

**Westinghouse AXIOM Fuel Rod Cladding Material – Lead Test Assembly
Program (Non-Proprietary)**

April 2016

(25 pages attached)

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Westinghouse AXIOM™ Fuel Rod Cladding Material – Lead Test Assembly Program

April 21, 2016

Safety Brief

- Meeting Location and Emergency Response protocol
 - Building exits and muster point
- April Nuclear Safety Trait at Westinghouse:

Decision Making

Attributes:

- DM.1 Consistent Processes
- DM.2 Conservative Bias
- DM.3 Accountability for Decisions

It is vital to reinforce Nuclear Safety in our industry



Introductions

- Westinghouse Participants today:
 - Andrew Bowman, Licensing Engineer, AXIOM Program
 - Ed Mercier, Product and Plant Licensing Manager, AXIOM Program
 - Andrew Atwood, Materials and Fuel Rod Design Manager, AXIOM Cladding development
 - Adam Smith, Project Manager, AXIOM LTA program
- Representatives from Dominion:
 - Cary Laroe, Manager, Nuclear Fuel Engineering
 - Paula Larouere, Consulting Engineer, Fuel Performance Analysis
 - Brian Vitiello, Project Engineer, Nuclear Fuel
- Representative from Southern Co:
 - Robert (Bob) Florian, Principal Engineer, Nuclear Fuel



Agenda

- Purpose and Mission Statement
- Background and History
- Current Status of AXIOM Alloy Development
- AXIOM Cladding LTA Program Overview
- Licensing Approach
- Program Schedule
- Summary and Closeout

Goal for today: Raise awareness of Westinghouse AXIOM cladding product development and intent to pursue an LTA program with utility partners.



Purpose and Mission Statement

- The purpose of today's meeting
 - Present the current status of the AXIOM alloy development program
 - Outline plans for a Lead Test Assembly (LTA) program to gather data to support submittal and review of a licensing topical report on the AXIOM cladding material
- AXIOM cladding is designed for high duty operations in challenging coolant chemistry conditions offering:
 - Improved corrosion and hydrogen pickup performance superior to our **Optimized ZIRLO™** cladding material
 - Long term dimensional stability and improved creep performance
 - Compatibility with elevated lithium coolant chemistry conditions

Background and History

- AXIOM cladding material has been in development for over 15 years including Lead Test Rod campaigns to support final alloy selection which were initiated in 2005
- AXIOM alloy has been irradiated in a variety of reactors worldwide including:
 - Five power reactors
 - Two test reactors
 - Max burnup 75 GWD/MTU

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Background and History (cont.)

- An extensive PIE database of poolside and hot-cell results has been developed, including
 - Poolside and hot-cell oxide measurements
 - Poolside and hot-cell length measurements
 - Poolside and hot-cell profilometry measurements
 - Hot-cell mechanical testing at burnups over 70 GWD/MTU
 - Metallography, scanning electron microscopy (SEM), and transmission electron microscopy (TEM) evaluation of irradiated microstructure and second phase particle (SPP) composition
 - High precision creep and growth measurements
 - Hydrogen content measurements

Current Status of AXIOM Alloy Development

- Westinghouse has selected the final AXIOM cladding composition.
- AXIOM material selection was based on multiple variables that included:
 - Corrosion and hydrogen
 - Creep and growth behavior
 - Compatibility with fuel rod design criteria
 - Tolerance for coolant chemistry variability
 - Strength properties
 - Anticipated compliance with 10 CFR 50.46c requirements
 - Manufacturability
 - Microstructure stability at high burnup

Alloy selection based on best overall performance to ensure that all operating requirements were considered

Selected AXIOM Alloy Composition and Performance

ZIRLO®	SRA	1	1	0.1			Bal.
Optimized ZIRLO	pRXA	1	0.68	0.1			Bal.

