BGE

Calvert Cliffs Nuclear Power Plant

License Renewal Project

Aging Management Review Report

for the

Turbine Building

Revision 2

May, 1996

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LIST OF EFFECTIVE PAGES

Revision	Pages	Summary of Change
0	All	Initial revision prepared using LCM-10S, Revision 1.
1	All	Changes made to reflect disposition of Technical Problem Reports written against Revision 0 and to correct transcription errors between the results and the final report sections.
2	All	Wording changes to make the language in the final report sections more consistent with the language used in the Integrated Plant Assessment Methodology. Also, technical changes regarding the aging management strategy used to address degradation effects associated with corrosion in structural steel.

1.0 INTRODUCTION

1.1 TURBINE BUILDING DESCRIPTION

This section describes the scope and boundaries of the Turbine Building as it was evaluated. Section 1.1.1 provides a brief synopsis of the building as described in existing plant documentation. The Turbine Building boundary is defined in Section 1.1.2 to clarify the portions of the structure considered in this evaluation. Section 1.1.3 is a detailed breakdown of the unique system functions and is provided as a basis for component scoping and the identification of component-specific functions.

1.1.1 Turbine Building LCM Description

The Turbine Building is an integrated steel structure, with metal siding, supported on reinforced concrete foundations. Included in the Turbine Building are the turbine-generator bays, heater bays, and the turbine-generator concrete pedestals which project through the building to the operating deck at elevation 45 feet. The turbine generator units 1 and 2 are separated by an expansion joint in the superstructure. The circulating water intake and discharge conduits are incorporated into the spread footings.

The Turbine Building is a Class II structure with the exception of the auxiliary feedwater pump enclosure, which is Class I. All of the structural steel columns, beams, and roof trusses of the building have been designed as independent members and in accordance with AISC.

The unit 1 and 2 auxiliary feedwater pump rooms, rooms 603 and 605, contain the auxiliary feedwater pumps; piping and manual valves associated with the main steam system and the auxiliary feedwater system; and cables associated with reactor coolant temperature channels A and B; pressurizer level, channels A and B; steam generator level, channels A and B; and salt water pumps, channels A, B, and C. The rooms also contain the remote hot shutdown control panel, which is considered an alternate means of maintaining the plant in a hot shutdown condition. Piping inside the auxiliary feedwater pump rooms is required to maintain the integrity of the secondary side of the steam generators.

1.1.2 Turbine Building LCM Boundary

The auxiliary feedwater pump rooms and their structural components provide support and shelter to safety related and non-safety related equipment inside the Turbine Building. The system boundary addressed by this scoping and evaluation included all auxiliary feedwater pump room structural components serving such functions but did not include commodity items such as pipe supports and snubbers. Structural components within this system boundary include supports for the following major device types:

Motors (MOTOR) and pumps (PUMP).

Also included in the system boundary are structural supports for non-safety related access platforms. During an abnormal event such as a seismic event, failure of these non-safety related components must not adversely affect the operability of other safety related components.

1.1.3 Turbine Building Intended Functions

A detailed review of the Turbine Building intended functions was completed during the system scoping process described in the BGE Integrated Plant Assessment Methodology. The following system functions for the Turbine Building were identified as structural intended functions on Table 1S of "Component Level Scoping of Four Site Structures; Intake Structure, Turbine Building, FOST Enclosure, CST Enclosure."

1.1.3.1 Function LR-S-1

Provides structural and/or functional support, or both, to safety related equipment.

1.1.3.2 Function LR-S-2

Provides shelter/protection to safety related equipment, including radiation shielding for equipment qualification and HELB protection.

1.1.3.3 Function LR-S-4

Serves as a missile barrier (internal or external).

1.1.3.4 Function LR-S-5

Provides structural and/or functional support to non-safety related equipment whose failure could directly prevent satisfactory accomplishment of any of the required safety related functions.

1.1.3.5 Function LR-S-6

Provides a flood protection barrier (internal flooding event).

1.1.3.6 Function LR-S-7

Provides rated fire barriers to confine or retard a fire from spreading to or from adjacent areas of the plant.

1.2 EVALUATION METHODS

Turbine Building structural components within the scope of license renewal were evaluated in accordance with BGE procedure EN-1-305,[1] "Component Aging Management Review Procedure for Structures," Revision 0. The results of these evaluations are summarized in Sections 3.0 through 5.0.

1.3 TURBINE BUILDING SPECIFIC DEFINITIONS

This section provides the definitions for any specific terms unique to the Turbine Building component level evaluation.

Term	Definition
None	N/A

1.4 TURBINE BUILDING SPECIFIC REFERENCES

References utilized in the completion of the Turbine Building component level evaluation are listed in Table 1-1. Drawings and procedures used as source documents in the evaluation were taken at the revision level of record at the start of this task which was October 1994. The update performed in Revisions 1 and 2 of this report incorporated several TPRs. The update performed in Revision 2 was performed to address a new strategy in the aging management of corrosion affects on structural steel. Only references affected by Revisions 1 and 2 update have been revised.

[1] Revision 0 and Revision 1 were done to LCM-10S. EN-1-305 is new version of LCM-10S which updated procedure format and terminology.

Table 1-1

Turbine Building Specific References

Document ID.	Document Title	Revision No.	Date	Type
UFSAR	Calvert Cliffs Nuclear Power Plant Units 1 and 2, Updated Final Safety Analysis Report	14	1992	Report
Technical Specification	Calvert Cliffs Nuclear Power Plant, Units 1 and 2, Technical Specification	182 159	9/27/93 9/27/93	Report
---	Component Level Scoping of Four Site Structures; Intake Structure, Turbine Building, FOST Enclosure, CST Enclosure	1	1996	Report
EPRI RP-2643-27	Class I Structures License Renewal Industry Report	---	12/91	Report
NUMARC 90-01	Pressurized Water Reactor Containment Structures License Renewal Industry Report	1	9/91	Report
---	Mather, B., "How to Make Concrete that will be immune to the effects of freezing and thawing," ACI Fall Convention, San Diego	---	11/89	Paper
ASTM C33-82	"Standard Specification for Concrete Aggregates," American Society of Testing and Materials	---	1982	Spec
---	Civil and Structural Design Criteria for Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2, by Bechtel Power Corp.	0	8/2/91	Guide
6750-C-9	Specification for Furnishing and Delivery of Concrete - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2	8	4/70	Spec
ACI 318-63	"Building Code Requirements for Reinforced Concrete," American Concrete Institute	---	1963	Code
ACI 201.2R-67	"Guide to Durable Concrete," American Concrete Institute	---	1967	Std
---	"Concrete Manual," U.S. Department of the Interior	8th Edition	1975	Code
6750-C-23E	Specification for Furnishing and Installation of Piezometer - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2	0	11/73	Spec
ASTM C-289-66	"Potential Reactivity of Aggregates (Chemical Method)," American Society of Testing and Materials	---	1966	Code
ASTM C-295-65	"Petrographic Examination of Aggregates for Concrete," American Society of Testing and Materials	---	1965	Code
---	Letter from Charles County Sand & Gravel Co. to Bechtel Corp.	---	6/30/72	Letter

Table 1-1

Turbine Building Specific References

Document ID.	Document Title	Revision No.	Date	Type
---	Skoulikidas, T., Tsakopoulos, A., and Moropoulos, T., "Accelerated Rebar Corrosion When Connected to Lightning Conductors and Protection of Rebars with Needles Diodes Using Atmospheric Electricity," in Publication ASTM STP 906, "Corrosion Effects of Stray Currents and the Techniques for Evaluating Corrosion of Rebars in Concrete"	---	---	Paper
ACI-209R-82	"Prediction of Creep, Shrinkage, and Temperature Effects in Concrete Structures," American Concrete Institute	---	1982	Std
---	"Design and Control of Concrete Mixtures," Portland Cement Association	13th Edition	1988	Guide
IAEA-TECDOC-670	"Pilot Studies on Management of Aging of Nuclear Power Plant Components," International Atomic Energy Agency	---	10/92	Report
MN-3-100	Painting and Other Protective Coatings	---	9/94	Proc
TRD-A-1000	Coating Application Performance Standard	8	8/91	Spec
6750-A-24	Specification for Painting and Special Coatings	12	10/82	Spec
6750-C-19	Specification for Furnishing, Detailing, Fabricating, Delivering, and Erecting Structural Steel	3	9/70	Spec
ACI 215R-74	"Consideration for Design of Concrete Structures Subjected to Fatigue Loading," American Concrete Institute	---	1986	Std
---	"Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings," American Institute of Steel Construction	---	1963	Spec
---	Brockengrough, R.L., and Johnson, B.G., "Steel Design Manual," United States Steel Corporation	---	5/74	Text
NUREG-0797	Safety Evaluation Report Related to the Operation of Comanche Peak Steam Electric Station, Units 1 and 2	---	7/81	SER
ANSI/ANS-6.4	"Guidelines on the Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power Plants," American Nuclear Standard	---	1985	Code
---	Hilsdorf, H.R., Kropp, J., and Koch, H.J., "The Effects of Nuclear Radiation on the Mechanical Properties of Concrete," Douglas McHenry International Symposium on Concrete and Concrete Structures, American Concrete Institute Publication SP-55	---	1978	Paper

Table 1-1

Turbine Building Specific References

Document ID.	Document Title	Revision No.	Date	Type
NUREG/CR4652, ORNL/TM-10059	Naus, D.J., "Concrete Component Aging and its Significance Relative to Life Extension of Nuclear Power Plants," Oak Ridge National Laboratory, Oak Ridge, TN	---	9/86	Paper
ACI 349-85	"Code Requirements for Nuclear Safety Related Concrete Structures," American Concrete Institute	---	1985	Code
---	EQ Design Manual, Calvert Cliffs Nuclear Power Plant	17	1992	Guide
ASME Section III, Division 2	"Code for Concrete Reactor Vessels and Containments," American Society of Mechanical Engineers Boiler and Pressure Vessel Code	---	1986	Code

2.0 STRUCTURAL COMPONENTS WITHIN THE SCOPE OF LICENSE RENEWAL

The Turbine Building components were scoped in accordance with the process described in the BGE Integrated Plant Assessment Methodology. The Turbine Building was scoped using procedure LCM-11S. The purpose of component scoping is to identify all structural components whose functions are identified in Section 1.1.3. These structural components are designated as components within the scope of License Renewal.

As a result of the scoping, 22 structural component types were identified as providing one of the structure's intended functions listed in Section 1.1.3. A summary of the scoping result is in Table 2-1.

Table 2-1

Turbine Building Structural Components Within the Scope of License Renewal

STRUCTURAL COMPONENT TYPE	INTENDED FUNCTION(S)
Concrete Walls	LR-S-1, 2, 4, 6, and 7
Ground Floor Slab and Equipment Pads	LR-S-1, 2, 4, 6, and 7
Elevated Floor Slabs	LR-S-1, 2, 6, and 7
Cast-in-Place Anchors/Embedments	LR-S-1, 2, 6, and 7
Ductbanks	LR-S-1 and 2
Grout	LR-S-1, 2, 6, and 7
Fluid Retaining Walls and Slabs	LR-S-1, 2, 6, and 7
Post Installed Anchors	LR-S-4 and 5
Building Siding Clips	LR-S-2
Fire Doors, Jambs, and Hardware	LR-S-2, 6, and 7
Access Doors, Jambs, and Hardware	LR-S-2, 6, and 7
Caulking and Sealants	LR-S-2, 6, and 7
Watertight Doors	LR-S-2, 6, and 7
Steel Beams	LR-S-1, 2, and 7
Baseplates	LR-S-1, 2, 4, 5, and 7
Floor Framing	LR-S-1, 2, and 7
Steel Bracing	LR-S-4
Platform Hangers	LR-S-5
Steel Decking	LR-S-1, 2, and 7
Jet Impingement Barriers	LR-S-4
Floor Grating	LR-S-5
Stairs and Ladders	LR-S-5

3.0 STRUCTURAL COMPONENTS PRE-EVALUATION

Per the BGE Integrated Plant Assessment Methodology, the pre-evaluation task is not conducted on structures. Structural components are assumed to be passive and long-lived and therefore, subject to an aging management review. Consequently, Table 2-1 also represents a list of structural component types subject to aging management review.

4.0 STRUCTURAL COMPONENTS AGING EFFECTS EVALUATION

4.1 EVALUATION

The evaluation of Turbine Building structural components within the scope of license renewal was completed in accordance with BGE procedure EN-1-305, "Component Aging Management Review Procedure for Structures," Revision 0. This procedure evaluated all twenty-two component types identified in Section 2.1. The evaluation accomplished the following:

(1) Identified POTENTIAL aging mechanisms for each structural component type.

(2) Identified PLAUSIBLE component aging mechanisms for each structural component type or specific components within the component type based on the following:

- environmental conditions
- material of construction
- impact on intended functions

(3) Developed attributes for programs to manage the effects of aging from those aging mechanisms identified as PLAUSIBLE.

(4) Evaluated program adequacy to demonstrate that the effects of aging will be managed so that the intended function(s) will be maintained for the period of extended operation.

These steps are discussed in greater detail in the sections that follow.

4.2 AGING MECHANISMS

4.2.1 Potential Aging Mechanisms

This step of the aging evaluation identifies aging mechanisms that are considered to be POTENTIAL for a given component type. An aging mechanism is considered POTENTIAL for a structural component if the evaluation concludes that the aging mechanism could occur in generic applications of the structural component type throughout the plant due to susceptible materials of construction and conducive environmental service conditions.

A comprehensive list of 18 aging mechanisms was developed that may be applicable to structural component types. This was based on the EPRI industry reports prepared for the PWR containment structure and Class I structures. Other references used to prepare this list include the following:

- NRC NPAR Reports
- IAEA Reports
- DOE Reports

The list of aging mechanisms and materials they affect are shown in Table 4-1. The specific description of each is provided in Attachment 1 of procedure EN-1-305 or is described in detail in Section 1.0 of the corresponding appendices (A through T) in the component aging management review results.

Each aging mechanism was evaluated for applicability (i.e., POTENTIAL) to the structural component type based on its material of construction and the environmental conditions where the component type could be located. This approach ensures all the components within a component type will be evaluated if the potential of degradation exists.

The results of the structural component type POTENTIAL scoping of the component list of aging mechanisms are presented in the second column of Table 4-1.

4.2.2 <u>Component Grouping</u>

The grouping of structural components which are within the scope of license renewal is primarily based on their materials and their special functions, if any, that contribute to safety, or in the opinion of the evaluator, warrant special attention. The components are grouped into four categories:

(1) Concrete (including reinforcing steel)

(2) Structural steel

(3) Architectural items such as doors, roofing materials, and protective coating

(4) Additional components that may have a unique function in the structure

4.2.3 <u>Plausible Aging Mechanisms</u>

The identification of PLAUSIBLE aging mechanisms is accomplished through a careful review of the POTENTIAL aging mechanism list, the development of which is discussed in Section 4.2.1. A potential aging mechanism is considered plausible if when it is allowed to continue without any additional preventative or mitigative measures, the aging mechanism would result in the Turbine Building structural component not being able to perform its intended function. An aging

mechanism is also considered plausible if there is insufficient evidence to conclude that future degradation will have no impact on the intended functions of the Turbine Building structural component. The plausibility determination is made through a careful consideration of all the factors required to allow the aging mechanism to occur. In particular, the aging mechanism is scoped for plausibility on the basis of:

- Material of construction
- Environmental service conditions
- Design and construction considerations
- Impact on intended functions
- Physical conditions of the component

The results of the aging mechanism plausibility scoping is an aging mechanism component matrix listing the aging mechanism and its disposition. The aging mechanism matrix developed for each structural component type is included in Attachment 3 in the evaluation results.

Aging mechanisms determined to be PLAUSIBLE are provided specific aging management recommendations to mitigate the effects of the aging mechanism. Table 4-2 summarizes the results of the plausibility determination and recommendations for the Turbine Building.

4.2.4 Aging Management Program Identification

Once plausible aging mechanisms have been identified, the evaluation is continued to determine whether existing plant programs adequately address the effects of aging for the renewal term. If existing programs would not manage the effects of aging during a renewal term, a one-time inspection could be conducted, modifications could be made to the programs, or new programs could be initiated to adequately manage the effects of aging. This evaluation did not include a determination of whether recommended changes to existing programs or new program recommendations would actually be implemented or which programs would be included in the FSAR Supplement.

4.2.5 Aging Management Recommendations

The evaluation of all structural component types in the Turbine Building identified a total of eight (8) aging mechanisms that have the POTENTIAL to degrade these components. A detailed review of the specific component intended functions, material of construction and its basis of design and construction identified PLAUSIBLE component aging mechanisms as shown in the second column of Table 4-2. In some cases, the conclusion that the aging mechanism is

PLAUSIBLE was made because the condition of the component was not available or could not be readily verified due to lack of accessibility.

Recommended aging management activities include actions to perform condition assessment, to verify conditions conducive to degradation do not exist, and to develop inspection and monitoring programs to ensure degradation can be detected and corrective actions can be taken.

The following is a summary of the recommendations:

(1) Continue visual inspection of coated structural steel components in Class 1 portions of the Turbine Building.

