

ENCLOSURE 5

M210113

2021 Technology Update Presentation

Non-Proprietary Information

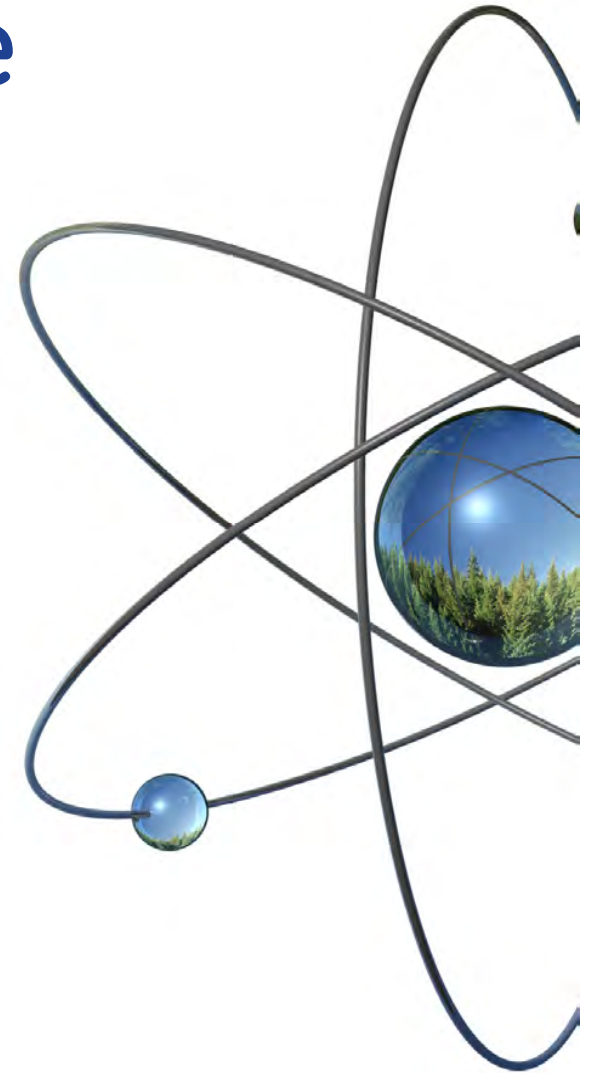
INFORMATION NOTICE

Enclosure 5 is a non-proprietary version of the 2021 Technology Update 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 [[]].

Non-Proprietary Information

2021 Technology Update for the US NRC August 17

Brian R. Moore
General Manager
Core & Fuel Engineering



HITACHI

Thank You for Participating

- Safety Minute
- Introductions
- Why we are here... sharing technical performance and direction
- Don't be bashful in Q&A periods
- NRC Opening Statements

Non-Proprietary Information

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HITACHI

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August 17 - NRC Tech Update Agenda

