Westinghouse Presentation
on
Westinghouse Fuel Performance Update Meeting
(Slide Presentation of December 9-10, 2003)
(Non-Proprietary)

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Fuel Performance Update

NRC/Westinghouse Meeting
Columbia, SC
December 9, 2003

Agenda

- Fuel Performance Summary
- Investigation of 17x17 OFA Leaking Fuel
- [ ]a,c Investigation

Overall PWR Fuel Reliability (50 to 60 Plants per Year, W and CE Fuel)

a, b, c

CE-NSSS PWR Fuel Reliability
(11 Plants per Year)

a, b, c

[ ]

CE-NSSS Fuel Performance
- Design Solutions Being Implemented

- First full region implementation at Calvert Cliffs 1 in Spring 2002 of TURBO grid design for 14x14 product

- Historical grid-to-rod fretting mechanism most probable cause of current leakers in 16x16 plants
  - The introduction of the Inconel top grid is being pursued at several plants
  - PIE work scheduled to investigate leakers
  - Follow-up inspections scheduled for design enhancements

- Development of the 16x16 NGF product is in progress
  - LTAs scheduled for 2005

W-NSSS PWR Fuel Reliability (40 to 50 Plants per Year)

a, b, c

[ ]

Leakage Mechanisms Observed in W-NSSS Plants Shutdown in 2001 to Date

a, b, c

Initiatives to Address Performance Issues

a, c

Initiatives to Address Performance Issues

- Integrated Quality Assessment in progress
  - Identify the critical margins of every assembly component and identify the design requirements, manufacturing steps and reactor operations that affect them
  - Identify and implement (prioritized) changes in product and process to assure critical margins are not compromised

- Process Change Management
  - Assessment of Change Process at all sites and with suppliers
  - Actions from assessment to improve robustness of process changes
  - Human performance impacts of people changes on critical to quality processes

17x17 RFA/RFA-2 Implementation

a, b, c

Current Status of RFA

a, c

W-NSSS Performance Observations

- Debris mitigation features have generally provided very effective protection
  - no debris related leakers in 2002
  - debris induced leakers in 2003 being investigated

[ ] a, c

Investigation of 17x17 OFA Leaking Fuel

Status of 17x17 OFA Leakers

a, c

17x17 OFA Root Cause Investigation

a, c

17OFA Leakers Observed from 1998-May 2003

a, b, c

[ ]

Analysis Model

a, b, c

[ ]

Conclusions - Manufacturing Change Analysis

- Reviews performed of :

[ ]a, c

Conclusions - Operating Plant Change Analysis

a, c

Conclusions - Design Change Analysis

a, c

Fuel Leakage Mechanism Analysis

Purpose:

- To make a determination of the most likely causes of the leaking fuel

Process:

- An assessment was made of :
  - the available PIE data
  - the coolant activity signature by comparison with the coolant activity database
- A systematic evaluation of the data was made for each plant against potential leakage mechanisms
- Trends and patterns were identified

Reconciliation: Change Analysis to Fuel Leakage Mechanism Analysis

[ ] a, c

Recommendations

<u>Areas for further study</u>

- Continue the efforts of the Flawless Fuel Team
- Complete the IQA process
- Confirm that there is no mixed core effect of [Jedinstvo nozzles] [a, c]
- Continue to track coolant activity and refine assessments of potential leakage mechanisms as appropriate

Recommendations

Actions

[ ] a, c

Fall Outage 17x17 OFA

- Fall Outage 17x17 OFA Leaking Rod Exams

[ ] a, c

- Some leakage mechanisms eliminated based on the site examinations
- The manufacturing records review is being performed
- In order to determine the root cause, further site examinations and/or hot cell examinations are being considered

Assessment of Leakage Mechanisms

Based on the fall outage 17x17 OFA root cause examinations, the potential leakage mechanisms were evaluated

[ ] a, c

[ ][a, c] Investigation

Root Cause Investigation

a, c

Observations on Leaking Rod C02

a, b, c

Observations on Leaking Rod C02

a, b, c

Observations on Leaking Rod C02

a, b, c

Similarity with Previously Observed Leakers

a, b, c

Assessment of Leakage Mechanisms

a, b, c

Overall Fuel Performance Summary

- Westinghouse mission is flawless (zero defect) fuel performance
- Fuel performance improvement has reached plateau and raised concerns
- Significant activities underway; Integrated Quality Assessment, Process Change Management, Human Performance to achieve the next level of improvement
- Leaker root cause and corrective actions being identified and implemented for observed leakage mechanisms
- Working with Customers, fuel issues are being effectively managed:
  - RFA and RFA2 continues to be successfully implemented
  - 17x17OFA leakers being investigated
  - 15x15 Upgrade well advanced
  - Turbo and Inconel top grid design enhancements being implemented on CE product lines
- With the support of our Customers, the emphasis on PIE increases

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Westinghouse Advanced Alloy Development Update

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Advanced Alloy Development

- Continuing Development of alloys for clad and structural materials
  - Started with stainless steel and Inconel
  - Zircaloy 4 became standard material
  - Improved Zirc 4 with lower tin and optimized heat treatments
  - ZIRLO™
  - Optimized ZIRLO™ [ ]a,c
  - Next step - [ ]a,c

What is the need for a New Alloy?

a, c

What is the Need for a New Alloy?

a, c

What is the Need for a New Alloy?

a, c

Why Qualify a New Alloy Now?

- It takes many years to bring a new alloy to full maturity

[ ]a, c

Goals of [ ] a, c Development Program

- Factors considered in new alloy development
  - Corrosion [ ] a, c
  - Abnormal chemistry (Li)resistance
  - Growth & Creep
  - Long term storage/hydrogen pickup
  - Fabricability/weldability/weld performance
  - Licensing/mechanical & physical properties
  - LOCA / transient properties
  - Neutronics/cost/reactor system impacts

[ ] a, c Development Program

[ ] a, c

Example of Relative Corrosion Rates of Advanced Alloys 800 °F (427 °C) Steam Test

a, b, c

What is [ ]a, c

[ ]a, b, c

Example of Corrosion Data at 932 °F

a, b, c

[ ]

Example of Corrosion Tests, 800 °F Steam - [ ]a, c

a, b, c

[ ]

Corrosion Testing

a, b, c

Particle Size Measurements - [ ] a, c

a, b, c

[ ]

Example of Microstructure Characterization STEM Image - [ ] a, c

a, b, c

[ ]

Room Temperature Tensile Properties

a, b, c

[ ]

