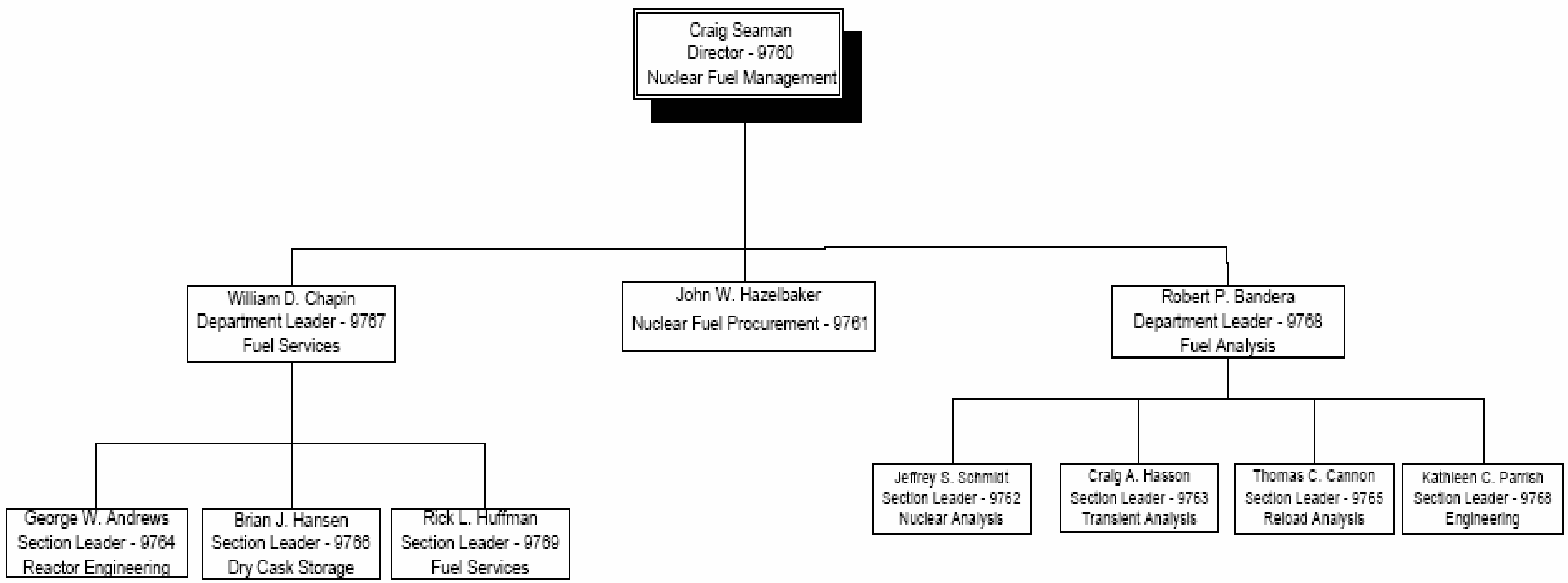
Nuclear Fuel Update

Palo Verde Nuclear Generating Station

December 9, 2004
Meeting with US NRC

NUCLEAR FUEL MANAGEMENT 2004



Review of 2003-4

- March 2003 Meeting with NRR
- CENTS Implementation
- Steam Generator Replacement
- Power Uprate
- CPC Replacement
- Dry Cask Storage in Production

Agenda Today

- Fuel Performance
- Considering Dual LTA Program
- CEA Replacement
- Planned License Submittals
- Dry Cask Storage Update

Palo Verde
Fuel Performance

Fuel & Clad Performance

Clad Performance

Uprate Conditions

High Burnup Leakers

Fabrication Issues

Integrated Fuel Performance

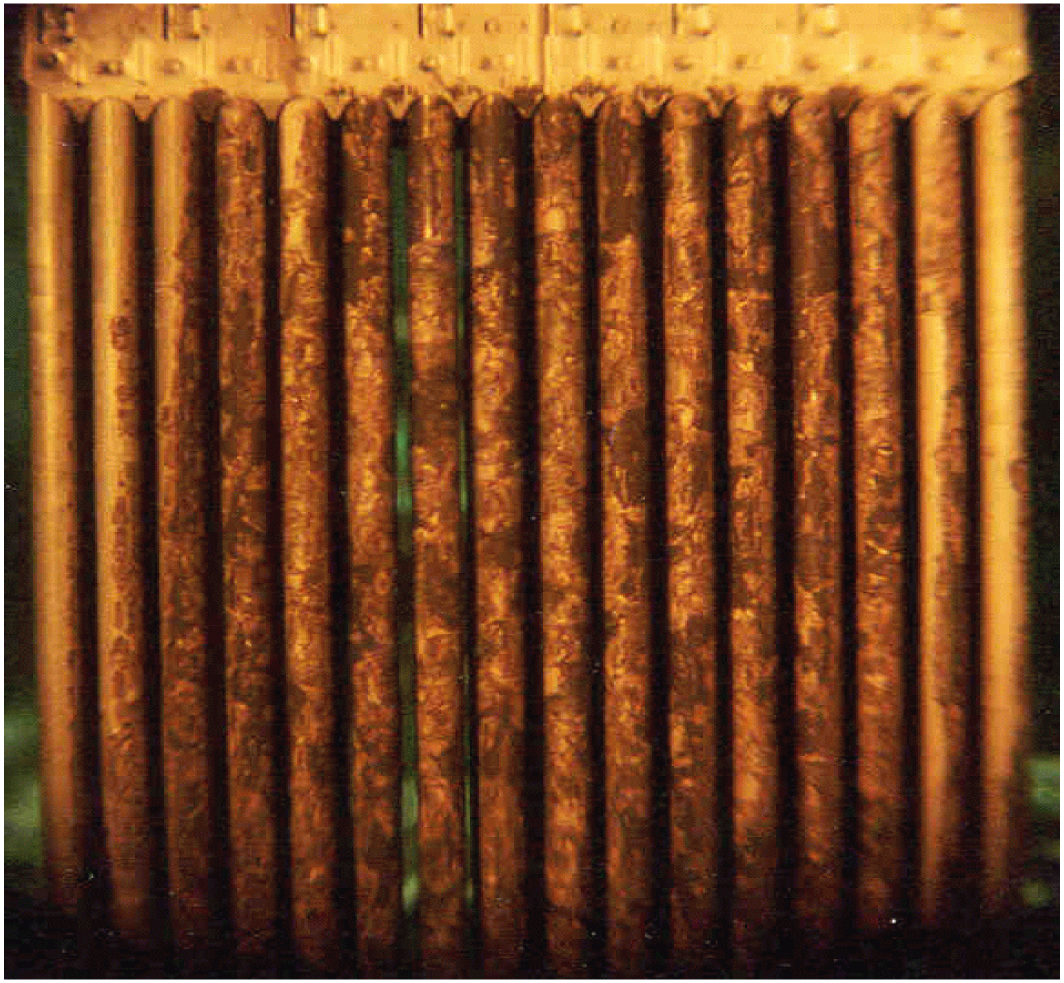
- Clad Performance Strategy:
  - Advanced Clad Alloys
  - Primary Chemistry
  - CRUD/Oxide Software
  - Low Duty Core Designs
- Multi Phase Performance Program
  - 3876 MW and 3990 MW Conditions
- Long Range Fuel Inspection Plan

Early Learnings in Fuel Performance

- Evolution of Core Design Strategies
  - Low Leakage Checkerboards
  - Feed-Face-Feed Strategies
  - Modified Checkerboards
- Unit 2 Cycle 9
  - Axial Offset Anomaly (CIPS)
  - Fuel Failures
- Cause of CRUD and Oxidation
  - Different Fuel Duty Cycles
  - Different Solutions

