**AMP 301 IN-SERVICE INSPECTION FOR CONTAINMENT STEEL ELEMENTS (VERSION 2020)**

### Programme Description

This AMP provides guidance for in-service inspection of steel containment shells and their integral attachments, steel liners (including sump liners) or concrete containments and their integral attachments, containment penetrations, hatches and airlocks and moisture barriers, and pressure-retaining bolting.

This AMP is applicable for operation, extended shutdown, delayed construction, post final shut down. For delayed construction and post final shutdown period, the SSCs within the scope of this AMP may be change depend on the plant status.

The primary ISI method specified in this AMP is visual examination. Limited volumetric examination (ultrasonic (UT) measurement) and surface examination (e.g. liquid penetrant) may also be necessary in some instances to detect ageing effects when degradation exceeds the visual examination criteria. This approach is consistent with recommendations in the different member states national codes and standards [1-21] as well as with the other in-service inspection codes and guidance documents [22-36].

Protective coatings applied to the carbon steel containment surfaces that are intended and credited for preventing corrosion are also required to be examined for evidence of flaking, blistering, peeling, discoloration, and other signs of distress. AMP 308 defines the minimum scope of the monitoring and maintenance programme for Service Level I coatings applied to steel and concrete surfaces inside containment (e.g., steel liner, steel containment shell, structural steel, supports, penetrations, and concrete walls and floors) including any Service Level I coatings that are credited for preventing loss of material due to corrosion in accordance with this AMP. Therefore, AMP 308 is recommended for monitoring and maintenance of protective coatings as per the scope stated therein.

Stainless steel penetration sleeves, dissimilar metal welds, bellows, and steel components that are subject to cyclic loading but have no current plant licensing basis fatigue analysis are also monitored for cracking. If surface examination for cracking is not possible, appropriate leak rate tests may be conducted for pressure boundary components, as in AMP 304.

For the management of cracking, the programme monitors for evidence of surface breaking linear discontinuities if a visual inspection technique is used as the non-destructive examination (NDE) method, or for relevant flaw presentation signals if a volumetric (UT), method is used as the NDE method.

The programme attributes are augmented to incorporate the following ageing management activities:

* To address the potential loss of material due to corrosion in the inaccessible areas of the boiling water reactor (BWR) Mark I steel containment and for corrosion of BWR Mark I steel drywells in the sand pocket [37-39];
* To address the potential of torus cracking as identified in the heat-affected zone at the high pressure cooling injection (HPCI) turbine exhaust pipe torus penetration in a BWR MARK I containment [40];
* To require surface examination of two plies containment bellows to detect cracking [41]. The local leak rate test (LLRT) performed on the two plies bellows in accordance with AMP 304 cannot accurately measure the leakage rate through the bellows under accident conditions;
* To address the high strength pressure-retaining bolting degradation and failures [42].

The program is also supplemented to perform surface examination’ of pressure-retaining components that are subject to cyclic loading but have no current licensing basis (CLB) fatigue analysis; and based on plant-specific OE, a one-time volumetric examination of metal shell or liner surfaces that are inaccessible (inaccessible areas are described in attribute 3 of AMP 306) from one side.

### Evaluation and Technical Basis

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

This programme addresses the steel/metallic containment pressure retaining components and their integral attachments, and the steel/metallic liners (including sump liners) of concrete pressure retaining components and their integral attachments, containment moisture barriers, containment pressure-retaining bolting, and metal containment surface areas, including welds and base metal in light-water cooled plants (PWR, VVER, BWR). The concrete portions of containments are inspected in accordance with AMP 302.

The scope includes the accessible areas of the internal and external surfaces of the BWR Mark I plants torus and drywell, drywell and wet-well of BWR Mark II and III plants, freestanding metallic PWR containments, and liner plates of BWR Mark I, II, III, and PWR concrete containments. The scope of the programme is extended to the inaccessible areas when conditions exist in accessible areas that could indicate the presence of, or result in, degradation to such inaccessible areas, including steel/metallic elements that are embedded in concrete, including the sand pocket region of BWR Mark I containments. The scope also includes the components associated with the BWR containment pressure suppression system.

Protective coatings that are credited for corrosion protection of the steel elements are also inspected.

Following elements are exempt from examination:

* Components that are outside the boundaries of the containment, as defined in the plant-specific design specification;
* Piping, pumps, and valves that are part of the containment system or that penetrate or are attached to the containment vessel.

Examination requirements for containment supports are addressed in AMP 303.

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

This is a condition monitoring programme and hence no preventive actions are addressed. However, the programme is augmented for BWR Mark I steel containments to include preventive actions to ensure that moisture levels associated with an accelerated corrosion rate do not exist in the exterior portion of the BWR Mark I steel containment drywell shell. The actions consist of ensuring that the sand pocket area drains and/or the refueling seal drains are clear and operational [37-39].

