Westinghouse
Fuel Performance Update
(Slide Presentation of December 5, 2001)

December 2001

Introduction

Presented by:
William Slagle

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December 5, 2001
Slide #2

Agenda

Presentation	Presenter	Time
Introduction	Slagle	8:00 – 8:10 am
Fuel Performance	Grimoldby Smith	8:15 – 9:45 am 10:00 – 11:30 am
NRC Presentation to PE Department, CR 301, 11:30 am – 12:00 pm		
Lunch in CR 201, 12:00 pm – 1:00 pm		
LTA/HIBU Programs	Mitchell	1:00 – 1:20 pm
Low Tin ZIRLO	Mitchell	1:25 – 1:45 pm
Code/Methodology Consolidation	Benjaminsson	1:50 – 2:20 pm
IRI Topical Closeout	Ferguson/Davis	2:25 – 2:55 pm
CEA/RCCA Investigation	Grimoldby Karoutas	3:10 – 3:40 pm 3: 45 – 4:15

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Westinghouse Fuel Performance Update

Presented by:
Rod Grimoldby

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Agenda

- Plant Performance Summary
- Leakage Mechanisms
- Fuel Examinations
- Top Nozzle Spring Screw Update
- North Anna Top Nozzle Separation Update
- Braidwood Thimble Tube Wear Root Cause Investigation

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Fuel Performance Summary Last Cycle

a, c

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Westinghouse PWR Fuel Reliability

(40 to 50 Plants per Year)

a, c

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Leakage Mechanisms Observed in Westinghouse Plants 1995- 2001
(from a population of over 6 million fuel rods)

a, c

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Effectiveness of Corrective Actions in Westinghouse NSSS

a, c

Year 2001 Fuel Examinations

Plans by category

	Plan	Completed
Root cause		
Corrosion		
Fuel rod		
Structural		
RFA		
Crud sampling		
High Burnup LTA		
RCCA		
QRTN		
GT Fiberscope		

a, c

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Summary

- Westinghouse mission is flawless (zero defect) fuel performance
- Fuel performance continues to improve with 98% of plants exceeding the INPO standard for coolant activity
- 78% of plants currently are true zero defects plants
- Root cause and corrective actions identified and implemented for observed leakage mechanisms
- Working together with our customers we continue to increase the emphasis on PIE

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Top Nozzle Spring Screw Fracture Update

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Top Nozzle Spring Screw

- Hot Cell Results (VC Summer Top Nozzles)
- Fall 2001 Outages

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Top Nozzle Spring Screw - Hot Cell Test Background

Test Articles

- Six V+ top nozzles from V.C. Summer spent fuel pool
  - Five from region 13 "N"
  - One from region 11 "L"
- Basis for selection
  - Assemblies re-nozzled - nozzles in storage cans
  - UT/Spring scale results - Thread indications

Test Objectives

- Determine condition of springs and screws
- Determine relative effectiveness of UT and spring scale inspection
- Determine presence of cracks in threaded region
- Determine force vs deflection characteristics and total relaxation for springs

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Top Nozzle Spring Screw - Hot Cell Test Results

Screws

- No cracks in threads
- As expected, wide variation of screw head fracture condition observed
- Spring Scale (field tests) and UT (improved at hot cell) detect functionality of joint with reasonable accuracy
- Spring Scale is preferred for field detection of non-functional joints

Springs

- Spring characteristics as expected
  - Force vs deflection
  - Total relaxation (cannot obtain irradiation relaxation) Spring rates are within design prediction

No change in Engineering Position:

- Position is based on field experience & risk of loose parts
- Spring Scale consistently detected loss of functionality

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Top Nozzle Spring Screw - Fall 2001 Outage Results

- Continued application of risk based approach to inspection / repair
  - Most 1X fuel used improved, shot peened screws not susceptible to cracking (design in place since September 1999)
  - No 2X fuel used the highest risk clamp design for Fall 2001 outages
- Eleven Westinghouse plant outages completed successfully.
  - 1, 14x14 plant
  - 2, 15x15 plants
  - 7, 17x17 plants
  - 1, 17x17 XL plant
- No major surprises, no loose parts, no critical path impacts
  - 17x17 XL plant had one raised clamp (non-shot peened Alloy 718 screws)

