4.0 AGING MANAGEMENT ACTIVITIES AND PROGRAM ATTRIBUTES

This section provides the options to manage aging effects during an extended period of operation. Since this report is generically applicable to the plants identified in Section 1.1 of this document, only program attributes are given. Plant-specific details will be developed during the preparation of license renewal applications. The program attributes are based on requirements currently accepted in the industry. Since the rate of age-related degradation does not change, for most aging effects these requirements will remain acceptable to maintain intended functions consistent with the CLB during an extended period of operation. Additional justification for aging effects that do not occur at a linear rate, if applicable, will be provided at the end of the program description in Section 4.0. Therefore, PWR containment intended functions are maintained during an extended period of operation.

Section 3.0 identifies the aging effects that require management during an extended period of operation. Section 4.1 provides program attributes using current license basis, and Section 4.2 provides additional activities and attributes required to manage aging effects.

Details and implementation guidance are provided. Deviations from the attributes provided will require descriptions and justifications in plant-specific applications. Aging management attributes are summarized by aging management program (AMP) tables (see Table 4-1). These tables summarize program attributes and activities that will be the basis for programs implemented by utilities during an extended period of operation.

TABLE 4-1
AGING MANAGEMENT PROGRAM ATTRIBUTES

Attribute	Description
Scope	Structures, components, or subcomponents and applicable aging effects.
Surveillance Techniques	Monitoring, inspection, and testing techniques used to detect aging effects.
Frequency	Time period between program performance or when a one-time inspection must be completed. Inspection for the effect will take place when an event has occurred.
Acceptance Criteria	Qualitative or quantitative criteria that determine when corrective actions are required.
Corrective Action	Actions to further analyze, prevent, or correct the consequences of the effect. Preventive actions should include evaluation of failures to determine where similar effects may occur and actions, if practical, to mitigate or eliminate the effect from occurring.
Confirmation	Post-maintenance test or other techniques to confirm that the actions have been completed and are effective.

4.1 CURRENT ACTIVITIES AND PROGRAM ATTRIBUTES

The mechanisms that may result in aging effects for the systems, structures, and components within the scope of this report are adequately managed using current licensing basis (CLB) inspection and test programs based on ASME Code Section XI, Subsections IWE and IWL, and American Concrete Institute (ACI) codes. The CLB programs are summarized through seven identified aging management programs. They are summarized in Table 4-2, along with the component, aging mechanism, and aging effect.

These aging management programs are discussed in the following subsections. The attributes are based on current plant maintenance, inspection, and testing programs that follow the 1992 Code Edition and Addenda of ASME Section XI, Subsections IWE and IWL. This is in compliance with 10 CFR 50.55a. It is noted that in U.S. NRC SECY-96-080, the U.S. NRC recognized the effectiveness of the inspection and testing requirements given in the 1992 ASME Code, including Addenda of Section XI, Subsections IWE and IWL, for managing the aging effects associated with containment structures. They therefore incorporated these Code requirements by reference into 10 CFR 50.55a. Further, as demonstrated by LER and NPRD data in Section 2.0, these inspection and testing programs have been proven effective in inspection, monitoring, and maintenance of age-related degradation. Therefore, the inspection practice following 1992 ASME Code Section XI, Subsections IWE and IWL, requirements provide acceptable means to identify and quantify degradation effects so that indications of the above aging effects can be evaluated or repaired prior to the loss of an intended function.

It is recommended that a utility incorporate into their inservice inspection programs, for the extended period of operation, these aging management programs that are based on the 1992 Code Edition, and Addenda, of ASME Section XI, Subsections IWE and IWL. Further, the modifications given in SECY-96-080 (introduced in SECY-93-328, the proposed rule) to address U.S. NRC concerns related to tendon examinations and inaccessible areas should also be included. These include the following:

- The following four recommendations for tendon examination included in Regulatory Guide 1.35, Rev. 3, should be included.
  - Requires that grease caps that are accessible be visually examined to detect grease leakage or grease cap deformation
  - Requires the preparation of an engineering evaluation report when consecutive surveillance indicates a trend of prestress loss to below the minimum prestress requirements
  - Requires an evaluation to be performed for instances of wire failure and slip of wires in anchorages
  - Addresses sampled sheathing filler grease and reportable conditions

TABLE 4-2
CURRENT LICENSING BASIS AGING MANAGEMENT PROGRAMS

Aging Management Program	Components	Aging Mechanism	Aging Effects
AMP-5.1 and AMP-5.2	Concrete Containment[1] Shield Building[1]	Freeze-Thaw	– Cracking of the concrete – Increased porosity and/or permeability of the concrete – Scaling of the concrete surface – Corrosion resulting from loss of protective concrete cover, coating, or protective concrete chemistry
AMP-5.3 and AMP-5.4	Concrete Containment[2] Foundation Basemat[2]	Aggressive Chemical Attack	– Cracking of the concrete – Increased porosity and/or permeability of the concrete – Scaling of the concrete surface – Decrease in tensile and compressive strength and/or modulus of elasticity – Loss of strength
	Reinforcing Steel	Corrosion	– Corrosion resulting from loss of protective concrete cover, coating, or protective concrete chemistry – Additional cracking of the concrete – Increased porosity and/or permeability of the concrete – Loss of bond strength between reinforcement steel and the concrete – Increase in the volume of reinforcement or embedded steel resulting from the formation of rust by-products, resulting in concrete cracking – Reduction in cross-sectional area or thickness or loss of material – Loss of strength

TABLE 4-2 (Continued)
CURRENT LICENSING BASIS AGING MANAGEMENT PROGRAMS

Aging Management Program	Components	Aging Mechanism	Aging Effects
AMP-5.5	Penetration Anchor	Fatigue	– Cracking of the concrete – Increased porosity and/or permeability of the concrete – Corrosion resulting from loss of protective concrete cover, coating, or protective concrete chemistry – Loss of strength
	Liner	Corrosion	– Reduction in cross-sectional area or thickness or loss of material
		Coating Degradation	– Corrosion resulting from loss of protective concrete cover, coating, or protective concrete chemistry
	Electrical Penetrations Bellows	Transgranular Stress Corrosion Cracking (TGSCC)	– Cracking of steel component – Loss of seal or pressure-retaining capability
	Mechanical Penetrations	Bellows Fatigue and	– Fatigue-induced cracking of component
		Fatigue of Penetration	– Loss of seal or pressure-retaining capability
		Embrittlement of Gaskets	– Loss of seal or pressure-retaining capability
		Corrosion and SCC	– Reduction in cross-sectional area or thickness or loss of material – Cracking of steel component – Loss of seal or pressure-retaining capability

TABLE 4-2 (Continued)
CURRENT LICENSING BASIS AGING MANAGEMENT PROGRAMS

Aging Management Program	Components	Aging Mechanism	Aging Effects
AMP-5.5	Fuel Transfer Tube Penetration [3]	Mechanical Wear	– Reduction in cross-sectional area or thickness or loss of material
		Embrittlement of Gaskets	– Loss of seal or pressure-retaining capability
		Corrosion and SCC	– Reduction in cross-sectional area or thickness or loss of material – Cracking of steel component – Loss of seal or pressure-retaining capability
	Airlocks and Hatches[4]	Mechanical Wear	– Reduction in cross-sectional area or thickness or loss of material
		Embrittlement of Gaskets or Loss of Pressure Retention	– Loss of seal or pressure-retaining capability
	Free-Standing Steel Containment	Fatigue	– Fatigue-induced cracking of component
		Corrosion	– Reduction in cross-sectional area or thickness or loss of material

TABLE 4-2 (Continued)
CURRENT LICENSING BASIS AGING MANAGEMENT PROGRAMS

Aging Management Program	Components	Aging Mechanism	Aging Effects
AMP-5.6	Post-Tensioning Systems	Corrosion and Concrete Degradation	– Reduction in cross-sectional area or thickness or loss of material – Reduction in prestress force – Breakage of wires or strands
		Prestress Force Losses	– Leakage of corrosion inhibiting medium
		Stress Corrosion	– Loss of strength
		Cracking	– Loss of strength – Reduction in prestress force – Cracking of steel component – Loss of strength
AMP-5.7	Foundations	Settlement	– Cracking of concrete – Added stress induced by loss of supporting system clearances

Notes:

(1) The freeze-thaw aging management program is applicable only as indicated in Subsection 3.2.1 and is a plant-specific issue.
(2) For inaccessible below-grade concrete structures.
(3) For fatigue, see mechanical penetrations.
(4) For corrosion, see mechanical penetrations.

- Visible evidence of degradation such as leaching and surface cracking may be an indication of concrete degradation in inaccessible areas. Therefore, an evaluation of the potential degradation of surrounding inaccessible areas should be initiated.

Consistent with SECY-96-080, duplication examinations required by both the periodic routine and expedited examination program requirements should be avoided. Further, the utility is allowed to use recently performed examination of the post-tensioning system to satisfy the requirements for the expedited examination of the containment post-tensioning system.

The specified modifications and clarifications given in SECY-96-080 to amend 10 CFR 50.55a are recommended for incorporation into a utility's license renewal plan that addresses containment structures. The four modifications to the final rule of 10 CFR 50.55a are:

- Expansion of the evaluation of inaccessible areas of concrete containments to include metal containments and the liners of concrete containments.

- Permission of alternative lighting and resolution requirements for remote visual inspection of the containment.

- The maximum direct examination distance specified in Table IWA-2210-1 may be extended and the minimum illumination requirements specified in Table IWA-2210-1 may be decreased provided that the conditions or indications for which the visual examination is performed can be detected at the chosen distance and illumination.

- Examination of pressure-retaining welds and pressure-retaining dissimilar metal welds are optional.

- An alternative sampling plan has been added.

The clarification to the new containment rule (NRC SECY-96-080) that more clearly defines the frequency of Subsection IWE general visual examination is also included in the attributes.

The utility should document, per ASME Section XI IWA-6000, for each inaccessible area identified, the following per the NRC SECY-96-080 requirements:

- 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

- A description of necessary corrective actions

The above requirement is identical for the evaluation of suspect inaccessible areas identified through visual inspection of concrete areas near tendon anchorage or through examination of metal containments and the liners of concrete containments.

In general, the current maintenance program that a utility implements are made up of the following activities: routine inspections; periodic inspections; condition survey; nondestructive examinations and sampling inspections; remedial and preventive measures. These activities, along with the additional requirements from the containment rule, are discussed in the subsections that follow along with a discussion of each of the aging management programs.

4.1.1 Routine Inspections

General visual examinations of the accessible surfaces of the containment may be part of the plant routine maintenance procedures. These inspections may be made at intervals of 6 months to 2 years depending on the particular plant procedures [Ref. 29]. The frequency of the routine inspections falls within the accepted time period to detect degradation prior to the loss of intended function. The general visual examination detects indications of concrete and steel degradation, including: cracking, spalling, discoloration, wetting, and staining for concrete; flaking, blistering, peeling, and discoloration for coated steel surfaces; and, cracking, discoloration, wear, pitting, excessive corrosion, arc strikes, gouges, surface discontinuities, and dents for uncoated steel surfaces. Damage to seals or fatigue cracking may also be visible. Visual examination is an acceptable method for the detection of the above indications of aging effects that result from coating degradation and corrosion on steel liners and steel containment and concrete degradation.

The intended functions of the containment affected by the above aging effects and degradation mechanisms are the protection of the environment from the unacceptable release of radiation and the protection of containment interior systems from external loadings. The objective of these inspections is to detect the activity of any degradation mechanisms and to determine any changes to the concrete condition or properties that could affect the integrity of the structure and its future serviceability in advance of the loss of the intended function, so that repairs or an evaluation of the suspect area can be made.

4.1.2 Periodic Inspections

Existing surveillance programs to check periodically for evidence of containment concrete component degradation include post-tensioned tendon system surveillance programs. The un-bonded, post-tensioned tendon system surveillance program typically includes inspection of the tendon, wire or strand, anchorage hardware and surrounding concrete, corrosion protection medium, and free water. The tendon wire or strand is subjected to both visual and mechanical testing. A visual examination is performed on the tendon anchorheads, wedges, buttonheads, shims, and the concrete extending outward a distance of 2 feet from the edge of the bearing plate. Indications are cracking in anchor heads, evidence of active corrosion, broken or unseated wires, broken strands, and cracks in the concrete adjacent to the bearing plates (in excess of 0.01 inch).

The chemistry and volume of the corrosion protection medium and free water are monitored. The chemistry is monitored for levels of chlorides, nitrates, and sulfides, as well as pH, which may contribute to a corrosive environment. Documentation includes observations of cracks in the concrete and tendon anchorage hardware along with broken strands and damaged or missing hardware. Visual examinations and testing are acceptable methods for the detection of the above indications of aging effects that result from corrosion of the mechanical components and degradation of concrete surrounding the post-tensioned system, and other aging degradation mechanisms that result in the loss of prestress force.

The individual plant CLB complies with requirements as defined in Regulatory Guide 1.35, Regulatory Guide 1.90, and ASME Code Section XI, Subsection IWL. The frequency of the inservice inspections following the first 5 years of operation is similar to those discussed in the above listed regulatory guides that fall within the accepted time period to detect degradation prior to the loss of intended function. The above activities effectively detect and manage the aging effects of prestress force loss and corrosion in metal components, as well as concrete degradation for the post-tensioning systems of the PWR containment. The intended functions of the containment affected by the aging affects that degrade the post-tensioned system are the protection of the environment from the unacceptable release of radiation and the protection of containment interior systems from external loadings.

- Leak Rate Testing

Leak rate testing is performed as required by 10 CFR 50, Appendix J to ensure leaktight integrity, which supplements the ASME Code Section XI requirements. Type A testing measures the leak rate of the entire primary containment system for comparison with permissible leak rate in the plant technical specifications. The pressure used for the Type A leak rate test is based on the plant containment design pressure. For most plants, the test pressure corresponds to the design pressure; however, for a few older vintage plants the test pressure is less than the full design pressure.

Type B tests measure the leakage locally at penetrations, airlocks, and hatches at the design pressure condition. Leakage is an indication of degradation, including fatigue-induced flaws, embrittlement of gaskets, corrosion-induced flaws, and mechanical wear.

Section V.A of Appendix J requires a general visual examination of accessible interior and exterior surfaces of containment structures prior to the Type A testing to uncover structural degradation that could impact the capability of the containment to perform its intended function. Similar requirements are found in the ASME Code Section XI, Subsections IWE and IWL. Coated areas of the liner or steel containment are examined for evidence of degradation, which includes flaking, blistering, peeling, discoloration, and other signs of deterioration. Uncoated areas are examined for evidence of cracking, discoloration, wear, pitting, excessive corrosion, arc strikes, gouges, surface discontinuities, dents, and other signs of surface irregularities. Welds are examined as part of the surface. Seals, gaskets, and penetration assemblies are also subject to visual inspection for the above listed signs of degradation. The concrete exterior of the steel-lined containment is examined for evidence of cracking, spalling, discoloration, wetting, and staining. Visual inspection and leak rate testing are acceptable methods for the detection of the indications of aging effects resulting from fatigue, TGSCC, mechanical wear, embrittlement of gaskets, loss of pressure retention, and corrosion, which can be repaired or evaluated prior to the loss of the containment intended function.

The above activities effectively detect and manage the effects of fatigue at penetration anchors, coating degradation, TGSCC of electrical penetration bellows, fatigue in bellows and mechanical penetrations, mechanical wear and embrittlement, corrosion of the accessible areas of the liner or steel containment, concrete degradation above grade, and loss of pressure retention for the components of the PWR containment. The effects are detected prior to the loss of the containment intended function and are managed through evaluation and repair.

4.1.3 Condition Survey

The purpose of the concrete condition survey is to examine the concrete surface to identify, define, and assess areas of degradation. ACI 201.1R-68 (Revised 1984) includes the recommended steps and level of detail for the condition survey. The following briefly describes elements of a condition survey.

Present condition survey includes the surface condition, overall alignment of the structure, evidence of alkali-aggregate or other reaction, and other inspection findings. Indications of concrete degradation include cracking, spalling, discoloration, wetting, and staining. Monitoring and repair, as required, of such indications provide an effective program for the management of concrete degradation and associated liner and steel containment corrosion resulting from water infiltration of the protective concrete layer.

The survey includes photographs of degraded conditions. The conditions can be described using the standard terminology associated with the durability of concrete provided in the appendix to ACI 201.1R. The terminology addresses cracks, deterioration, and textural defects resulting from construction. The primary focus of this survey is to detect and assess degradation that can lead to adverse impact on the intended functions.

The ASME Code Section XI, Subsection IWL, provides a methodology for the examination of the concrete surface. All surfaces including those protected by coatings, except as exempted, are visually examined for evidence of conditions indicative of degradation, as defined in ACI 201.1. Currently, a VT-3C visual examination can be conducted for all accessible areas to determine the general structural condition through the identification of suspect areas, where evidence of deterioration is found. Evidence of degradation includes cracking, spalling, staining, wetting, and discoloration, as stated above. Specifications for examination method VT-3 are employed, i.e., those for minimum illumination, maximum direct examination distance, and maximum procedure demonstration lower case character height. VT-1C visual examinations are conducted for selected suspect areas. Examination specifications for examination method VT-1 are employed.

Subsection IWE of the ASME Code Section XI provides a methodology for examination and inspection subsequent to repair or replacement for the Class MC pressure-retaining components and their integral attachments. Inspections are made prior to leak rate testing.

Embedded or inaccessible portions of the containment vessels, parts, and appurtenances are exempt.

Accessible surface areas of the steel containment vessel pressure-retaining boundary, except those that are submerged or insulated, are subject to general visual examination. VT-3 visual examination is applied for areas including those that are submerged and insulated. Paint or coatings shall not be removed for visual inspection. Coated areas are examined for evidence of flaking, blistering, peeling, discoloration, and other signs of deterioration. Uncoated areas are examined for evidence of cracking, discoloration, wear, pitting, excessive corrosion, arc strikes, gouges, surface discontinuities, dents, and other signs of surface irregularities.

The visual examinations discussed above are acceptable methods for the detection of the indications of aging effects that result from coating degradation and corrosion on steel liners and steel containment, and concrete degradation. Subsection IWE provides for visual inspection and leak rate testing in accordance with 10 CFR 50.55a Appendix J, and therefore also provides acceptable methods for the detection of the indications of aging effects resulting from fatigue, transgranular stress corrosion cracking (TGSCC), mechanical wear, embrittlement of gaskets, loss of pressure retention, and corrosion. The frequency of inspection for concrete is the same for the ASME and ACI Codes, i.e. beyond the first 5 years. The 5-year frequency is acceptable for the detection of aging effects, such that repairs or evaluations can be made prior to the loss of containment intended functions.

Settlement is monitored for plants founded on soft soil. Only a few plants have any settlement issues that require monitoring so this is an issue for individual plant application only. Monitoring programs are effective with surveys performed during construction, with results compared against design predictions, and with periodic surveys performed through the life of the plant or until indications show that significant settlement has ceased. Settlement generally occurs within the first 5 or 6 years of operation or where the soil foundation under a plant's foundation has experienced a substantial change in the groundwater level. Major differential settlement, if present, can be seen as concrete cracking or apparent differences in surface elevation. Visual examinations detect cracking, and surveys monitor differences in surface elevations. The above activities effectively detect and manage the aging effects of differential settlement for the PWR containment. Repairs or evaluations can be made before intended functions are lost. Significant aging effects of differential settlement would result in the loss of intended functions including the protection of the environment from the unacceptable release of radiation and the protection of containment interior systems from external loadings.

4.1.4 Nondestructive Examination/Sampling Inspection Technology

Nondestructive examination (NDE) methods, destructive testing, and sampling methods currently available for PWR containment concrete components are summarized in Tables 4-3 and 4-4, respectively. These methods may be used to supplement visual inspection and testing, when further investigation of indications is necessary. The methods are described in detail in the report "Inservice Inspection and Structural Integrity Assessment Methods for Nuclear Power Plant Concrete Structures" [Ref. 29].

