XI.M11B CRACKING OF NICKEL-ALLOY COMPONENTS AND LOSS OF MATERIAL DUE TO BORIC ACID-INDUCED CORROSION IN REACTOR COOLANT PRESSURE BOUNDARY COMPONENTS (PWRs ONLY)

Program Description

This program replaces AMPs XI.M11, "Nickel-Alloy Nozzles and Penetrations" and XI.M11A, "Nickel-Alloy Penetration Nozzles Welded to the Upper Reactor Vessel Closure Heads of Pressurized Water Reactors." It addresses the issue of cracking of nickel-alloy components and loss of material due to boric acid-induced corrosion in susceptible, safety-related components in the vicinity of nickel-alloy reactor coolant pressure boundary components. A final rule (September 2008) updating 10 CFR 50.55a requires the following American Society of Mechanical Engineer (ASME) Boiler and Pressure Vessel (B&PV) Code Cases: (a) N-722, "Additional Examinations for PWR Pressure Retaining Welds in Class 1 Components Fabricated with Alloy 600/82/182 Materials, Section XI, Division 1" to establish long-term inspection requirements for the pressurized water reactor (PWR) vessel, steam generator, pressurizer components and piping if they contain the primary water stress corrosion cracking (PWSCC) susceptible materials designated alloys 600/82/182; and (b) N-729-1, "Alternative Examination Requirements for PWR Reactor Vessel Upper Heads With Nozzles Having Pressure-Retaining Partial-Penetration Welds, Section XI, Division 1" to establish new requirements for the long-term inspection of reactor pressure vessel upper heads.

In addition, dissimilar metal welds need additional examinations to provide reasonable assurance of structural integrity. The U.S. Nuclear Regulatory Commission (NRC) issued Regulatory Information Summary (RIS) 2008-25, "Regulatory Approach for Primary Water Stress Corrosion Cracking (PWSCC) of Dissimilar Metal Butt Welds in Pressurized Water Reactor Primary Coolant System Piping" (October 2008) which stated the regulatory approach for addressing PWSCC of dissimilar metal butt welds. The RIS documents the NRC's approach to ensuring the integrity of primary coolant system piping containing dissimilar metal butt welds in PWRs and, in conjunction with the mandated inspections of ASME Code Case N-722, ensures that augmented in-service inspections (ISI) of all nickel-based alloy components and welds in the reactor coolant system (RCS) continue to perform their intended functions.

As stated in this RIS, the NRC has found that MRP-139, "Primary System Piping Butt Weld Inspection and Evaluation Guideline" (2005), and MRP interim guidance letters provide adequate protection of public health and safety for addressing PWSCC in dissimilar metal butt welds pending the incorporation of ASME Code Case N-770, containing comprehensive inspection requirements, into 10 CFR 50.55a. It is the intention of the NRC to replace MRP-139 by incorporating the requirements of ASME Code Case N-770 into 10 CFR 50.55a.

The impacts of boric acid leakage from non-nickel alloy reactor coolant pressure boundary components are addressed in AMP XI.M10, "Boric Acid Corrosion." The Water Chemistry program for PWRs relies on monitoring and control of reactor water chemistry based on industry guidelines as described in AMP XI.M2, "Water Chemistry."

Evaluation and Technical Basis

1. ***Scope of Program:*** The program is focused on managing the effects of cracking due to PWSCC of all susceptible nickel alloy-based components of the reactor coolant pressure boundary (including nickel-alloy welds). The program also manages the loss of material due to boric acid corrosion in susceptible components in the vicinity of nickel-alloy components.

These components could include, but are not limited to, the reactor vessel components (reactor pressure vessel upper head), steam generator components (nozzle-to-pipe connections, instrument connections, and drain tube penetrations), pressurizer components (nozzle-to-pipe connections, instrument connections, and heater penetrations), and reactor coolant system piping (instrument connections and full penetration welds).

