

**Westinghouse
Presentation on
ZIRLO Characterization Plant
(Slide Presentation of July 11, 2002)**

June 2002



Westinghouse

A BNFL Group company

ZIRLO™ Characterization Plan

Westinghouse Electric Company

Presented by:

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July 11, 2002

ZIRLO™ Characterization Plan

- Meeting Objective

- Present Low Tin ZIRLO™ Characterization plan to support license extension for Low Tin ZIRLO™ cladding consistent with presentations to NRC in 2001 and 2002
- Obtain feedback on scope of planned efforts

ZIRLO™ Characterization Plan

- Program Objective

- By performing Low Tin ZIRLO™ Characterization, we will demonstrate that Low Tin ZIRLO™ is not a new material, but a minor change within the technical envelope of a well-proven ZIRLO™ cladding

ZIRLO™ Characterization Plan

- Background
 - Westinghouse intent to license Low Tin ZIRLO™ presented to NRC on Oct 29, 2001
 - Strategy to develop Low Tin ZIRLO™ characteristics database defined
 - Low Tin ZIRLO™ characteristics will be demonstrated to be compatible with standard ZIRLO™ properties
 - Westinghouse intent to license Low Tin ZIRLO™ and strategy reiterated to NRC on May 14-15, 2002 semi-annual meeting
 - General approach seemed reasonable

ZIRLO™ Characterization Plan

Changes in fabrication	Benefit or impact
Change tin level range from [] ^{a, c}	Reduce Corrosion
esting	
Ex-core	Provide data used in reload evaluation
In-core - Exposure in LTA	Gather PIE data to validate models and demonstrate benefits

ZIRLO™ Characterization Plan



ZIRLO™ Characterization Plan

- Low Tin ZIRLO™ Ex-Core Testing

- Test Material

- ZIRLO™ with nominal tin content of []a, c

- ZIRLO™ with nominal tin content of []a, c

- Standard tin ZIRLO™ (C)

- Planned Tests

- Physical properties

- Mechanical Properties

- Microstructure

- High Temperature/LOCA Tests

ZIRLO™ Characterization Plan

- Summary of Basic Properties Characterization

Physical tests

Density
Emissivity - oxidized and unoxidized
Specific Heat
Thermal Conductivity
Thermal Expansion
 Axial / longitudinal
 Diametrical/hoop or transverse
Alpha-Beta Transition Temperature

Mechanical Tests:

Axial Mechanical Test:

Yield Strength
Ultimate strength
Elongation at failure
Modulus of elasticity
Poisson's ratio axial/diametral

ZIRLO™ Characterization Plan

- Summary of Basic Properties Characterization (Cont'd)

Hoop Burst Test:

- Yield Strength
- Ultimate strength
- Strain at failure
- Modulus of elasticity

Biaxial Burst Test:

- Ultimate strength
- Microhardness Traverse
- Fatigue
- Microstructure:

- Particle Size

High Temperature/LOCA tests:

- Quench Tests
- Ring Compression Tests
- Metal-Water Reaction (High Temperature)**
- Burst Test (Strain & Temperature @ burst)
- LOCA creep

ZIRLO™ Characterization Plan

Physical properties

–Density (A, B)

- » Immersion Method
- » At Room Temperature with extrapolation to higher temperature based on measured value of thermal expansion

–Emissivity (A, C)

- » Oxidized and unoxidized Condition
- » ASTM Method C-835
- » Minimum 500 C and maximum 1200 C

–Specific Heat (A,B,C)

- » ASTM method E1269-01
- » From Room Temperature to 1200 C

ZIRLO™ Characterization Plan

Physical properties (Cont'd)