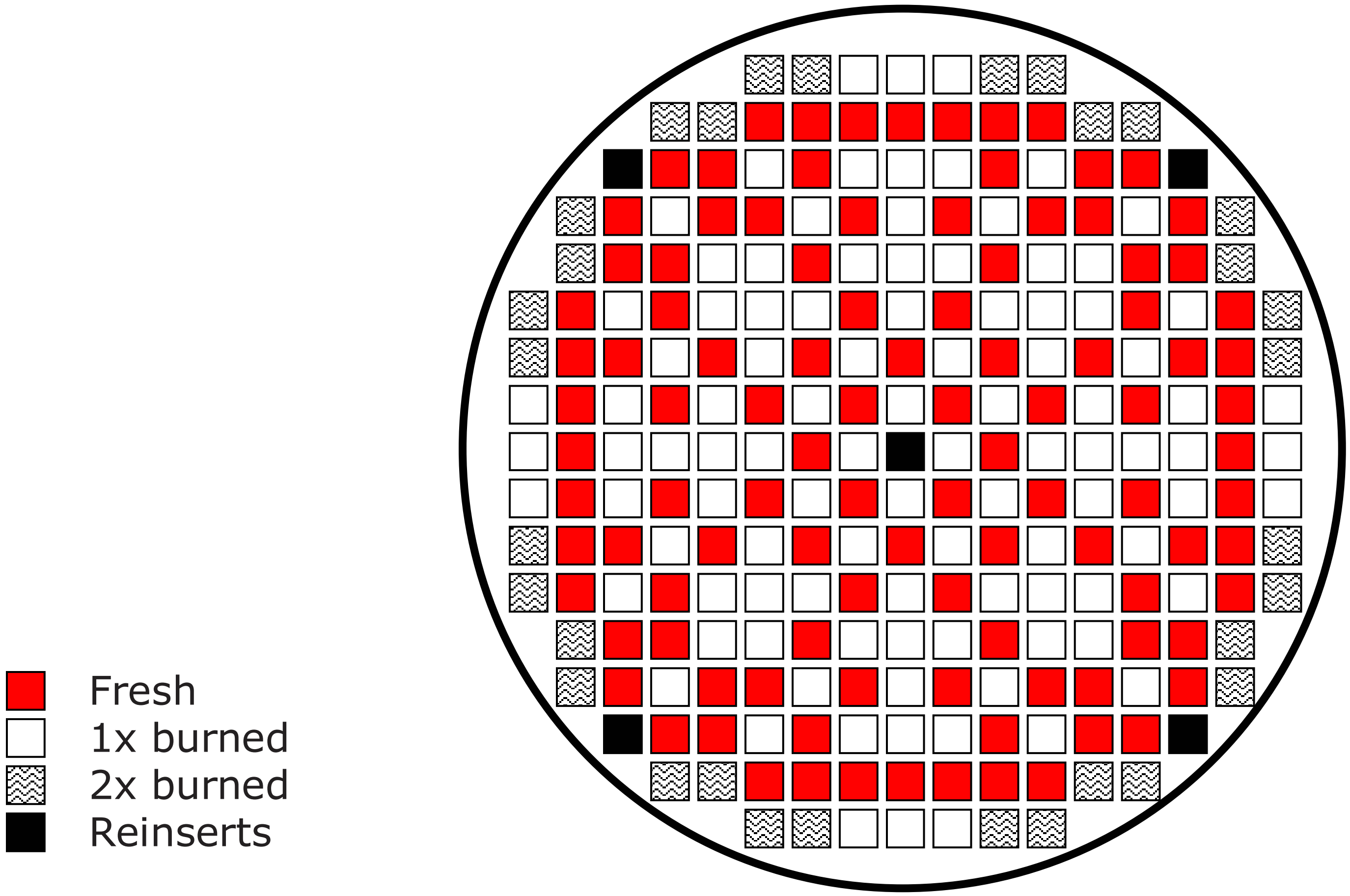
Clad CRUD in Unit 2 Cycle 9

P2L5xx Assembly Face



The Two Duty Cycles

Typical (U2C13) Core Design



Fuel Performance in Uprate Conditions

- 3% Power and ~2 °F Inlet Temperature
- New Steam Generators
- Increased Clad Oxidation
  - Spallation Risk
- Increased Steaming Rate
  - Each 1 °F or 1% Power is Worth 10% Steaming Rate
  - Higher Source Term from New Steam Generators
  - CRUD & AOA Risk

