6.6 Inservice Inspection of Class 2 and 3 Components

Class 2 and Class 3 systems of the U.S. EPR are designed to permit periodic inspection and testing of important components and piping to assure the integrity and capability of the systems. The inservice inspection (ISI) and preservice inspection (PSI) program for Class 2 and Class 3 components is fully described, as that term is defined in SRM-SECY-04-0032 (Reference 1), in this section. The program complies with the applicable requirements of 10 CFR 50.55a.

Systems subject to ISI requirements include the safety injection system (GDC 36, GDC 37, GDC 39, and GDC 40), ESF filter system (GDC 42 and GDC 43), and cooling water systems (GDC 45 and GDC 46). The safety injection system is addressed in Section 6.3, the ESF filter system (containment atmospheric cleanup) is addressed in Section 6.5.1, and the cooling water systems are addressed in Sections 9.2 and 10.4.9.

The preservice testing (PST) and inservice testing (IST) of pumps and valves are performed in accordance with the ASME Code for Operation and Maintenance of Nuclear Power Plants (OM Code) (Reference 2), as described in Section 3.9.6. Inservice inspection of threaded fasteners is addressed in Section 3.13.2.

The preservice and inservice inspections meet the requirements set forth in Section XI of the ASME Boiler and Pressure Vessel Code (Reference 3) as specified in 10 CFR 50.55a(g) with exceptions as permitted in 10 CFR 50.55a(g)(6)(i). The code of record (ASME Code edition) for the design of the U.S. EPR is identified in Section 5.2.1.1. The PSI program for Class 2 and Class 3 components consists of complete performance of the examinations, excluding pressure testing, initially selected for the Class 2 and Class 3 portions of the ISI program. The pressure testing requirements that are excluded for PSI are identified in Reference 3 as Examination Category C–H of Table IWC-2500-1 for Class 2 and Examination Category D–B of Table IWD-2500-1 for Class 3.

No exemptions to or relief from code requirements are requested, or code cases invoked, for Class 2 or Class 3 preservice or inservice inspection requirements for the U.S. EPR.

A COL applicant that references the U.S. EPR design certification will identify the implementation milestones for the site-specific ASME Section XI preservice and inservice inspection program for Class 2 and Class 3 components, consistent with the requirements of 10 CFR 50.55a (g). The program will identify the applicable edition and addenda of the ASME Code Section XI, and will identify additional relief requests and alternatives to Code requirements.

6.6.1 Components Subject to Examination

Preservice inspections and periodic inservice inspections are required for Quality Group B and Quality Group C components of the U.S. EPR. These components are defined as Class 2 and Class 3 components, respectively, by the ASME Code, Section III (Reference 4). The ASME Code Class 2 and Class 3 components subject to inspection include metallic vessels, heat exchangers, storage tanks, piping systems, pumps, valves, bolting, and supports that meet the definition for Quality Group B and Quality Group C components presented in RG 1.26, "Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants." Subsubarticle NCA-2130 of Section III of the ASME Code presents the construction requirements for these components, and Section XI presents their preservice and inservice inspection requirements. Section 3.2.2 includes a list of the ASME Code Class 2 and Class 3 pressure retaining components and addresses application of the 10 CFR 50.55a regulatory and Section III code criteria to their classification.

Class 2 pressure retaining components and their welded attachments are pressure tested and are inspected by visual, surface, and volumetric examination techniques, as required by Subsection IWC of Section XI of the ASME Code. Certain Class 2 components are exempt from surface and volumetric examination in accordance with IWC-1220. These include:

- For Class 2 systems (except the emergency feedwater system), components and piping segments NPS 4 and smaller. This includes those that have one inlet and one outlet, both of which are NPS 4 and smaller, and those that have multiple inlets or multiple outlets whose cumulative pipe cross-sectional area does not exceed the cross-sectional area defined by the outside diameter of NPS 4.

- For the emergency feedwater system, components and piping segments NPS 1-1/2 and smaller. This includes those that have one inlet and one outlet, both of which are NPS 1-1/2 and smaller, and those that have multiple inlets or multiple outlets whose cumulative pipe cross-sectional area does not exceed the cross-sectional area defined by the outside diameter of NPS 1-1/2.

- Vessels, piping, pumps, valves, other components, and component connections of any size in statically pressurized, passive safety injection systems (i.e., the safety injection system accumulators and their attached piping and components).

