## AMP 315 Spent fuel pool (VERSION 2020)

### Programme Description

This AMP provides specific guidance to manage ageing of spent fuel and fuel handling pools to ensure adequate leak tightness. This AMP is applicable to pools with stainless steel liner filled with fuel cooling water. It focuses on leakage due to ageing of steel components (e.g. liner, liner welds, leakage collection system) of pools with stainless steel liners. The assessment related to the adequacy of leaktightness of spent fuel pool needs to establish acceptance criteria and trend lines in accordance with national requirements.

### Evaluation and Technical Basis

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

The programme addresses the assessment of pools with stainless steel liner housing spent fuel, or which may house primary components for decontamination (e.g. spent fuel pool, refuelling cavity, fuel transfer canal/refuelling canal). The programme also addresses the leakage collecting system in these pools. In addition to the requirement of this AMP, for concrete components of these pools, AMP 306 is referred.

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

Objective of this AMP is to ensure that the structural integrity and functional adequacy of the pool liner is maintained. It also ensures that deterioration of attached structures (especially concrete structures) due to adverse effects of leakage are minimal. The said objectives are essential to be maintained during the service life of the pool liner. Prompt maintenance and cleaning of leakage collecting system can ensure that clogging of the channels/pipes will not result in further damage of the channels/pipes/substructure. In addition, knowledge of the location and drainage areas contributing to each leak chase channel will provide a better diagnostic option of the location of the liner leak.

Chemistry of spent fuel pool water is controlled according AMP 103.

***3. Detection of ageing effects:***

Due to inaccessibility of most parts of pools, different methods are used to detect ageing effects of steel components of pools (corrosion, bulges or depressions, SCC, thermal and mechanical loading, fatigue, wear/tear, and chemical corrosion).

Visual inspection of accessible parts and parts above the water level is used to detect aging effects. Visual inspection could be performed according to AMP 306. For leakage collection system remote visual inspection can be performed. Visual inspection for steel components is focused on ageing effects such as discontinuities, damage, presence of corrosion products, bulges or depressions, leaching and efflorescence and the presence of sediments.

Degradation of leaktightness can also be inferred through monitoring of data obtained from leakage collection systems. In case leakage is observed further evaluation for identifying location of leak and repairing, can be carried out by air pressure tests, vacuum testing, etc. The chemical composition of the leakage provides further insights on the condition of the reinforced concrete structure, see appendix of [1].

The temperature of coolant inside pool, water level, water chemistry, volume of leakage is measured, collected and trended to avoid possible acceleration of degradation effects.

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

The amount of leakage through leakage collection system, temperature, water chemistry, rate of temperature change of coolant and water level in the pool are monitored and trended.

Observations from periodic visual inspection are collected, properly documented and reviewed.

All above mentioned data are trended and evaluated. Observed data and results of the evaluation are compared with acceptance criteria to decide further actions, if necessary.

Groundwater sampling and levels can be considered as part of the general assessment.

***5.***  ***Mitigating ageing effects:***

This AMP is a condition monitoring programme and does not include actions to mitigate ageing effects. However, controlling of temperature of water, water chemistry and prompt maintenance and cleaning of leakage collecting system prevents acceleration of ageing effects on liner.

***6. Acceptance criteria:***

The assessment related to the adequacy of leaktightness of spent fuel pool needs to establish acceptance criteria and trend lines in accordance with national requirements. The AMP calls for results to be evaluated by qualified engineering personnel based on acceptance criteria for each parameter 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.

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

Corrective actions are focused on more detailed evaluation by testing such as ultrasound testing, penetration testing, vacuum box testing, etc. for locations where leaks are observed/predicted based on evaluations.

***8. 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 implements a feedback process to periodically evaluate plant and industry-wide operating experience and research and development (R&D) results [2], 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 ageing management.

Operating experience information are available in Ageing Management of Concrete Structures in Nuclear Power Plants (IAEA Nuclear Energy Series No. NP-T-3.5 [2] as well as CANDU Owners Group (COG) [3], EPRI, OECD-NEA, WANO, INPO, IAEA and NRC generic communications.

Six cases of spent fuel pool leakage have been detected in the US.

Leakage of radioactive water (appr. 10 liters/hour) from the spent fuel pool liner connection weld was also reported at Gravelines-1 NPP I France.