Elevated Temperature (735 °F) Tensile Properties

a, b, c

The Alloys Meet Mechanical Design Requirements

a, b, c

Why LTA(s) are Critical

a, c

[ ][a, c] LTA Strategies

[ ][a, c]

Key criteria for [ ]a, c LTAs

[ ]a, c

Example of Potential [ ]$^{a, c}$ LTA Cycles and Other [ ]$^{a, c}$ Applications

[ ]a, c

Example of Potential [ ]a, c LTA Cycles with Fall 04 or Spring 05 Start

[ ]a, c

Next Steps for [ ]a, c LTAs

- Close and frequent communication between key stake holders
  - NRC
  - Utility - customers
  - Westinghouse

- Guidance and input from NRC on any anticipated regulatory actions

- Definition of expectations for new alloys
  - Industry trends
  - Regulatory trends
  - Customer demands

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High BU LTA Programs and Other Testing

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Purpose of extending burnup limits

- Westinghouse is positioned to extend burnup limits up to 75 GWd/mtU as soon as the regulatory environment permits

- This will provide for improved fuel cycle economics and reduced volume of discharged fuel
  - The current Westinghouse fuel product will support High Burnup fuel cycles with excellent fuel performance
  - Although current Westinghouse fuel designs are capable of reaching 75 GWD/MTU, design enhancements are being developed to add margin for plant uprates

Plans to go to Higher Burnup

- Actions:
  - Follow NRC and industry programs on LOCA/RIA/high burnup
  - Get high burnup data on Westinghouse products
  - Benchmark and modify as needed fuel performance and LOCA codes to high burnup data
  - Extend license of ZIRLO™ to include Optimized ZIRLO™ cladding for increased fuel duty capability (this will support high burnup capability even under up-rate conditions)
  - Produce, submit and get approval for high burnup licensing topical

Plan for Extending Fuel BU Limits

- Sources of Data:
  - Ex-core testing
  - General evaluation of fuel operation
  - Specific poolside examination of fuel for a given performance parameter
  - Specific hotcell examination of fuel for a given performance parameter
  - Test reactor operation of fuel or fuel component

Westinghouse High Burnup ZIRLO LTA Summary

a, b, c

Other Test Programs

a, b, c

ZIRLO™ Hotcell Exams

[ ] a, b, c

Summary of LTA Programs

a, b, c

Summary of LTA Programs (cont.)

a, b, c

Summary of LTA Programs (cont.)

a, b, c

Summary of LTA Programs (cont.)

a, b, c

Summary of LTA Programs (cont.)

a, b, c

Summary of LTA Programs (cont.)

a, b, c

Summary

- Obtaining data from various plants with different operating conditions and heats of material

- Data obtained is sufficient to obtain high burnup licensing

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Fuel Development Program Update

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Margin Generation – New Fuel Design and Features

- Objective
  - Describe the commonality of approach of Westinghouse product development across the product lines and fuel arrays

- Overall Outline
  - Significant Focus
  - Common Approaches and Enabling Technologies
  - Global Sharing
  - Margin Enhancements
  - Advanced Alloy Development
  - Summary

Significant Focus

Product Development for [ ] a, c

- Main objective has been to develop fuel designs with [ ] a, c

[ ] a, c

- These will complement our already introduced product upgrades
  - 14x14 Turbo CE
  - 14x14 422 VANTAGE + Westinghouse

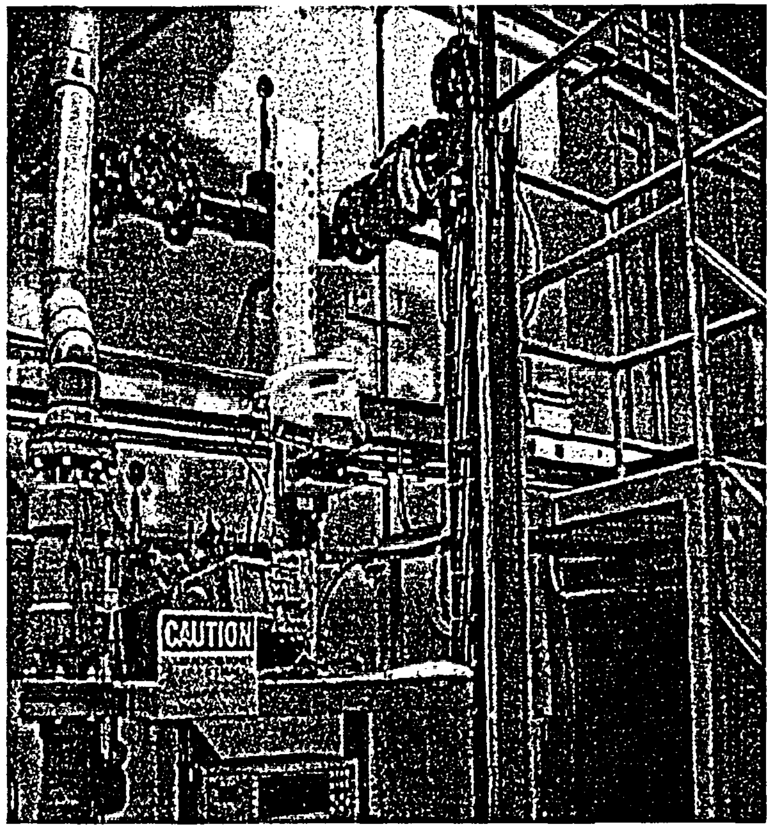
Common Approach and Enabling Technologies

Process
- New Product Development Process

Analysis and Software
- Integrated solids modeling & analysis
- Computational Fluid Dynamics (CFD)
- Latest reload methods, e.g. PAD, BOB

Testing

[ ] a, c



Global Sharing

Key Experts, Best Processes and Technologies

- Key experts utilized from all over the world
  - Columbia, Vasteras, Windsor, Monroeville, technical consultants, customers

- Best technologies from our worldwide experience
  - [ ] a, c
  - [ ] a, c
  - [ ] a, c
  - [ ] a, c

- Sharing of design approach, test results, and lessons learned across all product lines

Margin Enhancements

a, c

Margin Enhancements

a, c

Advanced Alloy Development

- ZIRLO™
  - Excellent performance, low growth, low corrosion
  - Licensed to 62K; [ ] a, c

[ ] a, c

Considers both incore and post-irradiation long term storage

NGF Features

a, c

NGF Features

a, b, c

NGF Features

Optimized to Match Assembly Requirements

- Common Approach
  - [ ]a,c
  - [ ]a,c

NGF Features

a, b, c

NGF Features

a, c

NGF Features

a, c

17x17 LTA Programs for NGF Fuel

[ ] a, c

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CE 16x16 Next Generation Fuel
LTA Licensing Plan

