

## XI.M18 BOLTING INTEGRITY

### Program Description

The program manages aging of closure bolting for pressure retaining components. The program relies on recommendations for a comprehensive bolting integrity program, as delineated in NUREG-1339, and industry recommendations, as delineated in the following documents:

- NUREG-1339, "Resolution of Generic Safety Issue 29: Bolting Degradation or Failure in Nuclear Power Plants."
- Electric Power Research Institute (EPRI) NP-5769, "Degradation and Failure of Bolting in Nuclear Power Plants" (with the exceptions noted in NUREG-1339 for safety-related bolting).
- EPRI TR-104213, "Bolted Joint Maintenance and Application Guide."

The program generally includes periodic inspection of closure bolting for indication of loss of preload, cracking, and loss of material due to corrosion, rust, etc. The program also includes preventive measures to preclude or minimize loss of preload and cracking.

Aging management program (AMP) XI.M1, "ASME Section XI Inservice Inspection, Subsections IWB, IWC, and IWD," includes inspection of safety-related and non-safety-related closure bolting and supplements this bolting integrity program. AMPs XI.S1, "ASME Section XI, Subsection IWE"; XI.S3, "ASME Section XI, Subsection IWF"; XI.S6, "Structures Monitoring"; XI.S7, "RG 1.127, "Inspection of Water-Control Structures Associated with Nuclear Power Plants"; and XI.M23, "Inspection of Overhead Heavy Load and Light Load (Related to Refueling) Handling Systems," manage inspection of safety-related and non-safety related structural bolting.

### Evaluation and Technical Basis

1. **Scope of Program:** This program manages aging of closure bolting for pressure retaining components within the scope of license renewal, including both safety-related and non-safety-related bolting. This program does not manage aging of reactor head closure stud bolting (AMP XI.M3) or structural bolting (AMPs XI.S1, XI.S3, XI.S6, XI.S7, and XI.M23).
2. **Preventive Actions:** Selection of bolting material and the use of lubricants and sealants is in accordance with the guidelines of EPRI NP-5769 and the additional recommendations of NUREG-1339 to prevent or mitigate degradation and failure of safety-related bolting. NUREG-1339 takes exception to certain items in EPRI NP-5769 and recommends additional measures with regard to them. Of particular note, use of molybdenum disulfide ( $\text{MoS}_2$ ) as a lubricant has been shown to be a potential contributor to stress corrosion cracking (SCC) and should not be used. Preventive measures also include using bolting material that has an actual measured yield strength limited to less than 1,034 megapascals (MPa) (150 kilo-pounds per square inch [ksi]). Bolting replacement activities include proper torquing of the bolts and checking for uniformity of the gasket compression after assembly. Maintenance practices require the application of an appropriate preload based on guidance in EPRI documents, manufacturer recommendations, or engineering evaluation.

3. **Parameters Monitored/Inspected:** This program monitors the effects of aging on the intended function of bolting. Specifically, bolting for safety-related pressure retaining components is inspected for leakage, loss of material, cracking, and loss of preload/loss of prestress. Bolting for other pressure retaining components is inspected for signs of leakage. High strength closure bolting (actual yield strength greater than or equal to 1,034 MPa [150 ksi]), if used, should be monitored for cracking.
4. **Detection of Aging Effects:** The American Society of Mechanical Engineers (ASME) Section XI Inservice Inspection, Subsections IWB, IWC, and IWD program implements inspection of Class 1, Class 2, and Class 3 pressure retaining bolting in accordance with requirements of ASME Code Section XI,<sup>12</sup> Tables IWB-2500-1, IWC-2500-1, and IWD-2500-1. These include volumetric and visual (VT-1) examinations, as appropriate. In addition, for both ASME Code class bolting and non-ASME Code class bolting, periodic system walkdowns and inspections (at least once per refueling cycle) ensure detection of leakage at bolted joints before the leakage becomes excessive. Bolting inspections should include consideration of the guidance applicable for pressure boundary bolting in NUREG-1339 and in EPRI NP-5769 and EPRI TR-104213.