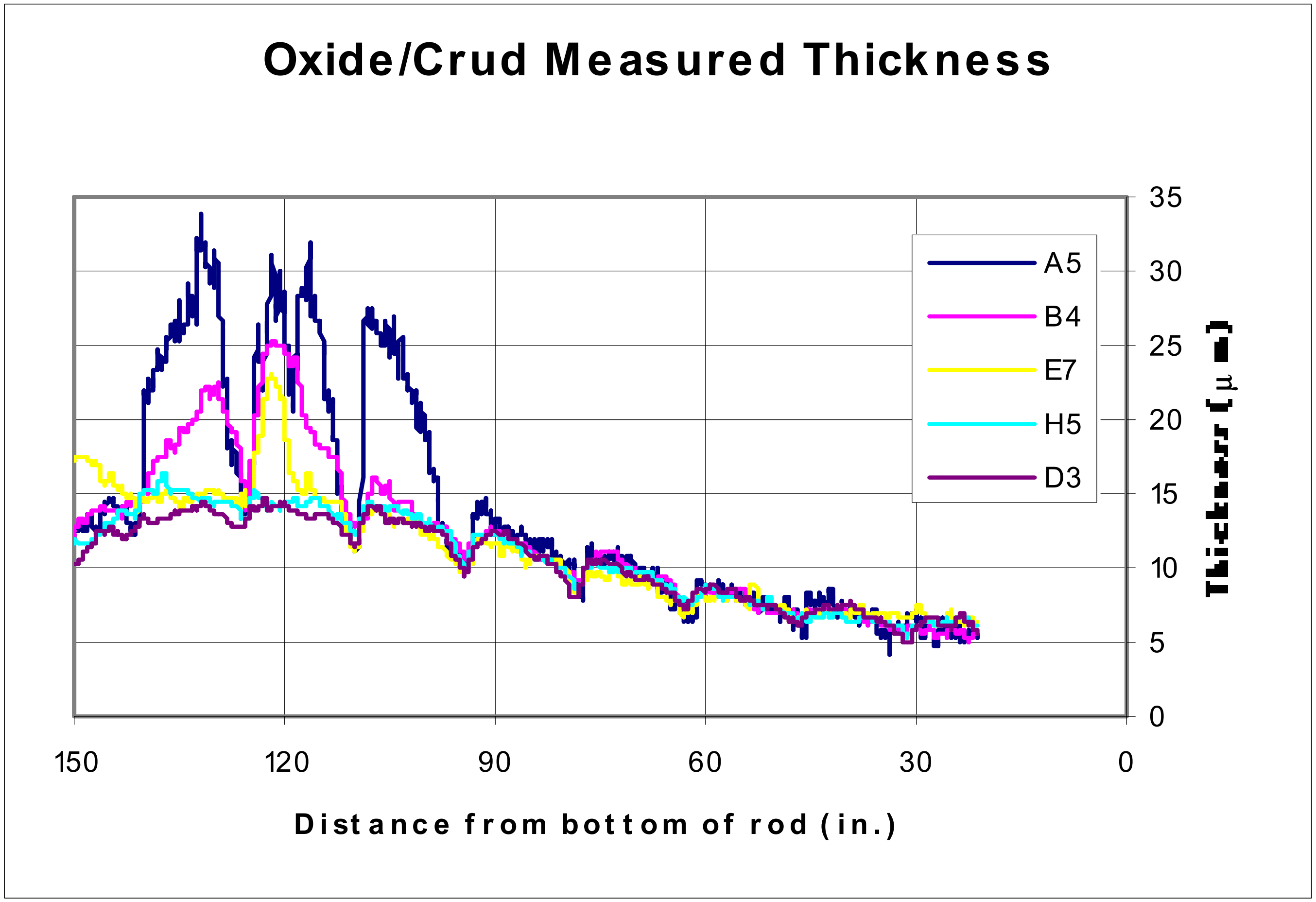
ZIRLO^{TM} Clad

- Westinghouse Low Tin Zirconium Based Alloy
- First Implementation in Unit 2 Cycle 11
  - Protect High Duty 2 Cycle Assemblies
- Licensing Limitation
  - Fuel Duty Index
  - Maximum Oxide Thickness
- 2R11 Inspection Results
  - Performance as Expected

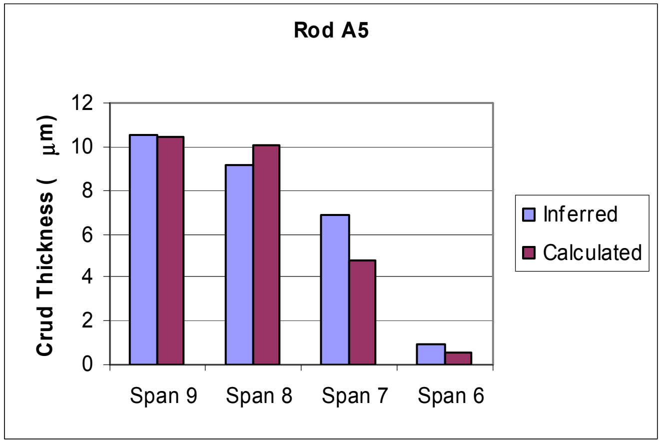
New Lattice Design

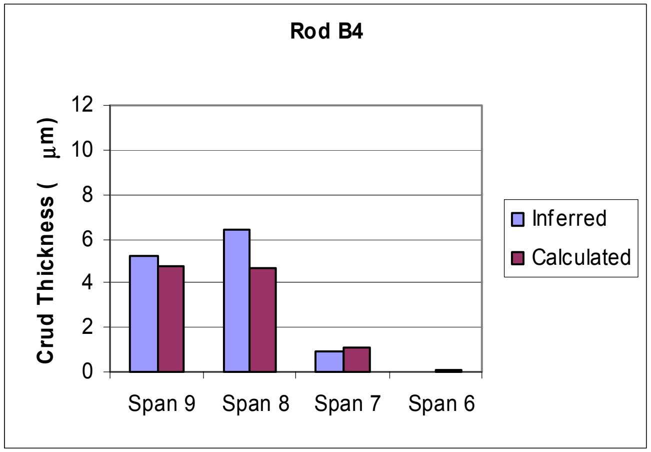
- First Implementation in Unit 2 Cycle 12
  - Protect High Duty First Burn Assemblies
- Design Concept – Balance Power & Flow
  - In-House Designed Based on APS CRUD Model
  - Three Enrichments, Four Pin Types
- Extensive Design Review
  - In-House, Westinghouse, URA