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Agenda

- CE 16x16 NGF Design Expectations
- CE 16x16 NGF Design
- NGF LTAs
- General Program Schedule
- LTA Licensing Plan

CE 16x16 NGF Design Expectations

- Three (3) issues that we expect to resolve through implementation of a 16x16 NGF design:
  - Increase margin to Grid-To-Rod fretting failures
  - Increase thermal margin to accommodate further power uprates in the future
  - Increase margin to core crudding resulting from hot spots in the core

CE 16x16 NGF Assembly

a, c

"I" Spring Rod Support

a, c

Side Supported Vane

a, c

ABB-TV DNB Correlation for 14x14 Turbo Fuel

a, b, c

DNB Performance for CE 16x16 NGF Side Supported Vanes Relative to ABB-TV correlation for CE 14x14 Turbo

a, b, c

Intermediate Flow Mixers (IFMs)

- Add 2 IFMs to lower steaming rate, reduce crud and hotspots
- Add IFMs in selected grid spans where crud and corrosion is highest

Axial Temperature Profile with & without IFM

a, b, c

Where to Insert Two IFMs ?

a, b, c

NGF LTAs to be Implemented at Waterford 3 [ ] a, c

[ ] a, c

General Program Schedule

a, c

LTA Licensing Plan

a, c

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BWR Update

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BWR Agenda

- BWR Fuel Update
  - Fuel Design Overview
  - Fuel Experience
  - Near-Term Licensing Activities

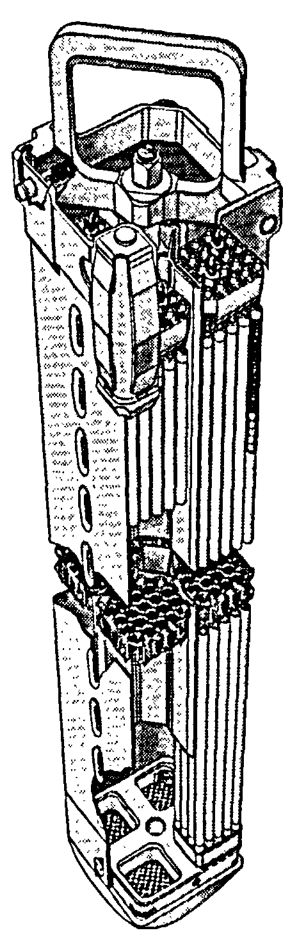
10x10 SVEA Design Evolution

- SVEA-96

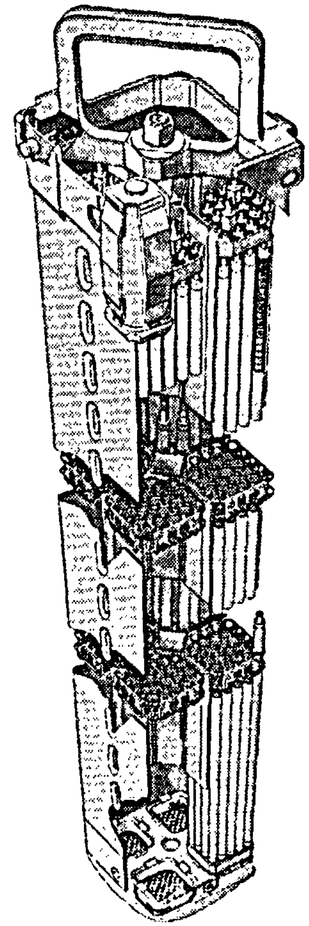
[ ] a, c

- SVEA-96+

[ ] a, c



SVEA-96/96+



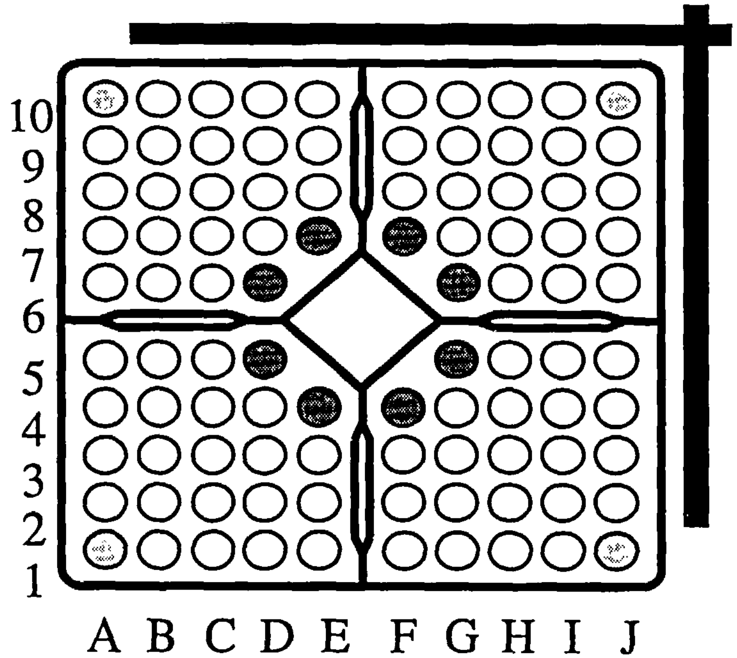
SVEA-96 Optima2

SVEA-96 Optima2 Fuel Design

- SVEA-96 Optima2
  - 10x10 Rod Design

[ ] a, c

  - Low Pressure Drop Design
  - Improvements
    - Uranium Utilization
    - Shutdown Margin
    - Critical Power Performance
    - Thermal-Hydraulic Stability
    - Pressure Drop
  - Tin Alloy Liner

