XI.S6 STRUCTURES MONITORING

Program Description

Implementation of structures monitoring under 10 CFR 50.65 (the Maintenance Rule) is addressed in Nuclear Regulatory Commission (NRC) Regulatory Guide (RG) 1.160, Rev. 2, and NUMARC 93-01, Rev. 2. These two documents provide guidance for development of licensee-specific programs to monitor the condition of structures and structural components within the scope of the Maintenance Rule, such that there is no loss of structure or structural component intended function.

The structures monitoring program consists of periodic visual inspections by personnel qualified to monitor structures and components for applicable aging effects, such as those described in the American Concrete Institute Standards (ACI) 349.3R, ACI 201.1R, and American National Standards Institute/American Society of Civil Engineers Standard (ANSI/ASCE) 11. Visual inspections should be supplemented with volumetric or surface examinations to detect stress corrosion cracking (SCC) in high strength (actual measured yield strength greater than or equal to 150 kilo-pound per square inch [ksi] or greater than or equal to 1,034 MPa) structural bolts greater than 1 inch (25 mm) in diameter. Identified aging effects are evaluated by qualified personnel using criteria derived from industry codes and standards contained in the plant current licensing bases, including ACI 349.3R, ACI 318, ANSI/ASCE 11, and the American Institute of Steel Construction (AISC) specifications, as applicable.

The program includes preventive actions delineated in NUREG-1339 and in Electric Power Research Institute (EPRI) NP-5769, NP-5067, and TR-104213 to ensure structural bolting integrity, if applicable.

The program also includes periodic sampling and testing of ground water and the need to assess the impact of any changes in its chemistry on below grade concrete structures.

If protective coatings are relied upon to manage the effects of aging for any structures included in the scope of this aging management program (AMP), the structures monitoring program is to address protective coating monitoring and maintenance.

Evaluation and Technical Basis

1. ***Scope of Program:*** The scope of the program includes all structures, structural components, component supports, and structural commodities in the scope of license renewal that are not covered by other structural AMPs (i.e., “ASME Section XI, Subsection IWE” (AMP XI.S1); “ASME Section XI, Subsection IWL” (AMP XI.S2); “ASME Section XI, Subsection IWF” (AMP XI.S3); “Masonry Walls” (AMP XI.S5); and NRC RG 1.127, “Inspection of Water-Control Structures Associated with Nuclear Power Plants” (AMP XI.S7). Examples of structures, structural components, and commodities in the scope of the program are concrete and steel structures, structural bolting, anchor bolts and embedments, component support members, pipe whip restraints and jet impingement shields, transmission towers, panels and other enclosures, racks, sliding surfaces, sump and pool liners, electrical cable trays and conduits, trash racks associated with water control structures, electrical duct banks, manholes, doors, penetration seals, and tube tracks. The applicant is to specify other structures or components that are in the scope of its structures monitoring program. The scope of this program includes periodic sampling and testing of ground water and may include inspection of masonry walls and water-control structures

provided all the attributes of “Masonry Walls” (AMP XI.S5) and NRC RG 1.127, “Inspection of Water-Control Structures Associated with Nuclear Power Plants” (AMP XI.S7) are incorporated in the attributes of this program.

2. ***Preventive Action:*** The structures monitoring program is a condition monitoring program. The program should include preventive actions delineated in NUREG-1339 and in EPRI NP-5769, NP-5067, and TR-104213 to ensure structural bolting integrity, if applicable. These actions emphasize proper selection of bolting material, lubricants, and installation torque or tension to prevent or minimize loss of bolting preload and cracking of high strength bolting. If the structural bolting consists of ASTM A325, ASTM F1852, and/or ASTM A490 bolts, the preventive actions for storage, lubricants, and stress corrosion cracking potential discussed in Section 2 of RCSC (Research Council for Structural Connections) publication “Specification for Structural Joints Using ASTM A325 or A490 Bolts,” need to be used.

3. ***Parameters Monitored or Inspected:*** For each structure/aging effect combination, the specific parameters monitored or inspected depend on the particular structure, structural component, or commodity. Parameters monitored or inspected are commensurate with industry codes, standards, and guidelines and also consider industry and plant-specific operating experience. ACI 349.3R and ANSI/ASCE 11 provide an acceptable basis for selection of parameters to be monitored or inspected for concrete and steel structural elements and for steel liners, joints, coatings, and waterproofing membranes (if applicable).

