ENCLOSURE 2

MFN 10-151

Draft Technology Update Presentation

Non-Proprietary Information

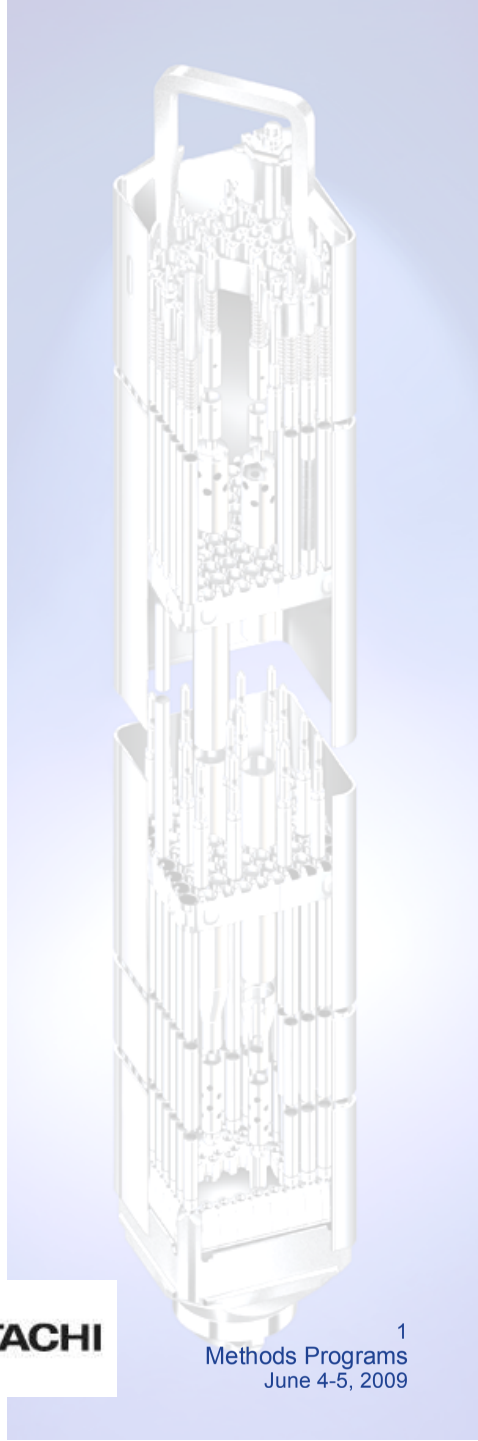
IMPORTANT NOTICE

Enclosure 2 is a non-proprietary version of the Draft Technology Update Presentation from Enclosure 1, which has the proprietary information removed. Portions that have been removed are indicated by open and closed double brackets as shown here [[ ]].

Global Nuclear Fuel - Americas

AETNA Development Status

GNF Technology Update
May 2010



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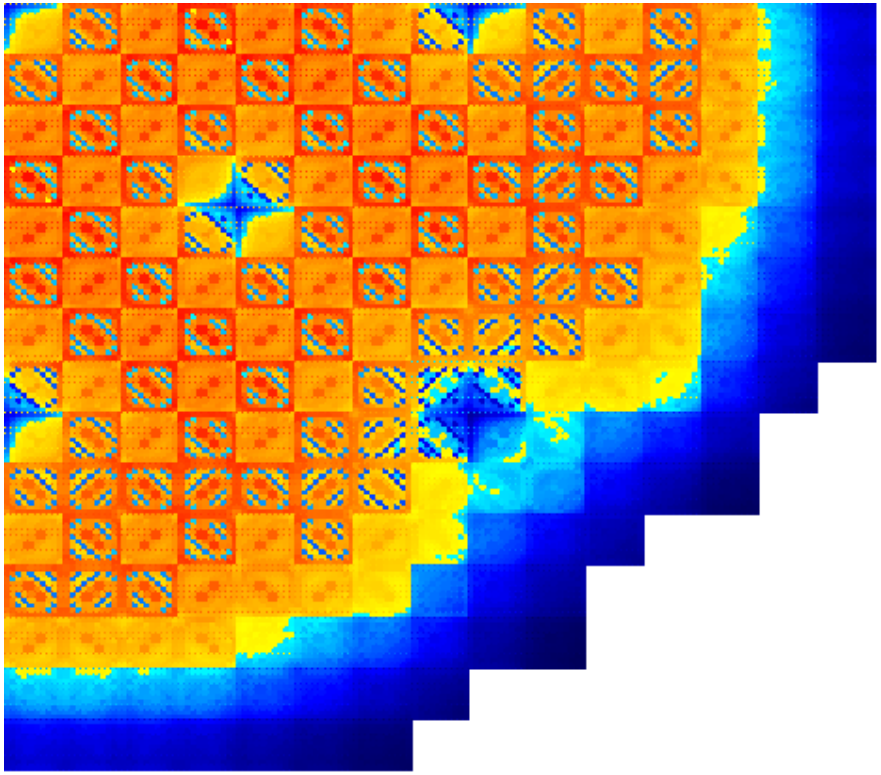
Overview