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North Anna Top Nozzle Separation

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Top Nozzle Separation

North Anna Occurrence

- Top nozzle separated from fuel assembly during routine handling
  - Welded top nozzle with 304 stainless steel top grid sleeves

- Root Cause - Intergranular Stress Corrosion Cracking of top grid sleeves

- Previous occurrences thought to be isolated

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Top Nozzle Separation

Current Status

- Way forward identified and being implemented
- All susceptible fuel identified in cores and SFPs
  - Three plants had susceptible fuel under irradiation
    - Two successfully unloaded with anchors installed
    - Third plant has not yet shut down
- Chemistry reviews completed for:
  - Braidwood, North Anna, Surry, Catawba, McGuire, Comanche Peak, Shearon Harris, V C Summer, Indian Point 2, Seabrook, Turkey Point, Diablo Canyon 2
  - Recommendations for sulfate monitoring issued
- Grid sleeve inspection criteria established
- Inspections completed at several plants

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Top Nozzle Separation

Completed Inspections

- Inspections - More than 50 FAs:
  - Three plants
    - All had evidence of corrosion

- Inspections - 15 FAs or less
  - Two plants with "clean" SFP chemistry
    - No evidence of corrosion
  - One plant without complete chemistry records
    - Evidence of corrosion

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Top Nozzle Separation

FA Handling Overview

- Short Term Solutions
  - Removing FAs from the core
  - Handling FAs in the Spent Fuel Pool

- Long Term Solutions
  - Option # 1: Tooling Solution
  - Option # 2: Anchor Solution
  - Option # 3: Tie Rod Solution

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Top Nozzle Separation

Removing FAs from the Core

- Alter Core Offload Sequence
  - Remove core component from FA
    - Requires special tooling
  - Transfer core component to empty FA in the FTS containment upender or RCCA change fixture
  - Transfer FA and core component to SFP

- Insert Fuel Anchors into FAs
  - Work will be performed in the core
  - Offload FA into SFP

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Top Nozzle Separation

Handling FAs in the Spent Fuel Pool

Option # 1:
- Fabricate existing design Nozzleless Handling Tool for affected FA designs.

Option # 2:
- Install Fuel Anchors.

Note: Anchors can be removed for re-installation of core components.

Top Nozzle Separation

Long Term Solutions

Option # 1: Tooling Solution

- Develop a more robust Nozzleless Handling tool. New tool will incorporate all of the present positive attributes while incorporating all of the recent lessons learned. Grippers will be lengthened.

Option # 2: Anchor Solution - Improved Anchor Design

- Key feature is a low profile design to allow the insertion of core components. Grippers will be lengthened.

Option # 3: Tie Rod Solution

- The top and bottom nozzles will be tied together with a rod passing through the instrumentation tube. Will allow handling with core components in place.

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Top Nozzle Separation

Current Status

- Anchors installed at four plants (one used screw type)
- Nozzleless Handling Tool used at two plants - third planned

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Top Nozzle Separation

Summary - Top Nozzle Separation

- Four previous occurrences
  - FAs with welded top nozzle and 304 stainless steel sleeves
- Spent fuel pool chemistry guidelines established
  - Recommendations for sulfate monitoring issued
- Grid sleeve inspection criteria established
- Handling contingencies established and further tooling developments under consideration

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Braidwood Thimble Tube Wear Root Cause Investigation

Background

- **First discovered on Braidwood Unit 1 Region A fuel assemblies susceptible to T/N separation**
- **These fuel assemblies were to receive anchors as a contingency to support handling loads in the event the top grid sleeves separates**
- **The anchors grip by expanding in the thimble tubes at the approximate axial location where RCCA rodlet tips are parked during operation**
  - **Many anchors were installed and functioned as expected**
  - **Some failed to grip in the thimble tubes**

