## AMP 134 EXTERNAL SURFACES MONITORING OF MECHANICAL COMPONENTS (VERSION 2021)

### Programme Description

The External Surfaces Monitoring of Mechanical Components programme is based on system inspections and walk-downs. This programme consists of periodic visual inspections, physical manipulation and measurement inspections of metallic and polymeric components, such as piping, piping components (especially welding joints), ducting, polymeric components, and other components subject to ageing management review (AMR) For the intended period of operation the programme manages ageing effects through visual inspections of external surfaces for evidence of loss of material, cracking and change in material properties. The size of the surface discontinuities is measured and checked for its acceptability. Conditional measurements are implemented after visual inspections. The measurement inspections of the components are carried out in order to check the conformity of their shapes and geometric dimensions, and also to check the acceptability of the discontinuities identified in the visual inspection (in terms of size, location and number) to the requirements of the relevant standards. When appropriate for the component and material, manipulation may be used to augment visual inspection to confirm the absence of elastomeric hardening or loss of strength. Loss of material due to boric acid corrosion is managed by AMP 110.

### Evaluation and Technical Basis

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

This AMP visually inspects the external surface of in-scope mechanical components, and monitors external surfaces of metallic components, in systems within the scope of intended period of operation subject to AMR for loss of material and leakage. Cracking of stainless steel components exposed to an air environment containing halides may also be managed. This programme also visually inspects and monitors the external surfaces of polymeric components in mechanical systems that are within the scope of intended period of operation and are subject to AMR for changes in material properties (such as hardening or loss of strength), cracking, and loss of material due to wear. This programme manages the effects of ageing of polymer materials in all environments to which these materials are exposed.

The programme may also be credited with managing loss of material from internal surfaces of metallic components and with loss of material, cracking, and change in material properties from the internal surfaces of polymers, for situations in which material and environment combinations are the same for internal and external surfaces such that external surface condition is representative of internal surface condition (see AMP 135). When credited, the programme describes the component internal environment and the credited similar external component environment inspected.

The inspections of underground components that are accessible during normal operation or refueling outages for which access is not restricted are conducted within this AMP. For other underground piping ageing is managed through AMP125.

The inspection scope, and monitoring of ageing effects, may be determined using a risk based inspection technique.

In a risk based approach, a percentage of the scope is inspected based on consequence of failure and likelihood of material ageing. It assumes that the place in question is not visible, i.e. under lagging or in a trench.

Risk based inspection relies on determination of consequence of failure vs likelihood of failure (due to material ageing). Once a SSC is known to be vulnerable to a degradation mechanism, the most susceptible areas are targeted. High risk areas include locations where water can ingress so characteristic features may include:

* Corrosion staining;
* Poor design of cladding;
* Cladding damage;
* Missing or damaged sealants.

Once an area of water ingress has been identified, lagging is removed from the local area. This includes around the site of ingress and also where it is expected that water may settle. 6 o’clock positions of pipework and pipe supports are common sites of degradation and are always to be included in the scope.

The key aspect of risk based inspection is that if degradation is found, the inspection is extended until all the degradation is identified and there is no further degradation. It is inferred from a risk based inspection approach that the risk is fully understood, enabling targeted inspections to be performed.

External coatings are managed through AMP308.

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

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

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

The External Surfaces Monitoring of Mechanical Components programme utilizes periodic plant system inspections and walk-downs to monitor for material degradation and leakage. This programme inspects components such as piping, piping components, ducting, elastomeric components, polymeric components, and other components. For metallic components, coatings deterioration is an indicator of possible underlying degradation. The ageing effects for flexible polymeric components may be monitored through a combination of visual inspection and manual or physical manipulation of the material. “Manual or physical manipulation of the material” means touching, pressing on, flexing, bending, or otherwise manually interacting with the material. The purpose of the manual manipulation is to reveal changes in material properties, such as hardness, and to make the visual examination process more effective in identifying ageing effects such as cracking.

Guidance for these inspections can be found in [1-5, 9].