Degradation of pressure boundary closure bolting due to crack initiation, loss of preload, or loss of material may result in leakage from the mating surfaces or joint connections of pressure boundary components. Periodic inspection of pressure boundary components for signs of leakage ensures that age-related degradation of closure bolting is detected and corrected before component leakage becomes excessive. Accordingly, pressure retaining bolted connections should be inspected at least once per refueling cycle. The inspections may be performed as part of ASME Code Section XI leakage tests or as part of other periodic inspection activities, such as system walkdowns or an external surfaces monitoring program.

High strength closure bolting (actual yield strength greater than or equal to 1,034 MPa (150 ksi) may be subject to stress corrosion cracking. For high strength closure bolts (regardless of code classification), volumetric examination in accordance to that of ASME Code Section XI, Table IWB-2500-1, Examination Category B-G-1, should be performed.

5. **Monitoring and Trending:** The inspection schedules of ASME Section XI components are effective and ensure timely detection of applicable aging effects. If a bolting connection for pressure retaining components not covered by ASME Section XI is reported to be leaking, it may be inspected daily or in accordance with the corrective action process. If the leak rate is increasing, more frequent inspections may be warranted.
6. **Acceptance Criteria:** Any indications of aging effects in ASME pressure retaining bolting are evaluated in accordance with Section XI of the ASME Code. For other pressure retaining bolting, indications of aging should be dispositioned in accordance with the corrective action process.
7. **Corrective Actions:** Replacement of ASME pressure retaining bolting is performed in accordance with appropriate requirements of Section XI of the ASME Code, as subject to the additional guidelines and recommendations of EPRI NP-5769. Replacement of other pressure retaining bolting (i.e., non-ASME code class bolting) is performed in accordance with the guidelines and recommendations of EPRI TR-104213. As discussed in the

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<sup>12</sup> Refer to the GALL Report, Chapter I, for applicability of other editions of the ASME Code, Section XI.

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, review and approval processes, and administrative controls 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 the confirmation process and administrative controls.
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:** Degradation of threaded bolting and fasteners in closures for the reactor coolant pressure boundary has occurred from boric acid corrosion, SCC, and fatigue loading (U.S. Nuclear Regulatory Commission [NRC] IE Bulletin 82-02, NRC Generic Letter 91-17). SCC has occurred in high strength bolts used for nuclear steam supply system component supports (EPRI NP-5769). The bolting integrity program developed and implemented in accordance with the applicant's docketed responses to NRC communications on bolting events have provided an effective means of ensuring bolting reliability. These programs are documented in EPRI NP-5769 and TR-104213 and represent industry consensus.

Degradation related failures have occurred in downcomer Tee-quencher bolting in boiling water reactors (BWRs) designed with drywells (ADAMS Accession Number ML050730347). Leakage from bolted connections has been observed in reactor building closed cooling systems of BWRs (LER 50-341/2005-001).

The applicant is to evaluate applicable operating experience to support the conclusion that the effects of aging are adequately managed.

## 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 50.55a, *Codes and Standards*, Office of the Federal Register, National Archives and Records Administration, 2009.
- ASME Section XI, *Rules for Inservice Inspection of Nuclear Power Plant Components*, The ASME Boiler and Pressure Vessel Code, 2004 edition as approved in 10 CFR 50.55a, The American Society of Mechanical Engineers, New York, NY.
- EPRI NP-5769, *Degradation and Failure of Bolting in Nuclear Power Plants*, Volumes 1 and 2, Electric Power Research Institute, April 1988.
- EPRI TR-104213, *Bolted Joint Maintenance & Application Guide*, Electric Power Research Institute, December 1995.
- NRC Generic Letter 91-17, *Generic Safety Issue 79, Bolting Degradation or Failure in Nuclear Power Plants*, U.S. Nuclear Regulatory Commission, October 17, 1991.

NRC IE Bulletin No. 82-02, *Degradation of Threaded Fasteners in the Reactor Coolant Pressure Boundary of PWR Plants*, U.S. Nuclear Regulatory Commission, June 2, 1982.

NRC Morning Report, *Failure of Safety/Relief Valve Tee-Quencher Support Bolts*, March 14, 2005. (ADAMS Accession Number ML050730347)

NUREG-1339, *Resolution of Generic Safety Issue 29: Bolting Degradation or Failure in Nuclear Power Plants*, U.S. Nuclear Regulatory Commission, June 1990.