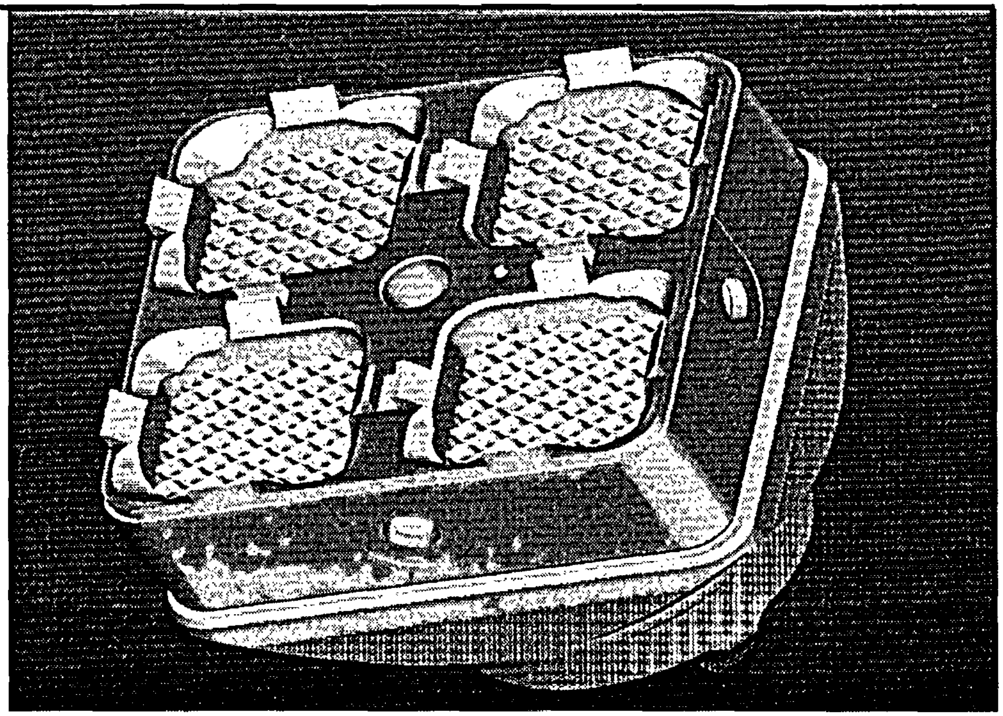


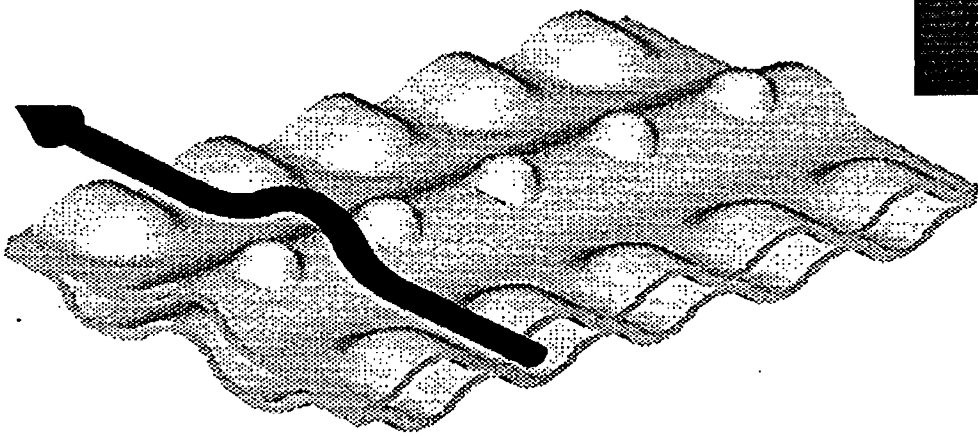
SVEA-96 Optima2 Fuel Design

a, c

TripleWave Debris Filter

- Milestones
  - All testing finished
  - LFA inserted 2001
  - Inspection 2002
  - Reloads in 2003





SVEA Reloads

a, c

SVEA Reloads

a, c

Fuel Burnup Distribution

a, c

BWR Cladding: Average Oxide Thickness SVEA 10x10

a, c

BWR Rod Growth - SVEA 10x10

[ ]a, c

SVEA Channel Growth

[ ] a, c

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Channel Bow for Standard and β-quenched SVEA Channels