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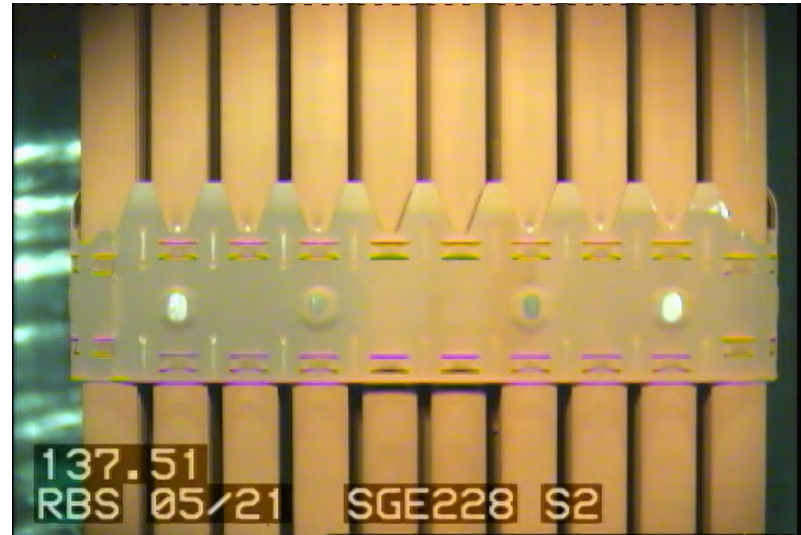
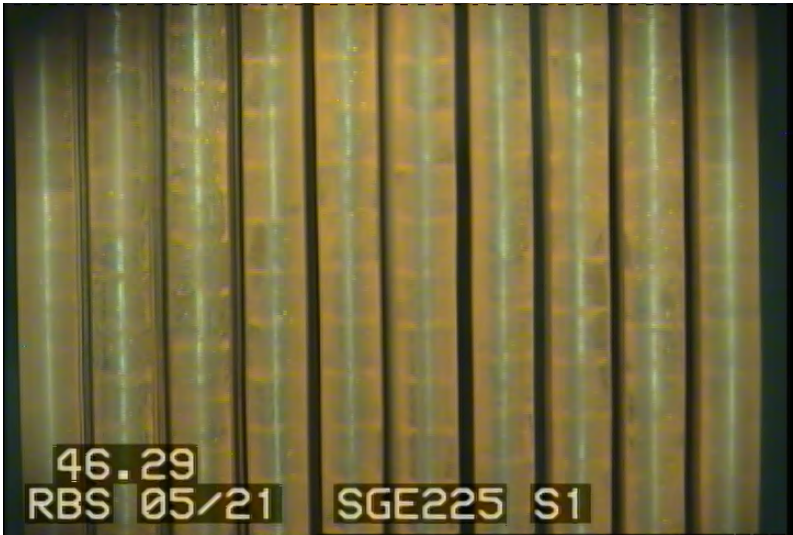
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HITACHI

2021 Technology Update: US NRC



Fuel Experience Update

Rob Schneider, GNF Fuel Reliability

Agenda

- Fuel Experience Summary
 - Total, current designs
- Reliability Trend
 - historical, recent trends
- GNF2 experience details
- GNF3 experience details
- Details - recent fuel failures
- New Fuel Reload Surveillance Status
- LUA Surveillance Status & Objectives
 - GNF3 and ATF variants
- Rod Gap Observations

GNF Fuel Experience

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Largest BWR Fuel Experience Base in the World

NRC requested formats for reliability data

Fuel Performance formats

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

provided in slide #9 and 10

- Failed rods per year broken down by failure mechanism

provided in slide #11

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

is provided in slide #5 by product line and #8 as function of time

Non-Proprietary Information

Fuel Experience Update (through July 2021, 10x10 fuel)

