ENCLOSURE 5

MFN 13-096

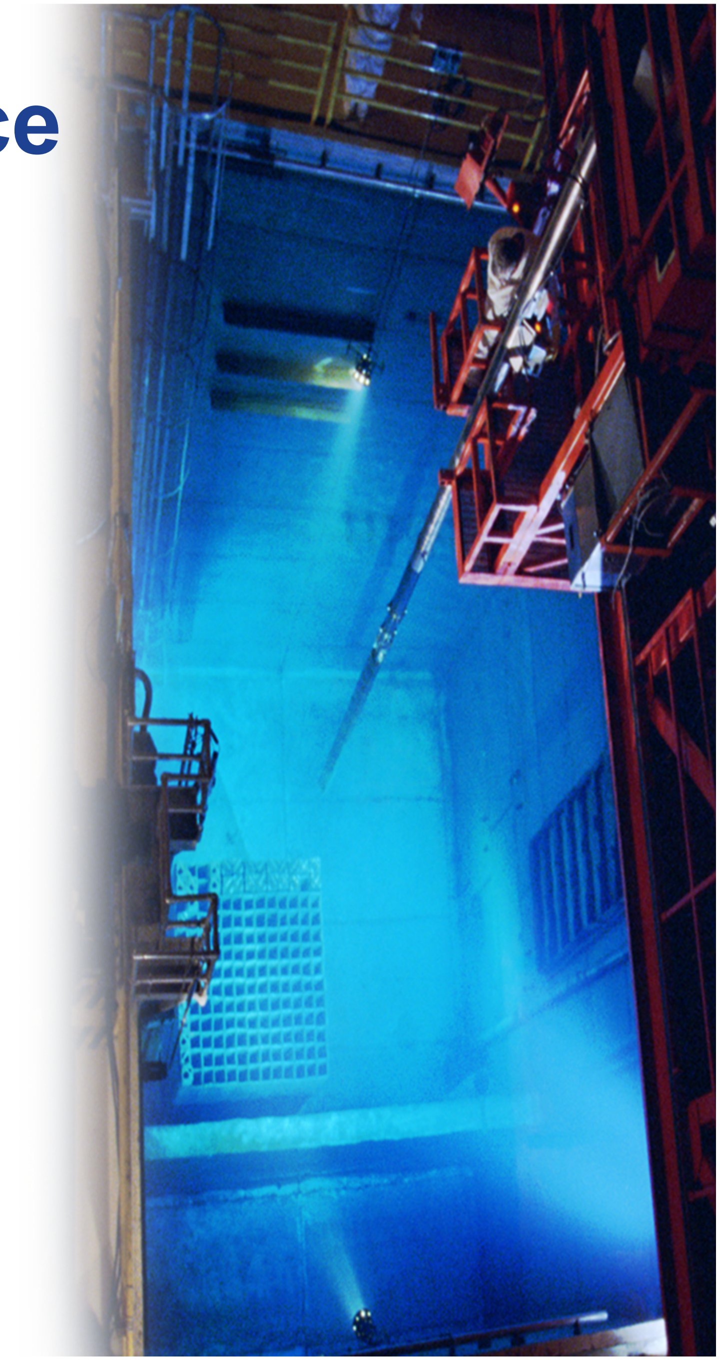
ACRS Subcommittee Presentations

Non-Proprietary Information – Class I (Public)

INFORMATION NOTICE

Enclosure 5 is a non-proprietary version of the ACRS Subcommittee Presentations from Enclosure 4, which has the proprietary information removed. Portions that have been removed are indicated by open and closed double brackets as shown here [[ ]].

Fuel Reliability & Experience (featuring GNF2)



ACRS – GNF Meeting
November 2013
R. Schneider

Global Nuclear Fuel
A Joint Venture of GE, Toshiba, & Hitachi

Reliability: at or near all time high

Briefly achieved "Zero Leakers Operating" in US for a few months in spring 2012, and in US/Mexico spring 2013

- Only low-level debris fretting seen
  - Concentration in certain plants (PFD and steam plant mods work)
  - GNF2_Defender low debris failure rate

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GNF

Current Leakers – no GNF2

US/Mexico

- 4 plants, all ~100% GE14 cores, single small debris failures, low activity release
- 3 of the 4 to be discharged winter ‘14 outages
- 3 of the 4 in pumped-forward drains plants w/ history of debris failures