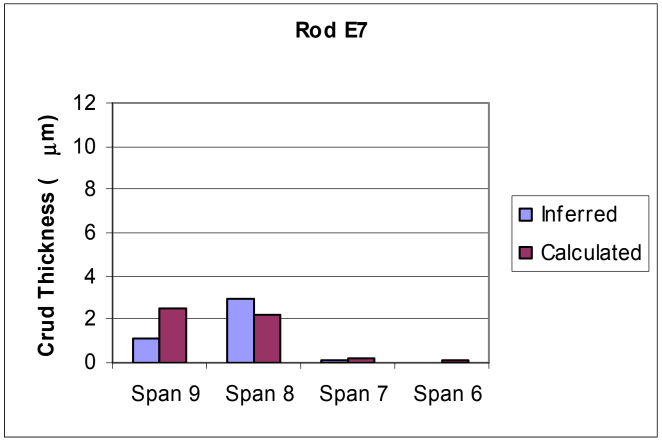
Crud Model Development

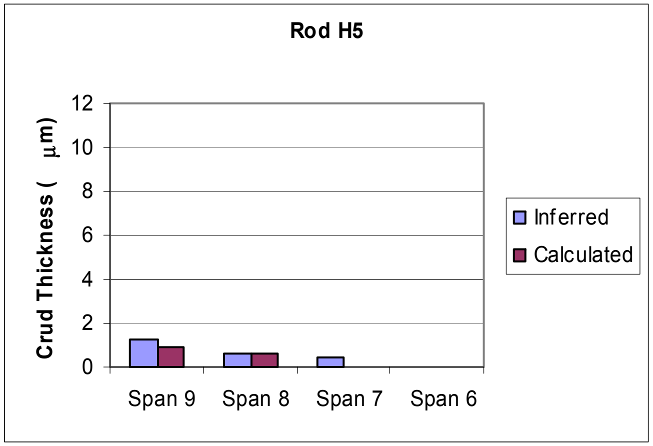


Crud Model Results









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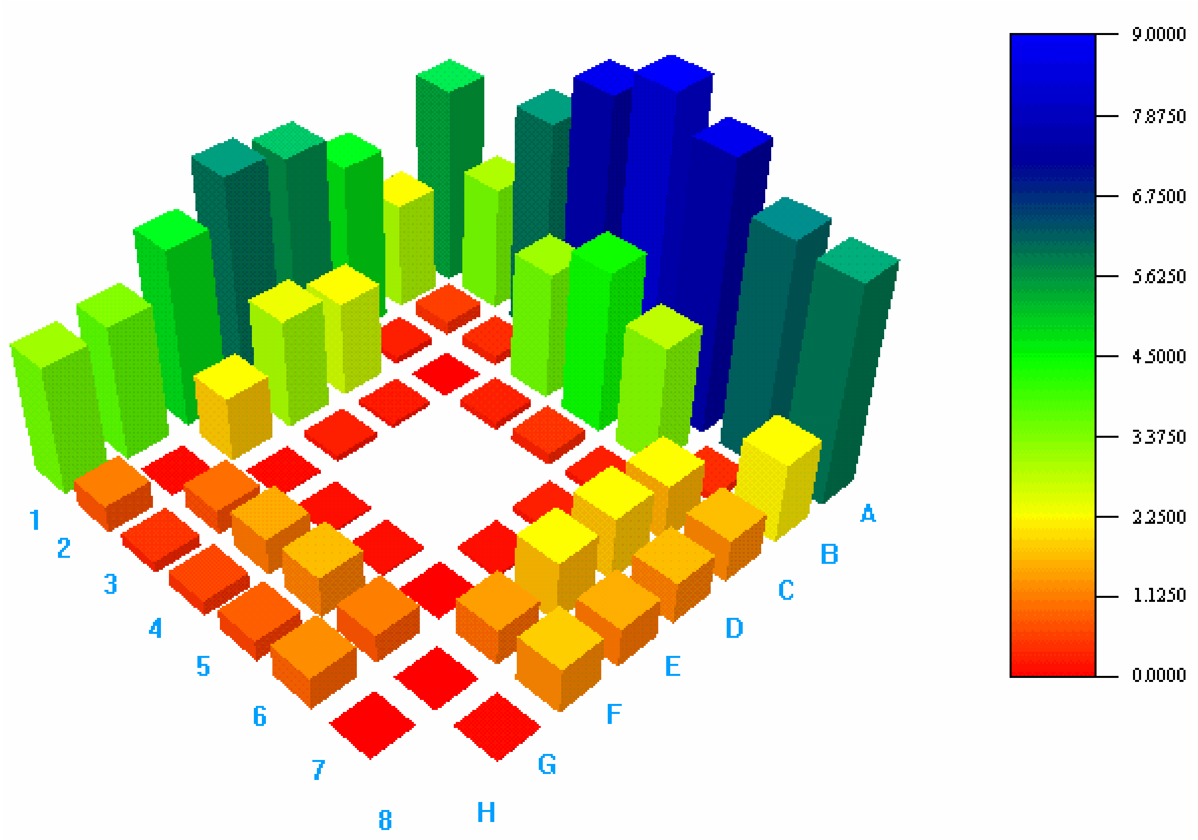
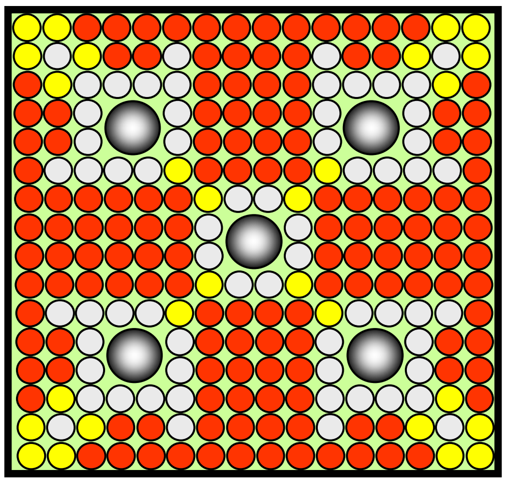
Crud Model Results



Revised Lattice Design Objectives

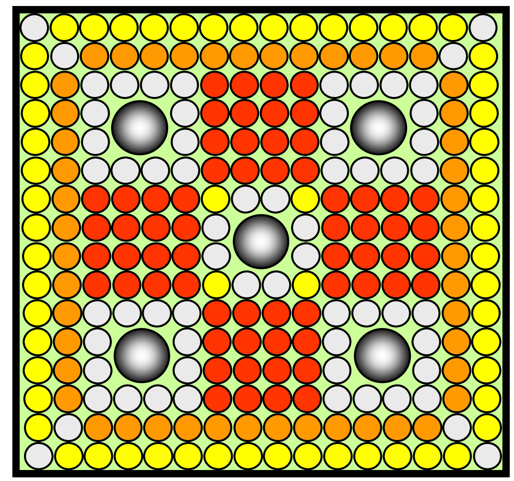
- Smallest Change Possible
- Change Only Well Understood Lattice Feature(s)
- No Operational, Licensing, Manufacturing Impact
- Minimal Safety Analysis Impact