- AETNA Highlights
- Qualification Strategy
- Plant Operating Data
- Hot Eigenvalue Trend
- TIP Trend
- Power/Exposure Profiles Trend
- Summary
- Conclusions

AETNA Highlights

- Model all fuel bundles, control blades, and T/H within core
- Coupled neutronic-T/H feedback
- 3D coarse-mesh spatial resolution
- 3-group energy structure
- Diffusion theory physics (homogeneous solution)
- Pin power reconstruction (heterogeneous solution)
- Detailed nuclear data obtained from LANCER



Improve Current and Future Applications (e.g. EPU, ESBWR, MOX)

AETNA Feature Detail

Built Upon PANAC11 Software Base

Retain Functionality, User Interface and Automation Support

Cross Section Model

- Expanded Functional Matrix
  - 100% Void Branch / History
  - Control Blade History
- Improved Spectral History Models (Void & Control Blade)
- Fuel Temperature History Model

T/H Physics

- No “Lumped” channels
- Multiple Bypass Regions
- ESBWR Modeling
  - 16 Bundle Chimney
  - Natural Circulation Heat Balance

Nodal Physics Models

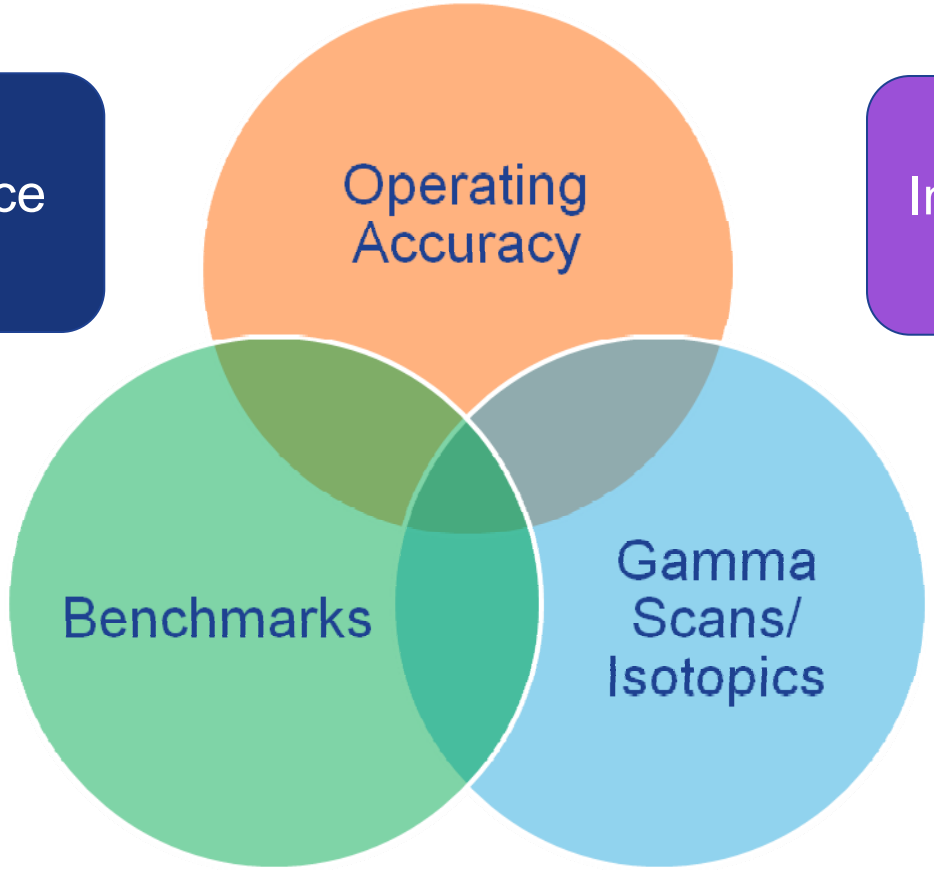
- Semi-Analytic Nodal Method
- 3 Energy Groups
- Improved Pin Power Reconstruction
- Isotopic tracking includes ^{241}Pu-^{241}Am, ^{135}I-^{135}Xe, ^{149}Pm-^{149}Sm, ^{140}Ba
- Multiple control blade modeling
- Exposure Dependent Fuel Temperatures
- Channel Distortion
- Advanced Detector Models

Target Platform: Windows PC

Qualification Strategy

Verification & Validation Approach

User Acceptance Testing



Integration Testing

Plant Operating Data

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Hot Eigenvalue (k_{eff}) Trend

