

In Development

A Strategic Plan to Improve Management of Materials Aging in the Nuclear Industry

By Brent Barker

In 2002, maintenance workers at the Davis-Besse nuclear plant in Ohio discovered that corrosion had created a football-sized cavity in the reactor pressure vessel head. It did not lead to an accident, but the U.S. Nuclear Regulatory Commission (NRC) shut down the plant for two years to correct the problem. The fact that such extensive corrosion had gone undetected raised questions about aging management practices and procedures.

“It’s paramount to have a strong understanding of aging of materials in nuclear reactors, where high temperatures, intense radiation, cyclic stress, and water chemistry accelerate degradation,” said EPRI Senior Technical Executive Robin Dyle. “The discovery at Davis-Besse, along with observations at other plants in the 1990s and early 2000s of stress corrosion cracking, defects in dissimilar metal welds, and other degradation, had at times caught the industry by surprise and led to a call for action.”

In 2003, U.S. nuclear owners and operators, working under the auspices of the Nuclear Energy Institute (NEI), established an initiative to improve materials management. Formally referred to as “[NEI 03-08, Guideline for the Management of Materials Issues](#),” the initiative established roles, responsibilities, and procedures for full industry cooperation, integration, and funding. A strategic plan called for:

- Proactive inspection
- Research priorities consistent with the most important gaps
- Consistent implementation of aging management guidance
- Coordination of activities and sharing of operating experience across the industry

“This was the industry saying, ‘We’re going to get ahead of materials challenges and resolve them quickly before they become problems. We’re going to self-police our aging management practices,’” said EPRI Principal Technical Leader Wayne Lunceford. “All the U.S. nuclear utilities endorsed the initiative, committing to fully participate and comply with its requirements.”

EPRI Programs Provide Industrywide Guidance and Rapid Response

The majority of the technical work was organized into six EPRI programs:

- Boiling Water Reactor Vessel and Internals Project
- Materials Reliability Program
- Steam Generator Management Program
- Nondestructive Evaluation Program
- Water Chemistry Control Program
- Primary Systems Corrosion Program

“Utility representatives collaborate with EPRI to identify the research needed to address key aging management needs,” said Lunceford. “EPRI programs conduct the research and develop the appropriate aging management guidance, including maintenance and inspection criteria. Plant owners engage in the process and are responsible for managing the materials programs at their plants, including implementation of the guidance.”

Rapid response mechanisms are built into the initiative. When plants find degradation that is novel, unique, or not sufficiently understood, the operators share that information with the appropriate EPRI research program, which in turn shares it with the entire fleet.

“We get all the right people on a conference call, talk through the issue, and take appropriate action,” said Lunceford. When existing EPRI guidance needs to be updated based on the new information, the EPRI programs will issue interim guidance that notifies the fleet of an aging management concern. These documents guide plants in looking for evidence of a particular type of degradation in certain components, often including detailed instructions on when, where, and how to inspect. The results of these activities, along with the associated research, will guide any necessary additional actions.

“With aging management, the challenge is to find the next material vulnerability and address it before any failures occur,” said Dyle. “One of the Material Initiative’s key accomplishments is that it has defined protocols for industry action upon discovery of new issues.”

Since the implementation of the Materials Initiative, there have been a number of cases in which degradation issues have been effectively managed. One recent example involves the boiling water reactor’s shroud, a protective shield that surrounds the reactor core and is subject to intense radiation. In the U.S. fleet in the late 1990s, unanticipated cracking was found in the welds used to hold the shroud assembly together. While operators had discovered cracks running parallel to the welds, other nonparallel cracks emanating from the welds went undetected.

“The inspection techniques being used were focused on finding cracking oriented parallel to the welds. They weren’t developed to detect cracks oriented perpendicular to the welds,” said Lunceford, who manages projects assessing core shroud cracking. “To better understand the significance of the cracking, we issued interim guidance asking all boiling water reactor owners to inspect their shrouds using techniques capable of finding these cracks. In the end, we concluded that this issue is not likely to be a significant aging management concern. The interim guidance helped us to gather the information needed to support this conclusion.”

In pressurized water reactors, a comparable assembly surrounds the core and directs coolant past the fuel bundles. The assembly is held together by “baffle bolts” that are highly irradiated and susceptible to cracking. Under stress they can shear off, causing alignment problems.

“The Materials Reliability Program anticipated that there would be problems with the bolts, but visual and ultrasonic inspections found that a few plants had more degraded bolts than expected,” said Dyle. “In response, the program issued interim guidance making inspection criteria more comprehensive and rigorous.”

As a part of the Materials Initiative, the EPRI programs keep the NRC fully informed of their work, including research plans, activities, and results. The NRC has indicated in public meetings that the initiative is effective and positive.

“As the industry implements EPRI’s aging management guidance, we gain a better understanding of materials degradation, occasionally prompting changes in inspection requirements,” said Dyle.

“A significant fraction of the EPRI guidance implemented by the utilities is above and beyond the regulatory requirements for these plants,” said Lunceford. “The Materials Initiative has made the fleet safer and more reliable.”

“The initiative has been, and continues to be, very successful at resolving materials challenges and filling knowledge gaps. There are now far fewer materials-related surprises and fewer outages negatively impacted by such surprises,” said Dyle.

Key EPRI Technical Experts

Robin Dyle, Wayne Lunceford