The programme is also augmented to include preventive actions to ensure bolting integrity. The programme emphasizes that the selection of bolting material, installation torque or tension, and the use of lubricants and sealants are made to prevent or minimize loss of bolting preload and cracking of high-strength bolting [25, 26, 27, 43].

Preventive actions for storage, lubricants, and stress corrosion cracking potential are to be taken into account when selecting structural bolts [30-31, 42].

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

Non-coated surfaces are examined for evidence of cracking, discoloration, wear, pitting, excessive corrosion, arc strikes, gouges, surface discontinuities, dents, and other signs of surface irregularities, including discernible liner plate bulges.

For the management of loss of material, the programme monitors for gross or abnormal surface conditions that may be indicative of loss of material occurring in the components.

For the management of cracking, the programme monitors for evidence of surface breaking linear discontinuities if a visual inspection technique is used as the NDE method, or for relevant flaw presentation signals if a volumetric UT method is used as the NDE method.

Painted or coated surfaces are examined for evidence of flaking, blistering, peeling, discoloration, and other signs of distress of the underlying metal shell or liner.

Stainless steel penetration sleeves, dissimilar metal welds, bellows, and steel elements and components that are subject to cyclic loading but have no fatigue analysis are monitored for cracking, fretting or lockup due to wear, general corrosion, pitting corrosion, crevice corrosion.

The moisture barriers (caulking, flashing and other sealants) are examined for loss of sealing function due to damage, erosion, surface cracks, tear, wear and other effects that permit intrusion of moisture in the inaccessible areas of the pressure retaining surfaces of the metal containment shell or liner.

Pressure-retaining bolting is examined for loss of material due to general corrosion, pitting corrosion, crevice corrosion and loss of preload due to self-loosening (potentially caused by change in material conditions) that cause the bolted connection to affect either containment leak-tightness or structural integrity.

Personnel airlock, emergency airlock, equipment hatch, control rod drive hatch is examined for loss of leak tightness due to wear of locks, hinges and closure mechanisms.

Concrete containments are examined for defects of coating, corrosion of reinforcement, liner and concrete due to chemical attack.

The sand pocket area drains and/or the refueling seal drains for water leakage of BWR Mark I steel containments are monitored periodically. The programme ensures the drains are clear to prevent moisture levels associated with accelerated corrosion rates in the exterior portion of the drywell shell. The acceptability of inaccessible areas of the BWR Mark I steel containment drywell is evaluated when conditions exist in the adjacent accessible areas that could indicate the presence of moisture or could result in degradation to such inaccessible areas.

The examination methods, frequency, and scope of examination specified ensure that ageing effects are detected before they compromise the design-basis requirements. Different codes and standards, and member states guidance documents recommend the scope and frequency of examinations; however, in absence of specific guidance, ASME Code [3] recommendations may be used. A general visual examination is normally required to be performed during a specific time interval.

The area which are inaccessible are evaluated for existing or potential steel degradation mechanisms. The acceptability of inaccessible areas is evaluated when conditions exist in accessible areas that could indicate the presence of or result in flaws or degradation in such inaccessible areas.

For each inaccessible area identified for evaluation, the following is provided:

* A description of the type and estimated extent of degradation, and the conditions that led to the degradation;
* An evaluation of each area, and the result of the evaluation, and;
* A description of necessary corrective actions.

Visual examinations are further supplemented to include a one-time volumetric examination of metal shell or liner surfaces that are inaccessible from one side, if triggered by plant-specific operational experience.

All accessible steel surfaces require general visual examination to detect degradation due to ageing. Examinations are implemented consistent with pertinent governing requirements or guidance documents for the plant. Detection of ageing effects occurs before there is a loss of the structure and structural component intended function(s). The parameters to be monitored or inspected are appropriate to ensure that the structure and component intended function(s) will be adequately maintained for the period of operation under all design conditions.

Standards for examination methods, procedures, and personnel are provided in the programme, with preference to well-established examination methods. These methods include volumetric UT examination methods for detecting flaws in bolting, physical measurements for detecting changes in dimension, and various visual (VT-3, VT-1) examinations for detection of general surface conditions and detection and sizing of surface-breaking discontinuities.

A description of the visual examinations is:

* Visual VT-1 examination detects discontinuities and imperfections, such as cracks, corrosion, wear, or erosion, on the surface of components;
* Visual VT-3 examination (a) determines the general mechanical and structural condition of components and their supports by verifying parameters such as clearances, settings, and physical displacements; (b) detects discontinuities and imperfections, such as loss of integrity at bolted or welded connections, lose or missing parts, debris, corrosion, wear, or erosion; and (c) observes conditions that could affect operability or functional adequacy of constant-load and spring-type components and supports.

