IN USE: NICKEL-BASED ALLOY AGING MANAGEMENT

ISSUE STATEMENT
Alloy 600 and its weld metal formulations (A82, A132, A182) have been used extensively in PWR reactor coolant system applications, but these materials are susceptible to primary water stress corrosion cracking (PWSCC) within the standard operating water chemistry of the PWR fleet. Research, development, and field testing has successfully resulted in a variety of established inspection strategies, an expanding set of mitigation and repair options, and a proven set of PWSCC-resistant replacement materials (A690, A52, and A152).

Inspection, repair, and mitigation challenges, however, remain at certain locations specific to small segments of the fleet, and at “cold” locations such as reactor vessel bottom mounted nozzles. Due to detections of PWSCC in “cold” locations, there is need for expanding the range of available mitigation options and re-evaluating the current inspection regime.

Moreover, as experience with A690 high-chromium materials as a replacement accumulates, additional PWSCC laboratory testing and analysis of operating experience can inform the periodic re-evaluation of inspection intervals for locations such as control rod drive mechanism penetrations.

DRIVERS

Operational
The primary driver for continued research into A600 materials is to ensure that inspection regimes, mitigation strategy options, and flaw disposition curves remain current relative to operational experience and laboratory data. For A690 materials, the primary driver is to ensure these materials are well characterized, including their increased resistance to PWSCC degradation and that these properties are understood with respect to nuclear plant management strategies.

Regulatory
Regulatory decisions regarding inspection frequency and scope must be properly informed by technical data and analysis. This roadmap will provide datasets and analysis for use by regulators, utilities, and other stakeholders.

RESULTS IMPLEMENTATION
The management of A600/690 materials for asset protection and regulatory compliance generally relies on technical bases established within MRP documents. Actions conducted through this roadmap will update and expand the body of knowledge in these basis documents regarding the degradation behavior of A600 and the use of A690 materials for mitigation and replacement.

Effective implementation is accomplished through improved guidance, the proper application of alternative management strategies, knowledge sharing with regulators, and the incorporation of current knowledge into the ASME Code and relevant Code Cases.

PROJECT PLAN
For Alloy 600 material locations:

- Continually monitor operating experience to assess whether changes to existing inspection and evaluation guidelines and their technical bases may be needed to support nuclear safety and asset management.
- As new PWSCC mitigation technologies are proven, develop technical bases for their incorporation into existing inspection regimes and seek their acceptance by the ASME code and the regulator. Currently, a project is underway to obtain a Safety Evaluation Review (SER) from the regulator on an MRP report for peening of specific Alloy 600 locations to improve their resistance to PWSCC. In parallel, companion ASME code cases were prepared.
- Currently, an effort is underway to update flaw disposition curves for Alloy 600 and its weld metals to account for recent test data.
For Alloy 690 materials locations:

- Monitor ongoing PWSCC research as described in the “Alloy 690 PWSCC Crack Growth Rate” and “Alloy 690 PWSCC Initiation” roadmaps and incorporate such research and operating experience into existing inspection regimes through regulatory action or the ASME code. A project has been completed to inform the regulator of the technical basis and to incorporate optimized inspection intervals for the reactor pressure vessel upper head penetrations constructed from Alloy 690 materials into the ASME code.

- Develop flaw disposition curves for A690 materials for potential incorporation into the ASME code. Currently, an effort is underway to develop flaw disposition curves for Alloy 690 and weld metals based on test data.

Significant activities currently underway are reflected in the Elements and Timeline chart (not a comprehensive list), and additional activities may be initiated as appropriate.

**RISKS**

Given the relative stability of current industry and regulatory guidance on nickel-based alloy management, there is minimal risk from untimely completion of actions under this roadmap. Nevertheless, that stability could be disrupted by unexpected leaks or inspection indications within the fleet. A well-planned, focused, modest level of effort is therefore appropriate to continue monitoring and responding to industry operating experience; effectively integrate relevant new mitigation methods and materials characterization data (e.g., peening, crack initiation, and crack growth rates); and inform regulatory decisions regarding inspection requirements.