Sample Lattice Comparison



Previous - 64 Er

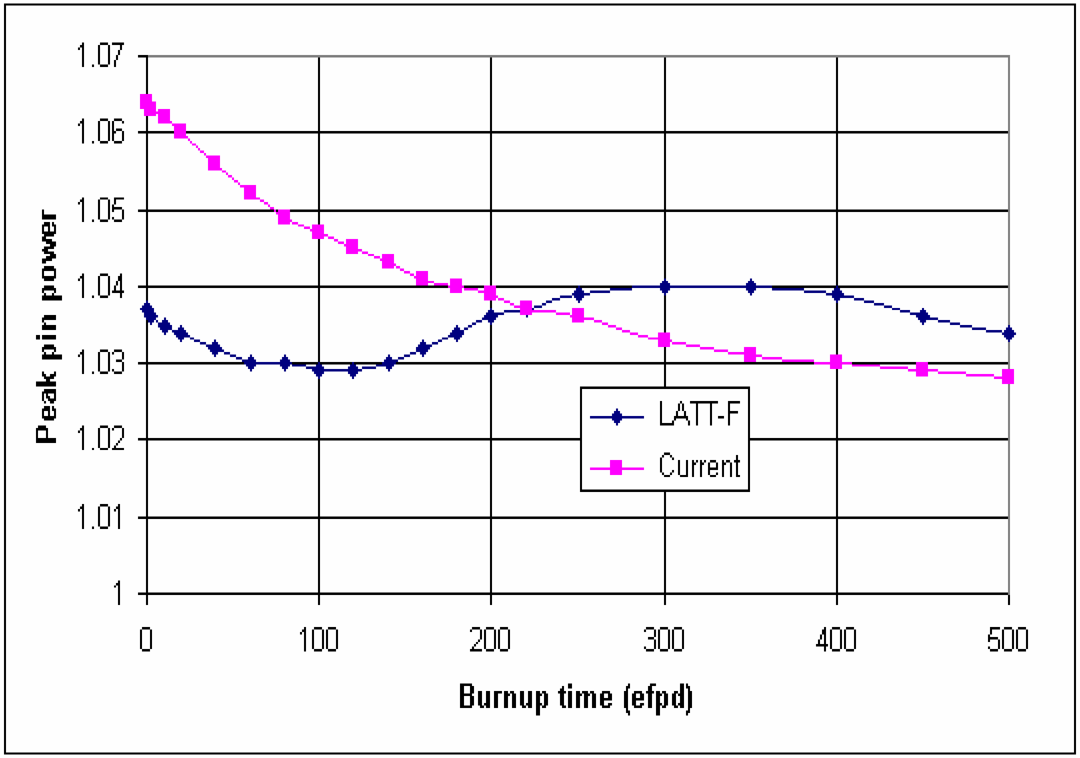
- 4.05 w/o
- 3.75 w/o
- 3.75 w/o Er



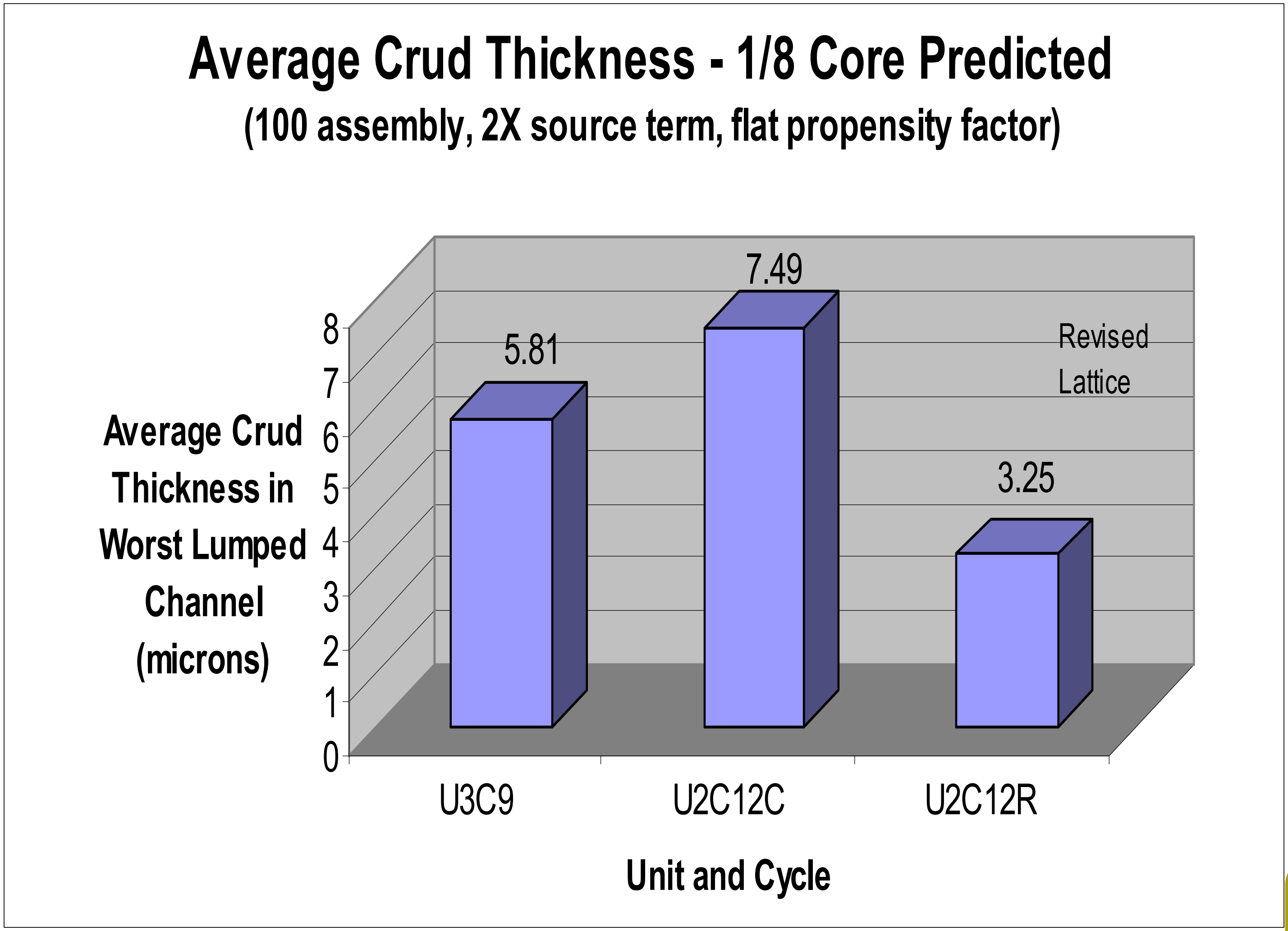
New - 64 Er

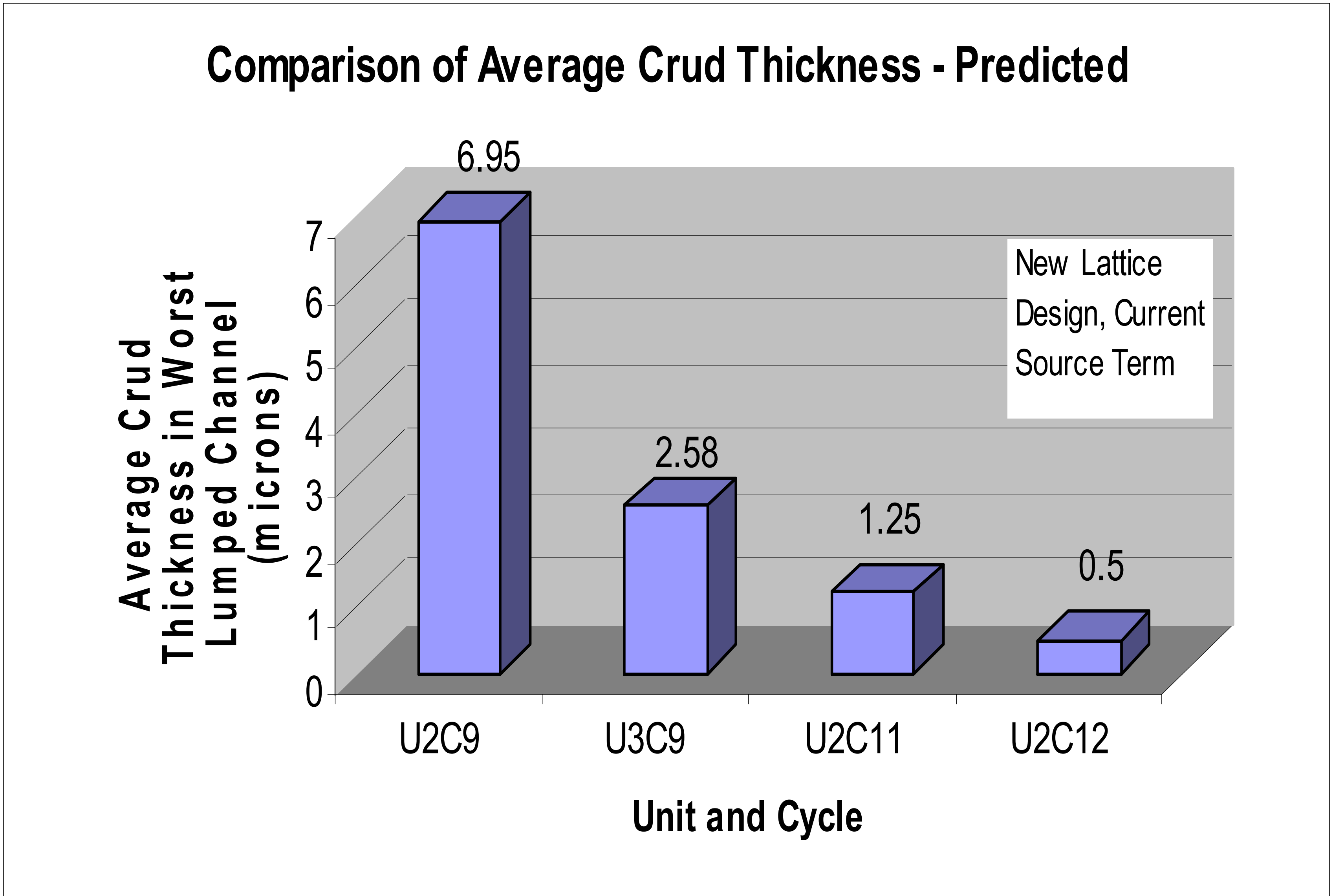
- 4.29 w/o
- 3.99 w/o
- 3.79 w/o
- 3.79 w/o Er

Pin Power Comparison



New Lattice CRUD Impact




Comparison of Average Crud Thickness - Predicted
Average Crud Thickness in Worst Lumped Channel (microns)
0
1
2
3
4
5
6
7
6.95
2.58
1.25
0.5
New Lattice Design, Current Source Term
U2C9
U3C9
U2C11
U2C12
Unit and Cycle

Long Term Fuel Inspection Program

- Proof of Design Concept
  - Davis-Besse: "I know because I looked"
- Zirlo
- New Lattice
- Other Planned Inspections
  - Assembly Bow
  - Top Grid

Flawless Fuel

- New Agreement with Westinghouse
  - Identify and Investigate All Failures
  - Incentive for Flawless Fuel
  - Reconstitute Failed Assemblies
- Sipping in Containment
- UT in Spent Fuel Pool