Visual examinations are performed, either directly or remotely, by line of sight from available viewing angles from ﬂoors, platforms, walkways, ladders, or other permanent vantage points, unless temporary access is required by the inspection plan. The visual examinations are performed with adequate illumination, sufficient to detect evidence of degradation.

Pertinent governing requirements or guidance documents are used.

Flaws or degradation identified during the performance of a VT–3 examination are examined in accordance with the VT–1 examination method. However, if the surface area requiring examination is not accessible for visual examination on the side requiring VT-1 examination, UT measurement is used to determine wall thickness and extent of degradation. The criteria in the material specification or governing requirements or guidance documents is used to evaluate containment bolting flaws or degradation. As an alternative to performing VT–3 examinations of containment bolted connections that can be disassembled, VT–3 examinations of containment bolted connections may be conducted whenever containment bolted connections are disassembled for any reason.

In general, a repair/replacement activity such as replacing a large containment penetration, cutting a large construction opening in the containment pressure boundary to replace steam generators, reactor vessel heads, pressurizers, or other major equipment; or other similar modification is considered a major containment modification and the applicable governing requirements or guidance documents are followed.

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

The methods for monitoring, recording, evaluating, and trending the data that result from the programme’s inspections provide for identification of adverse ageing trends such that corrective action can be performed as necessary in a timely manner.

With the exception of inaccessible areas, all surfaces are monitored by virtue of the examination requirements on a scheduled basis.

For plants with BWR Mark I containments, monitoring and trending requirements are augmented to address inaccessible areas of the drywell. The plant considers the following recommended actions based on plant-specific operating experience:

Define a corrosion rate that can be inferred from past UT examinations or estimate a corrosion rate by using representative samples in similar operating conditions, materials, and environments. If degradation has occurred, provide a technical basis using the defined or estimated corrosion rate to demonstrate that the drywell shell will have sufficient wall thickness to perform its intended function through the intended period of operation. Use UT thickness measurements of the drywell shell plates adjacent to the sand cushion to demonstrate that any degradation is consistent with the developed or established corrosion rate.

BWR Mark I containments have augmented monitoring and trending requirements to address corrosion of the torus and any necessary recoating [44].

* Corrosion due to presence of trapped water in PWR and BWR containments is monitored and trended. Potential locations for water to accumulate and potentially result in uniform or pitting corrosion of the steel include but are not limited to moisture barriers;
* the junction of the containment cylinder and intermediate floors and basement concrete of PWRs and Mark III BWRs, the areas adjacent to crane girder rails and supports attached to steel liner plates of concrete containments, and behind ice condenser baskets.

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

AMP 301 is a condition monitoring programme and no mitigating ageing effects are intended.

However, to mitigate corrosion on the sand pocket area drains and/or the refueling seal drains for water leakage of BWR Mark I steel containments, the plants ensure the drains are clear to prevent moisture levels associated with accelerated corrosion rates in the exterior portion of the drywell shell.

1. ***Acceptance criteria:***

The programme provides specific examination acceptance criteria for the examinations, which are in accordance with pertinent governing requirements or guidance documents for the plant. The programme contains three types of examination acceptance criteria:

* For visual examination (and surface examination as an alternative to visual examination), the examination acceptance criterion is the absence of any of the specific, descriptive relevant conditions; in addition, there are requirements to record and disposition surface breaking indications that are detected and sized for length by VT-1/EVT-1 examinations; for volumetric UT examination, the examination acceptance criterion is the capability for reliable detection of indications in bolting; in addition, there are requirements for system-level assessment of bolted or pinned assemblies with unacceptable volumetric (UT) examination indications that exceed specified limits; and
* For physical measurements, the examination acceptance criterion for the acceptable tolerances in the measurements is specified with justification.

Most of the acceptance standards rely on visual examinations. Areas that are suspect require an engineering evaluation or require correction by repair or replacement. For VT-1 and UT examinations, numerical values are specified for the acceptance standards. For the containment steel shell or liner, material loss locally exceeding 10% of the nominal wall thickness or material loss that is projected to locally exceed 10% of the nominal wall thickness before the next examination are documented. Such areas are corrected by repair or replacement or accepted by engineering evaluation (e.g. [45]).

Cracking of stainless steel penetration sleeves, dissimilar metal welds, bellows, and steel components that are subject to cyclic loading but have no current licensing basis fatigue analysis is corrected by repair or replacement or accepted by engineering evaluation.

1. ***Corrective actions:***

Repair and replacement are performed in accordance with pertinent governing requirements or guidance documents for the plant.

