Higher Burnup Workshop III

August 24, 2022

9:00 am – 11:30 am

Workshop Agenda

Time	*Topic*	*Speaker*
9:00-9:05	Welcome and Meeting Logistics	NRC
9:05-9:15	Overview and Status Update (IE Rulemaking & RFAA Table)	NRC
9:15-9:35	Research Information Letter (RIL) on Fuel Fragmentation, Relocation, and Dispersal (FFRD) on Higher Burnup Fuel	NRC
9:35-9:55	Update on FFRD and Licensing Implications	Industry
9:55-10:10	Discussion	NRC and Industry
10:10-10:20	Break	All
10:20-10:35	Storage and Transportation	NRC
10:35-10:45	Performing an Environmental Evaluation of the Transportation of Accident Tolerant Fuel (ATF)	NRC
10:45-11:05	Update on the Collaborative Research on Advanced Fuel Technologies for Light-Water Reactors (CRAFT)	Industry
11:05-11:20	Discussion	NRC and Industry
11:20-11:30	Public Comments	Public

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Opening Remarks

Joe Donoghue

Director

Division of Safety Systems (DSS)

Bo Pham

Director

Division of Operating Reactor Licensing (DORL)

Welcome and Introductions

Introductions

- Richard Chang, NRR/DORL - LLPB Branch Chief
- Stephanie Devlin-Gill, NRR/DORL – ATF Lead Project Manager
- Daniel King, NRR/DORL – ATF & Increased Enrichment (IE) Rulemaking DORL Project Manager
- Joey Messina, NRR/DSS – Technical Reviewer, Nuclear Methods & Fuels Analysis Branch
- Carla Roque-Cruz, NRR/DORL – IE Rulemaking DORL Lead Project Manager
- Stacy Joseph, NMSS - IE Rulemaking Project Manager
- James Corson, RES – Reactor System Engineer
- Drew Barto, NMSS – Senior Nuclear Engineer
- Jason Piotter, NMSS – Senior Mechanical Engineer
- John Wise, NRR/DNRL – Senior Technical Advisor
- Don Palmrose, NMSS – Senior Reactor Engineer

Meeting Logistics

- Meeting visuals and audio are through MS Teams.
- Participants are in listen-only mode until the discussion and public feedback period. During which, the NRC will allow attendees to un-mute.
- This is an Observation meeting. Public participation and comments are sought during specific points during the meeting.
  - NRC will consider the input received but will not prepare written responses.
  - No regulatory decisions will be made during this meeting.
- This meeting is being recorded.

Meeting Purpose

- Provide all stakeholders with updated information about current NRC and industry activities for higher burnup and increased enrichment.
- Exchange of information between NRC and industry on higher burnup and increased enrichment activities.
- Provide an opportunity for members of the public to ask questions of the NRC staff.

Increased Enrichment Rulemaking Update

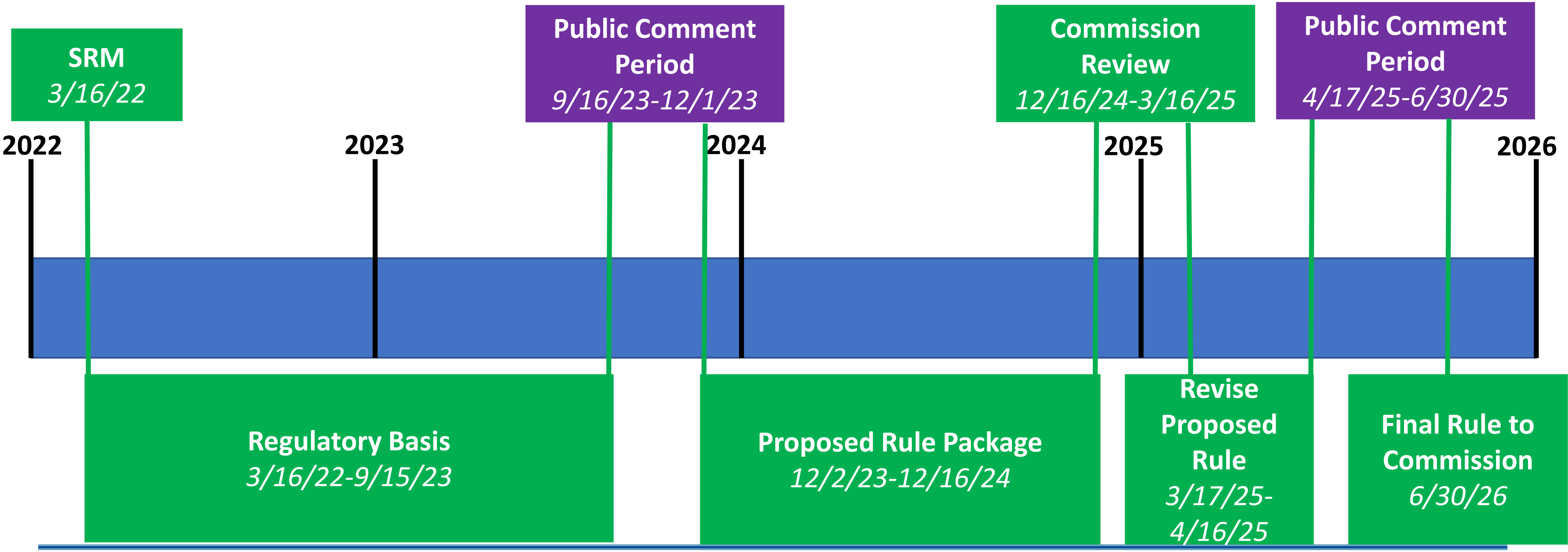
Carla Roque-Cruz, NRR/DORL

Stacy Joseph, NMSS/REFS

Status of Rulemaking Activity

- **Comment-Gathering Public Meeting held on 6/22/2022**
  - Meeting Summary: ML22208A001
- **NRC staff is developing the regulatory basis**
  - Discusses regulatory issues and alternatives to resolve them
  - Considers legal, policy, and technical issues
  - Considers costs and benefits of each alternative
  - Identifies the NRC staff's recommended alternative
  - Considers feedback obtained from the 6/22/2022 public meeting
- **Possible alternatives:**
  - Maintain status quo
  - Revise regulations
  - Revise guidance

Next Steps



Note: Dates listed are estimates only, and thus are subject to change.

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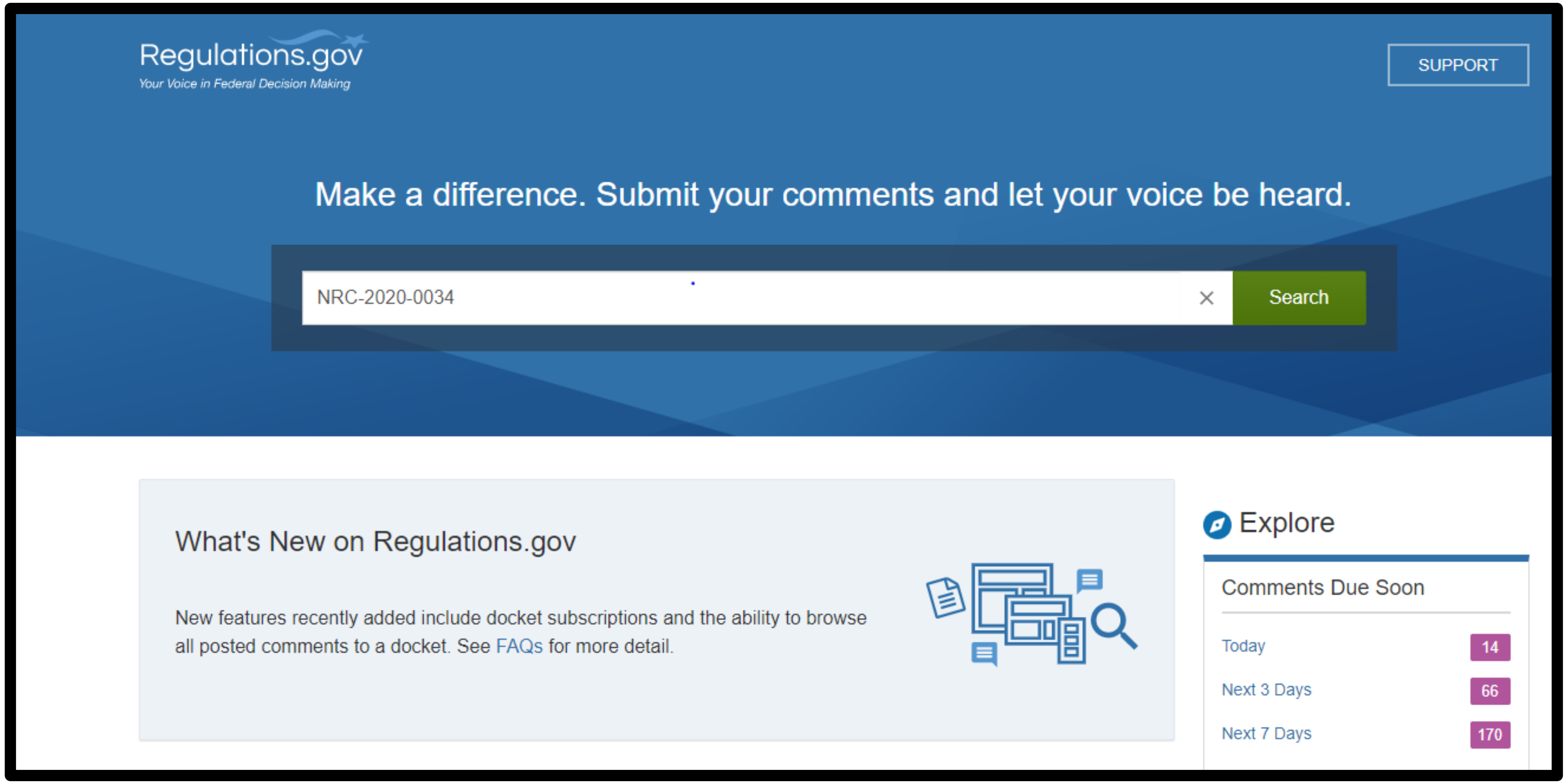
Stay Updated on IE Rulemaking

- Go to https://www.regulations.gov/ and search for docket ID **NRC-2020-0034.**



Regulatory Framework Applicability Assessment

Joseph Messina
Nuclear Methods and Fuel Analysis Branch
Office of Nuclear Reactor Regulation