   For concrete structures, parameters monitored include loss of material, cracking, increase in porosity and permeability, loss of foundation strength, and reduction in concrete anchor capacity due to local concrete degradation. Steel structures and components are monitored for loss of material due to corrosion. Structural bolting is monitored for loose bolts, missing or loose nuts, and other conditions indicative of loss of preload. High strength (actual measured yield strength ≥ 150 ksi or 1,034 MPa) structural bolts greater than 1 inch (25 mm) in diameter are monitored for SCC. Other structural bolting (ASTM A-325, ASTM F1852, and ASTM A490 bolts), and anchor bolts are monitored for loss of material, loose or missing nuts, and cracking of concrete around the anchor bolts. Accessible sliding surfaces are monitored for indication of significant loss of material due to wear or corrosion, debris, or dirt. Elastomeric vibration isolators and structural sealants are monitored for cracking, loss of material, and hardening. These parameters and other monitored parameters are selected to ensure that aging degradation leading to loss of intended functions will be detected and the extent of degradation can be determined. Ground water chemistry (pH, chlorides, and sulfates) are monitored periodically to assess its impact, if any, on below grade concrete structures. If necessary for managing settlement and erosion of porous concrete sub-foundations, the continued functionality of a site de-watering system is monitored. The plant-specific structures monitoring program should contain sufficient detail on parameters monitored or inspected to conclude that this program attribute is satisfied.

4. ***Detection of Aging Effects:*** Structures are monitored under this program using periodic visual inspection of each structure/aging effect combination by a qualified inspector to ensure that aging degradation will be detected and quantified before there is loss of intended function. Visual inspection of high strength (actual measured yield strength ≥ 150 ksi or 1,034 MPa) structural bolting greater than 1 inch (25 mm) in diameter is supplemented with volumetric or surface examinations to detect cracking. Other structural bolting (ASTM A-325, ASTM F1852, and ASTM A490 bolts) and anchor bolts are monitored for loss of material, loose or missing nuts, and cracking of concrete around the anchor bolts. Accessible sliding surfaces are monitored for indication of significant loss of material due to

wear or corrosion, debris, or dirt. Visual inspection of elastomeric vibration isolation elements should be supplemented by feel to detect hardening if the vibration isolation function is suspect. The inspection frequency depends on safety significance and the condition of the structure as specified in NRC RG 1.160, Rev. 2. In general, all structures and ground water quality are monitored on a frequency not to exceed 5 years. Some structures of lower safety significance, and subjected to benign environmental conditions, may be monitored at an interval exceeding five years; however, they should be identified and listed, together with their operating experience. The program includes provisions for more frequent inspections of structures and components categorized as (a)(1) in accordance with 10 CFR 50.65. Inspector qualifications should be consistent with industry guidelines and standards and guidelines for implementing the requirements of 10 CFR 50.65. Qualifications of inspection and evaluation personnel specified in ACI 349.3R are acceptable for license renewal.

The structures monitoring program addresses detection of aging affects for inaccessible, below-grade concrete structural elements. For plants with non-aggressive ground water/soil (pH > 5.5, chlorides < 500 ppm, or sulfates <1500 ppm), the program recommends: (a) evaluating the acceptability of inaccessible areas when conditions exist in accessible areas that could indicate the presence of, or result in, degradation to such inaccessible areas and (b) examining representative samples of the exposed portions of the below grade concrete, when excavated for any reason.

For plants with aggressive ground water/soil (pH < 5.5, chlorides > 500 ppm, or sulfates > 1500 ppm) and/or where the concrete structural elements have experienced degradation, a plant-specific AMP accounting for the extent of the degradation experienced should be implemented to manage the concrete aging during the period of extended operation.

5. ***Monitoring and Trending:*** Regulatory Position 1.5, "Monitoring of Structures," in NRC RG 1.160, Rev. 2, provides an acceptable basis for meeting the attribute. A structure is monitored in accordance with 10 CFR 50.65(a)(2) provided there is no significant degradation of the structure. A structure is monitored in accordance with 10 CFR 50.65(a)(1) if the extent of degradation is such that the structure may not meet its design basis or, if allowed to continue uncorrected until the next normally scheduled assessment, may not meet its design basis.

