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Fuel Performance and Cask Internals

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Meeting to Obtain Stakeholder Input on Potential Changes to Guidance for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance

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Introduction

- Current guidance in NUREG-1927 does not address cask/canister internals that are considered important to safety
  - Fuel performance for retrievability and cladding integrity functions
  - Basket components for structural integrity and criticality functions
- Staff is considering adding guidance to NUREG-1927 on this topic
- Aging management program (AMP) based on a surveillance demonstration program

AMP Element 1:
Scope of the Program

NUREG-1927: The scope of the program should include the specific structures and components subject to an aging management review

- Components/Materials of Construction
  - Specify spent fuel maximum burnup
  - Specify cladding types and maximum cladding temperature
  - Basket material/welds
  - Neutron absorbing materials
- Environment
  - Dry helium
- Aging effects for material/environment combinations
  - Fuel cladding breach
  - Assembly distortion
  - Residual moisture after drying
  - Changes in the hydride structure of the cladding

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AMP Element 2:
Preventive Actions

NUREG-1927: Preventive actions should mitigate or prevent the applicable aging effects

- Casks/Canisters dried per the accepted guidance in NUREG -1536, Standard Review Plan for Dry Cask Storage Systems
- Backfilled with helium cover gas
- Maximum cladding temperature is maintained below the recommended ISG-11 Rev 3 limits

AMP Element 3:
Parameters Monitored/ Inspected

NUREG-1927: Parameters monitored or inspected should be linked to the effects of aging on the intended functions of the particular structure and component

- Surveillance demonstration program meeting ISG-24:
  - Maximum cladding temperature
  - Inspection for the presence of fission gas in the cover gas
  - Inspection for presence of water vapor in the cover gas
  - Inspection for hydrogen to determine that any radiolysis of residual or bound water does not produce a flammable condition
  - Profilometry at the completion of the storage period to determine creep deformation
  - Gas puncturing at completion of storage to determine cladding stress for creep calculations
  - Cladding metallography at the completion of storage to determine condition of cladding hydrides

AMP Element 4:
Detection of Aging Effects

NUREG-1927: Define method or technique, frequency, sample size, data collection, and timing to ensure timely detection of aging effects

- Surveillance demonstration program meeting ISG-24:
  - Calibrated thermocouple lances to measure the radial and axial temperature profile
  - Fission gas analysis technique for the cover gas with sensitivity to detect release of 1% of the fission gas produced in 1% of the cask rods with the lowest burnup in the demonstration
  - Residual moisture detection technique with sensitivity to detect the vapor pressure at the bottom of the demonstration system
  - Hydrogen detection technique with sensitivity to detect 2% hydrogen in the cover gas of the demonstration

AMP Element 5:
Monitoring & Trending

NUREG-1927: Should provide for prediction of the extent of the effects of aging and timely corrective or mitigative actions

- As information/data from a fuel performance surveillance demonstration program becomes available, the licensee will monitor, evaluate, and trend the information via their Operating Experience Program and/or the Corrective Action Program to determine what actions should be taken to manage fuel and cladding performance, if any
- Similarly, the licensee will use its Operating Experience Program and/or Corrective Action Program to determine what actions should be taken if it receives information/ data from other sources than the demonstration program on fuel performance

AMP Element 6:
Acceptance Criteria

NUREG-1927: Acceptance criteria, against which the need for corrective action will be evaluated; should ensure that SSC functions are maintained

- ISG-24 acceptance criteria provide detailed guidance
- Cask internals and fuel performance criteria:
  - Temperature: spatial distribution and time history accurately determined - necessary since the behavior of the rods in the demonstration to the behavior expected of the rods in storage is temperature dependent.
  - Cladding Creep: total creep strain extrapolated to the total approved storage duration based on the best fit to the data, accounting for initial condition uncertainty shall be less than 1% - ISG-11 temperature limits are based on limiting creep to <1%

AMP Element 6:
Acceptance Criteria

NUREG-1927: Acceptance criteria, against which the need for corrective action will be evaluated; should ensure that SSC functions are maintained

- Cask internals and fuel performance criteria:
  - Hydrogen – maximum hydrogen content of the cover gas over the approved storage period shall be extrapolated from the gas measurements to be less than 5% - limit for precluding possible flammable mixture
  - Drying – The moisture content in the cask , accounting for measurement uncertainty, shall indicate no greater than one liter of residual water after the drying process is complete – Drying limit, in terms of residual moisture, in the SRP NUREG-1536
  - Fuel rod breach – fission gas analysis shall not indicate more than 1% of the fuel rod cladding breaches. – Recommended maximum number of cladding breaches during normal conditions of storage for containment analysis by ISG-5

AMP Element 7:
Corrective Actions

NUREG-1927: Corrective actions, including root cause determination and prevention of recurrence, should be timely

- Licensee Corrective Action Program commensurate with 10 CFR 72 Subpart G, or 10 CFR 50 Appendix B
- Licensee Corrective Action Program to capture and evaluate surveillance demonstration program data, other information/data, and additional operating experience to initiate corrective and/or preventative actions:
  - Corrective actions to prevent reoccurrence
  - Extent of condition to other susceptible components
  - Timely corrective actions

AMP Elements 8:
Confirmation Process

NUREG-1927: Confirmation process should ensure that preventive actions are adequate & appropriate corrective actions have been completed & are effective

- Licensee Quality Assurance Program consistent with 10 CFR 72 Subpart G, or 10 CFR 50 Appendix B
- What follow up action is going to be taken to determine whether preventative or corrective actions are a success
- Method to confirm any actions required are taken

AMP Elements 9:
Administrative Controls

NUREG-1927: Administrative controls should provide a formal review and approval process

- Licensee Quality Assurance Program consistent with 10 CFR 72 Subpart G, or 10 CFR 50 Appendix B
- Training requirements for inspectors or personnel
- Records retention requirements
- Specified in the Demonstration Project Plan or alternate surveillance demonstration program meeting the ISG-24 guidance
- Frequency for updating AMP based on industry-wide operational experience

AMP Element 10:
Operating Experience

NUREG-1927: Include past corrective actions; provide objective evidence to support a determination that the effects of aging will be adequately managed so that the SSC intended functions will be maintained during the period of extended operation

- Surrogate surveillance demonstration programs with storage conditions and fuel types similar to those in the dry storage system that satisfies the ISG-24 acceptance criteria is a viable method to obtain operating experience
- DOE Dry Cask Storage Demonstration Project is viable as a surrogate surveillance program for the industry
- Additional data/research to assess fuel performance

References

- NUREG-1927 – Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance

  http://pbadupws.nrc.gov/docs/ML1110/ML111020115.pdf
- NUREG-1536, Rev 1 – Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility

  http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1536/r1/sr1536r1.pdf
- ISG-5, Rev 1 – Confinement Evaluation

  http://www.nrc.gov/reading-rm/doc-collections/isg/isg-5R1.pdf
- ISG-11, Rev 3 – Cladding Considerations for the Transportation and Storage of Spent Fuel

  http://www.nrc.gov/reading-rm/doc-collections/isg/isg-11R3.pdf
- ISG-24 – The Use of a Demonstration Program as a Surveillance Tool for Confirmation of Integrity for Continued Storage of High Burnup Fuel Beyond 20 Years (in preparation for publication)

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Acronyms

- AMP – Aging Management Program
- CFR – Code of Federal Regulations
- DOE – U.S. Department of Energy
- ISG – Interim Staff Guidance
- SRP – Standard Review Plan