



NRC Regulations on High Burnup Fuel Storage and Transportation

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Overview

- Regulations Applicable to Spent Nuclear Fuel (SNF) Structural Evaluation
- High Burnup Fuel (HBF) Cladding Integrity
- Regulatory Tools
- Conclusions



Regulations Applicable to SNF Structural Evaluation

- SNF description
 - 72.236(a) – specify details of SNF to be stored (i.e. what is the burnup, PWR vs BWR, etc.)
 - 71.33 – describe...identify the package accurately...for evaluation of the package. The description must include...(b) With respect to the contents of the package... (3) Chemical and physical form...



Regulations Applicable to SNF Structural Evaluation

- SNF structural performance criteria
 - 72.236 (b),(c) and (d) – analyzed fuel geometry, under normal operation and postulated accidents, for criticality and shielding evaluations
 - 71.55(d)(2) - during normal conditions of transport (NCT), geometric form of content is not substantially altered
 - 71.55(e)(1) - after hypothetical accident conditions (HAC), the package must be subcritical assuming the fissile material is in the most reactive credible configuration...



Regulations Applicable to SNF Structural Evaluation

- SNF storage renewal – specific license
 - 10 CFR 72.42(a) - Licenses ...may be renewed...for a period not to exceed 40 years ... Application for ISFSI license renewals must include the following:(1) TLAs* that demonstrate that structures, systems, and components important to safety will continue to perform their intended function for the requested period of extended operation; and (2) A description of the AMP** for management of issues associated with aging that could adversely affect structures, systems, and components important to safety

* Time-limited aging analyses

** Aging management program

Regulations Applicable to SNF Structural Evaluation

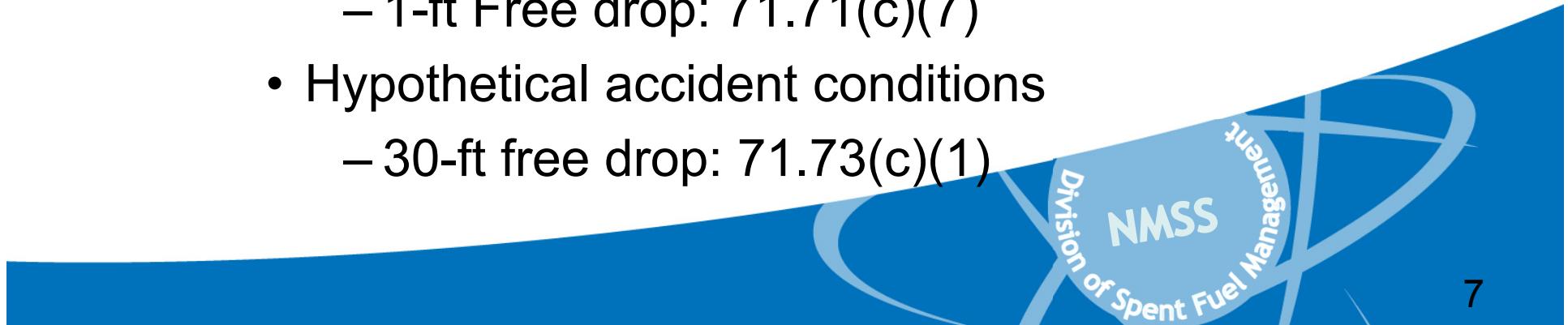
- SNF storage renewal, Certificate of Compliance (CoC)*
 - 72.240(c) – The application must be accompanied by a SAR**...must include (1) Design basis information...(2) Time-limited aging analysis that demonstrate that structures, systems, and components (SSCs) important to safety (ITS) will continue to perform their intended function ... (3) A description of the AMP...for management of issues associated with aging...affect SSCs ITS.

