## **AMP 157 INTERNAL COATINGS AND LININGS (VERSION 2021)**

### Programme Description

This AMP manages the internal coatings of in-scope piping, piping components, heat exchangers, and tanks. Proper maintenance of internal coatings/linings is essential to ensure that all intended functions of in-scope components are met. Degradation of coatings/linings can lead to a loss of material or cracking of the component base materials. Degradation of coatings/linings can also lead to downstream effects such as reduction in flow, reduction in pressure, or reduction in heat transfer resulting from debris produced by degraded coatings/linings. This programme consists of periodic visual inspections of internal coatings/linings exposed to closed-cycle cooling water (CCCW), raw water, treated water, treated borated water, waste water, fuel oil, and lubricating oil. Where the visual inspection of the coated/lined surfaces determines that the coating/lining is deficient or degraded, physical tests are performed, when possible. Electric Power Research Institute (EPRI) Report 1019157 [1], “Guideline on Nuclear Safety Related Coatings,” provides information on maintaining and periodically assessing the effectiveness of coatings. American Concrete Institute (ACI) Standard 201.1R 08 [2], “Guide for Conducting a Visual Inspection of Concrete in Service,” provides guidelines for inspecting concrete.

### Evaluation and Technical Basis

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

This AMP manages the internal coatings of in-scope components exposed to CCCW, raw water, treated water, treated borated water, waste water, fuel oil, or lubricating oil. The components within the scope of this AMP are piping, piping components, heat exchangers, and tanks, for which loss of coating/lining or degradation of coating/lining integrity could prevent the satisfactory accomplishment of the component’s intended function(s) or that of downstream component’s intended function(s). The ageing effects associated with fire water tank internal coatings/linings are managed by AMP 131. Coatings/linings that have a qualified service life are replaced prior to the end of its qualified life, without consideration of extending the life through condition monitoring.

Coatings/linings are an integral part of an in-scope component. Internal coatings/linings of in‑scope components are not evaluated as separate standalone components when determining whether they meet scoping criteria, such as SRS-57 [3] and 10 CFR 54.4(a) [4]. It is immaterial whether the coating/lining has an in-scope intended function because it is the intended function of the component that dictates whether the component is in-scope, and thereby the ageing effects of the coating/lining integral to the component are evaluated for a potential impact on the component’s and downstream component’s intended function(s).

For components with internally coated/lined surfaces that are effectively managed by this programme, the ageing effects of loss of material due to corrosion, cracking due to stress corrosion cracking (SCC), and loss of material due to selective leaching (dealloying) do not need to be managed by another programme. If this programme is not effective, then other programmes, such as AMP 120 and AMP 135 are used to manage the ageing effects that are not prevented by the coated/lined surface.

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

The programme is a condition monitoring programme and does not contain any preventive actions.

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

Internal visual inspections are intended to identify coatings/linings that do not meet acceptance criteria. Indications that the integrity of a coating/lining is challenged include:

* Blistering – formation of bubbles in a coating/lining;
* Cracking – formation of breaks in a coating/lining that extend through to the underlying surface;
* Flaking – detachment of pieces of the coating/lining itself either from its substrate or from previously applied layers;
* Peeling – separation of one or more coats or layers of a coating/lining from the substrate;
* Delamination – separation of one coat or layer from another coat or layer, or from the substrate;
* Volumetric expansion due to corrosion – rusting/corrosion of the substrate that occurs beneath or through the applied coating/lining;
* Spalling – a fragment, usually in the shape of a flake, detached from a concrete member.

Physical testing is used to identify the extent of potential degradation of the coating/lining.

Physical damage that is managed by this programme consists of the removal or reduction in the thickness of coating/lining by an age related mechanical method, such as damage that could occur downstream of a throttled valve as a result of cavitation or erosion. Physical damage that is caused by such non-age related events as installing scaffolding or assembly and disassembly of flanged joints is not addressed by this AMP.

Baseline coating/lining inspections occur in the 10-year period prior to the period of long term operation. Subsequent inspections are based on an evaluation of the effect of a coating/lining failure on the component’s intended function(s), potential problems identified during prior inspections, and known service life history. Subsequent inspection intervals are established by a coating specialist qualified in accordance with criteria provided by pertinent governing requirements or guidance documents for the plant, such as Regulatory Guide (RG) 1.54 [5]. Maximum inspection intervals, such as those provided in [6], are established to ensure the ageing effects are detected in an appropriate timeframe.

