Fuel Performance Update Meeting with NRC May 16, 2001

Sumit Ray
Manager of Product Engineering
Westinghouse Electric Company

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Agenda

- Introduction - Sumit Ray (Non-Proprietary)
- Update/closeout of 17% ECR for ZIRLO™ - Dave Mitchell (Non-Proprietary)
- Discussion on ZIRLO™ topical for CE Plant Application - Tom Rodack or Chuck Molnar (Non-Proprietary)
- Fuel Performance Update (COLA) - Rod Grimoldby (Proprietary)
  - General Update
  - Top Nozzle Screw Update/Integral Clamp Top Nozzle
  - North Anna Top Nozzle Issue Update

Agenda

- Fuel Performance Update (Windsor) - Tom Rodack (Proprietary)
  - Grid-to-Rod Fretting
  - Oxide Spallation
  - Palo Verde 2 Fuel Failures
  - Palo Verde 1 CEA Issue
- Next Generation Fuel - Dave Mitchell (Proprietary)
  - Standard update on LTA programs/other testing
  - Next Gen Fuel Program

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Introduction

- Westinghouse Electric Re-organization
  - Columbia, Pittsburgh and Windsor Second Level Management
    - Sumit Ray, Product Engineering
    - Tim Collier, Core Engineering
    - Tom Rodack, Windsor Fuel Engineering
  - Licensing Manager
    - Jay Akers, Core Engineering (Primary Licensing Responsibility)

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LOCA Basis Testing of ZIRLO™ Cladding

David Mitchell
Westinghouse Electric Company
May 16, 2001

Items for Discussion

- Background on Current issue
- Description of Testing
- Specimen Evaluations
- Results of Testing
- Conclusions

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Background on Current issue

- Question of applicability of current LOCA criteria to claddings containing Niobium.
- Work by Böhmert on E110 (Zr1Nb) showed.
  - Complete embrittlement is about 1/3 the value for Zircaloy-4
  - Higher hydrogen pickup for some cases compared to Zircaloy-4
- Westinghouse met with NRC on February 26, 2001 to discuss concerns and to present initial test results.
- Westinghouse also met with ACRS committee on April 4, 2001 to present findings to date.

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Description of Testing

- 30 Tests of ZIRLO™ and 31 Tests of Zircaloy-4 (61 Samples)
- Temperature Range
  - 1500 °F (815.6 °C)
  - 2300 °F (1260 °C)
- Measured Equivalent Cladding Reacted (ECR) Fraction
  - 0.03
  - 0.36
- Time
  - 3-60 Minutes

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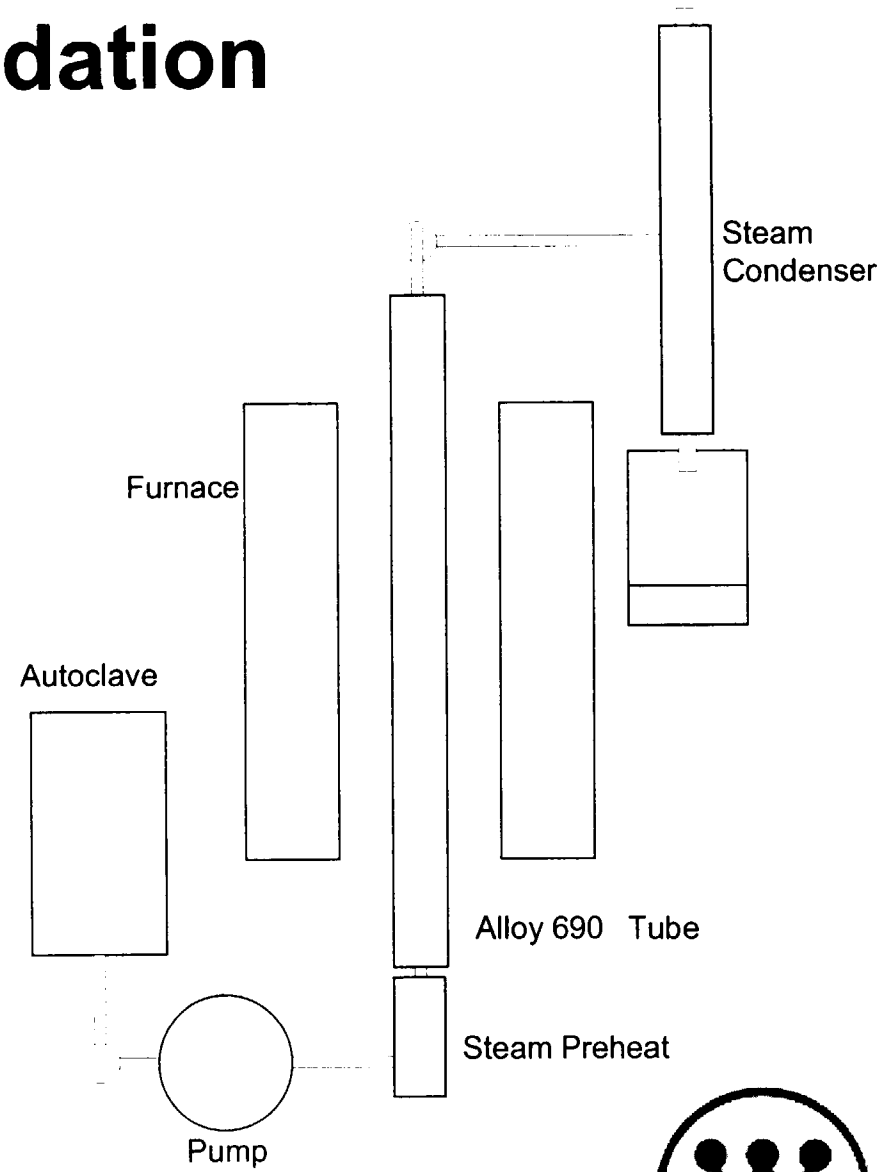
Steam Oxidation