* Similar regulation language in 71.42(a) for renewal of specific license

** Safety analysis report

Regulations Applicable to SNF Structural Evaluation

- SNF structural loading conditions
 - Storage (NUREG-1536, Section 3.5.1.4 guidelines)
 - handling accident side drop and end drop
 - non-mechanistic tip-over
 - Transportation
 - Normal conditions of transport
 - Vibration: 71.71(c)(5)
 - 1-ft Free drop: 71.71(c)(7)
 - Hypothetical accident conditions
 - 30-ft free drop: 71.73(c)(1)

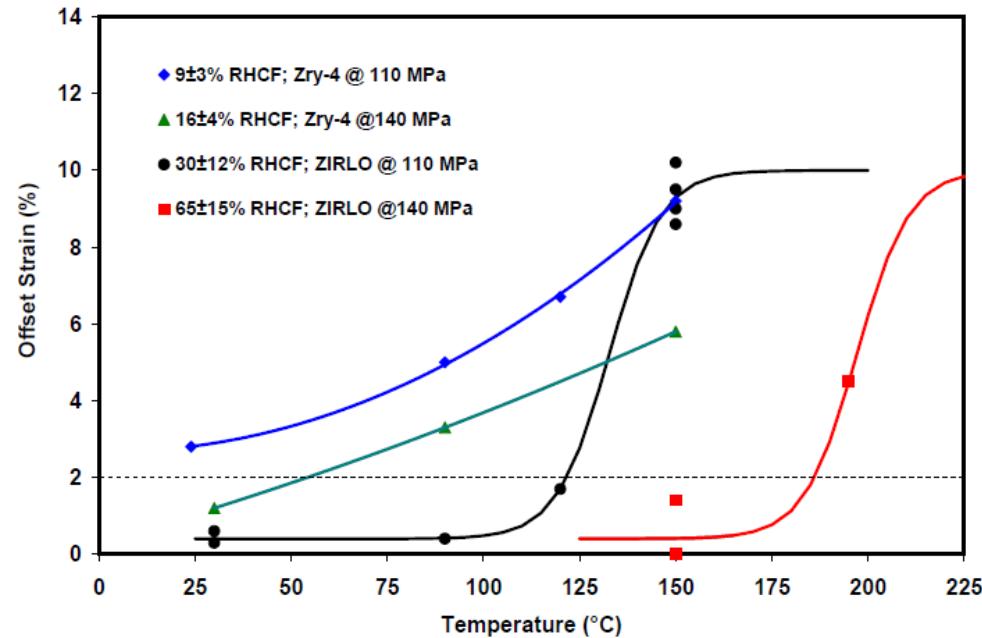
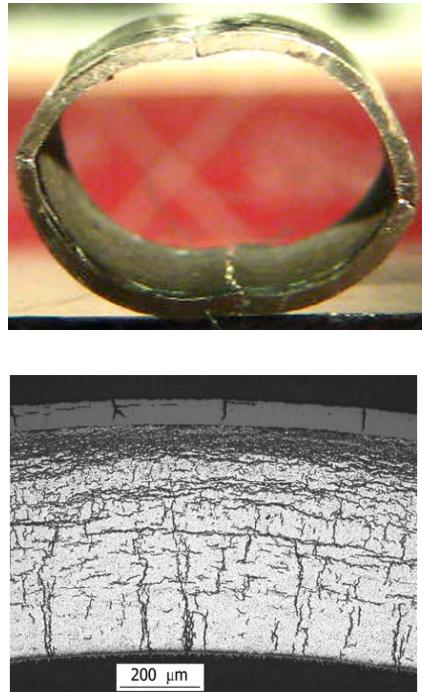


