## amp 304 Containment Leak Rate Testing (VERSION 2020)

### Programme Description

Containment leak rate tests are recommended to assure that (a) leakage through the containment or systems and components penetrating the containment does not exceed specified allowable leakage rates and (b) integrity of the containment structure is maintained during its service life.

IAEA [1-4] provides general guidance for performing containment leak rate tests. This AMP provides specific guidance for performing containment leak rate testing.

In some Member States, three types of tests are performed under the containment leak rate test (LRT) programme. Type A tests are performed to determine the overall primary containment integrated leakage rate at the loss of coolant accident peak containment pressure. Type B tests are intended to detect local leaks and to measure leakage across each pressure-containing or leakage-limiting boundary of containment penetrations. Type C tests are intended to detect local leaks and to measure leakage across containment isolation valves installed in containment penetrations or lines penetrating containment. If Type C tests are not performed under this programme, they could be included under an in-service test programme testing leakage for the systems containing the isolation valves, as AMP102.

The programme recommends a general inspection of the accessible interior and exterior surfaces of the containment structure and components be performed prior to any Type A test and at a periodic interval between tests based on the performance of the containment system, environmental conditions in the plant, and as agreed upon with the regulatory authority. General Visual examinations performed in accordance with the AMP 301 or AMP 302 programmes are an acceptable substitute. The purpose of the inspection is to uncover any evidence of structural deterioration that may affect the containment structural integrity or leak-tightness. If there is evidence of structural deterioration, the Type A test is not performed until corrective action is taken in accordance with the repair/replacement procedures.

### Evaluation and Technical Basis

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

The scope of the containment LRT programme includes all containment boundary pressure-retaining components.

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

The containment LRT programme is a performance monitoring programme that includes no preventive actions.

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

A containment LRT programme is effective in detecting leakage rate of the containment pressure boundary components, including seals and gaskets. Leakage rates through containment shells, containment liners, and associated welds, penetrations, fittings and other access openings are monitored. While the calculation of leakage rates and satisfactory performance of containment leakage rate testing demonstrates the leak-tightness and structural integrity of the containment, it does not by itself provide information that would indicate that ageing degradation has initiated or that the capacity of the containment may have been reduced for other types of loads, such as seismic loading. This would be achieved with the additional implementation of an acceptable containment in-service inspection programme as described in AMP 301 or AMP 302.

The leak rate tests are conducted at the containment design pressure or a pressure that permits a sufficiently accurate extrapolation of the measured leak rate to the leak rates at the accident pressures considered in the safety analysis.

Visual examinations are conducted on accessible interior and exterior surfaces of the containment system prior to initiating a Type A test and at a periodic interval between tests based on the performance of the containment system. The visual examinations are performed by qualified personnel.

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

Because the LRT programme is repeated throughout the operating license period, the entire pressure boundary is monitored over time. Type A tests are conducted at periodic intervals based on the historical performance of the overall containment system. Type B and C tests are conducted periodically at intervals based on the safety significance and historical performance of each boundary and isolation valve.

A typical step in an LRT is to confirm that leakage rates measured at high pressure can be correlated to those measured at a lower pressure. Absorption/release of air by the concrete surfaces is proportional to pressure and the ideal leakage characteristic of a containment structure is one that exhibits laminar behavior [5]. This lends confidence that the leak rate test itself has not initiated containment boundary failures.

Appropriate inspection frequency for containment leak rate testing is normally identified in the regulations, industry codes and standards of each member state [6-9]. In absence of any specific requirements in the plant design basis or regulations or applicable codes and standards, Type A tests are conducted at an interval of not more than 10 years; however, this interval may be increased to a maximum period of 15 years based upon two consecutive successful Type A tests. Type B and C tests are conducted at an interval no greater than 24 months or every refuelling cycle; however, the interval can also be increased to a maximum of 120 months for Type B and 60 months for Type C tests based upon two consecutive successful tests. Visual examination of the containment is performed at least every five years. Containment boundary components which may be excluded from periodic testing (for example Type B and Type C testing), still are ageing managed. Other programmes can be credited to manage ageing in such components. Additional details for identifying of appropriate inspection frequencies are provided in [8, 10-14]. The testing frequency is implemented consistently with regulation requirements and plant-specific operating experience.