High Burnup Fuel Performance

High Burnup Fuel Failure Trend

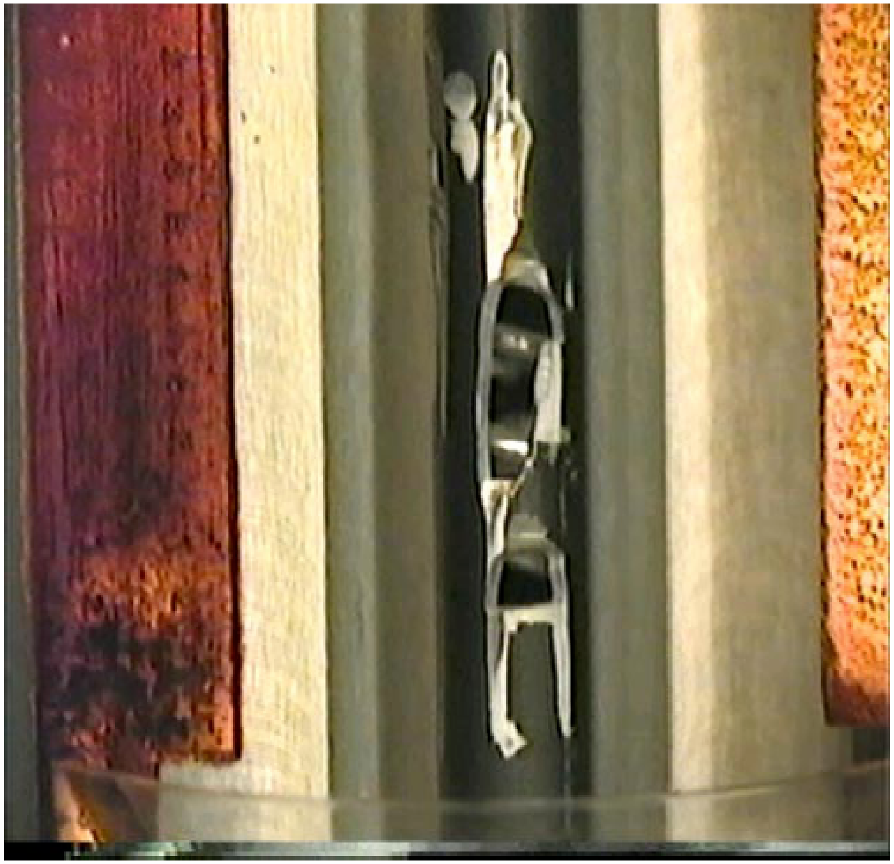
Loose Top Grid Cells

Top Grid Re-Design

High Burnup Fuel Failure Trend

- Mid 90's, Clean Cores Cycle After Cycle
- Ten Failed First Burn Pins in U2C9
- One Failed End Cap Weld (U1C9)
- Nine Indications Starting with U2C9
- Five of Nine Cycles with 1 or 2 Indications
- UT Has Failed Repeatedly to Locate Rods
- Three Identified Grid-Rod Fretting Failures

Figure 4.5.9 Assembly P2L108, Rod I10 – Through-Wall Spring (top) and Back-Up Arch (bottom) Wear Scars on 90° Face at Grid 10