Introduction

- The Regulatory Framework Applicability Assessment was issued in May 2022 and can be accessed at ADAMS Accession No. ML22014A112

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Regulatory Framework Applicability Assessment

and Licensing Pathway Diagram

for the Licensing of ATF-Concept, Higher Burnup,

and Increased Enrichment Fuels

MAY, 2022

Purpose

- Improve upon the initial scoping study presented in Tables A.1, A.2, and A.4 in the previous revision of the ATF Project Plan (version 1.1)
- Evaluate the applicability of existing regulations and guidance, as well as identify any updates needed

Initial Scoping Study

- An initial, rough scoping study was presented in Appendix A of version 1.1 the ATF Project Plan

Table A.1 Potentially Affected Regulations

Regulation (10 CFR)	Title	Affected by:	
		Burnup	Enrichment
50.34	Contents of Applications; Technical Information	✓	✓
50.46	Acceptance Criteria for Emergency Core Cooling Systems for Light Water- Nuclear Power Reactors	✓	✓
50.67	Accident Source Term	✓	✓
50.68	Criticality Accident Requirements		✓
50, Appendix I	Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low as is Reasonably Achievable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents	✓	✓
50, Appendix K	ECCS Evaluation Models	✓	✓
51	Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions (specifically, Tables S-3 and S-4)	✓	✓
70.24	Criticality Accident Requirements		✓
100	Reactor Site Criteria	✓	✓

Table A.2 Potentially Affected Guidance

Guidance Document	Title	Affected by: Burnup	Affected by: Enrichment
NUREG-0630	Cladding Swelling and Rupture Models for LOCA Analysis	✓	
NUREG-0800	Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition (Section 4.2, "Fuel System Design" in particular for burnup)	✓	✓
NUREG-1465	Accident Source Terms for Light-Water Nuclear Power Plants	✓	✓
NUREG-1555	Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan	✓	✓
NUREG-2121	Fuel Fragmentation, Relocation, and Dispersal During the Loss-of-Coolant Accident	✓	
NUREG/CR-7022 Vol. 1-2	FRAPCON-3.5	✓	✓
NUREG/CR-7023 Vol. 1-2	FRAPTRAN 1.5	✓	✓
NUREG/CR-7024	Material Property Correlations: Comparisons Between FRAPCON-3.5, FRAPTRAN 1.5, and MATPRO	✓	✓
NUREG/CR-7219	Cladding Behavior During Postulated Loss-of-Coolant Accidents	✓	
RG 1.183	Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors	✓	✓
RG 1.195	Methods and Assumptions for Evaluating Radiological Consequences of Design Basis Accidents at Light-Water Nuclear Power Reactors	✓	✓
RG 1.203	Transient and Accident Analysis Methods	✓	✓
DG 1327	Pressurized Water Reactor Control Rod Ejection and Boiling Water Reactor Control Rod Drop Accidents	✓	✓

Regulatory Framework Applicability Assessment

- NRC staff has more thoroughly assessed its regulatory framework and expand Tables A.1, A.2, and A.4 in version 1.1 of the ATF Project Plan
- This applicability analysis assesses the NRC's regulatory framework to specifically:
  - identify regulations and guidance that are impacted,
  - whether pertinent regulations and guidance do not speak to phenomena unique to high burnup, increased enrichment, or near-term ATF concepts
  - how those could be addressed

Example 1

#	Guidance Document Regulation	Burnup to 68 GWd/MTU	Burnup to 75 GWd/MTU	^{235}U Enrichment beyond 5.0 wt%	Chromium-coated Zirconium Cladding	Doped UO_2 Fuel Pellets
16	NUREG-0630 Cladding Swelling and Rupture Models for LOCA Analysis (ML053490337)	• Not fully applicable • Reason: NUREG-0630 models are hot-rod models and thus do not consider interactions between rods. Interactions between rods affect swelling and rupture behavior, which may impact the amount of fragmented fuel that may disperse, and should, thus, not be neglected. Closure: Interactions between rods should be considered for swelling and rupture modelling. • Reason: HBU rod internal pressures may exceed the rod internal pressures of the data provided in NUREG-0630. Closure: If the NUREG-0630 data is desired to be used, licensees should show that HBU rod internal pressures are bounded by the data provided in NUREG-0630.	• Not fully applicable • Reason: NUREG-0630 models are hot-rod models and thus do not consider interactions between rods. Interactions between rods affect swelling and rupture behavior, which may impact the amount of fragmented fuel that may disperse, and, should, thus, not be neglected. Closure: Interactions between rods should be considered for swelling and rupture modelling. • Reason: HBU rod internal pressures may exceed the rod internal pressures of the data provided in NUREG-0630. Closure: If the NUREG-0630 data is desired to be used, licensees should show that HBU rod internal pressures are bounded by the data provided in NUREG-0630.	• Fully applicable • No data gaps	• Not fully applicable • Reason: Cladding swelling and burst data presented is from bare zircaloy cladding, so should not be used if the benefits of coated cladding are to be credited. Closure: As stated in coated cladding interim staff guidance (ML19343A121), if NUREG-0630 is used, it would be useful for licensees to show that data bounds the performance of the coated cladding, or if new burst stress and ballooning strain limits are proposed, a significant body of data would be useful to demonstrate that the degree of swelling will not be underestimated. • Framework / approach described for modeling swelling and rupture remains fully applicable.	• Fully applicable • No data gaps

Guidance Document Regulation	Burnup to 68 GWd/MTU	Burnup to 75 GWd/MTU
NUREG-0630 Cladding Swelling and Rupture Models for LOCA Analysis (ML053490337)	• Not fully applicable • Reason: NUREG-0630 models are hot-rod models and thus do not consider interactions between rods. Interactions between rods affect swelling and rupture behavior, which may impact the amount of fragmented fuel that may disperse, and should, thus, not be neglected. Closure: Interactions between rods should be considered for swelling and rupture modelling. • Reason: HBU rod internal pressures may exceed the rod internal pressures of the data provided in NUREG-0630. Closure: If the NUREG-0630 data is desired to be used, licensees should show that HBU rod internal pressures are bounded by the data provided in NUREG-0630.	• Not fully applicable • Reason: NUREG-0630 models are hot-rod models and thus do not consider interactions between rods. Interactions between rods affect swelling and rupture behavior, which may impact the amount of fragmented fuel that may disperse, and, should, thus, not be neglected. Closure: Interactions between rods should be considered for swelling and rupture modelling. • Reason: HBU rod internal pressures may exceed the rod internal pressures of the data provided in NUREG-0630. Closure: If the NUREG-0630 data is desired to be used, licensees should show that HBU rod internal pressures are bounded by the data provided in NUREG-0630.

Applicability: identified as fully applicable or not fully applicable

Reason(s) stated for why the regulation or guidance is not fully applicable

If closure is necessary and has been identified, it is listed here

Example 2

- Green text indicates that the NRC may have an action to facilitate closure

#	Guidance Document Regulation	Burnup to 68 GWd/MTU	Burnup to 75 GWd/MTU	^{235}U Enrichment beyond 5.0 wt%	Chromium-coated Zirconium Cladding	Doped UO_2 Fuel Pellets
17	NUREG-0800 SRP Chapter 4.2 Fuel System Design (ML070740002)	• Not fully applicable • Reason: Interim RIA guidance provided in Appendix B does not match the most recent guidance given in RG 1.236. Closure: Appendix B should be updated, and readers should be directed to RG 1.236. Priority: Low (this is administrative in nature as RG 1.236 has been published to address RIA guidance up to 68 GWd/MTU); long-term • Reason: FFRD not	• Not fully applicable • Reason: Interim RIA guidance provided in Appendix B does not match the most recent guidance given in RG 1.236. Closure: Appendix B should be updated, and readers should be directed to RG 1.236. Note that RG 1.236 is not fully applicable to 75 GWd/MTU. Priority: Low; long-term • Reason: FFRD not thoroughly addressed	• Not fully applicable • Reason: Interim RIA guidance in Appendix B does not match the current RIA guidance in RG 1.236. RG 1.236 is also not applicable to fuel enriched to greater than 5.0 wt%. Closure: See discussion on RG 1.236 • Note: Increased enrichment could potentially lead to higher rod worth and peaking factors. Sections	• Not fully applicable • Note: Coated cladding interim staff guidance (ML19343A121) created to supplement SRP Section 4.2 in coated cladding reviews. • Reason: Interim RIA guidance in Appendix B does not match the current RIA guidance in RG 1.236. Note that RG 1.236 is also not applicable to coated cladding. Closure: See	• Not fully applicable • Reason: Interim RIA guidance in Appendix B does not match the current RIA guidance in RG 1.236. RG 1.236 is also not applicable to doped fuel. Closure: See discussion on RG 1.236 • Reason: Impact of additives on fuel performance has not been extensively quantified

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Next Steps

- Update the Regulatory Framework Applicability Assessment table as necessary
- Pursue closures identified in the table