Europe

- Forsmark-3, GE14, one suspect, frequent debris failures in this plant (~2-5 per annual cycle)

Fuel Experience Update (through Oct 2013, 10x10 fuel)

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Fuel Experience Update

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US GNF Fuel Failures per Year

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Latest GNF2 LUA Inspection Results

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Latest GNF2 LUA Inspection Results

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GNF

GNF2: Reloads & LUAs, Experience Summary

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GNF2: Reloads & LUAs, Experience Summary

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Summary

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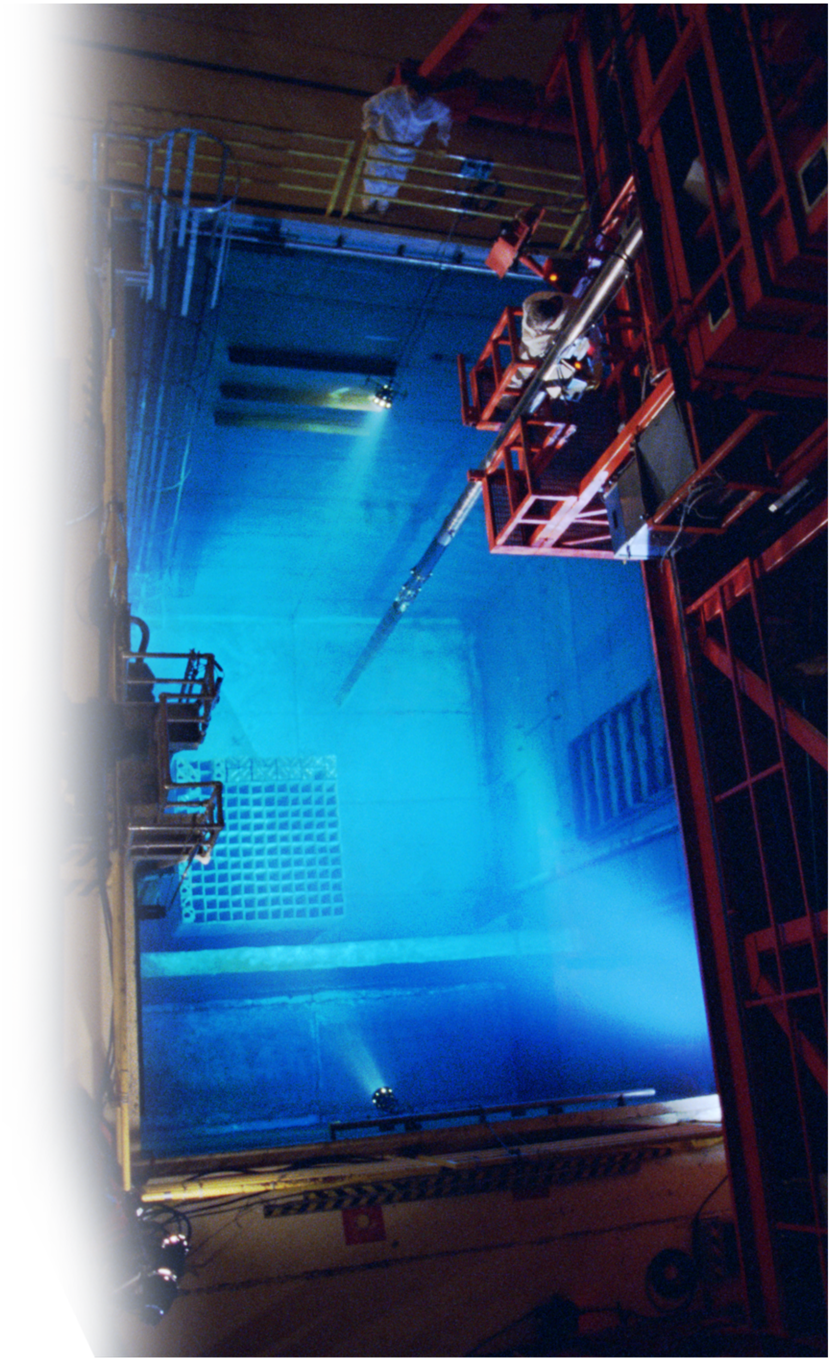
Global Nuclear Fuel

