**AMP 115 BOLTING INTEGRITY (VERSION 2020)**

### Programme Description

The programme manages ageing of closure bolting for pressure retaining components. The programme relies on recommendations for a comprehensive bolting integrity programme as delineated in pertinent governing requirements or guidance documents for the plant [1-7].The programme generally includes periodic inspection of closure bolting for indication of loss of preload, cracking, and loss of material due to corrosion, rust, etc. The programme also includes preventive measures to preclude or minimize loss of preload and cracking. Loss of preload is an applicable aging effect for bolting in any environment (for example in air as well as fluid environments). Closure bolting that is submerged or located in piping systems that contain air or gas, for which leakage is difficult to detect, may also be managed by this programme.

### Evaluation and Technical Basis

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

This programme manages ageing of closure bolting for pressure retaining components within the scope of ageing management, including both safety-related bolting for Class 1 and non-Class 1 components. This programme does not manage ageing of reactor head closure stud bolting (AMP 104) or structural bolting (AMP 127).

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

Selection of bolting material and the use of lubricants and sealants is in accordance with appropriate guidelines to prevent or mitigate degradation and failure of safety-related bolting. Of particular note, use of molybdenum disulfide (MoS2) as a lubricant has been shown to be a potential contributor to stress corrosion cracking (SCC) and is not used. Preventive measures also include using bolting material that has an actual measured yield strength limited to less than 1,034 MPa.

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

Bolting for safety-related pressure retaining components is inspected for leakage, loss of material, cracking, and loss of preload/loss of pre-stress. The programme includes volumetric and/or visual examinations, as appropriate. Degradation of pressure boundary closure bolting due to crack initiation, loss of preload, or loss of material may result in leakage from the mating surfaces or joint connections of pressure boundary components. Periodic inspection of pressure boundary components for signs of leakage ensures that age-related degradation of closure bolting is detected and corrected before component leakage becomes excessive. Accordingly, pressure retaining bolted connections are inspected at least once per refuelling cycle or maintenance outage cycle. The percentage of bolting inspected for different categories of joints and connections as specified in national requirements or guidance documents [1-7]. The inspections may be performed as part of leakage tests or as part of other periodic inspection activities, such as system walk-downs or an external surfaces monitoring programme. High strength closure bolting actual yield strength greater than or equal to 1,034 MPa, if used, are monitored for cracking. Closure bolting in locations that preclude detection of joint leakage, such as in submerged environments or where the piping systems contains air or gas for which leakage is difficult to detect, can be inspected as follows:

* + Submerged closure bolting is visually inspected for loss of material during maintenance activities, such that bolt heads are inspected when made accessible, and bolt threads are inspected when joints are disassembled. If opportunistic maintenance activities will not provide access to a representative sample of bolts heads and threads [7] the integrity of the bolted joint will be demonstrated. For example: (a) periodic pump vibration measurements are taken and trended; or (b) sump pump operator walkdowns are performed demonstrating that the pumps are appropriately maintaining sump levels.
  + For closure bolting where the piping systems contains air or gas for which leakage is difficult to detect, the integrity of the bolted joint will be demonstrated. For example (a) inspections are performed consistent with that of submerged closure bolting; (b) a visual inspection for discoloration is conducted when leakage of the environment inside the piping systems would discolor the external surfaces; (c) monitoring and trending of pressure decay is performed when the bolted connection is located within an isolated boundary; (d) soap bubble testing is performed; or (e) when the temperature of the fluid is higher than ambient conditions, thermography testing is performed.
  + For closure bolting for components that are not normally pressurized, the ageing effects associated with the closure bolting, at a minimum, is managed by checking the torque to ensure the closure bolting is adequately pre-loaded.

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

This programme monitors the effects of ageing on the intended function of bolting. Specifically, bolting for safety-related pressure retaining components is inspected for leakage, loss of material, cracking, and loss of preload/loss of pre-stress. Bolting for other pressure retaining components is inspected for signs of leakage. The inspection schedules of components are effective and ensure timely detection of applicable ageing effects.

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

Bolting replacement activities include proper torqueing of the bolts and checking for uniformity of the gasket compression after assembly. Maintenance practices require the application of an appropriate preload based on guidance, manufacturer recommendations, or engineering evaluation.

1. ***Acceptance criteria:***

Any indications of ageing effects in pressure retaining bolting are evaluated in accordance with pertinent governing requirements or guidance documents for the plant. Plant-specific acceptance criteria are derived from applicable national regulations, codes, standards and guidelines when alternative inspections or testing is conducted for submerged closure bolting or closure bolting where the piping systems contains air or gas for which leakage is difficult to detect.

1. ***Corrective actions:***

Replacement of pressure retaining bolting is performed in accordance with pertinent governing requirements or guidance documents for the plant.

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.

Appropriate sources of external operating experience are e.g. Owner’s Groups, OECD-NEA, WANO, IAEA and NRC generic communications.

Some specific examples of operating experience of component degradation are given in [8–9]. Degradation of threaded bolting and fasteners in closures for the reactor coolant pressure boundary has occurred from boric acid corrosion, SCC, and fatigue loading (U.S. Nuclear Regulatory Commission NRC Generic Letter 91-17 [9] and NRC IE Bulletin 82-02 [10].

SCC has occurred in high strength bolts used for nuclear steam supply system component supports [11]. The bolting integrity programme developed and implemented in accordance with the applicant’s docketed responses to NRC communications on bolting events have provided an effective means of ensuring bolting reliability.

Degradation related failures have occurred in downcomer Tee-quencher bolting in boiling water reactors (BWRs) designed with drywells [12]. Leakage from bolted connections has been observed in reactor building closed cooling systems of BWRs [13].

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 different national regulatory requirements (e.g., 10 CFR 50, Appendix B [14]).

### References

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7. UNITED STATES NUCLEAR REGULATORY COMMISSION, Generic Aging Lessons Learned for Subsequent License Renewal (GALL-SLR) Report — Final Report (NUREG-2191), USNRC, 2017
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10. UNITED STATES NUCLEAR REGULATORY COMMISSION, NRC IE Bulletin No. 82-02, Degradation of Threaded Fasteners in the Reactor Coolant Pressure Boundary of PWR Plants, USNRC, 1982
11. ELECTRIC POWERS RESEARCH INSTITUTE, Degradation and Failure of Bolting in Nuclear Power Plants, EPRI NP-5769, EPRI, Palo Alto, CA, 1988
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13. UNITED STATES NUCLEAR REGULATORY COMMISSION, NRC Licensee Event Report LER 50-341/2005-001, Manual Reactor Shutdown Due to Containment Cooler Leak, USNRC, January 24, 2005
14. 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