(2) Develop an age related degradation inspection program for coated surfaces of structural steel components that are not readily accessible.

(3) Sample the water quality of the groundwater using the existing groundwater monitoring wells.

(4) Develop a new program to address the inspection and maintenance of caulking and sealants in the Turbine Building.

Table 4-1

List of Potential Aging Mechanisms for Turbine Building Structural Components

Aging Mechanism Description	Potential to Affect Turbine Building?	Materials Affected
Freeze-Thaw	No	Concrete
Leaching of Calcium Hydroxide	Yes	Concrete
Aggressive Chemicals	Yes	Concrete
Reaction with Aggregates	Yes	Concrete
Corrosion in Embedded Steel/Rebar	Yes	Steel, Concrete
Creep	No	Concrete
Shrinkage	No	Concrete
Abrasion and Cavitation	No	Concrete
Cracking of Masonry Block Walls	No *	Block Walls
Settlement	Yes	Structure
Corrosion in Steel	Yes	Steel
Corrosion in Liner	No *	Steel Liners (Carbon and Stainless)
Corrosion in Tendons	No *	Post-tensioning System
Prestressing Losses	No *	Post-tensioning System
Weathering	Yes	Caulking and Sealants
Elevated Temperature	No	Concrete
Irradiation	No	Steel, Concrete
Fatigue	Yes	Steel, Concrete

* Affected components do not exist in the Class 1 portion of the Turbine Building.

Table 4-2

Turbine Building Aging Effects Evaluation Summary

STRUCTURAL COMPONENTS	PLAUSIBLE AGING MECHANISM	RECOMMENDATION	REMARKS
Concrete Walls	None	None	See justification in Appendices D and T.
Ground Floor Slabs and Equipment Pads	Aggressive chemicals Corrosion in embedded steel/rebar	The observation wells, installed during construction, can be restored to sample the groundwater for water quality testing. This data can be used to evaluate the impact of chemical attack on the exterior surfaces of exposed components.	See justification in Appendices B, C, D, E, J and T.
Elevated Floor Slabs	None	None	See justification in Appendices D and T.
Cast-in place Anchors/Embedments	Corrosion in steel	See recommendation for "Steel Beams"	See justification in Appendices K and T.
Ductbanks	None	None	See justification in Appendix D.
Fluid Retaining Walls and Slabs	None	None	See justification in Appendix D.
Post-installed Anchors	Corrosion in steel	See recommendation for "Steel Beams"	See justification in Appendix K.
Building Siding Clips	Corrosion in steel	See recommendation for "Steel Beams"	See justification in Appendix K.
Fire Doors, Jambs, and Hardware	Corrosion in steel	See recommendation for "Steel Beams"	See justification in Appendix K.
Access Doors, Jambs, and Hardware	Corrosion in steel	See recommendation for "Steel Beams"	See justification in Appendix K.
Caulking and Sealants	Weathering	Caulking and sealants which perform a fire barrier function will be addressed by the Appendix R Program. For caulking and sealants which perform an intended function other than fire barrier, an inspection and maintenance program which will identify degradation and ensure corrective action is taken before the component losses its ability to perform its intended function will be developed. The resolution to Issue Report IR1995-01698 will form the basis for this program.	See justification in Appendix O.
Watertight Doors	Corrosion in steel	See recommendation for "Steel Beams"	See justification in Appendix K.

Table 4-2

Turbine Building Aging Effects Evaluation Summary

STRUCTURAL COMPONENTS	PLAUSIBLE AGING MECHANISM	RECOMMENDATION	REMARKS
Steel Beams	Corrosion in steel	All exposed surfaces of structural steel components are covered by a protective coating. For accessible areas, significant coating degradation and/or the presence of corrosion will be identified, an issue report written, and corrective action taken through the following existing site programs: PEG-7, System Walkdowns QL-2-100, Issue Reporting MN-3-100, Protective Coating Program. For those structural steel components not readily accessible, significant coating degradation and/or the presence of corrosion will be determined utilizing an age related degradation inspection.	See justification in Appendix K.
Baseplates	Corrosion in steel	See recommendation for "Steel Beams"	See justification in Appendix K.
Floor Framing	Corrosion in steel	See recommendation for "Steel Beams"	See justification in Appendix K.
Steel Bracing	Corrosion in steel	See recommendation for "Steel Beams"	See justification in Appendix K.
Platform Hangers	Corrosion in steel	See recommendation for "Steel Beams"	See justification in Appendix K.
Steel Decking	Corrosion in steel	See recommendation for "Steel Beams"	See justification in Appendix K.
Jet Impingement Barriers	Corrosion in steel	See recommendation for "Steel Beams"	See justification in Appendix K.
Floor Grating	Corrosion in steel	See recommendation for "Steel Beams"	See justification in Appendix K.
Stairs and Ladders	Corrosion in steel	See recommendation for "Steel Beams"	See justification in Appendix K.

5.0 PROGRAM EVALUATION

5.1 PROGRAM ADEQUACY EVALUATION

Program adequacy evaluations were completed in accordance with EN-1-305, Revision 0, for those programs or aging management alternatives developed to address PLAUSIBLE component aging mechanisms. The evaluation of programs or aging management alternatives considered the following criteria as a means of establishing the adequacy of specific CCNPP programs:

1. Adequate programs must ensure management of the affects of aging for those structural components subject to plausible aging mechanisms.

2. Adequate programs must contain acceptance criteria against which the need for corrective action will be evaluated, and ensure that timely corrective action will be taken when these acceptance criteria are not met.

3. Adequate programs must be implemented by the facility operating procedures and reviewed by the onsite review committee.

The results of the program adequacy evaluations are provided in Section 5.2.

5.2 STRUCTURAL COMPONENTS SUBJECT TO ADEQUATE PROGRAMS

5.2.1 Existing Programs

The program evaluation task reviewed all existing CCNPP programs that were established to monitor, inspect, and repair Turbine Building structural components that are degraded by identified plausible aging mechanisms.

The Appendix R Program, implemented through procedure STP-F-592-1/2 for penetration fire barrier inspection, is adequate to manage the effects of aging for caulking and sealants which function as fire barriers without any modification.

PEG-7 in conbination with QL-2-100 and MN-3-100 for identifying, documenting, and correcting significant coating degradation are adequate for managing the effects of corrosion in accessible steel components.

5.2.2 Modified Existing Programs

This section provides the summary results for those structural components that were determined to have an existing CCNPP Program/Activity that with modification would become an adequate program to manage the effects of aging during the renewal period. The evaluation started from evaluating structural component types and applicable aging mechanisms and has focused to specific components or locations.

No modified existing programs were identified to manage the effects of aging into the license renewal period.

5.2.3 New Programs

This section provides the summary results for those structural components that were determined to require a new CCNPP Program/Activity be created as an adequate program to manage the affects of aging during the renewal period. Components that can be managed by the creation of such a new program include the following:

Ground floor slab: An investigative program to test the water quality of the groundwater should be developed to determine if there is any possibility of aggressive chemical attack on the Turbine Building ground floor slab.

Caulking and Sealants: A periodic inspection and maintenance program should be developed for components not covered by the Appendix R Inspection Program. The resolution to Issue Report IR1995-01698 will address the requirements for the inspection and maintenance of caulking and sealants not covered by the Appendix R Program.

Non-accessible Structural Steel: An age related degradation inspection, as defined in the BGE Integrated Plant Assessment Methodology, should be conducted for structural steel components that are not readily accessible. The ARDI Program must provide requirements for identification of a representative sample of components for inspection, the inspection sample size, appropriate inspection techniques, and requirements for reporting of results and corrective actions.

List of Attachments and Appendices For the Turbine Building Aging Management Review

Attachment 1

Potential Aging Mechanisms Applicable to Structural Components

ATTACHMENT 1: POTENTIAL AGING MECHANISMS APPLICABLE TO STRUCTURAL COMPONENTS

STRUCTURE NAME: Turbine Building

REVISION: 2
SYSTEM NUMBER: --

DATE: 5/7/96
Sheet 2 of 3

STRUCTURAL COMPONENTS	POTENTIAL AGING MECHANISMS APPLICABLE TO CONCRETE/ARCH. COMPONENTS															REMARKS
	A	B	C	D	E	F	G	H	I	J	K	O	R	S	T	
Concrete Walls	-	-	-	√	-	-	-	-	NA	-	-	-	-	-	√	Functions LR-S-1, 2, 4, 6, 7
Ground Floor Slabs & Equip. Pads	-	√	√	√	√	-	-	-	NA	√	-	-	-	-	√	Functions LR-S-1, 2, 4, 6, 7
Elevated Floor Slabs	-	-	-	√	-	-	-	-	NA	-	-	-	-	-	√	Functions LR-S-1, 2, 6, 7
Cast-in-Place Anchors / Embed.	-	-	-	-	-	-	-	-	NA	-	√	-	-	-	√	Functions LR-S-1, 2, 6, 7
Duct Banks	-	-	-	√	-	-	-	-	NA	-	-	-	-	-	-	Functions LR-S-1, 2
Grout	-	-	-	-	-	-	-	-	NA	-	-	-	-	-	-	Functions LR-S-1, 2, 6, 7
Fluid Retaining Walls & Slabs	-	-	-	√	-	-	-	-	NA	-	-	-	-	-	-	Functions LR-S-1, 2, 6, 7
Post-Installed Anchors	-	-	-	-	-	-	-	-	NA	-	√	-	-	-	-	Functions LR-S-4, 5
Building Siding Clips	-	-	-	-	-	-	-	-	NA	-	√	-	-	-	-	Function LR-S-2
Fire Doors, Jambs, Hardware	-	-	-	-	-	-	-	-	NA	-	√	-	-	-	-	Functions LR-S-2, 6, 7
Access Doors, Jambs, Hardware	-	-	-	-	-	-	-	-	NA	-	√	-	-	-	-	Functions LR-S-2, 6, 7
Caulking and Sealants	-	-	-	-	-	-	-	-	NA	-	-	√	-	-	-	Functions LR-S-2, 6, 7
Watertight Doors	-	-	-	-	-	-	-	-	NA	-	√	-	-	-	-	Functions LR-S-2, 6, 7

Legend:

A Freeze-thaw
B Leaching of calcium hydroxide
C Aggressive chemicals
D Reaction with aggregates
E Corrosion in embedded steel/rebar
F Creep
G Shrinkage
H Abrasion and cavitation
I Cracking of masonry block walls
J Settlement
K Corrosion in steel
L Corrosion in Liner
M Corrosion in tendons
N Prestressing losses
O Weathering
P (Not Used)
Q (Not Used)
R Elevated temperature
S Irradiation
T Fatigue
U (Not Used)
V (Not Used)
NA Not applicable
\- Not potential

ATTACHMENT 1: POTENTIAL AGING MECHANISMS APPLICABLE TO STRUCTURAL COMPONENTS

STRUCTURE NAME: Turbine Building

REVISION: 2

SYSTEM NUMBER: --

DATE: 5/7/96

STRUCTURAL COMPONENTS	POTENTIAL AGING MECHANISMS APPLICABLE TO STEEL COMPONENTS							REMARKS
	K	L	M	N	R	S	T	
Steel Beams	√	NA	NA	NA	-	-	√	Functions LR-S-1, 2, 7
Baseplates	√	NA	NA	NA	-	-	√	Functions LR-S-1, 2, 4, 5, 7
Floor Framing	√	NA	NA	NA	-	-	√	Functions LR-S-1, 2, 7
Bracing	√	NA	NA	NA	-	-	√	Function LR-S-4
Platform Hangers	√	NA	NA	NA	-	-	√	Function LR-S-5
Decking	√	NA	NA	NA	-	-	√	Functions LR-S-1, 2, 7
Jet Impingement Barriers	√	NA	NA	NA	-	-	-	Function LR-S-4
Floor Grating	√	NA	NA	NA	-	-	-	Function LR-S-5
Stairs & Ladders	√	NA	NA	NA	-	-	-	Function LR-S-5

Legend:

A Freeze-thaw	G Shrinkage	M Corrosion in tendons	S Irradiation
B Leaching of calcium hydroxide	H Abrasion and cavitation	N Prestressing losses	T Fatigue
C Aggressive chemicals	I Cracking of masonry block walls	O Weathering	U (Not Used)
D Reaction with aggregates	J Settlement	P (Not Used)	V (Not Used)
E Corrosion in embedded steel/rebar	K Corrosion in steel	Q (Not Used)	NA Not applicable
F Creep	L Corrosion in Liner	R Elevated temperature	- Not potential

Attachment 2

Plausible Aging Mechanisms Applicable to Structural Components

ATTACHMENT 2: PLAUSIBLE AGING MECHANISMS APPLICABLE TO STRUCTURAL COMPONENTS

REVISION: 2 DATE: 5/7/96

STRUCTURE NAME: Turbine Building SYSTEM NUMBER: -- Sheet 2 of 3

STRUCTURAL COMPONENTS	PLAUSIBLE AGING MECHANISMS APPLICABLE TO CONCRETE/ARCH. COMPONENTS															REMARKS
	A	B	C	D	E	F	G	H	I	J	K	O	R	S	T	
Concrete Walls	-	-	-	102	-	-	-	-	NA	-	-	-	-	-	104	Functions LR-S-1, 2, 4, 6, 7
Ground Floor Slabs & Equip. Pads	-	101	PA	102	PB	-	-	-	NA	103	-	-	-	-	104	Functions LR-S-1, 2, 4, 6, 7
Elevated Floor Slabs	-	-	-	102	-	-	-	-	NA	-	-	-	-	-	104	Functions LR-S-1, 2, 6, 7
Cast-in-Place Anchors / Embed.	-	-	-	-	-	-	-	-	NA	-	PC	-	-	-	104	Functions LR-S-1, 2, 6, 7
Duct Banks	-	-	-	102	-	-	-	-	NA	-	-	-	-	-	-	Functions LR-S-1, 2
Grout	-	-	-	-	-	-	-	-	NA	-	-	-	-	-	-	Functions LR-S-1, 2, 6, 7
Fluid Retaining Walls & Slabs	-	-	-	102	-	-	-	-	NA	-	-	-	-	-	-	Functions LR-S-1, 2, 6, 7
Post-Installed Anchors	-	-	-	-	-	-	-	-	NA	-	PC	-	-	-	-	Functions LR-S-4, 5
Building Siding Clips	-	-	-	-	-	-	-	-	NA	-	PC	-	-	-	-	Function LR-S-2
Fire Doors, Jambs, Hardware	-	-	-	-	-	-	-	-	NA	-	PC	-	-	-	-	Functions LR-S-2, 6, 7
Access Doors, Jambs, Hardware	-	-	-	-	-	-	-	-	NA	-	PC	-	-	-	-	Functions LR-S-2, 6, 7
Caulking and Sealants	-	-	-	-	-	-	-	-	NA	-	-	PD	-	-	-	Functions LR-S-2, 6, 7
Watertight Doors	-	-	-	-	-	-	-	-	NA	-	PC	-	-	-	-	Functions LR-S-2, 6, 7

Legend:

A	Freeze-thaw	G	Shrinkage	M	Corrosion in tendons	S	Irradiation
B	Leaching of calcium hydroxide	H	Abrasion and cavitation	N	Prestressing losses	T	Fatigue
C	Aggressive chemicals	I	Cracking of masonry block walls	O	Weathering	U	(Not Used)
D	Reaction with aggregates	J	Settlement	P	(Not Used)	V	(Not Used)
E	Corrosion in embedded steel/rebar	K	Corrosion in steel	Q	(Not Used)	NA	Not applicable
F	Creep	L	Corrosion in Liner	R	Elevated temperature	-	Not potential

ATTACHMENT 2: PLAUSIBLE AGING MECHANISMS APPLICABLE TO STRUCTURAL COMPONENTS

STRUCTURE NAME: Turbine Building

REVISION: 2

SYSTEM NUMBER: --

DATE: 5/7/96

Sheet 3 of 3

STRUCTURAL COMPONENTS	PLAUSIBLE AGING MECHANISMS APPLICABLE TO STEEL COMPONENTS														REMARKS
	K	L	M	N	R	S	T								
Steel Beams	PC	NA	NA	NA	-	-	104								Functions LR-S-1, 2, 7
Baseplates	PC	NA	NA	NA	-	-	104								Functions LR-S-1, 2, 4, 5, 7
Floor Framing	PC	NA	NA	NA	-	-	104								Functions LR-S-1, 2, 7
Bracing	PC	NA	NA	NA	-	-	104								Function LR-S-4
Platform Hangers	PC	NA	NA	NA	-	-	104								Function LR-S-5
Decking	PC	NA	NA	NA	-	-	104								Functions LR-S-1, 2, 7
Jet Impingement Barriers	PC	NA	NA	NA	-	-	-								Function LR-S-4
Floor Grating	PC	NA	NA	NA	-	-	-								Function LR-S-5
Stairs & Ladders	PC	NA	NA	NA	-	-	-								Function LR-S-5

Legend:

A Freeze-thaw
B Leaching of calcium hydroxide
C Aggressive chemicals
D Reaction with aggregates
E Corrosion in embedded steel/rebar
F Creep
G Shrinkage
H Abrasion and cavitation
I Cracking of masonry block walls
J Settlement
K Corrosion in steel
L Corrosion in Liner
M Corrosion in tendons
N Prestressing losses
O Weathering
P (Not Used)
Q (Not Used)
R Elevated temperature
S Irradiation
T Fatigue
U (Not Used)
V (Not Used)
NA Not applicable
\- Not potential

Attachment 3

Structural Components

Aging Mechanism Matrix Codes

ATTACHMENT 3

STRUCTURAL COMPONENTS - AGING MECHANISM MATRIX CODES

REVISION: 2 DATE: 5/7/96

STRUCTURE NAME: Turbine Building

SYSTEM NUMBER: -- Sheet 2 of 3

CODE	JUSTIFICATION	REMARKS
101	See Appendix B	
102	See Appendix D	
103	See Appendix J	
104	See Appendix T	

ATTACHMENT 3

STRUCTURAL COMPONENTS - AGING MECHANISM MATRIX CODES

REVISION: 2 DATE: 5/7/96

STRUCTURE NAME: Turbine Building

SYSTEM NUMBER: --

CODE	JUSTIFICATION	REMARKS
PA	See Appendix C	
PB	See Appendix E	
PC	See Appendix K	
PD	See Appendix O	

Attachment 4

Summary of Aging Management Review Results

Attachment 4

SUMMARY OF AGING MANAGEMENT REVIEW RESULTS

REVISION: 2
DATE: 5/7/96

STRUCTURE/SYSTEM NUMBER: -- STRUCTURE NAME: Turbine Building

	COMPONENTS AFFECTED			
AGING MECHANISM	CONCRETE	STEEL	ARCH	PROGRAM/COMMENT
Freeze-Thaw	None	None	None	Not Needed
Leaching of $Ca(OH)_2$	None	None	None	Not Needed
Aggressive Chemicals	Ground Floor Slab	None	None	None existing. Need to investigate water quality of groundwater.
Reaction with Aggregates	None	None	None	Not Needed
Corrosion of Embedded Steel/Rebar	Ground Floor Slab	None	None	None existing. Need to investigate water quality of groundwater.
Creep	None	None	None	Not Needed
Shrinkage	None	None	None	Not Needed
Abrasion/Cavitation	None	None	None	Not Needed
Cracking of Masonry Block Walls	None	None	None	Masonry block walls do not exist in the Class 1 portion of the turbine building.
Settlement	None	None	None	Not Needed
Corrosion in Steel	None	All carbon steel components	None	PEG-7,QL-2-100,MN-3-100,ARDI.
Corrosion in Liner	None	None	None	Steel liners do not exist in the Class 1 portion of the turbine building
Corrosion in Tendons	None	None	None	Prestressed tendons do not exist in the

Attachment 4

SUMMARY OF AGING MANAGEMENT REVIEW RESULTS

REVISION: 2
DATE: 5/7/96

STRUCTURE/SYSTEM NUMBER: -- STRUCTURE NAME: Turbine Building				
	COMPONENTS AFFECTED			
AGING MECHANISM	CONCRETE	STEEL	ARCH	PROGRAM/COMMENT
				Class 1 portion of the turbine building
Prestressing Losses	None	None	None	Prestressed tendons do not exist in the Class 1 portion of the turbine building
Weathering	None	None	Caulking and Sealants	Appendix R Program for components with fire protection function. For non-Appendix R components, develop an inspection and maintenance program to identify degradation and ensure corrective action is taken. The resolution to Issue Report IR1995-01698 to form the basis of this program.
Elevated Temperature	None	None	None	Not Needed
Irradiation	None	None	None	Not Needed
Fatigue	None	None	None	Not Needed

Attachment 5

Adequate Program Evaluation

Attachment 5

ADEQUATE PROGRAM EVALUATION

REVISION: 2 DATE: 5/7/96

STRUCTURE/SYSTEM NUMBER: STRUCTURE NAME: Turbine Building

STRUCTURAL COMPONENT DESCRIPTION: All accessible steel surfaces

AGING MECHANISM DESCRIPTION: Corrosion of steel

CCNPP PA or Task ID: MN-3-100, PEG-7, QL-2-100

Criteria 1: Adequate programs must ensure mitigation of the effects of agre related degradation for the SSCs within the scope of license renewal.

DISCOVERY DESCRIPTION/BASIS:

1. Is there a frequency interval in the PA or Task?

   YES X NO __

   Basis: System Engineer Walkdowns as directed by PEG-7 are conducted periodically as mandated by system performance, plant operating conditions, or as required by plant management. Walkdowns can be job specific or outage related but otherwise typically occur on a monthly basis.

2. Is the frequency interval consistent with industry standards, industry experience, experience unique to Calvert Cliffs, or vendors' recommendations?

   YES X NO __

   Basis: The PEG-7 walkdown frequency is consistent with industry standards and can be modified as necessary to reflect unique plant operating conditions specific to CCNPP.

3. Will the PA or Task be applicable to all structural components under the same component type?

   YES X NO __

   Basis: All coated surfaces in areas that are "reasonably accessible" are visually inspected during the PEG-7 activity.

REVISION: 2 **DATE:** 5/7/96

AGING MECHANISM DESCRIPTION: Corrosion of steel

CCNPP PA or TASK ID: MN-3-100, PEG-7, QL-2-100

Criteria 2: **Adequate programs must contain acceptance criteria against which the need for corrective action will be evaluated, and ensure that timely corrective action will be taken when these acceptance criteria are not met.**

ASSESSMENT/ANALYSIS/CORRECTIVE ACTION DESCRIPTION/BASIS:

1. Does the PA or Task have an action or alert value or condition parameter to determine the need for corrective action?

   YES X NO __

   Basis: There is no quantitative alert value to determine the need for corrective action. PEG-7 allows for degraded coatings to be documented on a checklist which is then used to prioritize corrective actions. MN-3-100 specifies appropriate technical procedures for corrective action based on the coatings service level.

2. Does the action value or condition provide sufficient indication of degradation to ensure that there will not be a functional failure prior to the next PA or Task?

   YES X NO __

   Basis: Conditions adverse to quality and functionality, indications of equipment stress or abuse, safety or fire hazards, and general housekeeping deficiencies are noted during PEG-7 system walkdowns conducted monthly. Structural degradation occurs at a sufficiently slow rate such that monthly inspections would detect degradation before loss of function could occur.

3. Will the action value or condition parameter remain the same during the renewal period ?

   YES X NO __

   Basis: The corrective actions and condition parameters prescribed in MN-3-100 are based on inspection of the surface condition of the painted component. This approach does not need to be revised during the renewal period.

Attachment 5 - Adequate Program Evaluation (continued)

REVISION: 2 **DATE: 5/7/96**

AGING MECHANISM DESCRIPTION: Corrosion of steel

CCNPP PA or TASK ID: MN-3-100, PEG-7, QL-2-100

4. Does the PA or Task ensure that corrective action is taken?

YES X NO __

Basis: PEG-7 requires deficiencies to be documented on a system walkdown report. Conditions adverse to quality will result in the initiation of an Issue Report per QL-2-100 requirements. MN-3-100 invokes the appropriate technical procedure to ensure proper application and that a qualified protective coating is used.

5. Does the PA or Task ensure that the corrective action is appropriately scheduled?

YES X NO __

Basis: QL-2-100 assigns a due date for corrective action to occur. The completion date is driven by engineering judgment based on the condition of the degraded coating and its contribution to the component's intended function.

Attachment 5 - Adequate Program Evaluation (continued)

REVISION: 2 **DATE: 5/7/96**

AGING MECHANISM DESCRIPTION: Corrosion of steel

CCNPP PA or TASK ID: MN-3-100, PEG-7, QL-2-100

Criteria 3: **Adequate programs must be implemented by the facility operating procedures and reviewed by the onsite review committee.**

CONFIRMATION/DOCUMENTATION DESCRIPTION/BASIS:

1. Does the PA or Task have a review/approval process?

   YES X NO __

   Basis: The procedure requires signatures from appropriate levels of supervision (i.e., POSRC, Manager of Calvert Cliffs Nuclear Power Plant, and GSQA) after it is submitted by the responsible engineer.

2. Does the PA or Task have a change/revision process?

   YES X NO __

   Basis: The "Record of Revisions and Changes" of the procedure documents the changes to the procedure.

Attachment 5

ADEQUATE PROGRAM EVALUATION

REVISION: 2 . DATE: 5/7/96

STRUCTURE/SYSTEM NUMBER: None STRUCTURE NAME: Turbine Building

STRUCTURAL COMPONENT DESCRIPTION: Caulking and Sealants

AGING MECHANISM DESCRIPTION: Weathering

CCNPP PA or Task ID: STP-F-592-1/2

Criteria 1: Adequate programs must ensure mitigation of the effects of age-related degradation for the SSCs identified as within the scope of license renewal.

DISCOVERY DESCRIPTION/BASIS:

1. Is there a frequency interval in the PA or Task?

   YES X NO __

   Basis: Both the Unit 1 and Unit 2 procedures are implemented in accordance with the frequency intervals specified in plant Technical Specification Section 4.7.12.

2. Is the frequency interval consistent with industry standards, industry experience, experience unique to Calvert Cliffs, or vendors' recommendations?

   YES X NO __

   Basis: The frequency interval is consistent with that commonly used in the industry for surveillance of fire barrier penetration seals. The frequency interval has been approved in association with the implementation of the CCNPP Appendix R Program.

3. Will the PA or Task be applicable to all structural components under the same component type?

   YES X NO __

   Basis: The procedure is applicable to fire barrier penetration seals including electrical conduit and cable tray penetration seals, HVAC duct penetration seals, and mechanical pipe penetration seals. The procedure also covers inspection of the fire resistivity of rated walls, ceilings, and floors. Data sheets are provided with the procedure to identify the fire areas requiring inspection.

Attachment 5 - Adequate Program Evaluation (continued)

REVISION: 2 **DATE:** 5/7/96

AGING MECHANISM DESCRIPTION: Weathering

CCNPP PA or TASK ID: STP-F-592-1/2

Criteria 2: **Adequate programs must contain acceptance criteria against which the need for corrective action will be evaluated, and ensure that timely corrective action will be taken when these acceptance criteria are not met.**

ASSESSMENT/ANALYSIS/CORRECTIVE ACTION DESCRIPTION/BASIS:

1. Does the PA or Task have an action or alert value or condition parameter to determine the need for corrective action?

   YES X NO __

   Basis: Acceptance criteria is provided for each type of penetration in Attachment A to the Unit 1 and Unit 2 procedures. The acceptance criteria provides the basis for determining the need for corrective action.

2. Does the action value or condition provide sufficient indication of degradation to ensure that there will not be a functional failure prior to the next PA or Task?

   YES X NO __

   Basis: The procedures in both units mandate visual inspection of the penetration fire barriers for indications of degradation or damage. The criteria implemented in the Calvert Cliffs penetration fire barrier surveillance procedures will ensure the fire barriers perform their intended functions at all times. This requirement is implemented in accordance with the requirements of Appendix R and CCNPP Technical Specifications.

3. Will the action value or condition parameter remain the same during the renewal period ?

   YES X NO __

   Basis: Since the surveillance procedures and the acceptance criteria in the procedures are to ensure the availability and the reliability of the fire barrier penetration seals, this acceptance criteria should not be changed during the renewal period.

Attachment 5 - Adequate Program Evaluation (continued)

REVISION: 2 **DATE:** 5/7/96

AGING MECHANISM DESCRIPTION: Weathering

CCNPP PA or TASK ID: STP-F-592-1/2

4. Does the PA or Task ensure that corrective action is taken?

   YES X NO __

   Basis: In accordance with Sections 5.4, 7.1, and Attachment B of the procedures for both units, any inspection results determined to be unsatisfactory will be reported to the Shift Supervisor for possible Tech Spec required action and to the Fire Protection System Engineer or Fire Protection Engineer for investigation and corrective action.

5. Does the PA or Task ensure that the corrective action is appropriately scheduled?

   YES X NO __

   Basis: All corrective actions must meet reporting requirements specified in Technical Specification 4.7.12 of both Units 1 and 2.

Attachment 5 - Adequate Program Evaluation (continued)

REVISION: 2 **DATE:** 5/7/96

AGING MECHANISM DESCRIPTION: Weathering

CCNPP PA or TASK ID: STP-F-592-1/2

Criteria 3: **Adequate programs must be implemented by the facility operating procedures and reviewed by the onsite review committee.**

CONFIRMATION/DOCUMENTATION DESCRIPTION/BASIS:

1. Does the PA or Task have a review/approval process?

   YES X NO __

   Basis: This procedure has a review/approval process per EN-4-104.

2. Does the PA or Task have a change/revision process?

   YES X NO __

   Basis: This procedure has a change/revision process per EN-4-104.

Attachment 7

Walkdown Report

Examination of Auxiliary Feedwater Pump Rooms

Calvert Cliffs Nuclear Power Plant

Attachment 7

Examination of Auxiliary Feedwater Pump Rooms
Calvert Cliffs Nuclear Power Plant
October 27, 1994

<u>Date of Inspection:</u> October 27, 1994

<u>Participants:</u> Lloyd Philpot G/C
David Knepper G/C
Patrick McCarraher G/C

<u>Summary:</u> An inspection of the Auxiliary Feedwater Pump Rooms located inside the Turbine Building was performed to support the Component Evaluation and Program Evaluation of the Turbine Building. Prior to the inspection a checklist was developed to establish those characteristics indicative of specific aging mechanisms. The interior and exterior of the pump rooms were inspected.

<u>Results:</u> The inspection checklist and corresponding findings are included on the following pages. This information will be used as input to the turbine building evaluation as needed.

Attachment 7

LCM INSPECTION CHECKLIST
AUXILIARY FEEDWATER PUMP ROOMS

Appendix	Aging Mechanism	Characteristic	Comments
A	Freeze-thaw	Scaling, cracking, spalling	No scaling, cracking, or spalling was observed
B	Leaching of calcium hydroxide	Leachate	No leachate was observed
C	Aggressive chemicals	Spills, discoloration	No aggressive chemicals were observed in the auxiliary feedwater pump rooms.
D	Reaction with aggregates	Map cracking	No map cracking was observed
E	Corrosion in embedded steel/rebar	Cracking, rust staining, spalling	No cracking, staining, or spalling was observed
F	Creep	NA	Creep is not a potential aging mechanism for this structure
G	Shrinkage	NA	Shrinkage is not a potential aging mechanism for this structure
H	Abrasion and cavitation	NA	This aging mechanism is not applicable to the auxiliary feedwater pump rooms
I	Cracking of masonry block walls	NA	This aging mechanism is not applicable to the auxiliary feedwater pump rooms
J	Settlement	Cracking	No cracking or other evidence of settlement was observed
K	Corrosion in steel	Rust	Minor areas of rust were found, however a periodic maintenance

Attachment 7

LCM INSPECTION CHECKLIST
AUXILIARY FEEDWATER PUMP ROOMS

Appendix	Aging Mechanism	Characteristic	Comments
			program could be used to control this aging mechanism
L	Corrosion in liner	NA	This aging mechanism is not applicable to the auxiliary feedwater pump rooms
M	Corrosion in tendons	NA	This aging mechanism is not applicable to the auxiliary feedwater pump rooms
N	Prestressing losses	NA	This aging mechanism is not applicable to the auxiliary feedwater pump rooms
O	Weathering	NA	This aging mechanism is not applicable to concrete in the auxiliary feedwater pump rooms
R	Elevated temperatures	Heat sources	Only minor heat generating sources were observed in the pump rooms
S	Irradiation	Radiation	No monitored radiation sources were observed inside the pump rooms
T	Fatigue	Vibrating equipment	The auxiliary feedwater pump rooms contain vibrating equipment. Fatigue caused by this equipment was considered in the original design of the structure. No cracking or spalling of the concrete around the base of this equipment was observed

Attachment 8

Attributes in New Program

ATTRIBUTES IN NEW PROGRAM

REVISION: 2 DATE: 5/7/96

STRUCTURE/SYSTEM NUMBER: None

STRUCTURE NAME: Turbine Building

STRUCTURAL COMPONENT DESCRIPTION: Ground Floor Slab

AGING MECHANISM DESCRIPTION: Aggressive Chemicals

APPLICABLE APPENDIX: Appendix C

BACKGROUND: The intended function of the turbine building's ground floor slab is to provide support, protection, and shelter to safety-related and non-safety related equipment inside the turbine building. Chemical attack is plausible if the chemistry of the groundwater has become significantly more aggressive than was originally anticipated.

RECOMMENDED ATTRIBUTES: Since degradation of the below grade portion of the turbine building ground floor slab would be plausible only if the water chemistry has become more aggressive, the proposed program will begin with investigative tasks followed by corrective action if necessary. The recommended approach is:

1. Restore the groundwater observation wells installed during initial plant construction for sampling purpose.

2. Secure samples of the groundwater for water chemistry testing. If the water chemistry meets the original design requirements (Cl ions < 500 ppm, SO_4 ions ≤ 1500 ppm), no further action is necessary.