- Clam shell resistance furnace.
- Specimens placed in Alloy 690 tube.
- Deaerated water from autoclave pumped into Alloy 690 tube.
- Exit steam condensed by water cooling jacket.



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Specimen Evaluations

- Specimen Evaluations
  - Oxide Layer Characteristics
  - Ring compression tests
    - Assess cladding ductility.
    - Room temperature and 275°F.
    - Test performed similar to Hobson & Rittenhouse (ORNL Report 4758) and Böhmert.
  - Optical metallography
    - Oxide thickness, α-stabilized layer, transformed-β layer.
    - Microhardness to assess oxygen penetration.
  - Hydrogen concentrations, oxygen uptake

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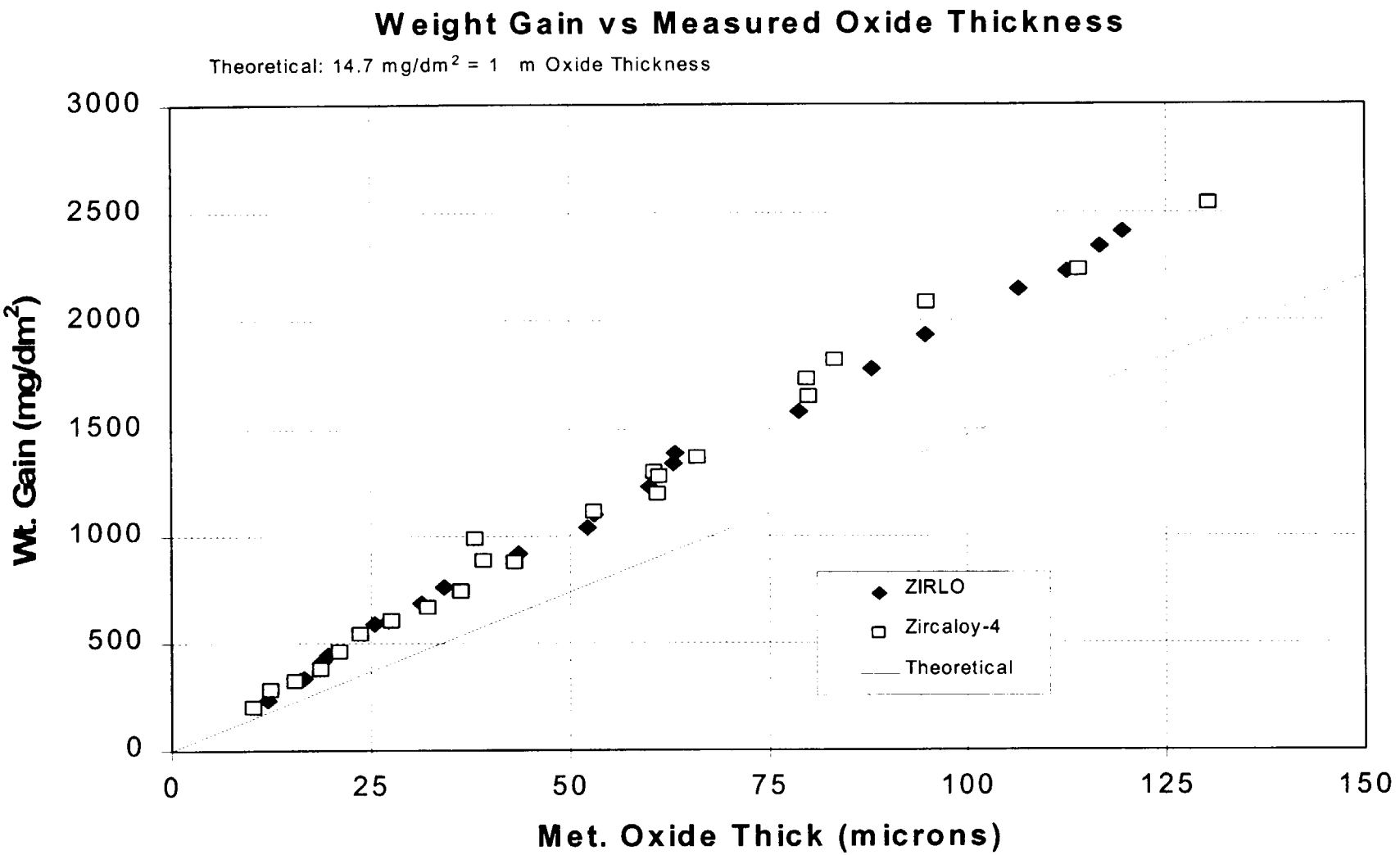