2. ***Preventive Actions:*** This program is a condition monitoring program and does not include preventive or mitigative measures. However, maintaining high water purity reduces susceptibility to PWSCC. Reactor coolant water chemistry is monitored and maintained in accordance with the Water Chemistry program. The program description and the evaluation and technical basis of monitoring and maintaining reactor water chemistry are presented in GALL AMP XI.M2, "Water Chemistry."

   At the discretion of the applicant, preventive actions to mitigate PWSCC may be addressed by various measures (e.g., weld overlays, replacement of components with more PWSCC-resistant materials, etc.).

3. ***Parameters Monitored/Inspected:*** This is a condition monitoring program that monitors cracking/PWSCC for nickel-alloy components and loss of material by boric acid corrosion for potentially affected steel component. Reactor coolant pressure boundary cracking and leakage are monitored by the applicant's in-service inspection program in accordance with 10 CFR 50.55a and industry guidelines (e.g., MRP-139). Boric acid deposits, borated water leakage, or the presence of moisture that could lead to the identification of cracking or loss of material can be monitored through visual examination.

4. ***Detection of Aging Effects:*** The program detects the effect of aging by various methods, including non-destructive examination techniques. Reactor coolant pressure boundary leakage can be monitored through the use of radiation air monitoring and other general area radiation monitoring, and technical specifications for reactor coolant pressure boundary leakage. The specific types of non-destructive examinations are dependent on the component's susceptibility to PWSCC and its accessibility to inspection. Inspection methods, schedules, and frequencies for the susceptible components are implemented in accordance with 10 CFR 50.55a and industry guidelines (e.g., MRP-139).

5. ***Monitoring and Trending:*** Reactor coolant pressure boundary leakage is calculated and trended on a routine basis in accordance with technical specification to detect changes in the leakage rates. Flaw evaluation through 10 CFR 50.55a is a means to monitor cracking.

6. ***Acceptance Criteria:*** Acceptance criteria for all indications of cracking and loss of material due to boric acid-induced corrosion are defined in 10 CFR 50.55a and industry guidelines (e.g., MRP-139).

7. ***Corrective Actions:*** Relevant flaw indications of susceptible components within the scope of this program found to be unacceptable for further services are corrected through implementation of appropriate repair or replacement as dictated by 10 CFR 50.55a and industry guidelines (e.g., MRP-139). In addition, detection of leakage or evidence of cracking in susceptible components within the scope of this program require scope expansion of current inspection and increased inspection frequencies of some components, as required by 10 CFR 50.55a and industry guidelines (e.g., MRP-139).

Repair and replacement procedures and activities must either comply with ASME Section XI, as incorporated in 10 CFR 50.55a or conform to applicable ASME Code Cases that have been endorsed in 10 CFR 50.55a by referencing the latest version of NRC Regulatory Guide 1.147.

As discussed in the Appendix for GALL, the staff finds the requirements of 10 CFR Part 50, Appendix B, acceptable to address the corrective actions.

8. ***Confirmation Process:*** Site quality assurance procedures and review and approval processes are implemented in accordance with the requirements of 10 CFR Part 50, Appendix B. As discussed in the Appendix for GALL, the staff finds the requirements of 10 CFR Part 50, Appendix B, acceptable to address confirmation process.

9. ***Administrative Controls:*** As discussed in the Appendix for GALL, the staff finds the requirements of 10 CFR Part 50, Appendix B, acceptable to address the administrative controls.

10. ***Operating Experience:*** This new program addresses reviews of related operating experience, including plant-specific information, generic industry findings, and international data. Within the current regulatory requirements, as necessary, the applicant maintains a record of operating experience through the required update of the facility's inservice inspection program in accordance with 10 CFR 50.55a. Additionally, the applicant follows mandated industry guidelines developed to address operating experience in accordance with NEI-03-08, "Guideline for the Management of Materials Issues."

