

CHAPTER III

STRUCTURES  
AND  
COMPONENT SUPPORTS



## **Structures and Component Supports**

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Chapter III A: Class 1 Structures

Chapter III B: Component Supports



## CHAPTER III A

### CLASS 1 STRUCTURES



## **Class 1 Structures**

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**A1. Group 1 Structures (BWR Reactor Bldg, PWR Shield Bldg, Control Rm/Bldg)**

A1.1 Concrete Elements

A1.2 Steel Elements

A1.3 Masonry Walls



## **A1. Group 1 Structures (BWR Reactor Bldg, PWR Shield Bldg, Control Rm/Bldg)**

### **Systems, Structures, and Components**

Class 1 structures are organized into nine groups and are discussed separately under subheadings A1 through A9. Review Table III A1 addresses the elements of BWR Reactor Building, PWR Shield Building, and Control Room Building. For this group, the applicable structural elements are identified: concrete, steel, and masonry walls. The aging management review is presented for each applicable combination of structural element and aging effect.

### **System Interfaces**

Physical interfaces exist with any system or component that either penetrates the structure wall or is supported by the structure wall, floor and roof. The direct interface is through the system or component supports that are anchored to the structure. Structures also protect housed systems or components from internal and external design basis events. In the case of tanks, there is a functional interface with the associated system. Water control structures are an integral part of the systems that provide plant cooling water and residual heat removal.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A1. Group 1 Structures (BWR reactor bldg., PWR shield bldg., Control room/bldg.)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A1.1	Concrete	Exterior Above and Below Grade; Foundation	Reinforced Concrete	Weather Exposed	Loss of Material (spalling, scaling) and Cracking	Freeze/Thaw	NUREG-1557 ASTM C33-90 ACI 318-63 ACI 349-85
A1.1	Concrete	Exterior Above and Below Grade; Foundation	Reinforced Concrete	Flowing Water	Increase in Porosity and Permeability, Loss of Strength	Leaching of Calcium Hydroxide	NUREG-1557 ACI 201.2R-77
A1.1	Concrete	All	Reinforced Concrete	Any	Expansion & Cracking	Reaction with Aggregates	NUREG-1557 ASTM C295-54 ASTM C227-50 ACI 201.2R-77

### III STRUCTURES AND COMPONENT SUPPORTS

#### A1. Group 1 Structures (BWR reactor bldg., PWR shield bldg., Control room/bldg.)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, freeze/thaw does not cause loss of material from reinforced concrete in foundations, and in above and below grade exterior concrete, for plants located in a geographic region of negligible weathering conditions (weathering index &lt;100 day-inch/yr). Loss of material from such concrete is not significant at plants located in areas in which weathering conditions are severe (weathering index &gt;500 day-inch/yr) or moderate (100-500 day-inch/yr), provided that the concrete mix design meets the air content (entrained air 3-6%) and water-to-cement ratio (0.35-0.45) specified in ACI 318-63 or ACI 349-85. Therefore, if these conditions are satisfied, aging management is not required.</p> <p>The weathering index is defined in ASTM C33-90, Table 3, Footnote E. Fig. 1 of ASTM C33-90 illustrates the various weathering index regions throughout the U.S.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, leaching of calcium hydroxide from reinforced concrete becomes significant only if the concrete is exposed to flowing water. Even if reinforced concrete is exposed to flowing water, such leaching is not significant if the concrete is constructed to ensure that it is dense, well-cured, has low permeability, and that cracking is well controlled. Cracking is controlled through proper arrangement and distribution of reinforcing bars. All of the above characteristics are assured if the concrete was constructed with the guidance of ACI 201.2R-77. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, investigations, tests, and petrographic examinations of aggregates performed in accordance with ASTM C295-54 or ASTM C227-50 can demonstrate that those aggregates do not react within reinforced concrete. For potentially reactive aggregates, aggregate-reinforced concrete reaction is not significant if the concrete was constructed in accordance with ACI 201.2R-77. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A1. Group 1 Structures (BWR reactor bldg., PWR shield bldg., Control room/bldg.)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A1.1	Concrete	Interior and Above Grade Exterior	Reinforced Concrete	Exposure to Aggressive Environment	Cracking, Loss of Bond, Loss of Material (spalling, scaling)	Corrosion of Embedded Steel	NUREG-1557 ACI 318-63 ACI 349-85
A1.1	Concrete	Below Grade Exterior; Foundation	Reinforced Concrete	Exposure to Aggressive Environment	Cracking, Loss of Bond, Loss of Material (spalling, scaling)	Corrosion of Embedded Steel	NUREG-1557
A1.1	Concrete	Interior and Above Grade Exterior	Reinforced Concrete	Exposure to Aggressive Environment	Increase in Porosity and Permeability, Cracking, Loss of Material (spalling, scaling)	Aggressive Chemical Attack	NUREG-1557
A1.1	Concrete	Below Grade Exterior; Foundation	Reinforced Concrete	Exposure to Aggressive Environment	Increase in Porosity and Permeability, Cracking, Loss of Material (spalling, scaling)	Aggressive Chemical Attack	NUREG-1557

### III STRUCTURES AND COMPONENT SUPPORTS

#### A1. Group 1 Structures (BWR reactor bldg., PWR shield bldg., Control room/bldg.)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, corrosion of exterior above-grade and interior embedded steel is not significant if the steel is not exposed to an aggressive environment (concrete pH &lt;11.5 or chlorides &gt;500 ppm). If such steel is exposed to an aggressive environment, corrosion is not significant if the concrete in which the steel is embedded has a low water-to-cement ratio (0.35-0.45), adequate air entrainment (3-6%), low permeability, and is designed in accordance with ACI 318-63 or ACI 349-85. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Plant-Specific Program	As described in NUREG-1557, for components exposed to groundwater such as foundations and exterior concrete below grade, evaluate on a case-by-case basis to ensure that aging effects due to corrosion of embedded steel will be managed to maintain intended functions during the period of extended operation.	Yes
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, aggressive chemical attack on interior and above-grade exterior reinforced concrete is not significant if the concrete is not exposed to an aggressive environment (pH &lt;5.5), or to chloride or sulfate solutions beyond defined limits (&gt;500 ppm chloride, or &gt;1500 ppm sulfate). Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Plant-Specific Program	As described in NUREG-1557, exterior below grade and foundation should be evaluated on a case-by-case basis to ensure that aging effects due to aggressive chemical attack will be managed to maintain the intended functions during the period of extended operation.	Yes

### III STRUCTURES AND COMPONENT SUPPORTS

#### A1. Group 1 Structures (BWR reactor bldg., PWR shield bldg., Control room/bldg.)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A1.1	Concrete	All	Reinforced Concrete	Soft Soil; Changes in Ground-water Conditions	Cracks; Distortion; Increase in Component Stress Level	Settlement	
A1.1	Concrete	Foundation	Reinforced Concrete	Flowing Water Under Foundation	Reduction in Foundation Strength	Erosion of Porous Concrete Subfoundation	IN 98-26
A1.1	Concrete	All	Reinforced Concrete	Outside Containment	Loss of Strength and Modulus	Elevated Temperature (>150°F general; >200°F local)	ACI 349-85
A1.2	Steel Components	Accessible Structural Steel	Carbon Steel	Various	Loss of Material	Corrosion	
A1.2	Steel Components	Inaccessible Structural Steel	Carbon Steel	Various	Loss of Material	Corrosion	NUREG-1557
A1.3	Masonry Walls	All	Concrete Block	Ambient Environment Inside Building	Cracking	Restraint; Shrinkage; Creep; Aggressive Environment	

### III STRUCTURES AND COMPONENT SUPPORTS

#### A1. Group 1 Structures (BWR reactor bldg., PWR shield bldg., Control room/bldg.)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Plant-Specific Program	The initial Licensing Basis for some plants included a program to monitor settlement. If no settlement was evident during the first decade or so, the NRC may have given the licensee approval to discontinue the program. However, if a de-watering system is relied upon for control of settlement, then the licensee needs to ensure proper functioning of the de-watering system through the period of extended operation.	Yes.  If applicable.
Plant-Specific Program	IN 98-26 proposes Maintenance Rule Structures Monitoring for managing erosion of cement from porous concrete subfoundations, if applicable. See Chapter XI.S6 for an evaluation of Structures Monitoring Program.  If a de-watering system is relied upon for control of erosion of cement from porous concrete subfoundations, then the licensee needs to ensure proper functioning of the de-watering system through the period of extended operation.	Yes.  If applicable.
Plant-Specific Program	For any concrete elements that exceed specified temperature limits, further evaluations are warranted. Appendix A of ACI 349-85 specifies the concrete temperature limits for normal operation or any other long-term period. The temperatures shall not exceed 150 °F except for local areas which are allowed to have increased temperatures not to exceed 200 °F.	Yes.  If applicable.
Structures Monitoring Program	See Chapter XI.S6 for an evaluation of Structures Monitoring Program.  The staff notes that inspection and maintenance of protective coatings are effective preventive measures for accessible areas.	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Plant-Specific Program	As described in NUREG-1557, inaccessible areas should be evaluated on a case-by-case basis to ensure that aging effects due to corrosion will be managed.	Yes
Masonry Wall Program	See Chapter XI.S5 for an evaluation of Masonry Wall Program.	No



**A2. Group 2 Structures (BWR Reactor Bldg. with Steel Superstructure)**

A2.1 Concrete Elements

A2.2 Steel Elements

A2.3 Masonry Walls



## **A2. Group 2 Structures (BWR Reactor Bldg with Steel Superstructure)**

### **Systems, Structures, and Components**

Class 1 structures are organized into nine groups and are discussed separately under subheadings A1 through A9. Review Table III A2 addresses the elements of BWR Reactor Building with Steel Superstructure. For this group, the applicable structural elements are identified: concrete, steel, and masonry walls. The aging management review is presented for each applicable combination of structural element and aging effect.