The extent of baseline and periodic inspections is also based on an evaluation of the effect of a coating/lining failure on the in-scope component’s intended function(s), potential problems identified during prior inspections, and known service life history. The extent of inspection is determined for each coating/lining material and environment combination. The extent of baseline and periodic inspections is established to ensure the ageing effects are detected prior to challenging a component’s intended function. Minimum inspection populations, such as those provided in [6], are established. The coating/lining environment includes both the environment inside the component and the metal to which the coating/lining is attached. Inspection locations are selected based on susceptibility to degradation and consequences of failure.

Coating/lining surfaces captured between interlocking surfaces (e.g., flange faces) are not required to be inspected unless the joint has been disassembled to allow access for an internal coating/lining inspection or other reasons. For areas not readily accessible for direct inspection, such as small pipelines, heat exchangers, and other equipment, consideration is given to the use of remote or robotic inspection tools.

In addition, where loss of coating or lining integrity cannot result in downstream effects such as reduction in flow, drop in pressure, or reduction in heat transfer for in-scope components, a representative sample of external wall thickness measurements can be performed every 10 years commencing 10 years prior to the period of long term operation. The purpose of the wall thickness measurements is to confirm the acceptability of the corrosion rate of the base metal in lieu of visual inspections of the coatings/linings.

The training and qualification of individuals involved in coating/lining inspections and evaluating degraded conditions is conducted in accordance with pertinent governing requirements or guidance documents for the plant.

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

A coatings specialist prepares a post-inspection report that includes: (i) a listing of all areas showing deterioration and their locations; and (ii) a prioritized list of areas to be repaired that indicates which areas must be repaired before returning the system to service. Photographs corresponding to inspection locations are used for documentation, when possible. A review of the previous two inspection reports, when available (i.e., two sets of inspection results may not be available to review for the baseline and first subsequent inspection of a particular coating/lining location), is conducted prior to performing an inspection. The review is to include the observations/results of the previous inspections and any associated repair activities. When corrosion of the base material is the only issue related to coating/lining degradation of the component and external wall thickness measurements are used in lieu of internal visual inspections of the coating/lining, the corrosion rate of the base metal is trended.

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

The programme is a condition monitoring programme and does not contain any mitigating actions.

1. ***Acceptance criteria:***

Acceptance criteria are provided by pertinent governing requirements or guidance documents for the plant. Examples of acceptance criteria are provided in [6].

1. ***Corrective actions:***

Results that do not meet the acceptance criteria are addressed by the corrective action programme under those specific portions of the quality assurance (QA) programme, such as 10 CFR Part 50, Appendix B [7]. Coatings/linings that do not meet acceptance criteria are repaired, replaced, or removed in accordance with the pertinent governing Codes and requirements or guidance documents for the plant. Physical testing is performed or an examination is conducted to ensure the integrity of repaired or replaced coatings/linings. Physical testing is performed or an examination is conducted to also ensure the integrity of the coatings/linings adjacent to the area where the coatings/linings is repaired or replaced.

If coatings/linings are credited for corrosion prevention (e.g., corrosion allowance in design calculations is zero or the “preventive actions” programme element of an AMP credited the coating/lining to inhibit an ageing effect) and the base metal has been exposed or it is beneath a blister, the component’s base material in the vicinity of the degraded coating/lining is examined to determine if the minimum wall thickness is met and will be met until the next inspection.

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.

Multiple plants have experienced the degradation of internal coatings resulting in diminished flow of various systems [11]. The flow restrictions were a result of the downstream accumulation of coating/lining debris clogging the system.

Multiple plants have experienced the degradation of internal coatings resulting in loss of material due to corrosion [12-13]. Many of these occurrences have been related to physical damage [14-17], such as turbulent flow and cavitation.

Industry experience pertaining to coatings degradation inside containment and the consequential clogging of sump strainers is provided in [18-21].

At the time when this AMP was produced, no relevant R&D was identified.

1. ***Quality management:***

Site quality assurance procedures, review and approval processes, and administrative controls are implemented in accordance with the different national regulatory requirements (e.g., 10 CFR 50, Appendix B [7]).