ZIRLO™ and Zircaloy-4 behave the same

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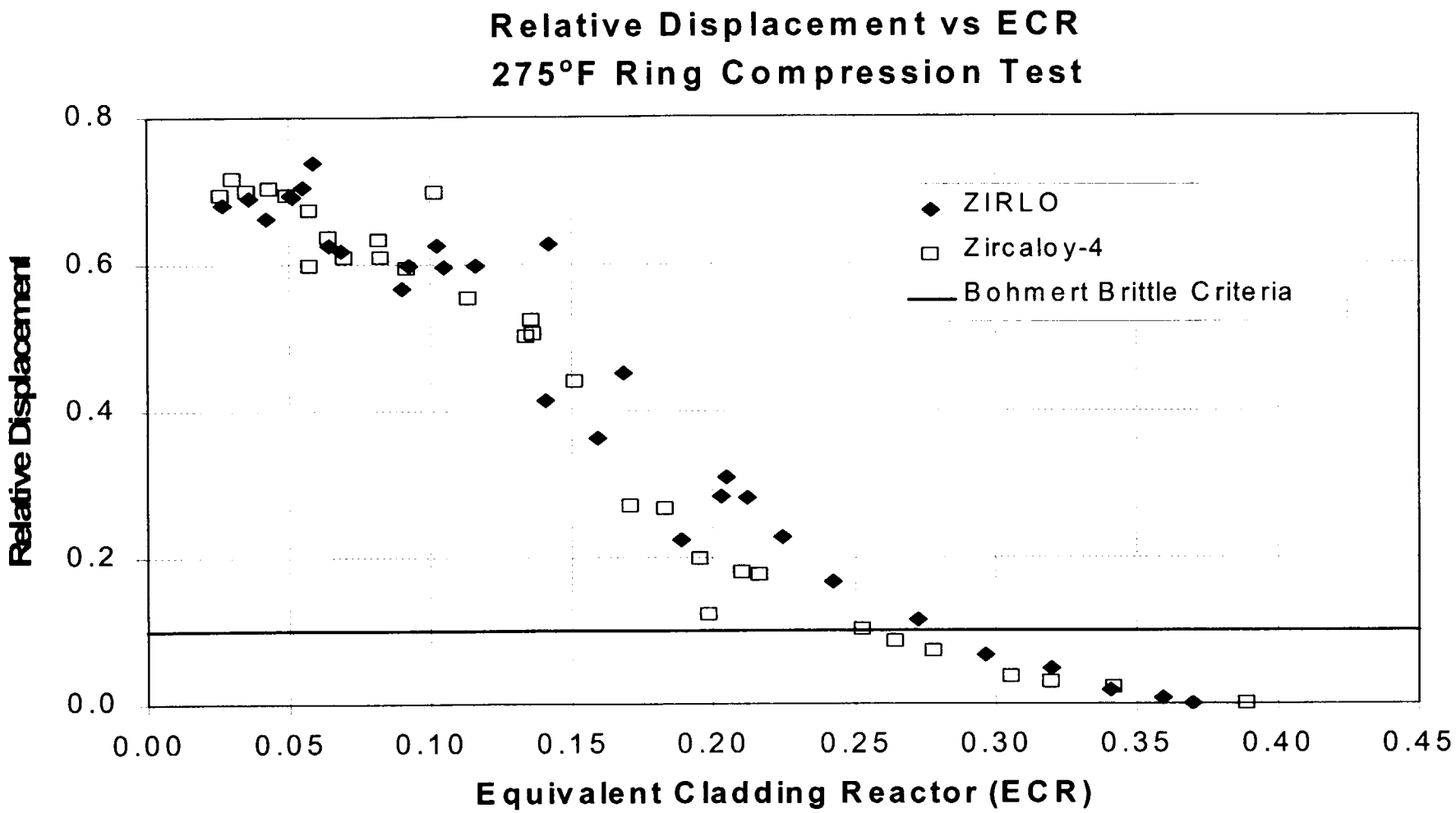

