality Analysis with Rack Inserts

NRC Pre-Submittal Meeting

John Hannah

May 17, 2011

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Guidance and Regulations

GDC 62: Prevention of Criticality in Fuel Storage & Handling

"Criticality in the fuel storage and handling system shall be prevented by physical systems or processes, preferably by use of geometrically safe configurations."

10 CFR 50.68 (b) (4)

The k-effective of the spent fuel storage racks loaded with fuel of the maximum fuel assembly reactivity must not exceed 0.95, at a 95 percent probability, 95 percent confidence level, if flooded with unborated water.

$$K_{max(95/95)} \leq 0.95$$

Basic Analysis and Requirements

$$K_{max(95/95)} = K_{\text{Nominal}} + \Delta K_{\text{Bias}} + \Delta K_{\text{Tolerance}} + \Delta K_{\text{Uncertainty}}$$

$\Delta K_{Bias} = \sum_{i=1} \Delta K_{Bi}$ Contribution from Biases

$\Delta K_{Tolerance} = \sqrt{\sum_{i=1} \Delta K_{Ti}^2}$ Contribution from Independent Tolerances

$\Delta K_{\text{Uncertainty}} = \sqrt{\sum_{i=1} \Delta K_{Ui}^2}$ Contribution from Independent Uncertainties

- Establish a peak, cold, uncontrolled, in-core lattice reactivity allowable for storage in the racks (in-core kinf criterion methodology)
- All storage rack locations assumed to contain identical fuel assemblies at their most reactive state as a function of both exposure and cooling time
- Consideration given to all credible abnormal conditions, manufacturing tolerance implications, and computational uncertainties

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Computational Tools and Validation

TGBLA06A

GEH/GNF 2-D lattice physics code

Calculates *in-core* kinf values

Determines exposure dependent, pin-by-pin isotopic specifications

Utilizes ENDF/B-V cross-section data

95/95 Bias and bias uncertainty of in-core kinf quantified using TGBLA to MCNP comparison.

MCNP-05P

GEH/GNF version of LANL code MCNP5

Calculates *in-rack* kinf values

Uses TGBLA defined peak reactivity isotopic specifications

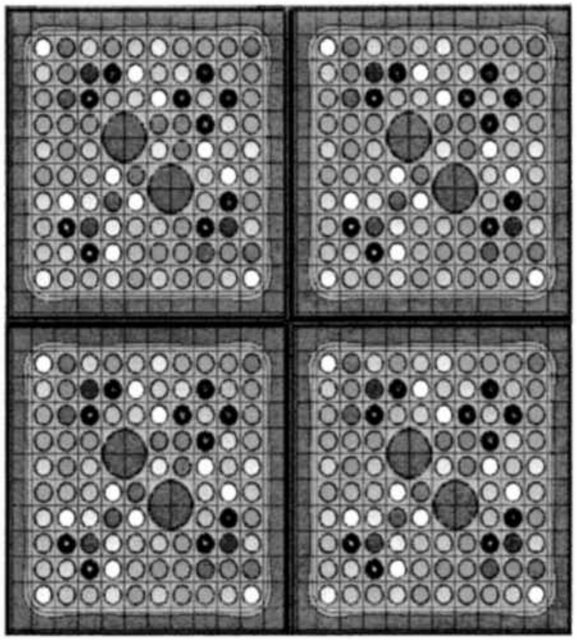
Utilizes ENDF/B-VII cross section data

95/95 Bias and bias uncertainty quantified and applied using 96 pin-lattice in water experiments.

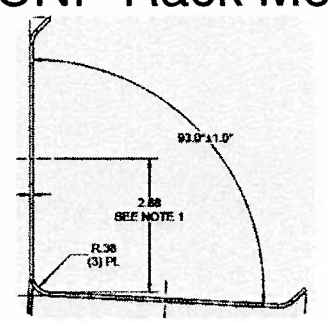
Reactivity penalties applied consistent with NEDO-33374-A, including:

- Depletion Isotopics Uncertainty
- Fission Product XS Uncertainty
- Actinide XS Uncertainty

Spent Fuel Rack Model



MCNP Rack Model



Rack Insert Schematic

- No credit taken for Boraflex – Panels are modeled as water
- No credit taken for axial or lateral neutron leakage (2-D Analysis)
- Assumes a single lattice design at peak reactivity for full bundle height in every storage location (Kinf > 1.27)
- Stainless steel rack modeled explicitly
- Assumes a single rack insert with a minimum 95/95 areal density of 0.0102 g $B10/cm^2$ in every storage cell