- For Class 2 systems (except the safety injection system), vessels, piping, pumps, valves, other components, and component connections of any size in systems or portions of systems that operate (when the system function is required) at a pressure equal to or less than 275 psig and at a temperature equal to or less than 200°F.

- Piping and other components of any size beyond the last shutoff valve in open-ended portions of systems that do not contain water during normal plant operating conditions.

U.S. EPR design standards include provisions for placing Class 2 piping and components, and establishing minimum structural clearances around them, so that access for inservice inspection is maintained. These provisions limit the welds or portions of welds that would otherwise be exempt from examination due to their inaccessibility because they are encased in concrete, buried underground, located inside a penetration, or encapsulated by a guard pipe.

Class 3 pressure retaining components and their welded attachments are pressure tested and are inspected by visual examination techniques, as required by Subsection IWD of Section XI of the ASME Code. Certain Class 3 components are exempt from VT-1 visual examination in accordance with IWD-1220. These include:

- Components and piping segments NPS 4 and smaller. This includes those that have one inlet and one outlet, both of which are NPS 4 and smaller, and those that have multiple inlets or multiple outlets whose cumulative pipe cross-sectional area does not exceed the cross-sectional area defined by the outside diameter of NPS 4 pipe.
- Components that operate at a pressure of 275 psig or less and at a temperature of 200°F or less in systems, or portions of systems, whose function is not required in support of reactor residual heat removal, containment heat removal, or emergency core cooling.

U.S. EPR design standards include provisions for placing Class 3 piping and components, and establishing minimum structural clearances around them, such that access for inservice inspection is maintained. These provisions limit the welds or portions of welds that would otherwise be exempt from examination due to their inaccessibility because they are encased in concrete, buried underground, located inside a penetration, or encapsulated by a guard pipe.

6.6.2 Accessibility

The U.S. EPR design provides ready access to systems, structures, and components to accommodate comprehensive inspections using currently available equipment and techniques. The accessibility incorporated into the design conforms to IWA-1500 and the requirements of 10 CFR 50.55a(g)(3)(ii). This readily accessible configuration allows enhanced flaw detection and reliable flaw characterization, and also lowers occupational radiation exposure through reduced inspection times.

Factors such as examination requirements, examination techniques, accessibility, component geometry, and material selection are used in evaluating component designs for ease of inspection. The components and welds requiring ISI have design features that allow ready inspection, including clearances for personnel and equipment, adequate examination surface distances, two-sided access, favorable materials, weld-joint simplicity, elimination of geometrical interferences, and proper weld surface preparation. Removable insulation is used on those piping systems requiring volumetric and surface inspection. Pipe hangers and supports are positioned to accommodate weld inspection. The surfaces of welds within the inspection boundary are finished to permit effective examination.

Permanent and temporary platforms are provided to facilitate access to pumps, valves, and pipe welds. Space is also provided to handle and store insulation, structural members, shielding, and similar materials related to the inspection. Hoists and other handling equipment are provided, and the lighting and power sources needed for the inspection equipment are installed at appropriate locations.

6.6.3 Examination Techniques and Procedures

Review of the existing inspection requirements is part of the design process, and this review results in component designs that allow examination by existing methods, and also results in recommendations for enhanced inspections. The visual, surface, and volumetric examination techniques and procedures are performed in accordance with Articles IWA-2000, IWC-2000, and IWD-2000 of Section XI of the ASME Code. The acceptance standards for the results of these examinations are in accordance with Articles IWC-3000 and IWD-3000 of Section XI.

Three different visual examination methods are used for detecting imperfections that are open to the surface. VT-1 examinations detect discontinuities and imperfections on the surface of components, including cracks, wear, corrosion, or erosion. VT-2 examinations detect evidence of leaks from pressure-retaining components during system pressure tests. VT-3 examinations determine the general condition of components and their supports by verifying parameters such as clearances, settings, and physical displacements. VT-2 and VT-3 examinations also detect discontinuities and imperfections such as loss of integrity at bolted or welded connections, loose or missing parts, debris, corrosion, wear, or erosion. Visual examination by remote viewing techniques is verified to provide resolution at least equivalent to that of direct observation.

Surface examinations are performed using either the liquid penetrant, magnetic particle, or eddy current method. Articles 6 and 7 of Section V of the ASME Code (Reference 5) present the performance requirements for liquid penetrant and magnetic particle examinations, respectively. Mandatory Appendix IV of Section XI of the ASME Code presents the requirements for performing eddy current examination for detecting surface flaws. Mechanized surface examination techniques are verified to provide results at least equivalent to manual surface examination techniques.