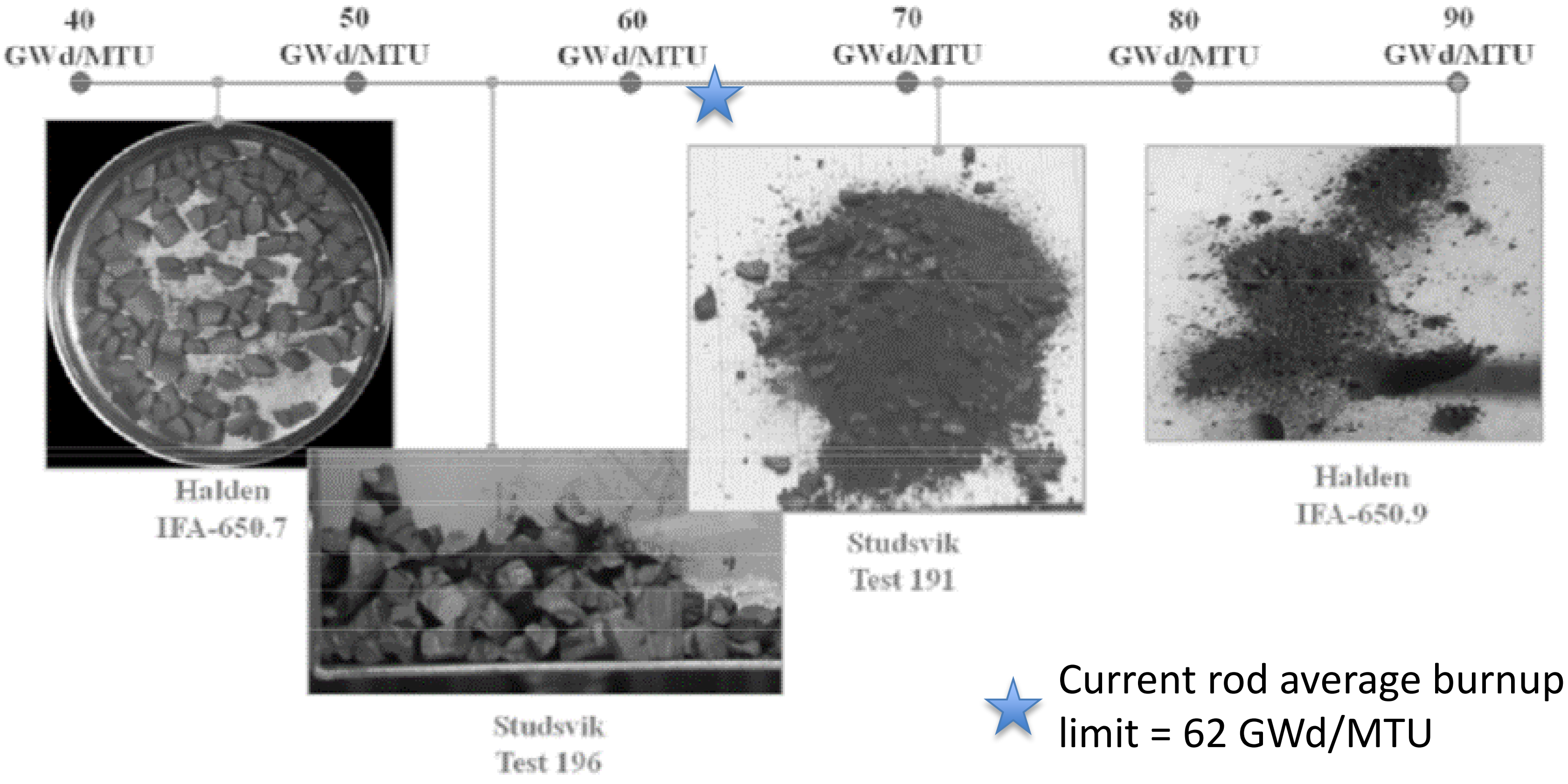
Research Information Letter on Fuel Fragmentation, Relocation, and Dispersal

James Corson, Ph.D.

Reactor Systems Engineer

Office of Nuclear Regulatory Research

Experiments have shown that fuel can fragment during Loss of Coolant Accident



★ Current rod average burnup limit = 62 GWd/MTU

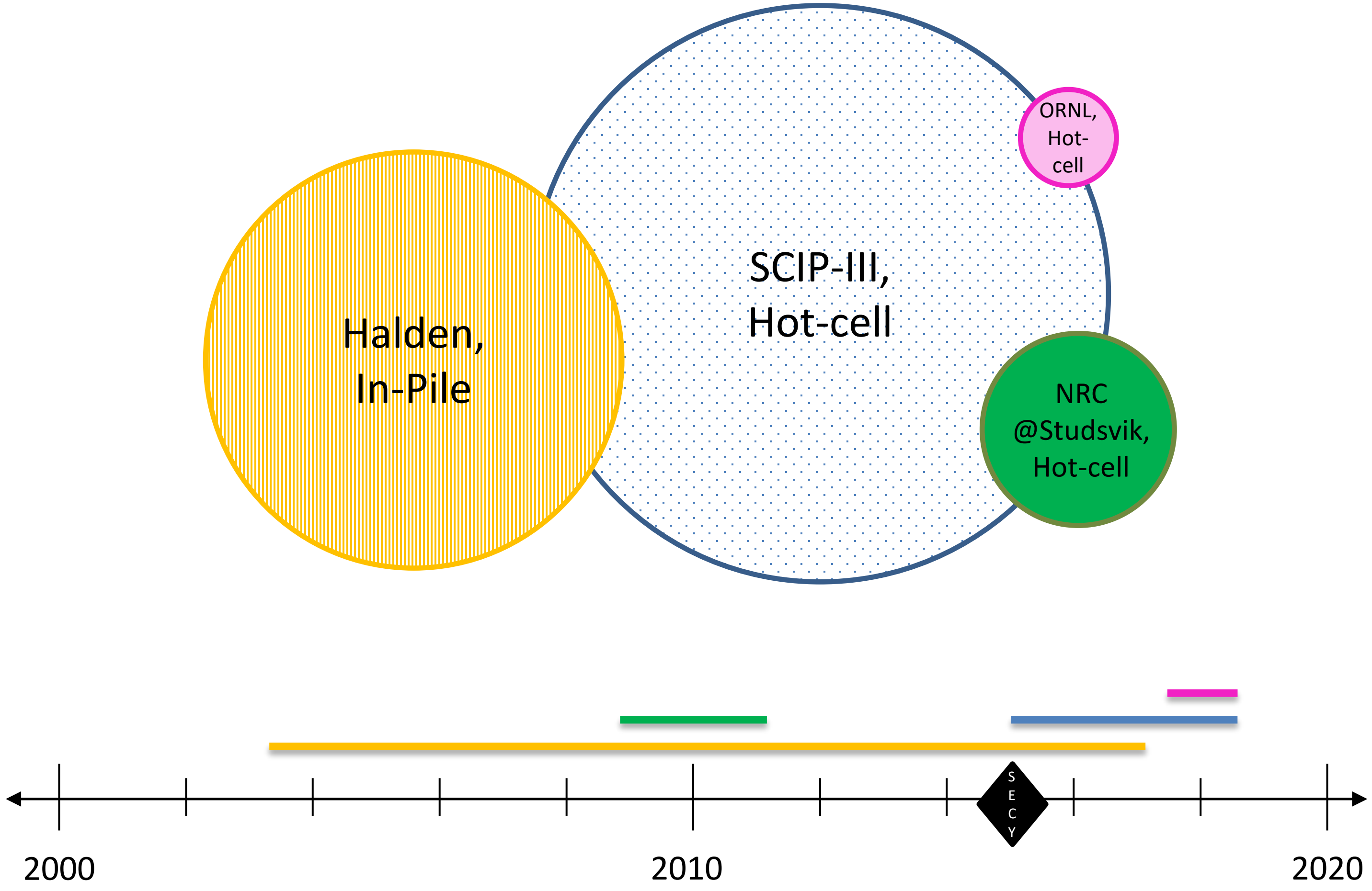
NRC Has Studied FFRD and Published Findings

- RIL 2008-01, "Technical Basis for Revision of Embrittlement Criteria in 10 CFR 50.46"
- NUREG-2121, "Fuel Fragmentation, Relocation, and Dispersal During the Loss-of-Coolant Accident"
- SECY-15-0148, "Evaluation of Fuel Fragmentation, Relocation and Dispersal under Loss-of-Coolant Accident (LOCA) Conditions Relative to the Draft Final Rule on Emergency Core Cooling System Performance during a LOCA (50.46c)"
- RIL 2021-13, "Interpretation of Research on Fuel Fragmentation, Relocation, and Dispersal at High Burnup"

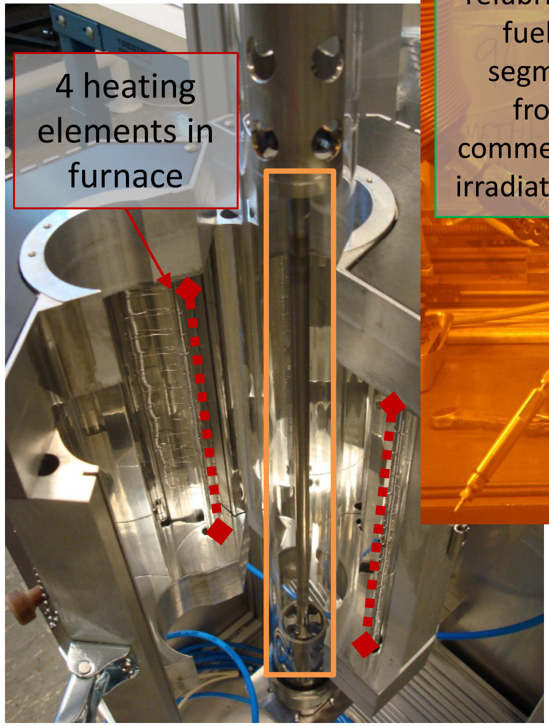
RES Staff Has Communicated Recent FFRD Findings in RIL 2021-13

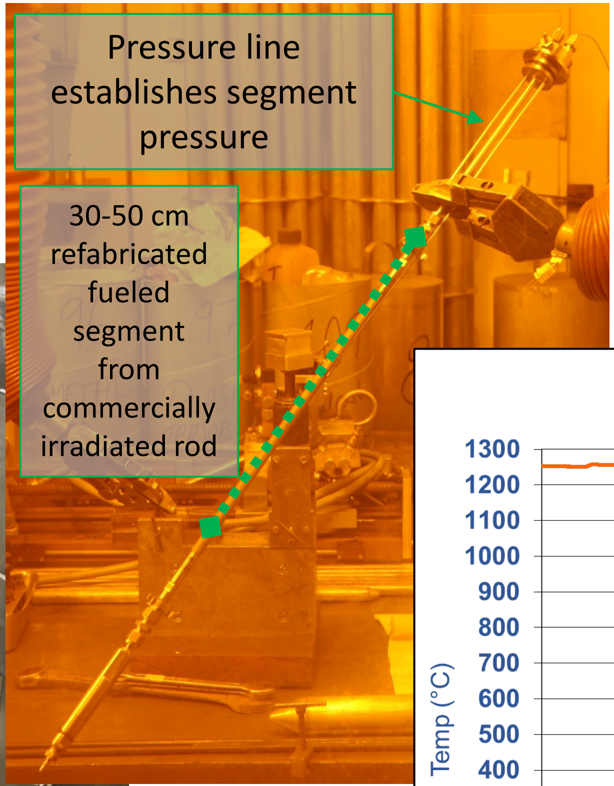
- Research Information Letters summarize research findings and discuss how information may be used in regulatory decisions
  - RIL 2021-13 is addressed to technical staff in NRR
  - RILs are not guidance
- Goal of RIL is to synthesize recent FFRD research

