U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Nuclear Energy University Programs
FY 2017 Annual Planning Webinar

IRP - Modeling of Spent Fuel Cladding in Storage and Transportation Environments

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IRP – Modeling of Spent Fuel Cladding in Storage and Transportation Environments

Introduction

- DOE is pursuing the technical basis on fuel integrity issues associated with the long term S&T of commercial LWR SNF
- To date, the focus has been on the four main cladding types for PWR fuel: Zry-4, low tin Zry-4, ZIRLO, and M5
- Emphasis has been on development of experimental data on cladding material properties and behavior as well as for benchmarking computer codes
- The above emphasis captures a majority of the fuel used in the U.S. fleet but has not addressed all of the fuel of interest. Work remains on BWR fuel cladding (Zr-lined Zry-2), Integrated Fuel Burnable Absorber (IFBA) PWR fuel, or newer cladding alloys (e.g., Optimized ZIRLO for PWRs and ZIRON for BWRs)

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Statement of Work

- Computer modeling and simulation needs to be developed to assess the performance of commercial SNF under long term storage and transportation conditions
- This modeling needs to assess hydride behavior in spent fuel cladding when the fuel goes through drying during the pool to dry storage transfer operations (i.e., hydride reorientation), pellet-clad interaction and pellet-pellet connectivity benefits in adding stiffness and strength to the fuel rod, and resistance to beam loadings to individual fuel rods and assemblies in the as-irradiated and dry condition

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Objective

- Needed is a benchmarked modeling capability to assess SNF performance in long-term S&T environments for other fuel/cladding types along with separate effects tests for benchmarking specific models in the fuel-performance code

- Tasking
  - Evaluate existing data base, particularly for hydrogen dissolution/ precipitation and perform separate effects tests as needed
  - Benchmark code to existing data
  - Use the benchmarked code to assess SNF performance behavior to BWR, IFBA, and other cladding types in the U.S. fleet

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Work to be Performed

- **Hydrogen dissolution/precipitation data inconsistency resolution**
- **Effects of cold-work (i.e. texture) on hydrogen precipitation under stress (conduct separate effects tests on non-irradiated/pre-hydrided samples cooled slowly under constant or decreasing hoop stress for standard fuel rod designs)**
- **Effects of hydrogen content (conduct separate effects test on non-irradiated/pre-hydrided samples to determine the effects of hydrogen content on axial connectivity/spacing of radial hydrides following slow cooling from a peak or constant hoop stress)**

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Tasks to be Performed

- **Task 1: Develop a detailed plan for conducting the work with any additional activities proposed**
- **Task 2: Conduct the study to develop the hydrogen dissolution/ precipitation data needed**
- **Task 3: Study the effects of cold-work on hydrogen precipitation under stress**
- **Task 4: Conduct a separate effects study to assess the effects of hydrogen on cladding behavior**
- **Task 5: Any additional testing proposed will be addressed in this task**
- **Task 6: Develop models supporting data developed for hydride formation and associated long-term effects**

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Deliverables

- **Detailed study plan (a detailed plan with activities and reports' schedule)**
- **Topical Reports (for each of the technical activities topical reports shall be developed to demonstrate significant contribution to the knowledge base)**
- **Progress Reports (Quarterly Reports, Annual Progress Reports outlining key accomplishments and progress to date)**
- **Final Report (three months prior to completion of the project, a draft final report will be submitted that summarizes the body of work accomplished and describes the sufficiency of the studies)**