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Subsequent Inspections

- Fiberscope inspections were conducted to investigate the failure to grip.
  - The inspection reveal wear in thimble tubes in which the anchor could not be installed
  - Some non-anchored thimble tubes also exhibited wear
  - The axial location of wear was the same location as the the park position (full out) for the RCCA rodlet tips
  - In some cases the wear was through-wall
- Braidwood Unit 1 operated its initial core with hafnium (Hf) RCCAs. All of the Hf RCCAs were replaced with Ag-In-Cd RCCAs at the EOC-3.
- Other non-Hf rodded assemblies showed some wear but no holes

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Past Experience

- Guide thimble (GT) thinning first observed during the hot cell exam of Point Beach Unit 1 assembly A25 in 1975
  - Metallographic exam of two GTs showed maximum of 45% wear at top bulge

- Eddy current exam on GT at Point Beach Unit 1 and 2 in 1977
  - Two types of EC tools: Average cross sectional wear and local azimuthal wear
  - Examined 49 GTs in 12 F/As (14x14 STD, Ag RCCA, single step)
  - 18 showed no wear
  - 21 had minor wear
  - 10 had wear ranging from 18 to 65% in the top 8 inches

Past Experience

- 17x17 D-loop
  - The maximum wear was 40 mils
- Salem Unit 1 Region 1 (17x17 STD, Ag RCCA, single step)
  - 6 F/As examined: No appreciable wear observed

Root Cause Investigation

- Root cause team formed
- Previous experience with guide thimble wear at CE NSSS plants was reviewed
- Inspection plan at Farley and Vogtle developed
  - Completed the fiberscope exam at Farley Unit 1 on 13 assemblies
    - Generally showed no wear
  - Completed the fiberscope exam at Voglte Unit 2 on 6 assemblies (5 of 6 were Hf rodded assemblies)
    - Up to 9 thimbles per assembly showed wear, but no holes

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Root Cause Investigation

- Factors considered
  - Braidwood Unit 1 Cycle 1 operating history
  - RCCA type
  - Fuel Type
  - First core operation
  - Thimble dimensions
  - Thimble tube material

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Impact on Handling and Operation

- There are no operational issues to be addressed as no Hf RCCAs are known to be in service or are planned for future use.
- The type of wear is judged to have a relatively small impact on the ability of the structure to support axial loads encountered during handling.
- Thimble tube wear imposes no restriction on fuel handling.

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Conclusions

- Wear is evident on many fuel assemblies examined. However, the wear appears to be more significant in fuel that has operated with Hf RCCAs.
  - There are no Hf RCCAs in service or planned for future use
- No instances of through-wall wear have been found in assemblies that operated with Ag-In-Cd RCCAs
- Thimble tube wear imposes no restriction on fuel handling and operation
- The observed wear can potentially affect anchor installation and nozzleless handling tool operation. These issues will be resolved through design changes to the tools.
- Westinghouse will continue to monitor this situation as more information becomes available but recommends no changes at this time.

CE Fuel Performance Update

Presented by:
Zeses Karoutas

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Outline

- Overview
- Issues
  - Grid-to-rod fretting
  - Oxide spallation
  - Palo Verde fuel failures
- Summary

Overview

- Good overall fuel performance continues
  - 90% of reactors meet INPO FRI coolant activity goal

- Grid-to-rod fretting is the leading cause of fuel failure
  - Design improvements are being implemented to increase grid-to-rod fretting margin

- Other fuel performance issues include:
  - Oxide spallation
  - Palo Verde fuel failures

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W/CE Nuclear Fuel Reliability as of November 1, 2001

a, b, c

W/CE Nuclear Fuel Reliability as of November 1, 2001

a, b, c

Grid-to-Rod Fretting

- Grid-to-rod fretting failures confirmed in 3 reactors
  - [ ]a, c
  - [ ]a, c
  - [ ]a, c
- Grid-to-rod fretting failures suspected in other plants
  - [ ]a, c
  - [ ]a, c
- [ ]a, c elevation most susceptible

Improvements to Address Grid-to-Rod Fretting

- Apply fuel management guidelines
  - [ ]a, c
- Design changes to limit gap formation in new fuel
  - [ ]a, c
  - [ ]a, c

Advanced Fuel Implementations

Calvert Cliffs 14x fuel design

- Qualification testing and TURBO LFA experience indicate substantial increase in margin to grid-to-rod fretting

