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Nuclear Energy University Programs (NEUP) Fiscal Year (FY) 2013 Annual Planning Webinar

RC-4: Materials Aging and Degradation (MAaD): Accelerated Test Techniques and Validation

Richard Reister, DOE-NE
Jeremy Busby, ORNL

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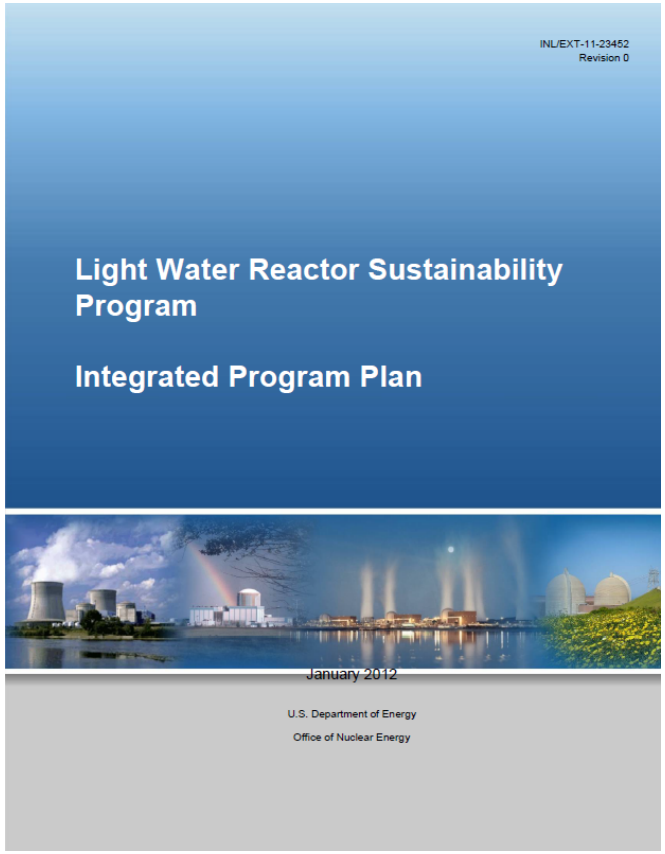
LWRS Vision and Goals

Vision

- Enable existing nuclear power plants to safely provide clean and affordable electricity beyond current license periods (beyond 60 years)

Program Goals

- Develop fundamental scientific basis to understand, predict, and measure changes in materials as they age in reactor environments
- Apply this knowledge to develop methods and technologies that support safe and economical long-term operation of existing plants
- Research new technologies that enhance plant performance, economics, and safety



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Technical Focus Areas Summary

Nuclear Materials Aging and Degradation

- Develop scientific basis for understanding and predicting long-term environmental degradation behavior of materials in nuclear power plants
- Provide data and methods to assess performance of systems, structures, and components essential to safe and sustained nuclear power plant operations
- Develop means to detect and characterize aging degradation processes

Risk-Informed Safety Margin Characterization:

- Develop a significantly improved safety analysis tool (RELAP-7) and a framework (RAVEN and Grizzly codes) to analyze the safety margin of aging plants.
- RELAP-7 is a “systems” code that will model the whole plant compared to existing codes (including the Hub) that are focused on highly localized phenomena in great detail.
- RAVEN is the simulation controller.
- Grizzly is the component aging and damage evolution model

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Technical Focus Areas Summary

- **Advanced Instrumentation, Information, and Control Systems Technologies**
  - Address long-term aging and obsolescence of existing instrumentation and control technologies and develop and test new technologies
  - Establish a strategy to implement long-term modernization of I&C systems
  - Develop advanced condition monitoring technologies for reliable plant operation
- **Advanced LWR Nuclear Fuel**
  - Improve scientific basis for understanding and predicting fundamental nuclear fuel performance at existing nuclear power plants
  - Develop high-performance, higher burn-up fuels with improved safety, cladding, integrity, and economics for existing LWR applications
  - Closely coordinated with the Fuel Cycle R&D program activities, which are oriented toward applications in advanced reactors
- **Systems Analysis and Emerging Issues**
  - Address high impact emerging issues such as potential backfit of cooling towers
  - Review potential research needs in response to Fukushima lessons learned

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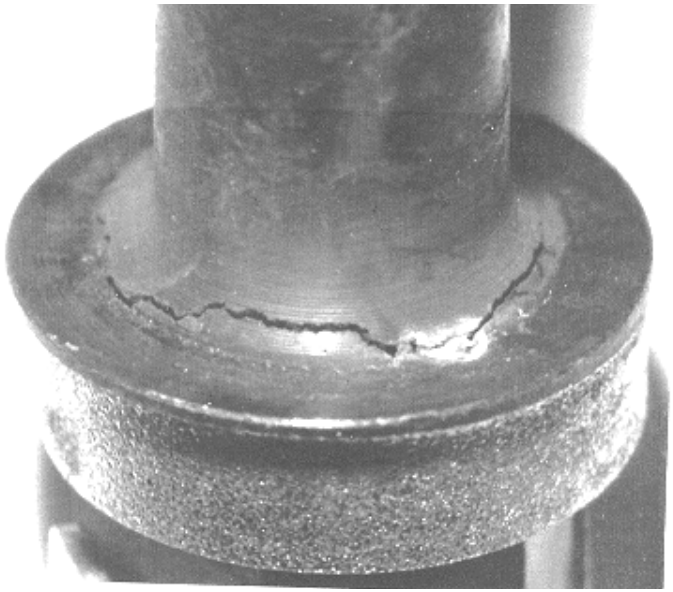
Materials Aging and Degradation Pathway