### **System Interfaces**

Physical interfaces exist with any system or component that either penetrates the structure wall or is supported by the structure wall, floor and roof. The direct interface is through the system or component supports that are anchored to the structure. Structures also protect housed systems and components from internal and external design basis events. In the case of tanks, there is a functional interface with the associated system. Water control structures are an integral part of the systems that provide plant cooling water and residual heat removal.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A2. Group 2 Structures (BWR reactor building with steel superstructure)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A2.1	Concrete	Exterior Above and Below Grade; Foundation	Reinforced Concrete	Weather Exposed	Loss of Material (spalling, scaling) and Cracking	Freeze/Thaw	NUREG-1557 ASTM C33-90 ACI 318-63 ACI 349-85
A2.1	Concrete	Exterior Above and Below Grade; Foundation	Reinforced Concrete	Flowing Water	Increase in Porosity and Permeability, Loss of Strength	Leaching of Calcium Hydroxide	NUREG-1557 ACI 201.2R-77
A2.1	Concrete	All	Reinforced Concrete	Any	Expansion & Cracking	Reaction with Aggregates	NUREG-1557 ASTM C295-54 ASTM C227-50 ACI 201.2R-77

### III STRUCTURES AND COMPONENT SUPPORTS

#### A2. Group 2 Structures (BWR reactor building with steel superstructure)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, freeze/thaw does not cause loss of material from reinforced concrete in foundations, and in above and below grade exterior concrete, for plants located in a geographic region of negligible weathering conditions (weathering index &lt;100 day-inch/yr). Loss of material from such concrete is not significant at plants located in areas in which weathering conditions are severe (weathering index &gt;500 day-inch/yr) or moderate (100-500 day-inch/yr), provided that the concrete mix design meets the air content (entrained air 3-6%) and water-to-cement ratio (0.35-0.45) specified in ACI 318-63 or ACI 349-85. Therefore, if these conditions are satisfied, aging management is not required.</p> <p>The weathering index is defined in ASTM C33-90, Table 3, Footnote E. Fig. 1 of ASTM C33-90 illustrates the various weathering index regions throughout the U.S.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, leaching of calcium hydroxide from reinforced concrete becomes significant only if the concrete is exposed to flowing water. Even if reinforced concrete is exposed to flowing water, such leaching is not significant if the concrete is constructed to ensure that it is dense, well-cured, has low permeability, and that cracking is well controlled. Cracking is controlled through proper arrangement and distribution of reinforcing bars. All of the above characteristics are assured if the concrete was constructed with the guidance of ACI 201.2R-77. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, investigations, tests, and petrographic examinations of aggregates performed in accordance with ASTM C295-54 or ASTM C227-50 can demonstrate that those aggregates do not react within reinforced concrete. For potentially reactive aggregates, aggregate-reinforced concrete reaction is not significant if the concrete was constructed in accordance with ACI 201.2R-77. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A2. Group 2 Structures (BWR reactor building with steel superstructure)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A2.1	Concrete	Interior and Above Grade Exterior	Reinforced Concrete	Exposure to Aggressive Environment	Cracking, Loss of Bond, Loss of Material (spalling, scaling)	Corrosion of Embedded Steel	NUREG-1557 ACI 318-63 ACI 349-85
A2.1	Concrete	Below Grade Exterior; Foundation	Reinforced Concrete	Exposure to Aggressive Environment	Cracking, Loss of Bond, Loss of Material (spalling, scaling)	Corrosion of Embedded Steel	NUREG-1557
A2.1	Concrete	Interior and Above Grade Exterior	Reinforced Concrete	Exposure to Aggressive Environment	Increase in Porosity and Permeability, Cracking, Loss of Material (spalling, scaling)	Aggressive Chemical Attack	NUREG-1557
A2.1	Concrete	Below Grade Exterior; Foundation	Reinforced Concrete	Exposure to Aggressive Environment	Increase in Porosity and Permeability, Cracking, Loss of Material (spalling, scaling)	Aggressive Chemical Attack	NUREG-1557
A2.1	Concrete	All	Reinforced Concrete	Soft Soil; Changes in Ground-water Conditions	Cracks; Distortion; Increase in Component Stress Level	Settlement	

### III STRUCTURES AND COMPONENT SUPPORTS

#### A2. Group 2 Structures (BWR reactor building with steel superstructure)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, corrosion of exterior above-grade and interior embedded steel is not significant if the steel is not exposed to an aggressive environment (concrete pH &lt;11.5 or chlorides &gt;500 ppm). If such steel is exposed to an aggressive environment, corrosion is not significant if the concrete in which the steel is embedded has a low water-to-cement ratio (0.35-0.45), adequate air entrainment (3-6%), low permeability, and is designed in accordance with ACI 318-63 or ACI 349-85. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Plant-Specific Program	As described in NUREG-1557, for components exposed to groundwater such as foundations and exterior concrete below grade, evaluate on a case-by-case basis to ensure that aging effects due to corrosion of embedded steel will be managed to maintain intended functions during the period of extended operation.	Yes
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, aggressive chemical attack on interior and above-grade exterior reinforced concrete is not significant if the concrete is not exposed to an aggressive environment (pH &lt;5.5), or to chloride or sulfate solutions beyond defined limits (&gt;500 ppm chloride, or &gt;1500 ppm sulfate). Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Plant-Specific Program	As described in NUREG-1557, exterior below grade and foundation should be evaluated on a case-by-case basis to ensure that aging effects due to aggressive chemical attack will be managed to maintain the intended functions during the period of extended operation.	Yes
Plant-Specific Program	The initial Licensing Basis for some plants included a program to monitor settlement. If no settlement was evident during the first decade or so, the NRC may have given the licensee approval to discontinue the program. However, if a de-watering system is relied upon for control of settlement, then the licensee needs to ensure proper functioning of the de-watering system through the period of extended operation.	Yes.  If applicable.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A2. Group 2 Structures (BWR reactor building with steel superstructure)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A2.1	Concrete	Foundation	Reinforced Concrete	Flowing Water Under Foundation	Reduction in Foundation Strength	Erosion of Porous Concrete Subfoundation	IN 98-26
A2.1	Concrete	All	Reinforced Concrete	Outside Containment	Loss of Strength and Modulus	Elevated Temperature (>150°F general; >200°F local)	ACI 349-85
A2.2	Steel Components	Accessible Structural Steel	Carbon Steel	Various	Loss of Material	Corrosion	
A2.2	Steel Components	Inaccessible Structural Steel	Carbon Steel	Various	Loss of Material	Corrosion	NUREG-1557
A2.3	Masonry Walls	All	Concrete Block	Ambient Environment Inside Building	Cracking	Restraint; Shrinkage; Creep; Aggressive Environment	

### III STRUCTURES AND COMPONENT SUPPORTS

#### A2. Group 2 Structures (BWR reactor building with steel superstructure)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Plant-Specific Program	<p>IN 98-26 proposes Maintenance Rule Structures Monitoring for managing erosion of cement from porous concrete subfoundations, if applicable. See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>If a de-watering system is relied upon for control of erosion of cement from porous concrete subfoundations, then the licensee needs to ensure proper functioning of the de-watering system through the period of extended operation.</p>	<p>Yes.</p> <p>If applicable.</p>
Plant-Specific Program	<p>For any concrete elements that exceed specified temperature limits, further evaluations are warranted. Appendix A of ACI 349-85 specifies the concrete temperature limits for normal operation or any other long-term period. The temperatures shall not exceed 150 °F except for local areas which are allowed to have increased temperatures not to exceed 200 °F.</p>	<p>Yes.</p> <p>If applicable.</p>
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>The staff notes that inspection and maintenance of protective coatings are effective preventive measures for accessible areas.</p>	<p>No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.</p>
Plant-Specific Program	<p>As described in NUREG-1557, inaccessible areas should be evaluated on a case-by-case basis to ensure that aging effects due to corrosion will be managed.</p>	<p>Yes</p>
Masonry Wall Program	<p>See Chapter XI.S5 for an evaluation of Masonry Wall Program.</p>	<p>No</p>



**A3. Group 3 Structures (Auxiliary Bldg, Diesel Generator Bldg, Radwaste Bldg, Turbine Bldg, Switchgear Rm, AFW Pumphouse, Utility/Piping Tunnels)**

A3.1 Concrete Elements

A3.2 Steel Elements

A3.3 Masonry Walls



**A3. Group 3 Structures (Auxiliary Bldg, Diesel Generator Bldg, Radwaste Bldg, Turbine Bldg, Switchgear Rm, AFW Pumphouse, Utility/Piping Tunnels)**

**Systems, Structures, and Components**

Class 1 structures are organized into nine groups and are discussed separately under subheadings A1 through A9. Review Table III A3 addresses the elements of Auxiliary Building, Diesel Generator Building, Radwaste Building, Turbine Building, Switchgear Room, AFW Pumphouse, and Utility/Piping Tunnels. For this group, the applicable structural elements are identified: concrete, steel, and masonry walls. The aging management review is presented for each applicable combination of structural element and aging effect.