HBF Cladding Integrity

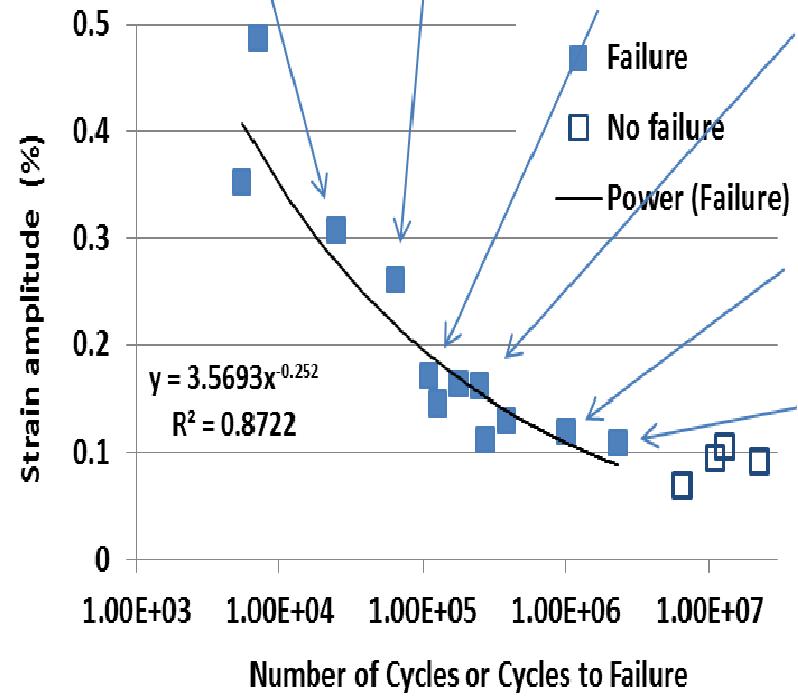
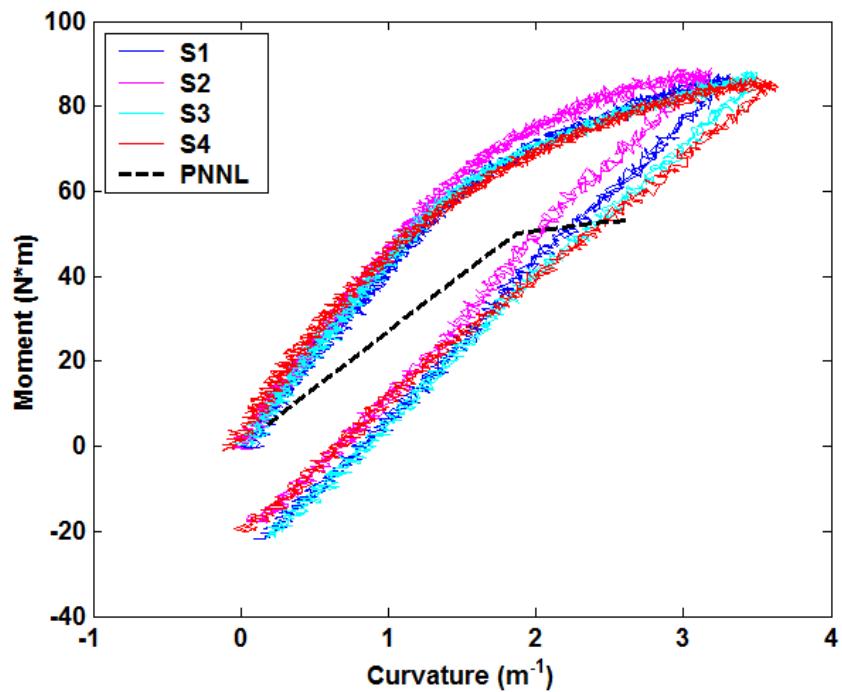
- Fuel rod structural performance by analysis
 - Analyzed configurations for criticality and shielding evaluation
 - Defueled rod assumption as bounding for structural analysis
 - Cladding at-temperature mechanical properties of material
 - Young's modulus, yield strength, elongation limit
- Ductile-to-brittle-transition temperature (DBTT)
 - Ovalization of defueled rod for secondary, pinch mode failure
- Demonstrable fuel rod performance
 - Implied ductile cladding behavior
 - Performance for cladding of different pedigree
- Effect of radial hydride on fuel rod bending strength

HBF Cladding Integrity

Ductile-to-Brittle-Transition Temperature (DBTT)



HBF Cladding Integrity



Regulatory Tools



- Regulatory bases hierarchy
 - Code of Federal Regulations, Title 10, Parts 71, 72
 - Regulatory guide (RG)
 - Standard review plan (SRP)
 - NUREG, NUREG/CR
 - Interim staff guidance (ISG)
 - Regulatory issue summary (RIS)
 - NRC/DOE National Laboratories research