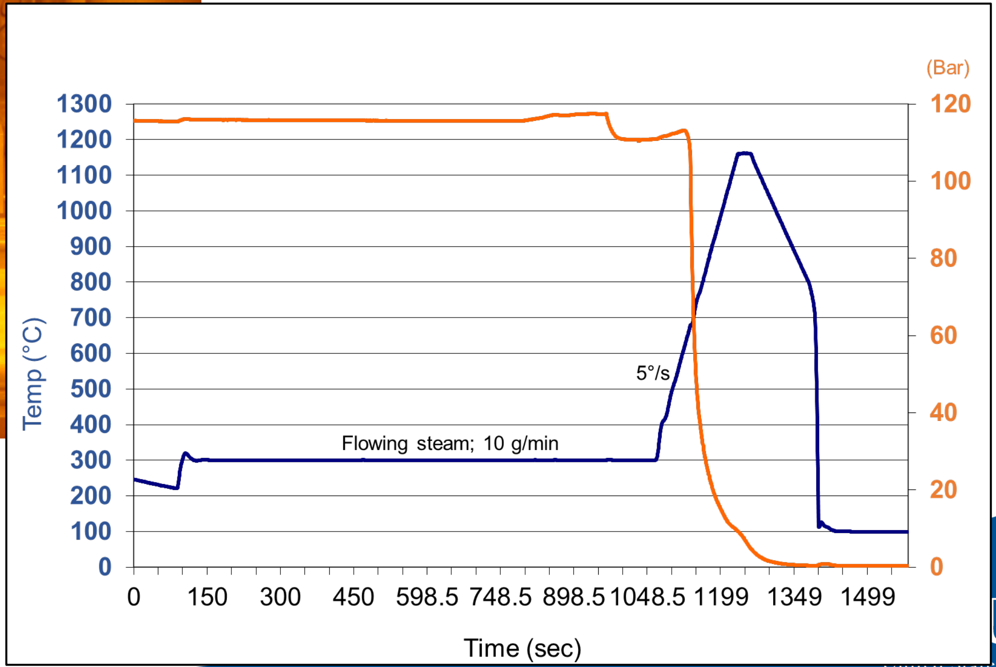
Data Sources for RIL 2021-13



Most tests reported in RIL 2021-13 were performed in hot cells



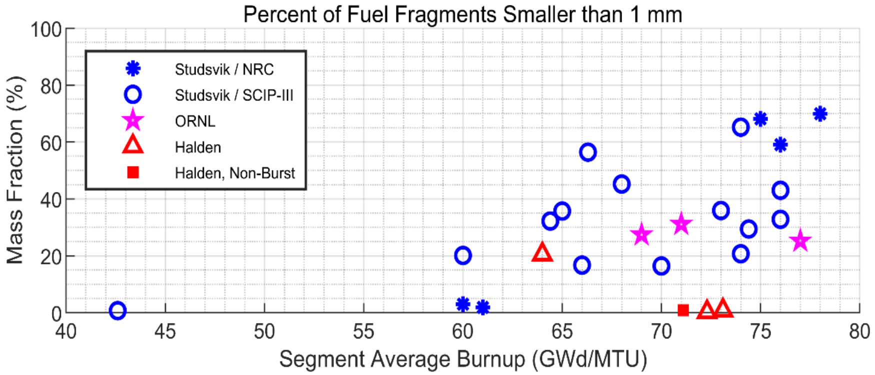


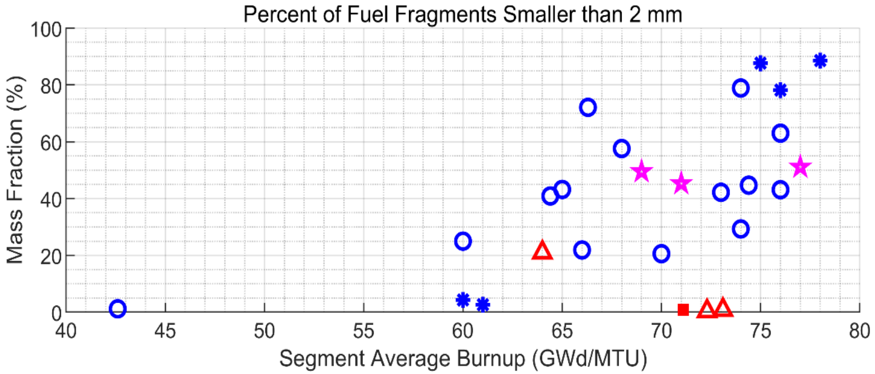


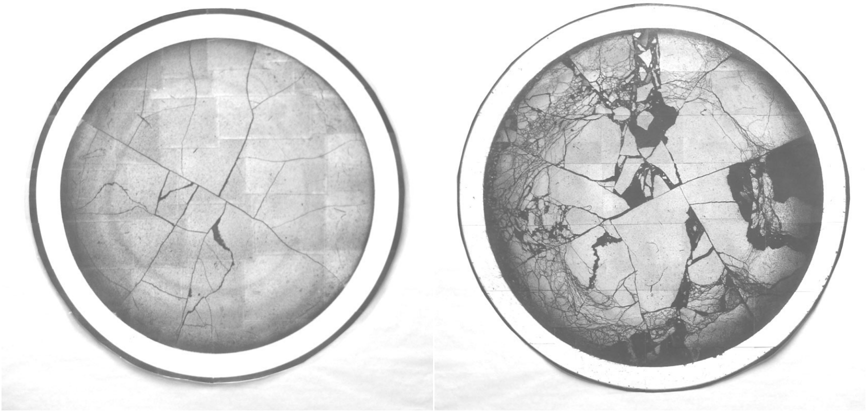
RIL 2021-13 Addresses Five Elements of NRC's Interpretation of FFRD Research

1. Fine fragmentation burnup threshold
2. Strain threshold for fragmentation
3. Dispersible mass fraction
4. Transient fission gas release
5. Fuel packing fraction

Element 1: Empirical threshold at which fuel pellets become susceptible to fine fragmentation





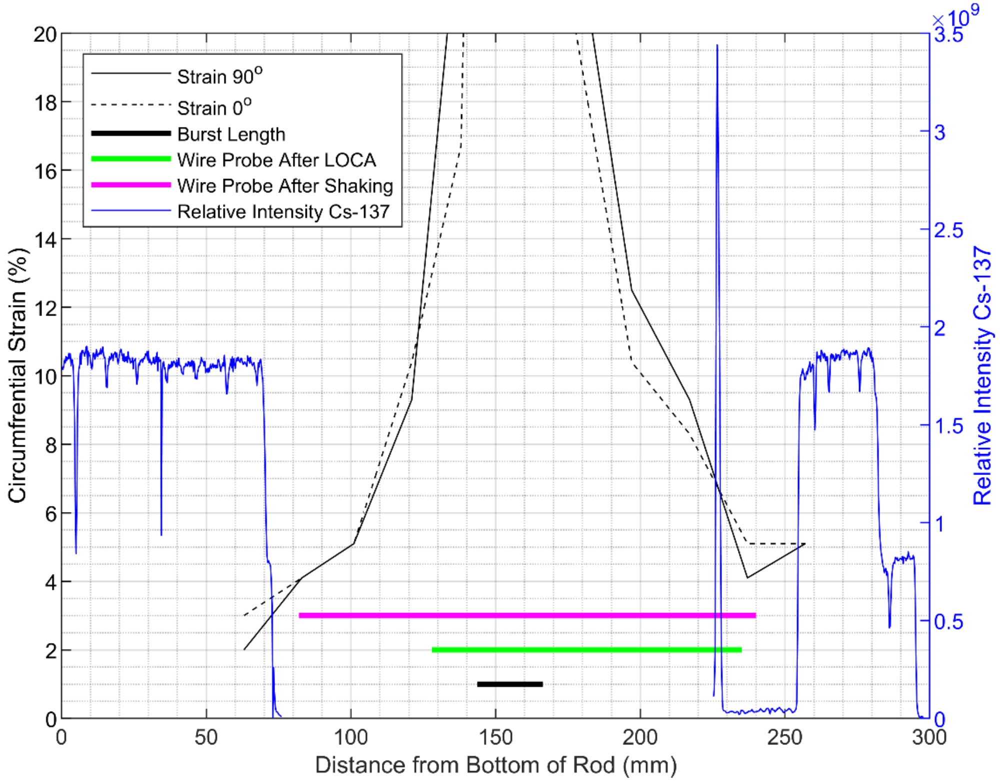


Segment from NRC's ANL LOCA program at 55 GWd/MTU before and after testing

Research supports a pellet-average burnup conservative limit of **55 GWd/MTU** as the **onset of fine fuel fragmentation**

FFRD

Element 2: A local cladding strain threshold below which relocation is limited



NRC test #	Strain threshold, top (%)	Strain threshold, bottom (%)
189	6.0	3.0
191	6.0	4.0
192	5.0	4.0
193	1.0	4.0
196	3.0	5.0
198	4.5	9.0

Research suggests **fuel relocation is limited** in regions of the fuel rod experiencing **less than 3% cladding strain**.