- Full batch implementation planned for Calvert Cliffs Unit 1 in Spring 2002 and Unit 2 in Spring 2003

CE 16x fuel designs

- [ ][a, c]

- Limited deployment planned for [ ][a, c] in Spring 2002
  - 32 of 92 assemblies to have [ ][a, c]

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Oxide Spallation

- Oxide spallation has been observed on OPTIN cladding in high duty applications
  - [ ][a, c]
  - [ ][a, c]
  - [ ][a, c]

- Fuel duty guidelines in use to keep within experience base

- ZIRLO™ being deployed at Palo Verde and Calvert Cliffs units
  - Fuel duty within database - no spallation observed with ZIRLO™
  - Surveillance inspections planned

Palo Verde 2 Cycle 9 Fuel Failures

- Efficient "ring" core design similar to prior cores without failure
- Mild Axial Offset Anomaly
- All assemblies UT scanned at EOC 9
  - [ ]a, c
- [ ]a, c
- Comprehensive examinations performed to characterize failed rods

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Palo Verde 2 Cycle 9 Fuel Failures

- Significant tenacious crud deposits

a, c

[ ]

- Through wall penetrations in crud regions
  - Suggests primary defect locations
- No evidence of debris or grid induced wear
- No correlation with fabrication processes
- Crud-enhanced corrosion hypothesized as failure mechanism (RCA continuing)

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Palo Verde 1 and 3 Cycle 9 Fuel Failures

- Palo Verde 1 EOC 9 exam results
  - [ ]a, c
    - [ ]a, c

- Palo Verde 3 EOC-9 exam results
  - [ ]a, c
    - [ ]a, c

- [ ]a, c

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CE Fuel Performance - Summary

- CE fuel performance improved steadily through the 1990s as debris fretting, the leading cause of fuel failures, was addressed
- Programs are in progress or proposed to address other fuel performance issues
  - grid improvements to address grid-to-rod fretting
  - implementation of ZIRLO™ cladding to improve clad performance
  - proposed program for crud mitigation

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LTA/HIBU Programs

Presented by:
David Mitchell

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Summary of LTA Programs

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Summary of LTA Programs (cont.)

a, b, c

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Summary of LTA Programs (cont.)

a, b, c

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Summary of LTA Programs (cont.)

a, b, c

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Other Test Programs Performance Data

a, b, c

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Low Tin ZIRLO™

Presented by:
David Mitchell

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Low Tin ZIRLO™ Introduction
Planned Schedule

a, c

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Low tin ZIRLO™ Introduction

a, c

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Alloy Comparison

a, b, c

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Low tin ZIRLO^{TM} Licensing

- A complete set of ZIRLO base material properties will be developed as agreed to at the October 29, 2001 meeting with the NRC

- LTAs will be licensed to all current criteria. Model adjustments will be used as needed to account for changes in material performance and reported by letter in exemption request

- Regions will be licensed to all current criteria, or to new criteria which will be justified. New models will be developed and used or current models will be justified and compared to test data. Information will be submitted for review and approval in a revision to WCAP-12610-P-A to expand ZIRLO definition to cover low tin condition for region introduction

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Code/Methodology Consolidation

High level plans and projected schedule

Presented by:
Ulf Benjaminson

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Introduction

- Neutronics Code Integration
  - Starting Point
  - Strategy
  - Overview of Plan
  - Licensing Impact

- Fuel Rod Performance Code Integration
  - Set of Codes
  - Target
  - Preliminary Plan

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Neutronics Code Integration

Starting Point

- Three sets of lattice and nodal codes
  - CE: DIT/ROCS
  - W: PHOENIX-P/ANC
  - Atom: PHOENIX-4/POLCA-7 (BWR and PWR)
- Three different reload system and safety analysis processes
- Basic idea: focus resources on a single code package

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Neutronics Code Integration

Strategy

- Strategy - first step
  - Integrate the physics code package
    - Cross section library
    - Lattice code
    - Nodal code based on ANC and POLCA-7