**System Interfaces**

Physical interfaces exist with any system or component that either penetrates the structure wall or is supported by the structure wall, floor and roof. The direct interface is through the system or component supports that are anchored to the structure. Structures also protect housed systems and components from internal and external design basis events. In the case of tanks, there is a functional interface with the associated system. Water control structures are an integral part of the systems that provide plant cooling water and residual heat removal.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A3. Group 3 Structures (Aux., diesel generator, radwaste, turbine buildings; and switchgear room, aux. feedwater pump house, utility/piping tunnels)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A3.1	Concrete	Exterior Above and Below Grade; Foundation	Reinforced Concrete	Weather Exposed	Loss of Material (spalling, scaling) and Cracking	Freeze/Thaw	NUREG-1557 ASTM C33-90 ACI 318-63 ACI 349-85
A3.1	Concrete	Exterior Above and Below Grade; Foundation	Reinforced Concrete	Flowing Water	Increase in Porosity and Permeability, Loss of Strength	Leaching of Calcium Hydroxide	NUREG-1557 ACI 201.2R-77
A3.1	Concrete	All	Reinforced Concrete	Any	Expansion & Cracking	Reaction with Aggregates	NUREG-1557 ASTM C295-54 ASTM C227-50 ACI 201.2R-77

### III STRUCTURES AND COMPONENT SUPPORTS

#### A3. Group 3 Structures (Aux., diesel generator, radwaste, turbine buildings; and switchgear room, aux. feedwater pump house, utility/piping tunnels)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, freeze/thaw does not cause loss of material from reinforced concrete in foundations, and in above and below grade exterior concrete, for plants located in a geographic region of negligible weathering conditions (weathering index &lt;100 day-inch/yr). Loss of material from such concrete is not significant at plants located in areas in which weathering conditions are severe (weathering index &gt;500 day-inch/yr) or moderate (100-500 day-inch/yr), provided that the concrete mix design meets the air content (entrained air 3-6%) and water-to-cement ratio (0.35-0.45) specified in ACI 318-63 or ACI 349-85. Therefore, if these conditions are satisfied, aging management is not required.</p> <p>The weathering index is defined in ASTM C33-90, Table 3, Footnote E. Fig. 1 of ASTM C33-90 illustrates the various weathering index regions throughout the U.S.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, leaching of calcium hydroxide from reinforced concrete becomes significant only if the concrete is exposed to flowing water. Even if reinforced concrete is exposed to flowing water, such leaching is not significant if the concrete is constructed to ensure that it is dense, well-cured, has low permeability, and that cracking is well controlled. Cracking is controlled through proper arrangement and distribution of reinforcing bars. All of the above characteristics are assured if the concrete was constructed with the guidance of ACI 201.2R-77. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, investigations, tests, and petrographic examinations of aggregates performed in accordance with ASTM C295-54 or ASTM C227-50 can demonstrate that those aggregates do not react within reinforced concrete. For potentially reactive aggregates, aggregate-reinforced concrete reaction is not significant if the concrete was constructed in accordance with ACI 201.2R-77. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A3. Group 3 Structures (Aux., diesel generator, radwaste, turbine buildings; and switchgear room, aux. feedwater pump house, utility/piping tunnels)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A3.1	Concrete	Interior and Above Grade Exterior	Reinforced Concrete	Exposure to Aggressive Environment	Cracking, Loss of Bond, Loss of Material (spalling, scaling)	Corrosion of Embedded Steel	NUREG-1557 ACI 318-63 ACI 349-85
A3.1	Concrete	Below Grade Exterior; Foundation	Reinforced Concrete	Exposure to Aggressive Environment	Cracking, Loss of Bond, Loss of Material (spalling, scaling)	Corrosion of Embedded Steel	NUREG-1557
A3.1	Concrete	Interior and Above Grade Exterior	Reinforced Concrete	Exposure to Aggressive Environment	Increase in Porosity and Permeability, Cracking, Loss of Material (spalling, scaling)	Aggressive Chemical Attack	NUREG-1557
A3.1	Concrete	Below Grade Exterior; Foundation	Reinforced Concrete	Exposure to Aggressive Environment	Increase in Porosity and Permeability, Cracking, Loss of Material (spalling, scaling)	Aggressive Chemical Attack	NUREG-1557
A3.1	Concrete	All	Reinforced Concrete	Soft Soil; Changes in Ground-water Conditions	Cracks; Distortion; Increase in Component Stress Level	Settlement	

### III STRUCTURES AND COMPONENT SUPPORTS

#### A3. Group 3 Structures (Aux., diesel generator, radwaste, turbine buildings; and switchgear room, aux. feedwater pump house, utility/piping tunnels)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, corrosion of exterior above-grade and interior embedded steel is not significant if the steel is not exposed to an aggressive environment (concrete pH &lt;11.5 or chlorides &gt;500 ppm). If such steel is exposed to an aggressive environment, corrosion is not significant if the concrete in which the steel is embedded has a low water-to-cement ratio (0.35-0.45), adequate air entrainment (3-6%), low permeability, and is designed in accordance with ACI 318-63 or ACI 349-85. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Plant-Specific Program	As described in NUREG-1557, for components exposed to groundwater such as foundations and exterior concrete below grade, evaluate on a case-by-case basis to ensure that aging effects due to corrosion of embedded steel will be managed to maintain intended functions during the period of extended operation.	Yes
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, aggressive chemical attack on interior and above-grade exterior reinforced concrete is not significant if the concrete is not exposed to an aggressive environment (pH &lt;5.5), or to chloride or sulfate solutions beyond defined limits (&gt;500 ppm chloride, or &gt;1500 ppm sulfate). Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Plant-Specific Program	As described in NUREG-1557, exterior below grade and foundation should be evaluated on a case-by-case basis to ensure that aging effects due to aggressive chemical attack will be managed to maintain the intended functions during the period of extended operation.	Yes
Plant-Specific Program	The initial Licensing Basis for some plants included a program to monitor settlement. If no settlement was evident during the first decade or so, the NRC may have given the licensee approval to discontinue the program. However, if a de-watering system is relied upon for control of settlement, then the licensee needs to ensure proper functioning of the de-watering system through the period of extended operation.	<p>Yes.</p> <p>If applicable.</p>

### III STRUCTURES AND COMPONENT SUPPORTS

#### A3. Group 3 Structures (Aux., diesel generator, radwaste, turbine buildings; and switchgear room, aux. feedwater pump house, utility/piping tunnels)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A3.1	Concrete	Foundation	Reinforced Concrete	Flowing Water Under Foundation	Reduction in Foundation Strength	Erosion of Porous Concrete Subfoundation	IN 98-26
A3.1	Concrete	All	Reinforced Concrete	Outside Containment	Loss of Strength and Modulus	Elevated Temperature (>150°F general; >200°F local)	ACI 349-85
A3.2	Steel Components	Accessible Structural Steel	Carbon Steel	Various	Loss of Material	Corrosion	
A3.2	Steel Components	Inaccessible Structural Steel	Carbon Steel	Various	Loss of Material	Corrosion	NUREG-1557
A3.3	Masonry Walls	All	Concrete Block	Ambient Environment Inside Building	Cracking	Restraint; Shrinkage; Creep; Aggressive Environment	

### III STRUCTURES AND COMPONENT SUPPORTS

#### A3. Group 3 Structures (Aux., diesel generator, radwaste, turbine buildings; and switchgear room, aux. feedwater pump house, utility/piping tunnels)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Plant-Specific Program	<p>IN 98-26 proposes Maintenance Rule Structures Monitoring for managing erosion of cement from porous concrete subfoundations, if applicable. See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>If a de-watering system is relied upon for control of erosion of cement from porous concrete subfoundations, then the licensee needs to ensure proper functioning of the de-watering system through the period of extended operation.</p>	<p>Yes.</p> <p>If applicable.</p>
Plant-Specific Program	<p>For any concrete elements that exceed specified temperature limits, further evaluations are warranted. Appendix A of ACI 349-85 specifies the concrete temperature limits for normal operation or any other long-term period. The temperatures shall not exceed 150 °F except for local areas which are allowed to have increased temperatures not to exceed 200 °F.</p>	<p>Yes.</p> <p>If applicable.</p>
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>The staff notes that inspection and maintenance of protective coatings are effective preventive measures for accessible areas.</p>	<p>No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.</p>
Plant-Specific Program	<p>As described in NUREG-1557, inaccessible areas should be evaluated on a case-by-case basis to ensure that aging effects due to corrosion will be managed.</p>	<p>Yes</p>
Masonry Wall Program	<p>See Chapter XI.S5 for an evaluation of Masonry Wall Program.</p>	<p>No</p>



**A4. Group 4 Structures (Containment Internal Structures, excluding Refueling Canal)**

A4.1 Concrete Elements

A4.2 Steel Elements



#### **A4. Group 4 Structures (Containment Internal Structures, excluding Refueling Canal)**

##### **Systems, Structures, and Components**

Class 1 structures are organized into nine groups and are discussed separately under subheadings A1 through A9. Review Table III A4 addresses the elements of Containment Internal Structures, excluding Refueling canal. For this group, the applicable structural elements are identified: concrete and steel elements. The aging management review is presented for each applicable combination of structural element and aging effect.