GNF Additive Fuel



ACRS – GNF Meeting
November 2013

Paul Cantonwine
Randy Dunavant

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Additive (UO2 + Aluminosilicate) Fuel

- Reasons for using additive
  - Additive fuel is an effective remedy for PCI
  - Barrier plus additive fuel provides defense in depth to PCI
  - Increased operating efficiency; i.e., further improvements to soft-operating guidelines
  - Support changes to core operating strategies; e.g., load following
  - Support new reactor design and operation; i.e. ESBWR

- Mechanisms provided protection against duty-related cladding failures
  - [[ ]]
  - [[ ]]

Additive (UO2 + Aluminosilicate) Fuel

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	Concentration wt%	Composition :SiO_2 : Al_2O_3 by wt
Experience Range	[[ ]]	[[ ]]
Licensing Range	[[ ]]	[[ ]]
Target Nominal	[[ ]]	[[ ]]
Derived from ASTM C776-00 Impurity Limit	[[ ]]	[[ ]]

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Low concentration minimizes effect on pellet properties

- Similar in-core densification and swelling as standard fuel
- Small impact to thermal conductivity
- Fission gas release comparable to standard fuel
- Corrosion (washout) characteristics comparable to standard fuel
- Response to RIA similar for additive and standard fuel
- AST assumptions apply equally well to additive and standard fuel

Additive forms a eutectic with UO2 at [[ ]]

- [[ ]]
- GNF ensures this criterion is met for both steady-state and AOOs.

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Additive Fuel PCI Resistance

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○ Additive UO_2
Non-barrier cladding
8 x 8 and 9 x 9
[[ ]]

△ Additive UO_2
Non-barrier cladding
10 x 10
[[ ]]

● Standard UO_2
Non-barrier cladding
10 x 10

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Additive Fuel Experience

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operation to bundle average exposures of [[ ]]

10x10 Additive Fuel Experience

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Status and Future Plans

Licensing:

Additive LTR submitted 2010

- Additive models and properties fully integrated into PRIME ECP

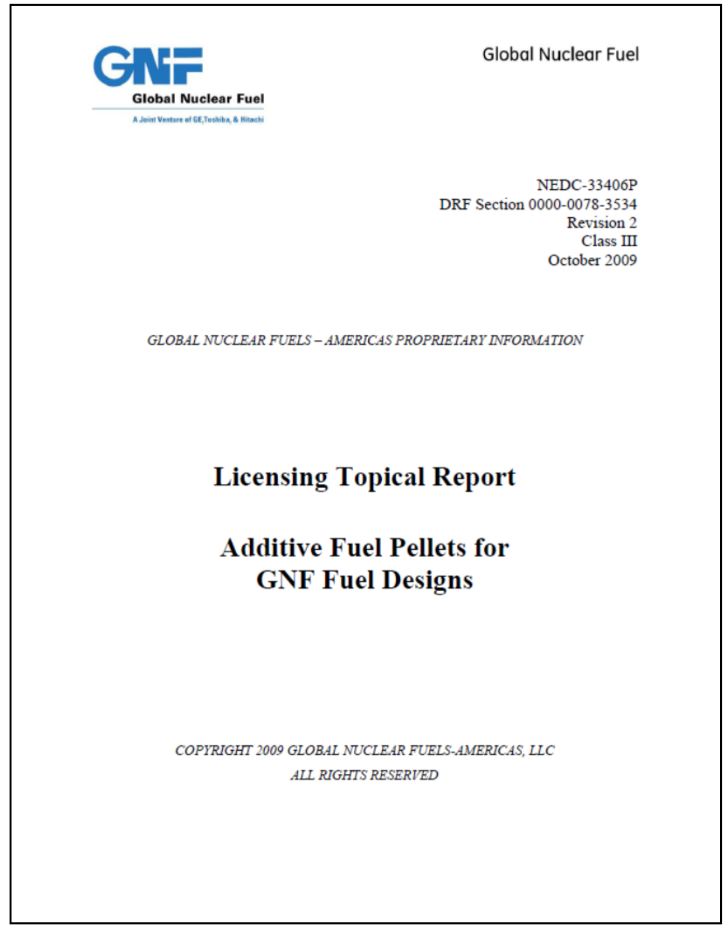
RAI responses complete

SE anticipated by end of 2013

Manufacturing and Implementation:

GNF has qualified its additive manufacturing process

GNF plans to provide additive fuel pellets to customers upon request for fuel reloads subsequent to licensing completion



Global Nuclear Fuel

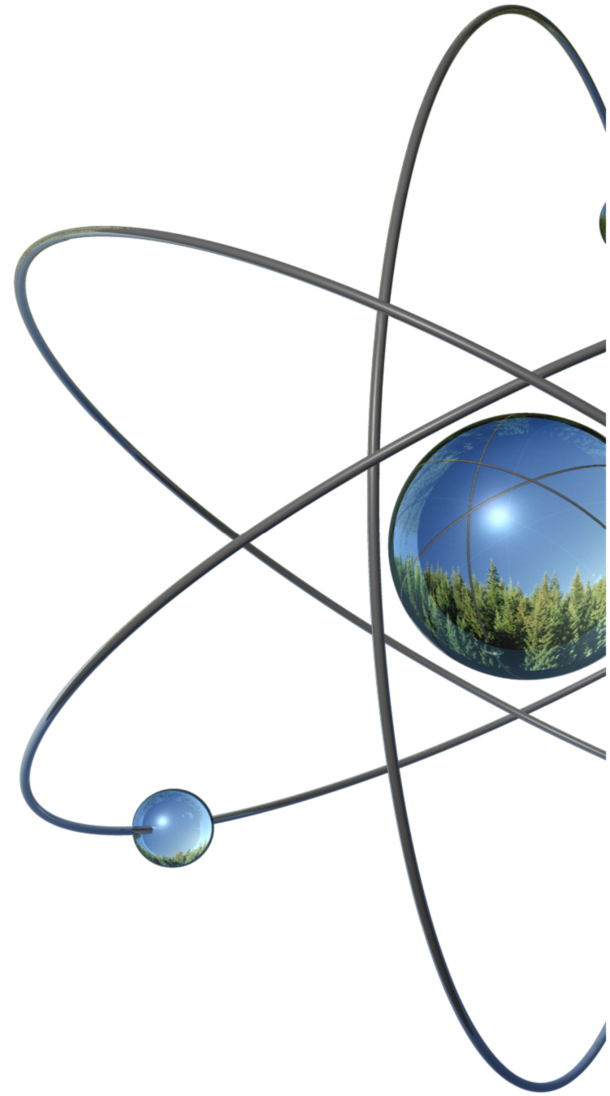
NEDC-33406P
DRF Section 0000-0078-3534
Revision 2
Class III
October 2009

GLOBAL NUCLEAR FUELS – AMERICAS PROPRIETARY INFORMATION

Licensing Topical Report

Additive Fuel Pellets for GNF Fuel Designs

NSF Channel Performance



Paul E. Cantonwine
Senior Engineer

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Short History of Zr-Nb-Sn-Fe alloys

1967: Kass publishes work on Zr-4 + Nb
Observed no corrosion benefit

1972: Amaev et al. publish work on E635 (Zr-1Nb-1Sn-0.5Fe)
Observed good in-reactor corrosion

1977: Sabol and McDonald reconsidered Zr-4 + Nb
Observe encouraging corrosion performance
Led to development of ZIRLO™ (Zr-1Nb-1Sn-0.1Fe)

~1980: GE begins investigating NSF (Zr-1Nb-1Sn-(0.25-0.5)Fe)

1996: Nikulina et al. publish work on E635
Observed that E635 was resistant to breakaway growth typical of Zircaloy

2002: GNF inserts first NSF Channel

GNF Planning Transition to NSF Channels

- NSF – 1% Nb, 1% Sn, 0.35% Fe
  - Effectively resistant to fluence bow
  - Effectively resistant to shadow bow
  - Creep bulge the same as Zircaloy