Direct and indirect techniques are used to investigate and detect degradation in the concrete system consisting of the concrete and the integral reinforcing steel. The direct techniques involve some combination of visual inspection and removal of material samples for testing where degradation is detected. Visual examination performed on a periodic basis is an effective method to detect degradation effects such as cracking, spalling, and volume changes. Where potentially significant degradation is observed, core samples can be removed for strength testing and petrographic examination. Indirect NDE methods are used to determine properties of concrete by comparing measurements of a particular property with established correlations.

Tables 4-5 through 4-8 review available nondestructive and destructive testing and sampling techniques for the material components of the PWR concrete. The primary degradation effects for concrete, reinforcing steel, steel containment and liners, and prestressing systems are listed along with the applicable examination methods.

4.1.5 Remedial/Preventive Measures

(1) Coatings and Joint Seals

CLB remedial/preventive measures applied at some plants include preventive maintenance of steel containment shells, concrete containment liners and associated components, and aid in the effective management of the aging effects of corrosion to the steel liner or containment. Prevention of corrosion for metal containments is mainly achieved with protective coatings. Typical containment coating systems are described in Reference 25. The coating systems are designed to provide good corrosion resistance. Surfaces that have been left uncoated, or that received only a primer coat with minimal surface preparation, such as the embedded base steel and the embedded parts of penetration sleeves/airlocks, are potentially susceptible to corrosion.

TABLE 4-3
SUMMARY OF APPLICATIONS FOR TESTING METHODS: NONDESTRUCTIVE

Test Method	Principle	Main Application	Advantages	Limitations
Visual	Includes detailed visual examination of observed distress.	To obtain general information regarding concrete distress.	Provides valuable information as to causes of distress and extent of damage.	Provides information on the condition of the exposed surface only. Additional testing methods are required.
Audio Method	Uses the difference in sounds to distinguish between delaminated and nondelaminated areas of the test structure.	To locate delaminations and voids.	Quick and inexpensive method. No extensive training is required.	Subjective to the person performing the test.
Electrical Method	Uses the resistance and potential difference measurements of a structure to determine the moisture content and rate of corrosion of the structure.	To determine the rate of corrosion of a structure.	Quick and inexpensive method. No extensive training is required.	Provides only a potential rate of and not the actual amount of corrosion present. It is also affected by moisture content.
Impulse Radar	Uses the principle of transmitted and reflected wave forms to locate objects in the structure tested.	To locate voids, embedded reinforcement, delaminations, flaws in concrete, tanks, and utilities embedded in the ground.	Quick, portable, and accurate in locating objects. No damage to concrete.	Affected by moisture. Skills are required in analysis of results.

TABLE 4-3 (Continued)
SUMMARY OF APPLICATIONS FOR TESTING METHODS: NONDESTRUCTIVE

Test Method	Principle	Main Application	Advantages	Limitations
Infrared Thermography	Uses the principle that all objects emit infrared rays. The infrared camera receives these rays and displays them on a color monitor.	To locate voids.	Quick and portable. No damage to concrete.	Affected by moisture. Skills required in the analysis of the results. Temperature dependent.
Magnetic Method	Generates a magnetic field and determines the intensity of the magnetic field.	To determine depth and location of reinforcement.	Quick and inexpensive method. No extensive training is required.	Temperature dependent. Ineffective in heavily reinforced area.
Microscopic Refraction	Estimates time traveled from the point of impact to the receiver.	To locate cracks, voids, and assess quality of concrete.	Quick and causes no damage to the concrete.	Influenced by the method of impact used.
Modal Analysis	Dynamic test based on vibrations induced to a structure.	Determines vibrational response of a structure.	Provides information about nature of structure when subjected to a dynamic load.	Relatively slow and costly process.
Nuclear Method	Emits gamma rays and receives the amount returned.	To determine the density of hardened concrete.	Has the ability to determine moisture present as a function of depth.	Expensive, slow, and needs a skilled operator. The density found is only for the top portion of the concrete.

TABLE 4-3 (Continued)
SUMMARY OF APPLICATIONS FOR TESTING METHODS: NONDESTRUCTIVE

Test Method	Principle	Main Application	Advantages	Limitations
Radiography	Gamma radiation attenuates when passing through the concrete. Extent of attenuation is controlled by density and thickness of concrete.	To locate internal cracks, voids, and vibrations in density and composition of concrete. To locate embedded reinforcing steel and voids in concrete.	Portable and relatively inexpensive compared to X-ray. Internal defects can be detected. No damage is done to the concrete.	Radiation intensity cannot be adjusted. Qualified technician required because of radiation source. Two opposite surfaces of component must be accessible.
Rebound Hammer	Measures surface hardness. Spring-driven hammer strikes the surface of concrete and rebound distance is noted on scale.	Estimation of compressive strength, uniformity, and quality of concrete.	Inexpensive. Large amounts of data can be quickly obtained. Good for determining uniformity of concrete. No damage to concrete tested.	Results are affected by the condition of the concrete surface tested. Does not give precise strength of predictions. Results are dependent on test operator.
Ultrasonic Pulse Velocity	Measures the transmission of an induced-pulsed compression wave propagating through the concrete.	Estimation of the quality and uniformity of concrete. Locates voids, cracks, and estimates depth of rebars.	Test can be performed quickly. It can also locate voids, cracks, and determine the depth of the reinforcement. No damage to the structure.	Does not give precise estimation of strength. Skills are required in analysis of results. Moisture variation and presence of rebar can affect results.

Notes:

Source: Ref. 29

TABLE 4-4
SUMMARY OF APPLICATIONS FOR TESTING METHODS: DESTRUCTIVE

Test Method	Principle	Main Application	Advantages	Limitations
Air Permeability	Determines the rate of recovery of air in a test hole after evacuation.	In situ assessment of the resistance of concrete to carbonation and to penetration of aggressive ions.	Locates corrosion and voids in grouted structural members.	Only a research model has been built.
Break-Off Test	Measures the internal force required at the top to break off the core at the bottom.	Estimation of strength of concrete.	Inexpensive and quick.	Minor repaired needed.
Chemical Method	Determines chemical characteristics of the concrete through different tests.	To identify chemical characteristics and determine chemical contents in concrete.	Provides information that may assist in determining cause(s) of distress.	Destructive and slow test to perform.
Cores	Physical measurement of actual corrosion using standard ASTM test methods.	To supplement and/or verify NDT results.	Informative.	Destructive and slow test.
Probe Penetration (Winds or Probe test)	Measures the depth of penetration into the concrete. Surface and subsurface hardness can be measured.	Estimation and compressive strength, uniformity, and quality of concrete.	Equipment is simple and durable. Good for determining quality of surface concrete.	Damages small areas. Does not give precise prediction of strength. Results are dependent on firing mechanism.

TABLE 4-4 (Continued)
SUMMARY OF APPLICATIONS FOR TESTING METHODS: DESTRUCTIVE

Test Method	Principle	Main Application	Advantages	Limitations
Pullout Test	Measures the force required to pull out a steel rod with an enlarged head cast into the concrete.	Estimates the compressive and tensile strength of concrete.	Measures directly the inplace strength of concrete.	Pull out devices must be inserted during construction or placed by coring in hardened concrete. Minor repairs are needed. Correlation to compressive strengths are questionable.

Notes:

Source: Ref. 29

TABLE 4-5
CONCRETE
SUMMARY OF DEGRADATION FACTORS, PRIMARY MANIFESTATIONS, AND METHODS AVAILABLE FOR THEIR DETECTION

		Direct Methods				Indirect Methods		
		Material Sampling/Testing						
Degradation Factor (Mechanism)	**Primary Manifestation (Effect)**	**Visual Inspection**	**Petrography**	**Strength**	**Chemical/ Microscopic**	**Ultrasonic**	**Acoustic Sounding**	**Penetrating Radar**
Chemical Attack				N/A				
Efflorescence/Leaching	Increased Porosity	Good	Good		Good	Good[2]	Good[2]	Fair[2]
Salt Crystallization	Cracking	Good[2]	Good		Good	Good[2]	Good[2]	Fair[2]
Alkali-Aggregate	Volume Change/Cracking	Good[2]	Good		Good	Good[2]	Good[2]	Fair[2]
Reactions[1]	Volume Change/Cracking	Good[2]	Good		Good			
Sulfate Attack	Increased	Good	Good		Good			
Bases and Acids	Porosity/Erosion							
Physical Attack					N/A			N/A
Freeze/Thaw Cycling	Cracking/Spalling	Good	Good	Good[3]		Fair	Fair	
Thermal	Cracking/Spalling	Good	Good	Good[3]				
Exposure/Thermal	Volume Change/Cracking	Good				Fair	Good	
Cycling	Section Loss	Good						
Irradiation	Cracking							
Abrasion/Erosion/ Corrosion								
Fatigue/Vibration								

Notes:

(1) Includes reactions of cement-aggregate and carbonate aggregate.
(2) After significant deterioration, material sampling/testing techniques would be used to identify the cause.
(3) The strength tests only reveal the effect that elevated temperature or irradiation has after the fact on mechanical properties. Testing must be done under representative conditions to determine effects while under service conditions.

N/A - Not applicable.

Source: Ref. 26

TABLE 4-6
MILD STEEL REINFORCEMENT
SUMMARY OF DEGRADATION FACTORS, PRIMARY MANIFESTATIONS, AND METHODS AVAILABLE FOR THEIR DETECTION

Degradation Factor (Mechanism)	Manifestation (Effect)	Method				
		Visual Inspection	Half Cell Potential or Polarization	Radiography	Material Sampling	Penetrating Radar
Corrosion	Concrete cracking/spalling, reduced section	Good	Good	Fair	Good	N/A
Elevated Temperature	Decreased yield strength	Poor	N/A	N/A	Good(1)	N/A
Irradiation	Reduced ductility, increased yield strength	Poor	N/A	N/A	Good(1)	N/A
Fatigue	Bond loss, fracture	Good	N/A	Fair	Good(1)	Poor

Notes:

(1) Material sampling, e.g., strength testing, only reveals the effects that elevated temperature or irradiation has after the fact on mechanical properties. Testing must be done under representative conditions to determine effects while under service conditions.

N/A - Not applicable.

Source: Ref. 26

TABLE 4-7
PRESTRESSING SYSTEM
SUMMARY OF DEGRADATION FACTORS, PRIMARY MANIFESTATIONS, AND METHODS AVAILABLE FOR THEIR DETECTION

Degradation Factor (Mechanism)	Manifestation (Effect)	Method		
		Visual Inspection	Half Cell Potential or Polarization	Material Sampling
Corrosion	Embrittlement, reduced section	Good	Good	Good
Elevated Temperature	Reduced strength, increased relaxation	Poor	N/A	Good(1)
Irradiation	Reduced ductility, increased strength	Poor	N/A	Good(1)
Fatigue	Concrete cracking, tendon failure	Good	N/A	Good(1)

Notes:

(1) Material sampling, e.g., strength testing, only reveals the effects that elevated temperature or irradiation has after the fact on mechanical properties. Testing must be done under representative conditions to determine effects while under service conditions.

N/A - Not applicable.

Source: Ref. 26

TABLE 4-8
STEEL CONTAINMENT SHELLS AND CONCRETE CONTAINMENT LINERS
SUMMARY OF DEGRADATION FACTORS, PRIMARY MANIFESTATIONS, AND METHODS AVAILABLE FOR THEIR DETECTION

Degradation Factor (Mechanism)	Manifestation (Effect)	Visual Inspection	Liquid Dye Penetrant	Magnetic Particle	Eddy Current	Magnetography	Ultrasonic	Electromagnetic Acoustic Transducer	Half Cell Potential
Corrosion General Pitting Crevice MIC Aggressive Chemical Attack Galvanic or Dissimilar Metal Corrosion	Rust staining, coating, peeling, pitting, cracking, rust	Good(6)	N/A	N/A	N/A	N/A	Good	Fair(7)	Fair(7)
Fatigue	Cracks	Good(1)	Good(5)	Fair(2)	Good(3)	Good(4)	N/A	N/A	N/A
Coating Degradation	Cracking, peeling, gouges, scratches, pinholes	Good	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes:

(1) Cracks under coatings cannot be visually detected unless the coating is deteriorated.
(2) Detection through a coating depends on flaw size, shape, depth, orientation and location, and coating thickness [Ref. 28].
(3) Good for detecting flaws in toe of weld through a coating system.
(4) Good for underwater surfaces on improperly cleaned weld surfaces.
(5) Good for uncoated surfaces and stainless steel surfaces.
(6) Detect deterioration of surface coating and corrosion. Does not detect corrosion under intact coating.
(7) Advanced technique for inspecting embedded portions of liner or steel shell. Limited effectiveness.
N/A - Not applicable.

The first line of preventive maintenance includes inspecting the accessible parts of the coating system at regular intervals, such as at the end of each operating cycle. Degraded areas of coatings are repaired by the removal of old coating, preparation of the surface, and application of new coating.

The flexible sealant joint that is installed for many plants at the juncture of the exposed steel containment or liner to the embedded portion at the base is a source of potential corrosion. The sealant protection against the entry of moisture, oxygen, microbes, or other potentially corrosive agents into this area is effective for about 2 to 10 years. Therefore, maintenance of these seals is important to the corrosion protection for the steel containment or liner in this area.

ASME Code Section XI, Subsection IWE, IWE-2500, is applied for the controlled inspection of containment coatings as moisture barriers.

(2) Bellows Repair/Replacement

Damage to stainless steel penetration bellows includes holes, dents, gouges, or cracks, some of which may result from fatigue. CLB repair and replacement programs applied at some plants aid in the effective management of bellows fatigue in mechanical penetrations or free-standing steel containment. Welded repairs have been made to both single-ply and double-ply bellows, including repair of holes using patches and repair of slots by groove welding [Ref. 25]. Dents can also be repaired using small contour anvils to force the convolution to its original shape. Surface blending can be used to repair minor dents or gouges.

Defective bellows assemblies can be replaced in cases where repair cannot be accomplished. Entire bellows assemblies have been removed and replaced in situ. The replacement method was qualified by fatigue testing and hydrotesting of the facsimile bellows as required by the ASME Code Case N-315, 1989.

The study reported in NUREG/CP-0120 [Ref. 28] recommends a replacement program for bellows assemblies that are part of the containment pressure boundary based on a 10- to 15-year bellows design life. The study found that most bellows failures initially have minor impact on the total penetration leakage as tested in accordance with Appendix J. It is recommended, however, that bellows be replaced or repaired when testing indicates loss of leaktightness, regardless of whether the integrated leakage for all the penetrations as a group is acceptable.

Degradation of bellows is managed by periodically leak testing the individual penetration assemblies. Results of the testing can be trended to determine penetration failures attributable to degradation of the leaktight capability of the bellows.

Penetration bellows assemblies require maintenance of their pressure-retaining function. Typical damage to bellows that is discovered during maintenance inspections include dents, holes, or gouges. If unrepaired, this damage can impact the fatigue life and the intended function of the bellows as part of the containment system boundary. Preventive steps that could extend the service life of bellows assemblies include:

- Welding procedures that minimize internal particulate contamination

- Carefully drying bellows following any activities that could have exposed the bellows to spray activities in the containment

A bellows replacement program should be established based on the leakage indication or a predicted service life.

(3) Cathodic Protection

Cathodic protection systems are used at some plants to control corrosion and provide assistance in the effective management of corrosion in the steel liner and containment, as well as post-tensioned systems. Cathodic protection systems use electrochemical reactions to prevent or stop the corrosion of carbon steel components. The method is based on converting all anodic areas on the corroding surface to cathodic areas. The two types of cathodic protection systems are the sacrificial (galvanic) anode system and the impressed- current anode system [Ref. 25]. Basically, the sacrificial anode system is generally limited to smaller components, such as a buried carbon steel pipeline. A typical sacrificial anode for that application is magnesium, which is sacrificed rather than the steel.

The impressed-current systems are used to protect larger components and are more complex, therefore requiring more maintenance. The use of an impressed-current system is an advantage in a low-conductivity environment, such as concrete. The anode can be located remotely, which produces more efficient current distribution over the surface of a component that is cathodically protected.

Overprotection by an impressed-current system with too large of a voltage difference or too much external current can cause damage to the containment. Types of damage include: blistering or loss of bond between the coating and the steel surface; hydrogen embrittlement of high-strength steels such as tendons in post-tensioned containments; or stray current corrosion of adjacent metal components.

Criteria for cathodic protection of buried steel pipelines have been developed by the National Association of Corrosion Engineers. These criteria are based on the voltage of the protected metal surface because the voltage drop can be readily measured by the use of a reference electrode.

4.1.6 Concrete – Freeze-Thaw Degradation (AMP-5.1 and AMP-5.2)

This degradation mechanism is potentially significant only in colder geographic regions where freeze-thaw cycles can cause damage. This issue is plant-specific and only requires action on a case-by-case basis. Damage can occur in areas where snow or water collects and freezes.

This can result in cracking or local deterioration of the concrete leading to potential corrosion of the steel. The inservice examination program to manage the aging effects of freeze-thaw is based on ASME Section XI, Subsection IWL and/or ACI documents that provide structured guidance for inspection and repair activities. Similar plant-specific programs may be substituted. The attributes associated with such an inspection program are shown in Tables 4-9 and 4-10 (AMP-5.1, for the concrete containment and AMP-5.2, for the shield building).

Surveillance or inspection techniques, frequency of inspection, acceptance criteria, corrective actions, and confirmation activities are defined for the program in Subsection IWL of the ASME Code Section XI for the concrete containment or in ACI procedures for the shield building. Inspection techniques for the detection of indications of aging effects resulting from freeze-thaw for the concrete containment include VT-3C or general visual inspection, as described in IWL-2500. Currently, a VT-3C or general visual examination can be conducted for all accessible areas to determine the general structural condition through the identification of suspect areas where evidence of deterioration is found. VT-1C or detailed visual examinations are conducted for selected suspect areas. Proper application of the examination methods is defined in Table IWL-2500-1 of Section XI, Examination Category L-A, which defines the surface area to be examined and the corresponding examination method. All areas subject to freeze-thaw damage are accessible for inspection, i.e., areas where snow or water collects in pools. ACI-201.1 R-68, as referenced in IWL-2510, provides guidance on evidence of conditions indicative of degradation. The above examination methods are acceptable for the detection of pattern cracking, spalling, and scaling, indications and aging effects of freeze-thaw degradation, which can be evaluated or repaired prior to the loss of an intended function. Similar guidance is provided in ACI-201.1 R-68, ACI-207.3 R-79, ACI-224.1R-89, and ASTM C823 for the shield building.

Subsection IWL-2410 provides inspection periods in terms of calendar years of operation. IWL-2410 recommends that the concrete be examined at 1, 3, and 5 years following the completion of the containment structural integrity test, and every 5 years thereafter. The 5-year interval should be extended for the plant license renewal period. This frequency is an accepted time period to detect degradation prior to the loss of intended function. A similar examination frequency is recommended for the shield building in ACI-349.3 R-95.

Article IWL-3000, Acceptance Standards, provides the acceptance criteria. Table IWL-2500-1 provides applicability of acceptance standards for corresponding surface areas. Acceptance is based on extent of degradation, such as crack width, acceptance based on evaluation, or acceptance based on repair. ACI-201.1 R-68, as referenced in IWL-2510, provides guidance on evidence of conditions indicative of degradation. Indications that do not meet acceptance criteria are subject to repair or evaluation, IWL-3212 and IWL-3213, until the condition is acceptable so that the intended function is maintained. Similar guidance is provided in ACI-201.2 R-77, ACI-224.1 R-89, ACI-224 R-89, ACI-301, ACI-318, and ACI-349 for the shield building.