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Neutronics Code Integration

Overview of Plan

a, c

Neutronics code integration

Licensing Impact

- Impact on CE plants

a, c

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Neutronics code integration

Licensing Impact

- Unified code system

a, c

[ ]

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Fuel Rod Performance Code Integration

Set of Codes

- PAD - PWR (Columbia/Pittsburgh)
- FATES - PWR (Windsor)
- ENIGMA – PWR, MOX (Springfields, Sellafield)
- STAV – BWR & PWR (Västerås)
- TREQ – PWR (ENUSA)

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Fuel Rod Performance Code Integration

Target

a, c

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Fuel Rod Performance Code Integration

Very Preliminary Plan

- Proposed plan

a, c

[ ]

- Likely to be speeded up

Fuel Rod Performance Code Integration

Very Preliminary Plan

- Some of the activities must be performed even without any convergence
- High burnup programs – gives the availability of data needed
- Time schedule is to be coordinated with the NGF – Next Generation Fuel project

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WOG IRI Closeout

Presented by
Scott Ferguson, WCNOC
Chairman WOG Fuel Working Group

NRC/Westinghouse Meeting
WOG IRI Closeout

Incomplete Rod Insertion (IRI) Issue

- In November 1997, the NRC provided the industry an opportunity to take the lead on IRI
- In January 1998, the WOG issued an IRI Position Paper to provide a long term process to resolve and close the IRI issue
  - WOG IRI Position Paper addressed three key points:
    - Established burnup screening thresholds based on current fuel data
    - New fuel design features and tools are available to reduce the potential of IRI
    - Additional high burnup fuel assembly drag data is needed to provide statistical confirmation to prevent future IRI events and to allow increasing screening thresholds to the currently licensed burnup limits, if possible.

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NRC/Westinghouse Meeting
WOG IRI Closeout

Incomplete Rod Insertion (IRI) Issue & Closeout

- In 1998, the WOG initiated a program to specifically address the third point (e.g., the need for more high burnup data)
- WOG IRI High Burnup Threshold program has been completed:
  - Drag data collected and analyzed from an additional 104 fuel assemblies
  - Topical Report, WCAP-15712 (Proprietary Class 2) "IRI High Burnup Threshold Assessment Program" completed:
    - WCAP-15712 will be provided to the NRC (December) for 'information only'

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NRC/Westinghouse Meeting
WOG IRI Closeout

Incomplete Rod Insertion (IRI) Issue & Closeout

- WOG IRI High Burnup Threshold Program Conclusions:
  - Additional drag data statistically 'fits' with previous drag data

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NRC/Westinghouse Meeting
WOG IRI Closeout

a, b, c

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NRC/Westinghouse Meeting
WOG IRI Closeout

a, b, c

NRC/Westinghouse Meeting
WOG IRI Closeout

Incomplete Rod Insertion (IRI) Issue & Closeout

- WOG IRI High Burnup Threshold Program Conclusions:
  - Additional drag data statistically 'fits' with previous drag data
  - Fuel assemblies with 1.1" Bottom Nozzle Rod Gap (BNRG) tend to have higher total drag
    - Larger BNRG keeps thimble tubes in compression (e.g., fuel rods not in contact with bottom nozzle) which could lead to thimble bow and high fuel assembly drag
  - Fuel assemblies with ZIRLO™ guide thimbles and a BNRG of 0.465" or 0.085" (majority of current product in use) have significantly less total drag:
    - Smaller BNRG causes thimble tubes to be less compressed due to expected fuel rod growth (e.g., fuel rods in contact with the bottom nozzle)

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NRC/Westinghouse Meeting
WOG IRI Closeout

a, b, c

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NRC/Westinghouse Meeting
WOG IRI Closeout

Incomplete Rod Insertion (IRI) Issue & Closeout

- WOG IRI High Burnup Threshold Program Conclusions:
  - Additional drag data statistically 'fits' with previous drag data
  - Fuel assemblies with 1.1" Bottom Nozzle Rod Gap (BNRG) tend to have higher total drag
    - Larger BNRG keeps thimble tubes in compression (e.g., fuel rods not in contact with bottom nozzle) which could lead to thimble bow and high fuel assembly drag
  - Fuel assemblies with ZIRLO™ guide thimbles and a BNRG of 0.465" or 0.085" (majority of current product in use) have significantly less total drag:
    - Smaller BNRG causes thimble tubes to be less compressed due to expected fuel rod growth (e.g., fuel rods in contact with the bottom nozzle)
  - Statistical analysis confirms that WOG guidelines are conservative and should not be changed