##### **System Interfaces**

Physical interfaces exist with any system or component that either penetrates the structure wall or is supported by the structure wall, floor and roof. The direct interface is through the system or component supports that are anchored to the structure. Structures also protect housed systems and components from internal and external design basis events. In the case of tanks, there is a functional interface with the associated system. Water control structures are an integral part of the systems that provide plant cooling water and residual heat removal.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A4. Group 4 Structures (Containment internal structures, excluding refueling canal)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A4.1	Concrete	All	Reinforced Concrete	Inside Containment, Exposure to Aggressive Environment	Increase in Porosity and Permeability, Cracking, Loss of Material (spalling, scaling)	Aggressive Chemical Attack	NUREG-1557
A4.1	Concrete	All	Reinforced Concrete	Inside Containment	Expansion & Cracking	Reaction with Aggregates	NUREG-1557 ASTM C295-54 ASTM C227-50 ACI 201.2R-77
A4.1	Concrete	All	Reinforced Concrete	Inside Containment	Loss of Strength and Modulus	Elevated Temperature (>150°F general; >200°F local)	ACI 349-85

### III STRUCTURES AND COMPONENT SUPPORTS

#### A4. Group 4 Structures (Containment internal structures, excluding refueling canal)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, aggressive chemical attack on interior and above-grade exterior reinforced concrete is not significant if the concrete is not exposed to an aggressive environment (pH &lt;5.5), or to chloride or sulfate solutions beyond defined limits (&gt;500 ppm chloride, or &gt;1500 ppm sulfate). Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program .</p> <p>As described in NUREG-1557, investigations, tests, and petrographic examinations of aggregates performed in accordance with ASTM C295-54 or ASTM C227-50 can demonstrate that those aggregates do not react within reinforced concrete. For potentially reactive aggregates, aggregate-reinforced concrete reaction is not significant if the concrete was constructed in accordance with ACI 201.2R-77. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Plant-Specific Program	<p>For any concrete elements that exceed specified temperature limits, further evaluations are warranted. Appendix A of ACI 349-85 specifies the concrete temperature limits for normal operation or any other long-term period. The temperatures shall not exceed 150 °F except for local areas which are allowed to have increased temperatures not to exceed 200 °F.</p>	<p>Yes.</p> <p>If applicable.</p>

### III STRUCTURES AND COMPONENT SUPPORTS

#### A4. Group 4 Structures (Containment internal structures, excluding refueling canal)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A4.1	Concrete	All	Reinforced Concrete	Inside Containment, Exposure to Aggressive Environment	Cracking, Loss of Bond, Loss of Material (spalling, scaling)	Corrosion of Embedded Steel	NUREG-1557 ACI 318-63 ACI 349-85
A4.2	Steel Components	All	Carbon Steel	Inside Containment	Loss of Material	Corrosion	
A4.2	Steel Components	Radial Beam Seats in BWR drywell; RPV Support Shoes for PWR with Nozzle Supports	Lubrite	Inside Containment	Lock-up	Wear	

### III STRUCTURES AND COMPONENT SUPPORTS

#### A4. Group 4 Structures (Containment internal structures, excluding refueling canal)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, corrosion of exterior above-grade and interior embedded steel is not significant if the steel is not exposed to an aggressive environment (concrete pH &lt;11.5 or chlorides &gt;500 ppm). If such steel is exposed to an aggressive environment, corrosion is not significant if the concrete in which the steel is embedded has a low water-to-cement ratio (0.35-0.45), adequate air entrainment (3-6%), low permeability, and is designed in accordance with ACI 318-63 or ACI 349-85. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>The staff notes that inspection and maintenance of protective coatings are effective preventive measures for accessible areas.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Structures Monitoring Program	See Chapter XI.S6 for an evaluation of Structures Monitoring Program.	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.



**A5.     Group 5 Structures (Fuel Storage Facility, Refueling Canal)**

A5.1 Concrete Elements

A5.2 Steel Elements

A5.3 Masonry Walls



## **A5. Group 5 Structures (Fuel Storage Facility, Refueling Canal)**

### **Systems, Structures, and Components**

Class 1 structures are organized into nine groups and are discussed separately under subheadings A1 through A9. Review Table III A5 addresses the elements of Fuel Storage Facility and Refueling Canal. For this group, the applicable structural elements are identified: concrete, steel, and masonry walls. The aging management review is presented for each applicable combination of structural element and aging effect.

### **System Interfaces**

Physical interfaces exist with any system or component that either penetrates the structure wall or is supported by the structure wall, floor and roof. The direct interface is through the system or component supports that are anchored to the structure. Structures also protect housed systems and components from internal and external design basis events. In the case of tanks, there is a functional interface with the associated system. Water control structures are an integral part of the systems that provide plant cooling water and residual heat removal.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A5. Group 5 Structures (Fuel storage facility, refueling canal)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A5.1	Concrete	Exterior Above and Below Grade; Foundation	Reinforced Concrete	Weather Exposed	Loss of Material (spalling, scaling) and Cracking	Freeze/Thaw	NUREG-1557 ASTM C33-90 ACI 318-63 ACI 349-85
A5.1	Concrete	Exterior Above and Below Grade; Foundation	Reinforced Concrete	Flowing Water	Increase in Porosity and Permeability, Loss of Strength	Leaching of Calcium Hydroxide	NUREG-1557 ACI 201.2R-77
A5.1	Concrete	All	Reinforced Concrete	Any	Expansion & Cracking	Reaction with Aggregates	NUREG-1557 ASTM C295-54 ASTM C227-50 ACI 201.2R-77

### III STRUCTURES AND COMPONENT SUPPORTS

#### A5. Group 5 Structures (Fuel storage facility, refueling canal)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, freeze/thaw does not cause loss of material from reinforced concrete in foundations, and in above and below grade exterior concrete, for plants located in a geographic region of negligible weathering conditions (weathering index &lt;100 day-inch/yr). Loss of material from such concrete is not significant at plants located in areas in which weathering conditions are severe (weathering index &gt;500 day-inch/yr) or moderate (100-500 day-inch/yr), provided that the concrete mix design meets the air content (entrained air 3-6%) and water-to-cement ratio (0.35-0.45) specified in ACI 318-63 or ACI 349-85. Therefore, if these conditions are satisfied, aging management is not required.</p> <p>The weathering index is defined in ASTM C33-90, Table 3, Footnote E. Fig. 1 of ASTM C33-90 illustrates the various weathering index regions throughout the U.S.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, leaching of calcium hydroxide from reinforced concrete becomes significant only if the concrete is exposed to flowing water. Even if reinforced concrete is exposed to flowing water, such leaching is not significant if the concrete is constructed to ensure that it is dense, well-cured, has low permeability, and that cracking is well controlled. Cracking is controlled through proper arrangement and distribution of reinforcing bars. All of the above characteristics are assured if the concrete was constructed with the guidance of ACI 201.2R-77. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, investigations, tests, and petrographic examinations of aggregates performed in accordance with ASTM C295-54 or ASTM C227-50 can demonstrate that those aggregates do not react within reinforced concrete. For potentially reactive aggregates, aggregate-reinforced concrete reaction is not significant if the concrete was constructed in accordance with ACI 201.2R-77. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A5. Group 5 Structures (Fuel storage facility, refueling canal)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A5.1	Concrete	Interior and Above Grade Exterior	Reinforced Concrete	Exposure to Aggressive Environment	Cracking, Loss of Bond, Loss of Material (spalling, scaling)	Corrosion of Embedded Steel	NUREG-1557 ACI 318-63 ACI 349-85
A5.1	Concrete	Fuel Storage Facility Below Grade Exterior; Foundation	Reinforced Concrete	Exposure to Aggressive Environment	Cracking, Loss of Bond, Loss of Material (spalling, scaling)	Corrosion of Embedded Steel	NUREG-1557
A5.1	Concrete	Interior and Above Grade Exterior	Reinforced Concrete	Exposure to Aggressive Environment	Increase in Porosity and Permeability, Cracking, Loss of Material (spalling, scaling)	Aggressive Chemical Attack	NUREG-1557
A5.1	Concrete	Fuel Storage Facility Below Grade Exterior; Foundation	Reinforced Concrete	Exposure to Aggressive Environment	Increase in Porosity and Permeability, Cracking, Loss of Material (spalling, scaling)	Aggressive Chemical Attack	NUREG-1557
A5.1	Concrete	All	Reinforced Concrete	Soft Soil; Changes in Ground-water Conditions	Cracks; Distortion; Increase in Component Stress Level	Settlement	

