

Westinghouse Non-Proprietary Class 3

**WEC-STP-2010-0040 NP-Attachment**

**"Revision to STP 3/4 Analysis of Downstream Debris  
Effects on Fuel, Response to RAI 04.04-4"**

**September 2010**

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# Revision to STP 3/4 Analysis of Downstream Debris Effects on Fuel

Response to RAI 04.04-4

# Background

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- RAI 06.02.02-2
  - STPNOC agreed to a COL license condition to submit an evaluation confirming the downstream effects of containment debris on the initial fuel are acceptable
- RAI 04.04-3
  - Provided description of analysis of flow blockage of fuel inlet

# Background

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- RAI 04.04-3 (continued)
  - Provided description of fuel debris test
  - Provided debris composition to be tested
  - Provided acceptance criterion for test
  - NRC audited supporting calculation
- RAI 04.04-4
  - Requested applicability of analysis, test, and acceptance criterion to current DCD fuel

# Revision to Debris Evaluation

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- Based upon feedback from NRC staff the debris evaluation has been expanded to address the following issues
  - Clarify the relationship between the analysis and the test acceptance criteria
  - Address the applicability of the acceptance criteria and license condition to the DCD fuel design
  - Address the applicability of the use of GOBLIN even though not yet approved for ABWR designs

## Revision to Debris Evaluation (cont.)

- Assess ABWR capabilities to cool the core even with complete fuel inlet blockage
  - [ ]<sup>a,c</sup>
  - [ ]<sup>a,c</sup>
- A new calculation was created (simpler than revision)

# Analyses Performed for Test Criterion

- Determine fuel inlet flow blockage that maintains fuel cooling for test acceptance criterion
  - [

] a,c

# Analysis Performed (Defense-in-Depth)

- Evaluate [

] a,c

# Analyses Performed (Defense-in-Depth)

- Evaluate [

] a,c

# Relationship between analysis and test

- Previous analysis results showed [ ]<sup>a,c</sup> blockage maintained flow sufficient to cool fuel
  - DP at [ ]<sup>a,c</sup> blockage was 0.35 bar ( 5.075 psid) across inlet.
  - Proposed COLA provided relationship between analysis and test
- Revised analysis and acceptance criterion provide a clear translation of analysis results to test criterion and includes additional conservatism.

# Acceptance Criterion methodology

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- Analysis is consistent with test configuration (no bypass)
- Determine increase in FA inlet loss coefficient ( $K_{inlet}$ ) that continues to cool fuel using GOBLIN

▪ [

] a,c

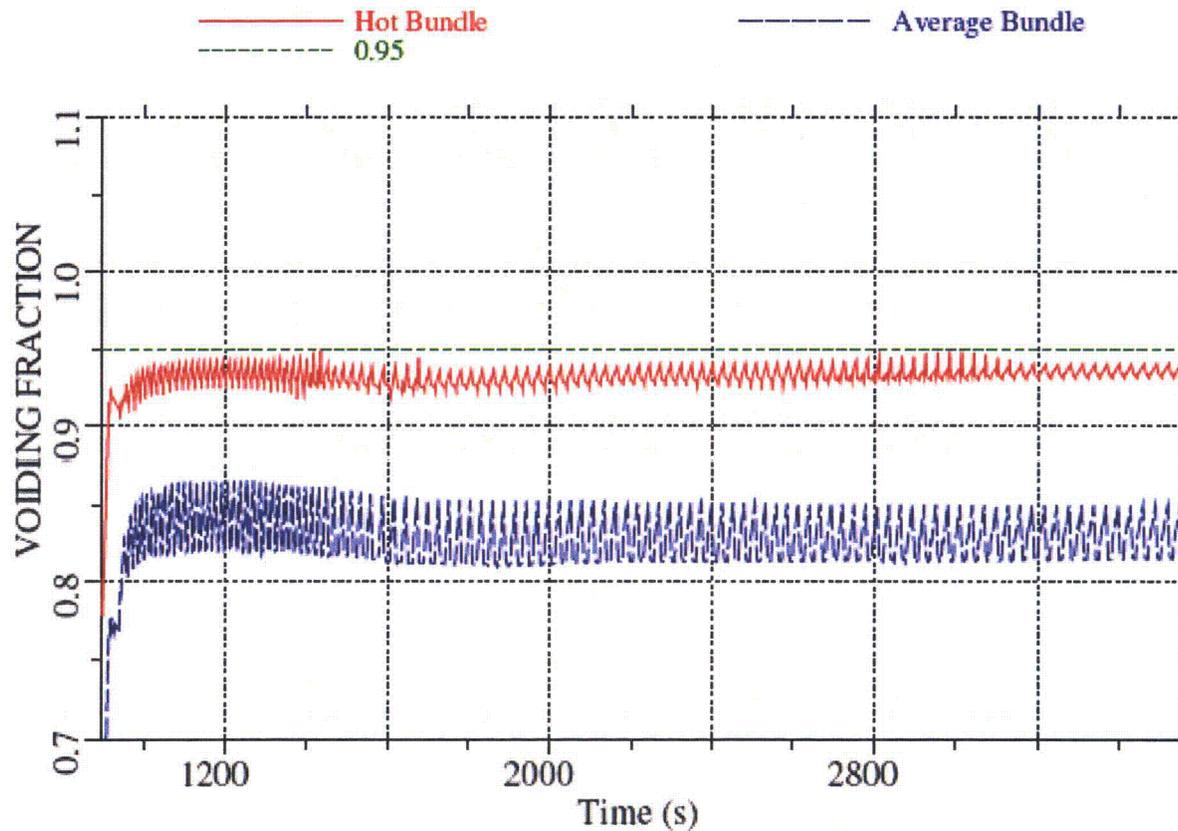
- Use  $\Delta P_f / \Delta P_i$  to define test acceptance criterion