NSF is in the same Zr – Nb,Sn,Fe Family as to E635 and ZIRLO

	NSF	E635	Zirlo
Sn	1.0	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

NSF Licensing/Transition Plan

- **2012 (September)**
  - GNF submitted request to expand LUC quantities of NSF channels from 2% to 8%
- **2013 (February)**
  - GNF submitted NSF Channel LTR (NEDE-33798P)
- **2013 (March)**
  - NRC approved expansion of LUC quantities for NSF channels from 2% to 8% (MFN 12-074-A)
- **2013 (June)**
  - GNF submitted a supplement to NSF Channel LTR to address proprietary marking comments.
- **2013 (November)**
  - Waiting for official acceptance of NSF Channel LTR
  - [[

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NSF Update - Lead-Use Channel Programs

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Fluence Bow of NSF

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Inferred Shadow Bow of NSF

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Creep Bulge of NSF

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Evaluating Delivering NSF in a Pre-oxidized condition

Difference is in the surface finish.

Etched Surface Condition

Pre-Oxidized Surface Condition

CORROSION OF PRE-OX NSF

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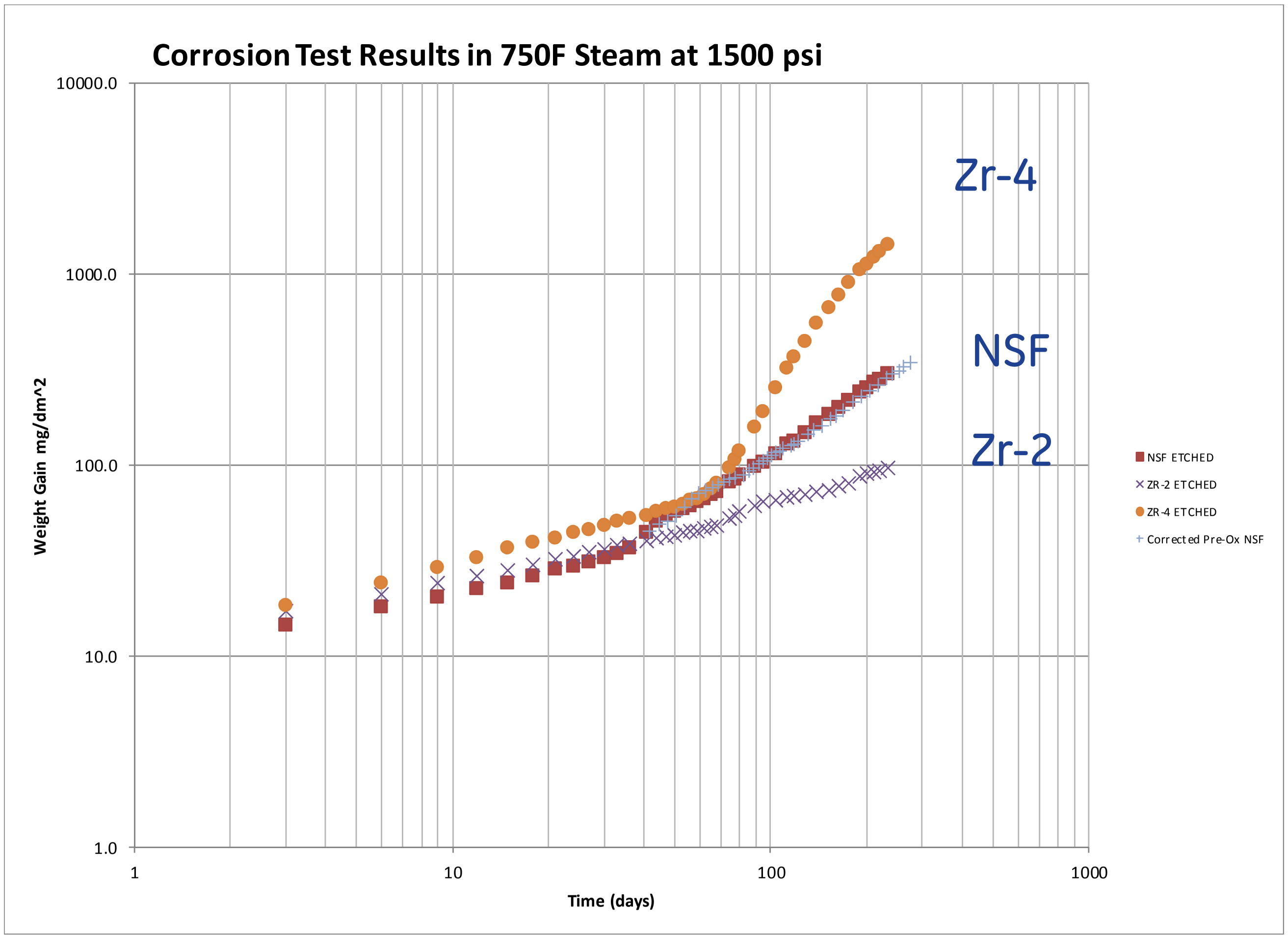
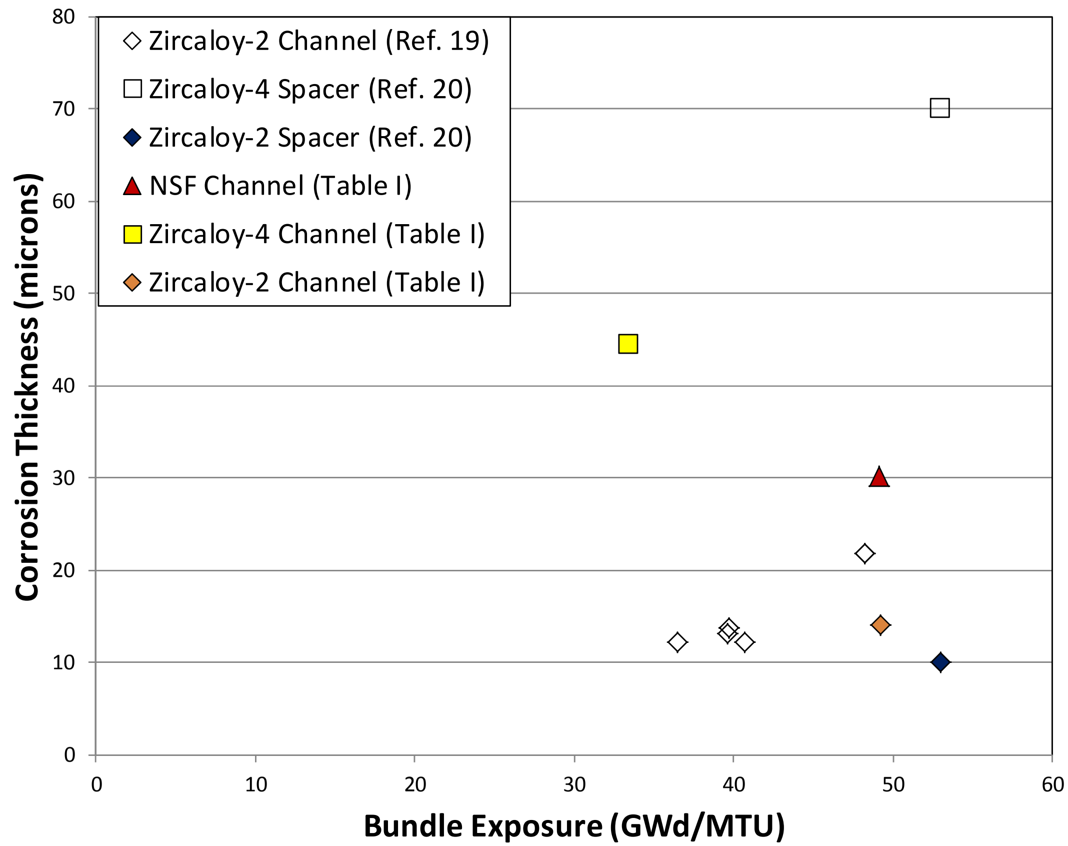
Out-of-Reactor Corrosion (NSF v. Zr-4 v. Zr-2)



In-Reactor Corrosion (NSF v. Zr-4 v. Zr-2)