Detected conditions that do not satisfy the examination acceptance criteria are required to be included in the plant corrective action programme, which may require repair, replacement, or analytical evaluation for continued service until the next inspection. The disposition will ensure that design basis functions will continue to be fulfilled for all licensing basis loads and events.

Examples of methodologies that can be used to analytically disposition unacceptable conditions include engineering evaluation methods, as well as supplementary examinations to further characterize the detected condition, or, alternatively, structural component repair and replacement procedures.

Measures are established to assure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and nonconformance are promptly identified and corrected. In the case of significant conditions adverse to quality, the measures assure that the cause of the condition are determined, and corrective actions taken to preclude repetition. The identification of the significant condition adverse to quality, the cause of the condition, and the corrective action taken is documented and reported to appropriate levels of management. Pertinent governing requirements or guidance documents can be used by the plants.

If moisture has been detected or suspected in the inaccessible area on the exterior of the BWR Mark I containment drywell shell or the source of moisture cannot be determined subsequent to root cause analysis, then:

Include in the scope any components that are identified as a source of moisture, if applicable, such as the refueling seal or cracks in the stainless-steel liners of the refueling cavity pools walls and perform ageing management review. Demonstrate, through use of VT-1 and ultrasonic examinations, that corrosion is not occurring or that corrosion is progressing so slowly that the age-related degradation will not jeopardize the intended function of the drywell shell.

Liner repair with an alternative solution can be a corrective action to improve leak tightness when traditional repair is not feasible (e.g. for inaccessible areas).

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 source of external operating experience is reference [46]. Similarly following international groups and organizations provide in their publications and workshops external operating experiences; CHECWORKS Users Group (CHUG), Owner´s Groups, OECD-NEA, WANO, INPO, IAES, NRC generic communications, etc.

Incidents informed in USNRC Information Notices (IN) 2004-09 [47] and IN 2010-12 [48] as well as in NUREG-1522 [49] report potentially significant safety problems regarding the degradation resulting from corrosion in steel containment shells and containment liners. USNRC IN 86-99 [37] and USNRC GL 87-05 [39] address the potential for corrosion of BWR Mark I steel drywells in the “sand pocket region”. The purpose of the sand is to act as a cushion and allow expansion of the drywell during operation. The steel containment is in contact with sand in those areas where corrosion has been detected. It is possible that condensation during initial construction, moisture pickup through the drain line during operation, and the leaking bellows wetted the sand, thereby causing corrosion of the containment steel plates. During construction, water was seen running down the outside of containment into the sand. The five drain lines, as well as other penetrations in the concrete shield, are open during operation and would allow moist air to enter and rise up the gap and later cool and condense as water. Water also was able to enter the gap through the holes in the bellows during refueling until repairs were made.

Reference [50] describes occurrences of corrosion in BWR Mark I steel containments, both inside the suppression chamber (torus) and outside the drywell. Reference [51] describes operating experience concerning degradation of floor weld leak-chase channel systems of steel containment shell and concrete containment steel liner that could affect leak tightness and ageing management of containment structures.

Some examples of OE related to liner bulges are noted in NUREG–1522 [49].

Degradation of steel components of containment were reported for the inside surface of the torus shell which was designed and constructed as uncoated [52]; on steel plate material in the drywells and wet wells of BWR plants and steel containments of PWR plants [39]; on the freestanding metallic containment and on containment liner plate [47] and on specific locations where concrete containments are susceptible to liner plate corrosion [53].

Torus cracking has been identified in the heat-affected zone at the high-pressure cooling injection (HPCI) turbine exhaust pipe torus penetration in a BWR MARK I containment [41]. Through‑wall cracking was identified by the plant in the heat-affected zone at the HPCI) turbine exhaust pipe torus penetration. The plant concluded that the cracking was most likely initiated by cyclic loading due to condensation oscillation during HPCI operation. These condensation oscillations induced on the torus shell may have been excessive due to a lack of an HPCI turbine exhaust pipe sparger that many plants have installed.

Other operating experience indicates that foreign objects embedded in concrete have caused through-wall corrosion of the liner plate at a few plants with reinforced concrete containments [48].

USNRC Information notice 92-20 [42] describes an instance of containment bellows cracking, resulting in loss of leak tightness. The two plies of similar construction bellows were in contact with each other, restricting the flow of the LLRT test (AMP 304) and revealed that the LLRT performed between the two plies could not be used to accurately measure the leakage rate that would occur through the bellows under accident conditions.