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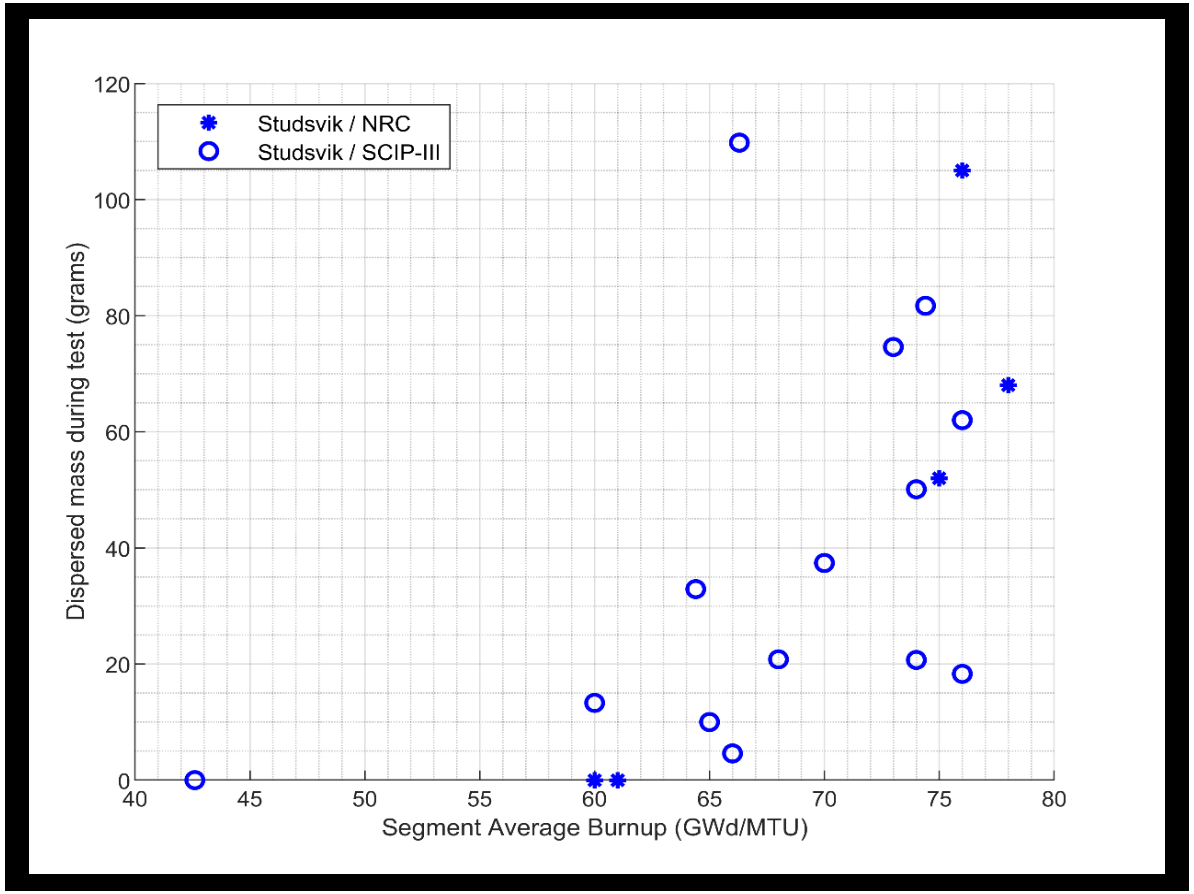
Element 3: A conservative value for the mass of "dispersible" fuel as a function of burnup

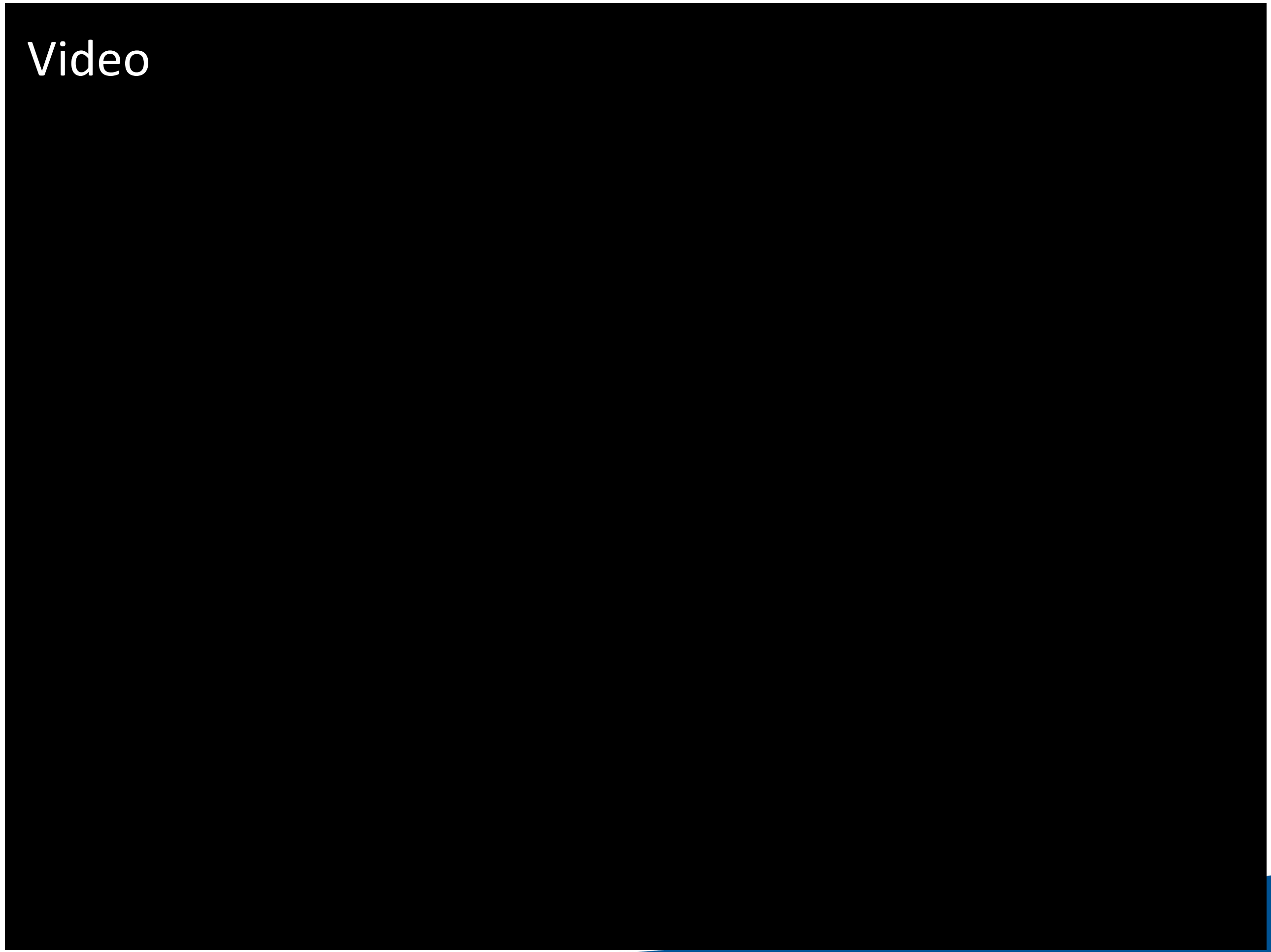
What do dispersal measurements look like?



Dispersal "during the test"

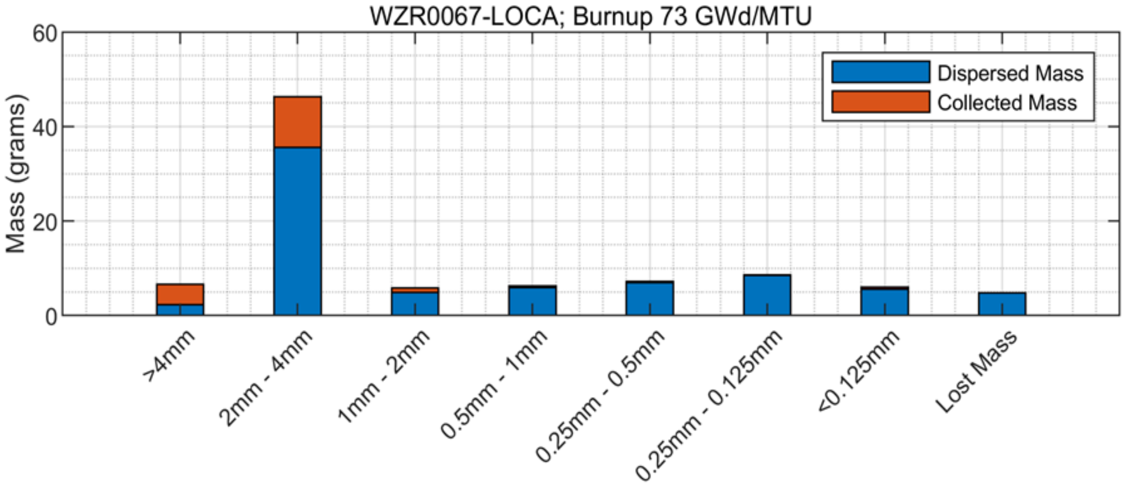
Element 3: A conservative value for the mass of "dispersible" fuel as a function of burnup

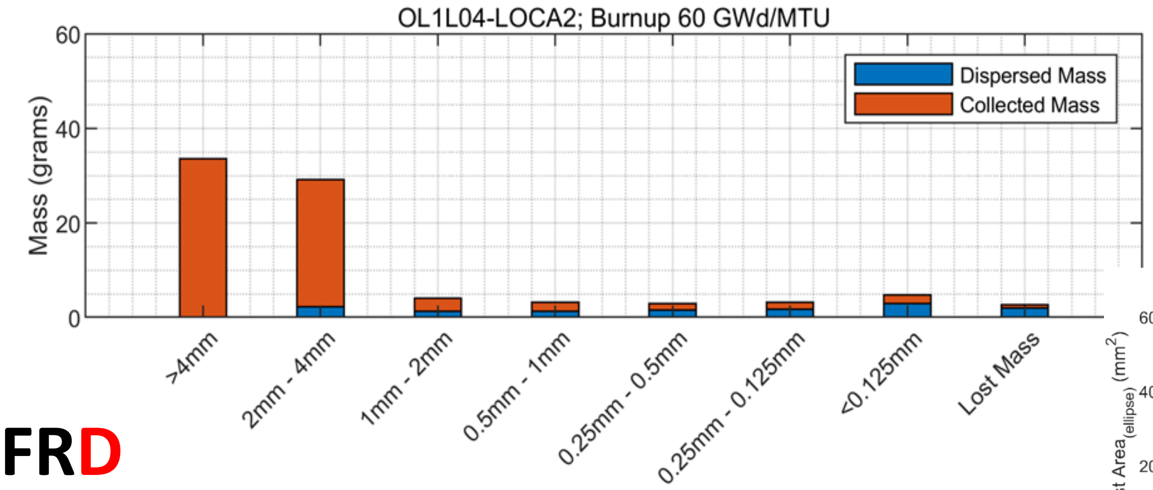
What do dispersal measurements look like?