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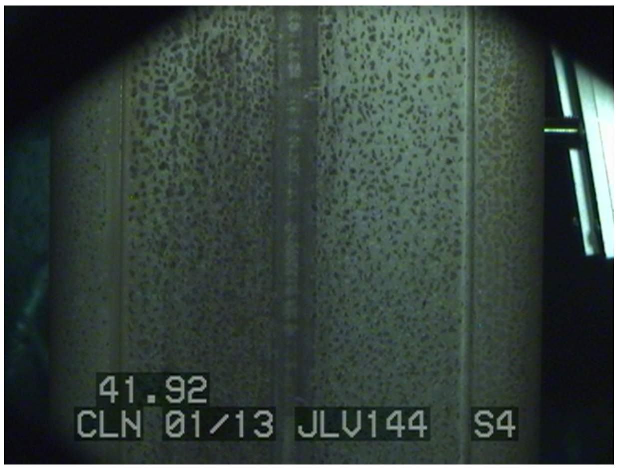
In-Reactor Shadow Corrosion (NSF v. Zr-4 v. Zr-2)

Zircaloy-4
Blade Side

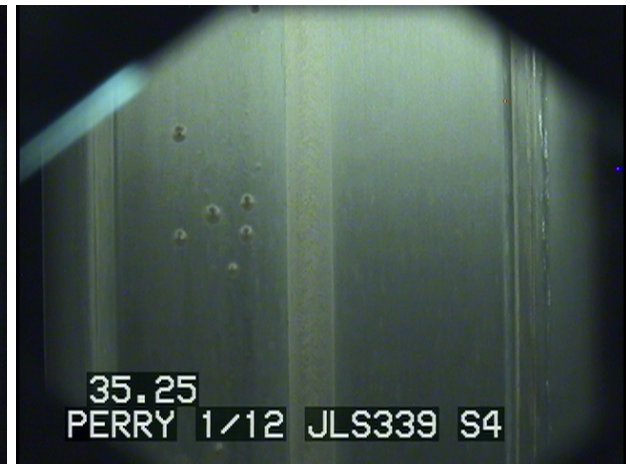


37922 inch-days
46 GWd/MTU

NSF
Blade Side

37922 inch-days
46 GWd/MTU

Zircaloy-2
Blade Side



51262 inch-days
40.4 GWd/MTU

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In-Reactor Corrosion (Etched NSF v. Pre-Ox NSF)

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Summary

- NSF is resistant to fluence bow and appears effectively resistant to shadow bow
- [[ ]]
  - Out-of-reactor corrosion of Pre-Ox = etched
  - Corrosion follows trend: Zr-2 < NSF < Zr-4
  - In-Reactor corrosion of Pre-Ox NSF appears normal
- [[ ]]

PRIME Introduction

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- New state-of-the-art fuel performance model
  - Address high exposure phenomena
  - US NRC approval in 2010
- PRIME application
  - Design & license fuel
  - Develop TMOL to protect SAFDL's
  - Inputs to downstream methods (PRIME implementation)
- PRIME impacts primarily due to thermal conductivity degradation (TCD)

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Chronological History

January 19, 2007, GNF Licensing Topical Report, "The PRIME Model for Analysis of Fuel Rod Thermal – Mechanical Performance," NEDC-33256P, NEDC-33257P, and NEDC-33258P, January 2007. (PRIME Submittal)

July 10, 2009, Implementation of PRIME Models and Data in Downstream Methods, NEDO-33173, Supplement 4, July 2009.

January 22, 2010, Final Safety Evaluation for Global Nuclear Fuel – Americas Topical Reports NEDC-33256P, NEDC-33257P, AND NEDC-33258P, "The PRIME Model For Analysis Of Fuel Rod Thermal-Mechanical Performance"

Chronological History, continued

March 5, 2010, Amendment 33 to NEDE–24011–P, General Electric Standard Application for Reactor Fuel (GESTAR II) and GNF2 Advantage Generic Compliance with NEDE-24011-P-A (GESTAR II), NEDC-33270P, Revision 3, March 2010.
(Approved August 30, 2010)

September 9, 2011, Final Safety Evaluation For GE Hitachi Nuclear Energy Americas Topical Report NEDO-33173, Supplement 4, Implementation of PRIME Models and Data In Downstream Methods"

May 2012, PRIME Implementation Readiness Complete

July 17-19 2012, NRC Audit of Downstream Codes Implementation

October 2012 NRC Letter Confirming Complete and Satisfactory Implementation in Downstream Codes

PRIME Implementation

- PRIME thermal model implemented downstream
  - Fuel conductivity and gap conductance
- [[ ]]
- [[ ]]