Examples of inspection parameters for metallic components include:

* Corrosion and material wastage (loss of material);
* Leakage from or onto external surfaces (loss of material);
* Worn, flaking, or oxide-coated surfaces (loss of material);
* Corrosion stains on thermal insulation (loss of material);
* Protective coating degradation (cracking, flaking, and blistering);
* Leakage for detection of cracks on the external surfaces of stainless steel components exposed to an air environment containing halides.

Examples of inspection parameters for elastomers and polymers include:

* Surface cracking, crazing, scuffing, and dimensional change (e.g., “ballooning” and “necking”);
* Discoloration;
* Exposure of internal reinforcement for reinforced elastomers.
* Hardening as evidenced by a loss of suppleness during manipulation where the component and material are appropriate to manipulation.

This AMP manages ageing effects of loss of material, cracking, and changes in material properties using visual inspection. For coated surfaces, confirmation of the integrity of the paint or coating is an effective method for managing the effects of corrosion on the metallic surface.

Degradation mechanisms include:

* Boric acid corrosion;
* Crevice corrosion;
* Galvanic corrosion;
* General corrosion;
* Pitting corrosion;
* Stress corrosion cracking.

When specified by regulatory requirements, inspections are conducted in accordance with the applicable requirements. In the absence of applicable requirements, plant-specific visual inspections are performed of metallic and polymeric component surfaces using plant-specific procedures implemented by inspectors qualified through plant-specific programmes. The inspections are capable of detecting age-related degradation and are performed at a period not to exceed one refueling cycle. Surfaces that are not readily visible during plant operations and refueling outages are inspected when they are made accessible and at such intervals that would ensure the components’ intended functions are maintained.

Surfaces that are insulated, or clad, may be inspected when the external surface is exposed (i.e., during maintenance) at such intervals that would ensure that the components’ intended functions are maintained. The intervals of inspections may be adjusted, as necessary, based on plant-specific inspection results and industry operating experience. According to [5], component surfaces that are insulated and exposed to condensation, and insulated outdoor components are periodically inspected every 10 years during the subsequent period of extended operation. Inspection locations are focused on the most susceptible to ageing because of time in service, severity of operating conditions, and lowest design margin. Detailed information regarding periodicity of inspections, inspection sampling, and alternative methods to removing insulation following the initial inspection is described in XI.M36 of [5]. For inaccessible components opportunistic inspections of external surfaces are usually undertaken when the components are exposed during maintenance or repair activities.

If plant-specific operating experience identifies cracking in stainless steel and aluminum, alternative methods to manage cracking are discussed in XI.M36 of [5].

Visual inspection will identify indirect indicators of flexible polymer hardening or loss of strength and include the presence of surface cracking, crazing, discoloration, and, for elastomers with internal reinforcement, the exposure of reinforcing fibres, mesh, or underlying metal. Visual inspection is 100 % of accessible components. Visual inspection will identify direct indicators of loss of material due to wear to include dimensional change, scuffing, and for flexible polymeric materials with internal reinforcement, the exposure of reinforcing fibres, mesh, or underlying metal. Manual or physical manipulation can be used to augment visual inspection to confirm the absence of hardening or loss of strength for flexible polymeric materials (e.g., HVAC flexible connectors, rubber expansion joints for water systems) where appropriate. The sample size for manipulation is at least 10 percent of available surface area. Hardening or loss of strength and loss of material due to wear for flexible polymeric materials are expected to be detectable prior to any loss of intended function.

This programme is credited with managing the following ageing effects:

* Loss of material and cracking for external surfaces;
* Loss of material for internal surfaces exposed to the same environment as the external surface;
* Cracking and change in material properties (hardening or loss of strength) of flexible polymers.

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

Visual inspection and manual or physical manipulation activities are performed and associated personnel are qualified in accordance with site controlled procedures and processes. This programme uses standardized monitoring and trending activities to track degradation. Deficiencies are documented using approved processes and procedures, such that results can be trended.

However, the programme does not include formal trending. Inspections are performed at frequencies identified in attribute 3.

