



Westinghouse Electric Company  
CE Nuclear Power LLC

2000 Day Hill Road  
Windsor, CT 06095  
USA

October 4, 2000  
LD-2000-0053

Mr. John S. Cushing, Project Manager  
U. S. Nuclear Regulatory Commission  
One White Flint North  
11555 Rockville Pike  
Rockville, MD 20852

**Subject:** Non-Proprietary ZIRLO Slides for October 17, 2000 Meeting

**Reference:** Letter, P. Richardson to J. Cushing, "Slides for Use in October 17, 2000 Meeting with NRC Regarding Implementation of ZIRLO Fuel Cladding," LD-2000-0052, dated October 3, 2000

Dear Mr. Cushing:

The reference CE Nuclear Power LLC (CENP) letter forwarded proprietary slides for discussions with the staff concerning the application of ZIRLO cladding to CENP fuel designs. This letter forwards non-proprietary copies of the discussion slides for NRC use and/or public disclosure as required by regulations.

Please do not hesitate to contact Virgil Paggen of my staff at 860-285-4700 or me if you have any questions.

Very truly yours,  
CE Nuclear Power LLC

Philip W. Richardson  
Licensing Project Manager

Attachment: As stated

cc: Z. Karoutas (Windsor)  
T Rodak (Windsor)  
C. Brinkman (Rockville)

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# **Plan for Implementing ZIRLO™ Cladding in CENP Fuel Designs**

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**Presentation to NRC Staff  
October 17, 2000**



# Agenda

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- **Purpose**
- **Background**
- **Affected Areas**
- **Technical Approach**
- **Licensing Approach**
- **Schedule**
- **Interested Utilities**
- **Summary**
- **Related CENP Topical Report References**



## Purpose

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- **Present plan for incorporation of ZIRLO™ cladding material in CE Nuclear Power (CENP) fuel designs and analysis methodologies**
- **Establish mutually agreed upon plan and schedule**

## Background

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- **OPTIN™ is nearing performance limits in high duty applications**
  - **Small amounts of oxide spalling have been observed on CENP OPTIN clad fuel**
- **Our clients are interested in using ZIRLO™ clad fuel to support more economic core designs and power uprate**



## Background

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- **ZIRLO™ is in widespread use**
  - **Licensed by NRC**
  - **Used in 38 Westinghouse plants**
  - **Used in Fort Calhoun Station (OPPD)**
- **ZIRLO cladding more robust than OPTIN™**
  - **Oxidation significantly reduced**
  - **No spallation has been observed**
- **Maximum Fuel Duty for CENP plants well within ZIRLO database**



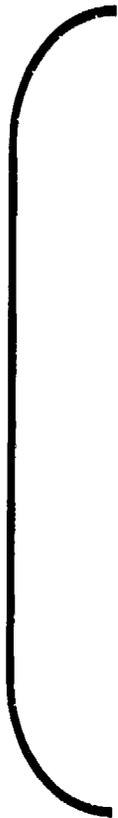
# ZIRLO™ Operating Experience

(As of 12/31/99)