Degradation of threaded bolting and fasteners in closures for the reactor coolant pressure boundary has occurred from boric acid corrosion, stress corrosion cracking (SCC), and fatigue loading [42,45,47-54]. SCC has occurred in high strength bolts used for nuclear steam supply system component supports [19]. The augmented scope, incorporating recommendations documented by EPRI in References [25-26] is necessary to ensure containment bolting integrity.

Care is exercised in the selection and application of lubricants and injection sealants to minimize the risk of SCC from potentially corrosive ions due to the gradual breakdown and/or synergistic interaction of such materials with prolonged exposure to leakage conditions. This would be of particular concern for fastener materials made of high-strength low-alloy steels and, austenitic and martensitic stainless steels which are known to be susceptible to halogen/sulfide SCC degradation. The bolting integrity programme developed and implemented in accordance with the plant’s docketed responses to USNRC communications on bolting events have provided an effective means of ensuring bolting reliability [26,30-31]. The incidence of various reported failures in high-strength bolting in component supports and other safety-related equipment [42] include materials that were subjected to high sustained tensile stresses out-of-specification pre-torqueing, aqueous environment caused by high humidity or primary and borated water leakage, and materials that were overly hard and out of specification.

The most frequently observed failure mode for the structural bolting was SCC. Bolting degradation or failure in NPPs scope includes all safety-related bolts, studs, embedments, machine/cap screws, other special threaded fasteners, and all their associated nuts and washers. Examples on how to address the inspections for structural bolting are available in industry recommendations [26-, 30-31].

During containment air leakage test in Swedish NPP Ringhals 2 (PWR) in 2014, a leakage of deaerated catalyzed hydrazine water was identified from the collecting duct in one section of the Reactor Building basemat carbon steel liner. After exposing the liner, visual inspection identified significant local corrosion. Before and after repairs were performed, analysis and thickness measurement of the liner were carried out [55].

During containment air leakage test in French NPP Bugey 5 (PWR) in 2015, two leakage tests were performed, one with the dry basemat conditions, the other one with flooded condition. The leakage measured with dry basemat condition was significantly greater than the one in the flooded condition that showed a leak in the lower part of the basemat liner. The corrective action was to put in place an additional tightness band (system MAEAVA 2) all around the basemat at the junction between the wall and the floor. This repair led to a quite reduced leak rate.

Reference [56] describes that at Ringhals 1 (BWR) in Sweden there was a small pitting hole in the liner. In connection with restarting the unit after the outage of 2017, a containment air test (CAT) was carried out with approved results. Upon inspection of the containment a leakage was found in the upper part of the liner. Three small pitting holes were visible. The investigation showed that water had collected between the liner and the concrete wall of the containment. To create a space between the liner and the wall when casting of concrete was done during construction, insulation was attached to the liner. The water originated from pools above the containment. The insulation, combined with intermittent leakage, provided the environment for corrosion of the liner. The corroded liner was replaced, and the insulation removed.

Corrosion in a steel liner located around a penetration was found at Barsebäck 2 in 1993 [57]. The underlying cause for corrosion was found to be that the area around the penetration had been grouted with porous concrete of bad quality during construction of the containment. A pipe was not properly mounted which resulted in the fact that water could not be drained from the concrete grouting when injected. The combination of the remaining water and small pockets of air caused a corrosion cell to arise. This was seen as a CCF which resulted in reparation of all grouted areas around the penetrations. Barsebäck 2 was commissioned in 1977 and the damage was discovered during a CAT after 15 years of operation. The liner is embedded in concrete and could therefore not be visibly inspected.

During a CAT performed in 1997 at Forsmark unit 1, it was detected that the toroid was not leak tight [57]. Dismantling and further inspection of the toroid showed corrosion on the toroid ring. The cause of corrosion was found to be damp isolation. The plastic film applied to protect the isolation from casting water during construction had actually collected water instead. Forsmark unit 1 was commissioned in 1980.

These experiences from Swedish NPP show that damages on liners and its connecting parts are difficult to detect due to the fact that they are embedded in concrete and therefore not accessible to visible inspections. Damages therefor commonly only appear after several years of operation, and are detected during CAT. The liner is embedded in concrete as protection from missiles.

In United Kingdom there was corrosion of the Primary Containment pressure retaining mild steel floor liner related to the sump liner, see reference [58]. The UK issue related to a through thickness corrosion of the floor liner with the corrosion mechanism emanating on the exposed surfaces of the sump liner. The liner was identified as having a 15.2mm diameter through wall hole in addition to some other areas of corrosion. Mildly acidic liquor emanating from plant operations, as an example, initiated corrosion form the inside of the sump, outwards to the concrete backed foundation basement of the Containment Structure. A review of articles and research at the time, typically noted corrosion form the outside of the liner inwards, due to foreign material, such as timber and other foreign materials being inadvertently left in place during placement of the concrete. It may be the case this scenario is judged to be more serious as the corrosion in the first instance is not visible, being on the distal side of the liner. Thus it is concluded that there is a lack of international reporting of this type of corrosion (i.e. corrosion from exposed to buried liner face) which seemed counter-intuitive due to the nature of the aggressive detritus that typically collects in the sump liners.