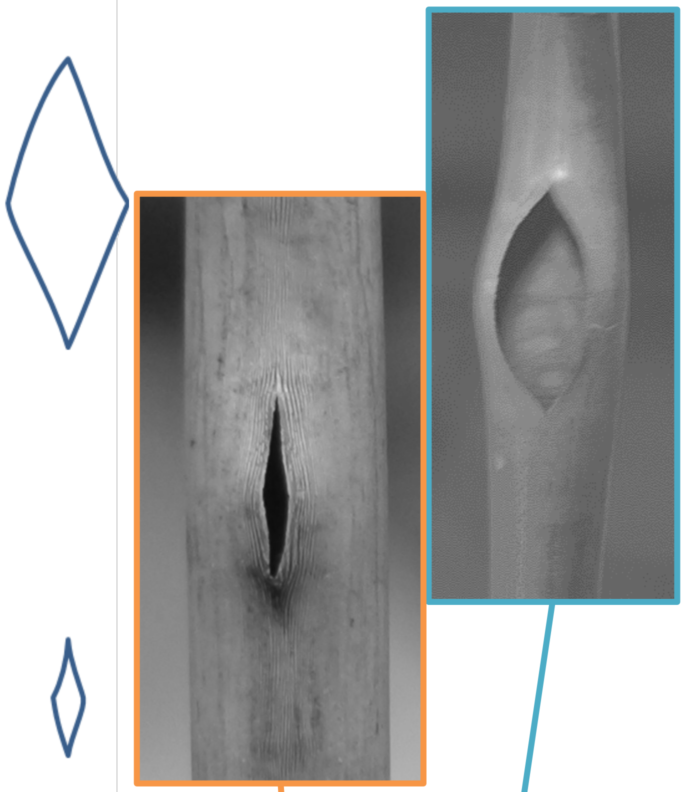


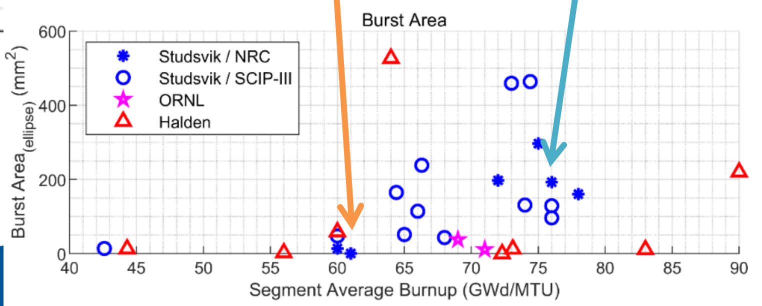
Dispersal "during shaking"

Element 3: A conservative value for the mass of "dispersible" fuel as a function of burnup









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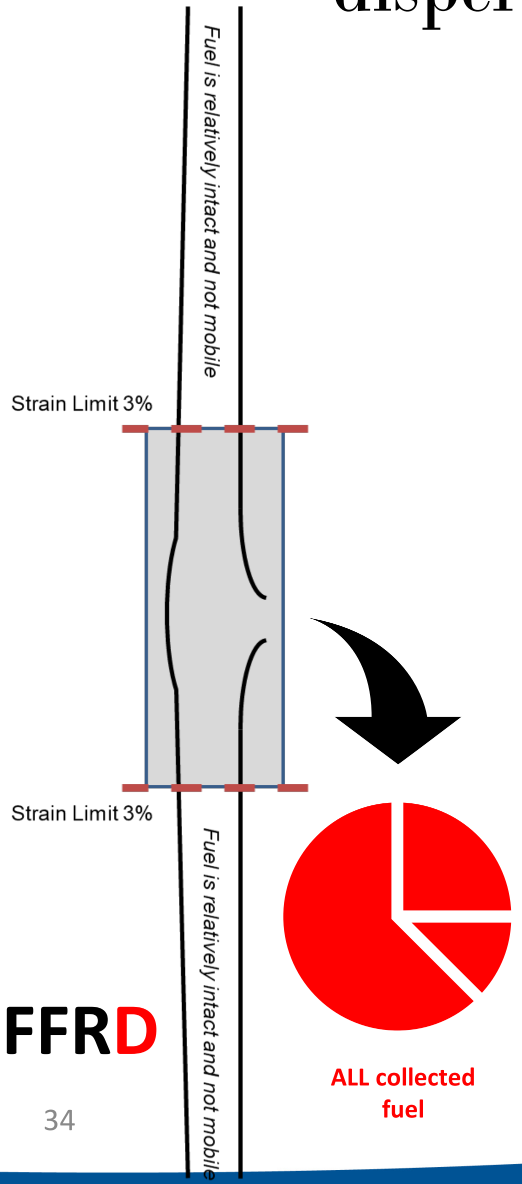
Element 3: A conservative value for the mass of "dispersible" fuel as a function of burnup



	Difference between dispersal predicted by the model and all mobile fuel observed in the experiment	
SCIP test	Mass (g)	Prediction/Measured
OL1L04-LOCA-2	125	250%
N05-LOCA	-19	76%
VUR1-LOCA-1	15	109%
WZR0067-LOCA	-16	83%
VUL2-LOCA1	-7	94%
VUL2-LOCA3	8	105%
VUL2-LOCA4	5	102%

Recommend a conservative model to predict the mass of fuel dispersal to be all fuel above the **burnup threshold of 55 GWd/MTU** in the length of the rod with **greater than 3% cladding strain** to disperse.

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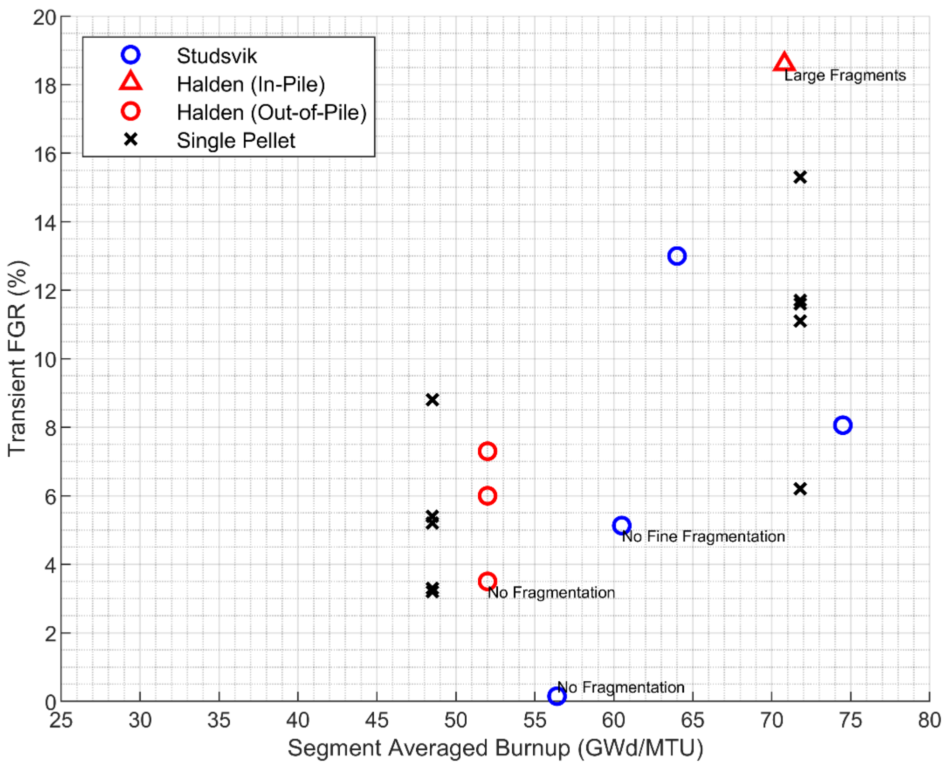
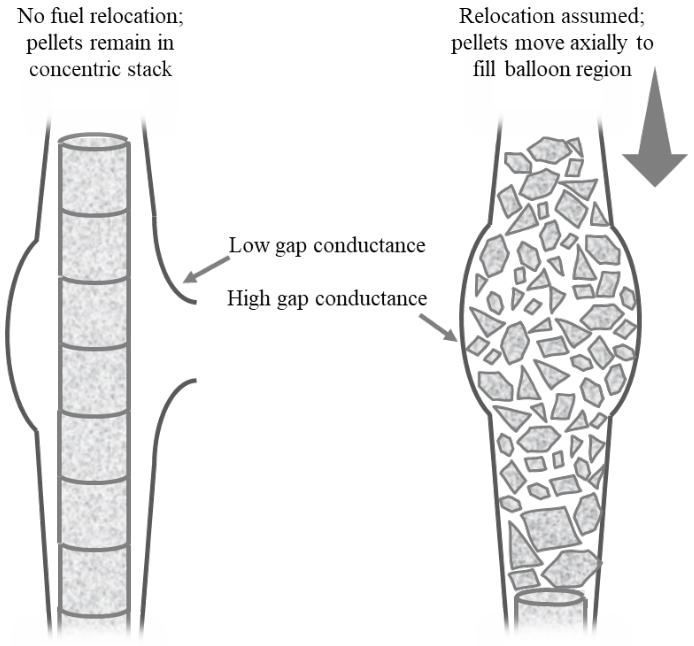
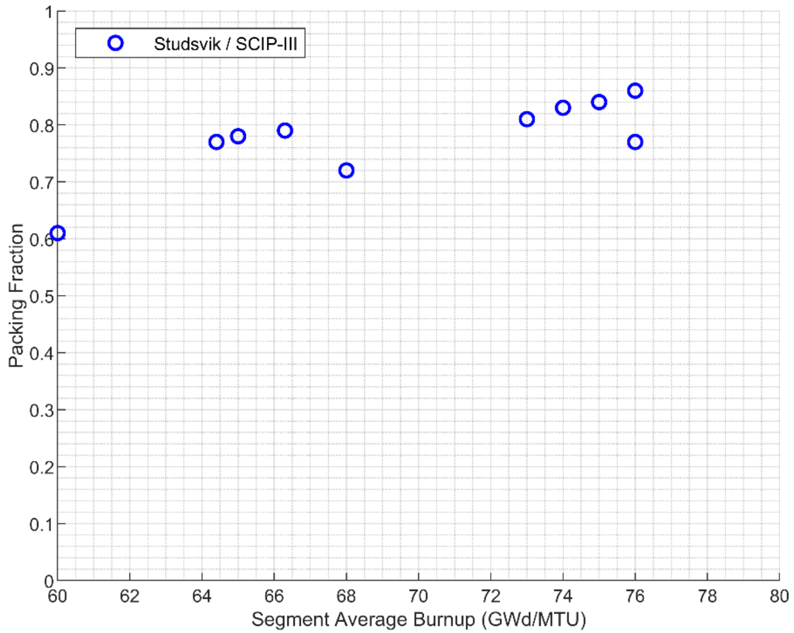
Element 4: Provide evidence of significant tFGR that may impact ballooning and burst behavior of high burnup fuel rods



Data shows increasing transient fission gas release with burnup. However, many other factors besides burnup impact tFGR (e.g., fuel temperature, stresses in fuel). Licensees will need to address tFGR in their LOCA evaluation models. Some models exist for tFGR, but more validation of those models is needed.