In 2005 at the Swedish NPP Ringhals unit 2, a drip leakage was identified through the bottom slab of the fuel pools. To find the cause of the leakage different activities were performed such as leak detection of the welds, examination of steel parts casted in the concrete and inspection of underlying concrete construction. The result was that the pool constructions were in good condition and that the leakage were from manufacturing defects in welds. Defects were repaired. Inspections, including testing of concrete samples, showed that the leakage of boric water didn´t have any influence on the concrete or rebars. Not all weld defects were found and a small leakage of boric water continued through the concrete even after the repairs. Subsequently, in 2014 another inspection of the concrete, including testing of concrete samples, were performed. Result of this inspection also showed that concrete has not been deteriorated. Cleaning of the leakage collecting systems to prevent the leakage from going through the concrete has also been performed. But since the pipes of the collecting systems have several 90 degrees angles it was not possible to clean the system completely.

Relevant R&D is focused on developing NDE methods and deployment techniques that can be used to identify leaks in spent fuel pool liners [1], [4], [5]. Sampling of Practices for Evaluation of Spent Fuel Pool Leakage in PWR Plants are also available in [1].

R&D on repair techniques for leaking spent fuel pool liners by the use of adhesive tapes is being performed in France [5].

In Elforsk report 10:62 [6] (Report written in Swedish, English translation of the title ‘Effect on concrete of boric acid-containing water and cast-in boron compounds’), a study has been made of the effects on concrete of its exposure to external water containing boric acid, and the effects on concrete of boric compounds cast into the concrete during its manufacture. The study concludes that it is unlikely that steel casted in concrete is affected by the boric acid.

In January 2012, the NRC issued a document that provides a summary of ageing effects and their management in reactor spent fuel pools (SFP), refueling cavities, tori, and safety-related concrete structures based on publicly available information [7]. According to [8], out of a total 104 commercial nuclear power plants (NPPs) in the United States, leakage has been reported from the concrete refueling cavity and liner plate at 10 different NPPs, spent fuel pool (SFP) leakage reported from 12 different NPPs, and 29 separate instances of age-related degradation in concrete safety-related structures has been reported from 25 U.S. NPPs.

According to [7], in the case of pressurized-water reactors (PWRs), borated water leakage may cause corrosion of the primary shield liner, reactor supports, and containment structure, or it may affect other structures and components on which the leaking water accumulates. The cause of leakage from the PWR SFPs through the base metal of the stainless steel liner, weld seams, or plug welds is usually due to blockage of the leak detection channels with boric acid crystals and pin holes in the liner plate welds. The concrete and associated steel reinforcement degradation was due to chemical attack in the raw water, leaching of concrete, and exposure to elevated temperatures. The field activities performed by the different licensees to detect and determine extent of degradation, methods used to correct or arrest the degradation, and evaluations performed to determine the impact of degradation on the load-carrying capacity of deteriorated concrete structures are also described in [7].

***9. 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 [9]).

### References

1. Advanced Electromagnetic Inspection Methods for Fuel Pool and Transfer Canal Liners. EPRI, Palo Alto, CA: 2012. 1025214.
2. IAEA Nuclear Energy Series No. NP-T-3.5, “Ageing Management of Concrete Structures in Nuclear Power Plants” Vienna, Austria, 2016.
3. COG R&D Work Package # 40541-Identify Leak Sources in Liquid Storage Tanks
4. Welding and Repair Technology Center: Boric Acid Attack of Concrete and Reinforcing Steel in PWR Fuel Handling Buildings. EPRI, Palo Alto, CA: 2012. 1025166
5. Welding and Repair Technology Center: Guideline for Nuclear Fuel Pool Repair Strategy. EPRI, Palo Alto, CA: 2016. 3002007902
6. Elforsk report 10:62, Inverkan på betong av borsyrahaltigt vatten och ingjutna borföreningar (Report written in Swedish, English translation of the title” Effect on concrete of boric acid-containing water and cast-in boron compounds”), Published on https://www.energiforsk.se/, 2010
7. UNITED STATES NUCLEAR REGULATORY COMMISSION, A Summary of Aging Effects and Their Management in Reactor Spent Fuel Pools, Refueling Cavities, Torii, and Safety-Related Concrete Structures, NUREG/CR-7111, USNRC, 2012.
8. UNITED STATES NUCLEAR REGULATORY COMMISSION, Assessment of In-service Condition of Safety-Related Nuclear Power Plant Structures, NUREG-1522, USNRC, 1995.
9. 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