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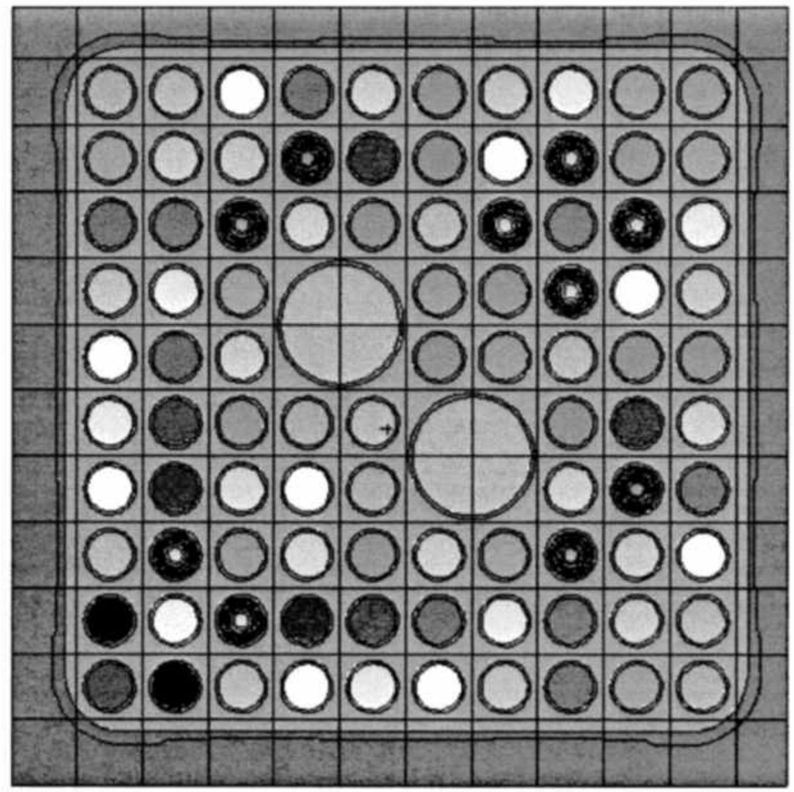
Design Basis Bundle Selection

- GNF2 utilized to bound all past and current fuel types in the PB SFP
- Peak, cold, uncontrolled in-core kinf just greater than 1.27 studied for all DBB candidates
- Each GNF2 lattice is analyzed independently with multiple enrichment/gad loadings considered
- The lattice/fuel loading combination resulting in the highest rack efficiency (in-rack kinf/in-core kinf) is used to:
  - Define nominal in-rack kinf value
  - Perform bias, tolerance, and uncertainty sensitivity studies



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Storage Scenarios Addressed

<u>Credible Normal Conditions</u>

- Fuel Assembly Channeling
- Eccentric Loadings
- Moderator Temperature
- Rotated Bundle

<u>Credible Abnormal Conditions</u>

- Dropped Fuel Assembly
- Misplaced Fuel Assembly
- Alternative Depletion Conditions
- Missing Rack Insert

<u>Manufacturing Tolerances</u>

- Fuel Enrichment
- Fuel Pellet Density
- Gadolinia Content
- Rod Cladding Thickness
- Rack Wall Thickness
- Rack Pitch
- Rack Insert Thickness
- Rack Insert B-10 areal density

<u>Interface Effects</u>

- Racks with Inserts Adjacent to Storage Modules without Inserts
- Storage Cells without a Poison Panel on Every Side (on module edge or next to an inaccessible location)

Comparison to Approved LARs

Topic	Consistent With:
TGBLA/MCNP Analysis Package	NEDO-33374-A
In-Core Kinf Criterion Methodology	NEDO-33374-A
Criticality Code Validation	NEDO-33374-A
Design Basis Bundle Selection	NEDO-33374-A
Bias, Tolerance, and Uncertainty Studies	NEDO-33374-A
Rack Insert, Boraflex, and Interface Treatment	ANP-2843
Statistical Rollup of K(95/95) Result	NEDO-33374-A

NEDO-33374-A : Safety Analysis Report for Fuel Storage Racks Criticality Analysis for ESBWR Plants – September 2010 (ML102860687)
ANP-2843 : LaSalle Unit 2 NPS Spent Fuel Pool Storage Criticality Safety Analysis with Neutron Absorbing Inserts and without Boraflex – January 2011 (ML110250051)