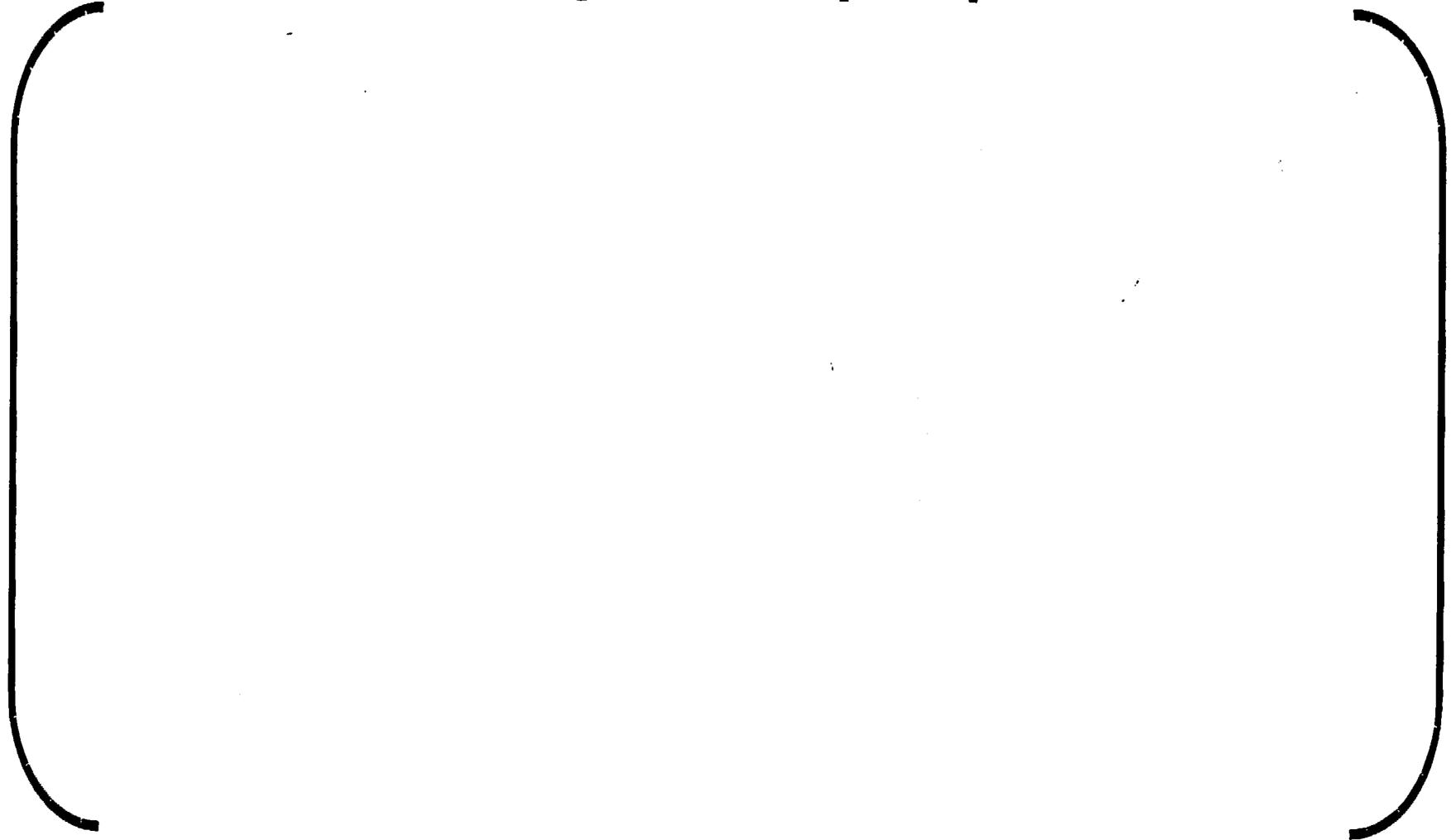


# ZIRLO™ Cladding in Westinghouse-Fueled PWRs

Number of PWRs



# ZIRLO™ High Burnup Experience



# ZIRLO™ Measured Oxide Thickness vs. Westinghouse Modified Fuel Duty Index



## Affected Areas

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- **Fuel Design**
- **Fuel Performance**
- **Transient Analysis**
  - **LOCA**
  - **non-LOCA**