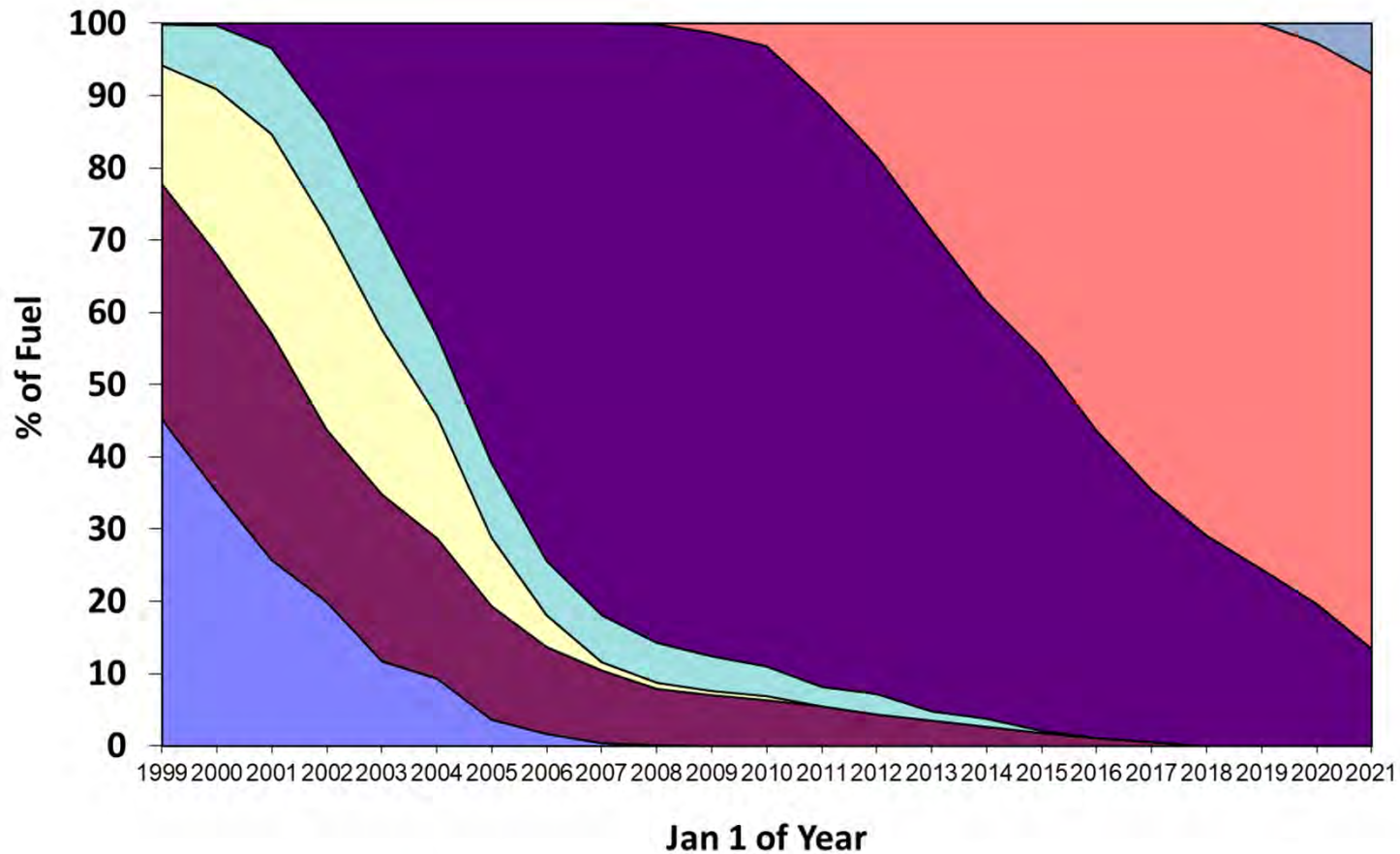
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Fuel Experience Update

GNF-A, plus ENUSA/Europe, % of all bundles in-core/operating as of Jan 1 of calendar year

- Currently only LV-1,-2 receiving GE14
- ~95% of all GE14 is discharged, ~47% of GNF2, including from plant S/D's (Pilgrim, Oyst Crk, KKM, DA past ~3 yrs)



Non-Proprietary Information

GNF2: Reloads & LUAs, Experience Summary

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Historical Reliability Trends

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GNF Fuel Failures per Year

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GNF Fuel Failures per Year – International

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Failed rods per year: by failure mechanism

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Rod Gap Surveillance

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Lead Assembly Surveillances

- GE14 LUAs Irradiations & Inspections complete
- GNF2 LUAs Irradiations & Inspections complete
 - New – GNF2_HBLUA inserted
- GNF3 LUAs in progress, nearing completion

GNF2_HBLUA

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GNF3 Inspection Plans

Poolside inspections

- Visual exams & COINs (oxide, crud profilometry/diameter) as outage schedules support
- Selected dimensional measurements

GNF3 is a variant on GNF2 – same fuel rod, pellet, cladding, materials

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BWR/6 Inspections – no “dryout” indications

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Summary

- **Fuel Experience:**

- 10x10 experience base ~6.3 million rods
- GNF2.02 and GNF3 have helped get to zero leakers

- **Reliability Trends**

- First-ever BWR fleet zero leakers
- Last US failure to occur ~ 16 months ago

- **GNF2 & GNF3 experience details**

- Transition to GNF3 reloads started in '19

- **New Fuel Reload Surveillance Status**

- Complete for legacy designs; extensive inspections.

