### AMP 319 NON-CONCRETE STRUCTURES MONITORING (VERSION 2021)

### Programme Description

This document provides guidance for developing a plant specific ageing management programme for miscellaneous non-concrete structures and components (SCs) such that there is no loss of structure or structural component intended function.

The structures monitoring programme consists of periodic visual inspections and non-destructive examination as necessary, by personnel qualified to monitor structures and components for applicable ageing effects in accordance with industry codes and standards of each country, such as [1-3]. General guidance for developing a condition assessment programme for managing ageing of NPP non-concrete structures has been provided by organizations such as the International Atomic Energy Agency [4]; the Electric Power Research Institute [5-6].

The evaluation methods and acceptance criteria recommended in [1-3, 7] can be used in the absence of, or to supplement, the guidance provided in the plant licensing documents. The person responsible for performing the structural evaluations is a qualified structural engineer, knowledgeable in the design, evaluation, and in-service inspection of non-concrete structures and performance requirements of nuclear safety-related structures and meet the qualification requirements of the appropriate member state regulatory authority. The personnel performing the inspections or testing at the plant, under the direction of the responsible structural engineer, is qualified structural engineers who have over one year of experience in the evaluation of in-service non-concrete structures or quality assurance related to non-concrete structures, and meet the qualification requirements required by the regulatory authority regarding the evaluation of in-service structures.

The programme includes preventive actions for degradation and failure of structural bolts. Guidance provided in applicable industry standards and guidance documents, including references [8-11] can be used to ensure structural bolting integrity.

If protective coatings are relied upon to manage the effects of ageing for any in-scope structure and structural component included in the scope of this AMP, or if degradation of coating can affect safety functions of the structure, monitoring programme is to address protective coating monitoring and maintenance. Otherwise, coatings on structures within the scope of this programme are inspected only as an indication of the condition of the underlying material.

Waterstops at concrete joints, joint sealants and gaskets between adjacent components are primarily constructed of metal or organic compounds and make a significant contribution to the leak tightness of containment buildings and other safety related structures. During operation, organic components degrade by exposure to oxygen, ozone, microorganisms, ultraviolet radiation, elevated temperatures and stress. Each of these mechanisms acts to cause depolymerization, which manifests itself in increased hardness, increased brittleness, dimensional shrinkage, loss of adhesion and crack formation.

### Evaluation and Technical Basis

1. ***Scope of the ageing management programme based on understanding ageing:***

The scope of the programme includes miscellaneous non-concrete structures and structural components.

Structures / components and / or related critical locations / parts in the scope of the programme are structural steel , support for platform, steel pile, structural bolting, anchorages, support members, weld, bolted connection, pipe whip restraint, jet impingement shield, transmission tower, panel, enclosure for electrical equipment and instrumentation racks, sliding support surface, sliding support bearing, radial beam seat in drywell, sump and pool liners, water stop, support for cable tray, support for emergency diesel generator (EDG), HVAC system components, HVAC duct, battery racks (side and end rails, spacers), trash racks / screens associated with water control structures, electrical duct banks, manholes, doors, seals, tube track, expansion joints, gaskets, moisture barriers (caulking, flashing, other sealants), caulking, flashing, other sealant on roof, steel edges supports that provide a sound technical basis for boundary conditions used in seismic analysis; steel bracings that ensure stability or containment of unreinforced masonry walls during a seismic event, chimney made of fiber reinforced polymer, vibration isolation elements, etc.

1. ***Preventive actions to minimize and control ageing degradation:***

The monitoring programme for the in-scope structures and structural components is a condition monitoring programme. However, the programme includes preventive actions to prevent degradation and failure of structural bolts. These actions include actions to prevent exposure to alternate wetting and drying from boric acid leakage in pressurized water reactors. In addition, to prevent stress corrosion cracking, molybdenum disulfide (MoS2) lubricant is not used for high strength bolts with actual yield strength greater than or equal to 1,034 MPa (150 ksi). Bolting replacement activities include proper torquing of the bolts. Maintenance practices for bolts require the application of an appropriate preload based on manufacturer recommendations, or engineering evaluation. Additional guidance provided in US Nuclear Regulatory Commission’s (NRC) document [8] and in EPRI documents [9-11] can be used to ensure structural bolting integrity. These documents 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.