3. If the water chemistry tests conclude that the concrete components are being degraded by chemical agents, the levels of chemical concentration will need to be assessed to determine the appropriate corrective action.

BASIS: Because of the design and construction of the turbine building ground floor slab, and the knowledge of the water chemistry during the design of the plant, it is unlikely that chemical attack to concrete is a major concern.

Attachment 8 (continued)

ATTRIBUTES IN NEW PROGRAM

REVISION: 2 DATE: 5/7/96

STRUCTURE/SYSTEM NUMBER: None

STRUCTURE NAME: Turbine Building

STRUCTURAL COMPONENT DESCRIPTION: Ground Floor Slab

AGING MECHANISM DESCRIPTION: Corrosion of Embedded Steel/Rebar

APPLICABLE APPENDIX: Appendix C

BACKGROUND: The intended function of the turbine building's ground floor slab is to provide support, protection, and shelter to safety-related and non-safety related equipment inside the turbine building. Corrosion of embedded steel/rebar in the ground floor slab is plausible if the chemistry of the groundwater has become significantly more aggressive than was originally anticipated.

RECOMMENDED ATTRIBUTES: Since degradation of the below grade portion of the turbine building ground floor slab would be plausible only if the water chemistry has become more aggressive, the proposed program will begin with investigative tasks followed by corrective action if necessary. The recommended approach is:

1. Restore the groundwater observation wells installed during initial plant construction for sampling purpose.

2. Secure samples of the groundwater for water chemistry testing. If the water chemistry meets the original design requirements (pH > 4.0, Cl ions < 500 ppm, and SO_4 ions < 1500 ppm), no further action is necessary.

3. If the water chemistry tests conclude that the concrete components are being degraded by chemical agents, the levels of chemical concentration will need to be assessed to determine the appropriate corrective action.

BASIS: Because of the design and construction of the turbine building ground floor slab, and the knowledge of the water chemistry during the design of the plant, it is unlikely that corrosion of embedded steel/rebar in the ground floor slab is a major concern.

Attachment 8 (continued)

ATTRIBUTES IN NEW PROGRAM

REVISION: 2 DATE: 5/7/96

STRUCTURE/SYSTEM NUMBER: None

STRUCTURE NAME: Turbine Building

STRUCTURAL COMPONENT DESCRIPTION: Caulking and Sealants

AGING MECHANISM: Weathering

APPLICABLE APPENDIX: Appendix O

BACKGROUND: The intended functions of caulking and sealants are to provide shelter and protection to safety related equipment (including HELB and radiation protection) inside the Turbine Building. The caulking and sealants have an additional intended function to provide a flood protective barrier for internal flooding events. The caulking and sealants are components which are typically replaced on condition. However inspections in the plant revealed that an inspection program was required to adequately manage the aging of these components.

Note: The caulking and sealants which require a new program to manage their aging do not perform the intended function of a fire barrier. Caulking and sealants which perform a fire barrier function are managed under an existing program.

RECOMMENDED ATTRIBUTES: The management program for the caulking and sealants is recommended to be developed in association with the resolution to Issue Report IR1995-01698. The program must manage the aging of the caulking and sealants in the Turbine Building which support intended functions of the structure. The recommended approaches are:

1. Identify all non-Appendix R caulking and sealants locations that support the structure's intended functions.

2. Develop an inspection and maintenance program which will identify degradation and ensure corrective action is taken before the component loses the ability to perform its intended function. The program should concentrate on caulking and sealants located in exterior walls and in interior walls and floors where HELB and flooding functions are performed.

REVISION: 2

DATE: 5/7/96

STRUCTURAL COMPONENT DESCRIPTION: Caulking and Sealants

AGING MECHANISM: Weathering

APPLICABLE APPENDIX: Appendix O

BASIS: The management program for the caulking and sealants is recommended to be developed in association with the resolution to Issue Report IR1995-01698. The issue report identified joints in the Auxiliary Building which showed signs of degradation. This concern is also applicable to the Turbine Building. Resolution of this issue report will ensure development of an aging management program for caulking and sealants in the Turbine Building such that these components will be able to perform their intended functions both during the current license period and the period of extended operations.

Attachment 8 (continued)

ATTRIBUTES IN NEW PROGRAM

REVISION: 2 DATE: 5/7/96

STRUCTURE/SYSTEM NUMBER: None

STRUCTURE NAME: Turbine Building

STRUCTURAL COMPONENT DESCRIPTION: Non-accessible structural steel

ARDM DESCRIPTION: Corrosion of Steel

APPLICABLE APPENDIX: Appendix K

BACKGROUND: Safety related structural steel in the Turbine Building is covered with an appropriate protective coating. Corrosion of structural steel can only occur if these protective coatings have been degraded. Aging management of degraded coating conditions on accessible structural steel in the Turbine Building is accomplished through the combination of existing plant programs. However, structural steel components not readily accessible require additional aging management.

RECOMMENDED ATTRIBUTES – An age related degradation inspection (ARDI) program as described in the BGE Integrated Plant Assessment Methodology should be implemented to address corrosion of non-accessible structural steel components which support the intended functions of the Turbine Building. The ARDI Program must consist of the following:

1. Identification of non-accessible locations.

1. Selection of representative structural steel components for inspection.

2. Development of an inspection sample size.

3. Use of Appropriate inspection techniques.

4. Requirements for reporting of results and corrective actions if aging concerns are identified.

BASIS: The ARDI Program will ensure that degraded conditions due to corrosion of steel are identified and corrected such that non-accessible structural steel components of the Turbine Building will be capable of performing their intended functions under all design conditions required by the current licensing basis.

APPENDIX A - FREEZE-THAW

1.0 MECHANISM DESCRIPTION[1]

Repeated cycles of freezing and thawing can alter both the mechanical properties and physical form of the concrete, thus affecting the structural integrity of the component. The freeze-thaw phenomenon occurs when water freezes within the concrete's pores, creating hydraulic pressure. This pressure either increases the size of the cavity or forces water out of the cavity into surrounding voids.

Freeze-thaw damage is characterized by scaling, cracking, and spalling. Scaling or surface flaking occurs in the presence of moisture and is aggravated by the use of deicing salts. Cracks or spalling occurs when voids are already filled with water, and freezing causes pressure to increase. In extreme cases of freeze-thaw damage, the cover over reinforcing steel is reduced, and the reinforcing steel is eventually exposed to accelerated corrosion. Concrete is vulnerable to the expansive effects of the resulting corrosion products, thereby weakening the concrete's resistance to further attack by aggressive environments.

To minimize the adverse effects of freeze-thaw, three factors must be considered in the design and placement of concrete:[2]

- The cement paste must have an entrained air system with an appropriate void spacing factor.
- The aggregate must be of a sufficiently high quality to resist scaling.
- The in-place concrete must be allowed to mature sufficiently before exposure to cyclic freezing and thawing.

As shown in Figure A-1, the optimal air content range extends from 3 to 7 percent based on the nominal size of coarse aggregate.[3]

2.0 EVALUATION

2.1 Conditions

According to Specification ASTM C33-82, "Standard Specification for Concrete Aggregates,"[4] the CCNPP site is located in the geographic region subject to *severe* weathering conditions. As stated in CCNPP's "Civil and Structural Design Criteria,"[5] the frost penetration depth is 20 to 22 inches.

2.2 **Potential Aging Mechanism Determination**

All Class 1 portions of the turbine building are located within the structure. Therefore, freeze-thaw is not a potential aging mechanism.

2.3 **Impact on Intended Functions**

Since freeze-thaw is not a potential aging mechanism, it will not affect the intended functions of any safety related structural component located inside the turbine building.

2.4 **Design and Construction Considerations**

CCNPP concrete design specification No. 6750-C-9[6] specifies:

> *9.3.1 The Portland cement concrete furnished, unless otherwise specified herein, shall conform to ASTM C-94 Specification for Ready Mix Concrete, ACI 318-63 Building Code Requirements for Reinforced Concrete, ACI 301-66 Standard Specifications for Structural Concrete for Building, and ACI Manual of Concrete Inspection.*
>
> *10.1.2.2 All aggregate shall conform to ASTM Designation C33.*

Section 10.1.16 of ASTM Designation C33-67 specifies that:

> *Procedures for making freezing and thawing tests of concrete are described in ASTM Method C290, "Test for Resistance of Concrete Specimens to Rapid Freezing and Thawing in Water," and in ASTM Method C291, "Resistance of Concrete Specimens to Rapid Freezing in Air and Thawing in Water."*

Both ASTM Methods C290 and C291 cover the method for determining the resistance of concrete specimens to rapidly repeated cycles of freezing and thawing in the laboratory.

Design specification No. 6750-C-9 for CCNPP also specifies:

> *10.4.2.1 The Subcontractor shall specify the air entraining agent he proposes to use. It shall be in accordance with ASTM C-260, capable of entraining 3-5% air, be completely water soluble, and be completely dissolved when it enters the batch. The Subcontractor shall give 30 days advance notice of the type of AEA he proposes to use.*

ACI 318[7] and its relevant ACI standards and ASTM specifications provide the physical property requirements of aggregate and air-entraining admixtures, chemical and physical requirements of air-entraining cements, and proportioning of concrete including containing entrained air to maximize the concrete resistance to freeze-thaw action.

2.5 **Plausibility Determination**

Not applicable.

2.6 **Existing Programs**

Not applicable.

3.0 CONCLUSION

The CCNPP site is located in the geographic region subject to *severe* weathering conditions, however, concrete structural components located inside the turbine building are not exposed to freeze-thaw cycles. Freeze-thaw is not a plausible aging mechanism for the structural components of the turbine building.

4.0 RECOMMENDATION

Freeze-thaw is not a plausible aging mechanism for any concrete structural components of the turbine building. No further evaluation or recommendation is required.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.
2. Mather, B., "How to Make Concrete that Will Be Immune to the Effects of Freezing and Thawing," ACI Fall Convention, San Diego, November 1989.
3. "Design and Control of Concrete Mixtures," Portland Cement Association, 13th Edition.
4. "Standard Specification for Concrete Aggregates," American Society of Testing and Materials, ASTM C33-82.
5. Civil and Structural Design Criteria for Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2, by Bechtel Power Corporation, Revision 0, August 2, 1991.
6. "Specification for Furnishing and Delivery of Concrete - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2," CCNPP's Design Specification No. 6750-C-9, Revision 8, April 1970.
7. "Building Code Requirements for Reinforced Concrete," American Concrete Institute, ACI 318-63.

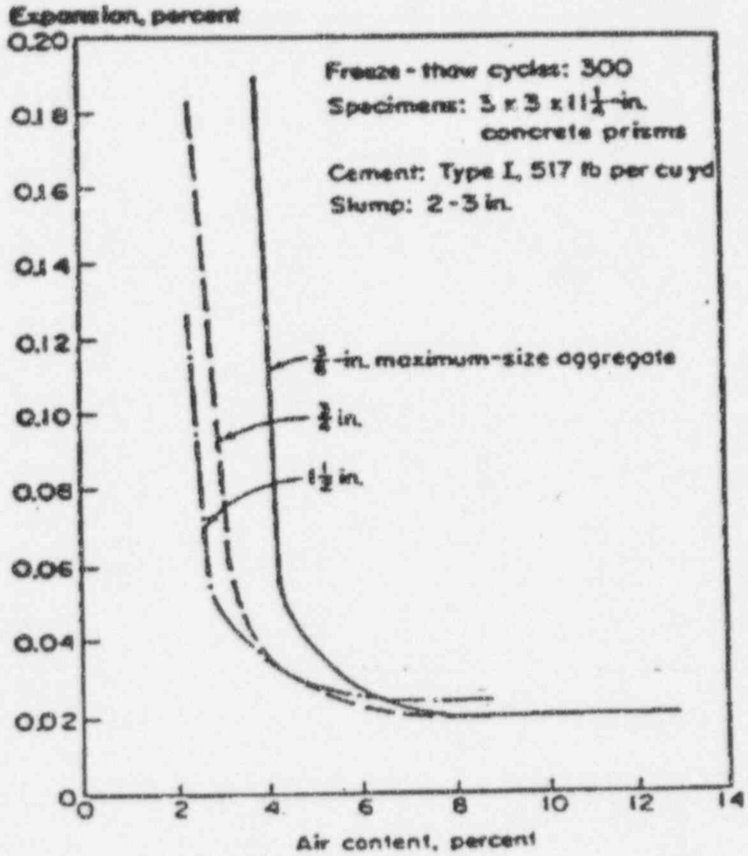


Figure A-1
Relationship between Air Content
Aggregate Size and Concrete Expansion
(Reference 3)

APPENDIX B - LEACHING OF CALCIUM HYDROXIDE

1.0 MECHANISM DESCRIPTION[1]

Water, either from rain or melting snow, that contains small amounts of calcium ions can readily dissolve calcium compounds in concrete when it passes through cracks, inadequately prepared construction joints, or areas inadequately consolidated during placing. The most readily soluble calcium compound is calcium hydroxide (lime). The aggressiveness or affinity of water to leach calcium hydroxide depends on its dissolved salt content and its temperature. Since leaching occurs when water passes through the concrete, structures that are subject to flowing liquid, ponding, or hydraulic pressure are more susceptible to degradation by leaching than those structures that water merely passes over. Leaching of calcium hydroxide is visible on concrete surfaces that have dried. The leachate is almost colorless until carbon dioxide is absorbed and the material dries as a white deposit. The white deposit is a product of water, free lime from the concrete, and carbon dioxide that has been absorbed from the air.

When calcium hydroxide is leached away, other cementitious constituents become exposed to chemical decomposition, eventually leaving behind silica and alumina gels with little or no strength. Leaching over a long period of time increases the porosity and permeability of concrete, making it more susceptible to other forms of aggressive attack and reducing the strength of concrete. Leaching also lowers the pH of concrete and threatens the integrity of the exterior protective oxide film of rebar.

Resistance to leaching and efflorescence can be enhanced by using concrete with low permeability. A dense concrete with a suitable cement content that has been well cured is less susceptible to calcium hydroxide loss from percolating water because of its low permeability and low absorption rate. The design attributes to enhance water-tightness include low water-to-cement ratio, smaller coarse aggregate, long curing periods, entrained air, and thorough consolidation.[3] Figure B-1 shows the impact on permeability due to water-to-cement ratio and curing time.

2.0 EVALUATION

2.1 Conditions

The underside of the turbine building ground floor slab could be in contact with underground water. A permanent dewatering system was installed during construction to maintain a stable groundwater table at El. 10'-0". The bottom of the ground floor slab is at El. 10'-0". A waterproof membrane was installed under the ground floor slab to prevent contact with the groundwater, however the condition of this membrane could not be ascertained during an October 27, 1994 inspection of the auxiliary feedwater pump rooms.

2.2 Potential Aging Mechanism Determination

Leaching of calcium hydroxide is a potential aging mechanism for the following structural component of the turbine building because it could be exposed to flowing liquid, ponding, or hydraulic pressure:

- Ground floor slab   Functions LR-S-1, 2, 4, 6, and 7

where:

LR-S-1: Provides structural and/or functional support(s) for safety-related equipment.

LR-S-2: Provides shelter/protection for safety-related equipment.

LR-S-4: Serves as a missile barrier (internal or external).

LR-S-6: Provides flood protection barrier (internal flooding event).

LR-S-7: Provides rated fire barriers to confine or retard a fire from spreading to or from adjacent areas of the plant.

Leaching of calcium hydroxide is not a potential aging mechanism for other structural components of the turbine building because they are located inside the turbine building.

2.3 Impact on Intended Functions

If the effects of leaching of calcium hydroxide were not considered in the original design or are allowed to degrade the above structural component unmitigated for an extended period of time, this aging mechanism could affect all the intended functions of the component listed in Section 2.2.