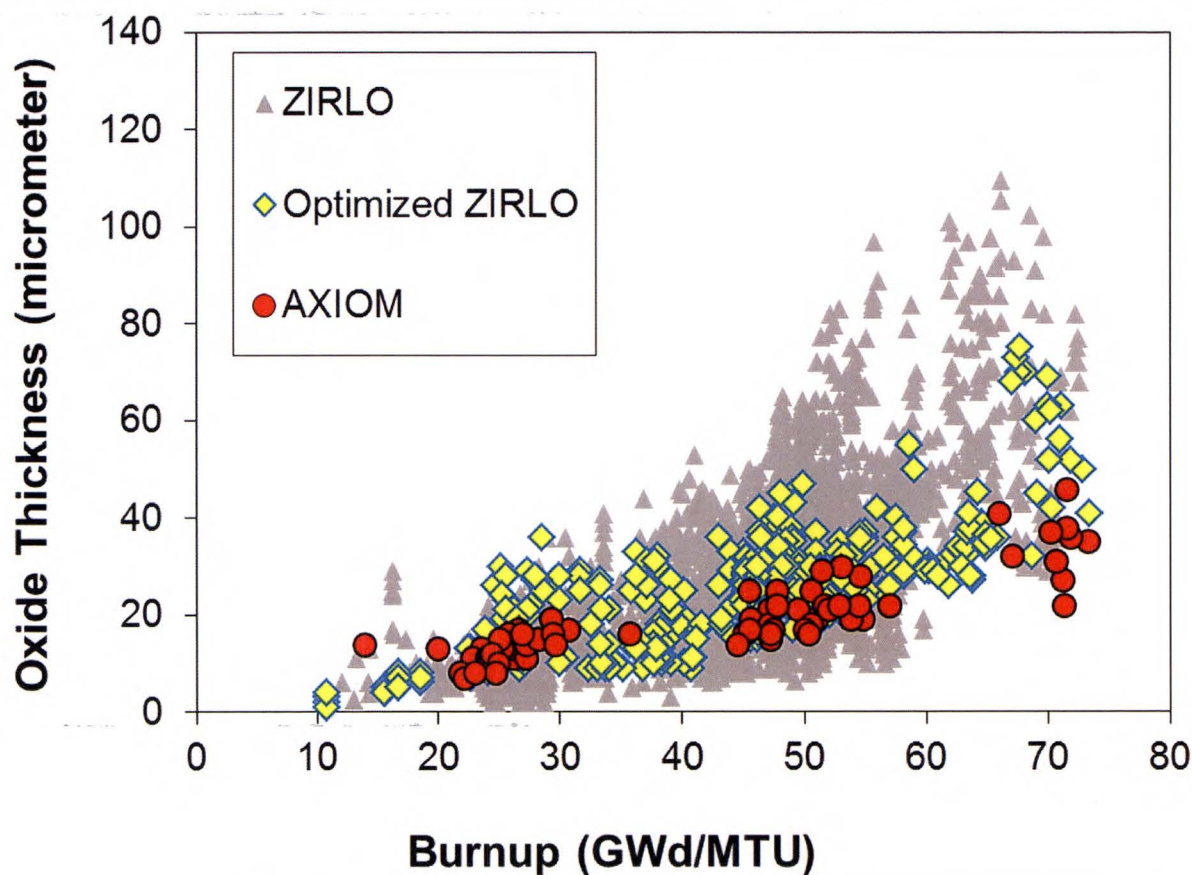
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- Selected performance of the chosen AXIOM cladding will be presented in the following slides

AXIOM Lead Test Rods Irradiation Experience

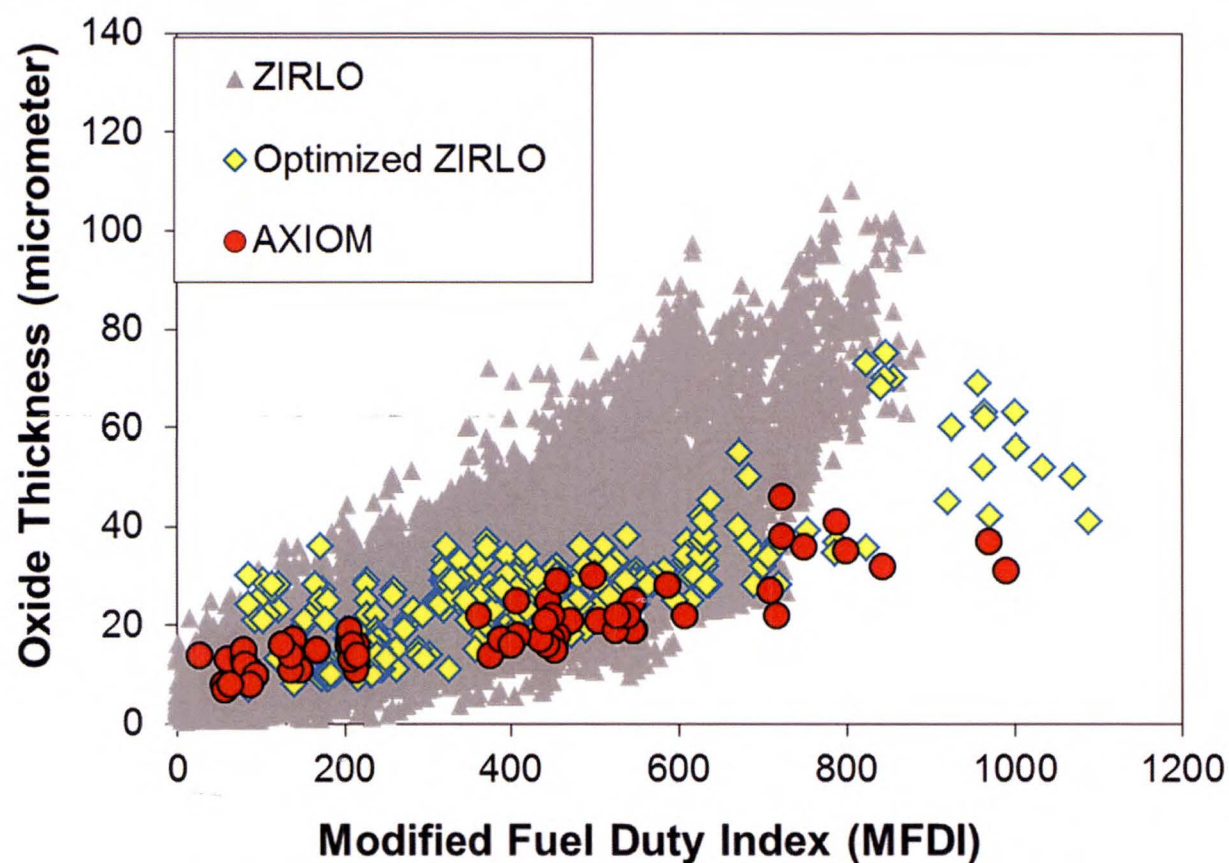
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Corrosion Experience