It could reasonably be assumed that foreign materials such as timber would have been removed from the concrete pour and that the higher alkalinity of the concrete and lack of oxygen would give some protection to the external surface of the steel liner to corrosion. By the same logic, the exposure of the internal surface of the mild steel liner to the effects of mildly acidic borated liquor and the potential for defects in the liner coating will inevitably result in corrosion.

The UK operational experience also noted that the sump liner inspections can be fraught with logistical and operational issues (due to the presence of active liquids and the over-riding need for personnel safety considerations) that can adversely impact the appropriate degree of thoroughness.

The likely root cause for the issues is as follows:

* Incorrect interpretation of the ASME XI code, resulting in too infrequent inspection. Should be Periodic and not 10 yearly.
* Unidentified corrosion though ineffective preparation for inspection and defects to the coating system

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

1. ***Quality management:***

Administrative controls, quality assurance procedures, review and approval processes, are implemented in accordance with the different national regulatory requirements (e.g., 10 CFR 50, Appendix B [59]).

### References:

1. UNITED STATES NUCLEAR REGULATORY COMMISSION, 10 CFR 50.55a, Codes and Standards, Office of the Federal Register, National Archives and Records Administration, USNRC, Latest Edition.
2. UNITED STATES NUCLEAR REGULATORY COMMISSION, 10 CFR Part 50, Appendix J, Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors, Office of the Federal Register, National Archives and Records Administration, USNRC, Latest Edition.
3. Inspection of Nuclear Power Plant Components, The ASME Boiler and Pressure Vessel Code, 2004 edition as approved in 10 CFR 50.55a, New York, NY. AMERICAN SOCIETY of MECHANICAL ENGINEERS, ASME Section XI, Rules for Inservice
4. THE JAPAN SOCIETY OF MECHANICAL ENGINEERS, JSME S NA1-2016, Code for Nuclear Power Generation Facilities - Rule on Fitness-for-Service for Nuclear Power Plants, JSME, (2017).
5. KERNTECHNISCHER AUSSCHUSS, Safety Standards of the Nuclear Safety Standards Commission (KTA), Components of the Reactor Coolant Pressure Boundary of Light Water Reactor Part: In-service Inspections and Operation Monitoring, KTA 3201.4 (2016-11), KTA (2016).
6. ATOMIC ENERGY REGULATORY BOARD, Inservice Inspection of Nuclear Power Plants, AERB/NPP/SG/O-2, AERB, Mumbai, India, (2004).
7. ATOMIC ENERGY REGULATORY BOARD, Life management of Nuclear Power Plants, AERB/NPP/SG/O-14, AERB, Mumbai India, (2005).
8. KERNTECHNISCHER AUSSCHUSS, Safety Standards of the Nuclear Safety Standards Commission (KTA), Ageing-Management in Nuclear Power Plants, KTA 1403 (2017-11), KTA (2017).
9. KERNTECHNISCHER AUSSCHUSS, Safety Standards of the Nuclear Safety Standards Commission (KTA), Pressure- and activity-retaining components of systems outside the primary circuit – Part 4: Inservice Inspections and Operational Monitoring, KTA 3211, KTA (2013).
10. KERNTECHNISCHER AUSSCHUSS, Safety Standards of the Nuclear Safety Standards Commission (KTA), Steel Containment Vessels – Part 4: Inservice Inspections, KTA 3401.4 (2017-11), KTA (2017).
11. KERNTECHNISCHER AUSSCHUSS, Safety Standards of the Nuclear Safety Standards Commission (KTA), Airlocks on the reactor containment of nuclear power plants - Personnel airlocks, KTA 3402, KTA (2014).
12. KERNTECHNISCHER AUSSCHUSS, Safety Standards of the Nuclear Safety Standards Commission (KTA), Cable Penetrations through the Reactor Containment Vessel of Nuclear Power Plants, KTA 3403, KTA (2015).
13. KERNTECHNISCHER AUSSCHUSS, Safety Standards of the Nuclear Safety Standards Commission (KTA), Isolation of operating system pipes penetrating the Containment Vessel in the case of a Release of Radioactive Substances into the Containment Vessel, KTA 3404, KTA (2013).