1. ***Detection of ageing effects***

In-service examinations (that can include inspections, testing and monitoring) and surveillance are essential elements for detection of ageing effects. The significant ageing effects are loss of material due to corrosion ( general corrosion, pitting corrosion, crevice corrosion), cracking and loss of strength due to creep and shrinkage, loss of mechanical function due to corrosion, debris, dirt, distortion, overload, wear, Reduction or loss of isolation function due to humidity, radiation hardening, sustained vibratory loading, loss of leak tightness due to material degradation, Loss of sealing function due to deterioration of gaskets, moisture barriers, seals (caulking, flashing, and other sealants), Loss of material properties due to irradiation, etc.

Visual inspections also include periodic mapping and measurements to provide a history of crack appearance and development that can assist in identifying their cause and establishing whether a crack is active or dormant.

For each structure/ageing 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 consider industry and plant-specific operating experience.

Periodic visual inspection of the non-concrete structures is performed to monitor and detect the presence of chemical attack, abrasion, erosion, cavitation, cracking, scaling, and signs of corrosion in the steel reinforcement and anchorage components

Steel structures and components are monitored for loss of material due to general corrosion, pitting corrosion, crevice corrosion. Seismic qualified anchorages and 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. Visual inspection of elastomeric vibration isolation elements is supplemented by feel to detect hardening if the vibration isolation function is suspect. In addition, for structures supported on seismic base isolation bearings, samples of the isolation bearings placed in immediate proximity of the actual bearings during construction are tested for shear modulus and material damping. Acceptance criteria are in accordance with applicable industry codes and standards of each member state.

[1,2] provide acceptable basis for selection of parameters to be monitored or inspected for non-concrete and steel structural elements and for steel liners, joints, coatings, and waterproofing membranes.

High-strength structural bolting (actual measured yield strength greater than or equal to 150 ksi or 1,034 MPa) susceptible to stress corrosion cracking (SCC) are monitored for SCC. Identified ageing effects are evaluated by qualified personnel using criteria derived from industry codes and standards contained in the plant current licensing bases [9-13]. ASME Code Section XI [14], Table IWB-2500-1 provides guidance for volumetric examination of bolts. An example of checks for anchor bolts and signs of impaired conditions to look for (caveats) is given in [15]. These include condition of the anchor bolt, nut, baseplate, underlying grout (if present), required bolt torque, concrete condition in the vicinity.

The inspection frequency depends on safety significance and the condition of the structure and structural component. In general, all structures and structural components are monitored on a frequency not to exceed 5 years. The programme includes provisions for more frequent inspections of structures and components to track the degradations that are beyond the acceptance criteria identified in attribute 6 below. Some structures of lower safety significance, and subjected to benign environmental conditions, may be monitored at an interval exceeding five years; however, they are identified and listed, together with their operating experience. For austenitic steel active drains leak detection, in-service inspection and thickness measurement are performed.

1. ***Monitoring and trending of ageing effects:***

The condition of the structures and structural components is monitored by periodic examination. In addition, the condition of structure is monitored and trended 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.

Optical aids, such as fiberscopes and borescopes, allow inspection of inaccessible regions. Optical aid selection depends on factors such as object geometry and access, expected defect size and resolution requirements. Video cameras can be used to record current conditions for future reference.

Quantitative baseline inspection data are established per preset acceptance criteria. Previously performed inspections that were conducted using comparable acceptance criteria are acceptable in lieu of performing a new baseline inspection.

1. ***Mitigating ageing effects:***

This AMP is a condition monitoring programme and no generic recommendations are included to mitigate ageing effects. However, if degradation of structures and components is detected that exceeds the acceptance criteria, plant specific actions can be identified based on detailed monitoring and trending, and structural evaluation to mitigate the root cause or source of degradation.

1. ***Acceptance criteria:***

The structures monitoring programme calls for inspection results to be evaluated by qualified engineering personnel based on acceptance criteria selected for each structure/ageing effect to ensure that the need for corrective actions is identified before loss of intended functions. The criteria are derived in accordance with industry codes and standards of each country, and design bases codes and standards, as applicable, and consider industry and plant operating experience.

References [1-3, 5, and 7] provide acceptable basis for selection of acceptance criteria.

Loose bolts and nuts and cracked high strength bolts are not acceptable unless accepted by engineering evaluation. Steel components associated with battery racks that present deterioration of material significant enough to compromise the ability of a battery rack to perform its intended function are not acceptable. Structural sealants are acceptable if the observed loss of material, cracking, and hardening will not result in 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 programme is to contain sufficient detail on acceptance criteria to conclude that this programme attribute is satisfied.

1. ***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. In addition, the corrective actions include assessment for mitigating the root cause of the degradation.

In absence of any plant specific requirements for corrective actions, the requirements in [16] can be used to address the corrective actions.

