U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Light Water Reactor Sustainability (LWRS) FY 2017 CINR Webinar: NEET-NSUF 1.1a & b

Federal POC: Richard Reister
Technical POC: Keith Leonard (ORNL)

Office of Light Water Reactor Technologies
Office of Nuclear Energy
U.S. Department of Energy

August 2016

U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Light Water Reactor Sustainability (LWRS) Program

LWRS Program Goal

- Develop fundamental scientific basis to allow continued long-term safe operation of existing LWRs (beyond 60 years) and their long-term economic viability

LWRS program is developing technologies and other solutions to

- Enable long term operation of the existing nuclear power plants
- Improve reliability
- Sustain safety

Nine Mile Point ~ Courtesy Constellation Energy

LWRS focus areas

- Materials Aging and Degradation
- Advanced Instrumentation and Controls
- Risk-Informed Safety Margin Characterization
- Reactor Safety Technologies

Technical Focus Areas Summary

- **Nuclear Materials Aging and Degradation**
  - Understand and predict long-term environmental degradation behavior of materials in nuclear power plants, including detecting and characterizing aging degradation
- **Advanced Instrumentation, Information, and Control Systems Technologies**
  - Address long-term aging and obsolescence of existing instrumentation and control technologies through a strategy for long-term modernization
- **Risk-Informed Safety Margin Characterization**
  - Develop significantly improved safety analysis tools (computer codes called RELAP-7 and Grizzly) and apply these tools to analyze the safety margin of aging plants
- **Systems Analysis and Emerging Issues**
  - Address high impact emerging issues such as flexible operations and water usage issues (the potential backfit of cooling towers)
- **Reactor Safety Technology**
  - Address emerging safety concerns in response to the Fukushima accident
  - Develop technologies to enhance the accident tolerance of current and future reactors

U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Materials Aging and Degradation

- **Metals: including Reactor Pressure Vessels, core internals, steam generators, and balance of plant**
  - Irradiation-Assisted Stress Corrosion Cracking
  - High-fluence phase transformations and swelling of core internals
  - High-fluence effects on RPV steel
  - Crack initiation in Nickel based alloys
  - Thermal Aging of Cast Austenitic Stainless Steels
  - Environmentally Assisted Fatigue
- **Concrete: Joint research plan with EPRI focused on radiation effects (supports and biological shield) and monitoring tools**
- **Cables: Joint research plan with EPRI and NRC to better predict and monitor cable aging**
- **Mitigation, repair, and replacement technologies: Weld repair techniques; Post irradiation annealing; Advanced replacement alloys; and Advanced Non-Destructive Examination techniques**

Neutron Radiation Assessment of Advanced Alloys for LWR Core Internals - NEET-NSUF 1.1a

This work is synergistic to the LWRS Advanced Replacement Materials and EPRI Advanced Radiation Resistant Materials projects that aim to develop new advanced alloys for use in LWR applications that may provide greater margins of performance than currently used alloys.

Current program activity involves testing of specific alloys with its collaborating partners through:

- Mechanical and fracture toughness properties.
- Microstructural stability under proton irradiation.
- High temperature oxidation testing.

Proposals are sought to provide in-depth assessment of neutron irradiation effects on select candidate alloys under LWR specific conditions, regarding:

- Long-term thermal / high fluence irradiation stability of microstructures (solute segregation and precipitate changes)
- IASCC initiation and growth under BWR and PWR conditions
- Assessment of irradiated fracture toughness properties

Alloys of interest

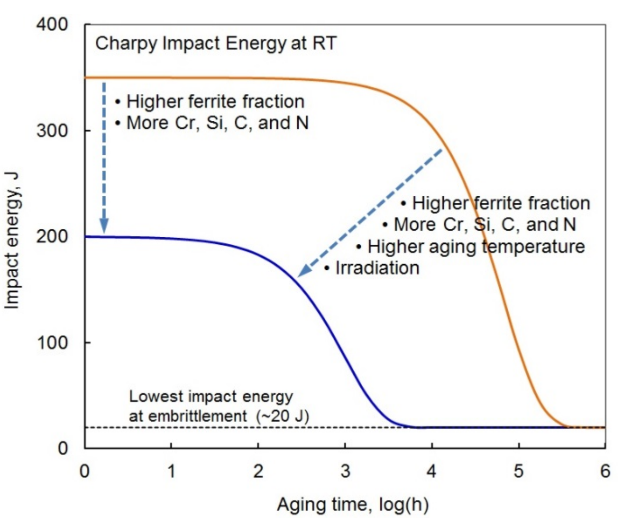
Ni-base (comparison to X-750): C22, 625, 690 and 725

Steels (comparison to 316L): 310, 439, 800, 9Cr F/M (grade 92) and 12 Cr F/M (HT9)

LWRS U.S. DEPARTMENT OF ENERGY Nuclear Energy

Synergistic Radiation and Thermal Aging Effects on Cast Austenitic Stainless Steel (CASS) - NEET-NSUF 1.1b

- Addresses DOE/NRC EMDA and EPRI MDM concerns regarding lack of long term data on CASS for 60 yrs and beyond.
- Aim: to systematically build a scientific knowledge base within a limited time frame.
- Current LWRS activities involve a 5 year accelerated thermal aging project examining model, archive heats and welded duplex (CF-series, austenitic / ferritic) CASS.
- Properties of CASS materials are highly dependent on their starting microstructure, specifically the amount of retained ferrite which may be between 3 to 30% depending on composition and casting method. The long-term precipitation of various phases (alpha-prime, G-phase, gamma, Laves, etc.) effects the overall materials properties.



Proposals are sought on the evaluation of combined thermal and irradiation aging of CASS materials to determined long-term materials performance.

- Proposals involving a combined modeling and experimental approach to evaluating the microstructure driven mechanical property changes are highly encouraged.
- New or proven small scale test specimen testing techniques to evaluate mechanical and fracture toughness changes in the materials will be beneficial to determining end of life predictions of embrittlement.