## Technical Approach - Fuel Design

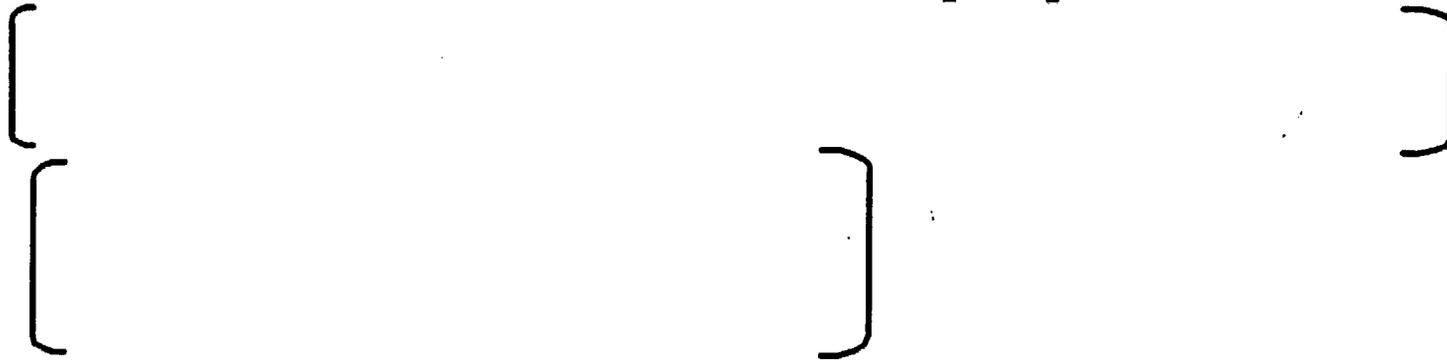
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- **Implement ZIRLO™ clad fuel in CENP [ ]**  
[ ]
- **No changes to other fuel assembly component materials (e.g., guide tubes, grids, etc.)**
- **ZIRLO material properties to be taken from previously approved Westinghouse topical reports**

# Technical Approach - Fuel Design

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- **Implement ZIRLO™ material properties in CENP**



- **ZIRLO rods will be implemented in CENP Zr-4 Standard and Turbo cages**



# Technical Approach - Fuel Design

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- **Summary**
  - **Use of ZIRLO improves waterside corrosion performance and reduces susceptibility to spallation**
  - **ZIRLO materials properties & models will be implemented with no change in methodology**
  - **No fuel performance issues are anticipated by introducing ZIRLO cladding in CENP Zr-4 Standard and Turbo grid cages, based on Westinghouse experience**



# Technical Approach Fuel Rod Performance

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- **Fuel Rod Performance Codes**
  - FATES3B
  - INTEG (DNB Propagation)
- **Principal ZIRLO™ Material Properties Affecting Fuel Performance**  
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- **Incorporate ZIRLO Material Properties in FATES3B Analysis Methodology**

# Technical Approach Fuel Rod Performance

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- **Incorporate ZIRLO™ Correlations in FATES3B**



# Technical Approach Fuel Rod Performance

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- **ZIRLO™ Axial Rod Growth**



# Technical Approach Fuel Rod Performance

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- **Incorporate ZIRLO™ Material Properties in FATES3B**