ZIRLO™ and Zircaloy-4 behave the same

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Hydrogen Analysis of Samples

Alloy	Temp °F	Time (min.)	Hydrogen (ppm)
ZIRLO™	1800	30	18
	1950	30	22
	2000	30	24
	2100	30	36
	2200	5	31
	2200	20	31
Zircaloy-4	1800	30	68
	1950	30	32
	2000	30	36
	2100	30	36
	2200	5	34
	2200	20	45

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Results of Testing

- Both oxide layers were dark, adherent, and with no laminations
- Hydrogen uptake is low for both ZIRLO™ and Zircaloy-4 with <100 ppm and values ranging from 18 to 68 ppm from 1800 to 2200 °F
- ZIRLO™ and Zircaloy-4 are effectively identical in response and performance to high temperature oxidizing conditions.
  - Fractions of Oxygen in Oxide Layer and Metal
  - Microhardness of
    - α-stabilized layer
    - transformed-β
  - Post Test Ductility using Ring Compression Tests.

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Conclusions

- ZIRLO™ and Zircaloy-4 show the same trends as a function of measured Equivalent Cladding Reacted (ECR).
- Tests are completed, Engineering review conducted and results accepted.
- ZIRLO™ and Zircaloy-4 perform the same after exposure to LOCA conditions. Therefore the same criteria are applicable to both alloys.

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Implementation of ZIRLO™ in CE Plants

Tom Rodack

Meeting at NRC

May 16, 2001

Topical Report Review Status

- ZIRLO™ properties and models have been added to CE codes and methods
- ZIRLO™ Topical was submitted January 22, 2001
- One month acceptance review states target to complete review is August 15, 2001
- Westinghouse issued letter on cause of OPPD fuel rod fretting failures
  - Cause related to grid design
- Expect first set of RAIs by May 16
- Meeting set at NRC on May 21 to discuss RAIs

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Implementation of ZIRLO™ Cladding

- Calvert Cliffs Nuclear Power Plant and Arizona Public Service have ordered ZIRLO™ cladding
  - Calvert Cliffs Unit 1 fuel delivery in November 2001
  - Palo Verde Unit 2 Cycle 1 fuel delivery in February 2002
- OPTIN clad is no longer an option for next batch of Calvert Cliffs fuel
- Engineering analysis initiated to support reloads
- Draft license amendments for utilities to reference ZIRLO™ & new LOCA Topical Reports

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Summary

- ZIRLO™ will provide real margin to oxidation and spallation fuel performance limits for CE reactors
- Topical report addressing application of ZIRLO™ cladding in CE fuel designs has been submitted
- APS and Calvert Cliffs have ordered ZIRLO™ cladding in next batches of fuel - analysis and ordering of material are in progress

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