Plant M1, Hot k_{eff}

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Plant M1, Hot k_{eff} Statistics

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Plant M, k_{eff} Trend Fit, P11

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Plant M1, k_{eff} Trend Fit, AETNA02

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Plant ABWR-1, Hot k_{eff}

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Plant K, Hot k_{eff} Cycles 21-36

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Plant K, k_{eff} Statistics

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TIP Trend

Plant K, Bundle TIP RMS

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Plant K, Axial TIP RMS

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Plant K, TIP RMS Cycles 21-36

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Plant M1, TIP Radial

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Plant ABWR-1, TIP Radial

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Plant E, TIP Radial

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Plant E, TIP RMS Cycle 7-11

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Profiles Trend

Plant M1, Axial Powers

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Plant M1, Axial Exposures

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Summary

Initial Observations for AETNA02

- Establish keff bias
  - Initial cycles lower
  - Other cycles higher → ENDF/B-VII
- Nuclear Design Basis keff – bathtub
- Power shape accuracy
  - Improved radial response
  - Large changes in axial shape
- SLMCPR uncertainties will improve

Integration Testing

- Windows production environment
- Automating lattice library
- Building user experience
  - PC Computing Cluster
  - Increased disk space requirements
  - Parallel job submittal

Conclusion

- A02 Qualification (V&V) is Ongoing
- Testing includes independent users with a broader base of plant cases
- Integration with other GNF ECPs in progress

2010 Technology Update

Marathon Control Rod Performance

Scott Nelson

May 20, 2010

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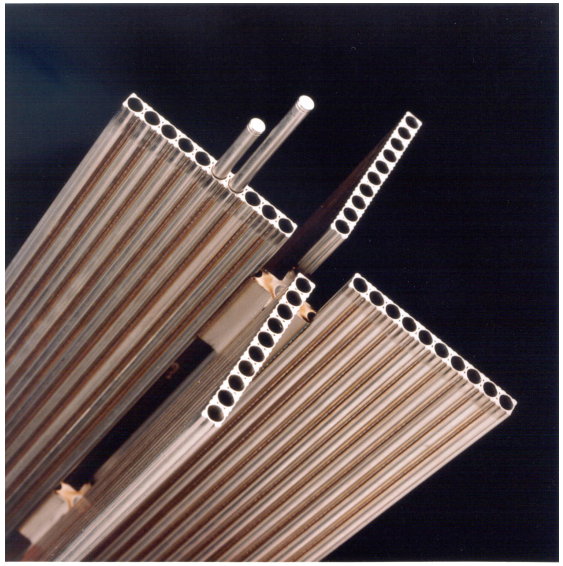
Marathon Control Rod Performance



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Marathon Surveillance Program Requirements

- The Marathon (NEDE-31758P-A, 1991) and Marathon-5S (NEDE-33284P-A Rev. 2, 2009) control rod Safety Evaluations contain surveillance programs.
- Require visual inspections of irradiated Marathon and Marathon-5S control rods.
- The status of the surveillance program was last updated in May 2010 via MFN 10-153.

Marathon Surveillance Program Status

- **MFN 10-153 contains new inspection results for four high depletion Marathon control rods.**

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Marathon Surveillance Program Status

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Marathon Surveillance Program Status

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Marathon Surveillance Program Status

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Marathon Surveillance Program Status

- MFN 10-153 contains a listing of planned visual inspections.

