Reactor Aging Management

Sustainable Nuclear Power Initiative

Focus Area Fact Sheet

Pacific Northwest
NATIONAL LABORATORY

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Focus Area Description

The Reactor Aging Management (RAM) Focus Area, within the Sustainable Nuclear Power Initiative (SNPI), seeks to develop technical solutions critical to support further extensions of operating licenses of current and future U.S. nuclear power plants, which today provide about 20 percent of the nation's electricity. The current license extension process (40 to 60 year) for operating plants is well established having undergone development in the 1970s and 1980s.

The Pacific Northwest National Laboratory (PNNL) served a leading role in developing the technical basis for the current nuclear reactor license extension process. Increasing electricity demands and environmental concerns regarding carbon emissions are prompting a renewed and growing interest in nuclear power. This interest spans the continuing safe operation of existing reactors and the reliability of new plants. Continued safe operation of existing reactors will ensure that nuclear power remains an essential part of the nation's energy and carbon management strategies, preventing a reduction in emission free nuclear power. Scientific studies and data collected on the aging of reactor components and systems well beyond 60 years will be critical for assessing the long-term, sustainable operation of today's plants. This knowledge will be equally pertinent to the design and operation of plants built in the future. Reactor aging and license extension is a topic being addressed internationally, by such leading nuclear economies such as France, Japan, and South Korea as they prepare to meet their future energy needs.

Developing the technical basis to safely extend U.S. reactor licenses for an additional 20 years could save electricity consumers over half a trillion dollars while avoiding emissions of over 10 billion tons of carbon into the atmosphere. Nuclear power plants currently provide over 70% of all carbon emission free electricity in the United States.

PNNL R&D Instrumentation and Laboratories for RAM Research

PNNL has been researching irradiated materials performance and reactor diagnostics for more than 30 years, leveraging a unique suite of capabilities.

PNNL R&D Laboratories and capabilities include:

- Sophisticated materials studies
- Advanced diagnostics
- Probabilistic risk assessment
- Integrated analyses for structural integrity, reliability and safety
- Suite of "salvaged parts" from canceled U.S. plants studied via full suite of novel NDE/ISI inspection processes
- Characterization and testing of activated and non-activated materials.

Activated materials testing is supported by:

- A diverse set of hot cells
- 500,000 square feet of radiological and nuclear facility space
- One Hazard Category II nuclear facility equipped with — fume hood, glove box, and highbay laboratories
- Radiological material processing facilities, post-irradiation examination capabilities.

Science and Technology Capabilities

PNNL is uniquely positioned to address reactor aging R&D, including risk-informed analysis of the diverse set of stressors and mechanisms that contribute to aging along with the assessment of materials performance and reliability. Research conducted in the RAM Focus Area will help develop the technical basis for a proposed international technical report or draft standard to advance online monitoring of reactor materials degradation and prognostics. PNNL expertise also serves the technical needs of the Nuclear Regulatory Commission (NRC). Since 1972, PNNL-led studies have supported the establishment of NRC criteria for plant license extensions. This knowledge base has been applied to other research endeavors where understanding materials performance is critical, such as with aging aircraft, long term stewardship and storage of nuclear materials, and embedded materials diagnostics and prognostics.

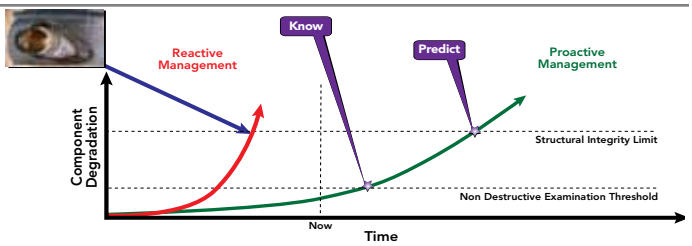
PNNL remains engaged in licensing and safety studies that align with a number of federal priorities. Some of these activities include:

- American Society of Mechanical Engineers (ASME) Code Work
- International Atomic Energy Agency (IAEA) Programs (e.g., Safety Aspects of Long Term Operation [SALTO] of water moderated reactors) and Plant Life Management (PLiM)
- Nondestructive Evaluation Inservice Inspection (NDE – ISI)
- Light Water Reactor Material (LWR) Studies
- Fatigue/fracture mechanics
- Proactive Management of Materials Degradation/ now evolving to Proactive Management of Material Degradation (PMMD), advanced diagnostics/NDE/ISI and prognostics
- Probabilistic Risk and Reliability Studies.

Reactor Aging Management Focus Area Objectives and Project Criteria

To help support a thorough, national R&D evaluation of the technical and overarching issues associated with extending power plant licenses beyond 60 years, the RAM Focus Area will initially conduct five research projects starting in Fiscal Year 09 in the following core areas:

- ***Demonstration of on-line monitoring and physics based prognostics.*** This project will investigate and demonstrate innovative methods coupled with damage models to support residual life determination for legacy U.S. nuclear power plants. The resulting capability will support license extension while also providing monitoring tools for incorporation into new power plant designs.



RAM research will advance understanding of how reactor materials age and lead to the ability to predict their long-term performance. This information is critical for U.S. nuclear regulators to determine the actual safe performance lifetime of the nation's nuclear power plants.

- ***Surface Damage and Environment-Induced Cracking Precursors in Light-Water Reactor Components.*** This research will study the most critical factors associated with the onset of cracking in materials focusing on nano-to-microscopic initiation precursors which lead to the development of stress corrosion cracks in LWR components.
- ***On-Line Flaw Detection in Reactor Piping using Acoustic Emission and Guided Wave Ultrasonic Techniques.*** This research will assess and demonstrate the effectiveness of combined acoustic emission and active inspection using acoustic emission and guided wave ultrasound transducers to detect and monitor crack growth in reactor components.
- ***Leak Rate Measurement for Prototypic PWR Primary Water Stress Corrosion Cracks.*** This research will develop and demonstrate an approach to quantitatively measure leak rates through representative intergranular stress-corrosion cracks in nickel-base alloy and weld metals.
- ***Adaptation of Existing PRAs to Support RAM.*** This research will help establish the methodological basis adapting probabilistic risk and reliability studies to support integrated reactor aging assessments for nuclear power plants.

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