TABLE 4-9
AGING MANAGEMENT PROGRAM ATTRIBUTES - AMP-5.1
CONCRETE CONTAINMENT- FREEZE-THAW DEGRADATION
CODE REFERENCES TO 1992 WITH 1992 ADDENDA ASME SECTION XI EDITION

Attribute	Description	Containment Application	
Scope	Components and applicable aging effects	Component Class CC Concrete Containment	Effect Reduced strength caused by concrete cracking, concrete degradation, and rebar corrosion
Surveillance Technique	Monitoring, inspection, or testing techniques used to detect the effect	Examine following ASME Subsection IWL, Requirements for Class CC Concrete Components of Light-Water Cooled Power Plants, Examination Category L-A, Concrete IWL-2510, Examination of Concrete IWL-2511, Areas Subject to Examination IWL-2512, Examination of Surface Condition (visual examination) ACI 201.1R-68, "Guide for Making a Condition Survey of Concrete in Service"	
Frequency	Time period between program performance or when a one-time inspection must be completed	Inspection: IWL-2410	
Acceptance Criteria	Qualitative or quantitative criteria that determine when corrective actions are needed	IWL-3110 and IWL-3210, Concrete Surface Condition • IWL 3111, Acceptance by Examination • IWL-3112, Acceptance by Evaluation, IWL-3300 • IWL-3211, Acceptance by Examination • IWL-3212, Acceptance by Evaluation; IWL-3300, Evaluation	
Corrective Actions	Actions to prevent, mitigate, or reverse the consequences of the effect	IWL-3113, Acceptance by Repair IWL-3112, Acceptance by Evaluation, IWL-3300 IWL-3213, Acceptance by Repair IWL-3212, Acceptance by Evaluation; IWL-3300, Evaluation	
Confirmation	Post-maintenance test or other techniques to confirm that the actions have been completed and are effective	IWL-2230, Preservice Examination of Repairs and Modifications IWL-3100 Preservice Examination following adjustment, repair, or replacement prior to return of the system to service IWL-3310 Evaluation Report All records generated by corrective actions and inspections shall be maintained as defined by 10 CFR Part 50, Appendix A, Criterion 1 - Quality Standards and Records	

TABLE 4-10
AGING MANAGEMENT PROGRAM ATTRIBUTES - AMP-5.2
CONCRETE SHIELD BUILDING - FREEZE-THAW DEGRADATION

Attribute	Description	Containment Application	
Scope	Components and applicable aging effects	<u>Component</u> Shield Building	<u>Effect</u> Reduced strength caused by concrete cracking, concrete degradation, and rebar corrosion
Surveillance Technique	Monitoring, inspection, or testing techniques used to detect the effect	Examine concrete surfaces in area of potential degradation using ACI guidance: AACI-201.1R-68, "Guide for Making a Condition Survey of Concrete in Service" ACI-207.3R-79, "Practices for Evaluation of Concrete in Existing Massive Structures for Service Conditions" ACI 224.1R-89, "Causes, Evaluation, and Repair of Cracks in Concrete Structures" ASTM C823, "Standard Recommended Practice for Examination and Sampling of Hardened Concrete in Constructions"	
Frequency	Time period between program-performance or when a one-time inspection must be completed	An evaluation frequency of at least once every 5 years is the recommendation that is contained in ACI 349.3R-95, "Evaluation of Existing Nuclear Safety-Related Concrete Structures"	
Acceptance Criteria	Qualitative or quantitative criteria that determine when corrective actions are needed	The following may be referenced for acceptance criteria: ACI 201.2R-77, "Guide to Durable Concrete" ACI 224.1R-89, "Causes, Evaluation, and Repair of Cracks in Concrete Structures" ACI 224R-89, "Control of Cracking in Concrete Structures" ACI 301, "Specification for Structural Concrete for Buildings" ACI 318, "Building Code Requirements for Reinforced Concrete" ACI 349	
Corrective Actions	Actions to prevent, mitigate, or reverse the consequences of the effect	The following documents may be referenced when developing a corrective action to mitigate a structural degradation that was determined to be a concern for continuous plant operation: ACI 207.3R-79, "Practices for Evaluation of Concrete in Existing Massive Structures for Service Conditions" ACI 224.1R-89, "Causes, Evaluation, and Repair of Cracks in Concrete Structures" ACI 318, "Building Code Requirements for Reinforced Concrete" "Concrete Manual," A Water Resources Technical Publication, U.S. Department of the Interior ACI 201.2R-77, "Guide to Durable Concrete" ACI 222R-89, "Corrosion of Metals in Concrete" ACI 224R-89, "Control of Cracking in Concrete Structures"	
Confirmation	Post-maintenance test or other techniques to confirm that the actions have been completed and are effective	Perform concrete inspections during any repair process in compliance with requirements of: ACI 301, "Specification for Structural Concrete for Buildings" ACI 318, "Building Code Requirements for Reinforced Concrete"	

Corrective actions involve repair and evaluations as defined in IWL-3112 and IWL-3113, for preservice examination of the concrete surface condition, and IWL-3212 and IWL-3213, for inservice examination of surface conditions. Evaluations should be performed in accordance with IWL-3300 and an evaluation report must be prepared. The report should provide the following information, as described in IWL-3310:

- The cause of the condition that does not meet the acceptance standards
- The acceptability of the concrete containment without repair
- Whether or not repair or replacement is required and the extent, method, and schedule of repair, if repair is required
- The extent, nature, and frequency of additional examinations

Use of Article IWL-4000 guidelines is recommended for the development of repair procedures. IWL-4000 describes repair procedures for degradation that is unacceptable according to the acceptance criteria or evaluation. The procedure recommends: defective materials be removed; visual examination of affected areas and reinforcing steel to ensure proper surface preparation before the placement of repair material; VT-1 visual examination of reinforcing steel and repair if required; chemical, mechanical, and physical compatibility between existing and repair material; and requirements for in-processing sampling and testing of repair materials. In addition, when detensioning of prestressing tendons is required for repair of the concrete surface, repair procedures should include specifications for repair materials, procedures for the application of repair materials, and procedures for the detensioning and retensioning of the prestressing system. These repairs correct the degradation that was detected and restore the surfaces, or an evaluation is provided that determines the acceptability of the suspect area so that the intended function is maintained. The repair is confirmed by preservice examination and testing prescribed by IWL -2230 and IWL-3100. Similar guidance is provided in ACI-207.3 R-79, ACI-224.1 R-89, ACI-224 R-89, ACI-222 R-89, ACI-318, and ACI-201.2 R-77 for the shield building.

Subsections IWL-2230 and IWL-3100 establish the preservice record of the repaired area. This is done by performing a post-repair examination of the affected area. The responsible engineer determines that there is no evidence of degradation sufficient to require further repair or evaluation. If evaluation is required, a report must be provided in accordance with IWL-3300, establishing the acceptability of containment without repair. The requirements of IWL-2230 and IWL-3100 provide the confirmation that the degradation has been eliminated and the intended function will be maintained. ACI-301 and ACI-318 apply to the shield building.

The intended function of the containment affected by freeze-thaw, i.e., protection of the environment from the unacceptable release of radiation and the protection of the containment interior systems from external loadings, are maintained since the potential aging effects are detected and repaired or evaluated prior to the occurrence of significant damage.

4.1.7 Concrete – Aggressive Chemical Attack (AMP-5.3 and AMP-5.4)

This program is applicable for below-grade concrete containment and basemat and inaccessible portions of the containment interior, only where groundwater chemistry and interior leakage provide an environment conducive to aggressive chemical attack. Deterioration due to chemical attack is a potential threat in plants where the groundwater is acidic (pH $\leq$ 5.5) and the chloride and/or sulfate concentrations are greater than 500 to 1500 ppm, respectively. The groundwater must be in direct contact with the foundation or exterior walls. Concrete degradation can occur, leading to corrosion of the reinforcing steel, below-grade parts of liners, and steel containments. This management program consists of three phases, including testing, inspection, and evaluation, management or repair. The extent of involvement is based on the level of indications from each phase. The primary step of this program is to test the groundwater and/or soil chemistry for sulfate and chloride content as well as pH, to determine if the environment would promote an aggressive chemical attack and to provide a benchmark for further monitoring, if required. The next step, if an aggressive chemistry is indicated, is the inspection of the concrete in the affected zone. When damage is indicated by inspection of concrete, then an evaluation can be performed for the inaccessible area or groundwater management can be employed.

Concrete inspection should be performed once a damaging environment is indicated by groundwater testing. Waterproofing membranes have most likely been provided in the design; however, the integrity of the waterproofing system cannot be ensured since it cannot be inspected because it is below ground. Sample areas of exterior surfaces that are below the groundwater table would be visually inspected where groundwater chemistry is suspect, focusing on the area where the groundwater fluctuates. If it is found from the visual inspections that there is no evidence of corrosion, cracking or other indications (e.g., loss of sealants at joints), then it can be assumed that the protective medium is sound and the inaccessible areas are protected.

If deterioration is found at the sample area, the acceptability of inaccessible areas is evaluated in accordance with changes to 10 CFR 50.55a, as described in SECY-96-080. Concrete containments are evaluated using the revised rule § 50.55a (b) (2) (ix) (E), while steel liners and steel containments are evaluated using the revised rule § 50.55a (b) (2) (x) (A).

Corrective actions may include repairs, groundwater management, or evaluation of the degradation rate. If deterioration is found, the need for repairs should be evaluated. If the repairs are not feasible due to technical or cost reasons, groundwater management could be undertaken. Groundwater management may consist of one or more of the following: use of a barrier system; lowering of the groundwater table; or performing an analysis to demonstrate that the rate of continued degradation will not cause loss of function for the remaining plant life (original or extended), or until corrective actions can be taken.

The groundwater testing program attributes are defined based on technical documents from the public domain. Surveillance or inspection techniques, frequency of inspection, acceptance criteria, corrective actions, and confirmation activities are defined for concrete inspection and testing and the repair program in Subsection IWL of the ASME Code Section XI for the concrete containment or in ACI procedures for the shield building.

Groundwater and/or soil testing and leakage monitoring programs are applied to monitor the environment for conditions conducive to aggressive chemical attack. These methods are acceptable for the detection of conditions required to instigate aggressive chemical attack. Further actions instigated by adverse indications will result in evaluation or repair, if so warranted, prior to the loss of an intended function. The frequency of inspection is based on practicality, i.e., inspection during each refueling outage, but is less than the frequency prescribed for concrete inspection, every 5 years, which is an accepted time period to detect degradation prior to the loss of intended function. Acceptance criteria for soil chemistry is based on public domain documents [Refs. 15, 17, 18]. Indications that do not meet acceptance criteria instigate further inspections, which may result in repairs or evaluations, until the condition is acceptable so that the intended function is maintained.

Concrete inspection techniques for detecting indications of aging effects from aggressive chemical attack include VT-3C or general visual inspection, as described in IWL-2500. These visual inspections would be applied initially in sample below-grade areas when, and only when, aggressive environments are indicated. Currently, a VT-3C or general visual examination can be conducted for all accessible areas to determine the general structural condition through the identification of suspect areas, where evidence of deterioration is found. Excavation most likely would be required to make the sample area available for inspection. VT-1C or detailed visual examinations are conducted for selected suspect areas of the sample area.

Proper application of the visual examination methods is defined in Table IWL-2500-1 of Section XI, Examination Category L-A, which defines the surface area to be examined and the corresponding examination method. ACI-201.1 R-68, as referenced in IWL-2510, provides guidance on evidence of conditions indicative of degradation. The above examination methods are acceptable for the detection of cracking, spalling, staining, seepage, voids, and discoloration, indications and aging effects of aggressive chemical attack that can be evaluated or repaired prior to the loss of an intended function. Similar guidance is provided in ACI-201.1 R-68, ACI-207.3 R-79, ACI-224.1R-89, and ASTM C823 for the shield building.

Paragraph IWL-2410 provides inspection periods in terms of calendar years of operation. IWL-2410 recommends that the concrete be examined at 1, 3, and 5 years following the completion of the containment structural integrity test, and every 5 years thereafter for accessible areas. The 5-year interval should be extended for the plant license renewal period. This frequency is an accepted time period to detect degradation prior to the loss of intended function. A similar examination frequency is recommended for the shield building in ACI-349.3 R-95. A single inspection of the inaccessible areas below grade should be sufficient unless excessive degradation is noted, i.e., where through evaluation the structural integrity and the protective environment of concrete coverage over embedded steel can not be projected with margin to remain intact for the extended life of the plant.

Article IWL-3000, Acceptance Standards, provides the acceptance criteria. Table IWL-2500-1 provides applicability of acceptance standards for corresponding surface areas. Acceptance is based on extent of degradation, such as crack width, acceptance based on evaluation, or acceptance based on repair. ACI-201.1 R-68, as referenced in IWL-2510, provides guidance on evidence of conditions indicative of degradation. Indications that do not meet acceptance criteria are subject to repair or evaluation until the condition is acceptable so that the intended function is maintained. Similar guidance is provided in ACI-201.2 R-77, ACI-224.1 R-89, ACI-224 R-89, ACI-301, ACI-318, and ACI-349 for the shield building.

Corrective actions involve the evaluation of the accessible area as described in SECY-96-080, which defines changes to 10 CFR 50.55a. Inaccessible areas of concrete containments are evaluated using the revised rule § 50.55a (b) (2) (ix) (E), while steel liners and steel containments are evaluated using the revised rule § 50.55a (b) (2) (x) (A). When conditions exist for accessible areas that are indicative of the existence or that would result in degradation of adjacent inaccessible areas, the acceptability of the inaccessible areas may be evaluated and the following should be provided in the ISI summary report required by IWA-6000:

- A description of the type and estimated extent of degradation and the cause of the degradation
- An evaluation of each inaccessible area and the result of the evaluation
- A description of corrective actions required (only if required) to mitigate the degradation

Use of Article IWL-4000 guidelines is recommended for the development of repair procedures, when repairs are applied. IWL-4000 provides repair procedures for unacceptable degradation according to the acceptance criteria or evaluation. The procedure requires: that defective materials be removed; visual examination of affected areas and reinforcing steel to ensure proper surface preparation before the placement of repair material; VT-1 visual examination of reinforcing steel and repair if required; chemical, mechanical, and physical compatibility between existing and repair material; and, requirements for in-processing sampling and testing of repair materials. In addition, when detensioning of prestressing tendons is required for repair of the concrete surface, repair procedures shall include specifications for repair materials, procedures for the application of repair materials, and procedures for the detensioning and retensioning of the prestressing system. These repairs correct the degradation that was detected and restore the surfaces, or an evaluation is provided that determines the acceptability of the suspect area so that the intended function is maintained. The repair is confirmed by preservice examination and testing prescribed by IWL-2230 and IWL-3100. Groundwater management is another option for correction. Similar guidance is provided in ACI-207.3 R-79, ACI-224.1 R-89, ACI-224 R-89, ACI-222 R-89, ACI-318, and ACI-201.2 R-77 for the shield building.

Paragraphs IWL-2230 and IWL-3100 establish the preservice record of the repaired area. This is done by performing a post-repair examination of the affected area. The responsible engineer determines that there is no evidence of degradation sufficient to require further repair or evaluation. If evaluation is required, a report shall be provided in accordance with IWL-3300 establishing the acceptability of containment without repair. The requirements of IWL-2230 and IWL-3100 provide the confirmation that the degradation has been eliminated and the intended function will be maintained. ACI-301 and ACI-318 apply to the shield building.

The intended function of the containment affected by aggressive chemical attack, i.e., protection of the environment from the unacceptable release of radiation and the protection of the containment interior systems from external loadings, are maintained since the potential aging effects are detected and repaired or evaluated prior to the occurrence of significant damage.

The aging management program attributes are shown in Tables 4-11 and 4-12.

4.1.8 Concrete Reinforcing Steel and Steel Embedments – Corrosion (AMP-5.3 and AMP-5.4)

This program is applicable for below-grade concrete containment and basemat, only where groundwater chemistry provides an environment conducive to aggressive chemical attack. For corrosion to be a potentially significant degradation mechanism for these structural components, water must be present causing deterioration of the concrete that acts as the protective medium. The same aging management programs used for aggressive chemical attack are applied here (AMP-5.3, Table 4-11, for the concrete containment, and AMP-5.4, Table 4-12, for the shield building and foundation mat).

TABLE 4-11
AGING MANAGEMENT PROGRAM ATTRIBUTES – AMP-5.3
CONCRETE CONTAINMENT - AGGRESSIVE CHEMICAL ATTACK - CORROSION
CODE REFERENCES TO 1992 WITH 1992 ADDENDA ASME SECTION XI EDITION

Attribute	Description	Containment Application	
Scope	Components and applicable aging effects	<u>Component</u> Class CC Concrete Containment	<u>Effect</u> Acidic solution - reduced strength caused by concrete cracking, concrete degradation, and rebar corrosion, or by increased porosity.
Surveillance Technique	Monitoring, inspection, or testing techniques used to detect the effect	1. Monitor quality of groundwater for plants where chemistry is questionable 2. Examine following ASME Subsection IWL, Requirements for Class CC Concrete Components of Light-Water Cooled Power Plants, Examination Category L-A, Concrete IWL-2510, Examination of Surface Condition (visual examination) ACI 201.1R-68, "Guide for Making a Condition Survey of Concrete in Service" 3. Leakage identification and monitoring program inside of containment building	
Frequency	Time period between program performance or when a one-time inspection must be completed	1. Each refueling outage 2. Inspection: IWL-2410 for accessible areas, one-time inspection for inaccessible area exterior to containment and below grade, unless further inspections are warranted by significant degradation, as determined by responsible engineer 3. Each refueling outage	

TABLE 4-11 (Continued)
AGING MANAGEMENT PROGRAM ATTRIBUTES - AMP-5.3
CONCRETE CONTAINMENT - AGGRESSIVE CHEMICAL ATTACK - CORROSION
CODE REFERENCES TO 1992 WITH 1992 ADDENDA ASME SECTION XI EDITION

Attribute	Description	Containment Application
Acceptance Criteria	Qualitative or quantitative criteria that determine when corrective actions are needed	1. Obtain water chemistry and compare to acceptable limits (pH>5.5 and chloride and/or sulfate concentrations < 500 or 1500 ppm, respectively) [Refs. 13, 15, and 16] 2. IWL-3110 and IWL-3210, Concrete Surface Condition • IWL 3111, Acceptance by Examination • IWL-3112, Acceptance by Evaluation, IWL-3300 • IWL-3211, Acceptance by Examination • IWL-3212, Acceptance by Evaluation, IWL-3300 3. Plant-specific leakage monitoring criteria • Collection of fluid, • Increase in temperature, • Increase in humidity level, <u>OR</u> • Change in fluid volume, • Increase in radioactivity

TABLE 4-11 (Continued)

AGING MANAGEMENT PROGRAM ATTRIBUTES – AMP-5.3

CONCRETE CONTAINMENT – AGGRESSIVE CHEMICAL ATTACK - CORROSION

CODE REFERENCES TO 1992 WITH 1992 ADDENDA ASME SECTION XI EDITION

Attribute	Description	Containment Application
Corrective Actions	Actions to prevent, mitigate, or reverse the consequences of the effect	1. Change water chemistry or redirect groundwater as necessary <u>OR</u> follow 2. 2. Perform evaluation as described in SECY-96-080: Evaluate per § 50.55a (b) (2) (ix) (E) for the examination of concrete containments Evaluate per § 50.55a (b) (2) (x) (A) for the examination of steel liners and steel containments 3. Remove standing fluid, clean and restore affected surface, and identify source of leak and repair following 2.
Confirmation	Post-maintenance test or other techniques to confirm that the actions have been completed and are effective	1. Re-examine affected surfaces after cleaning or restoration <u>AND</u> Re-examine at next outage 2. IWL-2230, Preservice Examination of Repairs and Modifications IWL-3100 Preservice Examination following adjustment, repair, or replacement prior to return of the system to service IWL-3310 Evaluation Report 3. Continue monitoring All records generated by corrective actions and inspections shall be maintained as defined by 10 CFR Part 50, Appendix A, Criterion 1 - Quality Standards and Records