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Non-Proprietary Information

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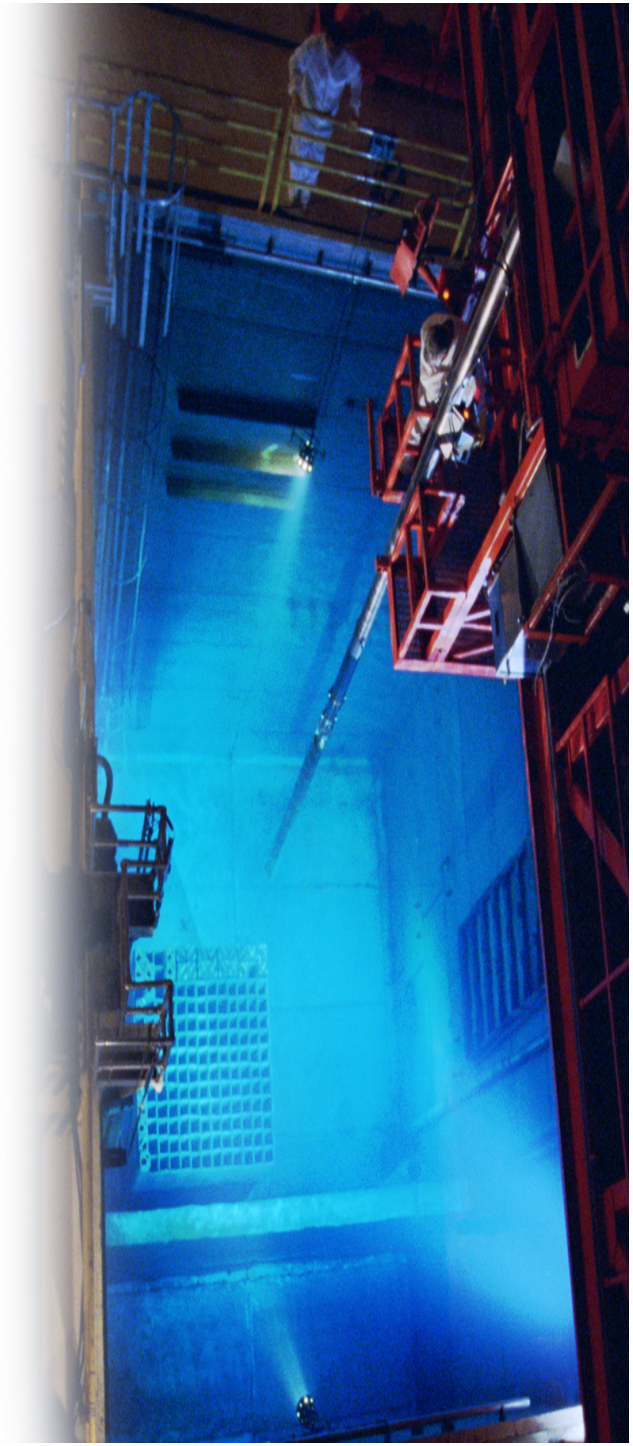
GNF Channel Performance Update

Paul Cantonwine

May 20, 2010



Summary: 2009 NRC Technology Update

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Outline

- Background
- GNF Operational Experience

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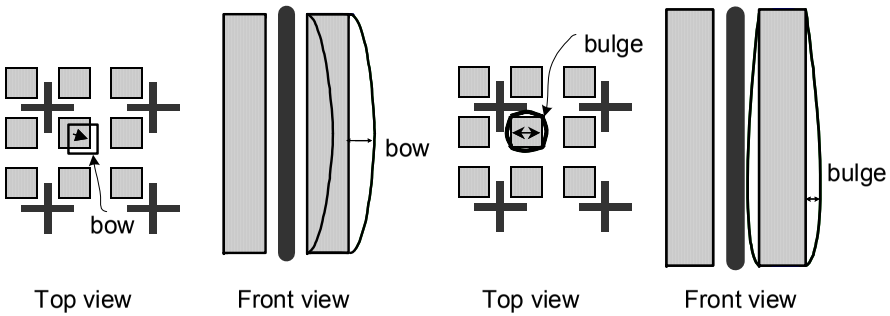
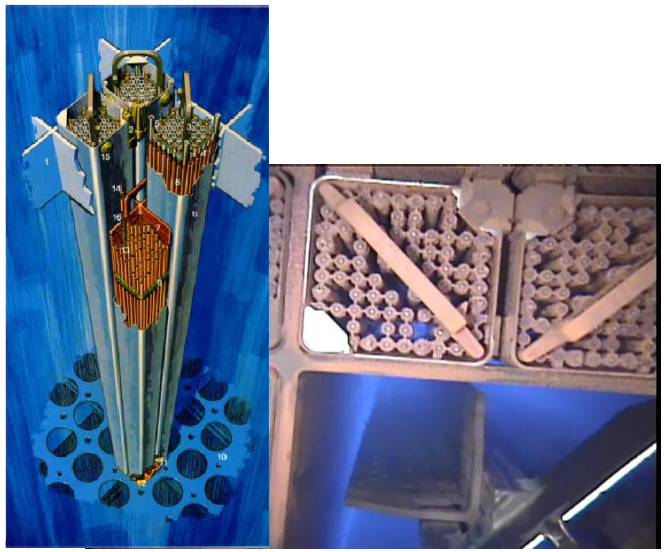
Channel Distortion Mechanisms

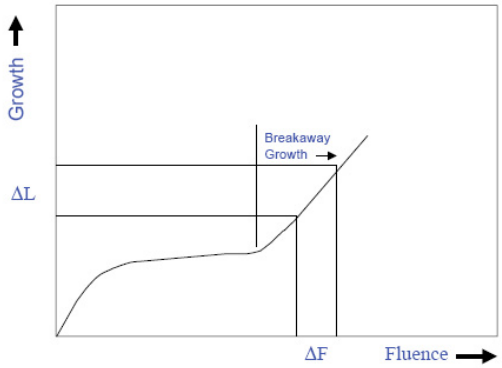


$$Bow \propto \Delta L$$

$$Bulge \propto \Delta P$$

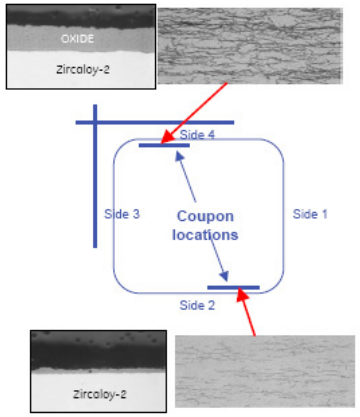


Fluence Gradient Bow



$$\Delta L \propto \Delta F$$

Shadow Bow



$$\Delta L \propto \Delta H$$

GNF Channel Performance: GNF Only and Mixed Vendor Core Designs

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Grand Gulf Details

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NSF Similar to E635 and ZIRLO