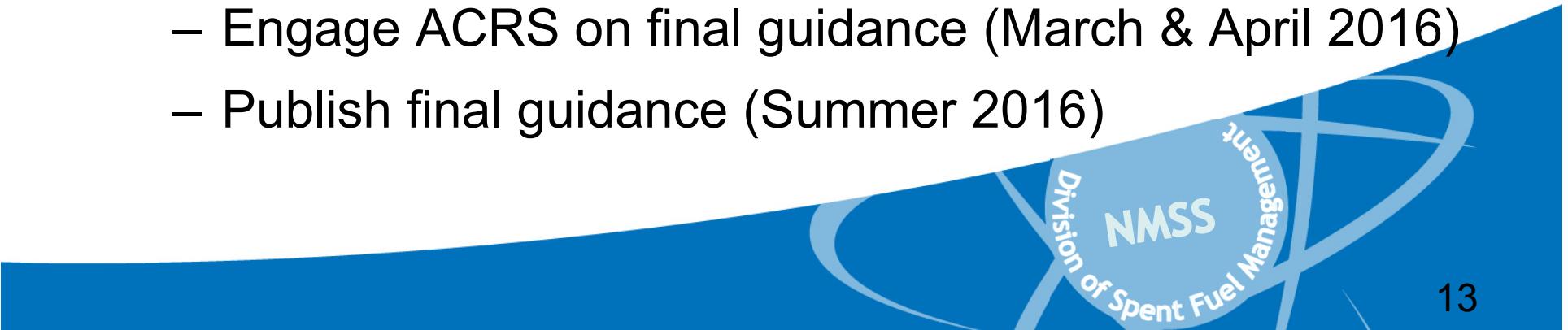
Example Regulatory Tools in Use



- ISG-11, Rev. 3, “Cladding Considerations for the Transportation and Storage of Spent Fuel”
- ISG-24, Rev. 0, “Use of a Demonstration Program as a Surveillance Tool for Confirmation of Integrity for Continued Storage of High Burnup Fuel Beyond 20 Years”
- NUREG/CR-7198, “Mechanical Fatigue Testing of High-Burn fuel for Transportation Application, May 2015
- NUREG/CR-7203, “A Quantitative Impact Assessment of Hypothetical Spent Fuel Reconfiguration in Spent Fuel Storage Casks and Transportation Packages,” September 2015

NUREG in Progress

- Draft NUREG-1927, Rev. 1
 - Example changes in the draft
 - Appendix B, example AMPs
 - HBU Fuel Monitoring and Assessment program (ISG-24 application)
 - Welded Stainless Steel Canisters (Consensus standards/NUREG reports)
 - Draft for public comment (July 2015)
 - Engage ACRS on final guidance (March & April 2016)
 - Publish final guidance (Summer 2016)



ISG in Progress

- ISG-2, Rev. 1, Retrievability
 - Guidance to provide flexibility in compliance with 10 CFR 72.122(l), retrievability
 - Provides guidance for system based retrieval
 - FRN requesting public comment (80 FR 63843)
 - ACRS subcommittee meeting 3/23/16
 - Expected date of issuance – Summer 2016



RIS in Progress



- Draft RIS-2014-0X, “Considerations in Licensing High Burnup Spent Fuel in Dry Storage and Transportation
 - Provides technical details for HBF licensing approaches
 - Incorporation of NRC/DOE research results
 - Being harmonized with
 - changes made in NUREG-1927, Rev. 1
 - changes made in ISG-2, Rev.1
- May morph into a standard review plan for licensing the HBF for storage and transportation



Example NRC/DOE Research

- HBF Bending and Fatigue Tests – Phase 2 at ORNL
 - Circumferential hydride in phase 1 tests; comparable phase 1 results expected of the HBF with hydride re-orientation
 - Projected test completion – March 2016
- Dry Cask Simulator Experiments at SNL
 - Above- and below-the-ground dry cask storage configurations
 - Obtain thermal-hydraulic data, including temperature, pressure, and flow measurements, and validate CFD models
 - Above-the-ground experiment starts in April 2016
 - 2 years for the experiment; additional 1 year for CFD validation
- DOE HBF demonstration project at North Anna

Conclusions

- Structural evaluations have provided reasonable assurance for the staff to find that the HBF would perform adequately for storage and transportation under normal and accident conditions
- Considerations such as moderator exclusion, burnup credit, and consequence analysis would provide additional basis for finding that the HBF can be safely stored and transported.
- NRC/DOE research results serve as pillars in confirming the cladding structural integrity for storage and transportation
- Challenges remain in effective use of the NRC/DOE HBF research results and their timely incorporation into the staff guidance documents



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Questions?