TABLE 4-12
AGING MANAGEMENT PROGRAM ATTRIBUTES - AMP-5.4
CONCRETE SHIELD BUILDING AND FOUNDATION MAT – AGGRESSIVE CHEMICAL ATTACK - CORROSION

Attribute	Description	Containment Application	
Scope	Components and applicable aging effects	Component Concrete Shield Building, Foundation Mat	Effect Acidic solution - Reduced strength caused by concrete cracking, degradation, and rebar corrosion, or by increased concrete porosity
Surveillance Technique	Monitoring, inspection, or testing techniques used to detect the effect	1. Monitor quality of groundwater for plants where chemistry is questionable 2. Examine concrete surfaces in area of potential degradation using ACI guidance: ACI 201.1R-68, "Guide for Making a Condition Survey of Concrete in Service" ACI-207.3R-79, "Practices for Evaluation of Concrete in Existing Massive Structures for Service Conditions" ACI 224.1R-89, "Causes, Evaluation, and Repair of Cracks in Concrete Structures" ASTM C823, "Standard Recommended Practice for Examination and Sampling of Hardened Concrete Constructions" 3. Leakage identification and monitoring program inside of shield building	
Frequency	Time period between program performance or when a one-time inspection must be completed	1. Each refueling outage 2. Inspection: every 5 years 3. Each refueling outage	

TABLE 4-12 (Continued)

AGING MANAGEMENT PROGRAM ATTRIBUTES - AMP-5.4

CONCRETE SHIELD BUILDING AND FOUNDATION MAT - AGGRESSIVE CHEMICAL ATTACK - CORROSION

Attribute	Description	Containment Application
Acceptance Criteria	Qualitative or quantitative criteria that determine when corrective actions are needed	1. Obtain water chemistry and compare to acceptable limits (pH>5.5 and chloride and/or sulfate concentrations < 500 or 1500 ppm, respectively) 2. ACI 201.2R-77, "Guide to Durable Concrete" ACI 224.1R, "Causes, Evaluation, and Repair of Cracks in Concrete Structures" ACI 224R-89, "Control of Cracking in Concrete Structures" ACI 301, "Specification for Structural Concrete for Buildings" ACI 318, "Building Code Requirements for Reinforced Concrete" ACI 349 3. Plant-specific leakage monitoring criteria • Collection of fluid, • Increase in humidity level, • Change in fluid volume, • Increase in temperature, OR • Increase in radioactivity

TABLE 4-12 (Continued)

AGING MANAGEMENT PROGRAM ATTRIBUTES - AMP-5.4

CONCRETE SHIELD BUILDING AND FOUNDATION MAT - AGGRESSIVE CHEMICAL ATTACK - CORROSION

Attribute	Description	Containment Application
Corrective Actions	Actions to prevent, mitigate, or reverse the consequences of the effect	1. Change water chemistry or redirect groundwater as necessary OR follow 2. 2. ACI 201.2R-77, "Guide to Durable Concrete" ACI 222R-89, "Corrosion of Metals in Concrete" ACI 224.1R, "Causes, Evaluation, and Repair of Cracks in Concrete Structures" ACI 224R-89, "Control of Cracking in Concrete Structures" ACI 207.3R-79, "Practices for Evaluation of Concrete in Existing Massive Structures for Service Conditions" ACI 318, "Building Code Requirements for Reinforced Concrete" "Concrete Manual," A Water Resources Technical Publication, U.S. Department of the Interior 3. Remove standing fluid, clean and restore affected surface, and identify source of leak and repair following 2.

TABLE 4-12 (Continued)

AGING MANAGEMENT PROGRAM ATTRIBUTES - AMP-5.4

CONCRETE SHIELD BUILDING AND FOUNDATION MAT – AGGRESSIVE CHEMICAL ATTACK - CORROSION

Attribute	Description	Containment Application
Confirmation	Post-maintenance test or other techniques to confirm that the actions have been completed and are effective	1. Perform concrete inspections during any repair process in compliance with requirements of: ACI 301, "Specification for Structural Concrete for Buildings" ACI 318, "Building Code Requirements for Reinforced Concrete" 2. Re-examine affected surfaces after cleaning or restoration <u>AND</u> Re-examine at next outage 3. Continue monitoring All records generated by corrective actions and inspections shall be maintained as defined by 10 CFR Part 50, Appendix A, Criterion 1 - Quality Standards and Records

4.1.9 Liner, Steel Containment Shell, Penetrations, and Airlocks and Hatches - Corrosion, SCC, TGSCC, Embrittlement and Loss of Pressure Retention, Mechanical Wear, and Fatigue (AMP-5.5)

This aging management program manages several potential aging effects: corrosion; SCC; TGSCC; embrittlement and loss of pressure retention; mechanical wear; and fatigue.

Potential corrosion is controlled by the use of coatings on exposed surfaces above grade, while local corrosion is managed by the inspections associated with the integrated leak rate tests or those applied through Section XI, Subsection IWE of the ASME Code. For embedded parts of the liner, corrosion is a potentially significant degradation mechanism. Corrosion of inaccessible areas is monitored through the inspection of adjacent accessible portions and sealing mechanisms, where degradation is indicative of possible degradation of the inaccessible area. Those areas of the liner and steel containment shell below grade are subject to deterioration when exposed to aggressive aqueous solutions. This has been discussed previously for aggressive chemical attack of the concrete. The attributes associated with an aging management program addressing this mechanism is given in Table 4-13.

Inspection and leakage monitoring programs, in combination with the programs that address aggressive chemical attack for the below-grade portion of containment, provide an effective program for management of the effects of corrosion. A portion of the inspection program is based on ASME Section XI, Subsection IWE, which provides structured guidance for inspection and repair activities. Similar plant-specific programs may be substituted. Surveillance or inspection techniques, frequency of inspection, acceptance criteria, corrective actions, and confirmation activities are defined for the program in Subsection IWE of the ASME Code Section XI for the free-standing steel containment or the concrete containment steel liner. Similar plant-specific programs may be substituted. Inspection techniques for the detection of indications of aging effects resulting from corrosion include visual inspection and local leak rate testing as described in IWE-2500. The inspection program is applied in combination with a leakage monitoring program, which limits the exposure of steel components to corrosive environments. Seals, moisture barriers, gaskets, welds, as part of the containment surface, and accessible surface areas near inaccessible areas are subject to visual inspection. General visual examination can be performed for all accessible surface areas, while VT-3 visual examination is applied for areas that are submerged or insulated, and for moisture barriers, seals, and gaskets. Containment penetration welds, as part of the surface, and pressure-retaining bolting are visually inspected using the VT-1 examination methods. Nondestructive testing and VT-1 visual examinations are conducted for selected suspect areas and augmented inspections are required for repairs or suspect areas. Inaccessible regions are protected through inspection of seals, moisture barriers, gaskets, and nonvisible damage can be indicated by corrosion of accessible areas near inacessible areas.

TABLE 4-13

AGING MANAGEMENT PROGRAM ATTRIBUTES – AMP-5.5

LINER, STEEL CONTAINMENT SHELL, PENETRATIONS, COATINGS, AND AIRLOCKS AND HATCHES – EMBRITTLEMENT AND LOSS OF PRESSURE RETENTION, MECHANICAL WEAR, FATIGUE, CORROSION, SCC, AND TGSCC

CODE REFERENCES TO 1992 WITH 1992 ADDENDA ASME SECTION XI EDITION

Attribute	Description	Containment Application	
Scope	Components and applicable aging effects	<u>Component</u> Steel Containment Steel Liner Coatings Airlock & Hatches Penetrations per Table 2-17	<u>Effect</u> Corrosion due to borated or demineralized water, chloride and/or sulfate in groundwater or galvanic action of dissimilar metals, stress corrosion cracking • Reduced load capacity caused by loss of material • Leakage
Surveillance Technique	Monitoring, inspection, or testing techniques used to detect the effect	1. Examine components per Subsection IWE, Requirements for Class MC and Metallic Liners of Class CC Components of Light-Water Cooled Power Plants Examination Categories: E-A, Pressure-Retaining Welds in Vessels E-A-1, Nonpressure-Retaining Welds E-B, Pressure-Retaining Welds in Containment Penetrations E-C, Pressure-Retaining Welds in Airlocks and Equipment Hatches E-D, Seals and Gaskets E-E, Integral Attachments E-F, Pressure-Retaining Dissimilar Metal Welds E-G, Pressure-Retaining Bolting E-P, All Pressure-Retaining Components • IWE-2500, Examination and Pressure Test Requirements per Table IWE-2500-1 (VT-1; VT-3; 10 CFR 50, Appendix J) <u>OR</u> • IWA-2240, Alternative Examinations • IWE-2600, Condition of Surface to Be Examined 2. Leakage identification and monitoring program inside containment	

TABLE 4-13 (Continued)

AGING MANAGEMENT PROGRAM ATTRIBUTES - AMP-5.5

LINER, STEEL CONTAINMENT SHELL, PENETRATIONS, COATINGS, AND AIRLOCKS AND HATCHES B EMBRITTLEMENT AND LOSS OF PRESSURE RETENTION, MECHANICAL WEAR, FATIGUE, CORROSION, SCC, AND TGSCC

CODE REFERENCES TO 1992 WITH 1992 ADDENDA ASME SECTION XI EDITION

Attribute	Description	Containment Application
Frequency	Time period between program performance or when a one-time inspection must be completed	1. IWE-2400 Inspection Schedule IWE-2410 Inspection Program IWE-2412 Inspection Program B with Table IWE-2500-1 and IWA-2430(d) (Each 10 years follow 1st interval, 10-year inspection program of Table IWE-2412-1) 2. Each refueling outage
Acceptance Criteria	Qualitative or quantitative criteria that determine when corrective actions are needed	1. IWE-3112, Acceptance under Preservice Examination IWE-3122, Acceptance under Inservice Nondestructive Examinations IWE-3410, Acceptance Standards • Table IWE-3410-1, Acceptance Standards for each Examination Category 10 CFR 50, Appendix J, Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors, per Table IWE-2500-1 for Examination Category E-P IWE-3130, Inservice Visual Examinations IWE-3200, Supplemental Examinations IWE-3500 Acceptance Standards • IWE-3510, IWE-3511, IWE-3513 and IWE-3514 applies to visual examination of various components • IWE-3512 applies to augmented examinations • IWE-3515 applies visual examination and torque or load testing of pressure retaining bolting • IWE-5220 Testing Following Repair, Modification, or Replacement 2. Plant-specific leakage monitoring criteria • Collection of fluid, • Increase in humidity level, • Change in fluid volume, • Increase in temperature, OR • Increase in radioactivity

TABLE 4-13 (Continued)

AGING MANAGEMENT PROGRAM ATTRIBUTES - AMP-5.5

LINER, STEEL CONTAINMENT SHELL, PENETRATIONS, COATINGS, AND AIRLOCKS AND HATCHES - EMBRITTLEMENT AND LOSS OF PRESSURE RETENTION, MECHANICAL WEAR, FATIGUE, CORROSION, SCC, AND TGSCC

CODE REFERENCES TO 1992 WITH 1992 ADDENDA ASME SECTION XI EDITION

Attribute	Description	Containment Application
Corrective Actions	Actions to prevent, mitigate, or reverse the consequences of the effect	1. A. For accessible areas: IWE-3110, Preservice Examinations • IWE-3114, Repairs and Reexaminations (IWA-4000; IWA-2200; Table IWE-3410-1) IWE-3120, Inservice Nondestructive Examinations • IWE-3122.2, Acceptance by Repair • IWE-3122.3, Acceptance by Replacement • IWE-3122.4, Acceptance by Evaluation IWE-5250 Corrective Measures B. For inaccessible areas: • Perform evaluation as described in SECY-96-080 • Evaluate per § 50.55a (b) (2) (x) (A) for the examination of steel liners and steel containments 2. Remove standing fluid, clean and restore affected surface, and identify source of leak and repair following 1.

TABLE 4-13 (Continued)

AGING MANAGEMENT PROGRAM ATTRIBUTES - AMP-5.5

LINER, STEEL CONTAINMENT SHELL, PENETRATIONS, COATINGS, AND AIRLOCKS AND HATCHES - EMBRITTLEMENT AND LOSS OF PRESSURE RETENTION, MECHANICAL WEAR, FATIGUE, CORROSION, SCC, AND TGSCC

CODE REFERENCES TO 1992 WITH 1992 ADDENDA ASME SECTION XI EDITION

Attribute	Description	Containment Application
Confirmation	Post-maintenance test or other techniques to confirm that the actions have been completed and are effective	1. IWE-2200, preservice examination following adjustment, repair, or replacement prior to return of the system to service • IWE-2420, Successive Inspections • IWE-2430, Additional Examinations • IWE-3124, Repairs and Re-examinations 2. Re-examine affected surfaces after cleaning or restoration AND Re-examine at next outage All records generated by corrective actions and inspections shall be maintained as defined by 10 CFR Part 50, Appendix A, Criterion 1 - Quality Standards and Records

Visual evidence of corrosion for coated areas of the liner or steel containment, including welds, include flaking, blistering, peeling, discoloration, and other signs of deterioration. Uncoated areas are examined for evidence of discoloration, pitting, and rust. Gaskets, seals, and moisture barriers are inspected for wear, erosion, tears, surface cracks, and other flaws that may cause loss of the leaktight integrity. Leak rate testing of penetrations provides indications of visible or nonvisible degradation, i.e., through the detection of excessive leakage, and are performed in accordance with 10 CFR 50, Appendix J. Proper application of the examination methods is defined in Table IWE-2500-1 of Section XI, for all examination categories, which defines the parts to be examined and the corresponding examination method.

IWE-2420 requires successive inspections for suspect areas, i.e., re-examination during the next inspection period. The above examination methods are acceptable for the detection of the evidence of degradation, indications, and aging effects of corrosion that can be evaluated or repaired prior to the loss of an intended function.

Paragraph IWE-2410 provides inspection periods in terms of calendar years of operation. IWE-2412 recommends that the all examinations of steel liner or containment be performed within 10-year intervals following the completion of the first interval. The 10-year interval should be extended for the plant license renewal period. This frequency is an accepted time period to detect degradation prior to the loss of intended function.

Article IWE-3000, Acceptance Standards, provides the acceptance criteria. Table IWE-2500-1 and IWE-3410-1 provide applicability of acceptance standards for corresponding surface areas. Acceptance for visual inspections is based on the absence of evidence of degradation. Suspect areas shall be accepted by repair or evaluation. Acceptance standards are defined in IWE-3500. Acceptance criteria for augmented visual examination and nondestructive testing is defined in IWE-3120. Acceptance is based on the absence of flaws for visual inspection and acceptance for ultrasonic examination is based on a limit of 10-percent loss of material, current or projected prior to the next examination. IWE-5220 provides that leakage tests be performed following repair, modification, and replacement. 10 CFR 50, Appendix J provides acceptance criteria for leak rate testing. Plant-specific acceptance criteria are also applicable to the leakage monitoring program. Indications that do not meet acceptance criteria are subject to repair or evaluation until the condition is acceptable so that the intended function is maintained.

Corrective actions consist of repairs, replacement, or evaluation. Paragraph IWE-3100 provides for accessible areas requirements for repair and re-examination for suspect areas. IWE-3114 requires that repairs and re-examinations be conducted in accordance with IWA-4000 and IWA-2200. IWA-4000 provides rules and requirements for repair of pressure-retaining components and their supports, and IWA-2200 defines examination methods. Repairs must meet acceptance standards of Table IWE-3410-1. IWE-3122.2 requires that flaws or degradation unacceptable for continued service be removed by mechanical methods or repaired to the extent that IWE-3000 acceptance criteria are satisfied. IWE-3122.3 indicates that replacement is an acceptable alternative to repair. IWE-3122.4 permits acceptance by evaluation if the reduction in base metal is less than 10 percent of the nominal value, or the reduced thickness can be shown by analysis to satisfy design specifications.

When conditions exist for accessible areas that are indicative of the existence or that would result in degradation of adjacent inaccessible areas, the acceptability of the inaccessible areas may be evaluated and the following should be provided in the ISI summary report required by IWA-6000:

- A description of the type and estimated extent of degradation and the cause of the degradation
- An evaluation of each inaccessible area and the result of the evaluation
- A description of corrective actions required (only if required) to mitigate the degradation

IWE-5250 provides guidelines for corrective measures resulting from system pressure test indications. When leakage test acceptance criteria cannot be satisfied, the source of leakage is identified and the area examined to the extent required to provide repair. Repairs are made in accordance with IWA-4000, and leak rate testing is applied subsequent to return to service. The above repair procedure requirements correct the degradation that was detected and restore the surfaces so that the intended function is maintained.

IWE-2200 provides for preservice examination of all repairs and replacements prior to the return of service. Subsections IWE-2420 and IWE-2430 establish the record of the repaired area. This is done by performing a post-repair examination of the affected area and augmented examinations of suspect or repaired areas. The responsible engineer determines that there is no evidence of degradation sufficient to require further repair or evaluation. The requirements of IWE-2200, IWE-2420, and IWL-2430 provide confirmation that the degradation has been eliminated and the intended function will be maintained.

The intended function of the containment affected by corrosion, i.e., protection of the environment from the unacceptable release of radiation and protection of the containment interior systems from external loadings, are maintained since the potential aging effects are detected and repaired or evaluated prior to the occurrence of significant damage.

Leakage monitoring programs internally control the exposure of containment steel to aggressive chemical attack, while AMP-5.3 and AMP-5.4 protect the containment or shield building exterior. These programs in combination with AMP-5.5 protect the containment from corrosive degradation.

Thermal cycling of attached hot piping systems causes a potentially significant stress having a fatigue effect at hot penetrations without bellows for PWR concrete containments, and at penetration bellows assemblies for PWR free-standing steel containments. Current programs that effectively manage the aging effects of fatigue-related degradation include: visual inspections during leak rate testing and local inspection of the liner and the exterior concrete surface around hot penetrations for evidence of distress, as shown in AMP-5.5.

4.1.10 Containment Post-Tensioning System Degradation (AMP-5.6)

A prestressing system can be subjected to stress corrosion cracking (SCC). These losses can be managed through the tendon surveillance programs. Any loss of intended strength functions associated with the concrete and reinforcing systems is evaluated within the surveillance programs. Corrosion is managed effectively by visual inspection and testing of the tendon anchorage hardware and wire samples, evaluation of the corrosion protection medium, and identification of any free water in the system.

Surveillance or inspection and testing techniques, frequency of inspection, acceptance criteria, corrective actions, and confirmation activities are defined for the program in Subsection IWL of ASME Code Section XI. Inspection and testing techniques for the detection of the indications of aging effects resulting from SCC and other degradation mechanisms include mechanical testing of wires or strands of the tendon, tendon load testing, visual inspection of the tendons, and testing of the corrosion protection medium and free water chemistry, as described in IWL-2520. Inspection and testing of the tendons monitors the indications of aging effects such as cracks, corrosion, missing hardware, and pitting, while monitoring of the grease and free water chemistry identifies the conditions conducive to SCC. Tendon anchorage hardware and the surrounding concrete are visually inspected through the application of the VT-1 inspection. Indications of damage are cracking, staining, and spalling. ACI-201.1 R-68, as referenced in IWL-2510, provides guidance on evidence of conditions indicative of degradation, for surrounding concrete areas. Proper application of the examination methods is defined in Table WL-2500-1 of Section XI, Examination Category L-B, which defines the surface area to be examined and the corresponding examination method. The above examination methods are acceptable for the detection of indications and aging effects of post-tensioning system degradation resulting from SCC, which can be evaluated or repaired prior to the loss of an intended function.