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NRC/Westinghouse Meeting
WOG IRI Closeout

Incomplete Rod Insertion (IRI) Issue & Closeout

- Bases for Closeout of IRI Issue:
  - Implementation of fuel design features, such as IFM grids, thicker thimble tubes or smaller BNRG, reduce the potential for IRI
  - Additional drag data statistically 'fit' with previous drag data
  - Statistical analysis confirms that WOG guidelines are conservative

- WOG Position:
  - The commitment between the WOG and the NRC for confirmation of IRI guidelines at higher burnup is complete
  - The IRI issue has been addressed and additional analysis or testing is not needed
  - The IRI issue, with respect to fuel assembly/thimble tube bowing, is closed with the submission of WCAP-15712 to the NRC for information purposes

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Status of Palo Verde CEA Failures

Presented by:
Zeses Karoutas

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Palo Verde 1 CEA Failures

- Palo Verde Unit 1 CEA failures discovered EOC9
- Inspections of Palo Verde Unit 1 CEA failures discovered EOC9

[ ] a, b, c

- CEALL predicted IASCC in Cycle 9
- CEALL expected to be conservative

Palo Verde 1 CEA Failures

- APS replaced all full strength CEAs
- 10 CFR 21 closed with negative finding
  - CEALL not suspect
  - NSAL-01-5 issued
- Palo Verde Units 2 and 3 JCO prepared by APS
- Root Cause Analysis Team formed and work in progress

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Palo Verde 1 CEA Failures

a, b, c

Palo Verde 2,3 CEA Failures

- Palo Verde Unit 3 CEA failures observed after shutdown of Cycle 9 in October 2001

[ ] a, b, c

- APS immediately shut down Palo Verde Unit 2 (in Cycle 10)

[ ] a, b, c

  - Inspections and evaluations are planned

- APS has replaced all full strength CEAs in Units 2 and 3

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Palo Verde 2,3 CEA Failures

- All 3 PVNGS back to near 100% power
- CEALL predicts IASCC margin at end of Unit 3 Cycle 9 and Unit 2 Cycle 10
- Preliminary conclusion is that earlier than expected Palo Verde CEA failures are specific to interaction between B_4C/feltmetal
- Information indicates B_4C/Ag-In-Cd design is not subject to the same mechanism causing failure in Palo Verde CEAs
- B_4C/feltmetal is only used in System 80 plants (Palo Verde and Korean plants)

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CEA Designs

a, b, c

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Activities

- Westinghouse will continue investigations and keep CE plant customers informed
- Evaluation of CEALL non-conservatism in progress
- Evaluation of impact of Palo Verde CEA failures on other CE plants in progress
- Inspections of Palo Verde Unit 2 CEA fingers planned for January 2002
- Inspections of Palo Verde Unit 2 Cycle 8 CEA fingers (4) planned for January 2002

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Farley Unit 1 Cycle 18 Incomplete Rod Insertion In Dashpot (IRID)

Presented by:

Rod Grimoldby

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Farley Unit 1
IRID

- Event Description
- Background
- Root Cause Investigation
- Inspection and Testing Results
- Root Cause Conclusion
- Ongoing activities to address broader issues

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Farley Unit 1
IRID

Event Description during BOC 18 Start-up

During heat-up at 450 °F an RCCA (R25), located in a fresh FA, did not fully insert during rod operability testing. Insertion stopped in the dashpot at step 24 (~15 inches from the bottom). Heat-up continued and at 547 °F drop testing was performed. Three RCCAs (R25, R31 & R47) did not fully insert. Insertion stopped in the dashpot in each instance (R25 at step 24, R31 at step 24 and R47 at step 18) however, R47 subsequently fully inserted after approximately 90 seconds. Four other RCCAs showed relatively slow times through the dashpot.