	NSF	E635	Zirlo
Sn	0.95	1.25	1.0
Nb	1.0	1.0	1.0
Fe	0.35	0.37	0.1
O	0.12	0.06	0.14

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Model for Shadow Bow

$$ShadowBow \propto (HPU)(\Delta t)$$

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Status of Lead-Use Channel Programs

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Status of LTR

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Summary: 2010 NRC Technology Update

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Non-Proprietary Information

GNF Fuel Experience & Reliability

NRC Technology Update May 2010

Paul Cantonwine, Rob Schneider

Global Nuclear Fuel
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Agenda

- **Fuel Experience Summary**

  Total, current designs

- **Reliability Trend**

  historical, recent trends

- **Details**

  GE14 failures

- **New Fuel Reload Surveillance Status**
- **LUA Surveillance Status**
- **Rod Gap Observations**

GNF Fuel Experience

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NRC requested formats for reliability data

(1) Fuel Performance

- TOTAL Number of failed rods per year (not failed assemblies)

  REPLY: this is provided in slide #8

- Failed rods per year broken down by failure mechanism

  REPLY: this is provided in slide #9

- Failure Rate (failed rods per million manufactured) in US

  REPLY: this is provided in slide #5

Fuel Experience Update (through Apr 2010, 10x10 fuel)

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Fuel Experience Update

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Historical Reliability Trends

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GNF Fuel Failures per Year – All designs

(Total number of failed rods (or bundles, same for all data) per year)

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Failed rods per year broken down by failure mechanism

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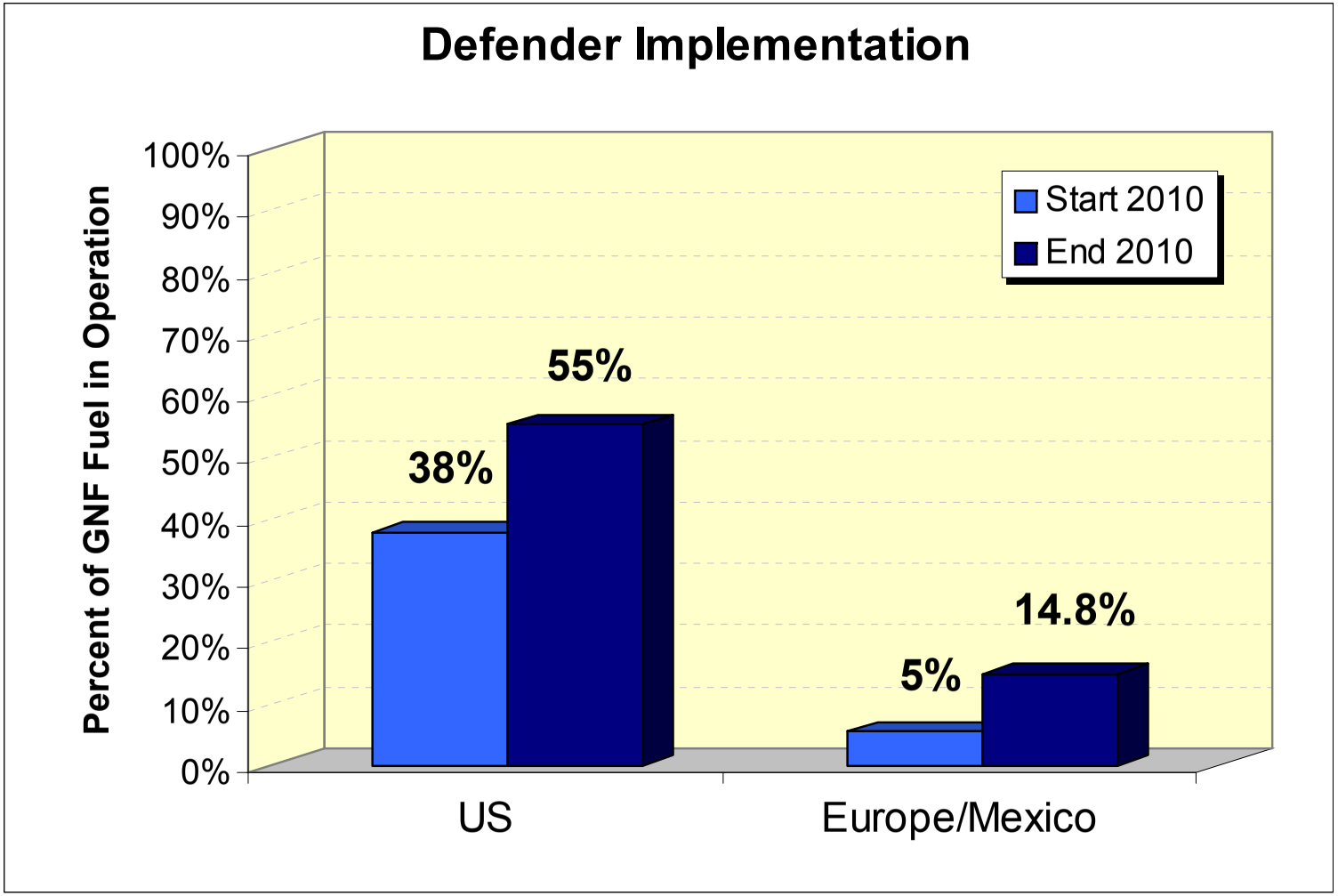
Stop Debris Failures…..