    Cracking of Alloy 600 has occurred in domestic and foreign PWRs (NRC Information Notice [IN] 90-10). Furthermore, ingress of demineralizer resins also has occurred in operating plants (NRC IN 96-11). The Water Chemistry program, AMP XI.M2, manages the effects of such excursions through monitoring and control of primary water chemistry. NRC GL 97-01 is effective in managing the effect of PWSCC. PWSCC also is occurring in the vessel head penetration (VHP) nozzle of U.S. PWRs as described in NRC Bulletins 2001-01, 2002-01 and 2002-02.

References

10 CFR Part 50, Appendix B, *Quality Assurance Criteria for Nuclear Power Plants*, Office of the Federal Register, National Archives and Records Administration, 2009.

10 CFR Part 50.55a, *Codes and Standards*, Office of the Federal Register, National Archives and Records Administration, 2009.

ASME Code Case N-722, *Additional Examinations for PWR Pressure Retaining Welds in Class 1 Components Fabricated with Alloy 600/82/182 Materials*, July 5, 2005.

ASME Code Case N-729-1, *Alternative Examination Requirements for PWR Reactor Vessel Upper Heads with Nozzles Having Pressure-Retaining Partial-Penetration Welds*, March 28, 2006.

ASME Code Case N-770, *Alternative Examination Requirements and Acceptance Standards for Class 1 PWR Piping and Vessel Nozzle Butt Welds Fabricated with UNS N06082 or UNS*

W86182 Weld Filler Material With or Without Application of Listed Mitigation Activities, January 26, 2009.

MRP-139, Revision 1, *Primary System Piping Butt Weld Inspection and Evaluation Guideline*, Materials Reliability Program, December 16, 2008.

NEI-03-08, *Guideline for the Management of Materials Issues,* Nuclear Energy Institute, May 2003.

NRC Bulletin 2001-01, *Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles*, U.S. Nuclear Regulatory Commission, August 3, 2001.

NRC Bulletin 2002-01, *Reactor Pressure Vessel Head Degradation and Reactor Coolant Pressure Boundary Integrity*, U.S. Nuclear Regulatory Commission, March 18, 2002.

NRC Bulletin 2002-02, *Reactor Pressure Vessel Head and Vessel Head Penetration Nozzle Inspection Programs*, U.S. Nuclear Regulatory Commission, August 9, 2002.

NRC Generic Letter 97-01, *Degradation of Control Rod Drive Mechanism Nozzle and Other Vessel Closure Head Penetrations*, U.S. Nuclear Regulatory Commission, April 1, 1997.

NRC Information Notice 90-10, *Primary Water Stress Corrosion Cracking (PWSCC) of Inconel 600*, U.S. Nuclear Regulatory Commission, February 23, 1990.

NRC Information Notice 96-11, *Ingress of Demineralizer Resins Increases Potential for Stress Corrosion Cracking of Control Rod Drive Mechanism Penetrations*, U.S. Nuclear Regulatory Commission, February 14, 1996.

NRC Inspection Manual, Inspection Procedure 71111.08, *Inservice Inspection Activities*, March 23, 2009.

NRC Inspection Manual, Temporary Instruction 2515/172, *Reactor Coolant System Dissimilar Metal Butt Welds*, February 21, 2008.

NRC Regulatory Guide 1.147, Revision 15, *Inservice Inspection Code Case Acceptability*, ASME Section XI, Division 1, U.S. Nuclear Regulatory Commission, January 2004.

NRC Regulatory Information Summary 2008-25, *Regulatory Approach for Primary Water Stress Corrosion Cracking of Dissimilar Metal Butt Welds in Pressurized Water Reactor Primary Coolant System Piping*, U.S. Nuclear Regulatory Commission, October 22, 2008.

NUREG-1823, *U.S. Plant Experience with Alloy 600 Cracking and Boric Acid Corrosion of Light-Water Reactor Pressure Vessel Materials*, U.S. Nuclear Regulatory Commission, April 2005.