2.4 Design and Construction Considerations

Leaching attack can be minimized by providing a low-permeability concrete mix design during construction. CCNPP concrete design specification No. 6750-C-9[4] specifies:

> *9.3.1 The Portland cement concrete furnished, unless otherwise specified herein, shall conform to ASTM C-94 Specification for Ready Mix Concrete, ACI 318-63 Building Code Requirements for Reinforced Concrete, ACI 301-66 Standard Specifications for Structural Concrete for Building, and ACI Manual of Concrete Inspection.*
>
> *12.1 Concrete Quality*

12.1.1.1 Portland cement shall conform to ASTM Designation C-94-67, Alternate No. 1 and ACI 301-66.

12.1.2.1 Concrete shall meet the following requirements:

Class	28-Day Strength (psi)	Nominal Slump at Point of Placement (in.)	Slump Tolerance (in.)	Maximum Aggregate Size	Use and Location
A-1	2,000	4	± 1	3/4 in.	Electrical Duct Encasement & Lean Concrete Backfill
A-2	2,000	4	± 1	1-½ in.	Electrical Duct Encasement & Lean Concrete Backfill
B-1	3,000	3	± ½	3/4 in.	Strucural Concrete Walls & Slabs less than 12" thick & Congested Rebar
B-2	3,000	3	± ½	1-½ in.	Turbine Pedestal & other Structural Concrete
B Grout	3,000	--	--	#4	Construction Joints
C-1	4,000	3	± ½	3/4 in.	Walls & Slabs less than 12" thick & Congested Rebar
C-2	4,000	2	± ½	1-½ in.	Containment Base Slab and Other Structural Concrete
C-3	4,000	3	± ½	3/8 in.	Stair Treads
High Density Concrete	4,000				High Density Concrete for Nuclear Shielding. Use Where Directed.
C Grout	4,000	--	--	#4	Containment Joints
D-1	5,000	3	± ½	3/4 in.	Walls and Slabs less than 12" thick and Congested Rebar
D-2	5,000	2	± ½	1-½ in.	Containment Walls and Dome and Other Structural Concrete
D Grout	5,000	--	--	#4	Construction Joints
Dry Pack	4,000	0	--	#4	As Directed
Tremie Concrete	4,000	6		3/4 in.	As Directed
AA	1,000	5	± 2	1-½ in.	Earth Alternate
AAA	1,000	5	± 2	3/4 in.	Earth Alternate

12.1.5 Mix Design

12.1.5.1 The Constructor shall retain an approved Testing Laboratory, at his own cost, to design and test initial concrete mixes. The initial mixes shall be designed in accordance with ACI Standards 613 and 301 to produce a required strength of 15 percent over specified strength for reinforced concrete at 28 days and 25 percent over specified strength for post-tensioned concrete at 28 days for each class of concrete with slump and maximum sizes of aggregate as specified in the Classification Table (Section 12.1.2).

12.1.5.2 The Constructor shall furnish the Subcontractor with mix designs one month prior to the manufacture of concrete. Furnishing mix designs shall not relieve the Subcontractor of his responsibility for compliance with the provisions of the Specification. Where necessary, the Constructor shall increase or decrease cement factors as deemed necessary for design mixes using statistical methods described in the ACI 214-65 for the particular class of concrete. An increase in the water-cement ratio of a mix design or a decrease in its cement quantity shall constitute a new mix design and the provisions of Section 12.1.5.1 of this Specification shall apply. Calcium chloride shall not be used.

2.5 Plausibility Determination

Based on the discussion in Section 2.1, the turbine building ground floor slab is located at the designed underground water table and may be subjected to some hydraulic pressure. However, as discussed in Section 2.4, concrete used for the ground floor slab was designed in accordance with ACI 318[5] and its relevant ACI standards and ASTM specifications to maximize resistance to leaching of calcium hydroxide. A walkdown of the auxiliary feedwater pump rooms conducted October 27,1994 observed only slight traces of leaching on concrete surfaces and were judged to have no adverse impact on the integrity of these components. Therefore, leaching of calcium hydroxide is not a plausible aging mechanism for the auxiliary feedwater pump room ground floor slab.

2.6 Existing Programs

There are no existing programs at CCNPP that are designed specifically to identify or to repair damage to concrete due to leaching of calcium hydroxide. Since leaching of calcium hydroxide is not a plausible aging mechanism that could degrade the safety related structural components of the turbine building, no management program is necessary.

3.0 CONCLUSION

Although the turbine building ground floor slab could be subjected to hydraulic pressure due to underground water, the concrete mix was designed for low permeability and high compressive strength which provide the best protection

against leaching. Therefore, leaching of calcium hydroxide is not a plausible aging mechanism for any concrete structural components of the turbine building. This conclusion is supported by an October 27,1994 walkdown inspection during which only minor traces of leaching were detected.

4.0 RECOMMENDATION

Leaching of calcium hydroxide is not a plausible aging mechanism for any concrete structural components of the turbine building. No further evaluation or recommendation is required.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. " Design and Control of Concrete Mixtures," Portland Cement Association, Thirteenth Edition.

3. "Guide to Durable Concrete," American Concrete Institute, ACI-201.2R-67.

4. "Specification for Furnishing and Delivery of Concrete - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2," CCNPP's Design Specification No. 6750-C-9, Revision 8, April 1970.

5. "Building Code Requirements for Reinforced Concrete," American Concrete Institute, ACI 318-63.

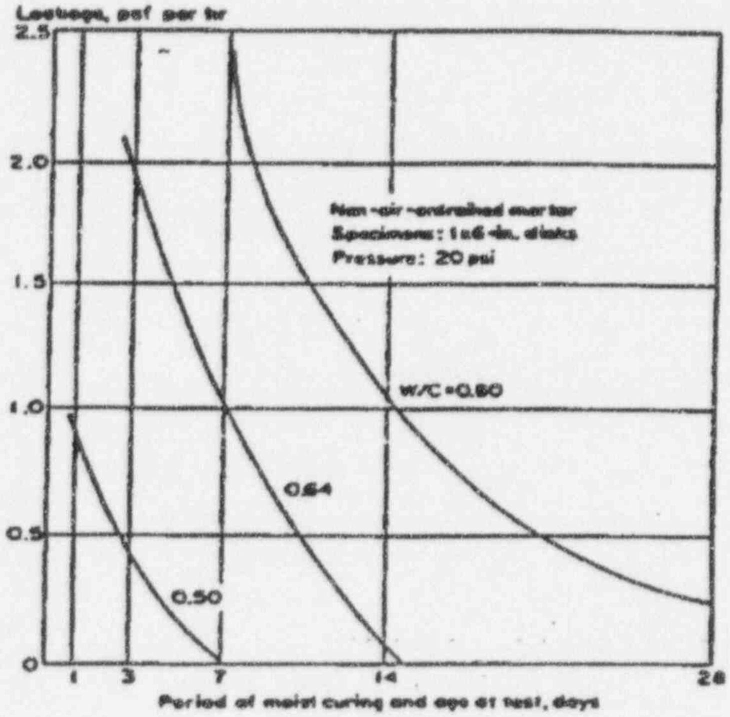


Figure B-1
Effect of Water-Cement Ratio
and Curing Duration on Permeability
(Reference 2)

APPENDIX C - AGGRESSIVE CHEMICALS

1.0 MECHANISM DESCRIPTION[1]

Concrete, being highly alkaline (pH > 12.5), is vulnerable to degradation by strong acids. Acid attack can increase porosity and permeability of concrete, reduce its alkaline nature at the surface of the attack, reduce strength, and render the concrete subject to further deterioration. Portland cement concrete is not acid-resistant, although varying degrees of resistance can be achieved depending on the materials used and the attention to placing, consolidating, and curing. No Portland cement concrete, regardless of its composition, will withstand exposure to highly acidic fluids for long periods.

Below grade, sulfate solutions of sodium, potassium, and magnesium sometimes found in groundwater may attack concrete, often in combination with chlorides. The exposed surfaces of structures located near industrial plants are vulnerable to industrial pollution from the sulfur-based acid rain and are subject to deterioration. Sulfate attack produces significant expansive stresses within the concrete, leading to cracking, spalling, and strength loss. Once established, these conditions allow further exposure to aggressive chemicals. Groundwater chemicals can also damage foundation concrete. A dense concrete with low permeability may provide an acceptable degree of protection against mild acid attack. Any factors that tend to improve the compressive strength of the concrete will have a beneficial effect on low permeability. Therefore, the better the quality of the constituent material, the less permeable the concrete. Low water-to-cement ratio, smaller aggregate, long curing period, entrained air, and thorough consolidation all contribute to watertightness.

Concrete thus constructed has a low permeability and effective protection against sulfate and chloride attack. Minimum degradation threshold limits for concrete have been established at 500 ppm chloride or 1,500 ppm sulfates. The use of an appropriate cement type (e.g., ASTM C150, Type II) and pozzolan (e.g., fly ash) also increases sulfate resistance.

2.0 EVALUATION

2.1 Conditions

There are no aggressive chemicals stored inside the Class 1 portion of the turbine building. Therefore, none of the internal structural components are exposed to the risk of aggressive chemicals.

There is no heavy industry near the CCNPP site that could release aggressive chemicals to the atmosphere. However, external concrete is exposed to an environment containing chloride ions due to the plant's proximity to the Chesapeake Bay.

The below-grade exterior surface of the auxiliary feedwater pump rooms could be exposed to groundwater on a more or less continuous basis. A passive dewatering system, installed during construction, maintains a stable groundwater level at El. +10.0 ft (UFSAR 2.7.3.2), which is just at the ground floor slab's bottom surface. A waterproof membrane installed in the subgrade below the ground floor slab, protects the underside of the slab, however, there is no way to inspect this membrane.

2.2 Potential Aging Mechanism Determination

Attack by aggressive chemicals is a potential aging mechanism for the following concrete structural component of the turbine building because it is exposed to outside environment:

- Ground floor slab — Functions LR-S-1, 2, 4, 6, and 7

where:

LR-S-1: Provides structural and/or functional support(s) for safety-related equipment.

LR-S-2: Provides shelter/protection for safety-related equipment.

LR-S-4: Serves as a missile barrier (internal or external).

LR-S-6: Provides flood protection barrier (internal flooding event).

LR-S-7: Provides rated fire barriers to confine or retard a fire from spreading to or from adjacent areas of the plant.

Other concrete structural components are located inside the turbine building; therefore, attack by aggressive chemicals is not a potential aging mechanism.

2.3 Impact on Intended Functions

If the effects of attack by aggressive chemicals were not considered in the original design or are allowed to degrade the above structural component unmitigated for an extended period of time, this aging mechanism could affect all the intended functions of the component listed in Section 2.2.

2.4 Design and Construction Considerations

The turbine building was constructed with concrete that complies with CCNPP's design specification No. 6750-C-9[2] to assure low permeability. Another design consideration was the use of a waterproof membrane to protect the ground floor slab concrete, however, the condition of the membrane could not be ascertained. These properties provide the best protection against chemical attacks.

2.5 Plausibility Determination

Based on the discussion in Sections 2.1 and 2.4, attack by aggressive chemicals is not a plausible aging mechanism for the structural components located inside the Class 1 portion of the turbine building.

Because the chemical composition of the groundwater is unknown, attack by aggressive chemicals to the below-grade portion of the turbine building is a plausible aging mechanism.

2.6 Existing Programs

There are no existing programs at CCNPP that are designed specifically to identify or to repair damage to concrete due to aggressive chemicals. Since attack by aggressive chemicals is not a plausible aging mechanism for concrete components inside the turbine building, no management program is needed for these components.

3.0 CONCLUSION

There are no aggressive chemicals stored in the Class 1 portion of the turbine building. The concrete components inside the turbine building are constructed of high quality, low permeability concrete. Attack by aggressive chemicals to concrete located inside the Class I portion of the turbine building is not plausible. The bottom of the ground floor slab is located at the groundwater level and may be exposed to groundwater. Because the quality of the groundwater is not known, degradation due to aggressive chemicals is plausible for the turbine building ground floor slab.

4.0 RECOMMENDATION

During initial plant construction, groundwater observation wells were installed to monitor the fluctuation of the groundwater table, and samples were taken for groundwater quality testing.[3] Although the wells are still in place, the monitoring activities have been discontinued. It is recommended that the groundwater quality be tested using these wells. This data can be used to evaluate the effects of chemical attacks on the underside of the turbine building's ground floor slab.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. "Specification for Furnishing and Delivery of Concrete - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2," CCNPP's Design Specification No. 6750-C-9, Revision 8, April 1970.

3. "Specification for Furnishing and Installation of Piezometers - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2," CCNPP's Design Specification No. 6750-C-23E, Revision 0, November 1973.

APPENDIX D - REACTIONS WITH AGGREGATES

1.0 MECHANISM DESCRIPTION[1]

Certain mineral constituents of all aggregates react with chemical compounds that compose the Portland cement, most notably alkalis. Alkalis may also be introduced from admixtures, salt-contaminated aggregates, and penetration by seawater or solutions of deicing salt. However, it is only when the expansive reaction products become extensive and cause cracking of concrete that aggregate reactivity is considered a deleterious reaction.

Three principal deleterious reactions between aggregates and alkalis have been identified as alkali-aggregate, cement-aggregate, and expansive alkali-carbonate reactions.

Alkali-aggregate reaction, more properly designated as alkali-silica reaction, involves aggregates that contain silica and alkaline solutions. All silica minerals have the potential to react with alkaline solution, but the degree of reaction and ultimate damage incurred can vary significantly. Alkali-silica reaction can cause expansion and severe cracking of concrete structures. Reactive materials in the presence of potassium, sodium, and calcium oxides derived from the cement react to form solids, which can expand upon exposure to water.

Cement-aggregate reaction occurs when the alkalis in cement and some siliceous constituents of the aggregates react. This reaction is complicated by environmental conditions that produce high concrete shrinkage and alkali concentrations on the surface due to drying. Sand-gravel aggregates from some river systems in the Midwestern United States have been involved in deteriorated concrete attributable to this reaction.

Expansive alkali-carbonate reaction occurs between certain carbonate aggregates and alkalis, and produces expansion and cracking. Certain limestone aggregates, usually dolomitic, have been reported as reactive.

Aggregates that react with alkalis can cause expansion of varying severity, even to the extent of producing cracking of the concrete and resulting loss of strength and durability if the expansion is severe. The cracking is irregular and has been referred to as *map cracking*.

Moisture must be available for chemical reactions between aggregates and alkalis to occur. Consequently, areas that are either consistently wet or

alternately wet and dry are susceptible to deterioration given the presence of potentially reactive aggregates.

The deleterious effects of reactive aggregates are best avoided by using aggregates from sources that have a proven record of service. If such records are unavailable, aggregates should be examined petrographically to identify potentially reactive constituents. Chemical reactions of aggregates for both fast and slow reaction rates were recognized as early as 1940. The method to identify the reactive constituents in concrete aggregates was first published in ASTM C-289, "Potential Reactivity of Aggregates (Chemical Method)"[2] and ASTM C-295, "Petrographic Examination of Aggregates for Concrete"[3] in 1952 and 1954, respectively. Both standards provide guidance for selecting aggregates and cements to avoid alkali-aggregate reactions.

2.0 EVALUATION

2.1 Conditions

The aggregates used in the concrete of the CCNPP turbine building came from sites in Charles County, Maryland[4], which is not in the geographic regions known to yield aggregates suspected of or known to cause aggregate reaction.

2.2 Potential Aging Mechanism Determination

Reaction with aggregates is a potential aging mechanism for the following concrete structural components if reactive aggregates were used in the concrete structure construction:

- Concrete walls — Functions LR-S-1, 2, 4, 6, 7
- Ground floor slab and equipment pads — Functions LR-S-1, 2, 4, 6, 7
- Elevated floor slabs — Functions LR-S-1, 2, 6, 7
- Ductbanks — Functions LR-S-1, 2
- Fluid retaining floors and slabs — Functions LR-S-1, 2, 6, 7

where:

LR-S-1: Provides structural and/or functional support(s) for safety-related equipment.

LR-S-2: Provides shelter/protection for safety-related equipment.

LR-S-4: Serves as a missile barrier (internal or external).

LR-S-6: Provides flood protection barrier (internal flooding event).

LR-S-7: Provides rated fire barriers to confine or retard a fire from spreading to or from adjacent areas of the plant.

2.3 Impact on Intended Functions

If the effects of reaction with aggregates were not considered in the original design or are allowed to degrade the above structural components unmitigated for an extended period of time, this aging mechanism could affect all the intended functions of components listed in Section 2.2.

2.4 Design and Construction Considerations

All aggregates used in construction of the CCNPP turbine building were investigated, tested, and examined based on the following specifications:

CCNPP's design specification No. 6750-C-9[5] specifies:

> *10.1.1.1 Cement shall be Portland cement, Type II conforming to ASTM Designation C-150, . . . The cement shall not contain more than 0.60 percent by weight of alkalies calculated as Na_2O plus 0.658 K_2O. Only one brand of cement shall be used for all work. . . .*
>
> *15.2.3.1 The Bidder, at his expense, shall retain an approved independent testing laboratory to sample and test aggregates and the aggregate source in accordance with methods as specified in ASTM Designation C-33. Acceptability of aggregate and source shall be based on the following ASTM tests:*

Method of Test	*ASTM Designation*
. . .	. . .
Potential Reactivity	*C-289*

15.2.3.4 Upon award of the subcontract, the Subcontractor shall submit for petrographic analysis, in accordance with ASTM Designation C-295, a 5-pound sample of quarried material, or if alluvial, 2-1/2 pounds each of sand and coarse material which has been certified as sampled at the proposed aggregate source by an approved testing laboratory.

15.2.3.6 . . . Aggregates will be tested during the progress of the work. . . .The following user tests will be performed on every 4,000 tons of aggregates delivered to the jobsite:

Method of Test	*ASTM Designation*
. . .	. . .
Potential Reactivity	*C-289*

Both ASTM C289 and C295 provide guidance for selecting aggregates and cements to avoid alkali-aggregate reactions, and both standards were specified for use in CCNPP's concrete specification. The aggregates used in the turbine building concrete were specifically investigated, tested, and examined in accordance with the ASTM specifications to determine potential for reactivity with alkalis.