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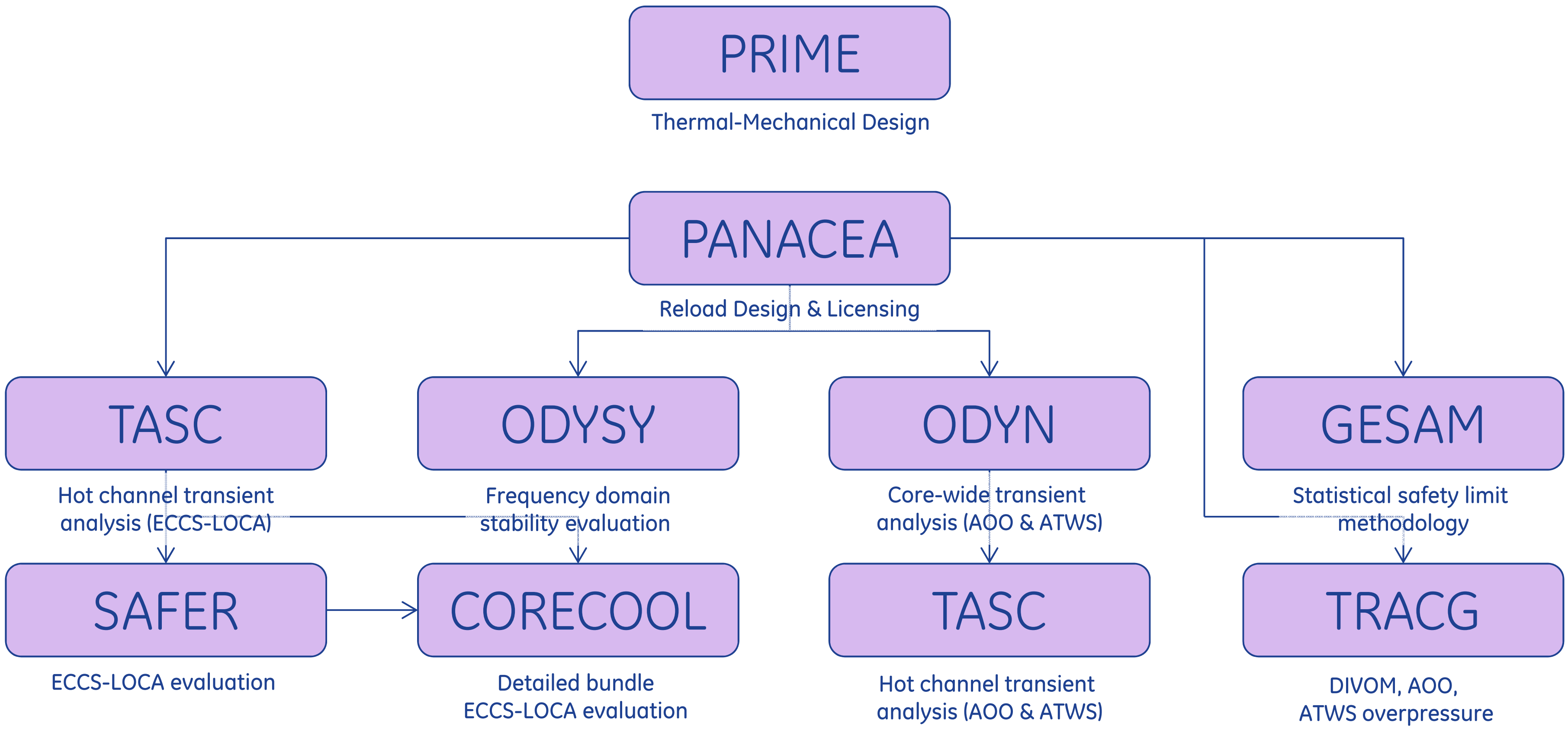
Downstream Implementation



Downstream Implementation Status

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Summary

- PRIME impacts T-M licensing, as well as downstream gap conductance and fuel conductivity
- Audit is complete, no findings
- PRIME 50.46 notices complete and transmitted
- PRIME Implementation into Downstream Analyses
  - Asset enhancement projects (MELLLA+, EPU) and ECCS/LOCA now
  - Reload licensing in domestic fuel cycles starting with designs that begin in the Fall of 2012
- PRIME has been implemented across GEH/GNF