- **LUA Surveillance Status & Objectives**

- GNF3 LUA Inspections approaching completion
- Detailed inspections Fall '21 after Feb '21 discharge

Non-Proprietary Information

2021 Technology Update: US NRC

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ATF Program Update

Russ Fawcett



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ARMOR Status & Plans – 3 Pathways

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IronClad – Maturing & Retiring Risks

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GE ATF Phase 2C Program Targets

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Acknowledgement

The financial support of GE Hitachi Nuclear and Global Nuclear Fuels is gratefully acknowledged. Part of the material presented is based upon work supported by the **Department of Energy [National Nuclear Security Administration]** and as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

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NRC Tech Update

PRIME Downstream Inputs

August 2021



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PRIME Downstream Inputs

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PRIME Downstream Inputs Phenomena - Example

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PRIME Downstream Inputs

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NRC Tech Update

PRIME Licensing for HBU & LEU+

August 2021



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PRIME Licensing – HBU & LEU+

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T/M LTR Key Areas

PRIME Methods

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PRIME Models

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NRC Tech Update LEU+

August 2021



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Focus Areas for LEU+ & Higher Burnup

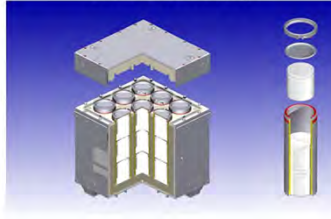
Enrichment
Facilities

UF6 Transport

New Powder
Container
GNF-A NPC Package

Criticality
Methods

Fabrication
Facilities



Front End (Dirt to Box)

RAJ-II Fresh
Fuel Transport

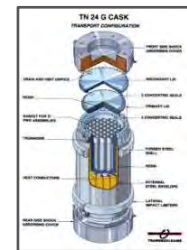
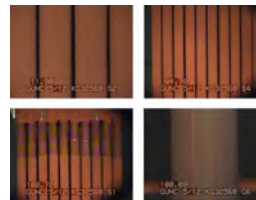
Fuel Storage