a, c

SVEA 10x10 Fuel Leakers 1993 - 2003

a, c

TripleWave Debris Filter - Efficiency

a, c

CPR Improvement

a, c

10x10 Fuel Performance Summary

a, c

Focus on BWR Fuel Reliability

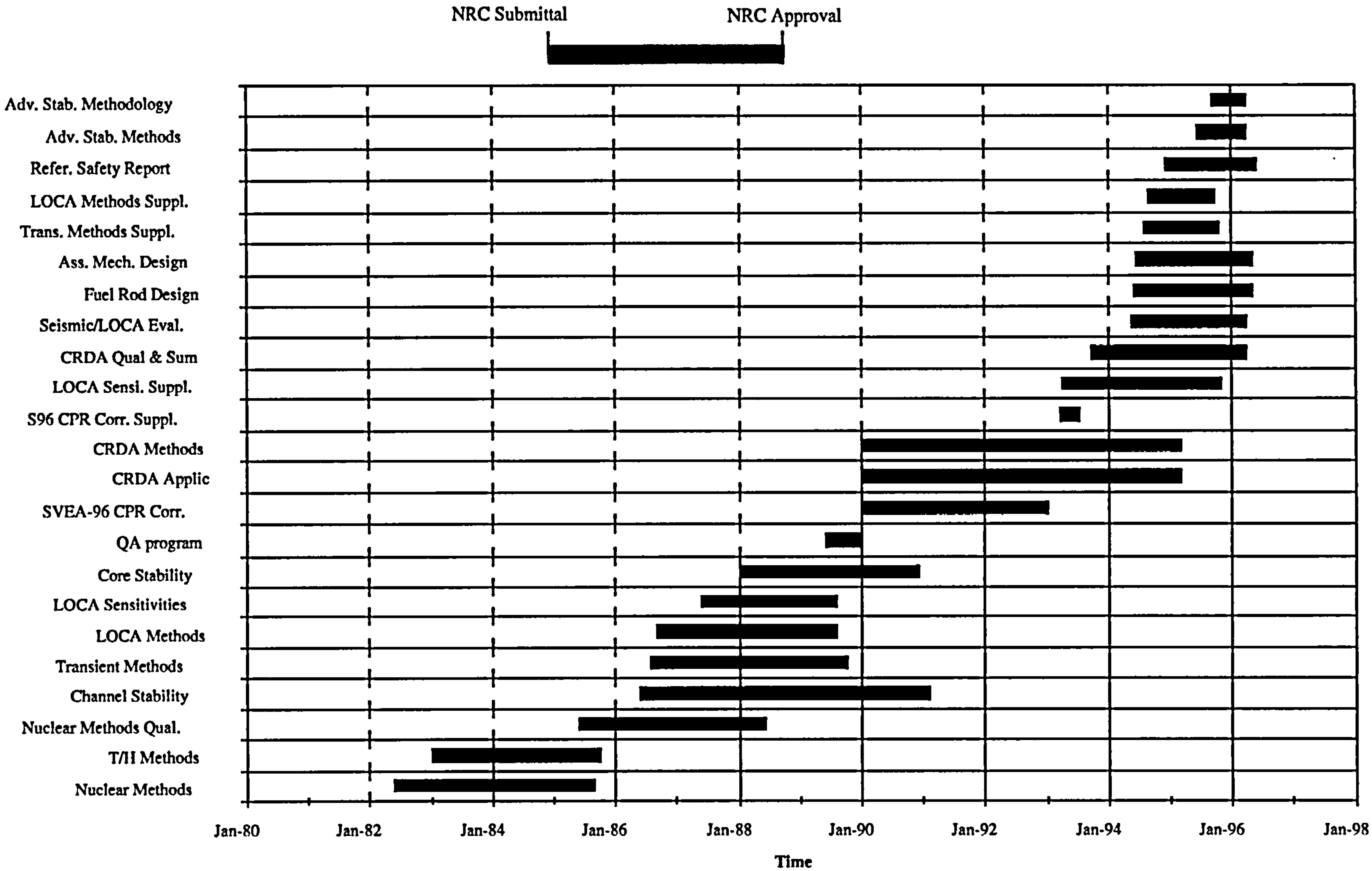
a, c

BWR Licensing Activities

Topics:

- Historical Perspective
- Activities to Support Introduction of SVEA-96 Optima2 Fuel into the U.S.
- Near Term Activities to Improve Licensing Analysis Methodology

Westinghouse BWR Topical Reports - History



Westinghouse BWR Topical Reports - Near Term History

- CENPD-389-P-A, SVEA-96+ CPR Correlation, 9/99
- CENPD-390-P-A, Advanced Nuclear Methods, 12,2000
- CENPD-392-P-A, Improved SVEA-96 CPR Correlation, 9/2000
- WCAP-15682-P-A, Improvements to Westinghouse BWR ECCS Evaluation Models, 3/03

Support Introduction SVEA-96 Optima2 Fuel into the U.S.

Report No	Title	Submittal Date	Approval Date
WCAP-16078	ECCS Evaluation Model Code Sensitivity for SVEA-96 Optima2	[	] a, c
WCAP-16081	10x10 SVEA-96 Optima2 Critical Power Correlation		]

Improvements to Licensing Analysis Methodology

Report No	Title	Submittal Date	Approval Date
WCAP-16047	Improved CPR Application Methodology for SVEA-96/96+ Fuel		
WCAP-15836	Fuel Rod Design Methods for Boiling Water Reactors – Supplement 1		

a, c

Improvements to Licensing Analysis Methodology

Report No	Title	Submittal Date	Approval Date
WCAP-15942	BWR Fuel Assembly Mechanical Design Methodology – Supplement 1		
WCAP-00000	Supplement 1 to BWR Reload Methodology (CENPD-300-P-A)		

a, c

Improvements to Licensing Analysis Methodology

Report No	Title	Submittal Date	Approval Date
WCAP-00000	Three-Dimensional Core Simulator-Based System Analysis Code, POLCA-T: Application to Stability Evaluations and Control Rod Drop Accident	[	] a, c
WCAP-00000	Supplement 1 toThree-Dimensional Core Simulator-Based System Analysis Code, POLCA-T: Application to Anticipated Operational Occurences		

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US BWR Project Review

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Topics

- Fabrication Split and Schedule
- Shipping/Transport
- Facilities Changes
- Licensing Activities

Major Component Sources for US BWR Fabrication

a, c

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Current Manufacturing Schedule

a, c

Shipping/Transport

a, c

Facilities Changes

a, c

Areas Affected by Layout Changes

a, c

Planned BWR Product Flow

a, c

Licensing Activities

a, c

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Results of Irradiated PWR Grid Impact Assessment

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Results of Irradiated PWR Grid Impact Assessment

- Agenda
  - Overview and Purpose
  - Current Grid Testing Methodology
  - Applicability to Westinghouse Grid Designs
  - Summary

Overview

- WCAP 13488-A, Addendum 1-A, Rev. 1:
  - Justifies BOL condition testing as bounding for irradiated grids
  - Applicable to all Westinghouse grids
- Westinghouse grids behave similarly:
  - Evaluation of grid deformation during impact loading
  - Grids designed at Columbia, Windsor, and Västerås
- Key aspects to grid crush:
  - Stiffness
  - Crush strength
  - Both form "Seismic Factor"
- Factors contributing to crush behavior:
  - Geometry
  - Hydrogen
  - Oxiding, or strap thinning

Irradiated PWR Grid Impact Assessment

- Today's discussion - Grid impact analysis and test methods for Westinghouse grids:
  - Traditional Westinghouse (Columbia) designs
  - "CE" (Windsor) designs
  - "Sweden" (Västerås) designs

- Path for today's discussion:
  - Effects of irradiation on grid dynamic capability
    - Grid impact strength requirements
    - Interaction of grid stiffness and grid impact strength
  - Applicability of test results to irradiated grids
  - Integration of methods between designs

Traditional Westinghouse (Columbia) Grids

- NRC Approval of WCAP-12488-A Addendum 1, Revision1 confirmed current testing method
- Basis:
  - [ ]a, c
  - [ ]a, c
- Grid acceptance criteria defined by column buckling
  - [ ]a, c
  - [ ]a, c
- Seismic Factor used to assess grid dynamic capability
  - [ ]a, c

Parametric Tests Supporting WCAP-12488-A Add. 1-A, Rev.1

- Conclusion - Use of production grid test data:
  - Continues to be valid approach
  - Used in seismic/LOCA analysis

- Basis:

[ ] a, c

Examples of Crushed Grids, Basis of WCAP-12488-A, Add. 1-A, Rev.1

a, b, c

Grid Impact Strength Sensitivity to Hydrogen

- Hydrogen concentration has no effect on hot crush strength

[ ] a, b, c

Grid Impact Strength Sensitivity to Strap Thinning

- Oxide provides benefit to offset base material thinning from oxidation

[ ] a, b, c

"CE" (Windsor) Grids

- Conclusion:
  - Columbia testing applicable to column buckling aspects of wavy strip design
  - Initial evaluations of plastic deformation aspects indicate:

[ ]a, b, c

- Basis:

a, b, c
[ ]

"Sweden" (Västerås) Grids

- Conclusion:
  - Material behavior change, based on testing of simulated irradiated grids at Columbia, are applicable to Västerås grids

- Basis:

a, b, c

[ ]

- Note: Currently, grids designed at Västerås not used in U.S. plants.