Volumetric examinations may be performed using radiography, ultrasonic, or eddy current techniques (manual or remote). Due to logistical and administrative control issues associated with radiography, ultrasonic examination is generally preferred for regularly scheduled volumetric examination of component welds, while eddy current examination is generally preferred for inspecting heat exchanger tubes and other small diameter or limited access components. Radiography is, however, a permissible volumetric examination technique and may be incorporated in the ISI program. Performance requirements for these three volumetric examination techniques are found in the following sections of the ASME Code:

- Ultrasonic: Section XI, Mandatory Appendices I, VII, and VIII.
- Eddy Current: Section V, Article 8.
- Radiography: Section V, Article 2.

The methods, procedures, and requirements to qualify personnel performing ultrasonic testing comply with the guidance provided in Appendix VII of Section XI of the ASME Code. In addition, performance demonstration for ultrasonic examination procedures, equipment, and personnel used to detect and size flaws is in accordance with the requirements of Appendix VIII of ASME Section XI. Use of Appendix VIII, its supplements, and Article I-3000 will be in accordance with the 2001 edition of the Code, no addenda, until use of these parts with a later edition and addenda of the Code may be approved in accordance with 10 CFR 50.55a.

Acoustic emission may be used to monitor the growth of flaws initially detected by other nondestructive examination methods, in accordance with ASME Code Section V, Article 13, and the requirements of Paragraph IWA-2234 of Section XI of the ASME Code.

Alternative examination methods, a combination of methods, or newly developed techniques may be substituted for the methods specified in Section XI of the ASME Code, provided the requirements of IWA-2240 are met. Use of the provision for alternative examination methods in IWA-2240 must be in accordance with the 1997 addenda of the Code until use of IWA-2240 in accordance with a later edition and addenda of the Code may be approved in accordance with 10 CFR 50.55a.

6.6.4 Inspection Intervals

Inspection schedules for Class 2 and Class 3 components are in accordance with the requirements of Subarticles IWA-2400, IWC-2400, and IWD-2400 of Section XI of the ASME Code, and are generally established so that all required inspections are completed during successive ten year intervals. Inservice examinations are intended to be performed during normal plant outages, such as refueling or maintenance shutdowns, that occur during the inspection interval. Thus, each inspection interval may be reduced (except the first interval of Inspection Program A) or extended by as much as one year to enable an inspection to coincide with a plant outage. It is not necessary that the inspection intervals be the same for the IWC (Class 2) and the IWD (Class 3) portions of the ISI program.

6.6.5 Examination Categories and Requirements

Examination and pressure testing categories and requirements for Class 2 and Class 3 components and piping—including the method of examination for the components and parts of the pressure retaining boundaries—are established in accordance with Subarticle IWA-2200 of the ASME Code, and conform to Tables IWC-2500-1 and IWD-2500-1, respectively.

6.6.6 Evaluation of Examination Results

Evaluation of the examination results is in accordance with Articles IWC-3000 (Class 2) and IWD-3000 (Class 3) of Section XI, and also Article IWA-3000. IWC-3000 and IWD-3000 present or reference parametric flaw size limits that may be used to determine the acceptability of returning affected components to immediate or continued service. The articles further specify the process for resolving unacceptable results so that an affected component may be returned to service. Depending upon the type of examination and the flaw characteristics, this may require supplemental examination, repair, replacement, or acceptance by analytical evaluation.

Components whose preservice examinations detect flaws that fail to meet the applicable Code requirements must be corrected by a repair / replacement activity to the extent necessary to meet those requirements prior to placing the component in service.

Components whose inservice volumetric and surface examinations detect flaws that exceed the acceptance standards of Table IWC-3410-1 are acceptable for continued service without a repair / replacement activity if an analytical evaluation, as described in IWC-3600, meets the acceptance criteria of IWC-3600 (the area containing the flaw shall be subsequently reexamined). Otherwise, repair or replacement to the extent necessary to meet the acceptance standards of Article IWC-3000 is required to qualify such components for return to service.

