### AMP 164 Outdoor piping, tanks and structures (VERSION 2021)

### Programme Description

This document provides guidance for developing a plant specific Ageing Management Programme (AMP) for managing the ageing of ferrous and non-ferrous alloy outdoor, above ground piping, tanks and structures, including their supports, in PWR, BWR and CANDU/PHWR nuclear power plants. The programme includes an assessment of the forms of degradation (aging effects/mechanisms) to which a component is susceptible and implementation of inspection techniques capable of detecting those forms of degradation. It addresses process water piping, fire water piping, feed water piping, steam water piping, service water piping, sea water piping, oil piping and instrumentation piping, auxiliary condensate storage tank, demineralized water tank, diesel oil storage tank, raw water tank, chemical addition tank, chlorination plant, ducting, transmission tower, stack; which are some examples of outdoor piping, tanks and structures. The programme relies on recommendations of the handbook on ageing management for nuclear power plants [1].

Supports and supporting arrangements for these outdoor piping, tanks and structures are also vital components from a degradation point of view. Discovery of support deficiencies during regularly scheduled inspections triggers an increase in the inspection scope in order to ensure that the full extent of deficiencies is identified. Degradation that potentially compromises the support function or its load capacity is identified for evaluation. The AMP includes acceptance criteria and corrective actions for these supports. Supports requiring corrective actions are re-examined during the next inspection period.

The primary inspection method specified in this AMP of these outdoor piping, tanks and structures and their supports is visual sample examination. The sample size of inspection varies depending on their importance with respect to safety. This approach is consistent with the recommendations in the different member states national codes and standards (e.g. [2]) as well as with regulatory guidance documents.

It is to be noted that, personnel performing the inspections of these outdoor piping, tanks and structures and theirs supports are qualified & certified in accordance with the member states codes and standards (e.g. [3]).

### Evaluation and Technical Basis

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

This programme is applicable to all in-scope ferrous and non-ferrous alloy above ground outdoor piping, tanks & structures and their supports of PWR, BWR and CANDU/PHWR nuclear power plants. Piping, tanks and structures of polymeric materials are not covered in this AMP.

The scope of the AMP includes exterior surfaces of outdoor piping, tanks, steel structures and their support members, bolting, welding, constant and variable load spring hangers, guides, stops and vibration isolation elements. Portions of supports/bolts that are inaccessible by being encased in concrete, buried underground or encapsulated by other structure and interior surfaces of piping and tanks are exempted from the examination. In absence of any specific guidance in plant licensing documents, IWF-1230 [4] can be used to identify the exempted supports.

The following degradation mechanisms and aging effects are considered in this AMP, although not all the mechanism are applicable to each item in the scope of this AMP (see section 3 for more details):

* Wear;
* Loss of preload;
* General corrosion;
* Stress Corrosion Cracking.

Other ageing management programmes that are relevant and integral to this programme are:

* AMP115: Ageing effects associated with bolting ;
* AMP 131: Fire water system;
* AMP 132: Above ground metallic tanks (AMP 132 is applicable to outside and inside surfaces of above ground tanks and including those tanks that are exposed to an indoor air environment);
* AMP 134: External surfaces monitoring of mechanical components (AMP 134 is also applicable to polymeric material);
* AMP 135: Inspection of internal surfaces in miscellaneous piping and ducting components;
* AMP 306: Structures Monitoring (AMP 306 is also applicable to concrete structures).

AMP 125 is for ‘buried and underground piping and tanks’. Buried piping and tanks are in direct contact with soil or concrete (e.g., a wall penetration). Underground piping and tanks are below grade but are contained within a tunnel or vault such that they are in contact with air and are located where access for inspection is restricted. Therefore, AMP 125 is not related to this AMP.

This programme does not cover the corrosion control for closed treated water systems. The ageing effect due to corrosion in recirculating piping is addressed in AMP 117 (Closed Treated Water Systems).

This AMP 164 is applicable to exterior surfaces of piping, tanks and steel structures. Therefore, AMP 157 (Internal Coatings and Linings) is not applicable. AMP 308 is for service level I coatings and is used in areas inside the reactor containment.

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

This programme includes preventive and mitigative actions for addressing degradation. Preventive actions utilized by this programme vary with the material of the piping, tanks and structures and the environment to which it is exposed. For example, the selection of bolting materials/gaskets, installation torque or tension and the use of lubricants and sealants should be such that to naturally prevent or mitigate degradation and failure of structural bolting [5].

Paintings are provided on piping, tanks, steel structures & their supporting members to arrest corrosion based on environmental conditions. These paintings are in accordance with the consensus standard recognized by the national authorities. Justification is needed when coatings are not provided.