In addition, it is recommended that the utility inspection program also include the following:

- The four recommendations for tendon examination included in Regulatory Guide 1.35, Rev. 3, should be included.
  - Requires that grease caps that are accessible must be visually examined to detect grease leakage or grease cap deformation.
  - Requires the preparation of an engineering evaluation report when consecutive surveillance indicates a trend of prestress loss to below the minimum prestress requirements.
  - Requires an evaluation to be performed for instances of wire failure and slip of wires in anchorages.
  - Addresses sampled sheathing filler grease and reportable conditions.

- Visible evidence of degradation of concrete, such as leaching and surface cracking, may be an indication of degradation in adjacent inaccessible areas. Therefore, an evaluation of the potential degradation of adjacent inaccessible areas should be performed.

Paragraph IWL-2420 provides inspection periods in terms of calendar years of operation. IWL-2420 recommends that the unbonded post-tensioning system be examined at 1, 3, and 5 years following the completion of the containment structural integrity test, and every 5 years thereafter. The 5-year interval should be extended for the plant license renewal period. This frequency is an accepted time period to detect degradation prior to the loss of intended function.

Article IWL-3000, Acceptance Standards, provides the acceptance criteria. Table IWL-2500-1 provides applicability of acceptance standards for corresponding components. Acceptance by examination for tendon force and elongation, IWL-3221.1, is based on the average of all measured tendon forces, the measured force of each individual tendon, and the measured tendon elongation. The average of all measured tendon forces for each type of tendon must be greater than or equal to the minimum required prestress. The measured tendon force of each individual tendon must but not be less than 95 percent of the predicted value; IWL-3221.1 specifies exceptions. The rate of change of prestress for each type of tendon calculated from current loads and those of the previous evaluation must be less than the maximum predicted rate of change of prestress. The measured tendon elongation must vary less than 10 percent from the previous value.

Acceptance standards for tendon wire or strand samples, IWL-3221.2, are that samples are free of physical damage, and that the ultimate tensile strength and elongation are not less than minimum specified values. IWL-3221.3 for tendon anchorage areas indicates acceptance when there is no evidence of degradation and crack widths for concrete less than 0.01 inch. Water content, reserve alkalinity, and soluble ion concentrations must be within limits specified in Table IWL-2525-1 for the corrosion protection medium as described in IWL-3221.4. Also there is a 10-percent limit on the absolute difference between corrosion medium removed and replaced, based on the tendon net duct volume.

IWL-3213, for the surrounding concrete, and IWL-3223, for the post-tensioning system, provide for repairs and subsequent examinations to satisfy acceptance standards of IWL-3000. Indications that do not meet acceptance criteria are subject to repair or evaluation until the condition is acceptable so that the intended function is maintained.

Corrective actions for the post-tensioning systems consist of repairs and evaluations as defined in IWL-3222 and IWL-3223 for inservice examination. Evaluations shall be performed in accordance with IWL-3300 and an evaluation report shall be prepared. The report should provide the following information, as described in IWL-3310:

- The cause of the condition that does not meet the acceptance standards

- The acceptability of the concrete containment without repair

- Whether or not repair or replacement is required and the extent, method, and schedule of repair, if repair is required

- The extent, nature, and frequency of additional examinations

Indications that do not meet acceptance criteria are subject to repair or evaluation, until the condition is acceptable so that the intended function is maintained.

IWL-3212 and IWL-3213 provide similar guidance for the surface condition of the surrounding concrete.

Use of Article IWL-4000 guidelines is recommended for the development of repair procedures. IWL-4000 provides repair procedures for degradation that is unacceptable according to the acceptance criteria or evaluation. The procedure for the surrounding concrete, IWL-4210, requires: removal of defective materials; visual examination of affected areas and reinforcing steel to assure proper surface preparation before the placement of repair material; VT-1 visual examination of reinforcing steel and repair if required; chemical, mechanical, and physical compatibility between existing and repair material; and requirements for in-processing sampling and testing of repair materials. In addition, when detensioning of prestressing tendons is required for repair of the concrete surface, repair procedures shall include specifications for repair materials, procedures for the application of repair materials, and procedures for the detensioning and retensioning of the prestressing system. IWL-4230 applies for the post-tensioning system. Weld repair of bearing and shim plates of the post-tensioning system must meet the requirements of IWA-4000. Restoration of the corrosion protection medium is required. These repairs correct the degradation that was detected and restore the surfaces so that the intended function is maintained. The repair is confirmed by preservice examination and testing prescribed by IWL-2230 and IWL-3100.

Subsection IWL-2230 and IWL-3100 establish the preservice record of the repaired area. This is done by performing a post-repair examination of the affected area. The responsible engineer determines that there is no evidence of degradation sufficient to require further repair or evaluation. If evaluation is required, a report shall be provided in accordance with IWL-3300 establishing the acceptability of containment without repair. The requirements of IWL-2230 and IWL-3100 provide the confirmation that the degradation has been eliminated and the intended function will be maintained.

The intended functions of the containment affected by SCC of the post-tensioning system, i.e., protection of the environment from the unacceptable release of radiation and protection of the containment interior systems from external loadings, are maintained since the potential aging effects are detected and repaired or evaluated prior to the occurrence of significant damage.

Several of the contributors to prestress losses are time-dependent. The loss of prestress force with time can be significant to license renewal. However, it is noted that the potential sources of degradation of prestress are managed by current inspection and surveillance programs. It is expected that a license renewal applicant will have to recalculate the acceptable predicted loss of prestress over a longer period (e.g., 60 years) and monitor the lower rate of prestress loss during the license renewal term. Calculation of the acceptable predicted prestress loss rate for the current license term is based on the assumption of a 40-year life. No additional requirements are made herein, other than to continue the current licensing basis (CLB) surveillance programs taking appropriate actions to address the loss of prestress force when surveillance trending results indicate the prestress force may fall below the minimum requirements. The aging management program attributes are given in Table 4-14.

This program in conjunction with AMP-5.3 provide effective management of post-tensioning system degradation for the plant license renewal periods.

4.1.11 Foundation - Settlement (AMP-5.7)

Differential settlement is monitored during the plant life for plants founded on soft compressible soil where it is a potentially significant degradation mechanism. Due to possible changes in the site conditions over the life of the plant that could increase settlement, i.e., lowering of the groundwater table, programs to monitor changes in groundwater table and to detect potentially significant settlement are included in the CLB requirements. Compliance with the CLB, unless otherwise justified, is part of the license renewal commitment. The aging management program attributes are given in Table 4-15 for those plants susceptible to settlement due to the soil groundwater characteristic on which the plant is founded.

4.2 ADDITIONAL ACTIVITIES AND PROGRAM ATTRIBUTES

There are no additional activities and program attributes required for aging management beyond those that have been identified and described in Section 4.1

TABLE 4-14

AGING MANAGEMENT PROGRAM ATTRIBUTES - AMP-5.6

CONTAINMENT POST-TENSIONING SYSTEM DEGRADATION

SCC, CORROSION, LOSS OF PRESTRESS LOADING

CODE REFERENCES TO 1992 WITH 1992 ADDENDA ASME SECTION XI EDITION

Attribute	Description	Containment Application	
Scope	Components and applicable aging effects	Component Class CC Concrete Containment Post-Tensioning System	Effect Loss of strength due to reduced tensile area Loss of strength due to cracking Loss of preload due to creep or binding, stress relaxation
Surveillance Technique	Monitoring, inspection, or testing techniques used to detect the effect	Examine following ASME Subsection IWL, Requirements for Class CC Concrete Components of Light-Water Cooled Power Plants, Examination Category L-B, Unbonded Post-Tensioning System IWL-2520, Examination of Unbonded Post-Tensioning Systems • Tendon: IWL-2521, Tendon Selection; IWL-2522, Tendon Force Measurements • Wire or Strand: IWL-2523, Tendon Wire and Strand Sample Examination and Testing • Anchorage Hardware and Surrounding Concrete: IWL-2524, Examination of Tendon Anchorage Areas; visual VT-1 in accordance with IWA-2411 • Corrosion Protection Medium: IWL-2525, Examination of Corrosion Protection Medium and Free Water • Free Water: IWL-2524, Examination of Tendon; IWL-2525, Examination of Corrosion Protection Medium and Free Water	
Frequency	Time period between program performance or when a one- time inspection must be completed	Inspection: IWL-2420	

TABLE 4-14 (Continued)

AGING MANAGEMENT PROGRAM ATTRIBUTES - AMP-5.6

CONTAINMENT POST-TENSIONING SYSTEM DEGRADATION

SCC, CORROSION, LOSS OF PRESTRESS LOADING

CODE REFERENCES TO 1992 WITH 1992 ADDENDA ASME SECTION XI EDITION

Attribute	Description	Containment Application
Acceptance Criteria	Qualitative or quantitative criteria that determine when corrective actions are needed	IWL-3220, Unbonded Post-Tensioning Systems • IWL-3221, Acceptance by Examination • IWL-3222, Acceptance by Evaluation, IWL-3300
Corrective Actions	Actions to prevent, mitigate, or reverse the consequences of the effect	IWL-3220, Unbonded Post-Tensioning Systems • IWL-3222, Acceptance by Evaluation, IWL-3300 • IWL-3223, Acceptance by Repair • IWL-3210, Surface Condition (for surrounding concrete) • IWL-3212 Acceptance by Evaluation, IWL-3300 • IWL-3213 Acceptance by Repair
Confirmation	Post-maintenance test or other techniques to confirm that the actions have been completed and are effective	• IWL-2230, Preservice Examination of Repairs and Modifications • IWL-3100, Preservice Examination following adjustment, repair, or replacement prior to return of the system to service • IWL-3310, Evaluation Report All records generated by corrective actions and inspections shall be maintained as defined by 10 CFR Part 50, Appendix A, Criterion 1 - Quality Standards and Records

TABLE 4-15
AGING MANAGEMENT PROGRAM ATTRIBUTES - AMP-5.7
FOUNDATION - SETTLEMENT

Attribute	Description	Containment Application	
Scope	Components and applicable aging effects	<u>Component</u>	<u>Effect</u>
		Concrete Foundations on Soil	Reduced design strength as a result of concrete cracking caused by settlement. Also, resulting steel reinforcement corrosion from exposing the reinforcement at the crack location caused by aggressive chemical attack. Reduced design strength as a result of change of seismic gap measurements between building structures caused by settlement.
Surveillance Technique	Monitoring, inspection, or testing techniques used to detect the effect	1. Perform settlement measurements using existing benchmark. 2. Inspect and document building gaps at various elevations and locations. 3. Identify any building misalignments during the inspection program.	
Frequency	Time period between program performance or when a one-time inspection must be completed	1. Perform an initial baseline inspection to document settlement and building gap measurements and to document any areas that are showing component or building misalignments due to settlement. Thereafter, perform inspections as appropriate to document conditions of previously identified areas of potential concern. [An evaluation frequency of at least once every 5 years is being recommended. This would be consistent with the recommendation that is made for concrete structures examination that is contained in ACI 349.3R-95, "Evaluation of Existing Nuclear Safety-Related Concrete Structures."] 2. Perform inspections at intervals as defined to be necessary as a result of previously identified areas of concern found during a baseline inspection or a subsequent inspection that were classified as being a concern for continuous plant operation.	
Acceptance Criteria	Qualitative or quantitative criteria that determine when corrective actions are needed	1. A qualified engineer is to review the building settlement measurements, building gap measurements, and any component misalignment and determine if they are within the original design basis for the buildings.	
Corrective Actions	Actions to prevent, mitigate, or reverse the consequences of the effect	1. Misalignment of any components due to building settlements or any situations of unacceptable building gaps are to be reviewed by the qualified engineer and appropriate action performed to mitigate any detrimental conditions to continuous plant operation.	
Confirmation	Post-maintenance test or other techniques to confirm that the actions were completed and are effective	1. Modifications to correct any building misalignment or insufficient building gaps are to inspected to applicable codes.	

5.0 SUMMARY AND CONCLUSIONS

The PWR containment associated with the plants listed in Table 1-1 have been reviewed for aging management as part of the Westinghouse Owners Group (WOG) Life Cycle Management/License Renewal (LCM/LR) program. The PWR containments are subject to an aging management review because they perform intended functions in a passive manner and are long-lived. This aging management review has identified aging effects and evaluated these effects to determine which require management during an extended period of operation. For those effects that require management, options have been provided.

Mechanical penetrations, associated with high temperature, may require action by the utility to perform a fatigue analysis, per TLAA requirements, to show that an existing analysis remains valid, or can be projected, to the extended period of operation.

5.1 SUMMARY

The PWR containment performs the intended functions of:

- Ensuring the integrity of the reactor coolant pressure boundary(1)
- Ensuring the capability to shut down the reactor and maintain it in a safe(1) shutdown condition
- Ensuring the capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposure comparable to the 10 CFR 100 guidelines
- Ensuring compliance with the U.S. NRC regulations for environmental qualification (10 CFR 50.49)

The PWR containment structure also supports system-level intended functions. This is discussed in Section 2.0.

The mechanisms identified from review of design limits, time-limited aging analyses (TLAAs), and aging are:

For concrete:

- Freeze-thaw
- Leaching of calcium chloride
- Alkali-aggregate reaction

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(1)This intended function is included as a result of the structural support provided by containment.

- Neutron irradiation embrittlement
- Interaction with aluminum
- Thermal aging embrittlement
- Aggressive chemical attack
- Direct current bond strength reduction
- Fatigue at penetration anchors

For the reinforcing steel, the steel liner and containment, prestressing systems, steel embedments, penetrations, fuel transfer tubes, airlocks, and hatches:

- Corrosion and coating degradation, as applicable
- SCC
- TGSCC
- Embrittlement and loss of pressure retention
- Mechanical wear
- Fatigue

For foundations:

- Settlement
- Concrete-related degradation mechanisms

Additional mechanisms or issues discussed are:

- Stress corrosion cracking for the prestressing systems
- Bellows degradation for mechanical and electrical penetrations
- Material compatibility for various components
- Mechanical wear, embrittlement and permanent set of gaskets for the fuel transfer tubes and gates and the airlocks and hatches
- Strain aging for the free-standing steel containment
- Loss of prestress force for tendons

Degradation mechanisms are addressed for subcomponents including penetration bellows, airlock and hatch control systems, and bulkhead penetrations.

The aging effects are identified in Section 2.0 of this document. The mechanisms and aging effects have been evaluated in Section 3.0 to determine potential degradation of the PWR containment intended functions. The aging effects of the following mechanisms require management during an extended period of operation. The recommended aging management program is identified.

<u>Concrete</u>

- Freeze-thaw; AMP-5.1 and AMP-5.2
- Aggressive chemical attack; AMP-5.3 and AMP-5.4x

<u>Reinforcing Steel</u>

- Corrosion in below-grade concrete structures; AMP-5.3 and AMP-5.4

<u>Containment Steel Liner</u>

- Corrosion; AMP-5.5
- Coating degradation; AMP-5.5

<u>Post-Tensioning Systems</u>

- Corrosion and SCC of prestressing systems; AMP-5.6
- Prestress force losses; AMP-5.6

<u>Electrical Penetrations</u>

- TGSCC of bellows; AMP-5.5

<u>Mechanical Penetrations</u>

- Fatigue of bellows; AMP-5.5
- Fatigue; AMP-5.5
- Embrittlement of gaskets; AMP-5.5
- Corrosion and SCC; AMP-5.5

<u>Fuel Transfer Tube Penetration</u>

- Mechanical wear; AMP-5.5
- Embrittlement of gaskets; AMP-5.5
- Corrosion and SCC; AMP-5.5

Airlocks and Hatches

- Mechanical wear; AMP-5.5
- Embrittlement of gaskets; AMP-5.5
- Loss of pressure retention; AMP-5.5

Foundations

- Settlement; AMP-5.7

Free-Standing Steel Containments

- Corrosion of inaccessible below-grade structure; AMP-5.5
- Fatigue of penetration bellows; AMP-5.5

These potential aging effects can be managed by the identified aging management options previously described in Section 4.0. It is noted that fatigue of the fuel transfer tube penetration is also possible, and the aging management program as defined for mechanical penetrations can be used. Also, airlocks and hatches are subject to corrosion and would follow the same program as given for mechanical penetrations.

5.2 CONCLUSIONS

Implementation of aging management options will manage identified aging effects. Therefore, it is concluded that PWR containment intended functions will be maintained during the extended period of operation for the plants identified in Table 1-1. System-level intended functions supported by the PWR containment will also be maintained.

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7.0 APPENDICES

7.1 IAEA SURVEY ON CONCRETE CONTAINMENT AGING

A worldwide survey of nuclear power plant owners and operators was conducted by the IAEA on monitoring and mitigation of aging on concrete containment buildings. The survey polled recipients on current experience and practices in aging management, innovative repair techniques, crack mapping and acceptance or repair guidelines, and condition indicators for monitoring the aging of concrete containments. Table 7-1 summarizes the general plant information from survey respondents. Table 7-2 summarizes the inspection and preventive maintenance programs, while Table 7-3 provides a summary of the results on observed degradation.

TABLE 7-1
RESULTS OF THE IAEA SURVEY OF NUCLEAR POWER PLANT OWNER/OPERATORS ON THE MANAGEMENT OF AGING OF CONCRETE CONTAINMENT BUILDINGS
Part 1 PWR General Plant Information

1C – CONTAINMENT DESIGN PARAMETERS

	Ringhals Unit 1	Ringhals Unit 2	Ringhals Units 3, 4	D. C. Cook Units 1, 2	Diablo Canyon Units 1, 2	R. E. Ginna Unit 1
Internal Design Pressure	(75.42 psi)	(73.00 psi)	(74.60 psi)	12 psig(7)	61.7 psig	60 psig
External Design Pressure	(14.50 psi)	(14.50 psi)	(14.50 psi)	12 psig(7)	17.7 psig	n/a
Leak Rate Test Pressure (max)	(43.50 psi)	(43.50 psi)	(41.00 psi)	12 psig (+0.5 -0.)	64.7 psia	35 psig
Allowable Leak Rate (Units)	(4)	(5)	(6)	(1)	(3)	(2)
Leak Rate Tests (Since In Service Date)	8 - 10	7	4	(5) - Unit 1 (4) - Unit 2	3	7
Proof Test (Struct. Integrity) Test Pressure	(65.30 psi)	(83.50 psi)	(67.40 psi)	16.1 psig	68.7 psia	69 psig
Normal Operating Conditions • Containment • Ice Bed	(13.8 - 14.5 psi) <140°F	(16.0 - 17.4 psi) <131°F	(13.8-16.7 psi) <120°F	-1.5 psig-+0.3 psig 60° - 120°F 10°F - 20°F	13.7/15.9 psig 120°F	14.9 to 15.2 psia 70°F
Relative Humidity (Internal)	20% - 40%	20% - 40%	20% - 40%	0% - 100%	20% - 100%	0% - 100%
Ambient Outside Conditions (Annual Temps)	86°F max 61°F min (8)	77°F max 3°F min	77°F max 3°F min	120°F max 0°F min	91°F max 39°F min	104°F max -16°F min

TABLE 7-1 (Continued)
RESULTS OF THE IAEA SURVEY OF NUCLEAR POWER PLANT OWNER/OPERATORS ON THE MANAGEMENT OF AGING OF CONCRETE CONTAINMENT BUILDINGS
Part 1 PWR General Plant Information

1A - PLANT INFORMATION

	Ringhals Unit 1	Ringhals Unit 2	Ringhals Units 3, 4	D. C. Cook Units 1, 2	Diablo Canyon Units 1, 2	R. E. Ginna Unit 1
No. Units at This Site	4	4	4	2	2	1
Owner/Operator	Vattenfall AB	Vattenfall AB	Vattenfall AB	Indiana Mich. Power Co.	Pacific Gas & Electric Co.	Rochester Gas Electric Corp.
Site Location (Coordinates)	Ringhals Varobacka Sweden, S-43022	Ringhals Varobacka Sweden, S-43022	Ringhals Varobacka Sweden, S-43022	Berrien Cnty., Michigan USA Latitude - 41° 58' - 32.07" Longitude-86° 33' - 54.87"	San Luis Obispo, Cal. USA	89 East Ave., New York, USA
Site Conditions	Near sea (0.2 km)	Near Sea (0.3 km)	Near sea (0.2 km)	Inland	Near sea (0.12 miles)	Inland
Inservice Date	January 1976	May 1975		Aug. 23, 1975 (Com'l Srvc) Unit 1 July 1, 1978 (Com'l Srvc) Unit 2	May 7, 1985 Unit 1 Mar. 13, 1986 Unit 2	September 19, 1969
Reactor Type	BWR-Mark II	PWR	PWR	PWR	PWR	PWR
Date of Design	Not indicated	Not indicated	Not indicated	1966 - 1972	July 1969	Oct. 1965

Notes:

(1) The overall allowable integrated leak rate equals 0.25 percent by weight of the containment air, per 24 hours at 12 psig.
(2) The overall allowable integrated leak rate equals 0.1528 percent by weight of the containment air, per 24 hours at 35 psig.
(3) The overall allowable integrated leak rate equals 0.10 percent by weight of the containment air, per 24 hours at 64.7 psig.
(4) The overall allowable integrated leak rate equals 0.60 percent by weight of the containment air, per 24 hours at 43.5 psig.
(5) The overall allowable integrated leak rate equals 0.021 percent by weight of the containment air, per 24 hours at 43.5 psig.
(6) The overall allowable integrated leak rate equals 0.021 percent by weight of the containment air, per 24 hours at 0.283 MPa.
(7) Internal Pressure Differential.
(8) Outside Primary Containment.