### III STRUCTURES AND COMPONENT SUPPORTS

#### A5. Group 5 Structures (Fuel storage facility, refueling canal)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, corrosion of exterior above-grade and interior embedded steel is not significant if the steel is not exposed to an aggressive environment (concrete pH &lt;11.5 or chlorides &gt;500 ppm). If such steel is exposed to an aggressive environment, corrosion is not significant if the concrete in which the steel is embedded has a low water-to-cement ratio (0.35-0.45), adequate air entrainment (3-6%), low permeability, and is designed in accordance with ACI 318-63 or ACI 349-85. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Plant-Specific Program	As described in NUREG-1557, for components exposed to groundwater such as foundations and exterior concrete below grade, evaluate on a case-by-case basis to ensure that aging effects due to corrosion of embedded steel will be managed to maintain intended functions during the period of extended operation.	Yes
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, aggressive chemical attack on interior and above-grade exterior reinforced concrete is not significant if the concrete is not exposed to an aggressive environment (pH &lt;5.5), or to chloride or sulfate solutions beyond defined limits (&gt;500 ppm chloride, or &gt;1500 ppm sulfate). Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Plant-Specific Program	As described in NUREG-1557, exterior below grade and foundation should be evaluated on a case-by-case basis to ensure that aging effects due to aggressive chemical attack will be managed to maintain the intended functions during the period of extended operation.	Yes
Plant-Specific Program	The initial Licensing Basis for some plants included a program to monitor settlement. If no settlement was evident during the first decade or so, the NRC may have given the licensee approval to discontinue the program. However, if a de-watering system is relied upon for control of settlement, then the licensee needs to ensure proper functioning of the de-watering system through the period of extended operation.	Yes.  If applicable.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A5. Group 5 Structures (Fuel storage facility, refueling canal)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A5.1	Concrete	Foundation	Reinforced Concrete	Flowing Water Under Foundation	Reduction in Foundation Strength	Erosion of Porous Concrete Subfoundation	IN 98-26
A5.1	Concrete	All	Reinforced Concrete	Outside Containment	Loss of Strength and Modulus	Elevated Temperature (>150°F general; >200°F local)	ACI 349-85
A5.2	Steel Components	Accessible Structural Steel	Carbon Steel	Various	Loss of Material	Corrosion	
A5.2	Steel Components	Inaccessible Structural Steel	Carbon Steel	Various	Loss of Material	Corrosion	NUREG-1557
A5.2	Steel Components	Liners	Stainless Steel	Exposed to Water	Crack Initiation and Growth, Loss of Material	Stress Corrosion Cracking and Crevice Corrosion	NUREG-1557
A5.3	Masonry Walls	Fuel Storage Facility	Concrete Block	Ambient Environment Inside Building	Cracking	Restraint; Shrinkage; Creep; Aggressive Environment	

### III STRUCTURES AND COMPONENT SUPPORTS

#### A5. Group 5 Structures (Fuel storage facility, refueling canal)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Plant-Specific Program	<p>IN 98-26 proposes Maintenance Rule Structures Monitoring for managing erosion of cement from porous concrete subfoundations, if applicable. See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>If a de-watering system is relied upon for control of erosion of cement from porous concrete subfoundations, then the licensee needs to ensure proper functioning of the de-watering system through the period of extended operation.</p>	<p>Yes.</p> <p>If applicable.</p>
Plant-Specific Program	<p>For any concrete elements that exceed specified temperature limits, further evaluations are warranted. Appendix A of ACI 349-85 specifies the concrete temperature limits for normal operation or any other long-term period. The temperatures shall not exceed 150 °F except for local areas which are allowed to have increased temperatures not to exceed 200 °F.</p>	<p>Yes.</p> <p>If applicable.</p>
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>The staff notes that inspection and maintenance of protective coatings are effective preventive measures for accessible areas.</p>	<p>No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.</p>
Plant-Specific Program	<p>As described in NUREG-1557, inaccessible areas should be evaluated on a case-by-case basis to ensure that aging effects due to corrosion will be managed.</p>	<p>Yes</p>
Plant-Specific Program	<p>Monitoring of the leak chase system drain lines and the leak detection sump is required for early detection and repair of leaks in liners. As described in NUREG-1557, current leakage detection and inventory monitoring systems provide timely means to identify, monitor, and repair liner degradation.</p>	<p>No</p>
Masonry Wall Program	<p>See Chapter XI.S5 for an evaluation of the Masonry Wall Program.</p>	<p>No</p>



**A6.     Group 6 Structures (Water-Control Structures)**

A6.1 Concrete Elements

A6.2 Steel Elements

A6.3 Masonry Walls



## **A6. Group 6 Structures (Water-Control Structures)**

### **Systems, Structures, and Components**

Class 1 structures are organized into nine groups and are discussed separately under subheadings A1 through A9. Review Table III A6 addresses the elements of Water-Control Structures. For this group, the applicable structural elements are identified: concrete, steel, and masonry walls. The aging management review is presented for each applicable combination of structural element and aging effect.

### **System Interfaces**

Physical interfaces exist with any system or component that either penetrates the structure wall or is supported by the structure wall, floor and roof. The direct interface is through the system or component supports that are anchored to the structure. Structures also protect housed systems and components from internal and external design basis events. In the case of tanks, there is a functional interface with the associated system. Water control structures are an integral part of the systems that provide plant cooling water and residual heat removal.

**Note:** Aging Management for earthen water-control structures (e.g., dams, canals, embankments) is not addressed in this table. See Chapter XI.S7 for applicable guidance.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A6. Group 6 Structures (Water-control structures)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A6.1	Concrete	Exterior Above and Below Grade; Foundation; Interior Slab	Reinforced Concrete	Weather Exposed	Loss of Material (spalling, scaling) and Cracking	Freeze/Thaw	Regulatory Guide 1.127, Rev.1 NUREG-1557 ASTM C33-90 ACI 318-63 ACI 349-85
A6.1	Concrete	Exterior Above and Below Grade; Foundation; Interior Slab	Reinforced Concrete	Flowing Water	Increase in Porosity and Permeability, Loss of Strength	Leaching of Calcium Hydroxide	Regulatory Guide 1.127, Rev.1 NUREG-1557 ACI 201.2R-77
A6.1	Concrete	All	Reinforced Concrete	Any	Expansion & Cracking	Reaction with Aggregates	Regulatory Guide 1.127, Rev.1 NUREG-1557 ASTM C295-54 ASTM C227-50 ACI 201.2R-77

### III STRUCTURES AND COMPONENT SUPPORTS

#### A6. Group 6 Structures (Water-control structures)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Regulatory Guide 1.127, Inspection of Water-Control Structures Associated with Nuclear Power Plants	<p>See Chapter XI.S7 for an evaluation of Regulatory Guide 1.127 and the FERC dam inspections and maintenance.</p> <p>As described in NUREG-1557, freeze/thaw does not cause loss of material from reinforced concrete in foundations, and in above and below grade exterior concrete, for plants located in a geographic region of negligible weathering conditions (weathering index &lt;100 day-inch/yr). Loss of material from such concrete is not significant at plants located in areas in which weathering conditions are severe (weathering index &gt;500 day-inch/yr) or moderate (100-500 day-inch/yr), provided that the concrete mix design meets the air content (entrained air 3-6%) and water-to-cement ratio (0.35-0.45) specified in ACI 318-63 or ACI 349-85. Therefore, if these conditions are satisfied, aging management is not required.</p> <p>The weathering index is defined in ASTM C33-90, Table 3, Footnote E. Fig. 1 of ASTM C33-90 illustrates the various weathering index regions throughout the U.S.</p>	No
Regulatory Guide 1.127, Inspection of Water-Control Structures Associated with Nuclear Power Plants	<p>See Chapter XI.S7 for an evaluation of Regulatory Guide 1.127 and the FERC dam inspections and maintenance.</p> <p>As described in NUREG-1557, leaching of calcium hydroxide from reinforced concrete becomes significant only if the concrete is exposed to flowing water. Even if reinforced concrete is exposed to flowing water, such leaching is not significant if the concrete is constructed to ensure that it is dense, well-cured, has low permeability, and that cracking is well controlled. Cracking is controlled through proper arrangement and distribution of reinforcing bars. All of the above characteristics are assured if the concrete was constructed with the guidance of ACI 201.2R-77. Therefore, if these conditions are satisfied, aging management is not required.</p>	No
Regulatory Guide 1.127, Inspection of Water-Control Structures Associated with Nuclear Power Plants	<p>See Chapter XI.S7 for an evaluation of Regulatory Guide 1.127 and the FERC dam inspections and maintenance.</p> <p>As described in NUREG-1557, investigations, tests, and petrographic examinations of aggregates performed in accordance with ASTM C295-54 or ASTM C227-50 can demonstrate that those aggregates do not react within reinforced concrete. For potentially reactive aggregates, aggregate-reinforced concrete reaction is not significant if the concrete was constructed in accordance with ACI 201.2R-77. Therefore, if these conditions are satisfied, aging management is not required.</p>	No