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

The programme includes an assessment of the forms of degradation to which the outdoor piping, tanks, steel structures and support components are susceptible and implementation of inspection techniques capable of detecting those forms of degradation, to ensure that the integrity/functionality of these systems is maintained and there is no loss of the structures and structural components intended functions. The examination methods, frequency, and scope of examination specified ensure that the ageing effects are detected before they compromise the design-basis requirements.

Examinations are conducted consistent with pertinent governing requirements or guidance documents for the plant. The sample size of examination/inspection may be determined based on the member states regulations or codes and standards. In absence of any specific guidance in the member states regulations or codes and standards or plant licensing documents, Table IWF-2500-1 [4] may be used to determine the sample size, extent, frequency, and examination methods.

In general, examination methods include volumetric examination methods for detecting flaws in piping, tanks & structures, physical measurements for detecting changes in dimension, and different visual (VT-3, VT-1) examinations for detection of general surface conditions. Wall thickness is determined by a non-destructive examination technique such as Ultrasonic Testing (UT). Changes in material properties may be monitored through destructive testing such as hardness test or tensile strength test.

For piping, inspection locations are selected based on risk, considering both susceptibility to degradation and consequences of failure. Characteristics such as coating type, coating condition, external environment, pipe contents, and pipe function, are considered for detecting the ageing effects.

For tanks, examinations may be conducted from the external surface of the tank using visual techniques or volumetric techniques. UT measurements are distributed uniformly over the surface of the tank. Double walled tanks may be examined by monitoring the annular space for leakage. Outdoor tanks should have a dike or retention pond capable of preventing runoff in the event of a tank overflow and should have provisions for sampling collected liquids and routing them to the liquid radwaste treatment system (e.g. [6]).

For steel structures, while deciding on in-service inspection intervals and their scope, the requirements concerning the use and reliability of a steel structure will be taken into account. In the in-service inspection programme, the following needs to be presented: items subject to inspection and the scopes of the inspections, inspection intervals, inspection instructions, applicable regulations, guides and standards, inspecting personnel & its competence requirements, preparation of the items of inspection for inspection, inspection reports (e.g. [7]).

The parameters which are monitored or inspected for addressing ageing effects also include corrosion; deformation; misalignment of supports; missing, detached, or loosened support items; improper clearances of guides and stops; and improper hot or cold settings of spring supports and constant load supports. Accessible areas of sliding surfaces are monitored for debris, dirt, or indications of excessive loss of material due to wear that could prevent or restrict sliding as intended in the design basis of the support. Loss of material is monitored by visual inspection of the exterior surface of the piping or tank and, in some instances, by measuring the wall thickness of the piping or tank.

Structural bolts are monitored for corrosion and loss of integrity of bolted connections due to self-loosening and material conditions that can affect structural integrity. 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) is monitored for SCC. For more details AMP 115 may be referred.

Elastomeric vibration isolation elements are monitored for cracking, loss of material, and hardening through VT-3 examination method. The VT-3 visual examination of elastomeric vibration isolation elements is supplemented by touch to detect hardening if the vibration isolation function is suspect.

The VT-3 visual examination is also conducted for the safety class 1, 2, & 3 piping supports to reveal loss of material due to corrosion and wear, verification of clearances, settings, physical displacements, loose or missing parts, debris or dirt in accessible areas of the sliding surfaces, or loss of integrity at bolted connections.

If the VT-3 visual examinations detect surface flaws which exceed acceptance criteria, supplementary surface VT-1 or volumetric UT examinations to determine the character of the flaw are required.

Adverse indications observed during inspections are entered into the plant corrective action programme. Examples of adverse indications resulting from inspections include leaks, material thickness less than minimum, coated piping or tank with accompanying coating degradation, and general or local degradation of coatings to expose the base material. Adverse indications that fail to meet the acceptance criteria, will result in the repair or replacement of the affected component.

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

Timely and reliable detection of ageing degradations provided by implementation of inspection and testing schedules, reliable examination methods and inspection personnel qualified according to applicable standards (e.g. [3]).

All the components of piping, tanks and steel structures are examined periodically, as required by different Member states codes and standards. In absence or to supplement the specific requirements in the plant licensing documents, inspection schedule prescribed in Table IWF-2400-2 of [4] may be used. The sequence of component support examinations for piping, tanks and structures established during the first inspection interval, is repeated during each successive inspection interval, to the extent practically feasible.

Changes of conditions of all the inspected components from prior examination are recorded. Component supports whose examinations do not reveal unacceptable degradations are accepted for continued service. Component supports whose examinations reveal unacceptable conditions and are accepted for continued service by corrective measures or repair/ replacement activity are re-examined during the next inspection period. When the re-examined component support, no longer requires additional corrective measures during the next inspection period, the inspection schedule may revert to its regularly scheduled inspection.

