Primary Systems Corrosion Research

Program Overview

Program Description

Materials degradation problems due to environmentally assisted cracking in nuclear power plants have cost the nuclear industry at least $10 billion in the last 30 years because of forced and extended outages, increased inspection requirements, component repairs and replacements, and increased scrutiny by the regulator. Inadequate understanding of the processes that lead to stress corrosion cracking has hampered the development of reliable predictive models and cost-effective mitigation technologies.

The Primary Systems Corrosion Research Program improves the useful life of components in boiling water and pressurized water reactors through a better understanding of the crack initiation and early propagation processes involved in stress corrosion cracking and irradiation-assisted stress corrosion cracking. Extensive international collaboration ensures that research findings reflect a wide range of nuclear technologies, operating conditions, and service environments.

Research Value

The Primary Systems Corrosion Research Program enhances nuclear industry understanding of the early stages of damage to irradiated materials used in boiling water and pressurized water reactor internals. Research results lead to improved predictive models and potential countermeasures that can significantly extend the useful life of plant components. International collaboration with utilities, vendors, regulators, and research organizations capitalizes on materials-related corrosion research around the world. Primary Systems Corrosion Research Program participants gain access to the following:

- Predictive models and mitigation techniques for material corrosion in reactor internals.
- Better understanding of early stages of stress corrosion cracking in nickel-base alloys and stainless steels.
- Methods to mitigate damage and significantly extend component life.
- Global knowledge sharing through international collaboration with utilities, vendors, regulators, and research organizations.

Approach

The Primary Systems Corrosion Research Program conducts and coordinates experimental and theoretical studies to advance the mechanistic understanding and predictive modeling of crack initiation and early crack propagation. Program results are transferred to the appropriate Electric Power Research Institute (EPRI) Issues Programs (Boiling Water Reactor Vessels and Internals Project, Materials Reliability Program, and Steam Generator Management Program) for application via inspection and evaluation guidelines and other mechanisms.

- Develop improved detection and mitigation technologies to manage materials degradation and corrosion-related issues.
- Participate in international research consortia to better understand the role of key parameters on irradiation-assisted stress corrosion cracking of reactor materials.
- Conduct crack growth rate testing of irradiated alloy materials to evaluate the effect of material composition, fluence, flux, stress intensity, and temperature.
- Develop test methods to study stress corrosion cracking initiation, coalescence, and growth in nickel-base alloys in pressurized water reactors.
- Design management strategies to address corrosion-related plant impacts, including forced and extended outages, increased inspection requirements, component repairs and replacements, and increased regulatory scrutiny.

Accomplishments

EPRI's Primary Systems Corrosion Research Program supports nuclear power industry efforts to identify and mitigate early stages of materials degradation to extend component life.

- Identified and characterized the effect of key parameters (fluence, stress, materials, and environment) on irradiation-assisted stress corrosion cracking in boiling water and pressurized water reactor environments.
- Coordinated the internationally sponsored Cooperative Irradiation-Assisted Stress Corrosion Cracking Research Program (CIR Program) since 1995.
- Developed improved prediction and evaluation of environmentally assisted cracking in light water reactor structural materials.

Current Year Activities

Primary Systems Corrosion Research Program R&D for 2010 will focus on improving the understanding of corrosion mechanisms in nuclear materials, leading to more effective management and mitigation strategies for existing plants and better materials selection for new plants. Specific efforts will include the following:

- Compile research results from the Cooperative Irradiation-Assisted Stress Corrosion Cracking Program.
- Conduct crack growth testing of fast reactor irradiated materials.
- Evaluate fracture resistance of light water reactor materials at low temperature.
- Characterize the role of localized deformation in irradiation-assisted stress corrosion cracking.
- Interaction of localized deformation and environmentally assisted cracking in austenitic alloys.
- Multiple crack initiation and crack coalescence in Alloy 600 materials.
- Short crack response of nickel alloys under primary water stress corrosion cracking conditions.
- Damage processes prior to crack initiation in nickel-base alloys.
- Characterization of surface oxide films on nickel-base alloys.

Estimated 2010 Program Funding

$3.7 million

Program Manager

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Summary of Projects

Project Number	Project Title	Description
P41.01.01.01	Primary System Corrosion Research	The PSCR project is a cross-cutting effort aimed at developing a deeper understanding of stress corrosion cracking (SCC) and irradiation-assisted stress corrosion cracking (IASCC) issues in BWRs and PWRs. Research projects address IASCC in irradiated stainless steels (multi-year collaborative project with DOE); SCC initiation and short crack growth in nickel alloys; effect of localized deformation on SCC in stainless steels and nickel alloys; effect of light water reactor environments on fracture resistance of irradiated stainless steels and nickel-base weld metals; effect of inhomogeneous microstructure and deformation in the heat- affected zone of Alloy 690 welds on SCC; effect of dissolved hydrogen on SCC nickel-alloy welds; and updates to the *Materials Handbook*, Materials Degradation Matrix, and Materials Information Portal.

Primary System Corrosion Research (052398)

Key Research Question

Materials degradation problems due to environmentally assisted cracking have cost the nuclear industry at least $10 billion in the last 30 years because of forced and extended outages, increased inspection requirements, component repairs and replacements, and increased scrutiny by regulators. A better fundamental understanding of the early stages of stress corrosion cracking (SCC) and irradiation-assisted stress corrosion cracking (IASCC) in light water reactor materials is essential to develop reliable models to predict damage progression and to develop cost-effective mitigation technologies.

Approach

The major elements of the Primary Systems Corrosion Research (PSCR) Program are to

- maintain and update the industry Material Degradation Matrix (MDM);
- address the knowledge gaps identified in the MDM and Issue Management Tables (IMTs);
- develop experimental data, mechanistically based predictive models, and countermeasures for irradiation-assisted stress corrosion cracking and intergranular stress corrosion cracking;
- investigate damage initiation processes using state-of-the art material characterization techniques;
- develop a Materials Information Portal integrating the MDMs and IMTs (usable retrieval system); and
- work with the Electric Research Institute (EPRI) Technology Innovation Office to conduct strategic materials research that complements the PSCR work.

The PSCR work is closely coordinated with other Issue Programs. The program will continue to develop alliances with the Department of Energy (DOE) and international partners to leverage EPRI resources to address material degradation and aging in light water reactors.

Impact

- Identify key knowledge gaps in material degradation that could pose a threat to long-term reliable operation of light water reactors
- Develop improved predictive models and potential countermeasures for irradiated boiling water reactor (BWR) and pressurized water reactor (PWR) materials used in reactor internals
- Develop reliable methods to predict and mitigate the early stages of damage and to significantly extend useful life of components
- Collaborate with international utilities, vendors, regulators, DOE, and research organizations to leverage program funding

How to Apply Results

The results of the Primary Systems Corrosion Research Program are transferred to the appropriate EPRI Issues Programs (Boiling Water Reactor Vessels and Internals Project, Materials Reliability Program, and Steam Generator Management Program) for further development and application by members

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Final Comprehensive CD of the Cooperative IASCC Research (CIR II) Program	06/30/10	Assembled Package
Final Overview Report on the Cooperative IASCC Research (CIR) Program	06/30/10	Technical Report
Experimental Results of Interaction between Localized Deformation and EAC – Final Report	12/24/10	Technical Report
Results of EAC Initiation and Short Crack Growth Studies on Ni Alloys	12/24/10	Technical Report