### III STRUCTURES AND COMPONENT SUPPORTS

#### A6. Group 6 Structures (Water-control structures)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A6.1	Concrete	All	Reinforced Concrete	Exposure to Aggressive Environment	Cracking, Loss of Bond, Loss of Material (spalling, scaling)	Corrosion of Embedded Steel	Regulatory Guide 1.127, Rev.1 NUREG-1557 ACI 318-63 ACI 349-85
A6.1	Concrete	All	Reinforced Concrete	Exposure to Aggressive Environment	Increase in Porosity and Permeability, Cracking, Loss of Material (spalling, scaling)	Aggressive Chemical Attack	Regulatory Guide 1.127, Rev.1 NUREG-1557
A6.1	Concrete	All	Reinforced Concrete	Soft Soil; Changes in Ground-water Conditions	Cracks; Distortion; Increase in Component Stress Level	Settlement	Regulatory Guide 1.127, Rev.1

### III STRUCTURES AND COMPONENT SUPPORTS

#### A6. Group 6 Structures (Water-control structures)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Regulatory Guide 1.127, Inspection of Water-Control Structures Associated with Nuclear Power Plants	<p>See Chapter XI.S7 for an evaluation of Regulatory Guide 1.127 and the FERC dam inspections and maintenance.</p> <p>As described in NUREG-1557, corrosion of exterior above-grade and interior embedded steel is not significant if the steel is not exposed to an aggressive environment (concrete pH &lt;11.5 or chlorides &gt;500 ppm). If such steel is exposed to an aggressive environment, corrosion is not significant if the concrete in which the steel is embedded has a low water-to-cement ratio (0.35-0.45), adequate air entrainment (3-6%), low permeability, and is designed in accordance with ACI 318-63 or ACI 349-85. Therefore, if these conditions are satisfied, aging management is not required.</p>	No
Regulatory Guide 1.127, Inspection of Water-Control Structures Associated with Nuclear Power Plants	<p>See Chapter XI.S7 for an evaluation of Regulatory Guide 1.127 and the FERC dam inspections and maintenance.</p> <p>As described in NUREG-1557, aggressive chemical attack on interior and above-grade exterior reinforced concrete is not significant if the concrete is not exposed to an aggressive environment (pH &lt;5.5), or to chloride or sulfate solutions beyond defined limits (&gt;500 ppm chloride, or &gt;1500 ppm sulfate). Therefore, if these conditions are satisfied, aging management is not required.</p>	No
Regulatory Guide 1.127, Inspection of Water-Control Structures Associated with Nuclear Power Plants	<p>See Chapter XI.S7 for an evaluation of Regulatory Guide 1.127 and the FERC dam inspections and maintenance.</p> <p>The initial Licensing Basis for some plants included a program to monitor settlement. If no settlement was evident during the first decade or so, the NRC may have given the licensee approval to discontinue the program. However, if a de-watering system is relied upon for control of settlement, then the licensee needs to ensure proper functioning of the de-watering system through the period of extended operation.</p>	No

### III STRUCTURES AND COMPONENT SUPPORTS

#### A6. Group 6 Structures (Water-control structures)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A6.1	Concrete	Foundation	Reinforced Concrete	Flowing Water Under Foundation	Reduction in Foundation Strength	Erosion of Porous Concrete Subfoundation	IN 98-26
A6.1	Concrete	Exterior Above and Below Grade; Foundation; Interior Slab	Reinforced Concrete	Flowing Water	Loss of material	Abrasion; Cavitation	Regulatory Guide 1.127, Rev.1
A6.2	Steel Components	Structural Steel	Carbon Steel	Various	Loss of Material	Corrosion	Regulatory Guide 1.127, Rev.1
A6.3	Masonry Walls	Intake Structure; Cooling Tower	Concrete Block	Various	Cracking	Restraint; Shrinkage; Creep; Aggressive Environment	

### III STRUCTURES AND COMPONENT SUPPORTS

#### A6. Group 6 Structures (Water-control structures)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Plant-Specific Program	<p>IN 98-26 proposes Maintenance Rule Structures Monitoring for managing erosion of cement from porous concrete subfoundations, if applicable. See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>If a de-watering system is relied upon for control of erosion of cement from porous concrete subfoundations, then the licensee needs to ensure proper functioning of the de-watering system through the period of extended operation.</p>	<p>Yes.</p> <p>If applicable.</p>
Regulatory Guide 1.127, Inspection of Water-Control Structures Associated with Nuclear Power Plants	See Chapter XI.S7 for an evaluation of Regulatory Guide 1.127 and the FERC dam inspections and maintenance.	No
Regulatory Guide 1.127, Inspection of Water-Control Structures Associated with Nuclear Power Plants	<p>See Chapter XI.S7 for an evaluation of Regulatory Guide 1.127 and the FERC dam inspections and maintenance.</p> <p>The staff notes that inspection and maintenance of protective coatings are effective preventive measures for accessible areas.</p>	No
Masonry Wall Program	See Chapter XI.S5 for an evaluation of the Masonry Wall Program.	No



**A7.     Group 7 Structures (Concrete Tanks)**

A7.1 Concrete Elements

A7.2 Steel Elements



## **A7. Group 7 Structures (Concrete Tanks)**

### **Systems, Structures, and Components**

Class 1 structures are organized into nine groups and are discussed separately under subheadings A1 through A9. Review Table III A7 addresses the elements of Concrete Tanks. For this group, the applicable structural elements are identified: concrete and steel. The aging management review is presented for each applicable combination of structural element and aging effect.

### **System Interfaces**

Physical interfaces exist with any system or component that either penetrates the structure wall or is supported by the structure wall, floor and roof. The direct interface is through the system or component supports that are anchored to the structure. Structures also protect housed systems and components from internal and external design basis events. In the case of tanks, there is a functional interface with the associated system. Water control structures are an integral part of the systems that provide plant cooling water and residual heat removal.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A7. Group 7 Structures (Concrete Tanks)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A7.1	Concrete	Exterior Above and Below Grade; Foundation	Reinforced Concrete	Weather Exposed	Loss of Material (spalling, scaling) and Cracking	Freeze/Thaw	NUREG-1557 ASTM C33-90 ACI 318-63 ACI 349-85
A7.1	Concrete	Exterior Above and Below Grade; Foundation	Reinforced Concrete	Flowing Water	Increase in Porosity and Permeability, Loss of Strength	Leaching of Calcium Hydroxide	NUREG-1557 ACI 201.2R-77
A7.1	Concrete	All	Reinforced Concrete	Any	Expansion & Cracking	Reaction with Aggregates	NUREG-1557 ASTM C295-54 ASTM C227-50 ACI 201.2R-77

### III STRUCTURES AND COMPONENT SUPPORTS

#### A7. Group 7 Structures (Concrete Tanks)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, freeze/thaw does not cause loss of material from reinforced concrete in foundations, and in above and below grade exterior concrete, for plants located in a geographic region of negligible weathering conditions (weathering index &lt;100 day-inch/yr). Loss of material from such concrete is not significant at plants located in areas in which weathering conditions are severe (weathering index &gt;500 day-inch/yr) or moderate (100-500 day-inch/yr), provided that the concrete mix design meets the air content (entrained air 3-6%) and water-to-cement ratio (0.35-0.45) specified in ACI 318-63 or ACI 349-85. Therefore, if these conditions are satisfied, aging management is not required.</p> <p>The weathering index is defined in ASTM C33-90, Table 3, Footnote E. Fig. 1 of ASTM C33-90 illustrates the various weathering index regions throughout the U.S.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, leaching of calcium hydroxide from reinforced concrete becomes significant only if the concrete is exposed to flowing water. Even if reinforced concrete is exposed to flowing water, such leaching is not significant if the concrete is constructed to ensure that it is dense, well-cured, has low permeability, and that cracking is well controlled. Cracking is controlled through proper arrangement and distribution of reinforcing bars. All of the above characteristics are assured if the concrete was constructed with the guidance of ACI 201.2R-77. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, investigations, tests, and petrographic examinations of aggregates performed in accordance with ASTM C295-54 or ASTM C227-50 can demonstrate that those aggregates do not react within reinforced concrete. For potentially reactive aggregates, aggregate-reinforced concrete reaction is not significant if the concrete was constructed in accordance with ACI 201.2R-77. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A7. Group 7 Structures (Concrete Tanks)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A7.1	Concrete	Exterior Above Grade	Reinforced Concrete	Exposure to Aggressive Environment	Cracking, Loss of Bond, Loss of Material (spalling, scaling)	Corrosion of Embedded Steel	NUREG-1557 ACI 318-63 ACI 349-85
A7.1	Concrete	Exterior Below Grade; Foundation	Reinforced Concrete	Exposure to Aggressive Environment	Cracking, Loss of Bond, Loss of Material (spalling, scaling)	Corrosion of Embedded Steel	NUREG-1557
A7.1	Concrete	Exterior Above Grade	Reinforced Concrete	Exposure to Aggressive Environment	Increase in Porosity and Permeability, Cracking, Loss of Material (spalling, scaling)	Aggressive Chemical Attack	NUREG-1557
A7.1	Concrete	Exterior Below Grade; Foundation	Reinforced Concrete	Exposure to Aggressive Environment	Increase in Porosity and Permeability, Cracking, Loss of Material (spalling, scaling)	Aggressive Chemical Attack	NUREG-1557
A7.1	Concrete	All	Reinforced Concrete	Soft Soil; Changes in Ground-water Conditions	Cracks; Distortion; Increase in Component Stress Level	Settlement	