# Technical Approach Fuel Rod Performance

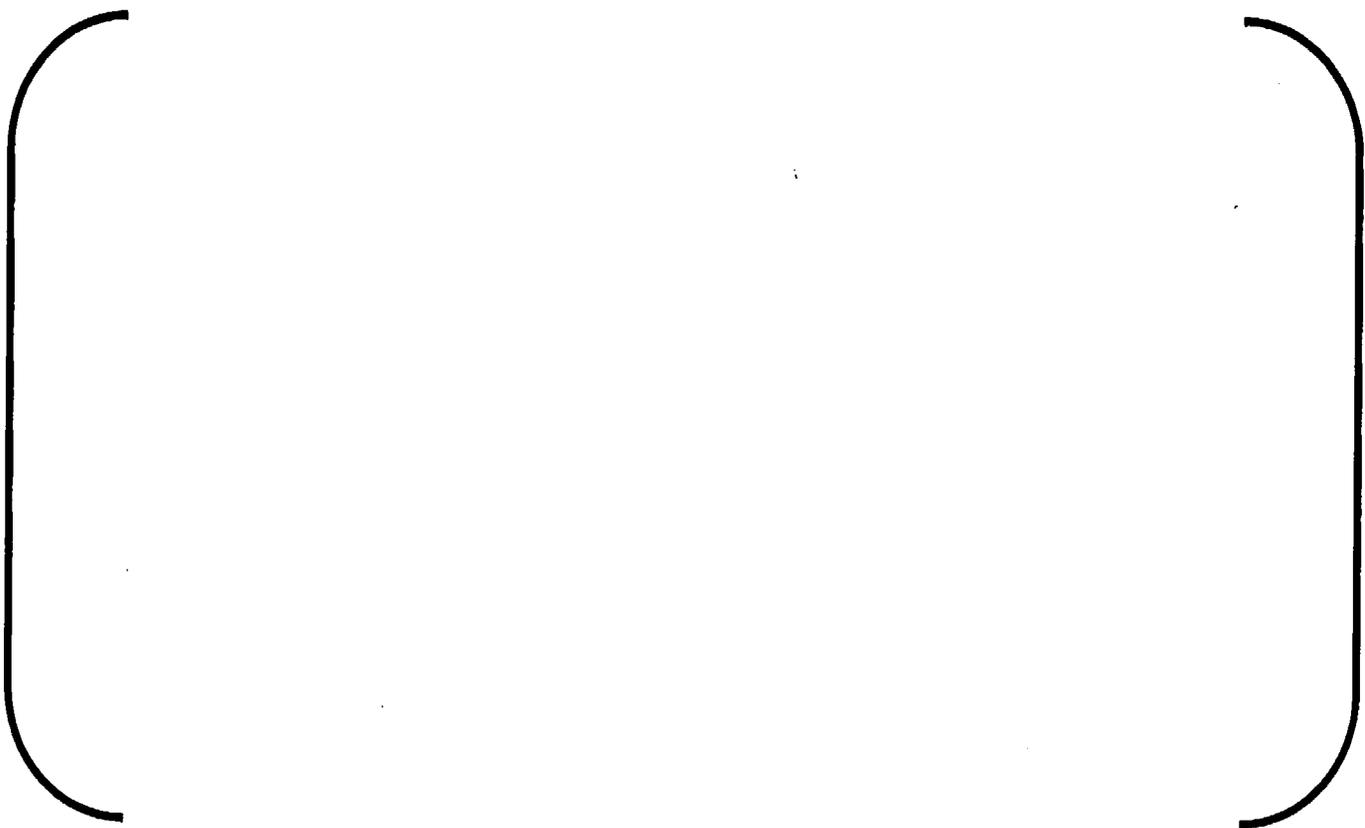
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- **Incorporate ZIRLO Material Properties in FATES3B**
- **Preliminary results of sample calculation for typical plant**
  - **Same rod design - only change in clad**
  - **Axial power distributions for steady-state and transient operation**
  - **Application of Fr as a function of burnup at the NCLO limit**
  - **Impact on maximum internal hot gas pressure**
  - **Impact on power-to-centerline melt**