14. KERNTECHNISCHER AUSSCHUSS, Safety Standards of the Nuclear Safety Standards Commission (KTA), Integral Leakage Rate testing of the Containment with the Absolute Pressure Method, KTA 3405, KTA (2015).
15. KERNTECHNISCHER AUSSCHUSS, Safety Standards of the Nuclear Safety Standards Commission (KTA), Pipe penetrations through the Reactor Containment Vessel, KTA 3407, KTA (2017).
16. KERNTECHNISCHER AUSSCHUSS, Safety Standards of the Nuclear Safety Standards Commission (KTA), Airlocks on the reactor containment of nuclear power plants - Equipment airlocks, KTA 3409, KTA (2009).
17. Government Office of Nuclear Safety: Ageing Management of Nuclear Power Equipment. Safety guide JB-2.1. Czech Republic, January 2010 (in Czech language).
18. HUNGARIAN ATOMIC ENERGY AUTHORITY, Guidelines 4.12 On ageing management during operation (in Hungarian), HAEA (2016, version 3).
19. NUCLEAR REGULATORY AUTHORITY OF THE SLOVAK REPUBLIC, Ageing management of Nuclear power plants – requirements, BNS I.9.2/2014, UJD SR, Bratislava, 2014.
20. NUCLEAR REGULATORY AUTHORITY OF THE SLOVAK REPUBLIC, Regulation No. 33/2012 Coll., on the regular, comprehensive and systematic evaluation of the nuclear safety of nuclear equipment. UJD SR, Bratislava, 2016.
21. CANADIAN STANDARDS ASSOCIATION, In-service Examination and Testing Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants, N287.7-08, CSA, Mississauga, Ontario, Canada (2008).
22. INTERNATIONAL ATOMIC ENERGY AGENCY, Assessment and management of ageing of major nuclear power plant components important to safety: BWR pressure vessels, IAEA-TECDOC-1470, IAEA, Vienna (2005).
23. NUCLEAR ENERGY AGENCY, Technical Basis for Commendable Practices on Ageing Management-SCC and Cable Ageing Project (SCAP) Final Report, OECD/NEA, CSNI/R (2010)15, NEA, PARIS, 2011.
24. UNITED STATES NUCLEAR REGULATORY COMMISSION, Generic Aging Lessons Learned (GALL) Report, NUREG-1801, Rev. 2, USNRC, 2010.
25. ELECTRIC POWER RESEARCH INSTITUTE, Degradation and Failure of Bolting in Nuclear Power Plants, Volumes 1 and 2, EPRI NP-5769, EPRI, Palo Alto, CA, 1988.
26. ELECTRIC POWER RESEARCH INSTITUTE, Nuclear Maintenance Applications Center: Bolted Joint Fundamentals. EPRI TR-1015336, EPRI, Palo Alto, CA, 2019.
27. ELECTRIC POWER RESEARCH INSTITUTE, Aging Effects for Structures and Structural Components (Structural Tools): B&W Owners Group Generic License Renewal Programme, BAW-2279P, EPRI TR-114881, EPRI, Palo Alto, CA, 2003.
28. ELECTRIC POWER RESEARCH INSTITUTE, Long-Term Operations: Subsequent License Renewal Aging Effects for Structures and Structural Components (structural tools); PRODUCT ID 3002013084, EPRI, Palo Alto, CA ,2018
29. ELECTRIC POWER RESEARCH INSTITUTE, How to Conduct Material Condition Inspections, EPRI TR-104514, EPRI, Charlotte, 1994.
30. RESEARCH COUNCIL ON STRUCTURAL CONNECTIONS, Specification for Structural Joints Using ASTM A325 or A490 Bolts, RCSC, (2009).
31. RESEARCH COUNCIL ON STRUCTURAL CONNECTIONS, Educational Bulletin No. 3 Recommendations for Purchasing, receiving and storing A325 or A490 Bolts, RCSC, (2009).
32. Normative Technical Documentation of Association of Mechanical Engineers (N.T.D. ASI) Section IV. Residual Lifetime Assessment of Nuclear Power Plant Equipment and Pipelines type VVER. (in Czech language), 2013.
33. Technical Standard of Czech Energetical Companies (ČEZ, a.s.) Lifetime management of Power Plants Equipment in ČEZ, ČEZ\_ST\_0006. April, 2012, (in Czech language).
34. Guide of Czech Energetical Companies (ČEZ, a.s.) Assets evidence, efficiency, condition and lifetime assessment. ČEZ\_PP\_0330, September 2012, (in Czech language).
35. HUNGARIAN ATOMIC ENERGY AUTHORITY, Guideline A4.21 Programme for the Maintenance, Testing and Surveillance in Nuclear Power Plants, 2016, version 1.