### III STRUCTURES AND COMPONENT SUPPORTS

#### A7. Group 7 Structures (Concrete Tanks)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, corrosion of exterior above-grade and interior embedded steel is not significant if the steel is not exposed to an aggressive environment (concrete pH &lt;11.5 or chlorides &gt;500 ppm). If such steel is exposed to an aggressive environment, corrosion is not significant if the concrete in which the steel is embedded has a low water-to-cement ratio (0.35-0.45), adequate air entrainment (3-6%), low permeability, and is designed in accordance with ACI 318-63 or ACI 349-85. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Plant-Specific Program	As described in NUREG-1557, for components exposed to groundwater such as foundations and exterior concrete below grade, evaluate on a case-by-case basis to ensure that aging effects due to corrosion of embedded steel will be managed to maintain intended functions during the period of extended operation.	Yes
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, aggressive chemical attack on interior and above-grade exterior reinforced concrete is not significant if the concrete is not exposed to an aggressive environment (pH &lt;5.5), or to chloride or sulfate solutions beyond defined limits (&gt;500 ppm chloride, or &gt;1500 ppm sulfate). Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Plant-Specific Program	As described in NUREG-1557, exterior below grade and foundation should be evaluated on a case-by-case basis to ensure that aging effects due to aggressive chemical attack will be managed to maintain the intended functions during the period of extended operation.	Yes
Plant-Specific Program	The initial Licensing Basis for some plants included a program to monitor settlement. If no settlement was evident during the first decade or so, the NRC may have given the licensee approval to discontinue the program. However, if a de-watering system is relied upon for control of settlement, then the licensee needs to ensure proper functioning of the de-watering system through the period of extended operation.	Yes.  If applicable.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A7. Group 7 Structures (Concrete Tanks)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A7.1	Concrete	Foundation	Reinforced Concrete	Flowing Water Under Foundation	Reduction in Foundation Strength	Erosion of Porous Concrete Subfoundation	IN 98-26
A7.2	Steel Components	Accessible Structural Steel	Carbon Steel	Various	Loss of Material	Corrosion	
A7.2	Steel Components	Inaccessible Structural Steel	Carbon Steel	Various	Loss of Material	Corrosion	NUREG-1557
A7.2	Steel Components	Liner	Stainless Steel	Exposed to Fluid Environment (water, fuel)	Crack Initiation and Growth, Loss of Material	Stress Corrosion Cracking, Crevice Corrosion	

### III STRUCTURES AND COMPONENT SUPPORTS

#### A7. Group 7 Structures (Concrete Tanks)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Plant-Specific Program	<p>IN 98-26 proposes Maintenance Rule Structures Monitoring for managing erosion of cement from porous concrete subfoundations, if applicable. See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>If a de-watering system is relied upon for control of erosion of cement from porous concrete subfoundations, then the licensee needs to ensure proper functioning of the de-watering system through the period of extended operation.</p>	<p>Yes.</p> <p>If applicable.</p>
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>The staff notes that inspection and maintenance of protective coatings are effective preventive measures for accessible areas.</p>	<p>No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.</p>
Plant-Specific Program	<p>As described in NUREG-1557, inaccessible areas should be evaluated on a case-by-case basis to ensure that aging effects due to corrosion will be managed.</p>	<p>Yes</p>
Plant-Specific Program	<p>Plant-specific evaluation to ensure that the aging effects due to stress corrosion cracking and crevice corrosion on liners will be managed to maintain their intended functions during the period of extended operation.</p>	<p>Yes</p>



**A8.     Group 8 Structures (Steel Tanks)**

A8.1 Concrete Elements

A8.2 Steel Elements



## **A8. Group 8 Structures (Steel Tanks)**

### **Systems, Structures, and Components**

Class 1 structures are organized into nine groups and are discussed separately under subheadings A1 through A9. Review Table III A8 addresses the elements of Steel Tanks. For this group, the applicable structural elements are identified: concrete and steel. The aging management review is presented for each applicable combination of structural element and aging effect.

### **System Interfaces**

Physical interfaces exist with any system or component that either penetrates the structure wall or is supported by the structure wall, floor and roof. The direct interface is through the system or component supports that are anchored to the structure. Structures also protect housed systems and components from internal and external design basis events. In the case of tanks, there is a functional interface with the associated system. Water control structures are an integral part of the systems that provide plant cooling water and residual heat removal.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A8. Group 8 Structures (Steel Tanks)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A8.1	Concrete	Foundation	Reinforced Concrete	Weather Exposed	Loss of Material (spalling, scaling) and Cracking	Freeze/Thaw	NUREG-1557 ASTM C33-90 ACI 318-63 ACI 349-85
A8.1	Concrete	Foundation	Reinforced Concrete	Flowing Water	Increase in Porosity and Permeability, Loss of Strength	Leaching of Calcium Hydroxide	NUREG-1557 ACI 201.2R-77
A8.1	Concrete	Foundation	Reinforced Concrete	Any	Expansion & Cracking	Reaction with Aggregates	NUREG-1557 ASTM C295-54 ASTM C227-50 ACI 201.2R-77

### III STRUCTURES AND COMPONENT SUPPORTS

#### A8. Group 8 Structures (Steel Tanks)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, freeze/thaw does not cause loss of material from reinforced concrete in foundations, and in above and below grade exterior concrete, for plants located in a geographic region of negligible weathering conditions (weathering index &lt;100 day-inch/yr). Loss of material from such concrete is not significant at plants located in areas in which weathering conditions are severe (weathering index &gt;500 day-inch/yr) or moderate (100-500 day-inch/yr), provided that the concrete mix design meets the air content (entrained air 3-6%) and water-to-cement ratio (0.35-0.45) specified in ACI 318-63 or ACI 349-85. Therefore, if these conditions are satisfied, aging management is not required.</p> <p>The weathering index is defined in ASTM C33-90, Table 3, Footnote E. Fig. 1 of ASTM C33-90 illustrates the various weathering index regions throughout the U.S.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, leaching of calcium hydroxide from reinforced concrete becomes significant only if the concrete is exposed to flowing water. Even if reinforced concrete is exposed to flowing water, such leaching is not significant if the concrete is constructed to ensure that it is dense, well-cured, has low permeability, and that cracking is well controlled. Cracking is controlled through proper arrangement and distribution of reinforcing bars. All of the above characteristics are assured if the concrete was constructed with the guidance of ACI 201.2R-77. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, investigations, tests, and petrographic examinations of aggregates performed in accordance with ASTM C295-54 or ASTM C227-50 can demonstrate that those aggregates do not react within reinforced concrete. For potentially reactive aggregates, aggregate-reinforced concrete reaction is not significant if the concrete was constructed in accordance with ACI 201.2R-77. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A8. Group 8 Structures (Steel Tanks)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A8.1	Concrete	Foundation	Reinforced Concrete	Exposure to Aggressive Environment	Cracking, Loss of Bond, Loss of Material (spalling, scaling)	Corrosion of Embedded Steel	NUREG-1557
A8.1	Concrete	Foundation	Reinforced Concrete	Exposure to Aggressive Environment	Increase in Porosity and Permeability, Cracking, Loss of Material (spalling, scaling)	Aggressive Chemical Attack	NUREG-1557
A8.1	Concrete	Foundation	Reinforced Concrete	Soft Soil; Changes in Ground-water Conditions	Cracks; Distortion; Increase in Component Stress Level	Settlement	

### III STRUCTURES AND COMPONENT SUPPORTS

#### A8. Group 8 Structures (Steel Tanks)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Plant-Specific Program	As described in NUREG-1557, for components exposed to groundwater such as foundations and exterior concrete below grade, evaluate on a case-by-case basis to ensure that aging effects due to corrosion of embedded steel will be managed to maintain intended functions during the period of extended operation.	Yes
Plant-Specific Program	As described in NUREG-1557, exterior below grade and foundation should be evaluated on a case-by-case basis to ensure that aging effects due to aggressive chemical attack will be managed to maintain the intended functions during the period of extended operation.	Yes
Plant-Specific Program	The initial Licensing Basis for some plants included a program to monitor settlement. If no settlement was evident during the first decade or so, the NRC may have given the licensee approval to discontinue the program. However, if a de-watering system is relied upon for control of settlement, then the licensee needs to ensure proper functioning of the de-watering system through the period of extended operation.	Yes.  If applicable.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A8. Group 8 Structures (Steel Tanks)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A8.1	Concrete	Foundation	Reinforced Concrete	Flowing Water Under Foundation	Reduction in Foundation Strength	Erosion of Porous Concrete Subfoundation	IN 98-26
A8.2	Steel Components	Accessible Structural Steel	Carbon Steel	Various	Loss of Material	Corrosion	
A8.2	Steel Components	Inaccessible Structural Steel	Carbon Steel	Various	Loss of Material	Corrosion	NUREG-1557
A8.2	Steel Components	Liner	Stainless Steel	Exposed to Fluid Environment	Crack Initiation and Growth, Loss of Material	Stress Corrosion Cracking, Crevice Corrosion	