The plant was returned to cold conditions to investigate the cause. During cool down at 250 °F, RCCA R25 was stepped into a fully inserted position and RCCA R31 fell into a fully inserted position after unlatching.

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Farley Unit 1
IRID

Background

- RCCAs were original equipment (OE) utilizing Ag-In-Cd absorber rods.
- Absorber has uniform diameter over its length
- Absorber is clad in 304 SS tubing
- No hard-face coating on cladding
- RCCAs had been in operation for approximately 18.8 EFPY
- As part of the RCCA replacement strategy, 31 OE RCCAs had been replaced and 17 OE RCCAs were scheduled for reloading into Cycle 18
- During insert shuffle at EOC17, 3 OE RCCAs being discharged could not be fully inserted into several previously discharged FAs, stopping between 6 and 24 inches from the bottom
- These 3 OE RCCAs were returned to their twice burned Cycle 17 host FAs and they fully inserted

Farley Unit 1
IRID

Background

- Additional inspections, tests and analyses were performed on the 17 OE RCCAs to be used in Cycle 18 (visual examinations, drag testing and drag work analyses)
- 7 of these OE RCCAs were rejected due to the visual presence of axial cracks at the rodlet tips and unacceptable drag performance
- These 7 RCCAs were replaced with previously discharged OE RCCAs which met the visual and drag criteria
- All 17 OE RCCAs for Cycle 18 were located in fresh FAs

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Farley Unit 1
IRID

Root Cause Investigation

- **All equipment/items which could potential cause the IRID were identified and evaluated**
- **The FAs and OE RCCAs were determined to be the most likely cause of the IRID**
- **Following the cool down, all 17 OE RCCAs were replaced with new RCCAs**
- **During the shuffle in the SFP, a series of inspections and tests were conducted to investigate the cause**

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Farley Unit 1
IRID

Root Cause Investigation

- **The following inspections and tests were performed**
  - **Drag tests using combinations of FAs and RCCAs (both new and OE)**
  - **Visual inspections of the OE RCCA tips**
  - **Fiberscope inspections of the FA guide thimble tubes**
  - **Ring gauge measurements of the OE RCCA rodlet diameters**

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Farley Unit 1
IRID

Inspection and Test Results

- RCCA R25 had high drag in all FAs tested and would not fully insert in the dummy FA
- OE RCCAs which performed normally had low drag in all FAs tested
- Concluded that FAs were in good condition and that the OE RCCAs were causing the IRID
- The visual inspection of the OE RCCAs after the cool down showed previously unseen axial cracks caused by the rodlet tip swelling
- Fiberscope inspections of the 2 FAs which experienced IRID did not show anything anomalous

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Farley Unit 1
IRID

Inspection and Test Results

- Ring gauge inspections of the RCCA rodlet tips on a number of different performing RCCAs showed tip swelling consistent with their behavior in the SFP and the core.
- Analytical evaluations of FA and RCCA dimensional changes during heat-up and reviews of FA PIE data to assess irradiation induced dimensional changes showed their potential to impact the RCCA performance
- The reviews of the manufacturing data for the Region 2K fresh fuel and the previous Region 2J fuel showed nothing unusual

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Farley Unit 1
IRID

Inspection and Test Results

- **The as manufactured drag data showed no statistical differences between the Region 2K and 2J fuel or between various populations within the Region 2K fuel**

- **Guide thimble tube dashpot internal diameters for the Region 2K fuel were within tolerance and in the lower half of the tolerance band**

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Farley Unit 1
IRID

Root Cause Conclusion

- **The swelling of the RCCA rodlet tips on the highly irradiated RCCAs was the cause of the Farley Unit 1 IRID events**

Corrective Action

- **All 17 OE RCCAs were replaced with new RCCAs**

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Farley Unit 1
IRID

Ongoing Activities

- **Communications being issued to all Customers**
- **WOG Issues Review Group (IRG) has been tracking this issue, currently determined to not be a Part 21 reportable issue**
- **Data is being collected on other plants to determine potential applicability**
- **Recommendations are being developed for plants that are using RCCAs beyond their 15 year design life**

BNFL