# Acceptance Criterion Results

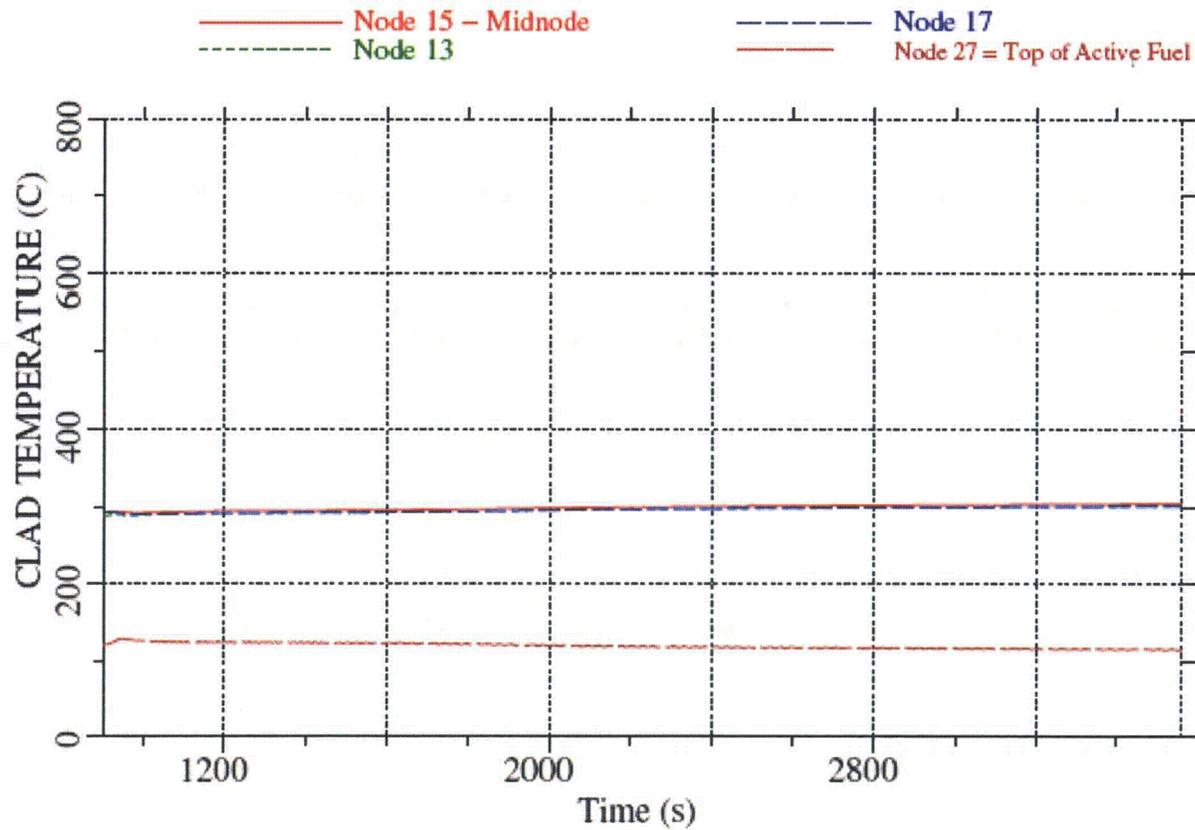
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- Fuel blockage test acceptance criterion
  - [ ]<sup>a,c</sup> blockage was acceptable
  - Derived Test Acceptance Criterion based upon [ ]<sup>a,c</sup>

# Top of Fuel Void Fraction([ ]<sup>a,c</sup> blocked)



# Clad Temperature ([ ] a,c blocked)



# Acceptance Criterion

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$$\left[ \frac{\Delta P_f}{\Delta P_i} \right]_{(\text{Test-Measured})} = \left[ \frac{\Delta P_f}{\Delta P_i} \right]_{(\text{Aly})} * \left( \frac{W_i}{W_f} \right)_{(\text{Aly})}^2 * \left( \frac{W_f}{W_i} \right)_{(\text{Test-Measured})}^2$$

$$\left[ \frac{\Delta P_f}{\Delta P_i} \right]_{(\text{Test-Measured})} \leq 1200 * \left( \frac{W_f}{W_i} \right)_{(\text{Test-Measured})}^2$$