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Compliance with Draft ISG and IN

Draft DSS-ISG-2010-01

- Fuel Assembly Selection ✓
- Depletion Analysis ✓
- Criticality Analysis ✓
- Criticality Code Validation ✓

Information Notice 2011-03

- Monte Carlo Bias Uncertainty ✓
- Depletion Uncertainty ✓

Summary

- Analysis performed will fulfill requirements of 10 CRF 50.68 and GDC 62 with consideration given to Draft ISG-2010-01 and IN-2011-03
- Consideration given to all credible abnormal conditions, manufacturing tolerance implications, and computational uncertainties in determining maximum in-rack eigenvalue
- Spent fuel racks will be demonstrated to remain >5% subcritical for storage of current and previous fuel types with peak, cold, uncontrolled in-core reactivities < 1.27

Interim Actions / TS - Jeff Dunlap (Exelon)

- ✓ NRC review of Boraflex degradation limits to be completed through the ongoing Task Interface Agreement process

- ✓ Basis for degradation limit established in Operability Evaluation 10-007 and Technical Evaluation 864431-15

- ✓ Most restrictive assembly limits Boraflex degradation to 45% from minimum certified Boraflex areal density
  - Minimum certified Boraflex areal density is 0.021 g/cm^2
  - Minimum allowable Boraflex areal density is 0.01155 g/cm^2

Exelon Generation

Interim Actions / TS

- ✓ Procedure NF-PB-310-2000 describes process to administratively declare cells inoperable below ^{10}B areal density of 0.01155 g/cm^2

- ✓ RACKLIFE model revised every 6 months to incorporate updated power history, fuel movement, and pool chemistry, per surveillance procedures RT-R-004-990-2/3
  - RACKLIFE results are compared against minimum allowable areal density of 0.01155 g/cm^2
  - RACKLIFE model bounds peak degradation values from most recent BADGER testing

- ✓ BADGER testing is performed every 4 years to validate the RACKLIFE model per surveillance procedure RT-R-004-995-2/3
  - BADGER results are compared against minimum allowable areal density of 0.01155 g/cm^2
  - Most recent BADGER tests were performed in January 2010 (Unit 2) and December 2009 (Unit 3). Minimum measured areal density from these campaigns was 0.0199 g/cm^2

Interim Actions / TS

- ✓ Unit 2 and Unit 3 Tech Specs will be the same
- ✓ Proposed Tech Specs *similar* to LaSalle with inserts
- ✓ TS 4.3.1.1 – include rack inserts as part of design
- ✓ TS 4.3.1.1.a. – maximum in-core k_{inf} of 1.27 at cold conditions
- ✓ TS 4.3.1.1.b. – in-rack $k_{eff} \leq 0.95$, including allowance for uncertainties described in the UFSAR (no change)
- ✓ TS 4.3.1.1.c. – nominal center-to-center distance between assemblies of 6.280 inches (no change)
- ✓ TS 4.3.1.1.d. (new) – rack inserts will have a minimum certified ^{10}B areal density of 0.0102 g/cm^2
- ✓ Not proposing a TS for installation
- ✓ Proposing a once per month telephone conversation as a group.

Comments

4.0 DESIGN FEATURES (continued)

4.3 Fuel Storage

4.3.1 Criticality

and/or rack inserts

4.3.1.1 The spent fuel storage racks are designed and shall be maintained with:

a. Fuel assemblies having a maximum k-infinity of ~~1.362~~ 1.27 in the normal reactor core configuration at cold conditions;

b. $k_{eff} \leq 0.95$ if fully flooded with unborated water, which includes an allowance for uncertainties as described in Section 10.3 of the UFSAR; and

c. A nominal 6.280 inch center to center distance between fuel assemblies placed in the storage racks.

d. The neutron absorbing rack inserts shall have a minimum certified ^{10}B areal density greater than or equal to 0.0102 g/cm^2.

4.3.1.2 The new fuel storage racks shall not be used for fuel storage. The new fuel shall be stored in the spent fuel storage racks.

4.3.2 Drainage

The spent fuel storage pool is designed and shall be maintained to prevent inadvertent draining of the pool below plant elevation 219 ft.

4.3.3 Capacity

The spent fuel storage pool is designed and shall be maintained with a storage capacity limited to no more than 3819 fuel assemblies.