6. ***Acceptance Criteria:*** The structures monitoring program calls for inspection results to be evaluated by qualified engineering personnel based on acceptance criteria selected for each structure/aging effect to ensure that the need for corrective actions is identified before loss of intended functions. The criteria are derived from design bases codes and standards that include ACI 349.3R, ACI 318, ANSI/ASCE 11, or the relevant AISC specifications, as applicable, and consider industry and plant operating experience. The criteria are directed at the identification and evaluation of degradation that may affect the ability of the structure or component to perform its intended function. Applicants who are not committed to ACI 349.3R and elect to use plant-specific criteria for concrete structures should describe the criteria and provide a technical basis for deviations from those in ACI 349.3R. Loose bolts and nuts and cracked high strength bolts are not acceptable unless accepted by engineering evaluation. Structural sealants are acceptable if the observed loss of material, cracking, and hardening will not result is loss of sealing. Elastomeric vibration isolation elements are acceptable if there is no loss of material, cracking, or hardening that could lead to the reduction or loss of isolation function. Acceptance criteria for sliding surfaces are (a) no indications of excessive loss of material due to corrosion or wear and (b) no debris or dirt

that could restrict or prevent sliding of the surfaces as required by design. The structures monitoring program is to contain sufficient detail on acceptance criteria to conclude that this program attribute is satisfied.

7. ***Corrective Actions:*** Evaluations are performed for any inspection results that do not satisfy established criteria. Corrective actions are initiated in accordance with the corrective action process if the evaluation results indicate there is a need for a repair or replacement. 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:*** 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.

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:*** Although in many plants, structures monitoring programs have only recently been implemented, plant maintenance has been ongoing since initial plant operations. NUREG-1522 documents the results of a survey sponsored in 1992 by the Office of Nuclear Regulatory Regulation to obtain information on the types of distress in the concrete and steel structures and components, the type of repairs performed, and the durability of the repairs. Licensees who responded to the survey reported cracking, scaling, and leaching of concrete structures. The degradation was attributed to drying shrinkage, freeze-thaw, and abrasion. The NUREG also describes the results of NRC staff inspections at six plants. The staff observed concrete degradation, corrosion of component support members and anchor bolts, cracks and other deterioration of masonry walls, and ground water leakage and seepage into underground structures. The observed and reported degradations were more severe at coastal plants than those observed in inland plants as a result of brackish and sea water. Previous license renewal applicants reported similar degradation and corrective actions taken through their structures monitoring program. Many license renewal applicants have found it necessary to enhance their structures monitoring program to ensure that the aging effects of structures and components in the scope of 10 CFR Part 54.4 are adequately managed during the period of extended operation. There is reasonable assurance that implementation of the structures monitoring program described above will be effective in managing the aging of the in-scope structures and component supports through the period of extended operation.

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 50.65, *Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants,* Office of the Federal Register, National Archives and Records Administration, 2009.

10 CFR 54.4, *Scope*, Office of the Federal Register, National Archives and Records Administration, 2009.

ACI Standard 201.1R, *Guide for Making a Condition Survey of Concrete in Service,* American Concrete Institute, 1992.

ACI Standard 318, *Building Code Requirements for Reinforced Concrete and Commentary,* American Concrete Institute.

ACI Standard 349.3R, *Evaluation of Existing Nuclear Safety-Related Concrete Structures,* American Concrete Institute, 2002.

AISC, *AISC Specification for Steel Buildings,* American Institute of Steel Construction, Inc., Chicago, IL.

ANSI/ASCE 11-90, 99, *Guideline for Structural Condition Assessment of Existing Buildings,* American Society of Civil Engineers.

EPRI NP-5067, *Good Bolting Practices, A Reference Manual for Nuclear Power Plant Maintenance Personnel*, Volume 1: Large Bolt Manual, 1987; Volume 2: Small Bolts and Threaded Fasteners, Electric Power Research Institute, 1990.

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.

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NRC Regulatory Guide 1.142, Rev. 2, *Safety-related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments)*, U.S. Nuclear Regulatory Commission, November 2001.

NRC Regulatory Guide 1.160, Rev. 2, *Monitoring the Effectiveness of Maintenance at Nuclear Power Plants,* U.S. Nuclear Regulatory Commission, March 1997.

NUMARC 93-01, Rev. 2, *Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants (Line-In/Line-Out Version),* Nuclear Energy Institute, April 1996.

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NUREG-1522, *Assessment of Inservice Condition of Safety-Related Nuclear Power Plant Structures,* June 1995.