# Technical Approach Fuel Rod Performance

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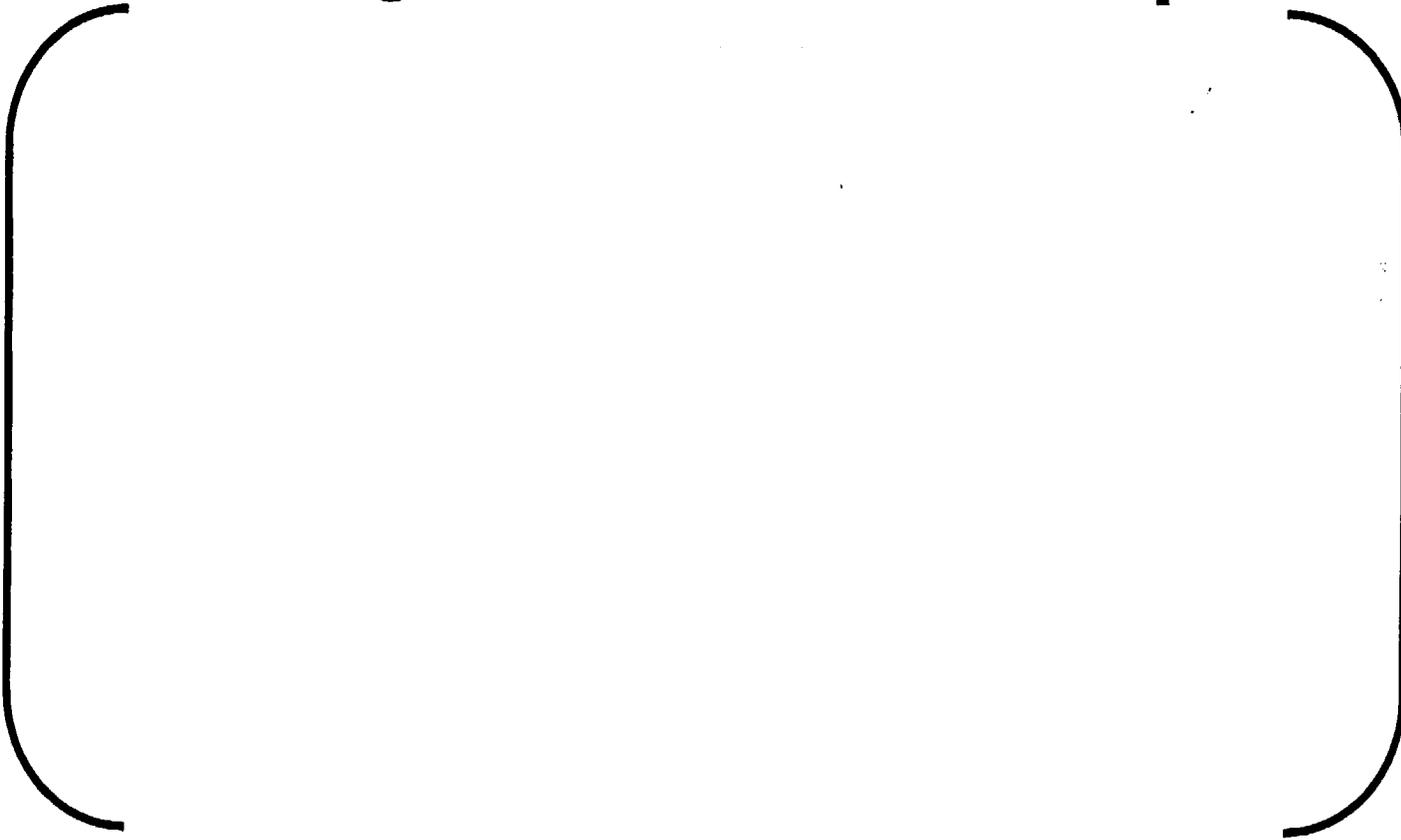
- **Axial Power Distributions**



# Technical Approach Fuel Rod Performance

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- **Radial Peaking Factor  $F_r$  versus Burnup**



# Technical Approach Fuel Rod Performance

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- **Maximum Internal Hot Gas Pressure**



# Technical Approach Fuel Rod Performance

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- **Power-to-Centerline Melt**



# Technical Approach Fuel Rod Performance

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- **Summary**
  - **ZIRLO™ impact on fuel performance**



# Technical Approach Transient Analysis

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- **Loss-of-Coolant Accident for Appendix K ECCS Performance Analysis**
- **Computer Codes Affected**
  - **LBLOCA**
    - **CEFLASH-4A/FII**
    - **COMPERC-II/LB**
    - **STRIKIN-II**
    - **COMZIRC**
  - **SBLOCA**
    - **CEFLASH-4AS**
    - **COMPERC-II/SB**
    - **STRIKIN-II**
    - **PARCH/REM**

# Technical Approach Transient Analysis

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- **Loss-of-Coolant Accidents (continued)**



# Technical Approach Transient Analysis

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- **Loss-of-Coolant Accidents (continued)**