Engineering
Methods

Fuel
Performance

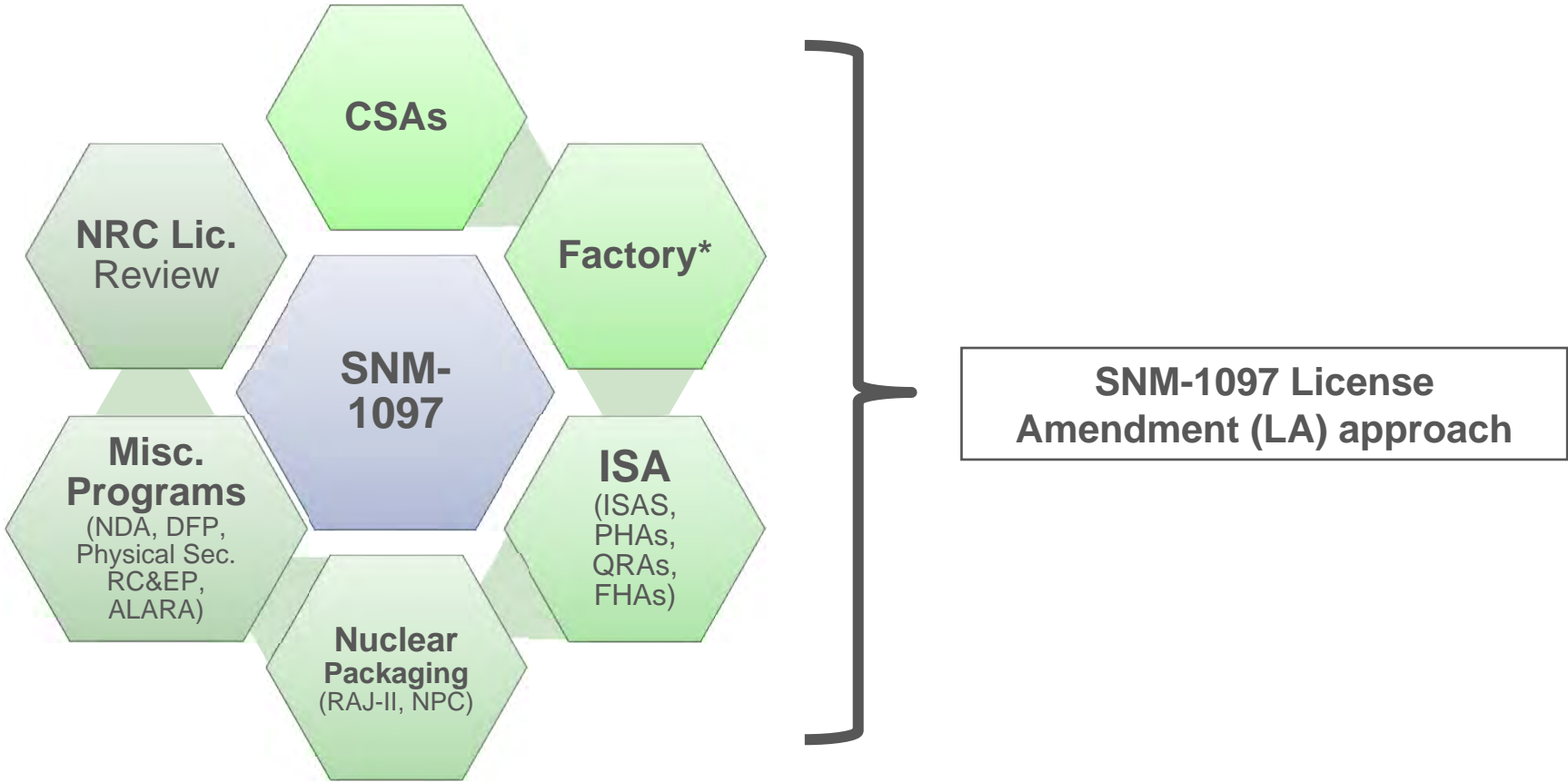
Licensing

Dry Cask Storage



In Service (Box to Cask)

GNF-A LEU+ Elements of Change in Facility



* Extent of factory changes depends on fuel form, enrichment limit

Transportation

RAJ-II Fresh Fuel (FF) Container

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New Powder Container (NPC) fresh fuel shipping

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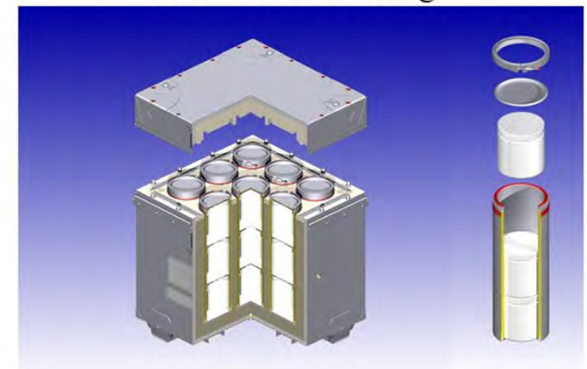
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GE Model 2000 irradiated fuel shipping cask