### III STRUCTURES AND COMPONENT SUPPORTS

#### A8. Group 8 Structures (Steel Tanks)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Plant-Specific Program	<p>IN 98-26 proposes Maintenance Rule Structures Monitoring for managing erosion of cement from porous concrete subfoundations, if applicable. See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>If a de-watering system is relied upon for control of erosion of cement from porous concrete subfoundations, then the licensee needs to ensure proper functioning of the de-watering system through the period of extended operation.</p>	<p>Yes.</p> <p>If applicable.</p>
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>The staff notes that inspection and maintenance of protective coatings are effective preventive measures for accessible areas.</p>	<p>No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.</p>
Plant-Specific Program	<p>As described in NUREG-1557, inaccessible areas should be evaluated on a case-by-case basis to ensure that aging effects due to corrosion will be managed.</p>	<p>Yes</p>
Plant-Specific Program	<p>Plant-specific evaluation to ensure that the aging effects due to stress corrosion cracking and crevice corrosion on liners will be managed to maintain their intended functions during the period of extended operation.</p>	<p>Yes</p>



**A9.      Group 9 Structures (BWR Unit Vent Stack)**

A9.1 Concrete Elements



## **A9. Group 9 Structures (BWR Unit Vent Stack)**

### **Systems, Structures, and Components**

Class 1 structures are organized into nine groups and are discussed separately under subheadings A1 through A9. Review Table III A9 addresses the elements of BWR Unit Vent Stack. For this group, the applicable structural elements are identified: concrete. The aging management review is presented for each applicable combination of structural element and aging effect.

### **System Interfaces**

Physical interfaces exist with any system or component that either penetrates the structure wall or is supported by the structure wall, floor and roof. The direct interface is through the system or component supports that are anchored to the structure. Structures also protect housed systems and components from internal and external design basis events. In the case of tanks, there is a functional interface with the associated system. Water control structures are an integral part of the systems that provide plant cooling water and residual heat removal.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A9. Group 9 Structures (BWR unit vent stacks)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A9.1	Concrete	Above and Below Grade; Foundation	Reinforced Concrete	Weather Exposed	Loss of Material (spalling, scaling) and Cracking	Freeze/Thaw	NUREG-1557 ASTM C33-90 ACI 318-63 ACI 349-85
A9.1	Concrete	Above and Below Grade; Foundation	Reinforced Concrete	Flowing Water	Increase in Porosity and Permeability, Loss of Strength	Leaching of Calcium Hydroxide	NUREG-1557 ACI 201.2R-77
A9.1	Concrete	Above and Below Grade; Foundation	Reinforced Concrete	Any	Expansion & Cracking	Reaction with Aggregates	NUREG-1557 ASTM C295-54 ASTM C227-50 ACI 201.2R-77

### III STRUCTURES AND COMPONENT SUPPORTS

#### A9. Group 9 Structures (BWR unit vent stacks)

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, freeze/thaw does not cause loss of material from reinforced concrete in foundations, and in above and below grade exterior concrete, for plants located in a geographic region of negligible weathering conditions (weathering index &lt;100 day-inch/yr). Loss of material from such concrete is not significant at plants located in areas in which weathering conditions are severe (weathering index &gt;500 day-inch/yr) or moderate (100-500 day-inch/yr), provided that the concrete mix design meets the air content (entrained air 3-6%) and water-to-cement ratio (0.35-0.45) specified in ACI 318-63 or ACI 349-85. Therefore, if these conditions are satisfied, aging management is not required.</p> <p>The weathering index is defined in ASTM C33-90, Table 3, Footnote E. Fig. 1 of ASTM C33-90 illustrates the various weathering index regions throughout the U.S.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, leaching of calcium hydroxide from reinforced concrete becomes significant only if the concrete is exposed to flowing water. Even if reinforced concrete is exposed to flowing water, such leaching is not significant if the concrete is constructed to ensure that it is dense, well-cured, has low permeability, and that cracking is well controlled. Cracking is controlled through proper arrangement and distribution of reinforcing bars. All of the above characteristics are assured if the concrete was constructed with the guidance of ACI 201.2R-77. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, investigations, tests, and petrographic examinations of aggregates performed in accordance with ASTM C295-54 or ASTM C227-50 can demonstrate that those aggregates do not react within reinforced concrete. For potentially reactive aggregates, aggregate-reinforced concrete reaction is not significant if the concrete was constructed in accordance with ACI 201.2R-77. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.

**III STRUCTURES AND COMPONENT SUPPORTS**  
**A9. Group 9 Structures (BWR unit vent stacks)**

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A9.1	Concrete	Above Grade	Reinforced Concrete	Exposure to Aggressive Environment	Cracking, Loss of Bond, Loss of Material (spalling, scaling)	Corrosion of Embedded Steel	NUREG-1557 ACI 318-63 ACI 349-85
A9.1	Concrete	Below Grade; Foundation	Reinforced Concrete	Exposure to Aggressive Environment	Cracking, Loss of Bond, Loss of Material (spalling, scaling)	Corrosion of Embedded Steel	NUREG-1557
A9.1	Concrete	Above Grade	Reinforced Concrete	Exposure to Aggressive Environment	Increase in Porosity and Permeability, Cracking, Loss of Material (spalling, scaling)	Aggressive Chemical Attack	NUREG-1557
A9.1	Concrete	Below Grade; Foundation	Reinforced Concrete	Exposure to Aggressive Environment	Increase in Porosity and Permeability, Cracking, Loss of Material (spalling, scaling)	Aggressive Chemical Attack	NUREG-1557
A9.1	Concrete	All	Reinforced Concrete	Soft Soil; Changes in Ground-water Conditions	Cracks; Distortion; Increase in Component Stress Level	Settlement	

**III STRUCTURES AND COMPONENT SUPPORTS**  
**A9. Group 9 Structures (BWR unit vent stacks)**

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, corrosion of exterior above-grade and interior embedded steel is not significant if the steel is not exposed to an aggressive environment (concrete pH &lt;11.5 or chlorides &gt;500 ppm). If such steel is exposed to an aggressive environment, corrosion is not significant if the concrete in which the steel is embedded has a low water-to-cement ratio (0.35-0.45), adequate air entrainment (3-6%), low permeability, and is designed in accordance with ACI 318-63 or ACI 349-85. Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Plant-Specific Program	As described in NUREG-1557, for components exposed to groundwater such as foundations and exterior concrete below grade, evaluate on a case-by-case basis to ensure that aging effects due to corrosion of embedded steel will be managed to maintain intended functions during the period of extended operation.	Yes
Structures Monitoring Program	<p>See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>As described in NUREG-1557, aggressive chemical attack on interior and above-grade exterior reinforced concrete is not significant if the concrete is not exposed to an aggressive environment (pH &lt;5.5), or to chloride or sulfate solutions beyond defined limits (&gt;500 ppm chloride, or &gt;1500 ppm sulfate). Therefore, if these conditions are satisfied, aging management is not required.</p>	No, if the structure/aging effect combination is within the scope of the applicant's Structures Monitoring Program.
Plant-Specific Program	As described in NUREG-1557, exterior below grade and foundation should be evaluated on a case-by-case basis to ensure that aging effects due to aggressive chemical attack will be managed to maintain the intended functions during the period of extended operation.	Yes
Plant-Specific Program	The initial Licensing Basis for some plants included a program to monitor settlement. If no settlement was evident during the first decade or so, the NRC may have given the licensee approval to discontinue the program. However, if a de-watering system is relied upon for control of settlement, then the licensee needs to ensure proper functioning of the de-watering system through the period of extended operation.	Yes.  If applicable.

### III STRUCTURES AND COMPONENT SUPPORTS

#### A9. Group 9 Structures (BWR unit vent stacks)

Item	Structure/Component	Region of Interest	Material	Environment	Aging Effect	Aging Mechanism	References
A9.1	Concrete	Foundation	Reinforced Concrete	Flowing Water Under Foundation	Reduction in Foundation Strength	Erosion of Porous Concrete Subfoundation	IN 98-26

**III STRUCTURES AND COMPONENT SUPPORTS**  
**A9. Group 9 Structures (BWR unit vent stacks)**

Aging Management Program (AMP)	Evaluation and Technical Basis	Further Evaluation
Plant-Specific Program	<p>IN 98-26 proposes Maintenance Rule Structures Monitoring for managing erosion of cement from porous concrete subfoundations, if applicable. See Chapter XI.S6 for an evaluation of Structures Monitoring Program.</p> <p>If a de-watering system is relied upon for control of erosion of cement from porous concrete subfoundations, then the licensee needs to ensure proper functioning of the de-watering system through the period of extended operation.</p>	<p>Yes.</p> <p>If applicable.</p>