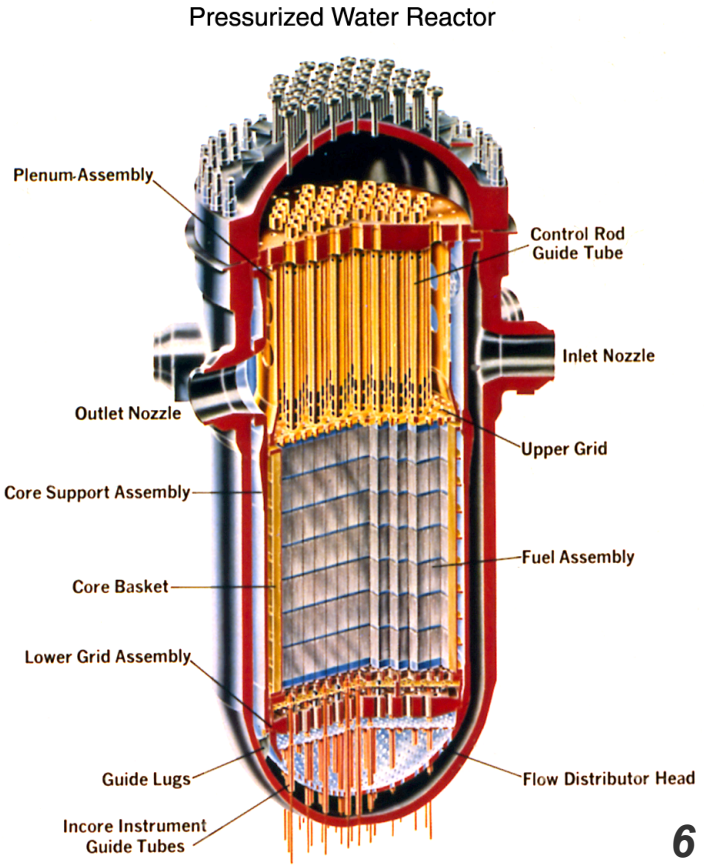
- **Increased lifetime leads to increased exposures**
  - Time at temperature
  - Stress
  - Coolant
  - Neutrons
- **Extending reactor life to 60, 80 years or beyond will likely increase susceptibility and severity of known forms of degradation**
- **New mechanisms of materials degradation are possible**

- **Provide data and methods to assess the performance of systems, structures, and components essential to safe and sustained NPP operations**



Materials Aging and Degradation

- **Develop the scientific basis for understanding and predicting materials aging and degradation within components, systems, and structures**
  - Reactor metals (RPV's, internals, steam generators, balance of plant, and weldments)
    - Mechanisms of IASCC
    - High-fluence effects on RPV steel
    - Crack initiation in Nickel based alloys
  - Concrete
    - Concrete aging for long term operation
    - Monitoring tools for concrete
  - Cabling
    - Assessment of cable aging issues
  - Mitigation, repair, and replacement technologies
    - Weld repair techniques
    - Post irradiation annealing
    - Advanced replacement alloys



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Materials Aging and Degradation tasks provide results in several ways

- ***Measurements of degradation:*** High quality data will provide key information for mechanistic studies, but has value to regulators and industry on its own.
- ***Mechanisms of degradation*****:** Basic research to understand the underlying mechanisms of selected degradation modes will lead to better prediction and mitigation.
- ***Modeling and simulation*****:** Improved modeling and simulation efforts have great potential in reducing the experimental burden for life extension studies. These methods can help interpolate and extrapolate data trends for extended life.
- ***Monitoring*****:** While understanding and predicting failures are extremely valuable tools for the management of reactor components, non-destructive monitoring must also be utilized.
- ***Mitigation strategies*****:** While some forms of degradation have been well-researched, there are few options in mitigating their effects. New technologies may overcome limits of degradation in key components and systems.

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Despite distinct material differences, there are some common testing needs

- Materials and components under extended service conditions will see very long lifetimes under stress, temperature, corrosive coolant, and/or neutron or gamma radiation fields.
- It is not viable to start laboratory tests at this time to duplicate 80 years of life in a timely manner. Extrapolating existing materials to extended service will require using accelerated test techniques to provide information in a timely manner.
- Techniques and approaches for providing relevant data using accelerated test techniques are sought in this call.

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Requested NEUP Work Scope

Development, validation, and demonstration of advanced accelerated testing techniques is requested

- **Modeling tools, experimental studies, and/or validation of accelerated testing and material response are appropriate for key reactor materials under relevant environments including, but not limited to stress, corrosive environment, radiation, and elevated temperature.**
- **Materials of interest to LWRS include, but are not limited to, core internal components (stainless steels), cast stainless steel piping, reactor pressure vessel steels, concrete and cable insulation.**
- **Universities engaging in this effort will be expected to produce concepts, supporting data and/or model predictions demonstrating the viability of these techniques with a high level of quality assurance.**