2.5 Plausibility Determination

Based on the discussion in Section 2.4, the aggregates used in CCNPP's turbine building concrete were specifically investigated, tested, and examined in accordance with the pertinent ASTM specifications to minimize the potential for reactivity with alkalis. For this reason, reactions with aggregates will not degrade any concrete components of the turbine building and will have no adverse impact on the intended functions of these concrete structural components. Therefore, reaction with aggregates is not a plausible aging mechanism for any concrete structural components of the CCNPP turbine building. This conclusion is supported by an

October 27, 1994 walkdown inspection report that documented no indication of concrete damage due to this mechanism.

2.6 Existing Programs

There are no existing programs at CCNPP that are designed specifically to identify or to repair damage incurred by reaction with aggregates. Since reaction with aggregates is not a plausible aging mechanism that could degrade the turbine building structural components, no management program is necessary.

3.0 CONCLUSION

Since the potential effects of aggregate reactions on all concrete components were well known and understood, measures to avoid using reactive aggregates were implemented for CCNPP in design specification No. 6750-C-9. The aggregates used in the turbine building concrete were specifically investigated, tested, and examined in accordance with applicable ASTM specifications to minimize any reactivity of aggregates with alkalis. This conclusion is supported by an October 27,1994 walkdown inspection during which no trace of reactions with aggregates was detected.

4.0 RECOMMENDATION

Reaction with aggregates is not a plausible aging mechanism for any concrete component of the CCNPP turbine building and requires no further evaluation or recommendation.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. "Potential Reactivity of Aggregates (Chemical Method)," American Society of Testing and Materials, ASTM C-289-66.

3. "Petrographic Examination of Aggregates for Concrete," American Society of Testing and Materials, ASTM C-295-65.

4. Letter from Charles County Sand & Gravel Co., Inc. to Bechtel Corporation, June 30, 1972.

5. "Specification for Furnishing and Delivery of Concrete - Calvert Cliffs Nuclear Power Plant Unit No. 1 and No. 2," Design Specification No. 6750-C-9, Revision 8, April 1970.

APPENDIX E - CORROSION OF EMBEDDED STEEL/REBAR

1.0 MECHANISM DESCRIPTION[1]

The environments that induce corrosion of reinforcing steel, embedded steel, and cast-in-place anchor bolts are similar. Therefore, this appendix is applicable to all structural components that are either part of or comprise these three component types.

Concrete's high alkalinity (pH > 12.5) provides an environment around embedded steel/rebar and protects them from corrosion. If the pH is lowered (e.g., to 10 or less), corrosion may occur. However, the corrosion rate is still insignificant until a pH of 4.0 is reached. A reduction in pH can be caused by the leaching of alkaline products through cracks, the entry of acidic materials, or carbonation. Chlorides can be present in constituent materials of the original concrete mix (i.e., cement, aggregates, admixtures, and water), or they may be introduced environmentally. The severity of corrosion is influenced by the properties and type of cement and aggregates as well as the concrete moisture content.

Galvanized decking and galvanized embedments are used in some structures. Since galvanizing material is not considered a dissimilar metal, its application will not aggravate corrosion of the structure.

Studies have also been conducted to determine the effects of stray electrical currents on reinforcing steel. Lightning conductors exchange electrons with the atmosphere and, if connected to reinforcing steel, may accelerate the corrosion process. However, while stray electrical currents can aggravate active corrosion, they are not age-related[2].

Corrosion products have a volume greater than the original metal. The presence of corrosion products on embedded steel or rebar subjects the concrete to tensile stress that eventually causes hairline cracking, rust staining, spalling, and more severe cracking. These actions will expose more embedded steel/rebar to a potentially corrosive environment and cause further deterioration in the concrete. A loss of bond between the concrete and embedded steel/rebar will eventually occur, along with a reduction in steel cross section. Rebar corrosion can cause deterioration of concrete from a series of hairline cracking, rust staining, spalling, and more severe cracking. These conditions can ultimately impair structural integrity.

The degree to which concrete will provide satisfactory protection for embedded steel/rebar depends in most instances on the quality of the concrete and the depth of concrete cover over the steel. The permeability of the concrete is also a major factor affecting corrosion resistance. Concrete of low permeability contains less water under a given exposure and, hence, is more likely to have lower electrical conductivity and better resistance to corrosion. Such concrete also resists absorption of salts and their penetration into the embedded steel and provides a barrier to oxygen, an essential element of the corrosion process. Low water-to-cement ratios and adequate air entrainment increase resistance to water penetration and thereby provide greater resistance to corrosion.

2.0 EVALUATION

At CCNPP, embedded steel has been used in composite structural members or as anchorages of concrete surface attachments. Reinforcing steel (rebar) and cast-in-place anchors are both treated as embedded steel in the evaluation of corrosion effects, because the environment and the technical basis for their corrosion induction are similar. The base plates under the columns or those used as part of attachments to the concrete surface are treated as structural steel, and the evaluation of their corrosion effects is addressed in Appendix K.

2.1 Conditions

There is no significant inventory of aggressive chemicals stored inside the Class 1 portion of the turbine building. Therefore, the turbine building's interior surface and all internal structural components are not exposed to the risk of aggressive chemicals.

The primary area of concern is the below-grade exterior surface which could be exposed to groundwater on a more or less continuous basis. A passive dewatering system, installed during construction, maintains a stable groundwater level at El. +10.0 ft (UFSAR 2.7.3.2), which is just at the ground floor slab's bottom surface. A waterproof membrane installed in the subgrade below the ground floor slab, protects the underside of the slab, however, there is no way to inspect this membrane.

2.2 Potential Aging Mechanism Determination

Corrosion of embedded steel/rebar is a potential aging mechanism for the following structural component of the turbine building because it is exposed to the outside environment and could be subjected to corrosive attack:

- Ground floor slab — Functions LR-S-1, 2, 4, 6, 7

where:

LR-S-1: Provides structural and/or functional support(s) for safety-related equipment.

LR-S-2: Provides shelter/protection for safety-related equipment.

LR-S-4: Serves as a missile barrier (internal or external).

LR-S-6: Provides flood protection barrier (internal flooding event).

LR-S-7: Provides rated fire barriers to confine or retard a fire from spreading or from adjacent areas of the plant.

Other concrete structural components are located inside the turbine building; therefore, corrosion of embedded steel/rebar is not a potential aging mechanism.

2.3 Impact on Intended Functions

If the effects of corrosion of embedded steel/rebar were not considered in the original design or are allowed to degrade the above structural component unmitigated for an extended period of time, this aging mechanism could affect all the intended functions of the component listed in Section 2.2.

2.4 Design and Construction Considerations

The turbine building was constructed with concrete that complies with CCNPP's design specification No. 6750-C-9[3], which adheres to the relevant ACI Codes and ASTM specifications for a concrete structure of low permeability. Also proper concrete covers were specified in accordance with ACI 318 Code to effectively prohibit exposure of embedded steel/rebar to the corrosive environment. Another design consideration was the use of a waterproof membrane to protect the underside of the ground floor slab.

2.5 Plausibility Determination

Based on the discussion in Sections 2.1 and 2.4, corrosion is not a plausible aging mechanism for embedded steel/rebar in the above-grade portion of the turbine building.

As discussed in Section 2.1, only the below-grade portion of the ground floor slab could be exposed to an aggressive environment on a continuous basis and could be susceptible to embedded steel/rebar corrosion. Because the chemical quality of the underground water is not known, corrosion of embedded steel/rebar is a plausible aging mechanism for the below-grade portion of the turbine building.

2.6 Existing Programs

There are no existing programs at CCNPP that are designed specifically to identify or to repair damage of the concrete structure due to corrosion of embedded steel/rebar.

3.0 CONCLUSION

Based on the discussions in Sections 2.1 and 2.4, corrosion of embedded steel/rebar is not a plausible aging mechanism for concrete components located inside the turbine building. No further evaluation is required for these concrete structural components.

Because the quality of the groundwater is not known, corrosion of embedded steel/rebar is a plausible aging mechanism for the below-grade portion of the ground floor slab.

4.0 RECOMMENDATION

During initial plant construction, groundwater observation wells were installed to monitor the fluctuation of the groundwater table, and samples were taken for groundwater quality testing.[5] Although the wells are still in place, the monitoring activities have been discontinued. It is recommended that the groundwater quality be tested using these wells. This data can be used to evaluate the effects of chemical attacks on the underside of the turbine building's ground floor slab.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," .EPRI's Project RP-2643-27, December 1991.

2. Skoulikidas, T., Tsakopoulos, A., and Moropoulos, T., "Accelerated Rebar Corrosion When Connected to Lightning Conductors and Protection of Rebars with Needle Diodes Using Atmosphere Electricity," in Publication ASTM -STP 906, "Corrosion Effect of Stray Currents and the Techniques for Evaluating Corrosion of Rebars in Concrete."

3. "Specification for Furnishing and Delivery of Concrete - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2," CCNPP's Design Specification No. 6750-C-9, Revision 8, April 1970.

4. "Calvert Cliffs Nuclear Power Plant, Units 1 and 2, Updated Final Safety Analysis Report (UFSAR)," Baltimore Gas and Electric Co.

5. "Specification for Furnishing and Installation of Piezometers - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2," CCNPP's Design Specification No. 6750-C-23E, Revision 0, November 1973.

APPENDIX F - CREEP

1.0 MECHANISM DESCRIPTION[1]

Creep is defined as the time-dependent increase of strain in hardened concrete that has been subjected to sustained stress. The sustained stress results from the dead load and live load of the structure and from temperature effects. Creep deformation is a function of loading history, environment, and material properties of the concrete. The time-dependent deformation of concrete under compressive load consists of strain resulting from progressive cracking at the aggregate-cement paste interface, from moisture exchange with the atmosphere, and from moisture movement within the concrete.

The effects of temperatures on creep are not linear. At 122 °F, creep strain is about two to three times as great as at room temperature (68 - 75 °F.) But from 122 °F to 212 °F, creep strain continues to increase four to six times that experienced at room temperatures. While little is known about creep rate beyond 212 °F, the maximum creep rate may have occurred between 122 °F and 176 °F.[2]

Creep is not visible because micro-cracking occurs at the aggregate cement-paste interface. The deformation resulting from cracking and from moisture exchange with the atmosphere is not recoverable. Creep deformation can generally be characterized as follows:

- Increased water-to-cement ratio results in increased creep magnitude.
- Increased aggregate-to-cement ratio results in increased creep magnitude for a given volume of concrete.
- Creep deformation is approximately proportional to the applied load for a level not exceeding about 40% to 60% of the ultimate strength of concrete.
- Concrete age at application of load affects creep (i.e., the older the concrete, the less the creep).
- Creep increases with increased temperature.
- Aggregate with a high modulus of elasticity and low porosity will minimize creep.

Creep-induced concrete cracks are typically not large enough to result in concrete deterioration or in exposure of the reinforcing steel to environmental stressors. Cracks of this magnitude do not reduce the concrete's compressive strength. Creep is significant when new concrete is subjected to load and decreases exponentially with time. Any degradation is noticeable in the first few years of plant life. According to ACI 209R-82,[2] 78% of creep occurs within the first year, 93% within 10 years, 95% within 20 years, and 96% within 30 years. At any given stress, high-strength concretes show less creep than low-strength concretes. ACI 209R-82 provides guidance for predicting creep in concrete structures.

2.0 EVALUATION

2.1 Conditions

There is no condition in CCNPP that could aggravate the effect of concrete creep initiated right after concrete construction. Most of the concrete creep will have occurred well before the time of a license renewal application. Therefore, creep of concrete structural components should not be regarded as an aging mechanism for license renewal.

2.1 Potential Aging Mechanism Determination

Creep is not a potential aging mechanism for any turbine building concrete structural components because creep proceeds at a decreasing rate with age and is not expected to continue after 40 years.

2.3 Impact on Intended Functions

Since creep is not a potential aging mechanism, it will not affect the intended functions of any turbine building structural component.

2.4 Design and Construction Considerations

At CCNPP, all turbine building reinforced concrete components were designed based on the working stress design method. The induced stresses are much lower than the ultimate strength of the concrete, which is specified as f'_c = 3,000 psi for all turbine building concrete structural components. Therefore, creep in all concrete components is minimal because of the low compressive stresses in concrete and the use of high-strength concrete. Besides, creep proceeds at a decreasing rate with age;

normally, 96 % of creep has occurred within 30 years.[2] Therefore, creep is not expected to continue during the license renewal period.

2.5 Plausibility Determination

Not applicable.

2.6 Existing Programs

Not applicable.

3.0 CONCLUSION

Most of the concrete creep occurred well before the time of license renewal application. Therefore, creep of concrete structural components should not be regarded as an aging mechanism for license renewal.

4.0 RECOMMENDATION

Not applicable.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. "Prediction of Creep, Shrinkage, and Temperature Effects in Concrete Structures," American Concrete Institute, ACI 209R-82.

3. "Specification for Furnishing and Delivery of Concrete - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2," CCNPP's Design Specification No. 6750-C-9, Revision 8, April 1970.

APPENDIX G - SHRINKAGE

1.0 MECHANISM DESCRIPTION[1]

A workable concrete mix typically contains more water than is needed to offset the effects of hydration. When concrete is exposed to air, large portions of the free water evaporate. As water evaporates, capillary tension develops in the water remaining in the concrete while the concrete dries and shrinks in volume. Should these stresses exceed the tensile strength of the concrete, a crack forms. Initial shrinkage occurs during curing and continues months after placement. Subsequent drying and shrinkage occurs in concrete that is not continuously wet or submerged. According to ACI 209R-82[2], 91% of the shrinkage occurs during the first year, 98% in 5 years, and 100% in 20 years.

Excessive shrinkage causes cracking of the concrete surfaces, which provides a means for aggressive elements to make contact with the embedded steel/rebar, thus promoting the possibility of corrosion. The aging mechanism due to corrosion of embedded steel/rebar is discussed in Appendix E.

2.0 EVALUATION

2.1 Conditions

There is no condition in CCNPP that could aggravate the effect of concrete shrinkage initiated right after concrete construction. Most of the concrete shrinkage will have occurred well before the time of a license renewal application. Therefore, shrinkage of concrete structural components should not be regarded as an aging mechanism within the scope of license renewal.

2.2 Potential Aging Mechanism Determination

Shrinkage is not a potential aging mechanism for any turbine building concrete structural component because shrinkage in concrete proceeds at a decreasing rate with age and is not expected to continue after 40 years.

2.3 Impact on Intended Functions

Since shrinkage is not a potential aging mechanism, it will not affect the intended functions of any turbine building structural component.

2.4 Design and Construction Considerations

Since shrinkage can be minimized by keeping the water content of the paste as low as possible, the use of low slump concrete is a major factor in controlling shrinkage.[3] As stated in paragraph 12.1.2.1 of CCNPP design specification No. 6750-C-9,[4] a low slump of 3 inches was specified for all concrete used in CCNPP's turbine building.

The development of concrete cracking due to shrinkage can also be minimized by providing adequate reinforcing steel. For this purpose, CCNPP has adopted the minimum reinforcing steel requirements specified in ACI 318-63[5].

Since low slump concrete is used at Calvert Cliffs to minimize concrete cracks from shrinkage and minimum reinforcing steel requirements are used to mitigate crack propagation, shrinkage of any concrete component of the turbine building is minimal.

2.5 Plausibility Determination

Not applicable.

2.6 Existing Programs

Not applicable.

3.0 CONCLUSION

Shrinkage in concrete is not a long-term aging mechanism and is not expected to continue after 40 years during the license renewal period.

4.0 RECOMMENDATION

Not applicable.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. "Prediction of Creep, Shrinkage, and Temperature Effects in Concrete Structures," American Concrete Institute, ACI 209R-82

3. *Design and Control of Concrete Mixtures*, 13th Edition, Portland Cement Association.

4. "Specification for Furnishing and Delivery of Concrete - Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2," CCNPP's Design Specification No. 6750-C-9, Revision 8, April 1970.

5. "Building Code Requirements for Reinforced Concrete," American Concrete Institute, ACI 318-63.

APPENDIX H - ABRASION AND CAVITATION

1.0 MECHANISM DESCRIPTION[1]

As water moves over concrete surfaces, it can carry abrasive materials or it can create a negative pressure (vacuum) that can cause abrasion and cavitation. If significant amounts of concrete are removed by either of these processes, pitting or aggregate exposure occurs due to loss of cement paste. These degradations are readily detected by visual examination in accessible locations.

Abrasion and cavitation occur only in concrete structures that are continuously exposed to flowing water. Cavitation damage is not common if velocities are less than 40 fps. In closed conduits, however, degradation due to cavitation can occur at velocity as low as 25 fps when abrupt changes in slope or curvature exist.

2.0 EVALUATION

2.1 Conditions

Neither the turbine building nor its structural components are exposed to continuously flowing water.

2.2 Potential Aging Mechanism Determination

Attack by abrasion and cavitation is not a potential aging mechanism for the structural components of the turbine building because the structure is not exposed to continuously flowing water.

2.3 Impact on Intended Functions

Not applicable.

2.4 Design and Construction Considerations

Not applicable.

2.5 Plausibility Determination

Not applicable.

2.6 Existing Programs

Not applicable.