Element 5: Establish a value for the packing fraction of relocated but non-dispersed fuel in the balloon region



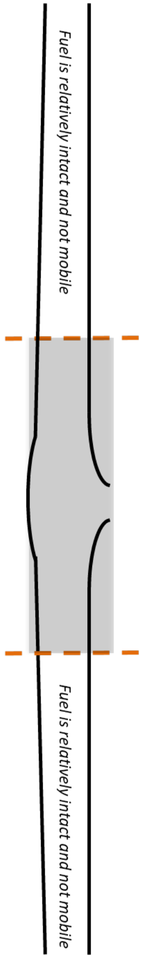


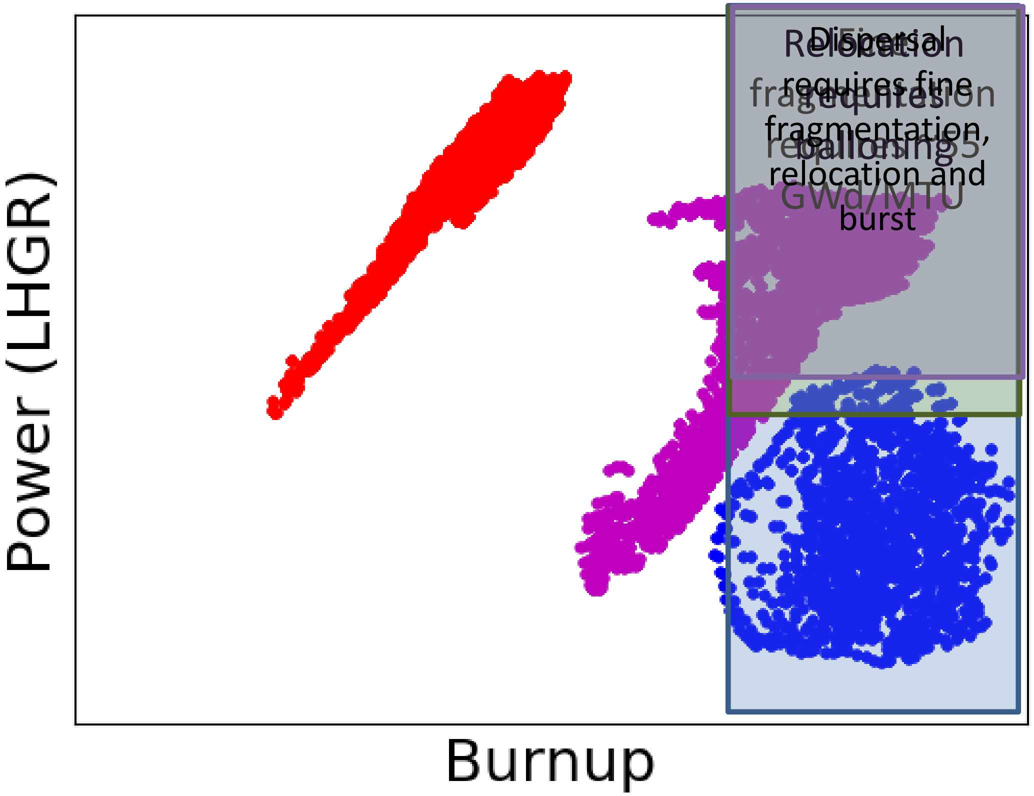
It is reasonable to use packing fraction values between 70 to 85 percent for fuel susceptible to fine fragmentation. (Fuel at lower burnup would likely have a lower packing fraction).

To determine the impact on ballooning and burst, it is important to examine a range of packing fractions to account for these effects.

FFRD

The RIL helps identify which rods are susceptible to FFRD





Overlap influenced by:

- ECCS response
- Plant design
- Loading pattern
- Fuel and cladding design
- Transient FGR

This information is prototypical of PWR. BWR's will have few if any rods susceptible to dispersal due to different operating practices, system pressure, etc.

There are limitations to the conclusions of the RIL

- Limits are not applicable to doped fuel or coated cladding.
- Limits are simplistic, derived as a function of burnup only
- Limits anticipate accurate prediction of cladding strain along the axial length of a fuel rod
- Burst opening size is presumed to be stochastic and therefore limits assume large opening size

NRC continues to participate in programs related to FFRD

- SCIP-IV (2019-2024) includes tests near burnup threshold identified in the RIL and tests on doped fuel
  - NRC is currently reviewing Studsvik's proposals for next phase of SCIP
- Idaho National Laboratory is working on a LOCA test plan for the TREAT reactor
  - NRC has provided feedback through EPRI's Collaborative Research on Advanced Fuel Technologies program

RIL 2021-13 Provides a Snapshot in Time of Our Understanding of FFRD and tFGR

- NRC continues to participate in experimental programs that may provide new information
- NRC encourages industry to engage with us to understand the impact of FFRD on licensing
- NRC welcomes questions and challenges from industry regarding our current understanding of FFRD outlined in the RIL

Questions?

Industry Presentation:
Update on FFRD and Licensing Implications

Discussion Period

Break

High Burnup and Increased Enrichment Spent Fuel Transportation and Dry Storage Research and Licensing

Andrew Barto
Division of Fuel Management
Office of Nuclear Material Safety and Safeguards

Overview

- Phase 1, 2, and 3 ATF/HALEU Research
- Other DFM-Sponsored Research related to ATF/HALEU
- ATF/HALEU Licensing Activity

ATF/HALEU Phase 1

- ORNL/TM-2020/1725: *Assessment of Existing Transportation Packages for Use With HALEU* (ML21040A518)
- ORNL/TM-2020/1833: *Isotopic and Fuel Lattice Parameter Trends in Extended Enrichment and Higher Burnup LWR Fuel, Vol. I: PWR Fuel* (ML21088A336)
- ORNL/TM-2020/1835: *Isotopic and Fuel Lattice Parameter Trends in Extended Enrichment and Higher Burnup LWR Fuel, Vol. II: BWR Fuel* (ML21088A354)
- ORNL/TM-2021/1961: *Extended Enrichment Accident-Tolerant LWR Fuel Isotopic and Lattice Parameter Trends* (ML21088A254)

ATF/HALEU Phase 2

- ORNL/TM-2021/2330: *Impacts of LEU+ and ATF on Fresh Fuel Storage Criticality Safety* (ML22098A137)
- *Impacts of LEU+ and HBU Fuel on Decay Heat and Radiation Source Term*
- *Light Water Reactor LEU+ Lattice Optimization*
- *Assessment of Core Physics Characteristics of Extended Enrichment and Higher Burnup LWR Fuels using the Polaris/PARCS Two-Step Approach Vol. 1: PWR Fuel*
- *Assessment of Core Physics Characteristics of Extended Enrichment and Higher Burnup LWR Fuels using the Polaris/PARCS Two-Step Approach Vol. 2: BWR Fuel*
- *Transition Core Modeling for Extended Enrichment, Accident Tolerant Fuels in LWR using Polaris/PARCS*
- *SCALE 6.2.4 Validation:*
  - *Criticality Safety*
  - *Radiation Source Term*
  - *Spent Fuel Applications*

ATF/HALEU Phase 3

- *Nuclear Data Updates for SCALE 7*
- *Polaris+PARCS Micro Depletion Assessment*
- *Detailed investigation of Decay Heat Validation at higher burnup for LEU+*
- *LEU+ Impact for Burnup Credit*
- *SCALE 6.3 Validation:*
  - *Criticality Safety*
  - *Radiation Shielding*
  - *Spent Fuel Applications*
  - *Reactor Physics*

Additional DFM HALEU Research

- Update NUREG/CR-7108 on burnup credit depletion code validation:
  - Include bias estimates for new cross section data (ENDF/B-VII.1)
  - include new radiochemical assay measurements (e.g., DOE sibling rod HBU RCA samples w/BU up to 66 GWd/MTU)
- Update NUREG/CR-7109 on burnup credit
  - Include fission product bias estimates for new cross section data (ENDF/B-VII.1)
  - Evaluate applicability of French HTC critical experiments at higher burnups
- Develop NUREG/CR with recommendations for sensitivity uncertainty (S/U) methods to select critical experiments for criticality code validation

ATF/HALEU Transportation Licensing

- BU-D: Fresh UO_2 powder package
  - DOT Revalidation request to increase enrichment from 5% to 10%
- Traveller: Fresh PWR fuel assembly package
  - Loose rods enriched up to 7%
  - Fuel assemblies enriched up to 6%
- Versa-Pac: Various uranium contents
  - Increased mass for uranium enriched up to 20%

ATF/HALEU Transportation Licensing, continued

- DN-30X: UF6 package
  - Modification of existing DN-30 package to transport "30B-X" UF6 cylinders
  - 30B-10 for up to 10% enriched UF6
  - 30B-20 for up to 20% enriched UF6
  - Internal criticality control system
  - Still under review – Certificate of Compliance anticipated by end of calendar year 2022.

Key Messages

- We are proactively working on our regulatory readiness for the front and back end of the nuclear fuel cycle to enable the safe use of new fuels to support industry's timelines for deployment of ATF/HALEU LWR fuel
- We are actively certifying transportation packages for new fuels.