Performance indicators are defined to enhance the assessment and improve the implemented programs. For example, statistical indicators such as comparisons between corrective and preventive maintenance efforts, number of repetitive faults, etc. can be used.

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

Inspections, testing and preventive maintenance are performed as per the approved procedure. The results of these activities are evaluated to determine the need for mitigating actions. The mitigating actions may include removal of surface indications, carrying out repairs or overhauling components or part replacements, design or layout changes such as to improve the geometry, stress levels, protective coatings, connector types etc.

1. ***Acceptance criteria:***

Acceptance criteria include technical specification, member state codes & standards, design standards, regulatory guides, procedural requirements, current licensing basis, industry codes or standards. The programme provides specific examination acceptance criteria for the inspection of the outdoor piping, tanks and structures and theirs supports to ensure that the need for corrective actions will be identified before loss of their intended functions. As a minimum, for visual examination, following conditions, as specified in IWF-3400 [2] are unacceptable:

1. Deformations or structural degradations of gaskets, fasteners, springs, clamps, or other support items;
2. Missing, detached, or loosened support items, including bolts and nuts;
3. Arc strikes, weld spatter, paint, scoring, roughness, or general corrosion on close tolerance machined or sliding surfaces;
4. Improper hot or cold positions of spring supports and constant load supports;
5. Misalignment of supports;
6. Improper clearances of guides and stops.
7. Other unacceptable conditions include:
   * Loss of material due to corrosion or wear;
   * Debris, dirt, or excessive wear that could prevent or restrict sliding of the sliding surfaces as intended in the design basis of the support;
   * Cracked or sheared bolts, including high-strength bolts, and anchors;
   * Loss of material, cracking, and hardening of elastomeric vibration isolation elements that could reduce the vibration isolation function.

The above conditions may be accepted provided the technical basis for their acceptance is documented.

1. ***Corrective actions:***

Corrective actions (repair or replacement) are required to be consistent with the pertinent governing requirements or guidance documents for the plant.

Evaluations are performed for any inspection results that do not satisfy established criteria. Corrective actions involving either repair, nondestructive evaluation, or testing are initiated in accordance with the corrective action process, if the evaluation results indicate that there is a need for repair or replacement before the piping, tanks or structures are returned to service. In addition, the corrective actions include assessment for mitigating the root cause of the degradation.

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 that the AMP is adequate for the plant. The plant need to implement a feedback process to periodically evaluate plant and industry-wide operating experience and Research & 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 sources of external operating experience are Owner’s Groups, WANO, IAEA [8] and NRC generic communications.

IWF sampling inspections as per [4] is other effective programme in managing ageing effects for supports of piping, tanks and structures. There is a reasonable assurance that the Subsection IWF inspection programme may also be effective in managing the ageing through the period of extended operation in addition to this AMP.

The programme includes provisions for continuing review of plant-specific and industry-wide operating experience, and research & development results, such that impact on the programme is evaluated and any necessary actions or modifications in the programme are performed.

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

1. ***Quality Management:***

Site quality assurance procedures, review & approval processes, and administrative controls are implemented in accordance with the nnational regulatory requirements to reduce the likelihood of failures due to degradation (e.g., 10 CFR 50, Appendix B) [9].

**References**

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Handbook on Ageing Management for Nuclear Power Plants, IAEA NE Series No. NP-T-3.24.

[2] AMERICAN SOCIETY OF MECHANICAL ENGINEERS, ASME Section XI, Rules for In-service Inspection of Nuclear Power Plant Components of Light-Water Cooled Power Plants, Division 1, Rules for Inspection and Testing of Components of Light-Water-Cooled Plants.

[3] CANADIAN GENERAL STANDARD BOARD, Qualification and Certification of Non-destructive Testing Personnel, Can/CGSB-48.9712, CAN/CGSB, Canada.

[4] AMERICAN SOCIETY OF MECHANICAL ENGINEER 2011a, Section XI, subsection IWF requirements for class 1, 2, 3, and MC components supports of light water cooled plants, article IWF-1000 and IWF-2000.

[5] 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.

[6] USNRC, REGULATORY GUIDE 1.143, Rev. 2, Design guidance for radioactive waste management systems, structures, and components installed in light-water-cooled nuclear power plants.

[7] The Finnish Centre for Radiation and Nuclear Safety (STUK), YVL 4.2.

[8] Safe Management of the operating lifetimes of Nuclear Power Plants, INSAG-14, IAEA.

[9] 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.