# Test Acceptance Criterion

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a,c

# Applicability to DCD Fuel Design

- Analyses were performed with OPTIMA2 fuel with Triple Wave + inlet filter
- Current DCD is based upon GE-7 (8x8, no debris filter)

# Applicability to DCD Fuel Design

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- The analysis acceptance criterion ensures adequate flow through assemblies to remove decay heat.
- Fuel assemblies used in ABWR must be hydraulically similar to maintain RIP performance, Hydraulic loads etc.
- [

] a,c

- Test Acceptance Criterion applies to DCD fuel and OPTIMA2

# Applicability of ABWR Evaluation Model

- Evaluation of acceptable fuel blockage and fuel rod fouling performed using GOBLIN / CHACHA
- The Westinghouse BWR Evaluation Model is approved and consists of the same codes and is utilized for US BWR reloads with OPTIMA2 fuel.
  - WCAP-16078-P-A
- GOBLIN / CHACHA models the basic phenomena important to Long Term Cooling
  - ABWR specific design features aren't significant for LTC
  - Analysis justifies and references Westinghouse BWR Evaluation Model

# ABWR Design Features

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- Elimination of Recirculation Loops
  - No Recirc line break (Core remains covered)
  - Reactor In-vessel Pumps
- Fine Motion Control Rod Drive System
- ECCS
  - 3 trains HP (2 HPCF, RCIC), 3 LPFL
- Containment Design Features
- I&C Systems