Mexico/Europe lagging on latest filter technology



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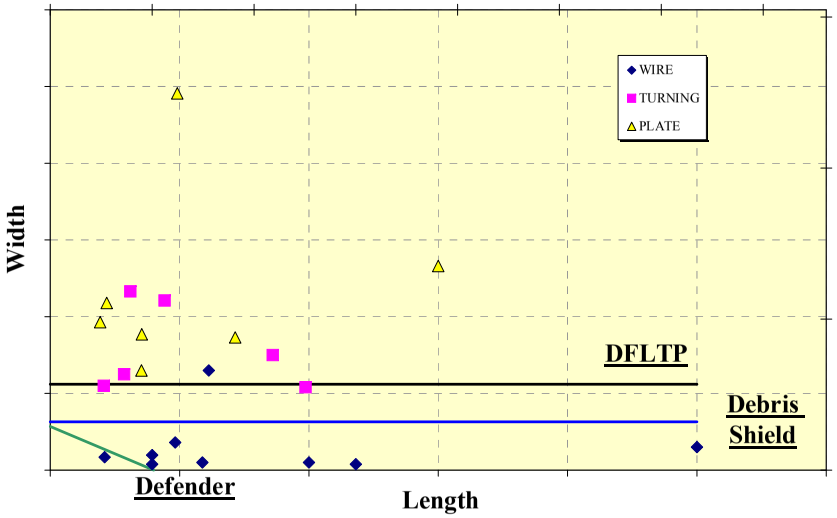
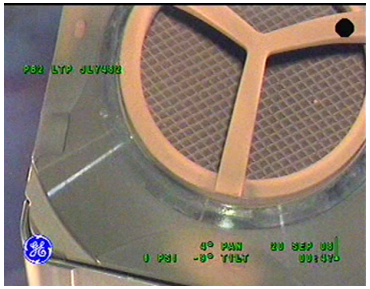
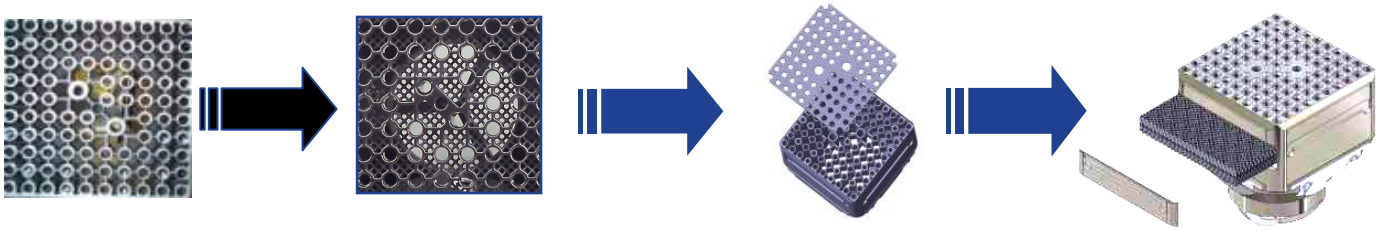
Debris Filter Technology for 10x10 Fuel



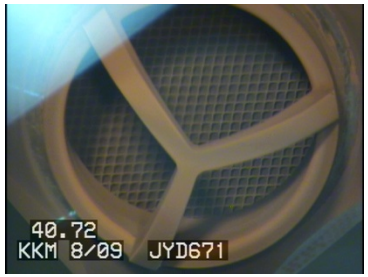
Debris Mitigation

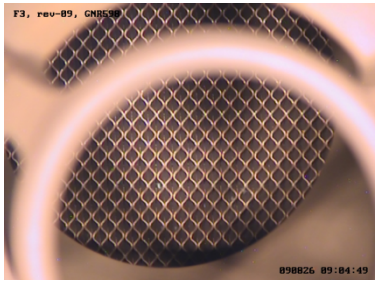
Keep debris out of the assembly with a filter on the lower nozzle (lower tie plate)