Summary and Conclusions

- WCAP 13488-A, Addendum 1-A, Rev. 1:
  - Justifies BOL condition testing as bounding for irradiated grids
  - Applicable to all Westinghouse grids

- Westinghouse grids behave similarly:
  - Evaluation of grid deformation during impact loading
  - Grids designed by Columbia, Windsor and Västerås

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Application of Fuel Criteria Evaluation Process (FCEP) to the 15x15 Upgrade Fuel Design - WCAP-12488-A

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DNB Correlation Applicability using FCEP

Westinghouse FCEP Section 6.0 specifies the guidelines relevant to determining Correlation Applicability for either grid design modifications or a new grid design:

"An existing DNB correlation will be valid and will meet the above design basis* without reservation provided the new fuel assembly geometry is [ ] a, c." (of the licensed database for the DNB correlation of interest).

"If the new geometry is [ ] a, c of the test data, Westinghouse will evaluate the geometry [ ] a, c."

* DNB design basis is that the probability of the limiting fuel rod not being in DNB be greater than 95 percent at a 95 percent confidence level.

DNB Correlation Applicability using FCEP

(Cont.):

"If additional test data are used, [ ][a,c]. The new data will then be [ ][a,c].

"If the new data [ ][a,c] it may be treated explicitly as a [ ][a,c] may be developed. If this step is necessary, it would involve NRC review."

Thus, there are three approaches that can be used: [ ][a,c]. If none of these approaches yield acceptable results, then a submittal to the NRC is required.

DNB Correlation Applicability using FCEP

As specified in the TER of FCEP:

> "An existing NRC approved DNB correlation is considered to be valid by Westinghouse for application to a new design when the new fuel assembly geometry is similar to or bracketed by the fuel assembly geometric parameters and correlation parameters of the critical heat flux (CHF) test data used to develop the approved DNB correlation."

DNB Correlation Applicability using FCEP

The relevant geometric parameters are:

a, b, c

[ ]

DNB Correlation Applicability using FCEP

The relevant correlation parameters are:

a, b, c

[ ]

Application of FCEP to 15x15 Upgrade Fuel

15x15 Design Evolution

- In the 1970's, Westinghouse performed a large number of CHF tests on rod bundles prototypical of the 15x15 (0.422 in OD rod) and 17x17 (0.374 in OD rod) Inconel "R-grid" mixing vane grid types. The WRB-1 CHF correlation was developed based on the results from these tests

- Westinghouse continued to develop new fuel products, including the Optimized Fuel Assembly (OFA) designs, which were "scaled" or extrapolated from the R-grid designs

- The 14x14 and 17x17 OFA designs were DNB tested and the results showed that WRB-1 accurately predicted CHF for OFA fuel designs (vertical springs)

Application of FCEP to 15x15 Upgrade Fuel

15x15 Design Evolution

- Based on the scaling method and the similarity of the 15x15 OFA design with the R-grid geometry, the WRB-1 correlation was extended to cover 15x15 OFA fuel without DNB tests. This extension was accepted by the NRC

- Similarly, when the 15x15 V5H product was first developed, it was again compared with the R-grid geometry and it was determined that the WRB-1 correlation could also be extended to cover the design again without DNB tests

- Thus, WRB-1 covered both vertical and diagonal spring designs

Application of FCEP to 15x15 Upgrade Fuel

15x15 Design Evolution

- In the process of getting a license amendment submittal approved for a licensee, the NRC staff insisted that Westinghouse perform DNB water tests on the 15x15 VANTAGE + fuel product (geometrically equivalent to the 15x15 V5H design with IFMs - diagonal spring)

- As a result, Westinghouse proceeded to perform a DNB test on the 15x15 VANTAGE + product with IFMs to confirm that the WRB-1 correlation would be applicable to this design (refer to the table below)

a, c

[ ]

Application of FCEP to 15x15 Upgrade Fuel

15x15 Design Evolution

- Based on the DNB test performed for the 15x15 V5H/VANTAGE + fuel product with IFMs, Westinghouse submitted an FCEP Notification to the NRC to document the fact that the WRB-1 correlation was applicable to the design (refer to NSD-NRC-99-5828)

- Note: the 15x15 V5H/ VANTAGE + design still has the same original V5H LPD mid-grid configuration as the 17x17 V5H design incorporated (diagonal spring with minor differences between array designs)

- [

]a, c

Application of FCEP to 15x15 Upgrade Fuel

15x15 Design Evolution

a, c

Application of FCEP to 15x15 Upgrade Fuel

a, b, c

[ ]

Application of FCEP to 15x15 Upgrade Fuel

a, b, c

[redacted]

Application of FCEP to 15x15 Upgrade Fuel

Summary

- Based on the assessment in the table on the preceding slide, it can be seen that both the 15x15 RFA-2 and the 15x15 Upgrade design meet the geometric conditions for WRB-1

- [ ]a, c

- [ ]a, c

- WRB-1 is applicable to both the 15x15 RFA-2 and the 15x15 Upgrade designs

Application of FCEP to 15x15 Upgrade Fuel

Summary (cont.)

- [

  ] a, c

- [
  ] a, c

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Global High Burnup Fuel Rod Design Project

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Drivers

- BNFL/Westinghouse currently supports fuel rod designs and licensing using no less than:

[ ] a, c

- None of the current codes/methodologies completely satisfy the need for:

[ ] a, c

History

- Westinghouse (Monroeville / Columbia)
  - PAD - Proven technology for PWRs throughout the world
- Västerås (ABB-ATOM)
  - STAV - Used for BWRs and PWRs throughout Europe and US
- Windsor (ABB-CE)
  - FATES - The standard for CE Core analysis
- Springfields (BNFL)
  - ENIGMA* - State of the art mechanistic modeling of MOX / UO2
  - Used for fuel licensing in UK, Switzerland, and Finland

[ ]a, c

Millions of Fuel Rods Analyzed!

Customer Need

- What are our customer needs?
  - High burnup in European and US plants
  - PWR and BWR MOX in Europe
  - Best-estimate methodologies to improve flexibility
  - Simple and integrated methodology and user friendly and robust code
  - The operation of the fuel should be "flawless"

Our Direction

- One Base Methodology / One Code
  - Integrated with standard design methodologies (core analysis, T/H, LOCA)
  - More complete database

- Multiple Fuel Products
  - All existing fuel and integral burnable absorber products
  - New cladding alloys under development
  - New fuel types and MOX in Europe
  - BWR and PWR fuel

- New Capabilities
  - High burnup capability (70-75 GWD/MTU)

Fully Supporting Flawless Fuel!