3.0 CONCLUSION

The CCNPP turbine building is not exposed to continuously flowing water. Therefore, abrasion and cavitation are not a potential aging mechanism for any structural components of the turbine building.

4.0 RECOMMENDATION

Not applicable.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

APPENDIX I - CRACKING OF MASONRY BLOCK WALLS

1.0 MECHANISM DESCRIPTION[1]

Masonry blocks walls can be designed as structural or shield walls. Masonry block wall cells may or may not contain reinforcing steel to provide structural strength to the wall. The extent of grouted cells varies with the specific design requirements for a bearing wall.

Some age-related degradation mechanisms that affect masonry block walls are the same as those that affect reinforced concrete walls. The potential for embedded steel and reinforced steel corrosion in block walls is similar to that of reinforced concrete.

Masonry block walls are vulnerable to unique age-related degradation mechanisms. Any restraint imposed on a masonry block wall that will prevent the wall from free expansion or contraction will induce stresses within the wall. Restraint against expansion results in small stresses depending on the strength of the block wall materials and thus rarely causes degradation of the concrete block wall. Moreover, expansion of the wall is offset by shrinkage from carbonation and drying. Restraint against free contraction causes tensile stresses within the wall. If these stresses exceed the tensile strength of the unit, the bond strength between the mortar and the unit, or the shearing strength of the horizontal mortar joint, cracks occur to relieve the stresses. Expansion or contraction of masonry block walls may be caused by changes in temperature, changes in moisture content of the constituent materials, carbonation, and movement of adjacent structural components (e.g., supporting floor or foundations).

Shrinkage due to moisture loss is among the principal causes of volume changes in masonry block walls. Factors affecting the drying shrinkage are the type of aggregate used, the method of curing, and the method of storage. Units made with sand and gravel aggregate will normally exhibit the least shrinkage; those with pumice, the highest. The difference between the moisture content of the masonry units during construction and the building in use will determine the amount of shrinkage that occurs. High-pressure steam curing and proper drying of concrete masonry units reduce the potential shrinkage of the walls.

If proper isolation is not provided at the joint between the masonry block wall and the supporting structural components (e.g., floor slabs or beams), long-term creep and variation in stiffness of the supporting components can also cause cracking.

Durability of the masonry mortar used at the block joints may affect the long-term structural integrity of the masonry block wall. Although aggressive environments and the use of unsound materials may contribute to the deterioration of mortar joints, most degradation results from water entering the concrete masonry and freezing.

The mechanisms cited above which cause cracking of concrete block walls are age-related. Although they are ongoing processes throughout a plant's life, most cracking occurs in the early stages of plant operation.

2.0 EVALUATION

2.1 Potential Aging Mechanism Determination

There is no masonry block wall in the Class 1 portion of the turbine building. Therefore, this aging mechanism does not apply to the turbine building.

2.2 Conditions

Not applicable.

2.3 Design Considerations

Not applicable.

2.4 Impact on Intended Functions

Not applicable.

2.5 Plausibility Determination

Not applicable.

2.6 Existing Programs

Not applicable.

3.0 CONCLUSION

Cracking of masonry block walls is not a plausible aging mechanism for CCNPP's turbine building.

4.0 RECOMMENDATION

Not applicable.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

APPENDIX K - CORROSION OF STEEL

1.0 MECHANISM DESCRIPTION[1]

Steel corrodes in the presence of moisture and oxygen as a result of electrochemical reactions. Initially, the exposed steel surface reacts with oxygen and moisture to form an oxide film as rust. Once the protective oxide film has been formed and if it is not disturbed by erosion, alternating wetting and drying, or other surface actions, the oxidation rate will diminish rapidly with time. Chlorides, either from seawater, the atmosphere, or groundwater, increase the rate of corrosion by increasing the electrochemical activity. If steel is in contact with another metal that is more noble in the galvanic series, corrosion may accelerate.

In some cases, corrosion of structural steel in contact with water may be microbiologically induced due to the presence of certain organisms, which is sometimes referred to as microbiologically influenced corrosion (MIC). These organisms, which include microscopic forms such as bacteria and macroscopic types such as algae and barnacles, may influence corrosion on steel under broad ranges of pressure, temperature, humidity, and pH. MIC effects on carbon steel may result in random pitting and general corrosion.

The rate of steel corrosion depends on site-specific environmental conditions and measures taken to prevent corrosion. A steel structure surface subjected to alternately wet and dry conditions corrodes faster than one exposed to continuously wet conditions. Atmospheric corrosion proceeds much more rapidly in areas where the atmosphere is chemically polluted by vapors of sulfur oxides and similar substances. Steel will corrode much faster in the vicinity of seawater because of sodium chloride in the atmosphere. The corrosion rate of steel usually increases with rising temperatures.

Corrosion products such as hydrated oxides of iron (rust) form on exposed, unprotected surfaces of the steel and are easily visible. The affected surface may degrade such that visible perforation may occur. In the case of exposed surfaces of structural steel with protective coatings, corrosion may cause the protective coatings to lose their ability to adhere to the corroding surface. In this case, damage to the coatings can be visually detected well in advance of significant degradation.

2.0 EVALUATION

2.1 Conditions

Steel can corrode in the presence of moisture and oxygen as a result of electrochemical reactions, especially in areas where there is an inadequate drainage system. In the turbine building, structural steel components vulnerable to corrosion are the steel members such as base plates and brackets that are not readily accessible for visual inspection and that can form pockets to harbor liquids.

2.2 Potential Aging Mechanism Determination

Corrosion is a potential aging mechanism for the following turbine building steel components because conditions conducive to steel corrosion discussed in Sections 1.0 and 2.1 exist:

· Steel beams	Functions LR-S-1, 2, and 7
· Baseplates	Functions LR-S-1, 2, 4, 5, and 7
· Floor framing	Functions LR-S-1, 2, and 7
· Steel bracing	Function LR-S-4
· Platform hangers	Function LR-S-5
· Steel decking	Functions LR-S-1, 2, and 7
· Jet impingement barriers	Function LR-S-4
· Floor grating	Function LR-S-5
· Stairs and ladders	Function LR-S-5
· Cast-in-place anchors	Functions LR-S-1, 2, 6, and 7
· Post-installed anchors	Functions LR-4 and 5
· Building siding clips	Functions LR-S-2
· Fire doors, jambs, and hardware	Functions LR-S-2, 6, and 7

- Access doors, jambs, and hardware — Functions LR-S-2, 6, and 7

- Watertight doors — Functions LR-S-2, 6, and 7

where:

LR-S-1: Provides structural and/or functional support(s) for safety-related equipment.

LR-S-2: Provides shelter/protection for safety-related equipment.

LR-S-4: Serves as a missile barrier (internal or external).

LR-S-5: Provides structural and/or functional support(s) for non-safety-related equipment whose failure could directly prevent satisfactory accomplishment of any of the required safety-related functions.

LR-S-6: Provides flood protection barrier (internal flooding event).

LR-S-7: Provides rated fire barriers to confine or retard a fire from spreading to or from adjacent areas of the plant.

2.3 Impact on Intended Functions

If corrosion of steel is allowed to degrade the above structural steel components unmitigated for an extended period of time, this aging mechanism could affect all intended functions of components listed in Section 2.2.

2.4 Design and Construction Considerations

Since corrosion was considered a potential degradation mechanism for all structural steel components of the turbine building, its effects were considered in the original design. As a result, all exposed structural steel surfaces in the turbine building except grating and metal decking, which are galvanized steel, were shop-painted or field-painted during the construction phase in accordance with CCNPP's design specifications No. 6750-C-19[2] and No. 6750-A-24[3].

Maintenance of protective coatings on CCNPP's equipment and structures inside containment follows the requirements specified in Calvert Cliffs Instruction Procedure MN-3-100[4]. This program sets forth procedural controls that comply with 10 CFR Part 50, Appendix B and satisfy the protective coating requirements in Regulatory Guide 1.54 which endorses ANSI N101.4-1972.

The post-installed anchors used for the platforms in the auxiliary feedwater pump enclosure are Hilti Kwik Bolt concrete anchors. Hilti anchor bolts are made of cold-rolled, high strength steel having a rust-resistant zinc coating. Anchors used for the jet impingement barriers are A354 Gr BD.

2.5 Plausibility Determination

Based on the discussion in Sections 2.1, 2.3 and 2.4, corrosion could affect the intended functions of all structural steel members and is, therefore, a plausible aging mechanism for all steel components listed in Section 2.2.

2.6 Existing Programs

System engineer walkdowns under PEG-7[5] will provide the discovery mechanism for degraded coating conditions. Conditions adverse to quality (such as degraded paint or corrosion) is reported in an Issue Report under QL-2-100[6]. The coatings program under MN-3-100[4] provides the administrative control over how corrective actions are performed. The combination of these existing plant programs will ensure that corrosion effects on accessible structural steel is adequately managed. These programs do not provide for the evaluation of the coating condition on structural steel components that are not normally accessible. An age related degradation inspection program as defined in the BGE Integrated Plant Assessment Methodology is necessary to address the aging effects of the non-accessible structural steel components.

3.0 CONCLUSION

All structural steel components of CCNPP's turbine building are vulnerable to corrosion attack if a corrosive environment prevails. All exposed structural steel surfaces in the turbine building are covered by a protective coating. In areas accessible for coating inspection, damage to coating can be detected visually well in advance of degradation due to corrosion of the structural steel.

Aging management of degraded coating conditions on accessible structural steel in the Turbine Building is accomplished through the combination of existing plant

programs. However, structural steel components not readily accessible require additional aging management.

4.0 RECOMMENDATION

Coatings on structural steel in accessible areas of the Class 1 portion of the Turbine Building is adequately managed by existing plant programs. A new program utilizing an age related degradation inspection should be developed to address degradation of coatings on structural steel components that are not normally accessible

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. "Specification for Furnishing, Detailing, Fabricating, Delivering, and Erecting Structural Steel," CCNPP's Design Specification No. 6750-C-19, Revision 3, September 1970.

3. "Specification for Painting and Special Coatings," CCNPP's Design Specification No. 6750-A-24, Revision 12, October 1982.

4. "Painting and Protective Coatings," Calvert Cliffs Nuclear Power Plant Administrative Procedure MN-3-100, Revision 2, Date 4/2/96

5. "Plant Engineering Section System Walkdowns", Plant Engineering Section Guideline PEG-7, Baltimore Gas and Electric Company, Revision 4, 11/30/95.

6. "Issue Reporting and Assessment", Calvert Cliffs Nuclear Power Plant Administrative Procedure QL-2-100, Revision 4. Date 1/2/96

APPENDIX L - CORROSION OF LINER

1.0 MECHANISM DESCRIPTION[1,2]

1.1 Carbon Steel Liner

Carbon steel liner corrosion can be either galvanic or electrochemical. Electrochemical corrosion of carbon steel is caused by exposure to aggressive aqueous solutions, which is described in Appendix K, "Corrosion of Steel."

Galvanic corrosion occurs only in the presence of electrolyte when the electrical potential difference between dissimilar metals placed in contact with each other results in the flow of electrons between them. The less resistant metal becomes the anode in this couple and is subject to corrosion, while the more resistant metal becomes the cathode and corrodes very little, if at all. The rate of galvanic corrosion is a function of the potential difference between the metals and the geometric relationship of the metals. Galvanic corrosion reduces the thickness of the anode metal.

Liner corrosion reduces liner plate thickness. Excessive reduction in thickness compromises the pressure retention capability of the liner. Corroded surfaces of the liner could result in separation of the protective coatings from the steel surface, and coating degradation becomes apparent.

1.2 Stainless Steel Liner

The stainless steel liner is prone to stress corrosion cracking (SCC), which is defined as cracking under the combined actions of corrosion and tensile stresses. The phenomenon of SCC can result in fracture of the metal. The stresses may be either applied (external) or residual (internal). The stress corrosion cracks themselves may be either transgranular or intergranular, depending on the metal and the corrosive agent. As is normal in all cracking, the cracks are perpendicular to the tensile stress. Usually there is little or no obvious visual evidence of corrosion. The three principal factors necessary to initiate stress corrosion cracking are tensile stresses, corrosive environment, and susceptible material. The tensile stresses necessary to cause SCC must be at or near the material's yield point. This is facilitated when the material is substantially cold worked, contains residual stress from welding, or is subjected to significant applied loads. Different corrosive environments induce different levels of SCC on various materials. With respect to material susceptibility, austenitic stainless steels, such as SA-240 Type 304, are prone to SCC, particularly when sensitization is present as in heat-affected zones and at creviced geometries.

In a sensitized condition, Type 304 stainless steel may develop intergranular stress corrosion cracking (IGSCC). The heat-affected zones of welds in Type 304 stainless steel are potential sites for IGSCC. IGSCC occurs when changes in the microstructure take place due to the welding heat, rendering the heat-affected zones

"sensitized", and when high residual stresses occur in and around the welds. The degree of sensitization depends on the metal's composition. For example, sensitization usually occurs when Cr combines with carbon. A low carbon content stainless steel, such as Type 304L, is relatively immune to IGSCC in the fuel pool environments. This is because the low carbon content (0.03 percent maximum) of Type 304L results in sensitization levels during welding so low that its heat-affected zones are resistant to IGSCC in the fuel pool environments.

2.0 EVALUATION

2.1 Potential Aging Mechanism Determination

There are no steel liners in the Class 1 portion of the turbine building. Therefore, this aging mechanism does not apply to the turbine building.

2.2 Conditions

Not applicable.

2.3 Impact on Intended Functions

Not applicable.

2.4 Design and Construction Considerations

Not applicable.

2.5 Plausibility Determination

Not applicable.

2.6 Existing Programs

Not applicable.

3.0 CONCLUSION

Corrosion of steel liners is not a plausible aging mechanism for CCNPP's turbine building.

4.0 RECOMMENDATION

Not applicable.

5.0 REFERENCES

1. "Pressurized Water Reactor Containment Structures License Renewal Industry Report," NUMARC Report 90-01, Revision 1, September 1991.

2. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

APPENDIX M - CORROSION OF TENDONS

1.0 MECHANISM DESCRIPTION[1]

When corrosion of prestressing tendons occurs, it is generally in the form of localized corrosion. Most corrosion-related failures of prestressing tendons have been attributed to pitting, stress corrosion, hydrogen embrittlement, or some combination of these.

Pitting is a highly localized form of corrosion. The primary parameter affecting its occurrence and rate is the environment surrounding the metal. The presence of halide ions, particularly chloride ions, is associated with pitting corrosion.

Stress corrosion results from the simultaneous presence of a conducive environment, a susceptible material, and tensile stress. The environmental factors known to contribute to stress corrosion cracking (SCC) in carbon steels are hydrogen sulfide, ammonia, nitrate solutions, and seawater. Prestressing tendon anchor heads, which are constructed of a high strength, low alloy steel bolting material, are vulnerable to SCC.

Hydrogen embrittlement (technically, not a form of corrosion) occurs when hydrogen atoms, produced by corrosion or excessive cathodic protection potential, enter the metal lattice. Hydrogen produced by corrosion is not usually sufficient to result in hydrogen embrittlement of carbon steel. Cathodic polarization is the usual method by which this hydrogen is produced. The interaction between the dissolved hydrogen atoms and the metal atoms results in a loss of ductility manifested as brittle fracture.

Corrosion of prestressing wires causes cracking or a reduction in the wires' cross-sectional area. In either case, the prestressing forces applied to the concrete are reduced. If the prestressing forces are reduced below the design level, a reduction in design margin results.

2.0 EVALUATION

2.1 Potential Aging Mechanism Determination

There are no prestressed tendons in the Class 1 portion of the turbine building. Therefore, this aging mechanism does not apply to the turbine building.

2.2 Conditions

Not applicable.

2.3 Impact on Intended Functions

Not applicable.

2.4 Design and Construction Considerations

Not applicable.

2.5 Plausibility Determination

Not applicable.

2.6 Existing Programs

Not applicable.

3.0 CONCLUSION

Corrosion of tendons is not a plausible aging mechanism for CCNPP's turbine building.

4.0 RECOMMENDATION

Not applicable.

5.0 REFERENCES

1. "Pressurized Water Reactor Containment Structures License Renewal Industry Report," NUMARC Report 90-1, Revision 1, September 1991.

APPENDIX N - PRESTRESS LOSSES

1.0 MECHANISM DESCRIPTION[1]

As the plant ages, tendons that were prestressed during construction tend to lose tension. Termed prestress losses, these reductions in stress are not readily observable. Several factors contribute to prestress losses:

- Stress relaxation of prestressing wires
- Shrinkage, creep, and elastic deformation of concrete
- Anchorage seating losses
- Tendon friction
- Reduction in wire cross section due to corrosion

2.0 EVALUATION

2.1 Potential Aging Mechanism Determination

There are no prestressed tendons in the Class 1 portion of the turbine building. Therefore, this aging mechanism does not apply to the turbine building.

2.2 Conditions

Not applicable.

2.3 Impact on Intended Functions

Not applicable.

2.4 Design and Construction Considerations

Not applicable.

2.5 Plausibility Determination

Not applicable.

2.6 Existing Programs

Not applicable.