# Technical Approach Transient Analysis

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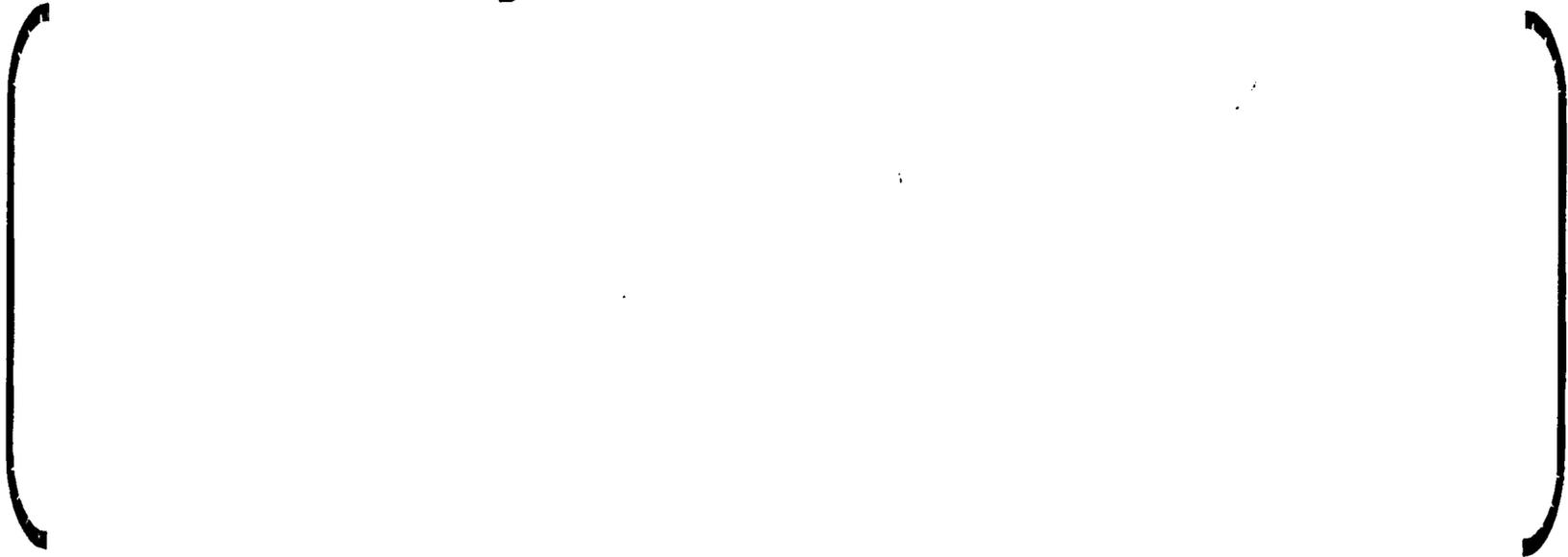
- **Non-LOCA Codes**



# Technical Approach Transient Analysis

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- **Non-LOCA Analysis**



# Technical Approach

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- **Summary**
  - **NRC has already approved ZIRLO™ material properties for Westinghouse.**
    - **WCAP-12610-P-A, “Vantage+ Fuel Assembly Core Report”**
    - **WCAP-15063-P-A, Rev. 1 w/errata, “Westinghouse Improved Performance Analysis and Design Model (PAD 4.0)”**
  - **CENP will utilize the previously approved ZIRLO material properties as the basis for the change**
  - **Implementation in CENP analysis methodologies**
    - **Verification and validation of all coding changes**
    - **Verification and validation of functionality**
    - **Perform sensitivity studies and sample applications**



# Licensing Approach

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- **Short Term**

- **Prepare letter report to NRC documenting process for implementing ZIRLO™ in CENP design methods**
- **Submit letter report to NRC by end of 2000**
- **Apply modified methods to support use of ZIRLO in CE plants in 2002**

- **Long Term**

- **Ongoing activity evaluating the synergisms and differences between CENP and Westinghouse licensing and design models and methods**
- **Coordination and integration where technically and economically feasible**



## Proposed Schedule

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- **NRC Meeting** **10/17/2000**
- **Submit Letter Report** **1/15/2001**
- **Start reload analyses using ZIRLO™** **6/15/2001**
- **First Plant Implementation** **3/2002**



# Interested Utilities

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## Summary

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- **CENP will incorporate ZIRLO™ cladding material into its fuel designs.**
  - **ZIRLO has already been approved by the NRC for use in Westinghouse analysis methodologies.**
  - **CENP will incorporate ZIRLO material properties into its analysis methodologies.**
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- **All work to be verified and validated; sensitivities to be assessed.**
  - **Letter report to NRC.**

# Related CENP Topical Report - References

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# Related CENP Topical Report - References

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