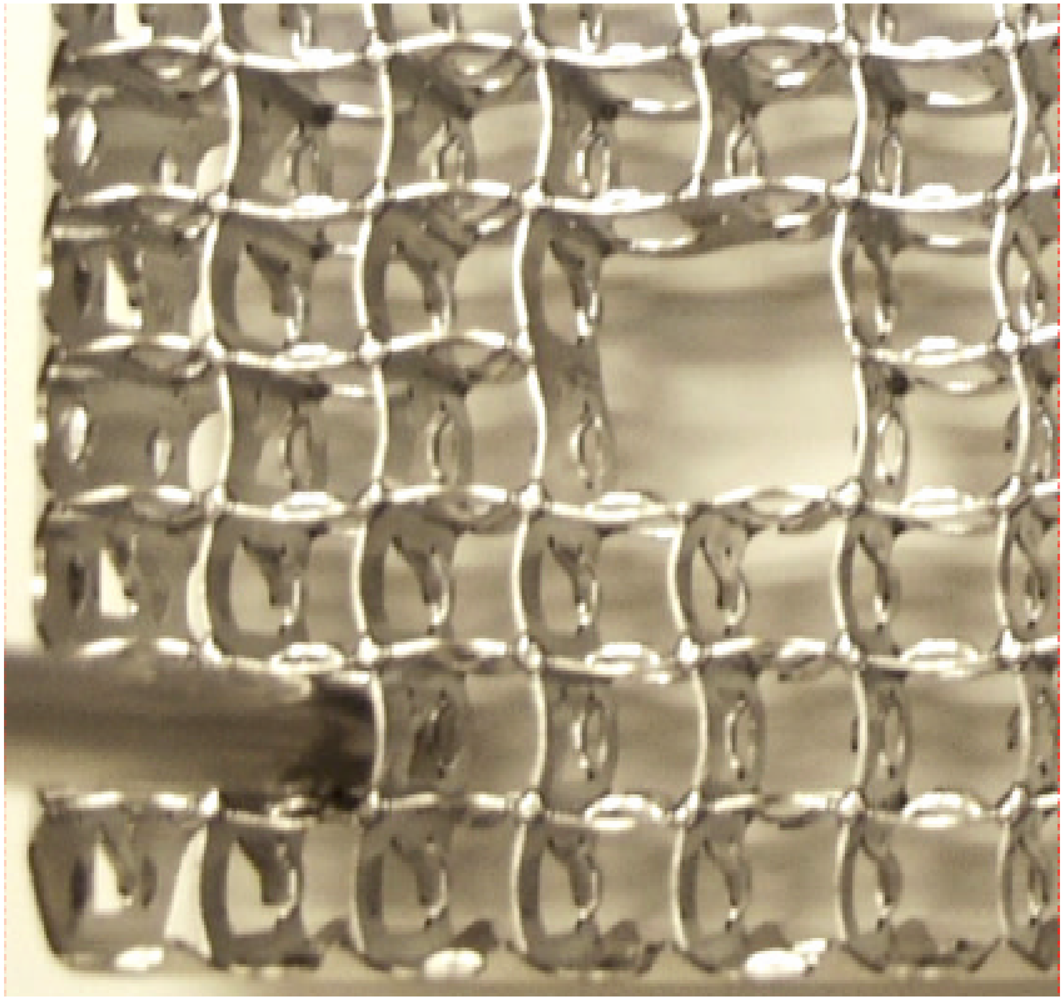


Loose Top Grid Cells

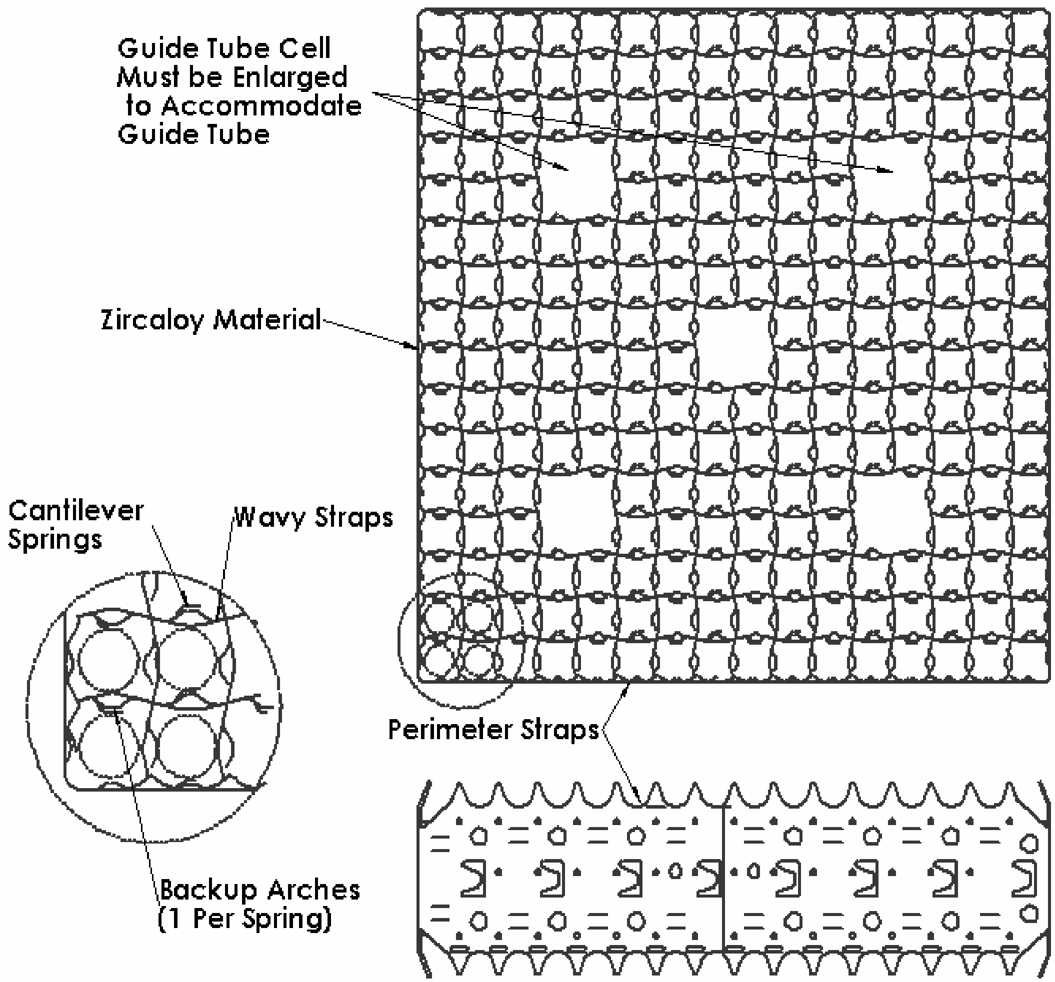
- PV1P Fabrication Campaign
- Description of Rod Support Features
- Root Causes
  - Bias in Grid Construction Tolerances
  - Force-Fit of 20 mil Oversize Guide Tube
  - Rod Pushing Table Mis-Alignment
  - Weaknesses in Inspection/QA Process

Loose Grid Cells & Grid-Rod Fretting

Current Zircaloy Top Grid



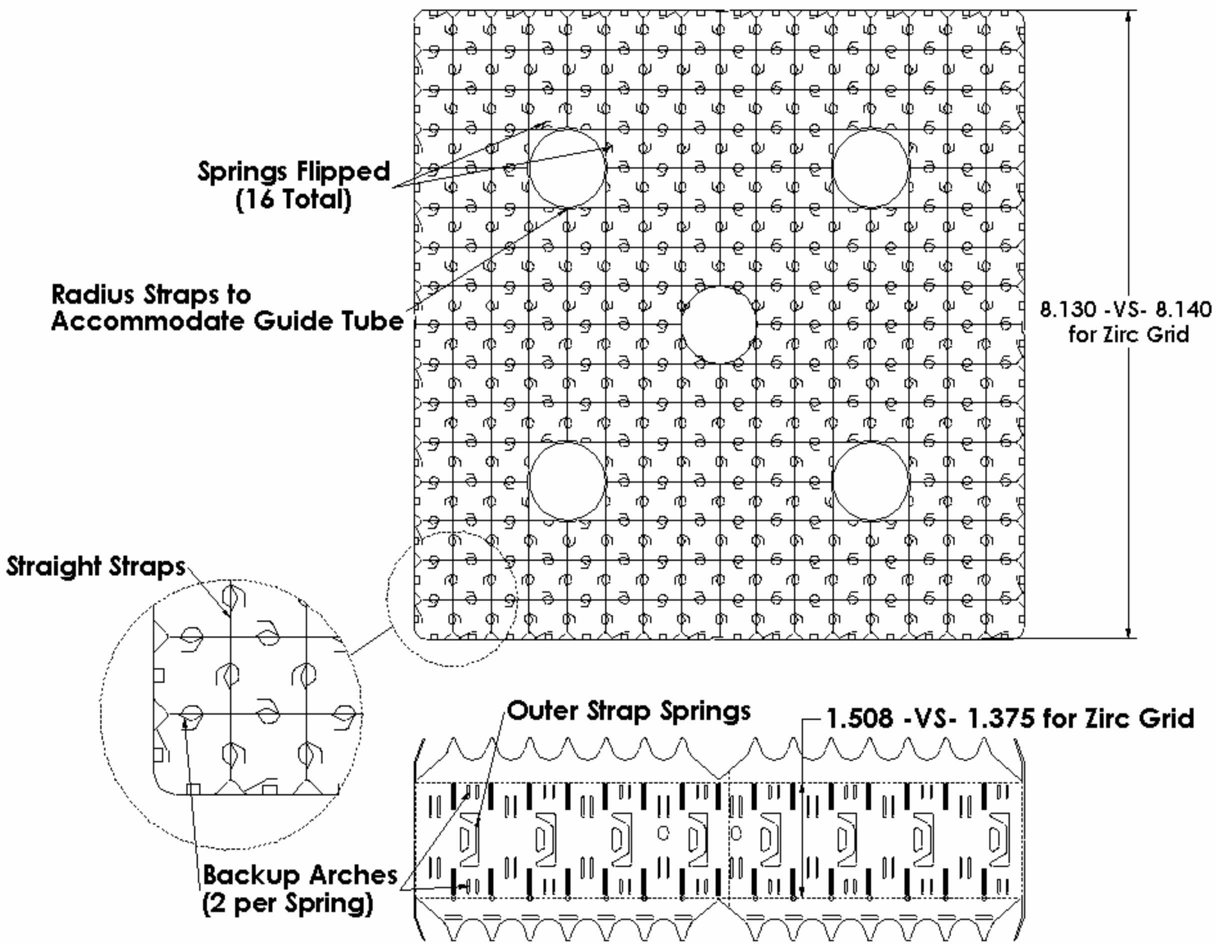
Current Zircaloy Top Grid



Top Grid Re-Design

- Zirc-4 to Inconel 625
- Wavy strip to Straight Strip
- Cantilever Spring Cut-out
- Double Back-up Arch
- Accommodation of Expanded Guide Tube
- Grid to Guide Tube Attachment
- Change to "Top Nozzle" (UEF)
  - Assembly Length Measurements Spring 2005

Proposed Inconel Top Grid



Dual LTA Program

Long Term Fuel Design Strategy

- Fuel Contract Timeline
  - 12 Years on Westinghouse Contract
- LTAs Needed to Demonstrate New Design
  - 8 Assembly, 3 Cycle LTA Programs
- AREVA and Westinghouse Designs
  - No Current Disaster Back-up to Columbia
  - More Options Lead to Better Designs
- Starts 2005

Specific Fuel Design Goals

- Materials for Higher Burnup/Duty
  - Cladding Oxidation
  - Dimensional Stability
- "Mixing" Grids
  - Minimize CRUD
  - Increase Thermal Margin
- Preserving/Increasing Operating Margins
- Improve Fuel Utilization
- Overall Robust Design for Flawless Fuel