[

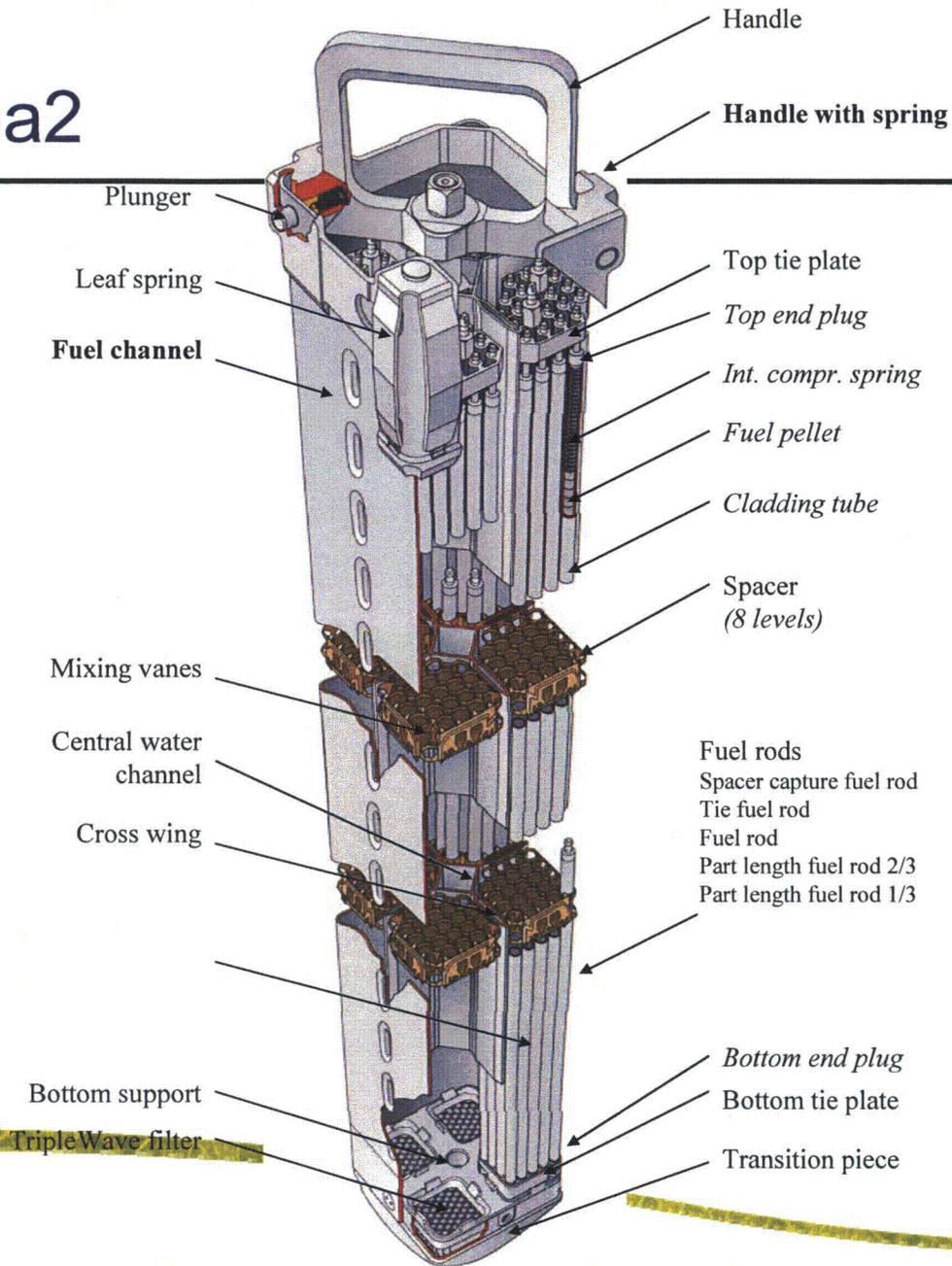


] a,c

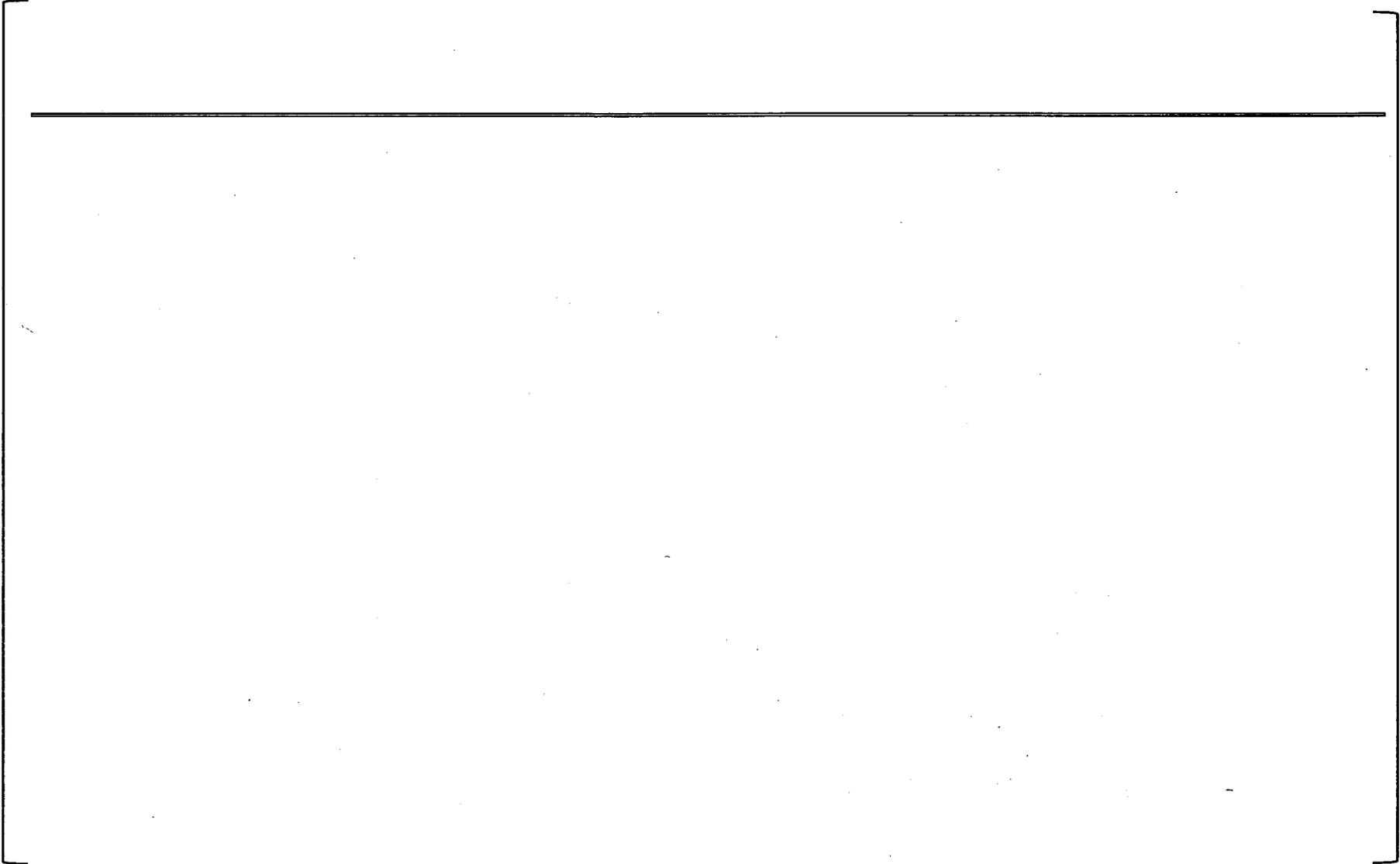