Performing a Transportation Evaluation of ATF with Increased Enrichment and Higher Burnup

Donald Palmrose, PhD

Senior Reactor Engineer

Office of Nuclear Material Safety and Safeguards

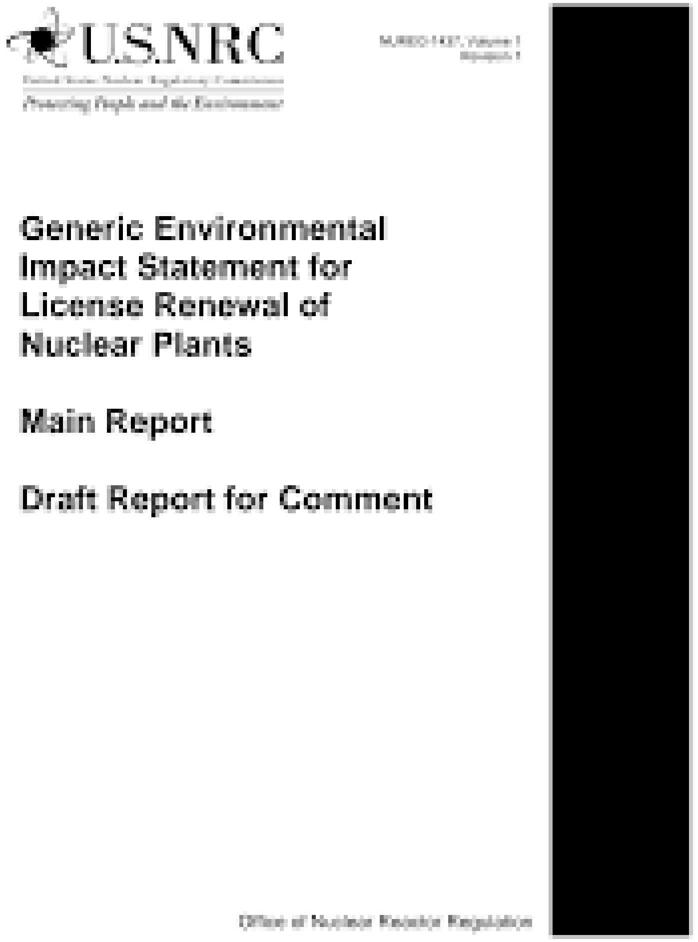
August 24, 2022

Outline

- 10 CFR 51.52 and Table S-4
- Past NRC Transportation Analyses and Assessments
- Need for a New Evaluation
- Leveraging Prior Transportation Reports and New ATF Studies
- Methodology
- Summary of Efforts to Date

10 CFR 51.52 and Table S-4

- 10 CFR 51.52, Environmental effects of transportation of fuel and waste – Table S-4
    - Environmental Reports for CPs, ESPs, or COLs of a light-water-cooled nuclear power reactor shall contain a statement concerning transportation of fuel and waste
- The transportation of fuel and waste can be considered a connected action under NEPA
- Two options under § 51.52
    - Meet the conditions of § 51.52(a) for use of Table S-4 (§ 51.52(c)), or
    - Provide a full description and detailed analysis of the environmental effects
- NUREG-1437 Revision 1 (2013) extended the § 51.52(a)(2) and (3) conditions to:
    - Not to exceed 5 percent by weight for uranium enrichment
    - Not to exceed 62 GWd/MTU for the average level of burnup


U.S.NRC

Generic Environmental Impact Statement for License Renewal of Nuclear Plants

Main Report

Draft Report for Comment

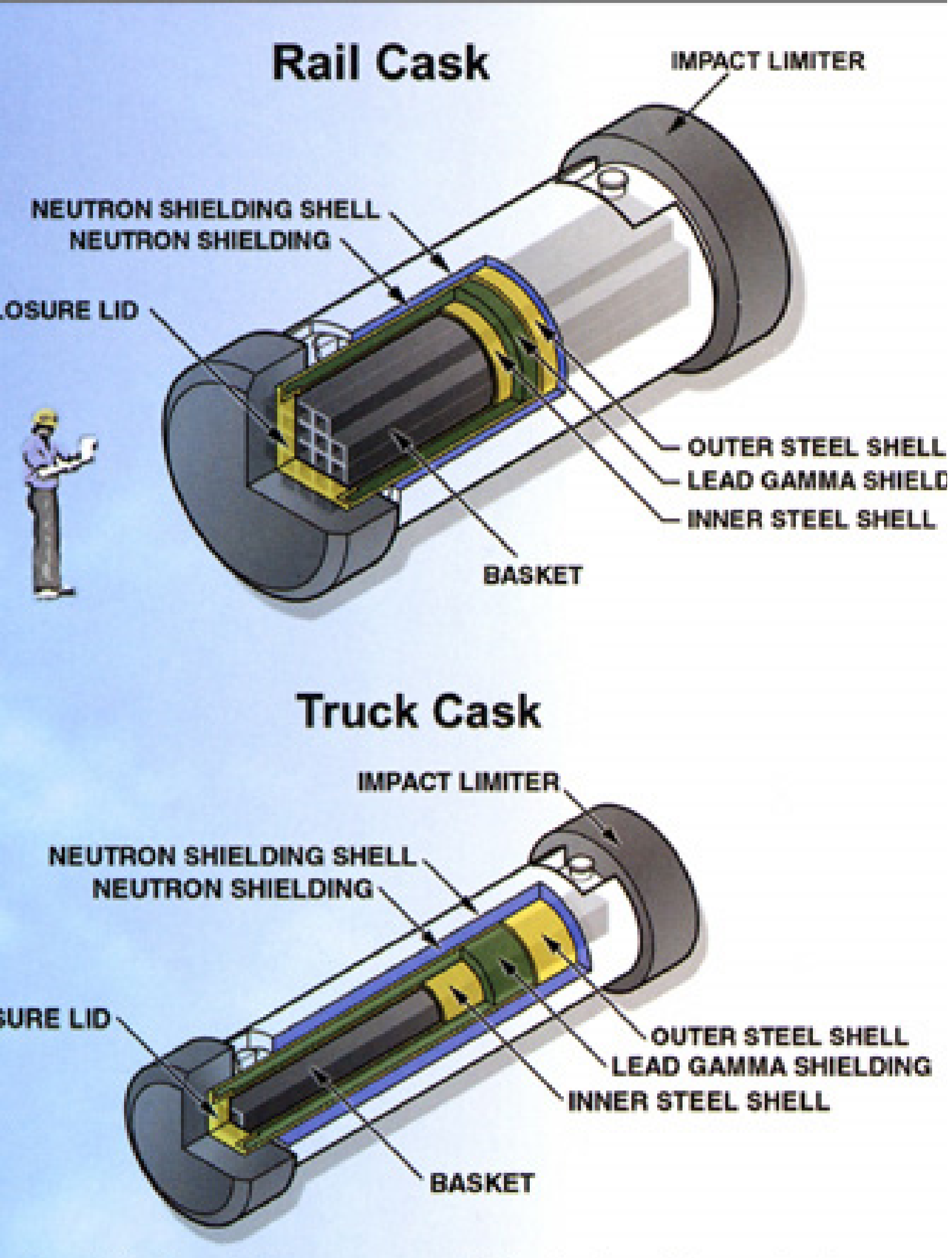
Office of Nuclear Reactor Regulation

Past NRC Transportation Analyses and Assessments

- WASH-1238 (1972) and Supplement 1 to WASH-1238 (NUREG-75/038 in 1975) for the basis of Table S-4
- NUREG-0170 (1977) “Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes”
- NUREG/CR-4829 (1987) “Shipping Container Response to Severe Highway and Railway Accident Conditions” also known as the “Modal Study”
- NUREG-1437 (1996) “Generic Environmental Impact Statement for License Renewal of Nuclear Plants” with Section 6.3
- NUREG-1437 Addendum 1 (1999) in part for “Section 6.3 – Transportation”
- NUREG/CR-6672 (2000) “Reexamination of Spent Fuel Shipment Risk Estimates”
- NUREG/CR-6703 (2001) on “Environmental Effects of Extending Fuel Burnup”
- NUREG-1437, Revision 1 (2013) with Section 4.12.1.1
- NUREG-2125 (2014) “Spent Fuel Transportation Risk Assessment”

Need for a New Evaluation

- As shown by past transportation analyses, the NRC has made generic assessments to extend conditions in § 51.52(a) and allow use of Table S-4
- Industry plans to deploy ATF concepts with increases in enrichment above 5 weight-percent U-235 and burnup higher than 62 GWd/MTU (i.e., outside of current conditions)
- There are two options on the NEPA evaluation of ATF deployment
  - Assess transportation effects at the time of an ATF LAR submittal with the potential of a site-specific transportation evaluation for every NPP site
  - Perform a transportation study of ATF deployment now to assess the potential application of Table S-4 in support of the environmental review of an ATF LAR submittal
- Staff is pursuing the second option in line with past practices



Spent fuel containers are specially designed to protect the public by withstanding accident conditions without releasing their radioactive contents.

https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/transport-spenfuel-radiomats-bg.html#spent

Leveraging Prior Transportation Reports and New ATF Studies

- Staff is applying information from these past studies
  - NUREG/CR-6672 for accident release cases and release fractions
  - NUREG/CR-6703 for the scope of the analysis and other information
  - NUREG-2125 to help inform transportation parameter values
- Applying information from ATF studies performed by ORNL for the NRC regarding radionuclide inventories at increased enrichment and higher burnup levels

Methodology

- Applying the guidance of:
  - DOE's "A Resource Handbook on DOE Transportation Risk Assessment" (2002)
  - NUREG-1555 "Standard Review Plan for Environmental Reviews for Nuclear Power Plants" (1999)
  - Regulatory Guide 4.2, Revision 3, "Preparation of Environmental Reports for Nuclear Power Stations," (2018)
- Use of NRC-RADTRAN (radiological transportation risk) with WebTRAGIS (routing)
- Scope similar to NUREG/CR-6703 (e.g., selected sites by regions)
- Certain parameter values selected from prior analyses to aid in direct comparison to Table S-4 (e.g., 0.5 MTU per spent fuel truck shipment)
- Incident-free and accident risk impacts for fresh fuel and spent fuel shipments
- Updated data and sensitivity cases as necessary (e.g., population density and shipment by rail)

Summary of Efforts to Date

- Staff sees the need to perform a study now to
  - Determine if Table S-4 can bound increases in enrichment and higher burnup levels
  - Inform future numerous ATF LARs environmental reviews
- NRC-RADTRAN analysis for the selected sites ongoing
- Would not address longer term ATF concepts (e.g., SiC cladding and extruded metallic fuel)
- Study to be published in a NUREG
  - Draft version for public comment
  - Goal to have a published final NUREG prior to first ATF deployment LAR

References

- WASH-1238 (1972) - ML14092A626
- Supplement 1 to WASH-1238 (NUREG-75/038 in 1975) - ML14091A176
- NUREG-0170 (1977) – Vol. 1: ML12192A283; Vol. 2: ML022590370 & ML022590506
- NUREG/CR-4829 (1987) – Vol. 1: ML070810403; Vol. 2: ML070810404
- NUREG-1437 (1996) - https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/index.html
- NUREG-1437 Addendum 1 (1999) - https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/index.html
- NUREG/CR-6672 (2000) – Vol. 1: ML003698324; Vol. 2: ML21089A142
- NUREG/CR-6703 (2001) - ML010310298
- NUREG-1437, Revision 1, Volume 1 (2013) - https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/index.html
- NUREG-2125 (2014) - ML14031A323

Industry Presentation:
Update on the Collaborative Research on Advanced Fuel Technologies for Light-Water Reactors (CRAFT)

Discussion Period

Public Comment Period

Adjourn

How did we do?

Link to NRC meeting feedback form:

https://feedback.nrc.gov/pmfs/

Meeting Code: 20220789