36. NUCLEAR REGULATORY AUTHORITY OF THE SLOVAK REPUBLIC, Corrosion monitoring of safety significant components of nuclear facilities, BNS II.3.4/2006, UJD SR, Bratislava, 2007.
37. UNITED STATES NUCLEAR REGULATORY COMMISSION, Information Notice No. 86-99, Degradation of Steel Containments, USNRC, 1986.
38. UNITED STATES NUCLEAR REGULATORY COMMISSION, Information Notice No. 89-79, Degraded Coatings and Corrosion of Steel Containment Vessels, USNRC, 1990.
39. UNITED STATES NUCLEAR REGULATORY COMMISSION, Generic Letter No. 87-05, Request for Additional Information Assessment of Licensee Measures to Mitigate and/or Identify Potential Degradation of Mark I Drywells, USNRC, 1987.
40. UNITED STATES NUCLEAR REGULATORY COMMISSION, Information Notice No. 2006-01, Torus Cracking in a BWR Mark I Containment, U.S. Nuclear Regulatory Commission, USNRC, 2006.
41. UNITED STATES NUCLEAR REGULATORY COMMISSION, Information Notice No. 92-20, Inadequate Local Leak Rate Testing, USNRC, 1992.
42. UNITED STATES NUCLEAR REGULATORY COMMISSION, Information Notice No. 91-17, Generic Safety Issue 79, Bolting Degradation or Failure in Nuclear Power Plants, USNRC, 1991.
43. UNITED STATES NUCLEAR REGULATORY COMMISSION, NUREG-1339, Resolution of Generic Safety Issue 29: Bolting Degradation or Failure in Nuclear Power Plants, USNRC, 1990.
44. UNITED STATES NUCLEAR REGULATORY COMMISSION, Information Notice No. 2011-15, Steel Containment Degradation and Associated License Renewal Aging Management Issues, USNRC, 2011.
45. NUCLEAR REGULATORY AUTHORITY OF THE SLOVAK REPUBLIC, Evaluation of acceptability of faults detected during the operation inspection of nuclear installation selected equipment, BNS II.3.1/2007, UJD SR, Bratislava, 2007.
46. INTERNATIONAL ATOMIC ENERGY AGENCY, Ageing Management of Concrete Structures in Nuclear Power Plants (IAEA Nuclear Energy Series No. NP-T-3.5 (2016).
47. UNITED STATES NUCLEAR REGULATORY COMMISSION, Information Notice No. 2004-09, Corrosion of Steel Containment and Containment Liner, USNRC, 2004.
48. UNITED STATES NUCLEAR REGULATORY COMMISSION, Information Notice No. 2010-12, Containment Liner Corrosion, USNRC, 2010.
49. UNITED STATES NUCLEAR REGULATORY COMMISSION, NUREG-1522, Assessment of Inservice Conditions of Safety-Related Nuclear Plant Structures, USNRC, 1995.
50. UNITED STATES NUCLEAR REGULATORY COMMISSION, Information Notice No. 2011-15, Steel Containment Degradation and Associated License Renewal Aging Management Issues, USNRC, 2011.
51. UNITED STATES NUCLEAR REGULATORY COMMISSION, Information Notice No. 2014-07, Degradation of Leak-Chase Channel Systems for Floor Welds of Metal Containment Shell and Concrete Containment Metallic Liner, USNRC, 2014.
52. UNITED STATES NUCLEAR REGULATORY COMMISSION, Information Notice No. 88-82, Torus Shells with Corrosion and Degraded Coatings in BWR Containments and Supplement 1, USNRC, 1988/1989.
53. UNITED STATES NUCLEAR REGULATORY COMMISSION, Information Notice No. 97-10, Liner Plate Corrosion in Concrete Containment, U.S. Nuclear Regulatory Commission, USNRC, 1997.
54. UNITED STATES NUCLEAR REGULATORY COMMISSION, Information Notice No. 82-02, Degradation of Threaded Fasteners in the Reactor Coolant Pressure Boundary of PWR Plants, USNRC, 1982.
55. WANO Event Report, Corrosion on Containment steel liner (basemat) Ringhals 2, WER PAR 15-0573, 28-09-2014.
56. IRS – INTERNATIONAL REPORTING SYSTEM FOR OPERATING EXPERIENCE, LEAKAGE THROUGH THE REACTOR CONTAINMENT LINER, Sweden, IRS number 8792
57. SWEDISH NUCLEAR RADIATION AUTHORITY – SKI rapport 02:58 – Utredning kring reaktorinneslutningar – konstruktion, skador samt kontroller och provningar
58. IRS – INTERNATIONAL REPORTING SYSTEM FOR OPERATING EXPERIENCE, REACTOR BUILDING SUMP LINER DEGRADATION, United Kingdom, IRS number 8461
59. UNITED STATES NUCLEAR REGULATORY COMMISION, 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.