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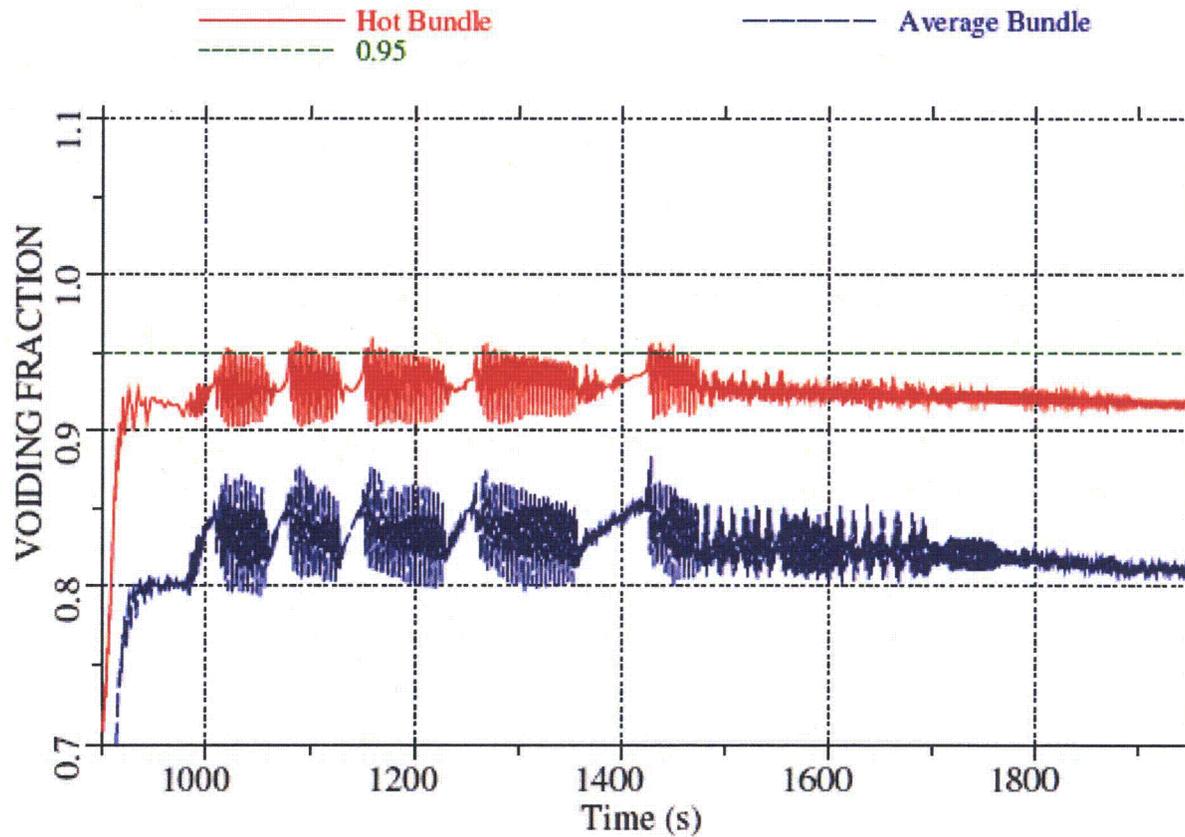
# SVEA-96 Optima2