Objective

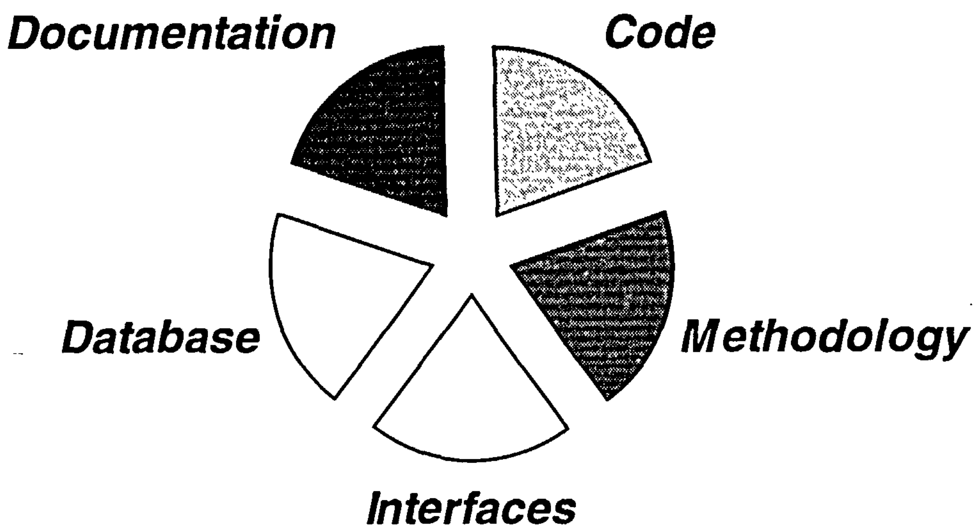
- What is our objective?
  - State-of-the-art fuel performance code, capable of modeling high burnup UO_2 fuel, MOX, IFBA, Erbia, Gadolinia, etc. for both BWR and PWR reactors
    - This code will work for all required cladding material types
  - State-of-the-art fuel rod design methodology
    - This methodology will be unified, efficient, and developed in tune with the FP code
    - This methodology will address all required FRD criteria
  - Set of interfaces for this code so that it may be used with any set of required design dependent systems
    - Physics, T&H, LOCA for W, CE, BNFL, ATOM

Objective (cont.)

- Consolidated, centralized database for calibration, validation, functional testing, and design assessment
- A licensed "system" (code, models, & methods) with appropriate licensing authorities to 70 or 75 GWD/MTU
- Complete implementation and training for the system for all sites and customers

Fuel Performance Analysis "System"

Program Breakdown



Technical Success

- Global High Burnup Fuel Rod Design team consists of leading experts in UK, US, and Europe with the necessary experience and knowledge for success!
- Experience and knowledge includes historical development and licensing approval of five (5) individual fuel performance codes along with application methodologies
- MOX modeling is based on extensive BNFL experience and research
- Westinghouse participation in EPRI Program
- Data: Integration of Westinghouse, BNFL, and CE Fuel Performance Databases

[ ] a, b, c

High Burnup Strategy Europe

[ ] a, c

High Burnup Strategy US:

[ ] a, c

Current Schedule

[ ] a, c

- Project is following a rigorous development process
- Numerous Technical and Management reviews throughout each phase.
- Input for Technical Requirements from both Internal and External Customers

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RAVE Program

NRC/Westinghouse Meeting
Columbia, SC
December 9, 2003

RAVE - 3D Transient Analysis Methodology

- Agenda
  - Overview and Purpose
  - Applicability to Westinghouse PWRs
  - Schedule
  - Summary

Overview and Purpose

- The objective of the RAVE program is to document the methodology to be used with current licensed codes, through an external communications interface, which will result in "realistic" estimates by reducing inconsistent assumptions
  - RETRAN-02 (Westinghouse version)
  - SPNOVA (ANCK)
  - VIPRE-01 (Westinghouse version)

- The first step of RAVE was the 3D Rod Ejection methodology, which was approved by the NRC in 2003 (WCAP-15806-P-A/WCAP-15807-NP-A)

- Representative limiting transients such as Loss of Flow, Locked Rotor and HFP/HZP Steamline Break will be explicitly modelled to demonstrate the methodology

- Submittal of the RAVE topical to the NRC is targeted for [ ] a,c

Overview and Purpose

- Changes compared to current non-LOCA methodology
  - Integrated data transfer among codes
  - Consistent assumptions of some transient parameters
  - 3D kinetics

- Not changed compared to current methodology
  - Acceptance criteria and design basis
  - Bounding analysis approach
  - DNB subchannel methodology

- 3D Rod Ejection links the SPNOVA and VIPRE codes, RAVE will link RETRAN to the already linked SPNOVA and VIPRE codes

- It is anticipated that with more realistic results, based on consistent assumptions, RAVE will potentially demonstrate enhanced [ ]a, c

Applicability to Westinghouse PWRs

- The 3D methodology will be applicable to all Westinghouse PWRs
- The linked codes have the same modelling capabilities as the individual "backbone" codes
- If the backbone code is appropriate for modelling a given characteristic or feature; then use of that same code in the linked format is also appropriate

RAVE Program Schedule

- Topical report submittal to the NRC is anticipated in [ ] a, c
- Westinghouse would like approval by [ ] a, c to support anticipated fuel upgrade and uprating submittals in [ ] a, c
- Westinghouse would welcome the use of an at-site audit, similar to that held for 3D Rod Ejection, to facilitate review of the RAVE methodology

Summary

- Thus RAVE is a methodology program designed to use consistent assumptions and linked NRC-approved computer codes in a 3D format to [ ][a,c]

- The methodology is an extension of that already approved for 3D Rod Ejection

- Topical submittal is anticipated in [ ][a,c]

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Westinghouse VIPRE Application

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VIPRE Overview

- VIPRE-01 - EPRI subchannel code used widely in the industry
  - 1986 SER on PWR licensing application
  - 1993 SER on LWR licensing application

- WCAP-14565-P-A, 1999
  - Westinghouse version of VIPRE-01 (VIPRE)
  - Model qualification for PWR applications
  - Qualification of Westinghouse DNB correlations
  - VIPRE equivalence to THINC and FACTRAN

Current Licensing Applications

- Applications in compliance with SER conditions

- Replace THINC for DNBR calculations
  - Steady state
  - Non-LOCA transients

- Replace FACTRAN for Non-LOCA hot rod calculations
  - Fuel surface heat flux input to DNBR calculation
  - Maximum clad temperature (Locked rotor event)
  - Fuel enthalpy (Rod Ejection)