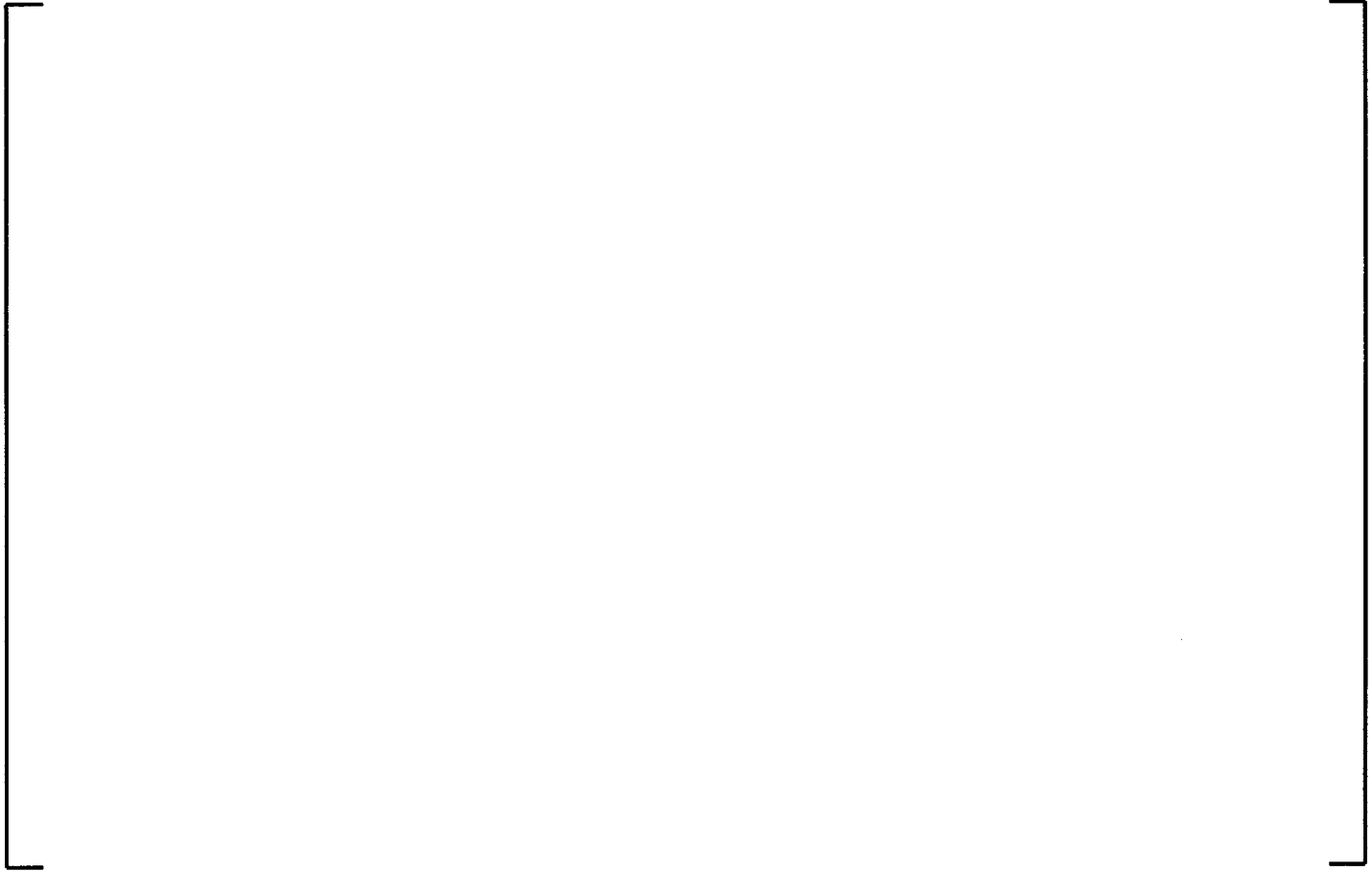
–Thermal Conductivity (A, C)

- » Modified Kohlaruse technique
- » Up to 1210 C

–Thermal Expansion (A, B, C)

- » Alpha-Beta Transition temperature
- » Axial/longitudinal
- » Diametral/Hoop
- » From Room Temperature to 1200 C

ZIRLO™ Characterization Plan



ZIRLO™ Characterization Plan



ZIRLO™ Characterization Plan



a, b, c

Westinghouse Non-Proprietary Class 3 ZIRLO™ Characterization Plan

Mechanical Properties (A, B, C)

–Axial Tensile Tests

- » **Properties:**

- Yield Strength
- Ultimate strength
- Elongation at failure
- Modulus of elasticity
- Poisson's ratio

- » **Temperatures:**

- RT: Connect with large Production Certification databases and prior data
- 390 °F (200 °C) Intermediate temperature to improve temperature-property curves
- 660 and 725 °F (350 and 385 °C) Near operating temperature for a range of reactors.
- 1110°F (600°C) Abnormal conditions.