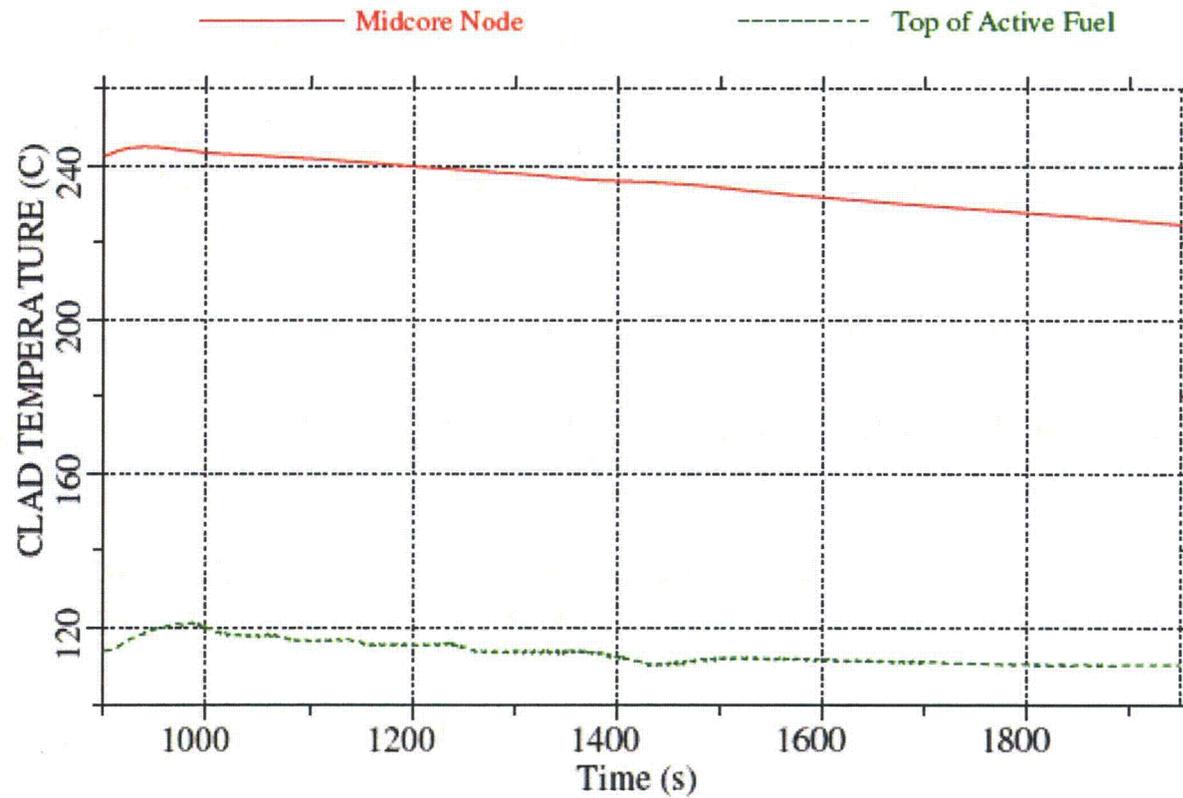
a,c



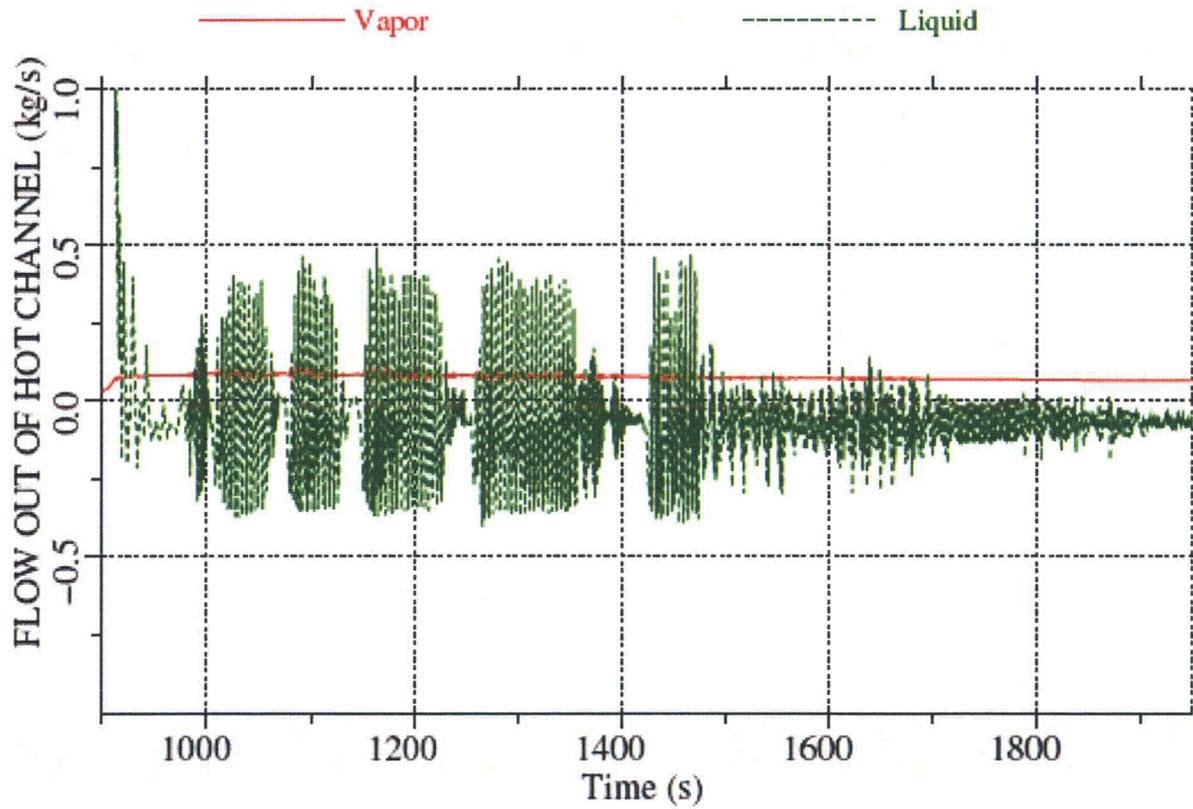
# Inlet Blockage [ ] a,c Top of Fuel Void Fraction