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GNF-A NPC Package



LEU+ Engineering Methods

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Target Timeline

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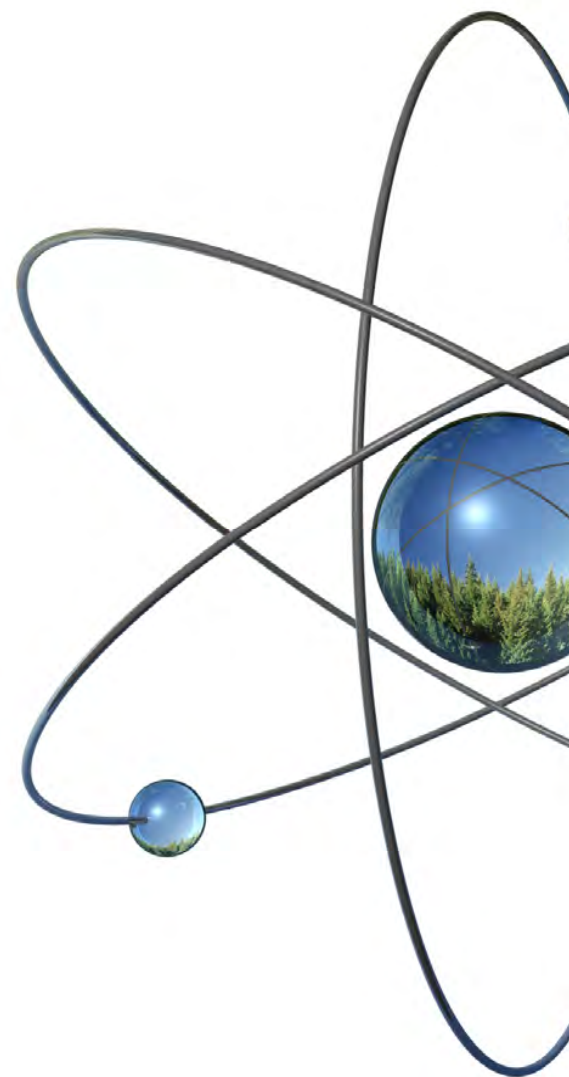


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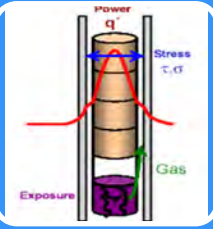
LANCR02 and LANCR02/PANAC11 LTRs for LEU+/HBU Support

NRC Technology Update
August 2021



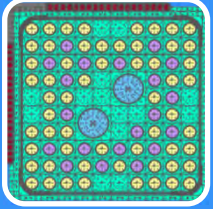
Methods Overview and Change Drivers

- TGBLA06/PANAC11 is GNF's approved steady state nuclear methodology in use today
- GESTAR Amendment 26 – Initial Approval of T6/P11 following MFN# 098-96
- NEDC-33173-P-A (IMLTR) - Approval for Expanded Operating Domains
- IMLTR Supplements 2-6 – Removed penalties associated with IMLTR
- [[



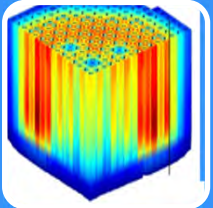
Fuel Rod Thermal-Mechanical

- Thermal Mechanical Behavior of Fuel Rod
- PRIME03 – Approved Production Tool



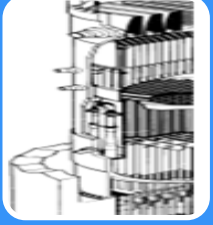
2D Lattice Physics

- Nuclear Behavior of Fuel Rods Within Bundle
- TGBLA06 – Approved Production Tool
- LANCR02 – Model and Qualification LTRs Approved



3D Core Simulation

- Nuclear + Thermal-Hydraulic Behavior of Bundles in Core
- PANAC11 – Approved Production Tool
- AETNA02 – Internally Qualified, no LTRs



3D Plant Simulation

- Best Estimate Analysis of Operational Transients (ODYN and TRACG)
- Frequency Domain Analysis of Core Stability (ODYSY)

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Agenda

- **NRC Technology Update 2020 Refresher: LEU vs LEU+/HBU – Assessing the Difference from a Nuclear Method Perspective**
 - Comparison Approach
 - Deltas Associated With Change at Lattice Level
 - Deltas Associated With Change at Core Level
- **LANCR02/PANAC11 Application Licensing Topical Report (ALTR) Overview**
 - LTR Requirements, Goals, and Strategic Vision
 - LTR Overview
- **LANCR02/PANAC11 Qualification Highlights and Status**
 - Uncertainty Quantification and LEU+/HBU Trend Evaluation Results
 - Next Steps and Current Submittal Timeline

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LEU vs LEU+/HBU –
Nuclear Method Perspective

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LEU vs LEU+/HBU – Nuclear Method Perspective

2020 Technology
Update Refresher

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LEU vs LEU+/HBU – Nuclear Method Perspective
Lattice Level Impacts – Typical Enrichment and Gad Distribution
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LEU vs LEU+/HBU – Nuclear Method Perspective

Core Level Impacts – Core Loading Pattern Changes

2020 Technology
Update Refresher

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LEU vs LEU+/HBU – Nuclear Method Perspective

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Non-Proprietary Information

LANCR02/PANAC11
Application Licensing Topical Report (ALTR)
Overview

LTR Requirements and Strategic Vision

What are we making?