Westinghouse Non-Proprietary Class 3 ZIRLO™ Characterization Plan

Mechanical Properties (Cont'd)

–Hoop Burst Test:

» **Properties:**

Ultimate strength

Elongation at failure

Modulus of elasticity

Temperatures:

RT, 390, 660, 725°F (RT, 200, 350, 385°C)

–Biaxial Burst Test:

» Ultimate strength

Temperatures:

RT, 390, 660, 725°F (RT, 200, 350, 385°C)

Westinghouse Non-Proprietary Class 3 ZIRLO™ Characterization Plan

Mechanical Properties (Cont'd)

–Fatigue (A)

- » Room temperature
- » Up to 10 million cycles
- » Tension and compression
- » 6 stress levels starting from [] a, b, c at 20 MPa interval

–Particle Size (A)

- » Size and distribution of intermetallic phase particles
- » Minimum of 100 particles to be photographed per sample

ZIRLO™ Characterization Plan

High Temperature/LOCA Tests (A, C)

–Quench Tests

- »Demonstrate acceptable cladding ductility under LOCA quench conditions.
- »Cladding will be rapidly oxidized in a high temperature steam environment to produce varying levels of oxide thickness.
- »The sample will be quenched to room temperature by submersion in water.

ZIRLO™ Characterization Plan

High Temperature/LOCA Tests

–Ring Compression Tests

- » Measure ductility retained by cladding following rapid oxidation.
- » Cladding samples rapidly oxidized in a high temperature steam environment to produce varying levels of oxide thickness.
- » The oxidized samples will then be cut into rings and used as ring compression samples.
- » Compression testing provides quantifiable ductility data for cladding that has been severely oxidized.

Westinghouse Non-Proprietary Class 3 ZIRLO™ Characterization Plan

High Temperature/LOCA Tests (Cont'd)

–Metal-Water Reaction (High Temperature)

- » Cladding samples will be oxidized at high temperature to produce a uniform oxide coating
- » The weight gain of the oxide will be recorded , oxidation rates calculated and compared with previous ZIRLO™ data

Westinghouse Non-Proprietary Class 3 ZIRLO™ Characterization Plan

High Temperature/LOCA Tests (Cont'd)

–Burst Test (Strain & Temperature @ burst)

- » [] sections of cladding are internally pressurized with argon.
- » Rapid temperature transients are produced by infra-red heating of the cladding to simulate LOCA conditions.
- » The burst temperature and physical condition of the tube following burst are recorded and used to calculate strain at burst.

ZIRLO™ Characterization Plan



ZIRLO™ Characterization Plan



Westinghouse Non-Proprietary Class 3 ZIRLO™ Characterization Plan

High Temperature/LOCA Tests (Cont'd)

–LOCA creep

- » Cladding tube sections are held at a constant temperature and pressure.
- » Temperatures will be chosen to provide test in all the alpha , alpha/beta , and beta phase ranges.
- » The diametral strain of the cladding will be measured as a function of time providing data about the creep behavior of the alloy.
- » Testing different temperature and pressure combinations will provide data on the cladding creep performance under LOCA conditions.

ZIRLO™ Characterization Plan

- Low Tin ZIRLO™ Licensing

- A complete set of ZIRLO™ base material properties updated with Low Tin ZIRLO™

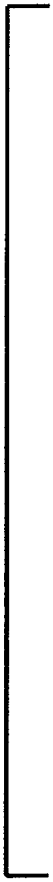
- Regions will be licensed to all current criteria. Current models will be justified and compared to test data. Information will be submitted for review and approval in addenda to WCAP-12610-P-A and CENPD 404-P-A to expand ZIRLO™ definition to cover low tin condition for region introduction

ZIRLO™ Characterization Plan

- Planned Changes in ZIRLO™ Specification

- Are minor - similar to past changes in Zirc-4
- Provide greater corrosion margin and higher fuel duty capability
- Will be submitted for review in addendum's to existing topical's with updated material properties
 - WCAP-12610-P-A and CENPD 404-P-A