TABLE 7-2
RESULTS OF THE IAEA SURVEY OF NUCLEAR POWER PLANT OWNER/OPERATORS ON THE MANAGEMENT OF AGING OF CONCRETE CONTAINMENT BUILDINGS
Part 2 Inspection, Investigation, and Preventive Maintenance Programs

INSPECTION PROGRAM

PLANT	CONCRETE – Visual Crack Mapping					
	Inspection Frequency	Formalized Procedure	Recorded Data(1)	Crack Distribution Record(2)	Crack Dimension Acceptance Criteria	Times Used in Repair Investi-gation
Diablo Canyon Units 1 & 2	4 times/year	Yes	None	N/A	No	None
D.C. Cook Unit 1	Every 2 years	Yes	None	Photographs	No(3)	None
R.E. Ginna(4)	None	N/A	N/A	N/A	N/A	N/A
Ringhals Unit 1	Every 5 years(5)	No	Length, cause	Drawings, photographs	No	None
Ringhals Units 2, 3, & 4	Every 5 years(5)	No	N/A	N/A	No	None

Notes:

(1) Data includes width, length, depth, cause, internal and/or external ambient temperature, air humidity, salinity, pollutants, and irradiation.
(2) Recorded with drawings, videos, or photographs.
(3) Each crack is evaluated separately.
(4) A preventive maintenance and inspection program is currently under development for implementation by 1996.
(5) Zones of tendon anchorage on buttresses.

TABLE 7-2 (Continued)
RESULTS OF THE IAEA SURVEY OF NUCLEAR POWER PLANT OWNER/OPERATORS ON THE MANAGEMENT OF AGING OF CONCRETE CONTAINMENT BUILDINGS
Part 2 Inspection, Investigation, and Preventive Maintenance Programs

INSPECTION PROGRAM (Continued)

PLANT	CONCRETE - NDE/NDT				
	Method(1)	Inspection Frequency	Formalized Procedure	Acceptance Criteria	Times Used in Repair Investigation
Diablo Canyon Units 1 & 2	None	N/A	N/A	N/A	N/A
D.C. Cook Unit 1	Probe penetration	N/A	No(2)	N/A	2
	Sounding	N/A	No(3)	N/A	2
R.E. Ginna(4)	None	N/A	N/A	N/A	N/A
Ringhals Units 1, 2, 3, & 4	Leakage	3 times in 10 years	No	Yes	None

Notes:

(1) May include pulse velocity, impact hammer, permeability, leakage, probe penetration, or pullout.
(2) Used to determine depth of void.
(3) Used to determine size of void.
(4) A preventive maintenance and inspection program is currently under development for implementation by 1996.

TABLE 7-2 (Continued)
RESULTS OF THE IAEA SURVEY OF NUCLEAR POWER PLANT OWNER/OPERATORS ON THE MANAGEMENT OF AGING OF CONCRETE CONTAINMENT BUILDINGS
Part 2 Inspection, Investigation, and Preventive Maintenance Programs
INSPECTION PROGRAM (Continued)

PLANT	CONCRETE - Instrumentation Monitoring							
	Instrument Type[1]	Number Installed	Inspection Frequency	Times Used in Repair Investi-gation	Formal Procedure	Data Records and Evaluation		
						(2)	(3)	(4)
Diablo Canyon Units 1 & 2	None	N/A	N/A	N/A	N/A	N/A	N/A	N/A
D.C. Cook Unit 1	None	N/A	N/A	N/A	N/A	N/A	N/A	N/A
R.E. Ginna[5]	None	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ringhals Units 1, 2, 3, & 4	None	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes:

(1) May include strain gauges, thermocouples, stress cells, humidity gauges, Invar wires or other types.
(2) Data is computer logged.
(3) Data is compared with original design specification.
(4) Operating limits are defined.
(5) A preventive maintenance and inspection program is currently under development for implementation by 1996.

TABLE 7-2 (Continued)
RESULTS OF THE IAEA SURVEY OF NUCLEAR POWER PLANT OWNER/OPERATORS
ON THE MANAGEMENT OF AGING OF CONCRETE CONTAINMENT BUILDINGS
Part 2 Inspection, Investigation, and Preventive Maintenance Programs

INSPECTION PROGRAM (Continued)

PLANT	CONCRETE - Cores			
	Inspection Frequency	Times Used for Repair Investigation	Formalized Procedure	Material Property Tests[1]
Diablo Canyon Units 1 & 2	Not inspected	N/A	N/A	N/A
D.C. Cook Unit 1	Not inspected	2	Yes	Strength, porosity, chemical
R.E. Ginna[2]	Not inspected	N/A	N/A	N/A
Ringhals Units 1, 2, 3, & 4	Not inspected	N/A	N/A	N/A

Notes:

(1) May include strength, porosity, modulus, chemical composition analysis.

(2) A preventive maintenance and inspection program is currently under development for implementation by 1996.

TABLE 7-2 (Continued)
RESULTS OF THE IAEA SURVEY OF NUCLEAR POWER PLANT OWNER/OPERATORS ON THE MANAGEMENT OF AGING OF CONCRETE CONTAINMENT BUILDINGS
Part 2 Inspection, Investigation, and Preventive Maintenance Programs

INSPECTION PROGRAM (Continued)

PLANT	Anchorage Elements				
	Inspection Technique(1)	Inspection Frequency	Formalized Procedure	Times Used in Repair Investigation	Acceptance Criteria
Diablo Canyon Units 1 & 2	Visual	4 times/year	Yes	None	No
D.C. Cook Unit 1	Visual	Every 2 years	Yes	None	Yes(2)
R.E. Ginna(3)	None	N/A	N/A	N/A	N/A
Ringhals Units 1, 2, 3, & 4	Visual	Every 5 years in buttresses	No	None	No

Notes:

(1) May include visual or pullout test.
(2) A material condition survey is performed by three engineers experienced in concrete design, testing, and in situ inspections. Acceptance of indications found during inspection is based on the engineering team's evaluation.
(3) A preventive maintenance and inspection program is currently under development for implementation by 1996.

TABLE 7-2 (Continued)
RESULTS OF THE IAEA SURVEY OF NUCLEAR POWER PLANT OWNER/OPERATORS ON THE MANAGEMENT OF AGING OF CONCRETE CONTAINMENT BUILDINGS
Part 2 Inspection, Investigation, and Preventive Maintenance Programs

INSPECTION PROGRAM (Continued)

PLANT	Reinforcing Steel				
	Inspection Technique(1)	Inspection Frequency	Formalized Procedure	Times Used in Repair Investigation	Acceptance Criteria
Diablo Canyon Units 1 & 2	Visual	4 times/year	Yes	None	No
	Half cell	As required	N/A	None	No
D.C. Cook Unit 1	Visual	Every 2 years	Yes	None	Yes(2)
R.E. Ginna(3)	None	N/A	N/A	N/A	N/A
Ringhals Units 1, 2, 3, & 4	None	N/A	N/A	N/A	N/A

Notes:
(1) May include visual, half cell or cover meter.
(2) A material condition survey is performed by three engineers experienced in concrete design, testing, and in situ inspections. Acceptance of indications found during inspection is based on the engineering team's evaluation.
(3) A preventive maintenance and inspection program is currently under development for implementation by 1996.

TABLE 7-2 (Continued)
RESULTS OF THE IAEA SURVEY OF NUCLEAR POWER PLANT OWNER/OPERATORS ON THE MANAGEMENT OF AGING OF CONCRETE CONTAINMENT BUILDINGS
Part 2 Inspection, Investigation, and Preventive Maintenance Programs

INSPECTION PROGRAM (Continued)

PLANT	Prestressing Steel				
	Inspection Technique[(1)]	Inspection Frequency	Formalized Procedure	Times Used in Repair Investigation	Acceptance Criteria
Diablo Canyon Units 1 & 2	N/A	N/A	N/A	N/A	N/A
D.C. Cook Unit 1	N/A	N/A	N/A	N/A	N/A
R.E. Ginna	N/A	N/A	N/A	N/A	N/A
Ringhals Unit 1	None	N/A	N/A	N/A	N/A
Ringhals Units 2, 3, & 4	Visual and grease chem.	Every 10 years	No	None	No
	Lift-off test and mech. prop. tests of wires	Every 10 years	Yes	None	Yes

Notes:

(1) May include lift-off test, load cell, visual, mechanical property tests on wires, grease chemistry.

TABLE 7-2 (Continued)
RESULTS OF THE IAEA SURVEY OF NUCLEAR POWER PLANT OWNER/OPERATORS ON THE MANAGEMENT OF AGING OF CONCRETE CONTAINMENT BUILDINGS
Part 2 Inspection, Investigation, and Preventive Maintenance Programs

INSPECTION PROGRAM (Continued)

PLANT	Steel Liner				
	Inspection Technique	Inspection Frequency	Formalized Procedure	Times Used in Repair Investigation	Acceptance Criteria
Diablo Canyon Units 1 & 2	Visual	4 times/year	Yes	None	No
	Leak test	Every 40 months	Yes	None	Yes
D.C. Cook Unit 1	Visual	Every 40 months	Yes	None	No
	Leak test	Every 40 months	Yes	None	Yes
R.E. Ginna[(1)]	None	N/A	N/A	N/A	N/A
Ringhals Units 1, 2, 3, & 4	Leak test	3 times in 10 years	Yes	None	Yes

Notes:

(1) A preventive maintenance and inspection program is currently under development for implementation by 1996.

TABLE 7-2 (Continued)
RESULTS OF THE IAEA SURVEY OF NUCLEAR POWER PLANT OWNER/OPERATORS ON THE MANAGEMENT OF AGING OF CONCRETE CONTAINMENT BUILDINGS
Part 2 Inspection, Investigation, and Preventive Maintenance Programs

INSPECTION PROGRAM (Continued)

PLANT	Penetration Assemblies					
	Assembly or Seal	Inspection Technique(1)	Inspection Frequency	Formalized Procedure	Times Used in Repair Investi-gation	Acceptance Criteria
Diablo Canyon Units 1 & 2	Assemblies	NDT local leak test	Air Locks - 6 months Pen.s - 24 months	Yes(2)	None	Yes
	Seal	NDT local leak test	24 months	Yes(2)	None	Yes
D.C. Cook Unit 1	Assemblies	NDT local leak test	18 months	Yes(2)	None	Yes
	Seal	NDT local leak test	18 months	Yes(2)	None	Yes
R.E. Ginna(3)	None	N/A	N/A	N/A	N/A	N/A
Ringhals Unit 1	Assemblies	NDT local leak test	Once every 6 months	Yes	None	Yes
Ringhals Units 2, 3, & 4	Assemblies	NDT local leak test	Electrical - every 3 years equipment and personnel every 6 months	Yes	None	Yes

Notes:

(1) May include ultrasonic and local leak test.
(2) Penetration is pressurized and leak rate is measured.
(3) A preventive maintenance and inspection program is currently under development for implementation by 1996.

TABLE 7-2 (Continued)
RESULTS OF THE IAEA SURVEY OF NUCLEAR POWER PLANT OWNER/OPERATORS ON THE MANAGEMENT OF AGING OF CONCRETE CONTAINMENT BUILDINGS
Part 2 Inspection, Investigation, and Preventive Maintenance Programs
PREVENTIVE MAINTENANCE PROGRAMS

PLANT	Activity[1]	Frequency	Location	Formalized Procedure
Diablo Canyon Units 1 & 2	Protective coating	Every 18 months	Containment interior liner	Yes
D.C. Cook Unit 1	Protective coating	Every 18 months	Containment interior liner	Yes
	Grouting refurbishment	Every 18 months	Containment exterior at cold joints	Yes
R.E. Ginna[2]	None	N/A	N/A	N/A
Ringhals Units 1, 2, 3, & 4	None	N/A	N/A	N/A

Notes:

(1) May include protective coating, grouting refurbishment, sealant removal or replacement, or cathodic protection.

(2) A preventive maintenance and inspection program is currently under development for implementation by 1996.

TABLE 7-3
RESULTS OF THE IAEA SURVEY OF NUCLEAR POWER PLANT OWNER/OPERATORS ON THE MANAGEMENT OF AGING OF CONCRETE CONTAINMENT BUILDINGS
Part 3 - Age Related Degradation Experience
3A – DEGRADATION OBSERVED IN CONCRETE CONTAINMENTS

Symptom	Ringhals Unit 1	Ringhals Unit 2	Ringhals Units 3,4	D.C. Cook Units 1-2	Diablo Canyon Units 1,2	R. E. Ginna Unit 1
CRACKING	YES	YES	NO	YES	NO	YES
• Age of Containment when Observed (yrs)	9	≈15	N/A	5	N/A	New
• Probable Causes (See 3B)	(10)	(10)	N/A	(1)+(10)	N/A	(13)
• Remedial Action (See 3B)	7	(4) h.	N/A	N/A	N/A	N/A
Location	Ring Slab But-tresses	Top of Dome Ring	N/A	Exterior and Dome	N/A	Varies
VOIDS / HONEYCOMBING	NO	NO	NO	YES	NO	NO
• Age of Containment when Observed (yrs)	N/A	N/A	N/A	10	N/A	N/A
• Probable Causes (See 3B)	N/A	N/A	N/A	(20) (1)	N/A	N/A
• Remedial Action (See 3B)	N/A	N/A	N/A	4a & (5) b.	N/A	N/A
• Location	N/A	N/A	N/A	Exterior	N/A	N/A
STAINING	NO	NO	NO	YES	NO	NO
• Age of Containment when Observed (yrs)	N/A	N/A	N/A	N/A	N/A	N/A
• Probable Causes (See 3B)	N/A	N/A	N/A	(21)	N/A	N/A
• Remedial Action (See 3B)	N/A	N/A	N/A	(1)	N/A	N/A
• Location	N/A	N/A	N/A	Dome	N/A	N/A

3B - CAUSES OF DEGRADATION AND REMEDIAL ACTIONS

Causes/Age-Related Degradation Mechanisms

(1) Freeze/Thaw
(2) Elevated Temperature
(3) Thermal Cycles/Thermal Gradient
(4) Sulfate Attack
(5) Seawater Exposure
(6) Acid/Industrial Chemical Attack
(7) Leaching
(8) Abrasion/Erosion/Cavitation
(9) Impact
(10) Shrinkage
(11) Sealant Breakdown
(12) Creep
(13) Leak Rate Tests
(14) Irradiation
(15) Chloride Attack
(16) Carbonation
(17) Alkali/Aggregate Reaction
(18) Fatigue/Vibration
(19) Stray Electrical Current
(20) Construction Defects
(21) Design Defects
(22) Other__________
(23) Other__________
(24) Other__________

Remedial Actions

(1) Not Necessary
(2) Increased Inspection
(3) Modify Procedure
(4) Crack Repair
  a. Epoxy Injection
  b. Routing and Sealant
  c. Stitching/Add'l Reinforcement
  d. Drilling and Plugging
  e. Flexible Sealing
  f. Grout Injection
  g. Dry Packing
  h. Polymer Impregnation
  i. Other
(5) Spalling / Delamination Repair
  a. Concrete Replacement
  b. Dry Pack
  c. Pre-placed Aggregate Concrete
  d. Shotcrete
  e. Sealers
  f. Other
(6) Replacement
(7) Protective Coating or Recoating
(8) Cathodic Protection System
(9) Others(Describe):__________
____

TABLE 7-3 (Continued)
RESULTS OF THE IAEA SURVEY OF NUCLEAR POWER PLANT OWNER/OPERATORS ON THE MANAGEMENT OF AGING OF CONCRETE CONTAINMENT BUILDINGS
Part 3 – Age Related Degradation Experience
3A - DEGRADATION OBSERVED IN CONCRETE CONTAINMENTS

Symptom	Ringhals Unit 1	Ringhals Unit 2	Ringhals Units 3-4	D.C. Cook Units 1-2	Diablo Canyon Units 1, 2	R. E. Ginna Unit 1
POP-OUTS	NO	NO	NO	YES	NO	NO
• Age of Containment when Observed (yrs)	N/A	N/A	N/A	5	N/A	N/A
• Probable Cause/s (See 3B)	N/A	N/A	N/A	(21)	N/A	N/A
• Remedial Action (See 3B)	N/A	N/A	N/A	(1)	N/A	N/A
• Location	N/A	N/A	N/A	Dome & Exterior	N/A	N/A
EFFLORESCENCE	NO	NO	NO	YES	NO	NO
• Age of Containment when Observed (yrs)	N/A	N/A	N/A	10	N/A	N/A
• Probable Cause/s (See 3B)	N/A	N/A	N/A	(7)	N/A	N/A
• Remedial Action (See 3B)	N/A	N/A	N/A	(1)	N/A	N/A
• Location	N/A	N/A	N/A	Exterior	N/A	N/A
SCALING	NO	NO	NO	NO	NO	NO
DELAMINATION	NO	NO	NO	NO	NO	NO
SPALLING	NO	NO	NO	NO	NO	NO
DUSTING	NO	NO	NO	NO	NO	NO
EXCESS. PERMEABILITY	NO	NO	NO	NO	NO	NO
CORROSION TO REINFORCING STEEL	NO	NO	NO	NO	NO	NO
CORROSION TO PRE-STRESSING STEEL	NO	NO	NO	Not in Design	Not in Design	NO

3B B CAUSES OF DEGRADATION AND REMEDIAL ACTIONS

Causes/Age-Related Degradation Mechanisms

(1) Freeze/Thaw
(2) Elevated Temperature
(3) Thermal Cycles/Thermal Gradient
(4) Sulfate Attack
(5) Seawater Exposure
(6) Acid/Industrial Chemical Attack
(7) Leaching
(8) Abrasion/Erosion/Cavitation
(9) Impact
(10) Shrinkage
(11) Sealant Breakdown
(12) Creep
(13) Leak Rate Tests
(14) Irradiation
(15) Chloride Attack
(16) Carbonation
(17) Alkali/Aggregate Reaction
(18) Fatigue/Vibration
(19) Stray Electrical Current
(20) Construction Defects
(21) Design Defects
(22) Other__________
(23) Other__________
(24) Other__________

Remedial Actions

(1) Not Necessary
(2) Increased Inspection
(3) Modify Procedure
(4) Crack Repair
  a. Epoxy Injection
  b. Routing and Sealant
  c. Stitching/Add'l Reinforcement
  d. Drilling and Plugging
  e. Flexible Sealing
  f. Grout Injection
  g. Dry Packing
  h. Polymer Impregnation
  i. Other
(5) Spalling / Delamination Repair
  a. Concrete Replacement
  b. Dry Pack
  c. Pre-placed Aggregate Concrete
  d. Shotcrete
  e. Sealers
  f. Other
(6) Replacement
(7) Protective Coating or Recoating
(8) Cathodic Protection System
(9) Others(Describe):__________

OG-98-064

NRC Project Number 686
WCAP-14756

May 29, 1998

To: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Attention: R.K. Anand, Project Manager
License Renewal Project Directorate

Subject: Westinghouse Owners Group
Response to NRC Request for Additional Information on WOG Generic Technical Report WCAP 14756, "License Renewal Evaluation: Aging Management Evaluation for Pressurized Water Reactor Containment Structure"

Reference:
1. NRC letter dated February 19, 1998 from R.K. Anand to R.A. Newton, Westinghouse Owners Group
2. WOG Letter, OG-98-041, March 17, 1998 from R.A. Newton to R.K. Anand, NRC

Attached are the Westinghouse Owners Group responses to the NRC's Request for Additional Information on WCAP-14756, "License Renewal Evaluation: Aging Management Evaluation for Pressurized Water Reactor Containment Structure". Please distribute these responses to the appropriate people in your organization for their review. As noted in Reference 2, the WOG is available to meet with members of the License Renewal Project Directorate to discuss our responses to assure that they correctly address the intent of each RAI.