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

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

1. ***Acceptance criteria:***

For each component/ageing effect combination, the acceptance criteria are defined to ensure that the need for corrective actions will be identified before loss of intended functions. For metallic surfaces, any indications of relevant degradation detected are evaluated. For example, measuring of the size of the detected discontinuities is provided in [6]. For stainless steel surfaces, a clean, shiny surface is expected. The appearance of discoloration may indicate the loss of material, or contamination with carbon steel impurities, or excessive heat during welding, on the stainless-steel surface. For aluminum and copper alloys exposed to marine or industrial environments, any indications of relevant degradation that could impact their intended function are evaluated. For flexible polymers, a uniform surface texture and uniform color with no unanticipated dimensional change is expected. Any abnormal surface condition may be an indication of an ageing effect for metals and for polymers. For flexible materials, changes in physical properties (e.g., the hardness, flexibility, physical dimensions, and color of the material are unchanged from when the material was new) are evaluated for continued service in the corrective actions programme. Cracks are absent within the material. For rigid polymers, surface changes affecting performance, such as erosion, cracking, crazing, checking, and chalking, are subject to further investigation. Acceptance criteria include design standards, procedural requirements, current licensing basis, industry codes or standards, and engineering evaluation.

1. ***Corrective Actions:***

If measured parameters are outside of the acceptance criteria, corrective actions are taken, or additional inspections are implemented to investigate the case.

The site corrective actions programme, quality assurance procedures, site review and approval process, and administrative controls are implemented in conformance with the pertinent governing requirements or guidance documents when indications or relevant conditions of degradation cannot be demonstrated to be acceptable.

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.

Inspections of external surfaces during the performance of periodic surveillance and maintenance activities have been in effect at many plants in support of plant component reliability programmes. These activities have proven effective in maintaining the material condition of plant systems, structures, and components. The elements that comprise these inspections (e.g., the scope of the inspections and inspection techniques) are consistent with industry practice. However, because the inspection frequency is plant-specific and depends on the plant operating experience, the plant-specific operating experience or applicable generic operating experience is further evaluated for the intended period of operation. The applicant evaluates recent operating experience and provides objective evidence to support the conclusion that the effects of ageing are adequately managed.

Research and development efforts and an effective operating experience (OE) exchange are important elements for implementing continuous improvement in this programme and in defining adequate corrective actions.

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

In September 2008, a licensee identified the dealloying of an aluminum bronze strainer drum exposed to brackish water. This was identified after an unexpected material failure occurred, during a planned maintenance evolution at an offsite repair facility. The maintenance evolution involved rigging the strainer drum into position for a machining operation. During the rigging, the strainer drum material failed at the rigging attachment point to the strainer. This failure of the strainer drum exposed the inner portion of the drum material where dealloying of the drum was visually observed during an inspection.

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], NP-090-11 [8])

### References

### [1] ELECTRIC POWER RESEARCH INSTITUTE, EPRI Technical Report 1007933, Aging Assessment Field Guide, EPRI, Palo Alto, CA, December 2003

### [2] ELECTRIC POWER RESEARCH INSTITUTE, EPRI Technical Report 1009743, Aging Identification and Assessment Checklist, EPRI, Palo Alto, CA, August 27, 2004

### [3] INSTITUTE OF NUCLEAR POWER OPERATIONS, Good Practice TS-413, Use of System Engineers, INPO 85-033, INPO, May 18, 1988

[4] UNITED STATES NUCLEAR REGULATORY COMMISSION, Generic Aging Lessons Learned (GALL) Report, NUREG-1801, Revision 2, XI.M36, “External Surfaces Monitoring of Mechanical Components,” USNRC, December 2010

[5] UNITED STATES NUCLEAR REGULATORY COMMISSION, Generic Aging Lessons Learned for Subsequent License Renewal (GALL-SLR) Report — Final Report (NUREG-2191), USNRC, 2017

[6] PNAE G-7-016-89, Methodology for controlling of basic materials, welding joints and surface cladding of equipment and pipelines of NPP. Visual and measurement control

[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, Latest Edition

[8] NP-090-11, Requirements on quality assurance programme for nuclear power plants, ROSTEXNADZOR, 2012

[9] ELECTRIC POWER RESEARCH INSTITUTE, EPRI Technical Report 3002011822, Long-Term Operations: Subsequent License Renewal Non-Class 1 Mechanical Implementation Guideline and Mechanical Tools EPRI, Palo Alto, CA, April 2018