LTR Requirements – Support Near Term Industry Objectives

1. [[

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LTR Goals – Enable Future Enhancements and Application Range Extensions

1. [[

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LTR Requirements and Strategic Vision

How will we use it?

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LTR Overview
Draft Table of Contents

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Non-Proprietary Information

Nuclear Method Qualification Highlights and Status

Non-Proprietary Information

Nuclear Method Qualification Highlights

Lattice Level Uncertainty Quantification and Trend Evaluation

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Non-Proprietary Information

Nuclear Method Qualification Highlights

Core Level Uncertainty Quantification and Trend Evaluation

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Nuclear Method Qualification Status

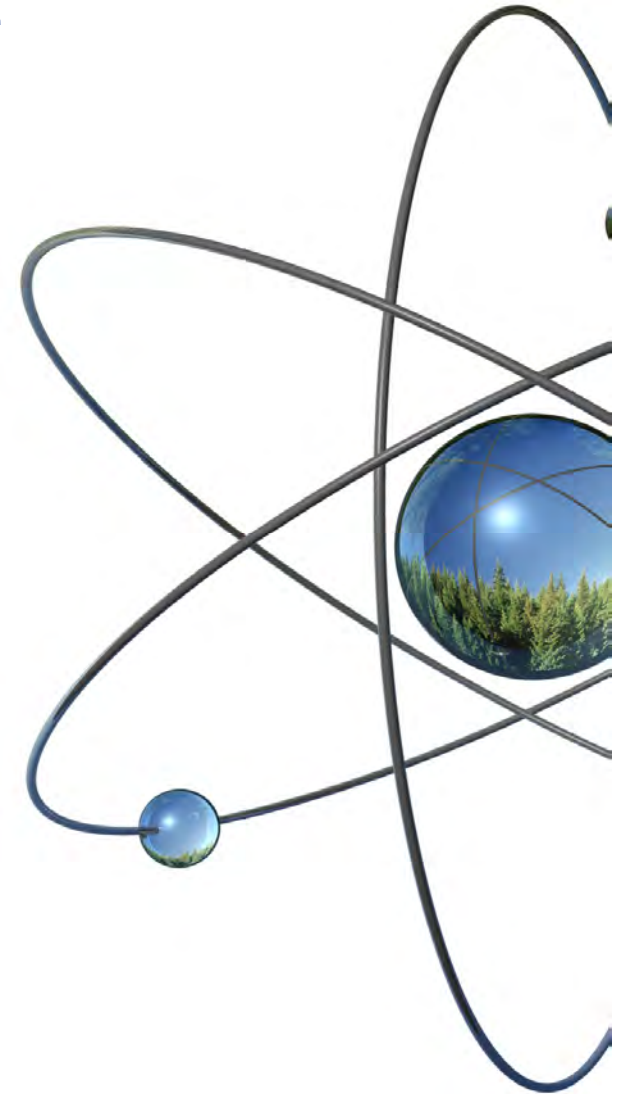
New Steps and Current Submittal Timeline

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Non-Proprietary Information

Channel Performance Update



Dan Lutz

August 17, 2021

Outline

- NSF Deployment Status
- NSF LUCs and Inspection Status
- Annual NSF Channel Performance Report

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NSF Deployment Status

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NSF Lead-Use Channel Programs

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NSF LUC Mini-batch Inspection Scope (SER Requirements)

For cycles prior to discharge

- Visual 5% of batch size (3-4)
- Length 5% of batch size (3-4)

