Transportation and Storage of Spent Fuel Having Burnups Exceeding 45 GWd/MTU

NEI Workshop on High Burnup Dry Storage

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Background

- Spent fuel with burnups less than 45 GWd/MTU - data supports long-term and short-term temperature limits that assure cladding integrity during dry cask storage

- Industry indicated a strong need to store and transport high burnup fuels within the next few years

- Staff has recently evaluated the technical basis for the storage and transportation of high burnup fuel through a few applications

- Staff is considering revising ISG-11

Regulatory Basis for Storage (10 CFR Part 72)

- Spent fuel cladding must be protected from degradation that leads to gross rupture {72.122(h)(1)}

- Storage systems must be designed to allow ready retrieval of the spent fuel for further processing or disposal {72.122(l)}

- Spent fuel cladding protected from gross rupture by maintaining both an inert cask environment and cladding temperatures below established limits

Regulatory Basis for Transportation (10 CFR Part 71)

- The geometric form of the package contents (i.e., spent fuel) should not become substantially altered under the conditions specified for normal and hypothetical accident conditions of transport

- Normal conditions of transport - no loss or dispersal of spent fuel, no significant increase in external surface radiation levels, and no substantial reduction in the effectiveness of the spent fuel package {71.43(f)}

- Hypothetical accident conditions - fuel damage would not result in exceeding the criticality {71.55(e)}, shielding and containment {71.51} requirements

Technical Understanding of High Burnup Fuels

- Literature review was performed to evaluate the impacts of dry cask storage conditions on high burnup fuel cladding integrity

- Zircaloy spent fuel cladding can withstand uniform creep strains of about one-percent before the cladding can become perforated if concentration of hydrogen is less than about 400-500 ppm which corresponds to cladding oxide thickness of approximately 70 micrometers

Technical Understanding of High Burnup Fuels (cont)

- Strength and ductility of irradiated Zircaloy do not appear to be significantly affected by corrosion-induced hydrides at hydrogen concentrations up to about 400 ppm

- There is limited data on the high burnup fuel characteristics and cladding performance under dry storage and transportation conditions

Classifications of High Burnup Fuel

- Review to-date has identified three possible categories of high burnup fuel (i.e. burnups greater than 45 GWd/MTU)
- Classification of fuel may be based on cladding oxide thickness which may be determined by consideration of the following:
  - Non-destructive or destructive measurements techniques
  - Measurements conducted via statistical sampling plan
  - Cladding oxidation predictions
  - Power history variables (e.g., flux, number of cycles, temperature, water chemistry)
- Category I
  - Intact spent fuel with oxide thickness less than 70 micrometers
  - Sufficient data regarding the mechanical and creep properties
  - Cladding temperature limit methodology employs a one-percent creep strain limit

Classifications of High Burnup Fuel (cont)

- Category 2
  - Spent fuel with oxide thickness between 70-80 micrometers
  - Less data regarding the mechanical and creep properties
  - Structurally intact fuel that may develop pinhole or hairline crack leaks during storage or transportation
  - Cladding temperature limit methodology employs a one-percent creep strain limit
  - Containment analyses should assume intact spent fuel but with increased rod breakage fractions
- Category 3
  - Spent fuel with oxide thickness greater than 80 micrometers or spent fuel with areas of detached oxide
  - Insufficient data regarding the mechanical and creep properties
  - Spent fuel must be treated as failed fuel (i.e., must be canned), or demonstrate cladding integrity with data and analyses as identified in ISG-11

Other NRC Efforts to Support Further Development of Acceptance Criteria

- Office of Research, in collaboration with EPRI and industry representatives, is conducting a research program to evaluate the mechanical and creep properties on high burnup fuels.
- SFPO is re-evaluating the cladding temperature limit methodologies and failure mechanisms of high burnup fuel under storage and transportation conditions.
- Staff coordinating efforts and knowledge base with NRR, RES, the Division of Waste Management, and the national laboratories to maintain regulatory consistency and anticipate problems with the storage, transportation, and disposal of high burnup fuels.
- Staff continues to look to the industry to develop additional data, analyses, and methods to support the safe storage and transportation of high burnup fuel.