1. ***Operating experience feedback and feedback of research and development results***

This AMP addresses the industry-wide generic experience. Relevant plant-specific operating experience is considered in the development of the plant AMP to ensure the AMP is adequate for the plant. The plant implements a feedback process to periodically evaluate plant and industry-wide operating experience and research and development (R&D) results, and, as necessary, either modifies the plant AMP or takes additional actions (e.g. develop a new plant-specific AMP) to ensure the continued effectiveness of the ageing management.

Appropriate source(s) of external operating experience are Ageing Management of Concrete Structures in Nuclear Power Plants (IAEA Nuclear Energy Series No. NP-T-3.5 [4] as well as CHECWORKS Users Group (CHUG), Owner’s Groups, OECD-NEA, WANO, INPO, IAEA and NRC generic communications.

Although in many plants, structures monitoring programmes have only recently been implemented, plant maintenance has been ongoing since initial plant operations. NRC’s NUREG-1522 [17] documents the results of a survey sponsored in 1992 by the NRC 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. [17] also describes the results of NRC staff inspections at six plants. The staff observed corrosion of component support members and anchor bolts. The observed and reported degradations were more severe at coastal plants than those degradations observed at inland plants, as a result of proximity to brackish water or seawater.

1. ***Quality Management:***

Administrative controls, quality assurance procedures, review and approval processes, are implemented in accordance with the different national regulatory requirements (e.g., 10 CFR 50, Appendix B [16]).

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### References

[1] AMERICAN CONCRETE INSTITUTE, Evaluation of Existing Nuclear Safety-Related Concrete Structures, ACI Standard 349.3R-02 (Reappeared 2018), ACI, Detroit, MI, 2018.

[2] AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Rules for Inservice Inspection of Nuclear Power Plant Components, Chapter XI, ASME, New York, NY. Year. 2019

[3] CANADIAN STANDARD ASSOCIATION, Requirement for Safety-Related Structures for CANDU Nuclear Power Plants, CSA N291-08 (R 2013), CSA, Canada, 2013.

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Energy Series No. NP-T-3.5, “Ageing Management of Concrete Structures in Nuclear Power Plants” Vienna, Austria, 2016.

[5] Electric Power Research Institute, Aging Identification and Assessment Checklist, TR 1011224, EPRI, Palo Alto, California, January 2005.

[6] Electric Power Research Institute, Aging Assessment Field Guide, TR 1007933, EPRI, Palo Alto, California, December 2003.

[7] AMERICAN INSTITUTE OF STEEL CONSTRUCTION, INC, AISC Specification for Structural Steel Buildings, ANSI/AISC 360-10, AISC, Chicago, IL, 2010.

[8] UNITED STATES NUCLEAR REGULATORY COMMISSION, Resolution of Generic Safety Issue 29: Bolting Degradation or Failure in Nuclear Power Plants, NUREG-1339, USNRC, 1990.

[9] Electric Power Research Institute, Degradation and Failure of Bolting in Nuclear Power Plants, Volumes 1 and 2, EPRI NP-5769, EPRI, Palo Alto, CA, 1988.

[10] Electric Power Research Institute, Good Bolting Practices, A Reference Manual for Nuclear Power Plant Maintenance Personnel, Volumes 1 and 2, EPRI NP-5067, Palo Alto, CA, 1988.

[11] Electric Power Research Institute, Bolted Joint Maintenance & Application Guide, EPRI TR-104213, EPRI, Palo Alto, CA, 1995.

[12] UNITED STATES NUCLEAR REGULATORY COMMISSION, Standard Review Plan for Review of Subsequent License Renewal Applications for Nuclear Power Plants, NUREG-2192, 2017.

[13] ELECTRIC POWER RESEARCH INSTITUTE, Good Bolting Practices, A Reference Manual for Nuclear Power Plant Maintenance Personnel, Volume 1: Large Bolt Manual; Volume 2: Small Bolts and Threaded Fasteners, NP-5067, EPRI, Palo Alto, CA,1990.

[14] AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Rules for Inservice Inspection of Nuclear Power Plant Components, Subsection IWB, Requirements for Class 1 Components of Light-Water Cooled Plants, ASME, New York, NY. Year.2019

[15] Seismic Quality Utility Group, Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment, SQUG GIP-3A, USA, 2001.

[16] UNITED STATES NUCLEAR REGULATORY COMMISSION, 10 CFR Part 50, Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants, National Archives and Records Administration, USNRC, Latest Edition.

[17] UNITED STATES NUCLEAR REGULATORY COMMISSION, Assessment of In-service Condition of Safety-Related Nuclear Power Plant Structures, NUREG-1522, USNRC, 1995.