CEA Replacement

CEA Replacement

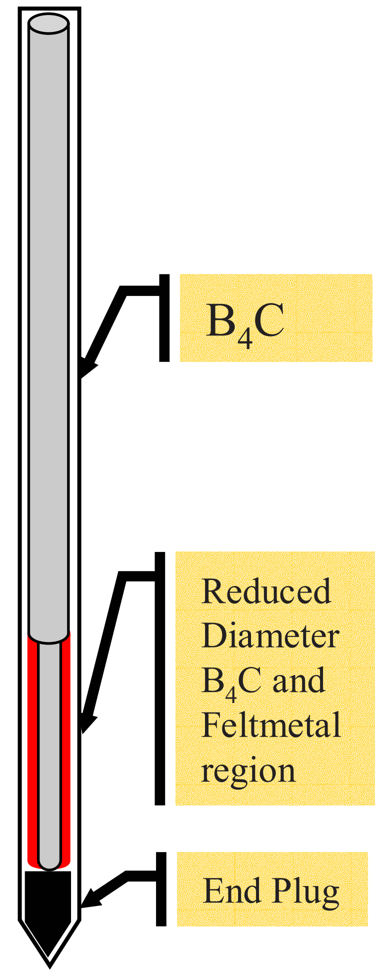
- Review CEA History
- Determination of New, Conservative Lifetime
- Design of New Replacement CEAs
- Replacement of PLCEAs

Review of CEA History

- CEA Clad Failures Observed - 2001
  - Cracks in High Fluence CEA Tips
  - Root Cause - IASCC, Inadequate Testing
  - U2/U3 With Small Pellet Less Severe
- All Full Length CEAs Replaced
  - Replaced by Design with Smallest Pellet
- Lifetime Software Abandoned

Control Element Assemblies

- 89 CEAs in 8 groups
  - 148 inches of B_4C poison
- 4-finger and 12-finger assemblies
  - B_4C wrapped in "Feltmetal" at bottom 8%
  - 12-finger CEAs span 5 assemblies
  - 688 total fingers



Determination of New Lifetime

- Investigated Various Options
- Monitored YGN Inspections
- Vendor Adjusted Software
- Inconel IASCC Threshold
- Observed Crack in U2C8 CEA

⇒ **5 Cycle Lifetime**

⇒ **Need New CEAs for Fall 2008**

Design of Future CEAs

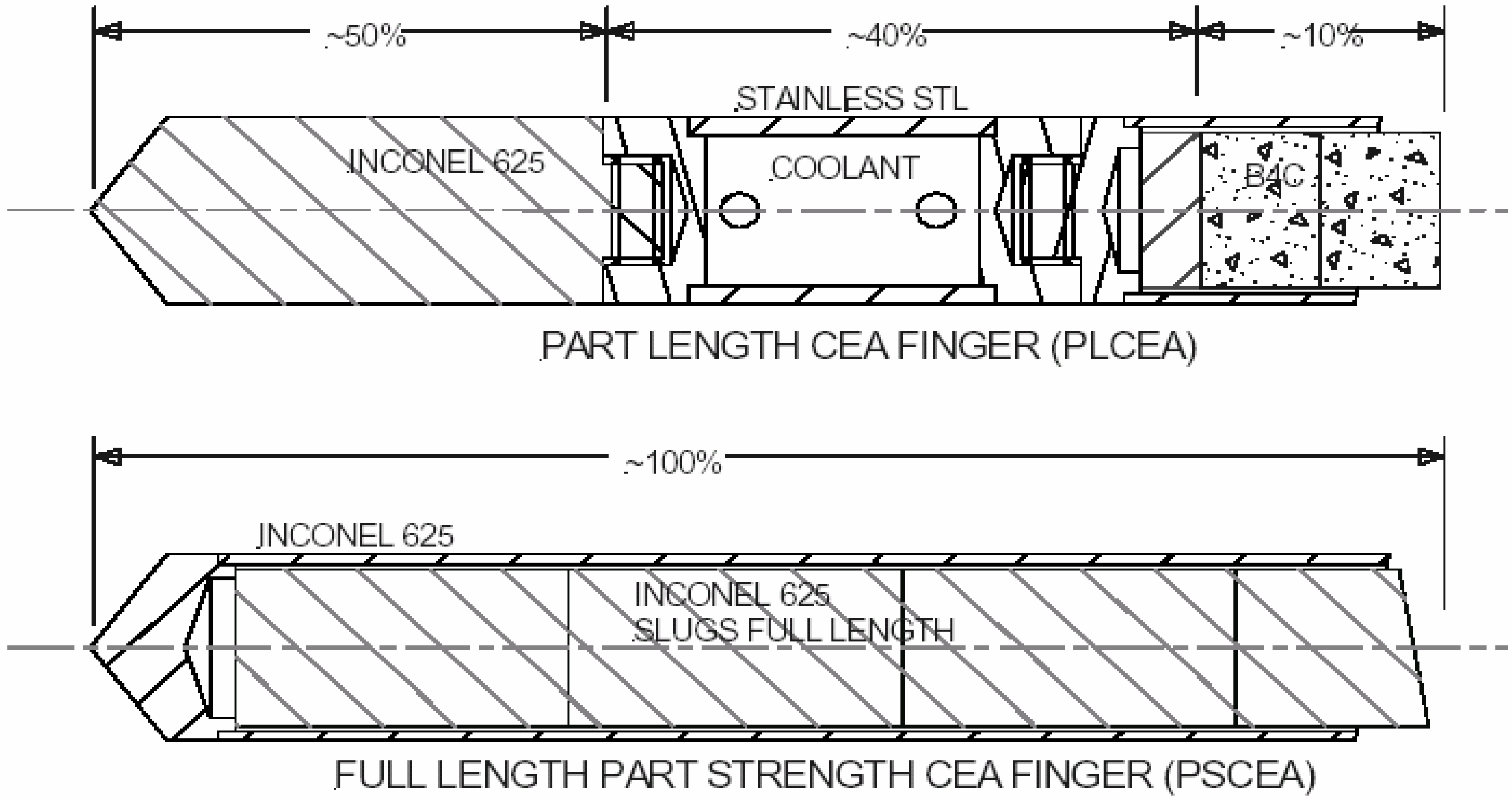
- Now: Unique Feltmetal Design
- Want:
  - Industry Standard AgInCd
  - Extended Tip Region
- CEDM Weight Restrictions
  - AgInCd Tip Region
  - Boron Carbide for Remainder
- Lifetime Issues Remain
  - 20 EFPY Design Lifetime
  - ~12 EFPY Experience Base

Replacement of PLCEAs

- Original Equipment
  - Part Length, Part Strength
  - Not Subject to Same Failure Mode
  - Replacing Now for Prudency
- Replacements
  - Full Length, Part Strength
  - Transparent to Safety Analysis
  - Tech Spec Change Approved
- U1 Done -- U3 Done -- U2 Spring 2005

New Design PSCEAs

Comparison of Part Strength CEAs



Planned License Submittals

2005 License Submittals

- (U1 & U3 Power Up-Rate in Review)
- TS 3.1.6
  Shutdown CEA Insertion Limits
- TS 5.6.5
  Core Operating Limits Report

Shutdown CEA Insertion Limits

- Current T.S. allows insertion to 144.75" withdrawn
  - 6.2" into active fuel
- Safety Analysis only covers insertion to 147.75"
  - 3.2" into active fuel
- Shutdown Margin is monitored per Core Data Book
  - 147.75" withdrawn, forces higher boron concentration
- T.S. 3.1.6 rewritten to reference COLR
  - Shutdown CEA COLR based on 147.75

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Core Operating Limits Report

- One Inconsistent Reference
  – CEA Drop Methodology Reference
- Currently Evaluating Changes
  – Update CEA Drop Reference
  – Remove CESSAR References
  – Update to Power Uprate SER