If you have any questions regarding these responses or scheduling a meeting date, please contact Charlie Meyer, Westinghouse, at (412) 374-5027, or myself at Wisconsin Electric Power Company, (414) 221-2002.

Very truly yours,

Roger A. Newton

Roger A. Newton, Chairman
LCM/LR Working Group
Westinghouse Owners Group

cc: R.K. Anand, Project Manager, USNRC License Renewal Project Directorate, (1L, 1A)
C.I. Grimes, Director, USNRC License Renewal Project Directorate (1L, 1A)
WOG LCM/LR Working Group (1L, 1A)
WOG Steering Committee (1L, 1A)
A.P. Drake, W (1L, 1A)
C.E. Meyer, W (1L, 1A)
W.S. LaPay, W (1L, 1A)

98OG064.doc

Response to NRC Request for Additional Information on WOG Generic Technical Report WCAP 14756, "License Renewal Evaluation: Aging Management Evaluation for Pressurized Water Reactor Containment Structure

General Comments (Items 1-4)

Request for Additional Information

1. Section 3.2 of the report indicates that many aging mechanisms are not significant because plant construction used specific national codes and standards, such as the ACI codes and guides and ASTM standards. For example, Section 3.2.2 of the report states that leaching of calcium hydroxides is not a significant degradation mechanism for PWR containment concrete components because of ACI 201.2R-77. However, NUREG-1522, Appendix A, documented containment concrete degradation in plants constructed to similar codes and standards. In addition, NUREG/CR-6424 states that "The performance of reinforced concrete structures in nuclear power plants has been good... However, as these structures age, incidences of degradation due to environmental stress or effects are likely to increase to potentially threaten their durability." Further, 10 CFR 50.55a requires containments be inspected according to Subsections IWE and IWL of the ASME Section XI Code. Section 3.3.II.B of the working draft standard review plan for license renewal (SRP-LR), dated September 1997, contains information on applicable aging effects for PWR containment structures. Section 3.3.III.C of the working draft SRP-LR also contains information on aging management programs for renewal. Please address these applicable aging effects for the containment structure and propose appropriate aging management programs for renewal or provide detailed justifications (e.g., operating experience) for excluding any applicable aging effects.

Response

This report addresses Westinghouse pressurized water reactor containment structures generically. It is recognized in the report that the codes and standards to which the plants are built result in quality construction. There may be isolated cases where a plant experiences a degradation mechanism and effect (e.g., leaching of calcium hydroxide) that is not associated with any or very few of the other Westinghouse plants. Review of NUREG-1522 did not indicate any generic type of concrete degradation. Further, as plants age they may be subject to incidences of degradation due to environmental stressor effects that may affect their integrity. However, these will be plant specific issues. The report does not attempt to address the plant specific issues since all of the plant are required to meet the rule given in SECY-96-080 that "incorporates the inspection criteria of subsections IWE and IWL to assure that the critical areas of containments are periodically inspected to detect and take corrective [actions] for defects that could compromise a containment's structural integrity." Inspections following IWL are discussed in Section 2.6.2 of the report. During these inspections, if deterioration is found, a utility is obligated to follow IWL requirements. Within a License Renewal application, the applicant would discuss the containment examinations as part of operating experience (L-A examination category) and identify degradation effects and the corrective actions taken. If the applicant considers this a significant aging effect for his plant, then he would be obligated to include a plant specific aging management program to address this issue.

In Section 3.3 of the working draft standard review plan for license renewal (SRP-LR), dated September 1997, eleven aging effects are defined. The report addresses all eleven (see Tables 2-16 to 2-18).

Request for Additional Information

2. Section 3.3 of the working draft SRP-LR indicates that inaccessible areas of PWR containment structures should be managed for the aging effects due to leaching of calcium hydroxide on concrete structures, aggressive chemical attack on concrete structures, reaction with aggregates on concrete structures, corrosion of structural steel and liner, corrosion of embedded steel. Section 3.3.III.C of the working draft SRP-LR provides additional information on managing aging effects in inaccessible areas. Please discuss aging management for inaccessible areas of containment structures.

Response

Aging management for inaccessible areas as described in the report for containment structures is consistent with the requirements described in Section 3.3.III.C of the working draft SRP-LR. Potential degradation of inaccessible areas due to leaching of calcium hydroxide on concrete structures, aggressive chemical attack on concrete structures, reaction with aggregates on concrete structures, corrosion of structural steel and liner, corrosion of embedded steel is addressed in Section 4.0 of the report.

It is recommended in the report that a utility incorporate into their inservice inspection programs, for the extended period of operation, the aging management programs that are based on the 1992 Code Edition, and Addenda, of ASME Section XI, Subsections IWE and IWL. Further, the modifications given in SECY-96-080 to address U.S. NRC concerns related to tendon examinations and inaccessible areas should also be included.

The utility implements maintenance programs made up of routine inspections, periodic inspections, condition surveys, etc. These programs, along with the aging management programs defined in the report, meet the inaccessible requirements given in the working draft SRP-LR that are based on 10 CFR 50.55a. The requirement for inaccessible areas requires an evaluation of inaccessible areas when conditions exist in accessible areas that could indicate the presence of, or the result of, degradation to such inaccessible areas. As stated previously, Section 4.0 in the report describe visible inspections and aging management that address leaching, aggregate reaction aging effects, chemical attack, and corrosion. This section should be consulted for more detail discussion.

It is recognized that the working draft SRP-LR encourages the review, on a case-by-case basis, of inaccessible areas when conditions in accessible areas may not indicate degradation. This review would be done only if there is a cause (e.g., occurrence of an event driven accident). The utility would then assess the situation and determine the proper course of action. This could include: application of nondestructive testing as summarized in Table 4-3 of the report; use of destructive testing as given in Table 4-4. The procedure adopted would be based on potential degradation mechanism, potential manifestation of effect within inaccessible area or accessible area, and the appropriate method for detection as given in Tables 4-5 to 4-8.

Request for Additional Information

3. Please discuss the operating experience of the containment structure and its components relating to the effects of aging, including any applicable generic communications.

Response

Recent operating experience is discussed in detail in Sections 2 and 7 of the report.

Section 2

2.6.3 IAEA Maintenance and Inspection History

Recent survey data of maintenance and inspection history from the International Atomic Energy Agency (IAEA) are discussed.

2.6.4 Observed Degradation

Summaries are provided of observed degradation associated with structures within the scope of the report. Attention is given to degradation identified in the IAEA surveys, U.S. NRC Information Notice 89-79, nuclear plant reliability data system (NPRDS), licensee event reports (LERs), leak rate testing, and SECY-96-080. References are given which can be consulted for a summary of containment pressure boundary component degradation occurrences at commercial nuclear power plants in the United States (Reference 1), and for discussions pertaining to historical performance of electrical and mechanical penetrations (Reference 7).

Section 7

In Section 7 (an appendix) a summary of age related degradation observed in concrete containments is given for Ringhals Unit 1 to 4, D.C. Cook Units 1 and 2, Diablo Canyon Units 1 and 2, and R.E. Ginna Unit 1.

Request for Additional Information

4. Specific codes, standards, or related documents that are used or described in the evaluation of aging management for the containment report should include the full title, edition, and the year of publication. For example, certain ACI publications listed on Table 4-10 and Table 4-12 of the containment report do not contain a full title, edition/revision and the year of publication. If specific sections of referenced documents are used in the aging management evaluations, the specific sections should be identified for staff review. Please provide the above information such that the staff can perform its review when the review effort is resumed at a later date.

Response

Sufficient information is given to permit identification of the intended document in the recommended aging management program as given in Tables 4-10 and Table 4-12. The date and title is given in the list of references or bibliography of the report. See also RAI 33.

It is noted that it may not be appropriate to indicate the applicable year of publication since this report applies to all Westinghouse PWR plants which have different licensing bases. For those cases where it is not possible to be explicit then it will be necessary for the utility to so identify in their license renewal application.

Specific Comments (Items 5 - 28)

Request for Additional Information

5. In Section 2.3.1 of the report, cross-section drawings of the containment building for Type 1a, Type 2 and Type 3 containments are provided, but the configuration for Type 1b containments is not shown. This configuration, with its elliptical bottom head and sand pocket, should be illustrated if these plants are to be covered by this study. Cross-section drawings should be provided separately for each type of containments (i.e., Types 1a, 1b, 2a, 2b, 2c, 3a, and 3b) with the corresponding configuration descriptions. In addition, a separate figure to show the details of sand pocket region and embedded shell region should be provided so that potential aging effects can be assessed .

Response

The figures that have been included in the report show the general type of configurations for the three types of containments associated with the Westinghouse PWR plants. The subtypes (i.e., Types 1a, 1b, 2a, 2b, 2c, 3a, and 3b) along with plant specific sand pocket regions, or any other plant specific features, will be included in the plant license renewal application. Therefore, it is not within the scope of this report to include the specific figures showing all of the subtypes of containment configuration. The description provided is considered adequate.

Request for Additional Information

6. Table 3-1, page 3-5, of the report describes the Criteria/Program, and the NUMARC/NRC Agreement for the ARDM "Reaction with Aggregates (Alkali-Aggregate Reactions)." The ARDM of "Reaction with Aggregates" in Column 1 and the "Aging Effects" in Column 2 "Expansion and Cracking" on page 3-6 appears to be a mismatch with the ARDM for "Elevated Temperature." Please verify this difference.

Response

A review of the information given in Table 3-1 where there appears to be a mismatch was reviewed. It was concluded that the ARDM entry in column 1 on page 3-6 should be "Elevated Temperature," and not "Reactions with Aggregates (Alkali-Aggregate Reactions)."

Request for Additional Information

7. Table 3-1 of the report refers to a phased program for evaluation of below grade level concrete for the ARDM "Corrosion of Embedded Steel" (pages 3-10 and 3-11) as described on sheet 3 of 18. Since no sheet 3 of 18 exists in the report, please complete the reference or provide the information as appropriate.

   The details of the phased approach/program to be used for "Corrosion of Embedded Steel" should be described separately on pages 3-10 and 3-11 under the column on "Criteria Program" for clarity and to facilitate review, rather than referenced on other pages.

Response

The reference to sheet 3 of 18 should be removed from the table. The sentences containing this page reference should not have been included in the table. It is agreed that the details of the program should be included within the column on "Criteria Program," and no reference to other pages should be given. The discussion pertaining to the NEI/U.S. NRC agreements is contained within this table.

The specific details related to the programs recommended within this report are contained in Section 4.1.7 and 4.1.8 and pertain to aging management programs AMP 5.3 and 5.4 for concrete, reinforcing steel, and steel embedments.

Request for Additional Information

8. Table 3-1, page 3-12, of the report for the ARDM "Corrosion of Liner (Below Grade)" in the "Criteria/Program" column references "Section 6.2 of the IR Report"

   Table 3-1 does not identify the specific "IR Report." Please identify the report and provide a discussion on the adequacy of the program for the staff review. Also, because Table 3-1 is considered to be a stand-alone summary of an aging management program, include a summary of the "IR Report" program in Table 3-1.

Response

The IR Report is: "PWR Containment Structures License Renewal Industry Report," Revision 1, EPRI TR-103835, July 1994.

The IR report program as described in Section 6.2 consist of: (1) visual inspection of susceptible locations to identify visible indications of degradation; (2) evaluation testing based on indications of significant deterioration from visual inspection; and (3) destructive testing if evaluation testing is not conclusive. Table 3-1 is not considered to be a stand-alone summary of the aging management program in the report, but a summary of NEI/NRC agreements related to an aging evaluation of PWR containment structures. The recommended aging management program related to corrosion of liner below grade is AMP 5-5 described in Table 4-13. This program incorporates the latest U.S. NRC position related to inaccessible areas (below grade) as described in SECY-96-080, and evaluation per § 50.55a (b) (2) (x) (A).

Request for Additional Information

9. Section 3.2 of the report addresses aging management review for structures and components. The tendon galleries as shown in Figure 2-3 appear to be part of the containment prestressed concrete structural components. Please discuss whether they should be subject to an aging management review for license renewal.

Response

The tendon galleries are not generically considered to be part of the containment prestressing structural system, and therefore are only subject to an aging management review for license renewal if they are considered, on a plant-specific basis, to support the integrity of the prestressing system. This would then be noted in any plant-specific license renewal application.

Request for Additional Information

10. Section 3.2.6 of the report concludes that there is no need to identify aging management options for concrete thermal aging embrittlement. However, the main steam line penetrations through the containment may be subject to this ARDM because the 500°F steam lines could cause local concrete heating beyond the 200°F ACI Code limit. Provide a discussion why plant specific evaluations and plant specific aging management reviews need not be addressed. Please also provide the maximum concrete temperatures at the main steam line penetrations.

Response

As noted in Section 3.2.6 local temperatures beyond 200°F is not permitted because of ACI 349 code limits. Therefore for hot piping design, provisions employing cooling coils and/or insulation are needed to maintain local temperatures within the 200°F code limit. Also, as discussed in Section 3.2.6 the local 200°F temperature could be exceeded for a short time due to accident conditions (event driven). However, to have thermal aging embrittlement the structure must be subjected to elevated temperatures for a prolonged time. Therefore, thermal aging embrittlement is not a viable aging effect for main steam line penetrations.

Request for Additional Information

11. Table 3-1 of the report indicates that stress corrosion cracking (SCC) is nonsignificant for stainless steel penetration bellows. However, plant operating experience has shown occurrences of SCC in bellows, which suggests that cracking is an applicable aging effect for bellows bodies. Please evaluate this issue.

Response

Table 3-1 summarizes PWR containment structures aging evaluation and status of NEI/U.S. NRC agreements, and not the specific aging management programs recommended in the report. Stress corrosion (SCC) and transgranular stress corrosion cracking (TGSCC) related to penetrations and bellows is discussed and evaluated within the report (see sections 3.2.24, 3.2.28, 4.1.9; Tables 2-17 and 4-13). This aging effect is managed by AMP 5.5.

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Request for Additional Information

12. Section 3.2.16 of the report indicates that fatigue at attachments and discontinuities is nonsignificant because the codes used in design addressed the issue. Please identify the specific structural components designed for fatigue loadings, including penetration sleeves and bellows assemblies. In addition, the additional fatigue cycles for a 20 year renewal period may affect the conclusion provided on page 3-41. Please address these issues and clarify whether fatigue is a TLAA for renewal.

Response

Fatigue is an important potential aging effect that must be evaluated for license renewal. It has been evaluated for many components within the report, and has been identified as a TLAA for renewal. Specifically, in Section 3.0 fatigue is evaluated for the following:

Section

3.2.9 Fatigue at Penetration Anchors
3.2.13 Fatigue - Reinforcing Steel
3.2.16 Fatigue at Attachments and Discontinuities - Liner, Airlocks, and Hatches
3.2.25 Fatigue - Mechanical Penetration Bellows
3.2.26 Fatigue - Mechanical (Piping) Penetrations
3.2.33 Fatigue - Airlock and Hatches
3.2.39 Fatigue - Free-Standing Steel Containment

In Section 3.3 fatigue is identified as a potential TLAA for the following components:

- Concrete Containment Penetration Anchors
- Mechanical Penetration Bellows
- Mechanical Penetrations associated with piping

The conclusions reached on page 3-41 for the components discussed in Section 3.2.16 will not be affected by 20 more years of service since the loading is below material yield stress.

Request for Additional Information

13. Section 3.2.20 on page 3-45 of the report, "Aging Effect Management," discusses loss of prestress for prestressing tendons. It states: "A revised predicted prestress loss rate must be calculated for the extended operation period and monitored for the plant life extension period, up to twenty years."

Please discuss how the prestress loss rate is determined for the additional 20 years of operation for the tendon to ensure that its intended function is maintained. In addition, Table 4-14 on page 4-50 does not address calculations for the prestress loss in the AMP. Further, the tendon prestress evaluation is a "time-limited aging analysis" and needs to be evaluated for license renewal in accordance with 10 CFR 54.21(c).

Response

In the report, losses in the prestressing system forces have been identified as a TLAA (Section 3.3). As noted in the RAI, an aging management program AMP 5.6 has been defined. However, a discussion of how the prestress loss rate is determined has not been given within the report since this is considered a plant specific issue that should be addressed within the applicants license renewal submittal.

Request for Additional Information

14. Section 3.2.23 of the report discusses material compatibility for electrical penetrations as part of the environmental qualification (EQ) program. Because EQ is a TLAA, provide a discussion on how the electrical penetrations will be qualified for the additional 20 years.

Response

It is agreed that EQ is a TLAA; however, the scope of this evaluation, as noted in Section 1.2, is limited to the metallic (structural portion) components of the electrical penetration that are part of the containment pressure boundary. Those components of the electrical penetration that would be subject to an EQ program is not addressed in this report.

Request for Additional Information

15. Section 3.2.39 of the report indicates that fatigue is nonsignificant because the design stresses were limited to below yield strength values. However, the actual local stresses at discontinuities can be significant and cause fatigue damage in steel elements such as crane supports, and other penetrations subject to vibratory loads. Please reevaluate fatigue.

Response

Steel structures as described in the RAI are governed by stress criteria as given in the American Institute of Steel Institute (AISC) specification. The stress criteria for fatigue recognizes loading conditions of members and connections subject to repeated variation of stress that causes the potential of fatigue. Discontinuities can result in stress raisers (local stresses). The criteria recognizes the potential increase at discontinuities by reducing the allowable stress for the particular detail that is being designed. Therefore, it is not necessary to consider fatigue effects for the steel structures identified in the RAI.

Fatigue in penetrations has been recognized as significant in the response to RAI 12. Vibratory loads will be associated with mechanical penetrations. This aging effect has been discussed and evaluated in Section 3.2.26, and it was concluded that an aging management program (AMP 5.5) was necessary to manage aging effects. Further, mechanical penetration aging due to fatigue has been identified as a TLAA in Section 3.3.