Class 2 and Class 3 components whose inservice visual examinations detect flaws that exceed the acceptance standards are acceptable for continued service without a repair / replacement activity or corrective measures if a supplemental volumetric or surface examination determines the flaws meet the acceptance standards for such an examination (IWC-3200), or an evaluation performed in accordance with IWC-3130 demonstrates the components are acceptable.

Class 2 and Class 3 piping whose inservice examinations detect flaws that exceed the acceptance standards may be evaluated by analytical procedures to determine acceptability for continued service to either the next inspection or to the end of the evaluation period. These analytical procedures and acceptance criteria may be based on a failure mode determination, a failure assessment diagram, or the applied stress, as presented in IWC-3640 and IWD-3640 for Class 2 and Class 3 piping, respectively.

Repairs and replacements of Class 2 and Class 3 components are done according to a Repair / Replacement Program implemented in accordance with Article IWA-4000 of Section XI of the ASME Code.

6.6.7 System Pressure Tests

Class 2 and Class 3 systems and components subject to pressure testing are tested using the fluid contained in the system as the pressurizing medium. The testing is done in accordance with Articles IWC-5000 (Class 2) and IWD-5000 (Class 3), and also Article IWA-5000 (General Requirements). The tests are conducted at the system pressure obtained while the system, or portion of the system, is in service performing its normal operating function, or at the system pressure developed during a test conducted to verify system operability (such as a test to demonstrate system safety function or to satisfy technical specification surveillance requirements).

The pressure retaining boundary includes those portions of the system required to operate or support the safety function, up to and including the first normally closed valve (including a safety or relief valve) or a valve capable of automatic closure when the safety function is required. Items outside the boundaries of Subparagraph IWC-5222(a) and open-ended discharge piping are excluded.

For hydrostatic testing, the test pressure is at least 1.10 times the system pressure for systems with a design temperature of 200°F or less. For systems with a design temperature above 200°F, the test pressure is at least 1.25 times the system pressure. The system pressure is the lowest pressure setting for safety or relief valves provided for overpressure protection within the test boundary, or the system design pressure for systems (or portions of systems) not provided with safety or relief valves.

For atmospheric storage tanks, the system test pressure is the nominal hydrostatic pressure that develops when the tank is filled to its design capacity. For 0–15 psi storage tanks, the test pressure is 1.1 times the design pressure of the vapor or gas space above the liquid level for which relief valves provide overpressure protection. Open-ended portions of suction or drain lines from storage tanks extending to the first shutoff valve are considered an extension of the storage tank.

6.6.8 Augmented ISI to Protect against Postulated Piping Failures

High-energy piping systems are defined in Section 3.6.1 as those systems that, during normal plant conditions (i.e., reactor startup, operation at power, hot standby, and reactor cooldown to cold shutdown conditions), are in operation or maintained pressurized at a maximum operating temperature that exceeds 200°F, or a maximum operating pressure that exceeds 275 psig. To protect against high-energy piping failures that could affect the integrity of the containment boundary, all welds in high-energy piping between containment isolation valves (or where no isolation valve is used inside containment, between the first rigid pipe connection to the containment penetration or the first pipe whip restraint inside containment and the outside isolation valve) are subject to augmented inservice inspection, in accordance with the requirements of Article IWC-2000 for Examination Category C–F welds. The inservice examination completed during each inspection interval is a 100 percent volumetric examination of circumferential and longitudinal pipe welds within the boundary of these portions of piping.

The access provisions incorporated into the design of the U.S. EPR provide access for personnel and equipment to inspect the affected welds. For high-energy pipes that penetrate the containment, inspection access through the penetration guard pipes (via hand holes, ports, or removable sections of guard pipe located outside the annular area) allow volumetric inspection of welds or seams that may be enclosed within the guard pipes.

6.6.9 References

1. Staff Requirements Memorandum, SECY-04-0032, "Programmatic Information Needed for Approval of a Combined License Without Inspections, Tests, Analyses, and Acceptance Criteria," U.S. Nuclear Regulatory Commission, May 14, 2004.

2. ASME OM Code, "Code for Operation and Maintenance of Nuclear Power Plants," The American Society of Mechanical Engineers, 2004.

3. ASME Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," The American Society of Mechanical Engineers, 2004.

4. ASME Boiler and Pressure Vessel Code, Section III, "Rules for Construction of Nuclear Facility Components," The American Society of Mechanical Engineers, 2004.

5. ASME Boiler and Pressure Vessel Code, Section V, "Nondestructive Examination," The American Society of Mechanical Engineers, 2004.

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