No filter | Standard (cast) | Debris Shield | Defender





Field stats through April '10: ***~20X lower failure rate w/ advanced filters***

NB 10x10 "no filter" rate was ~6.0

	Standard	Debris Shield	Defender	DS + Defender
Bundles	22,121	2,246	7,768	10,014
Failures	49	1	0	1
Failure Rate (failed bundles per thousand bundles)	2.22	0.45	0.00	0.10

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New Fuel Reload Surveillances

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Rod Gap Surveillance

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Lead Use Assembly Surveillance

- **GE14 LUA Irradiations & essentially all Inspections complete**
- **GNF2 LUAs began irradiation in 2005**

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GNF2 Inspection Plan

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GNF2: Reloads & LUAs, Experience Summary

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Latest GNF2 LUAs Inspection Results

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Upcoming for GNF2

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GNF2 Inspections Summary

New features inspected - performance as anticipated

Channels, Water Rods, Fuel Rods successfully removed/reinstalled

9 Inspection campaigns completed to date

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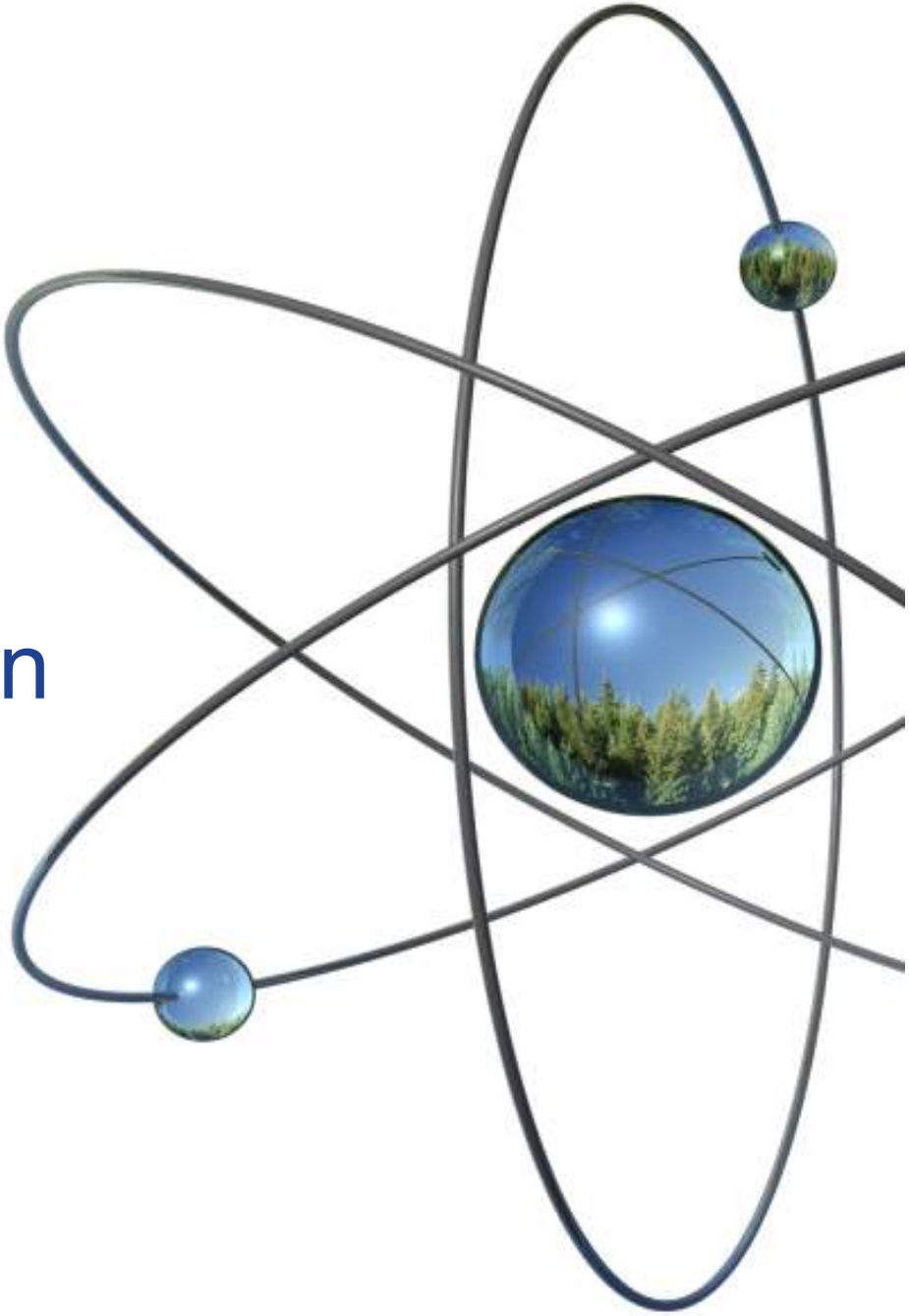
Non-Proprietary Information