For cycles after discharge

- Visual 20% of batch size
- Length 20% of batch size
- Bow and bulge 50% of batch size
- Corrosion measurement of 20 channels (FSECT)

NSF Channel Inspections

- ✓ GNF2 mini-batch discharge inspections are nearly done
- ✓ Clinton off-outage inspection completed Nov. 2020
- ✓ Grand Gulf off-outage inspection completed Jan. 2021
- ✓ Perry off-outage inspection completed April 2021
 - included GE14 4-cycle LUCs
- ✓ River Bend completed May 2021
 - included GNF3 LUAs
- ✓ Limerick 1/2 completed July 2021
 - included GE14 4-cycle LUCs

Cofrentes 2022 TBD

Pilgrim D-lattice plant substitution, TBD

Non-Proprietary Information

NSF Channel SIMCHAD/Length Measurement Database

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NSF Irradiation Growth Data

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NSF 100T/T2 Channel SIMCHAD Creep Bulge Database

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NSF 100T/T2 Channel SIMCHAD Creep Bulge Database

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NSF 120T/T2 Channel SIMCHAD Creep Bulge Database

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NSF 120T/T2 Channel SIMCHAD Creep Bulge Database

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NSF Total Channel Bow

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Non-Proprietary Information

NSF Channel Shadow Bow

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Non-Proprietary Information

Typical Recent NSF Visual Exam Results

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Non-Proprietary Information

FSECT Channel Corrosion Measurements

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Non-Proprietary Information

NSF Channel Corrosion

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Summary for 2021

Inspections required by SER are winding down

Greatly expanded database continues to demonstrate excellent NSF performance

- Fluence and shadow bow resistant with much less variability than Zr-2 and without late life breakaway
- Acceptable bulge
- Acceptable corrosion

NSF is performing very well!

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NRC Tech Update

Revision to GNF Crud / Oxide Models in PRIME

August 2021



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Background

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GNF current “loose/fluffy” Crud Model

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Supporting Data on Crud Behavior

What we will show:

- ✓ Glossary/photos
- ✓ [[

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Finally:

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Supporting Data on Crud Behavior

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Impacts to TMOL Analyses – [[

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Summary

✓ [[

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BWR/6 Support Side Entry Orifice (SEO) Part 21

Background – BWR/6 SEO

- [[]]

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New Discovery / 10 CFR Part 21 Evaluation

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SC 21-04 Revision 1

- [[

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Licensing Update

Kent Halac

Licensing Interactions

Recently Approved

- GESTAR Amendment 50 to Enhance LOCA Language Final SE Sep, 2020
- GESTAR Amendment 51 to Add LUA/LTA/HBLUA Programs Final SE Nov, 2020

Ongoing Review

- N/A

Near-Term Submittals

- [[

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Licensing Interactions

NRC Engagement

- **ARMOR Testing Update**
 - Topical Schedule Meeting – 3/17/21 (Rockville and Wilmington)
 - Virtual Meeting – 4/6/21 (Rockville and Wilmington)

- **Risk-Informed Burnup Extension**
 - Virtual Meeting – 2/2/21 (Rockville and Wilmington)
 - Virtual Meeting – 3/18/21 (Rockville and Wilmington)
 - Virtual Meeting – 4/5/21 (Rockville and Wilmington)
 - Tech Update – 8/17/21 (Rockville and Wilmington)

Methodology Update

CRDA

- GESTAR has been updated to Revision 30 to implement CRDA in April 2020.
- Updates to the Compliance Reports for GNF2 and GNF3 Issued in August 2020.
- CRDA benefits can now be realized
- LaSalle submitted LAR to implement CRDA.

ATF

- ARMOR/IronClad LTAs operating in Clinton and Hatch.
- GESTAR has been updated to Revision 31 to implement LUA/LTA/HBLUA in November 2020.
- LUA/LTA/HBLUA will allow for taking current fuel to higher burnups to gather data for full burnup extension in the future.
- Limerick Unit 2 installed [[]] HBLUA in Cycle 17.
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