ZIRLO™ Characterization Plan



ZIRLO™ Characterization Plan

- Byron LTA 1st Cycle (high Duty, High FDI) Rod oxide Data Summary

- Low tin ZIRLO™: []^{a, c}

- Standard ZIRLO™: []^{a, c}

ZIRLO™ Characterization Plan

- Low Tin ZIRLO™ Introduction

Planned Schedule

- First NRC meeting to layout planned licensing path ● Oct 29, 2001
- Low Tin ZIRLO™ Characterization plan ● July, 2002
- Submit Low Tin ZIRLO™ Addenda to ● Dec. 2002
 - WCAP-12610-P-A
 - CENPD 404-P-A
- NRC Approval of Low Tin ZIRLO™ Addenda ● July, 2003
- Region introduction of low tin ZIRLO™ ● []^{a, c}

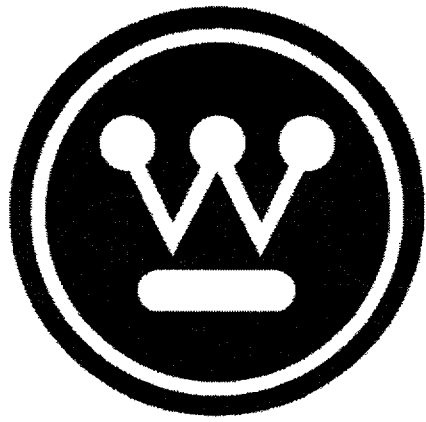
ZIRLO™ Characterization

- Summary

- Low tin ZIRLO™ Characterization consistent with earlier presentations
- Basic material properties characterization will be expanded
- Low Tin ZIRLO™ characteristics will be demonstrated to be compatible with standard ZIRLO™ properties and submitted as addenda to current WCAPs (WCAP-12610-P-A, CENPD 404-P-A)

**Westinghouse
Presentation on
DNB Testing
(Slide Presentation of July 11, 2002)**

June 2002



Westinghouse

A BNFL Group company

Westinghouse DNB Testing

Gerald Sieradzki
July 11, 2002



Westinghouse DNB Testing

Outline

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

Westinghouse DNB Testing

Closing of Columbia HTRF

- Columbia HTRF is closing down by 6/30/03
- All W DNB test data supporting NRC - approved DNB correlations were obtained from HTRF
- Closing down of HTRF has major impacts on future safety analysis in the U.S.

Westinghouse DNB Testing

Requirements of DNB Testing

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

- Fuel changes not covered by FCEP may require DNB tests

- []^{a, c}
-
-

Westinghouse DNB Testing

Alternate Test Facilities

- W is actively evaluating alternate DNB test facilities
- All alternate facilities are []^{a, c}
- Primary facility under consideration is []^{a, c}
- Backup facilities include:
 - []^{a, c}
 - []^{a, c}
 - Other facilities

Westinghouse DNB Testing

Westinghouse Qualification Process

- Over the years, W has developed a process for qualifying test facilities and data for safety analyses
 - Personnel qualification
 - Testing procedures
 - Data collection and reduction
 - Test bundle manufacturing, etc.

Westinghouse DNB Testing

Westinghouse Qualification Process (continued)

- The process was applied to Columbia HTRF and [
] ^{a, c}
- The process will include [
] ^{a, c}
- 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

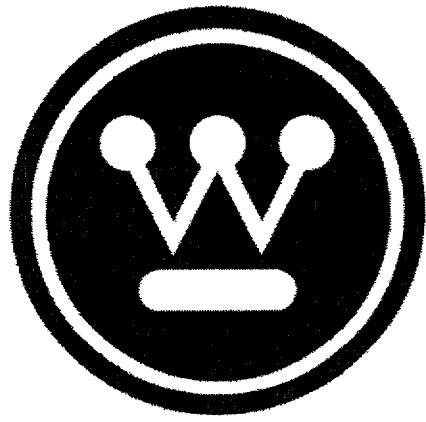
Potential Licensing Applications

- DNB test data collected from an alternate test facility will meet W QMS requirements
- DNB test data on future fuel designs will be used for qualification of 95/95 DNBR limit
 - An existing NRC-approved DNB correlation
 - Minor adjustment to a DNB correlation
 - A new DNB correlation

Westinghouse DNB Testing

Summary

- Because of the closing down of Columbia HTRF, W is evaluating alternate DNB test facilities to meet regulatory requirements for future fuel design changes
- W intends to apply its proven qualification process to any alternate test facility
- DNB data from an alternate test facility will be used for justifying the 95/95 DNBR limit of a DNB correlation



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