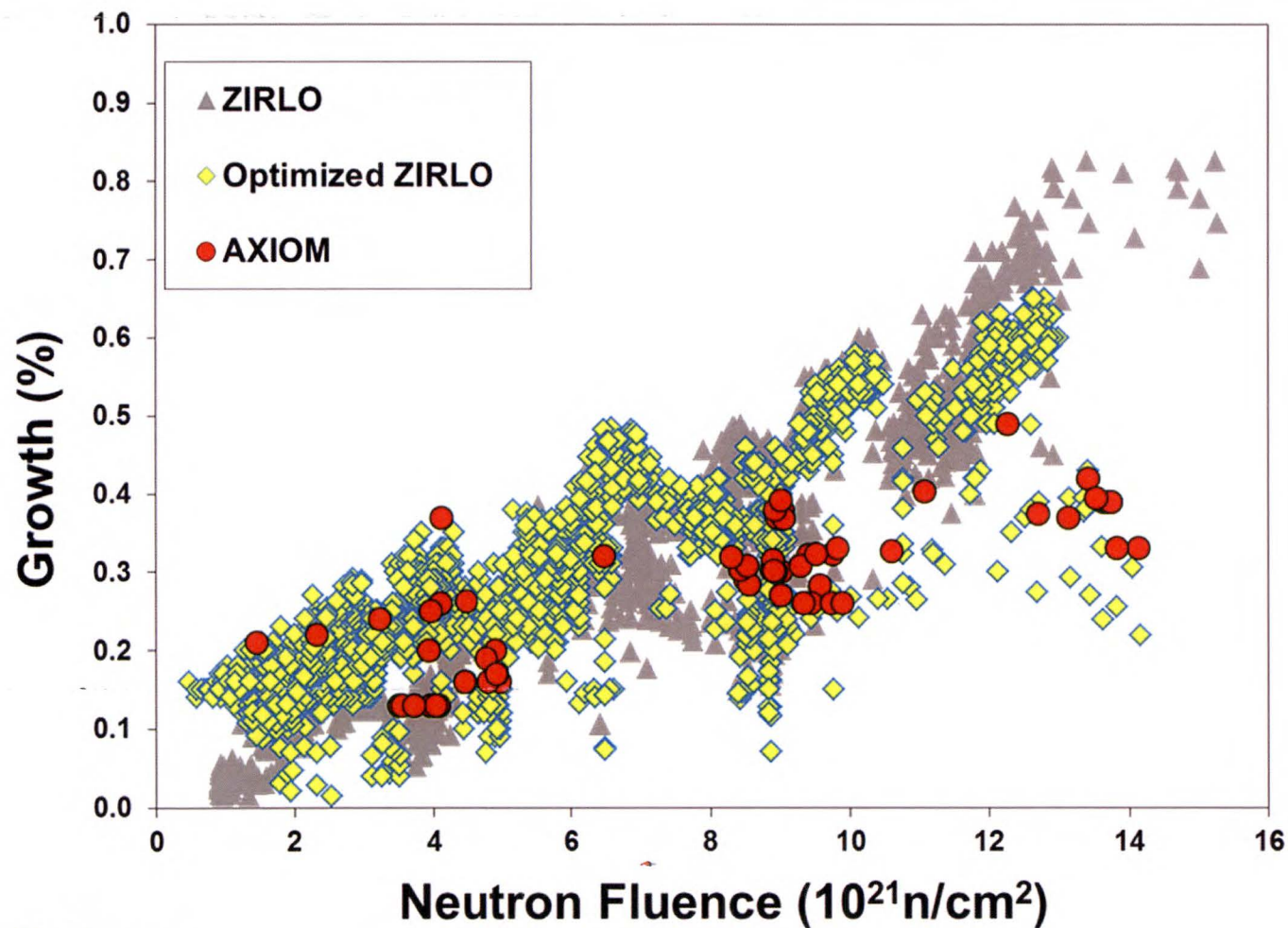


The oxide thickness of the AXIOM alloys are less than 50 μm for a burnup over 70 GWd/MTU

Corrosion Experience (cont.)



Fuel Rod Growth Experience - Poolside PIE Results



Vogtle Creep and Growth Program Results

a,b, c

AXIOM cladding has a steady-state creep rate that is less than the rate that is observed for *Optimized ZIRLO* and ZIRLO cladding

Hydrogen Pickup Experience – Hot-Cell PIE Results

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The hydrogen pickup fraction is about 10%, and the overall hydrogen content in metal is about 200 ppm for AXIOM cladding with burnup over 70 GWd/MTU

AXIOM Cladding LTA Program Overview

- [a, c]
- Use this opportunity to continue to show performance benefit relative to ZIRLO and **Optimized ZIRLO** fuel rods
 - Gather additional operating experience and poolside data to supplement the existing PIE database for AXIOM alloy to provide additional support for licensing and commercial introduction of AXIOM alloy as a new cladding material.

Customers for AXIOM Clad LTAs have been identified to demonstrate the performance benefits of AXIOM clad materials in representative operating conditions

AXIOM Cladding LTA Program Overview (cont.)

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- It is the intent to request LTAs be inserted in non-limiting locations and the overall quantity will be $< 10\%$ of core.
- The LTAs will be typical production fuel assemblies with the exception of the cladding material.
- The features of the lead test assemblies do not challenge the validity of the standard reload methodologies.
 - An AXIOM-specific Fuel Rod Design evaluation will be performed following the same process which was applied to the Lead Test Rod campaigns
- LTAs will be operated to typical discharge burn-ups.
- LTAs are planned to run for three cycles with pool side exams following each outage.

Licensing Approach – Exemption Requests

- Under current regulatory landscape, the program will require exemption requests allowable under 10 CFR 50.12:
 - 10 CFR 50.46 since AXIOM does not fall within Zircaloy or ZIRLO material compositions.
 - 10 CFR Appendix K since the Baker-Just equation required by Appendix K assumes the use of an alloy other than AXIOM alloy.

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Licensing Approach – Insertion of LTAs

- The LTAs will be evaluated as part of the reload evaluation
 - No Technical Specification changes are anticipated to be needed to support the LTA program.
 - Insertion of the LTAs will be evaluated following the 10 CFR 50.59 process.
 - UFSAR markups will be incorporated, as necessary.

Future Licensing Considerations

- Any LTAs planned to be inserted following completion of 10 CFR 50.46c rulemaking would be anticipated to follow the process identified previously until Licensees have demonstrated full compliance with the regulation.
 - Exemptions for applicable regulations (50.46 and Appendix K)
- After licensees have demonstrated compliance with 10 CFR 50.46c, no special exemptions will be required for LTAs using the AXIOM cladding and the 10 CFR 50.59 process will be applied as part of the reload incorporating the LTAs, noting the Technical Specification allowance for inclusion of LTAs in the reactor.

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Program Schedule for AXIOM Cladding LTAs

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AXIOM Cladding Development Program Timeline

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Summary and Alignment Strategy

- Review of the objectives for today's meeting:
 - Provide a clear understanding of the AXIOM Cladding program for all interested parties
 - Identify the Westinghouse and customer intent to submit request for exemption to applicable regulations under 10 CFR 50.12 to support LTAs.
 - Outline current licensing plan for a future material-specific topical report
 - Identify need for NRC resources with this pre-submittal meeting
 - Outline high level schedule for all potential stakeholders

**Thank you for your time and
consideration today.**

Thank You

Questions / Comments