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

This AMP is a performance monitoring programme and no generic recommendations are included to mitigate ageing effects. However, if leakage or 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:***

Acceptance criteria for leak rates are selected in order to demonstrate that the leak rate assumed in the safety analysis of the plant and approved by the member state regulatory agency is maintained throughout the operating lifetime of the plant. Results of the LRT programme are documented to demonstrate that the acceptance criteria for leakage have been satisfied. The test is conducted with the components of the containment in a state representative of the conditions that would prevail following an accident, in order to demonstrate that the specified leak rate would not be exceeded.

1. ***Corrective actions:***

When leakage rates do not meet the acceptance criteria, an evaluation is performed to identify the cause of the unacceptable performance and appropriate corrective actions are taken. Actions include corrective maintenance measures such as adjustment, repair or replacement of defective items to prevent recurrence.

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 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 of external operating experience is Ageing Management of Concrete Structures in Nuclear Power Plants, IAEA Nuclear Energy Series No. NP-T-3.5, 2016 [4].

NRC Information Notice (IN) 92-20, “Inadequate Local Leak Rate Testing,” [14] describes operating experience of inadequate local leak rate testing of two-ply steel expansion bellows that were used on some piping penetrations.

In the Swedish Ringhals Unit 2 NPP, significant water leakage was identified during containment air test from moisture collecting in a duct in a draining a section of the reactor containment basemat carbon steel liner. The cause of the leakage was from prior repairs of the toroid steel liner. The liner was damaged when removing the concrete. The mechanical damage was found and repaired. A new containment air test performed after this confirmed the leakage was small and the repairs were effective. Additional information about this is available in AMP 301.

During a leak test in France a leak was identified through the basemat. The leak was not active when water was put in the lower part of the structure. This result was used to justify that safety was not affected.

Part of a containment carbon steel hermetic liner (liner) is on the boundary of the spent fuel pool and containment in a WWER 440/V213 design in Czech Republic. It is located behind the stainless steel liner of the spent fuel pool. Evaluating the condition of this part of the liner is difficult as it is not accessible. Czech practice for evaluation is to use spent fuel pool´s drainage system during LRT, to measure the air flow through the drainage system. With such air flow measurement, it is possible to calculate the percentage of overall containment leakage caused by this part of the liner. This parameter is used as a supporting parameter for condition monitoring and for trending.

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 Part 50, Appendix B, [12]).

### References

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Maintenance, Surveillance and In-service Inspection in Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.6, IAEA, Vienna, 2002.

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Design of Reactor Containment Systems for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.10, IAEA, Vienna, 2004.

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Review of the Methods used for Leak Rate Measurements for WWER-440/230 Confinements and WWER-440/213 Containments, IAEA-EBP-WWER-10, IAEA, Vienna, 1998.

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

[5] CANADIAN STANDARDS ASSOCIATION, N287.6-11 Pre-operational Proof and Leakage Rate Testing Requirements for Concrete Containment Structures for Nuclear Power Plants, CSA, Mississauga, 2011.

[6] CANADIAN STANDARD ASSOCIATION, In-service Examination and Testing Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants, CSA N287.7-08 (R2013), CSA, Mississauga, Ontario, Canada, 2008.

[7] UNITED STATES NUCLEAR REGULATORY COMMISSION, Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors, 10 CFR Part 50, Appendix J, Office of the Federal Register, National Archives and Records Administration, USNRC, Latest Edition.

[8] AFCEN, RCC-CW Rules for Design and Construction of PWR nuclear civil works, 2015.

[9] THE JAPAN ELECTRIC ASSOCIATION, Leakage Rate Testing of Primary Reactor Containment Vessel, JEAC 4203-2008, Tokyo, Japan, 2008.

[10] NUCLEAR ENERGY INSTITUTE, Industry Guideline for Implementing Performance-Based Option of 10 CFR Part 50, Appendix J, NEI 94-01, Rev. 3-A, NEI, Washington DC 2012.

[11] UNITED STATES NUCLEAR REGULATORY COMMISSION, Performance-Based Containment Leak-Test Program, NRC Regulatory Guide 1.163, Rev. 0, USNRC, 1995.

[12] 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.

[13] SAFETY STANDARDS OF THE NUCLEAR SAFETY STANDARDS COMMISSION (KTA), KTA 3405 “Leakage Test of the Reactor Containment Vessel”, 2010.

[14] INTERNATIONAL ATOMIC ENERGY AGENCY, NRC Information Notice 92-20, “Inadequate Local Leak Rate Testing.” ML031200473. Washington, DC: U.S. Nuclear Regulatory Commission. 1992.