Request for Additional Information

16. Table 3-1 on page 3-15 of the report indicates that for containment penetration sleeves and pressure retaining attachments, and penetration bellows, a fatigue reanalysis conducted in accordance with ASME Section III, Subsection NB, is needed to show that the fatigue usage factors are maintained below unity throughout the license renewal period. However, Sections 3.2.9, 3.2.25, and 3.2.39 which discuss the fatigue issue for containment components, including penetration sleeves and bellows, do not address this reanalysis. Please clarify this inconsistency. Furthermore, fatigue analysis of containment penetration sleeves and bellows is a "time-limited aging analysis" and needs to be evaluated in accordance with 10 CFR 54.21(c).

Response

As discussed in the response to question 12, fatigue is an important potential aging effect and is identified as a TLAA in Section 3.3. Analysis is recognized as an acceptable means of demonstrating aging management when used in the original design basis. However, the use of CLB surveillance and testing programs for aging management can be used instead. Fatigue analysis (TLAA) is recognized in Table 3-4 as an acceptable means of showing aging management of mechanical penetrations.

Request for Additional Information

17. Table 3-4 of the report indicates that "concrete containment penetration anchors fatigue" and "mechanical penetrations bellows fatigue" TLAAs are described in Note (1). Note (1) states that, "Adequacy of component related to time-dependent degradation effect not based on analysis." Discuss how these components have been designed for fatigue.

Response

The design of concrete containment penetration anchors is generally based on primary stress where they are not subject to significantly high stress loading cycles, and therefore, fatigue does not control. However, if the penetration anchors are part of the mechanical (piping) penetration system a fatigue analysis defining usage factor may be appropriate as defined in Table 3-4. The anchor in this case would be considered part of the mechanical penetration.

Mechanical penetration bellows are designed for particular temperature, loading, and load cycle environment. As discussed in Section 3.2.25 fatigue is a potentially significant degradation mechanism when local defects or damage occur that reduce fatigue life. In-service-inspection (ISI) and testing of bellows has been used effectively to detect local damage. The bellows are replaced or repaired. The effects of fatigue of mechanical penetration bellows are managed following ASME Code Section XI, Subsection IWE as defined in aging management program AMP-5.5.

The aging management program defined within the report has been established based on current utility inspection and maintenance practices. The utility can choose to define an effective program of fatigue management using analysis to demonstrate that the usage factors are below unity throughout the license renewal term for these components. This approach would be defined in the plant license renewal application.

Request for Additional Information

18. Note (2) in Table 3-4 of the report indicates that the effects of aging would be adequately managed by CLB surveillance and testing programs, such as leak rate testing, for certain TLAAs. Justify how these programs would manage the effects of aging to ensure the intended functions for the period of extended operation in lieu of the TLAAs.

Response

Note (2) recognizes that the TLAA resolution can either be by analysis or by aging management. Note (2) follows the path where the TLAA is resolved by managing the aging effects. Examples of programs which manage aging effects are shown in Section 3.4 and Table 2-17:

- o Prestressing System , Prestress Force Losses; AMP-5.6
- o Concrete Containment Penetration Anchors Fatigue; AMP-5.5
- o Mechanical Penetration Bellows Fatigue; AMP 5-5.

These programs that are part of the overall aging management program given in the report for PWR containment structures. They are described with basis and justification in Section 4.

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Request for Additional Information

19. Tables 4-11 and 4-12, pages 4-32 and 4-35 of the report, describe the frequency for taking water samples as "each refueling outage." Because ground water chemistry could vary with the seasons, please discuss the basis for not taking and analyzing samples more frequently, at least until a data base has been established. Also, provide basis for the water sample chemistry acceptance criteria.

Response

The frequency for taking water samples is not limited to "each refueling outage" by Tables 4-11 and 4-12. The frequency is limited to the "time period between program performance ...". This means that each program to monitor the quality of groundwater for plants where chemistry is questionable must be completed in this time period. As stated in Section 4.1.7, "the primary step is to test the groundwater and/or soil chemistry for sulfate and chloride content as well as pH, to determine if the environment would promote an aggressive chemical attack and to provide a benchmark for further monitoring if required." It is expected that the utility ground water monitoring program would address potential seasonal variation in water chemistry. Over each refueling interval, the results from this program would be evaluated as part of the monitoring program to determine if other actions would be required.

The water chemistry acceptance criteria is a pH greater than 5.5 and chloride and/or sulfate concentrations less than 500 or 1500 ppm, respectively. The basis of this acceptance criteria follows an industry recognized criteria as given in the PWR industry report: "PWR Containment Structures License Renewal Industry Report," Revision 1, EPRI TR-103835, July 1994, Sections 4.1.3 and 6.1.

Request for Additional Information

20. Table 4-13 on page 4-40 of the report references the 1992 Edition with 1992 Addenda of ASME Section XI Code. However, Examination Categories E-A through E-P of Subsection IWE described on page 4-40 appear to be taken entirely from the 1989 Edition. This is also inconsistent with the statement described on page 2-61 where the 1992 Edition of the ASME Code, including the 1992 Addenda, is addressed. Please clarify the edition of the ASME Section XI, including its examination categories, that is relied on for license renewal.

Response

The RAI is correct that the examination categories E-A through E-P of Subsection IWE described on page 4-40 are taken from the 1989 Edition. This is an error, and they should reflect the 1992 ASME edition when using aging management program AMP-5.5 for license renewal. The correct examination categories are:

E-A	Containment surfaces
E-B	Pressure retaining welds
E-C	Containment surfaces requiring augmented examination
E-D	Seals, gaskets, and moisture barriers
E-F	Pressure retaining dissimilar metal welds
E-G	Pressure retaining bolting
E-P	All pressure retaining components

Request for Additional Information

21. Table 4-15 of the report addresses the management of foundation settlement by periodic inspection of gaps between buildings, and the measurements of settlements. Please provide a settlement monitoring program that would ensure that differential settlement of the containment base mat does not exceed the design criteria for a containment structure and its concrete base mat which is resting on soil or piles, or experiencing significant changes in ground water conditions. Also discuss how the program contains elements referred to in Subsection II.C of Section 3.0 of the working draft "Standard Review Plan for the Review of License Renewal Applications for Nuclear Power Plants," September 1997.

Response

It has been recognized in the evaluation of foundation degradation that settlement is potentially a significant age-related degradation mechanism. Most of the settlement will occur within the first 5 or 6 years of operation. Only those plants with significant long-term settlement issues will be affected. Because of possible changes in the site conditions over the life of the plant that could increase settlement, i.e., lowering of the groundwater table, programs to monitor changes in ground water table and to detect potentially significant settlement are part of the CLB for susceptible plants. Compliance with the CLB is to be part of the license renewal commitment. The settlement monitoring program that is followed by the susceptible plants is recognized to be plant specific, and therefore, not within the scope of this generic report that covers all of the Westinghouse PWR plants. The details of the utility program would be provided in the license renewal application. It is noted however that an aging management program has been defined, AMP-5.7, which has the attributes that are recommended to be contained within the site specific program. It may be necessary that a utility modify their program so as to be in compliance. The plant specific design criteria would be identified as part of the acceptance criteria.

The aging management program, AMP-5.7, contains elements that are consistent with Subsection II.C of Section 3.0 of the working draft "Standard Review Plan for the Review of License Renewal Applications for Nuclear Power Plants," September 1997. The consistency is through the program attributes: scope; surveillance technique; frequency; acceptance criteria; corrective actions; and confirmation.

Request for Additional Information

22. Section 4.1.9, page 4-39 of the report, states that "Those areas of the liner and steel containment shell below grade are subject to deterioration when exposed to aggressive aqueous solutions. This has been discussed previously for aggressive chemical attack of the concrete." Please describe how this discussion of the aggressive chemical attack of the concrete relates to the deterioration of the liner and steel containment shell below grade level. Also, please cite a reference to the previous discussion.

Response

The discussion referred to was in Section 4.17, Concrete - Aggressive Chemical Attack (AMP-5.3 and AMP-5.4). In this section it is stated:

> If deterioration is found at the sample area*, the acceptability of inaccessible areas is evaluated in accordance with changes to 10 CFR 50.55a, as described in SECY-96-080. Concrete containments are evaluated using the revised rule § 50.55a (b) (2) (ix) (E), while steel liners and steel containments are evaluated using the revised rule § 50.55a (b) (2) (x) (A).

Further, in this section the monitoring of inaccessible areas through inspection of adjacent accessible portions and sealing mechanisms are discussed for cases where degradation is indicative of possible degradation of the inaccessible area. This discussion is also applicable to managing the potential aging deterioration of the liner and steel containment shell below grade level.

* Sample areas are exterior concrete surfaces that are below the groundwater table.

Request for Additional Information

23. Section 4.1.9 on page 4-39 of the report states "Corrosion of inaccessible areas is monitored through the inspection of adjacent accessible portions and sealing mechanisms, where degradation is indicative of possible degradation of the inaccessible area." Please provide information to show that conditions exist in accessible areas that could indicate the presence of or result in certain degradation to the inaccessible areas. Also discuss the potential corrosion of inaccessible areas of structural steel and liner, when conditions in accessible areas may not indicate the presence of or result in degradation to such inaccessible areas, and how it would be managed for license renewal.

Response

The requirements given in SECY-96-080 are followed that require the licensee to evaluate the acceptability of inaccessible areas when conditions exist in accessible areas that could indicate the presence of or result in degradation to such inaccessible areas. Conditions that are considered indicative of potential degradation of inaccessible areas are cracking, spalling, staining, seepage, voids, pitting, rust, blistering, flaking, discoloration, wear, erosion, tears, and flaws. The potential for corrosion in inaccessible areas without conditions in accessible areas present is only deemed as a feasible aging effect if an event driven accident has occurred (e.g., spillage of boric acid; change in ground water chemistry outside of the norm due to an accident). In these cases it will be the responsibility of the licensee to implement the ISI summary report required by IWA-6000. See also the discussion given for RAI 2.

Request for Additional Information

24. Section 4.1.4 of the report addresses nondestructive examination/sampling inspection technology. Please discuss the implementation of Appendix VII, "Qualification of Nondestructive Examination Personnel for Ultrasonic Examination," and Appendix VIII, "Performance Demonstration for Ultrasonic Examination Systems," of ASME Section XI Code when ultrasonic examinations are used for inspection of containments.

Response

When implementing an aging management program that references ASME IWE sections for the management of containment aging effects, and it is necessary to use augmented ASME Section XI NDE inspection methods, the training qualification and certification of ultrasonic examination personnel will meet Appendix VII and Appendix VIII.

Request for Additional Information

25. Provide a discussion to address the management of aging effects due to erosion of cement for porous concrete if sub foundation layers of porous concrete are used in the construction of containment concrete basemat.

Response

This type of aging effect has not been addressed in the report since this type of construction is considered to be limited, and therefore, not appropriate for a generic report. If a plant uses porous concrete for sub foundation layers of a containment concrete basemat, this design would be outside of the engineering design characteristics for which this report is applicable. Therefore, the utility would have to address this construction and aging effect in its plant-specific license renewal application.

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Request for Additional Information

26. Provide a discussion to address the performance of examinations specified in Examination Category E-B for pressure retaining welds, and Examination Category E-F for pressure retaining dissimilar metal welds of Subsection IWE of ASME Section XI Code (1992 Edition and 1992 Addenda) for license renewal.

Response

Pressure retaining welds (Examination Category E-B) that are accessible are visually inspected using the VT-1 examination method. Nondestructive testing and VT-1 visual examinations are conducted for suspect areas and augmented inspections are required for repairs. Alternate examination methods can be used that meet the requirements of IWA-2240. The inspection frequency, acceptance criteria, corrective actions, and confirmation follow the IWE requirements as defined in Table 4-13 for aging management program AMP-5.5.

Pressure retaining dissimilar metal welds (Category E-F) that are accessible are inspected using surface examination methods. Surface examination methods are defined in Subsection IWA-2220 (magnetic particle examination; liquid penetrant examination). Also, as in the case of pressure retaining welds, alternate examination methods can be used that meet the requirements of IWA-2240. The inspection frequency, acceptance criteria, corrective actions, and confirmation follow the IWE requirements as defined in Table 4-13 for aging management program AMP-5.5.

Request for Additional Information

27. Please address aging management for elevated temperature of tendons for prestressed concrete containments for license renewal.

Response

The evaluation of prestressed concrete containment tendons for elevated temperatures is discussed in Section 3.2.18 of the report. It was noted that exposure of heat-treated and drawn prestressing wire to elevated temperatures can result in reduced tensile strength, an aging effect, due to permanent alternations of the internal crystalline transformations created during annealing. The temperatures experienced by PWR containment prestressing systems are well below temperatures where tensile strength will become significant. In Section 3.2.20 of the report, prestress force losses resulting from many effects are discussed. Elevated temperature is one of the effects evaluated. It was concluded that loss of prestress force due to wire stress relaxation caused by elevated temperatures can occur. The loss of prestress force has been identified as a potential time-dependent degradation effect. This potential source of degradation is currently managed by plant surveillance and testing programs following ASME Section XI, Subsection IWL. These ISE and testing programs monitor the loss of prestress, and conditions conducive to or evidence of corrosion and concrete degradation. They also provide criteria for the acceptance of mitigation actions, repairs, and subsequent inspections. A revised predicted prestress loss rate will have to be performed by the utility for an extended operation period and monitored for the plant life extension period. Aging management program AMP-5.6 is recommended to be followed by a utility to manage prestress force losses for license renewal.

Request for Additional Information

28. Operating experience indicates that grease leakage of prestressed concrete containments were found in some nuclear power plants such as Trojan, Calvert Cliffs, Arkansas Nuclear One Unite 1, Point Beach, Palisades, and Fort Calhoun. Please provide a discussion on how the aging effects of grease leaked into concrete is being managed and also discuss how the elements in Section 3.0.11.C of the draft working SRP-LR would be met. In addition, please discuss the potential effects of grease on the shear load capability of the concrete structure.

Response

Detrimental effects from grease leakage are not considered an aging effect for license renewal considerations since this event (grease leakage) would be occurring in the current licensing term, and if significant to the integrity of the containment structure, or prestressing system, must be so addressed as part of the plant's current on-going maintenance program. The examination and inspection of grease leakage significance, and its impact on the integrity of prestressed concrete containments would follow the ASME Section XI, Subsection IWL requirements. Concrete surfaces would be visually examined for evidence of conditions which may be indicative of damage or degradation. This program is considered part of the plant's CLB on-going program.

If there are ingredients within the grease that would cause degradation of the concrete, the utility should consider this as part of a concrete aggressive chemical attack mechanism, and manage the effect during the license renewal period following the aging management program AMP-5.3 given in the report. This aging management program meets the elements in Section 3.0.11.C of the draft working SRP-LR through the program attributes (scope; surveillance technique; frequency; acceptance criteria; corrective actions; and confirmation).

It is not possible to address the potential effects of grease on the shear load capability of the concrete structure since this is a plant specific issue. It will depend on the plant construction, and the degradation (cracking) of the concrete that allows the grease to leak. Since grease leakage issues are considered to occur in the current licensing term, the utility would address this potential effect in their license renewal application. If grease leakage occurs during the license renewal period for the first time, it is indicative of a potential aging effect and should be evaluated and managed as part of the plants maintenance and license renewal program.

Editorial Comments (Items 29 - 33)

Request for Additional Information

29. Section 2.3.1.1, page 2-11 of the report, states that the shield building foundation "thicknesses range from 6 to 9 feet." However Tables 2-3 lists foundation thicknesses that are lower. Please correct this inconsistency. Specifically, Page 2-11 under the shield building indicates that the containment base mats for containment Types 1a and 1b have a thickness range from 6 to 9 feet. However, this is true only for containment Type 1a in accordance with Table 2-3 on Page 2-9. For containment Type 1b, the base mat thickness is only 4 feet for Prairie Island 1 & 2. Furthermore, the thickness of the base mat should be addressed in Section 2.3.1.3 for the Type 3 containment configurations, where the base mat thickness is as low as 2 feet for R.E. Ginna.

Response

The comments made in the RAI are correct. The statements made in the report are in error. The range of thickness of the base mat for each type should be as given below:

Type 1a, 1b	4' to 9'
Type 2a, 2b, 2c	9' to 16'
Type 3a, 3b	2' to 18'

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Request for Additional Information

30. Table 3-1 on page 3-8 of the report, the ARDM of irradiation of steel does not include the containment wall reinforcing steel below grade level for concrete containments reinforced/prestressed. This component was included in Table B3 on page B-34 of NUREG-1557. The described item is missing from Table 3-1 on Page 3-8. Please clarify this difference.

Response

The statement made in the RAI is correct, and the entry in Table 3-1 on page 3-8 should read: "Containment wall reinforcing steel above and below grade."

Request for Additional Information

31. In Table 3-1, page 3-9 of the report, please clarify whether "Liner anchors" for the free-standing cylindrical and spherical steel containment with elliptical bottom presented under the ARDM "Irradiation of Steel" should be the "Sand pocket region" as described in Table B3 on page B-35 of NUREG-1557.

Response

The statement made in the RAI is correct. "Liner anchors" should be "Sand pocket region."

Request for Additional Information

32. Many of the sketches of equipment details provided in the report copy are not legible (e.g., Figures 2-2, 2-7, 2-10, and 2-13). Please provide clear and legible figures.

Response

The sketches provided within the report are given to provide overall general characteristics of the different configurations and types, and not to provide details. The level of detail, as requested in the RAI, would be provided as needed as part of the utility license renewal application.

Request for Additional Information

33. Please add the publication dates to all references/bibliography documents such as 6.1-11, 6.1-14, 6.1-17, 6.1-28, 6.2-3, 6.2-4, 6.2-5, 6.2-7, 6.2-8, 6.2-9, 6.2-11, 6.2-15, 6.2-71, 6.2-76, and 6.2-77.

Response

The requested dates are provided below:

6.1 References

11. ASME Boiler and Pressure Vessel Code Section III, Division 2 (1986).

14. ACI 349-85, Code Requirements for Nuclear Safety-Related Concrete Structures (1985).

17. ACI 318, "Building Code Requirements for Reinforced Concrete," American Concrete Institute, Detroit, Michigan (1977)

28. NUREG/CP-0120, SAND92-0173, "Containment Penetrations - Flexible Metallic Bellows Testing. Safety, Life Extension Issues," Fifth Workshop on Containment Integrity (1992).

6.2 Bibliography

3. ACI 224R-89, "Control of Cracking in Concrete Structures," American Concrete Institute, Detroit, Michigan (1989).

4. ACI 224.1R-89, "Causes, Evaluation, and Repair of Cracks in Concrete Structures," American Concrete Institute, Detroit, Michigan (1989).

5. ACI 228.1R-89, "In-Place Methods for Determination of Strength of Concrete," American Concrete Institute, Detroit, Michigan (1989).

7. ACI 349.3R-95, "Evaluation of Existing Nuclear Safety-Related Concrete Structures," (draft) (1995).

8. ACI 301, "Specification for Structural Concrete for Buildings," American Concrete Institute, Detroit, Michigan (1996).

9. ACI Committee 349, "Code Requirements for Nuclear Safety-Related Concrete Structures (ACI 349-93) and Commentary," American Concrete Institute, Detroit, (draft) (1993).

11. American Society of Mechanical Engineers (ASME), Boiler and Pressure Vessel Code (B&PVC), Section III, Subsection MC, Division 1 (date dependent on plant licensing basis).

15. Greimann and Fanous, ASME Pressure Vessel and Piping Technology—A Decade of Progress, "Reliability of Containments under Overpressure" (1985).

71. Reg Guide 1.20, "Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants," U.S. Nuclear Regulatory Commission (Rev. 2, May 1976).

76. Transactions of the 11th International Conference on Structural Mechanics in Reactor Technology, "Experiments to Determine Behavior of Pressure-Unseating Equipment Hatches," Volume F (1991).

77. Transactions of the ANS, "Safety Aspects of License Renewal," Volume 65, pp 294-295 (1992).