GE Hitachi
Nuclear Energy



Technology Update
COBRAG Qualification

Jens Andersen
Chief Consulting Engineer, Thermal Hydraulics

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COBRAG

- Best estimate computer code for analysis of BWR fuel bundle thermal hydraulics
  - Steady state multi-fluid model
  - Subchannel model
- Application:
  - Void fraction, Pressure drop, Critical power
- COBRAG models summarized at 2008 Technology update meeting
  - Detailed description contained in NEDE-32199P

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MFN 06-435

- MFN 06-435 outlines actions to update GE's void fraction data
- NEDC-33173P Supplement 1
  - Comparison to 10X10 pressure drop data
    - GE12, GE14 and GNF2 10X10 data
  - COBRAG benchmarking
    - NUPEC Void fraction data
    - GNF2 prediction
- Submitted April 5, 2010

GE14 Pressure Drop

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10X10 Void Fraction Error

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NUPEC Void Fraction Data

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GNF2 Benchmarking

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COBRAG Qualification

GE 3X3 Data

- Flow and quality distribution

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COBRAG Qualification

FRIGG 36 rod void fraction

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Similar accuracy as GE design correlation

COBRAG Qualification

FRIGG 64 rod void fraction

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Similar accuracy as GE design correlation

COBRAG Qualification

NUPEC void fraction

- 7 MPa

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Similar accuracy as other data

COBRAG Qualification

8X8 Pressure Drop and Critical Power

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COBRAG Qualification

9X9 Pressure Drop and Critical Power

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COBRAG Qualification

10X10 Pressure Drop and Critical Power

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COBRAG Qualification

Pressure Drop and Critical Power

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Accurate prediction independent of bundle size

COBRAG Application

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COBRAG Status and Schedule

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2010 Technology Update

Shutdown Margin

- Most Reactive Temperature

Gary Galloway

May 2010

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GNF2 Core & Fuel Design SDM Impact

- SDM has historically been most reactive at 68°F
- Evolutionary fuel products (larger water rods, more PLRs) have produced designs with more tendency towards positive moderator temperature coefficients.
- GNF2 is our first BWR/2-6 fuel product to have SDM characteristics where the most reactive temperature can be > 68°F for late-in-cycle exposures

Typical GNF2 SDM Behavior

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SDM Design & Licensing Calculations

- Since the introduction of GNF2 our technical design procedures (TDPs) have recognized this phenomenon.
- The SDM TDP requires that calculations for GNF2 be performed over a temperature span that ensures the minimum SDM has been determined.
- Information provided to the utilities for the BOC SDM demonstration include any impact of temperature dependency on SDM and its associated "R" value.

GDC 26 & Tech Spec Interpretations

- General Design Criteria 26 states:

  "{the reactivity control system} shall be capable of holding the reactor core subcritical under cold conditions."

- Many Tech Specs have interpreted this cold condition to be 68°F - the lowest temperature that the reactor might normally encounter.
- Implicit in this specification is that the lowest temperature will always be the most reactive for SDM.

Standard BWR Tech Spec Wording

- Current wording in both BWR/4 and BWR/6 Standard Tech Specs (Section 1) state the definition of SDM to be:

  "SDM shall be the amount of reactivity by which the reactor is subcritical or would be subcritical assuming that:

  a. The reactor is xenon free

  b. The moderator temperature is 68°F, and

  c. All control rods are fully inserted except for the single control rod of highest reactivity worth, which is assumed to be fully withdrawn. ..."

Suggested BWR Tech Spec Wording

- We would propose the following change (noted in red):

  "SDM shall be the amount of reactivity by which the reactor is subcritical or would be subcritical assuming that:

  a. The reactor is xenon free

  b. The reactor is at a moderator temperature corresponding to the most reactive state for the control rod condition defined in (c).

  c. All control rods are fully inserted except for the single control rod of highest reactivity worth, which is assumed to be fully withdrawn. ..."

Conclusions

- New fuel products (i.e., GNF2) have the potential for the most reactive SDM temperature to be greater than 68°F for late-in-cycle exposures.
- Our SDM calculations take this into account for all core design and reload licensing applications by requiring multi-temperature calculations for GNF2 fuel.
- Tech Specs which specify a discrete value for the most reactive SDM temperature (68°F) should be updated to specify a more generic "most reactive temperature".