# Inlet Blockage [ a,c ] Clad Temperature



# Inlet Blockage [ ] a,c

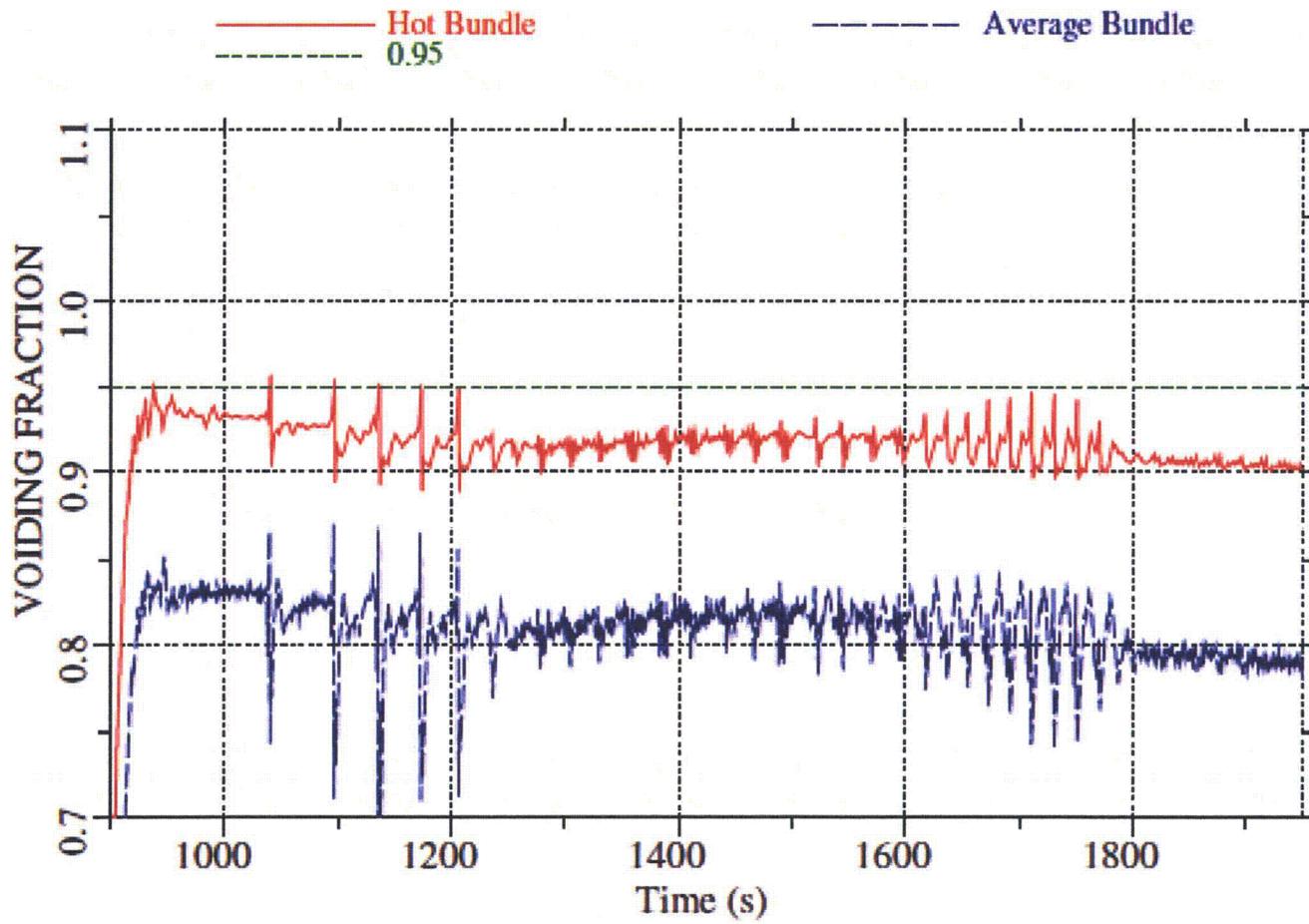


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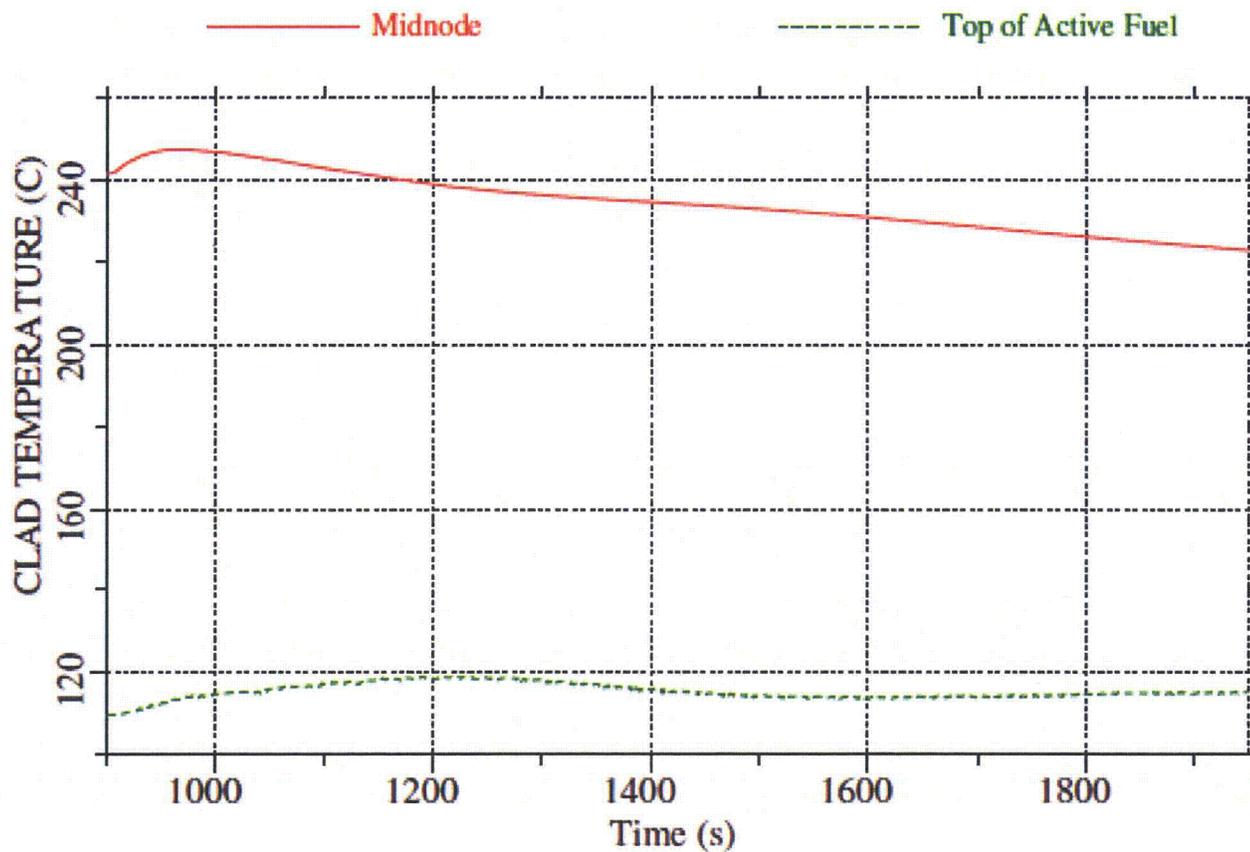
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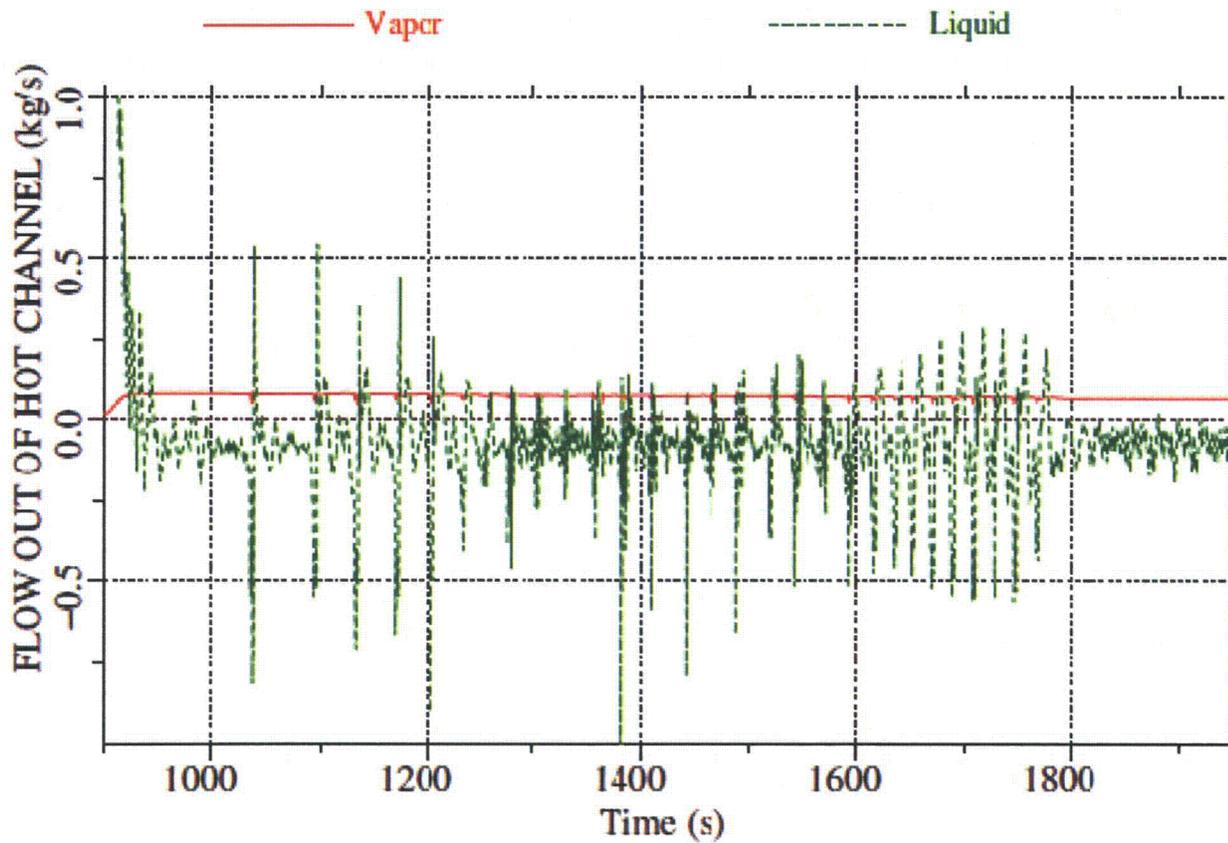
# [ ]<sup>a,c</sup> Results



# [ ]<sup>a,c</sup> Results



# [ ]<sup>a,c</sup> Results



# Summary

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- Respond to feedback and RAI 04.04-4
- Clarified Fuel Debris Acceptance Criterion
- Acceptable blockage is based upon heat balance and hydraulics
  - [ ] a,c
- [ ] a,c
- Confirmed applicability of models to address LTC phenomena