Recent Submittal

- Addendum 1 to WCAP-14565-P-A submitted in [ ]a,c
- Qualification of [ ]a,c DNB correlation with VIPRE
  - Approved correlations in CENPD-387-P-A
  - [ ]a,c fuels
  - [ ]a,c fuel
- Confirmation of NRC-approved limits and conditions
  - 95/95 DNBR limits
  - VIPRE equivalence to [ ]a,c

Review Status

- Response to RAI on Addendum 1 to WCAP-14565 submitted on [ ] a, c
- Additional discussion with staff held on [ ] a, c
- Approval needed for [ ] a, c

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CE Physics Methods and Code Integration with APA

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December 9, 2003

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 processes and safety analysis methodologies

- Basic idea: focus resources on a single code package

Overall Plan for Integrated Neutronics System

a, c

Neutronics code integration - Strategy

- Strategy for transition of CE-PWR to Westinghouse neutronics codes

[ ] a, c

Neutronics code integration - Project Plan

- Changes to APA software for transition

[ ] a, c

Neutronics code integration - New Methodology

- PARAGON

[ ] a, c

Neutronics code integration - Licensing Issues

- Current Benchmarking on CE type plants indicates good agreement with ROCS and plant measurements

a, c

Neutronics code integration - Licensing Issues

- PHOENIX/ANC SER
  - Approved for use in PWR analysis
  - No limitation in current SER to Westinghouse plants
  - Has been demonstrated via extensive benchmarking to yield good results on many different PWR lattice types (e.g. CE 14x14, 15x15, CE 16x16, W 16x16, 17x17, VVER)

Neutronics code integration - Licensing Issues

- FPL currently uses PHOENIX and ANC to verify Physics input to CE Safety Analysis for St. Lucie 2

- NRC approved use of PHOENIX and ANC to generate and verify COLR for St. Lucie 2
  - SER explicitly approved use of PHOENIX and ANC with CE Safety Analysis Methods on St. Lucie 2

Neutronics code integration - Licensing Issues

- APA consistent with current SERs for CE Safety Analysis Methods
  - Prior to implementation of PHOENIX and ANC for St. Lucie 2 design analysis, ABB-CE performed extensive review of CE safety analysis methodology topical reports and SERs to identify specific requirements for Physics methodology when used with CE Safety Analysis methods
  - These requirements were incorporated into the design procedures for use of PHOENIX and ANC to confirm CE Safety analysis Physics inputs on St. Lucie 2

Neutronics code integration - Licensing Issues

- For most CE plants a submittal will be required to revise the Tech Specs to add the APA and PARAGON topicals to the COLR reference list

- However Westinghouse believes that this revision does not constitute a significant technical change since:

[ ] a, c

Neutronics code integration - Summary

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Westinghouse DNB Testing

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Columbia, SC
December 9, 2003

Westinghouse DNB Testing

Outline:

- Closing of Columbia Test Facility (HTRF)
- Requirements of DNB Testing
- Westinghouse Qualification Process
- Alternate Test Facilities
- Westinghouse Direction
- Potential Licensing Applications
- Summary

Westinghouse DNB Testing

Closing of Columbia HTRF:

- Columbia HTRF has ceased testing operations and will close December 31, 2003 after completing test and data reports

- All Westinghouse DNB test data supporting NRC - approved DNB correlations were obtained from HTRF

- HTRF closure has major impacts on future safety analysis in the U.S.

Westinghouse DNB Testing

Requirements of DNB Testing:

- Westinghouse uses NRC-approved FCEP (WCAP-12488-A) for evaluating fuel design changes

- Fuel changes not covered by FCEP may require DNB tests
  - [ ] a, c
  - [ ] a, c
  - [ ] a, c

Westinghouse DNB Testing

Westinghouse Qualification Process:

- Over the years, Westinghouse has developed a process for qualifying test facilities and data for safety analyses
  - [ ]a, c
  - [ ]a, c
  - [ ]a, c
  - [ ]a, c
- The process was applied to Columbia HTRF and SKODA test loop for VVER-1000 applications
- The process will include initial benchmarking of an existing data set
- This same process will be applied to alternate test facilities
- NRC participation during qualification DNB testing of an alternate facility is welcomed

Westinghouse DNB Testing

Alternate Test Facilities:

- Westinghouse has evaluated alternate DNB test facilities
- [

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- [ ]a, c

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Westinghouse DNB Testing

Westinghouse Direction:

- Westinghouse will pursue the following options

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Westinghouse DNB Testing

Westinghouse Direction (continued):

[ ]a, c

Westinghouse DNB Testing

Potential Licensing Applications:

- DNB test data collected from each alternate test facility will meet Westinghouse QMS requirements

- DNB test data on future fuel designs will be used for qualification of 95/95 DNBR limit
  - [ ] a, c
  - [ ] a, c
  - [ ] a, c

Westinghouse DNB Testing

Summary:

- Because of the closure of Columbia HTRF, Westinghouse is moving forward with alternate DNB test facilities to meet regulatory requirements for future fuel design changes
- Westinghouse intends to apply its proven qualification process to each alternate test facility
- NRC participation during qualification DNB testing of each alternate facility is welcomed
- DNB data from alternate test facilities will be used for justifying the 95/95 DNBR limit of a DNB correlation

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Westinghouse Nuclear Fuel Licensing Update

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Overview

- Update on Fuel Related Activities Discussed in June:
  - WCAP-15604 "Limited Scope High Burnup LTA" - Approved Version Issued
  - WCAP-15682 "BWR ECCS Supplement 2" - Approved Version Issued
  - WCAP-15806 "3-D Rod Ejection" - Approved Version Issued
  - WCAP-10125 Addendum 1 "Transient Stress" - Revision being submitted

- Current NRC Submittal List
  - Topicals (see attached table)
  - LTA
    - Byron
    - Calvert Cliffs
    - Duke
    - Millstone 3
  - Exemptions – Millstone 3 currently in to the NRC for Approval

- Other Regulatory Topics

PWR Topical Update

a, c

PWR Topical Update (continued)

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BWR Topical Update

a, c

BWR Topical Update (continued)

a, c

High Burn LTA Program Summary

a, c

Miscellaneous Regulatory Activity

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[ ]

Other Regulatory Topics

- Need a final resolution on ZIRLO™ topical:
  - Addendum 1 to WCAP-12610 and CENPD-404
  - Optimized ZIRLO™ is ZIRLO™!
- Need to simplify the regulatory process for LTAs
- Alternate Source Pelleting/Powder Closeout
- Open Discussion

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