### References

1. ELECTRIC POWER RESEARCH INSTITUTE (EPRI), Report 1019157, Guideline on Nuclear Safety-Related Coatings, Revision 2, Palo Alto, California, December 2009.
2. AMERICAN CONCRETE INSTITUTE (ACI), Standard 201.1R-08, Guide for Conducting a Visual Inspection of Concrete in Service, Farmington Hills, Michigan, 2008.
3. INTERNATIONAL ATOMIC ENERGY AGENCY, Safe Long Term Operation of Nuclear Power Plants, IAEA Technical Report Series No. 57, IAEA, Vienna (2008).
4. UNITED STATES NUCLEAR REGULATORY COMMISSION, 10 CFR 54.4(a), Scope, Office of the Federal Register, National Archives and Records Administration, USNRC, Washington, Latest Edition.
5. UNITED STATES NUCLEAR REGULATORY COMMISSION, Service Level I, II, and III Protective Coatings Applied to Nuclear Power Plants, Regulatory Guide 1.54, Revision 3, USNRC, Washington, April 2017.
6. UNITED STATES NUCLEAR REGULATORY COMMISSION, Generic Aging Lessons Learned for Subsequent License Renewal (GALL-SLR) Report, NUREG-2191, USNRC, Washington, July 2017.
7. UNITED STATES NUCLEAR REGULATORY COMMISSION, 10 CFR Part 50, Appendix B, Quality Assurance Criteria for Nuclear Power Plants, Office of the Federal Register, National Archives and Records Administration, USNRC, Washington, Latest Edition.
8. UNITED STATES NUCLEAR REGULATORY COMMISSION, Failures of Protective Coatings in Pipes and Heat Exchangers, Information Notice 85-24, USNRC, Washington, March 1985.
9. Seabrook Station, Response to Request for Additional Information, NextEra Energy Seabrook License Renewal Application, Request for Additional Information - Set 18, RAI B.2.1.11-2, February 7, 2012. (See USNRC Agency Document Access and Management System (ADAMS) Accession No. ML12041A054.)
10. South Texas Project, Units 1 and 2 - Response to Requests for Additional Information for the South Texas Project License Renewal Application Aging Management Program, Set 14, March 28, 2012. (See USNRC ADAMS Accession No. ML12097A064.)
11. Brunswick Steam Electric Plant, Units 1 and 2; Special Inspection, IR 05000325-07-011, 05000324-07-011, on 08/02/2007 - 11/09/2007, November 16, 2007. (See USNRC ADAMS Accession No. ML073200779.)
12. Relief Request PRR-25, Proposed Alternative, Request for Relief for Temporary Acceptance of a Flaw in Salt Service Water (SSW) System Pipe Spool JF29-8-4, Pilgrim, March 5, 2014. (See USNRC ADAMS Accession No. ML14073A059.)
13. Millstone, Unit 2, Relief Request RR-04-13 for the Temporary Non-Code Compliant Condition of the Class 3 Service Water System 10 Inch Emergency Diesel Generator Supply Piping Flange, October 18, 2012. (See USNRC ADAMS Accession No. ML12297A333.)
14. Seabrook Station, Unit No. 1; Routine Integrated Report; Follow-Up Events, IR 05000443-11-005; 10/01/2011-12/31/2011, February 14, 2012. (See USNRC ADAMS Accession No. 12045A544.)
15. Highlights from the International Reporting System for Operating Experience for Events in 2010-2011, March 5, 2013. (See USNRC ADAMS Accession No. ML13063A135.)
16. Indian Point, Unit 3, Response to Request for Additional Information Regarding Relief Request 3-43 for Temporary Repair to Service Water Pipe, October 13, 2007. (See USNRC ADAMS Accession No. ML072890132.)
17. Callaway Plant, Unit 1 - Summary of 3/25/14 Verbal Relief Telephone Conference, Relief Request I3R-16, Temporary Non-Code Repair of The Train A Component Cooling Water Heat Exchanger to Control ESW Leakage, Third 10-Year Inservice Inspection Interval, April 8, 2013. (See USNRC ADAMS Accession No. ML14087A210.)
18. UNITED STATES NUCLEAR REGULATORY COMMISSION, Potential Plugging of Emergency Core Cooling Suction Strainers by Debris in Boiling-Water Reactors, Bulletin 96-03, USNRC, Washington, May 1996.
19. UNITED STATES NUCLEAR REGULATORY COMMISSION, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors, Generic Letter 04-02, USNRC, Washington, September 2004.
20. UNITED STATES NUCLEAR REGULATORY COMMISSION, Potential for Degradation of the Emergency Core Cooling System and the Containment Spray System After a Loss-Of-Coolant Accident Because of Construction and Protective Coating Deficiencies and Foreign Material in Containment, Generic Letter 98-04, USNRC, Washington, July 1998.
21. UNITED STATES NUCLEAR REGULATORY COMMISSION, Torus Shells with Corrosion and Degraded Coatings in BWR Containments, Information Notice 88-82, USNRC, Washington, November 1988.