3.0 CONCLUSION

Prestress loss in tendons is not a plausible aging mechanism for CCNPP's turbine building.

4.0 RECOMMENDATION

Not applicable.

5.0 REFERENCES

1. "Pressurized Water Reactor Containment Structures License Renewal Industry Report," NUMARC Report 90-1, Revision 1, September 1991.

APPENDIX O - WEATHERING

1.0 MECHANISM DESCRIPTION [1]

Components and structures that are located in an environment that is exposed to ambient conditions are susceptible to degradation due to weathering (indoor and outdoor). Aging mechanisms associated with weathering include exposure to sunlight (ultraviolet exposure), changes in humidity, ozone cycles, temperature and pressure fluctuations, and snow, rain, or ice. The effects of weathering on most materials are evidenced by a decrease in elasticity (drying out), an increase ir [illegible]., and shrinkage.

2.0 EVALUATION

2.1 Conditions

According to Specification ASTM C33-82, "Standard Specification for Concrete Aggregates," [2] the CCNPP site is located in the geographic region subject to severe weathering conditions. All outdoor components will experience the extreme temperature ranges, rain, snow, and changes in humidity expected at the CCNPP site. Additionally, inside the Turbine Building, components will experience similar temperature and humidity changes, throughout the life of the plant.

2.2 Potential Aging Mechanism Determination

Weathering is a potential aging mechanism for the following architectural components of the Turbine Building because they are exposed to the outside environment or similar in-building conditions:

- Caulking and sealants — Functions LR-S-2, 6, and 7

where:

LR-S-2: Provides shelter/protection for safety-related equipment.

LR-S-6: Provides a flood protection barrier (internal flooding event).

LR-S-7: Provides rated fire barriers to confine or retard a fire from spreading to or from adjacent areas of the plant.

2.3 Impact on Intended Functions

If the effects of weathering were not considered in the original design or are allowed to degrade the above components unmitigated for an extended period of time, this aging mechanism could affect all the intended functions of the components listed in Section 2.2.

2.4 Design and Construction Considerations

The caulking and sealants are components which are typically replaced on condition. However, inspections have indicated that a program of inspection and maintenance should be developed. Issue Report IR1995-01698 [3] was written to address this issue.

2.5 Plausibility Determination

Based on the discussion in Sections 2.3 and 2.4, weathering has been determined to be plausible for caulking and sealants in the CCNPP Turbine Building

2.6 Existing Programs

The caulking and sealants which perform a fire barrier function are addressed under the Appendix R Program as implemented by procedure STP-F-592-1/2 [4] for penetration fire barrier inspection. This procedure was determined to be adequate for managing the effects of weathering for the caulking and sealants.

3.0 CONCLUSION

Weathering is a plausible aging mechanism for the caulking and sealants in the Class I portion of CCNPP's Turbine Building. Management of the aging mechanism for caulking and sealants which perform functions other than those of a fire barrier will be established in conjunction with the resolution to Issue Report IR1995-01698. The Appendix R Program addresses the aging management for caulking and sealants which perform a fire barrier function.

4.0 RECOMMENDATION

Caulking and sealants which act as fire barriers are currently maintained through implementation of the Appendix R inspection program (STP-F-592-1/2). However, caulking and sealants which perform intended functions other than fire barrier do not have a program to manage their aging. An inspection program should be established in conjunction with the resolution to Issue Report IR1995-01698 to manage the effects of weathering for the caulking and sealants not included under the Appendix R Program.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. "Standard Specification for Concrete Aggregates," American Society of Testing and Materials, ASTM C33-82.

3. BGE Issue Report IR1995-01698, Building Joints (Aux Bldg. Exterior), dated 07/13/95.

4. "Penetration Fire Barrier Inspection," CCNPP's Surveillance Test Procedure, STP-F-592-1/2

APPENDIX R - ELEVATED TEMPERATURE

1.0 MECHANISM DESCRIPTION[1]

During normal plant operation, solar heat load and equipment heat loads contribute to an increase in temperature of the internal environment of a structure. Of all structural components in a structure, only components made of concrete material are potentially affected within the temperature range in which the structure will experience during normal plant operating conditions. As a result of elevated temperature, compressive strength, tensile strength, and the modulus of elasticity of concrete could be reduced by greater than 10 percent in the temperature range of 180 to 200 °F. Long-term exposure to high temperatures (> 300 °F) may cause surface scaling and cracking. Otherwise, there is no visible physical manifestation of concrete degradation due to exposure to elevated temperature.

ASME Code[2], Section III, Division 2 indicates that as long as concrete temperatures do not exceed 150 °F, aging due to elevated temperature exposure is not significant. Localized hot spots are limited in area and do not exceed 200 °F by design. ACI-349[3] allows local area temperatures to reach 200 °F before special provisions are required.

2.0 EVALUATION

2.1 Conditions

Table B-3 of Baltimore Gas and Electric Company's EQ Manual[4] lists the maximum anticipated temperature during normal and accident conditions in the Auxiliary Feedwater Pump Room to be 140 °F.

2.2 Potential Aging Mechanism Determination

Elevated temperature is not a potential aging mechanism for concrete structural components of the turbine building because they are not exposed to temperatures higher than the degradation threshold of elevated temperature for concrete (150 °F). Therefore, elevated temperature is not a potential aging mechanism for these components.

2.3 Impact on Intended Functions

Since elevated temperature is not a potential aging mechanism, it will not affect the intended functions of any safety related component located inside the turbine building.

2.4 **Design and Construction Considerations**

Since elevated temperature has no impact on the intended functions of components located inside the turbine building, no further discussion of CCNP's design and construction considerations is necessary.

2.5 **Plausibility Determination**

Based on the discussion in Sections 2.1, no structural components are exposed to temperatures higher than the degradation threshold of elevated temperature for concrete. Therefore, elevated temperature is not a plausible aging mechanism for any structural components of the CCNPP turbine building.

2.6 **Existing Programs**

Since elevated temperature is not a plausible aging mechanism, a program to control this degradation mechanism is not needed to maintain the intended functions of the Class 1 portion of the turbine building.

3.0 **CONCLUSION**

Based on this evaluation, elevated temperature is not a plausible aging mechanism because none of the intended functions of the turbine building are affected by this aging mechanism.

4.0 **RECOMMENDATION**

Elevated temperature is not a plausible aging mechanism for any structural components of the turbine building. Therefore, no further evaluation or recommendation is necessary.

5.0 **REFERENCES**

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. "Code for Concrete Reactor Vessels and Containments," ASME Boiler and Pressure Vessel Code, Section III, Division 2, 1986.

3. "Code Requirements for Nuclear Safety Related Concrete Structures," American Concrete Institute, ACI 349-85.

4. "EQ Design Manual - Calvert Cliffs Nuclear Power Plant, Unit No. 1 and 2," Baltimore Gas and Electric Co.

APPENDIX S - IRRADIATION

1.0 MECHANISM DESCRIPTION[1,2]

1.1 Concrete

Concrete components in a nuclear power plant exposed to excessive neutron or gamma radiation (incident flux > 10^{10} MeV/cm^2-sec)[3] could be impaired due to aggregate growth, decomposition of water or thermal warming of concrete. As the temperature of concrete increases and free water within the concrete evaporates, the structural characteristics of concrete are degraded. With the water loss, concrete can experience a decrease in its compressive, tensile, and bonding strengths, and in its modulus of elasticity. However, this loss of free water which results in a small decrease in concrete density will have little effect on concrete's gamma attenuation properties unless water loss is significant, depleting the presence of hydrogen atoms which contribute to concrete's shielding characteristics of fast neutrons. Typically, gamma radiation affects the cement paste portion of the concrete, producing heat and causing water migration.

Existing experimental data provide some general information on the impact of direct radiation on the mechanical properties of concrete[4]. The average concrete sample does not begin to experience a compressive or tensile strength loss until exposure exceeds a neutron fluence of 10^{19} neutrons/cm^2. The experimental data[4] indicate minimal compressive loss for exposure up to 5×10^{19} neutrons/cm^2.

1.2 Reinforcing Steel

Steel degradation due to neutron irradiation is caused by the displacement of atoms from their normal lattice positions to form both interstices and vacancies. The effect of this mechanism is to increase the yield strength, decrease the ultimate tensile ductility, and increase the ductile-to-brittle transition temperature. These defects on a macroscopic level produce what is referred to as radiation-induced embrittlement, which is encountered in the design and operation of reactor pressure vessels. By comparing the currently available stress-strain curves for unirradiated and irradiated mild steel, a reduction in ductility of rebar subjected to high radiation exposure (> 10^{18} neutrons/cm^2) is indicated[5].

1.3 Structural Steel

The effects of irradiation on structural steel are the same as those described for reinforcing steel with regard to the effects on yield strength and the modulus of elasticity. Structural steel will exhibit an increase in yield strength and a decrease in ductility after it is subjected to fluence in excess of 10^{18} neutrons/cm^2.

2.0 EVALUATION

2.1 Conditions

Table B-3 of Baltimore Gas and Electric Company's EQ Manual[7] lists the total integrated dose (rads) in the auxiliary feedwater pump room as negligible.

2.2 Potential Aging Mechanism Determination

Irradiation is not a potential aging mechanism for structural components of the turbine building because of the negligible levels of radiation present in the environment. Therefore, irradiation is not a potential aging mechanism for these components.

2.3 Impact on Intended Functions

Since irradiation is not a potential aging mechanism, it will not affect the intended functions of any safety related component located inside the turbine building.

2.4 Design and Construction Consideration

Since irradiation has no impact on the intended functions of components located inside the turbine building, no further discussion of CCNPP's design and construction considerations is necessary.

2.5 Plausibility Determination

Based on the discussion in Section 2.1, no structural component is exposed to radiation higher than the degradation threshold set forth in Sections 1.1, 1.2, and 1.3 for concrete and steel. Therefore, irradiation is not a plausible aging mechanism for any structural component of the CCNPP turbine building.

2.6 Existing Programs

There are no existing programs at CCNPP designed to identify damages to structural components of the turbine building due to radiation. However, since this is not a plausible aging mechanism that could degrade these components, no future program is necessary.

3.0 CONCLUSION

Based on this evaluation, irradiation is not a plausible aging mechanism because none of the intended functions of the turbine building are affected by this aging mechanism.

4.0 RECOMMENDATIONS

Irradiation is not a plausible aging mechanism for the structural components in the turbine building. No further evaluation or recommendation is required.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

2. "Pressurized Water Reactor Containment Structures License Renewal Industry Report," NUMARC Report 90-1, Revision 1, September, 1991.

3. "Guidelines on the Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power Plants", American Nuclear Standard ANSI/ANS-6.4

4. Hilsdorf, H.R., Kropp, J., and Koch, H.J., "The Effects of Nuclear Radiation on the Mechanical Properties of Concrete," Douglas McHenry International Symposium on Concrete and Concrete Structures, American Concrete Institute Publication SP-55, 1978

5. Naus, D.J., "Concrete Component Aging and its Significance Relative to Life Extension of Nuclear Power Plants," NUREG/CR-4652, ORNL/TM-10059, Oak Ridge National Laboratory, Oak Ridge, Tenn., September 1986

6. "Code Requirements for Nuclear Safety Related Concrete Structures," ACI 349-85, American Concrete Institute, Detroit, Michigan

7. "EQ Design Manual - Calvert Cliffs Nuclear Power Plant, Unit No. 1 and 2," Baltimore Gas and Electric Co.

APPENDIX T - FATIGUE

1.0 MECHANISM DESCRIPTION[1]

Fatigue is a common degradation of structural members produced by periodic or cyclic loadings that are less than the maximum allowable static loading. Fatigue results in progressive, localized damages to structural materials.

Two types of fatigue exist for structural components. The first mechanism, sometimes referred to as low-cycle fatigue, is low frequency (<100 cycles for concrete structures and $<1 \times 10^5$ for steel structures) of high-level repeated loads due to abnormal events such as SSE or strong winds. Structures exposed to such events must be thoroughly evaluated by analysis or by inspection or both after occurrence. The fatigue degradation caused by such loading may not occur or may occur only a few times during the service life of a structure. Therefore, low-cycle fatigue is not age-related and is not a license renewal issue.

The other fatigue mechanism is high frequency of low-level, repeated loads such as equipment vibration. Referred to as high-cycle fatigue, it is an age-related degradation mechanism.

1.1 Concrete

The fatigue strength of concrete structures has become a concern due to the widespread adoption of ultimate strength design procedures and the use of high-strength materials that require concrete structural members to perform satisfactorily under high-stress levels. Repeated loading causes cracking in component materials of a member and alters its static load-carrying characteristics.

Fatigue strength of plain concrete is essentially the same whether the mode of loading is tension, compression, or flexure. The stress-to-fatigue life relationship can be represented by an S-N curve as shown in Figure T-1, where S represents the maximum stress in the cycle and N represents the number of cycles required to produce failure. A series of specimen testing determines fatigue behavior, and the results are plotted on a log-scale. At a given number of service cycles (N) the material has a defined allowable fatigue strength. Review of S-N curves of plain concrete beams in ACI report 215R-74[2] indicates the following:

- *Fatigue strength of concrete decreases with the increasing number of cycles. The S-N curves for concrete are approximately linear between 10^2 and 10^7 cycles. This indicates that there is no limiting value of stress below which the fatigue life will be infinite.*

- *A decrease of the range between maximum and minimum load results in increased fatigue strength for a given number of cycles. When the minimum and maximum loads are equal, the strength of the specimen corresponds to the static strength of concrete determined under normal test conditions.*

The fatigue strength of plain concrete for a life of 10 million cycles for tension, compression, or flexure is roughly about 55 percent of its static strength.

Fatigue fracture of concrete is characterized by considerably larger strains and cracking as compared with fracture of concrete under static loading.

Fatigue failure of reinforcing steel has not been a significant factor in its application as reinforcement in concrete structures. There have been few documented cases of reinforcing fatigue failures in the concrete industry. ACI report 215R-74[2] notes that the lowest stress range known to have caused a fatigue failure of a straight hot-rolled deformed bar embedded in a concrete beam is 21 ksi. This failure occurred after 1.25×10^6 cycles of loading on a concrete beam containing a No. 11, Grade 60 rebar, when the minimum stress level was 17.5 ksi.

1.2 Steel

Fatigue of steel structures may cause progressive degradation and is initiated by plastic deformation within a localized region of the structure. A nonuniform distribution of stresses through a cross-section may cause a stress level to exceed the yield point within a small area and cause plastic movement after the number of stress reversal cycles reaches the material's endurance limit. This is the maximum stress to which the steel can be subjected for a given service life. Such conditions will eventually produce a minute crack. The localized plastic movement further aggravates the nonuniform stress distribution, and further plastic movement causes the crack to grow.

The fatigue behavior of steel structures strongly depends on their surface conditions (e.g., whether they are polished or in an as-received condition). The fatigue strength of structural steel components is generally represented by a modified Goodman diagram as shown in Figures T-2, which is generated from the S-N curves. The fatigue strength of structural steel decreases as the number of cycles increases until the fatigue limit is reached. If the maximum stress does not exceed the fatigue limit, an unlimited number of stress cycles can be applied at that stress ratio without causing failure.

2.0 EVALUATION

2.1 Conditions

Some of the internal structural components of the turbine building are subject to high cycle, low-level repeated load, such as equipment vibration load, during normal plant operation. The building siding clips were designed for abnormal events such as seismic and hurricane loads that are regarded as low cyclic load condition. Such loads may not occur or may occur for a very short duration only a few times during the service life of the turbine building. Therefore, the fatigue damage of these structural components is not age-related.

2.2 Potential Aging Mechanism Determination

Fatigue is a potential aging mechanism for the following structural components of the turbine building because they could experience high frequency of low-level, repeated loads such as equipment vibration load:

- Concrete walls — Functions LR-S-1, 2, 4, 6, 7
- Ground slab and equipment pads — Functions LR-S-1, 2, 4, 6, 7
- Elevated floor slab — Functions LR-S-1, 2, 6, 7
- Steel beams — Functions LR-S-1, 2, 7
- Base plates — Functions LR-S-1, 2, 4, 5, 7
- Floor framing — Functions LR-S-1, 2, 7
- Steel bracingFunction LR-S-4
- Platform hangers — Function LR-S-5
- Decking — Functions LR-S-1, 2, 7

where:

LR-S-1: Provides structural and/or functional support(s) for safety-related equipment.

LR-S-2: Provides shelter/protection for safety-related equipment.

LR-S-4: Serves as a missile barrier (internal or external).

LR-S-5: Provides structural and/or functional supports for non-safety-related equipment whose failure could directly prevent satisfactory accomplishment of any of the required safety-related functions.

LR-S-6: Provides flood protection barrier (internal flooding event).

LR-S-7: Provides rated fire barriers to confine or retard a fire from spreading to or from adjacent areas of the plant.

Fatigue is not a potential degradation mechanism for other turbine building structural components because they are not subject to the high frequency of low level, repeated loads.

2.3 Impact on Intended Functions

If the effects of fatigue were not considered in the original design or are allowed to degrade the above structural components unmitigated for an extended period of time, this aging mechanism could affect all intended functions of components listed in Section 2.2.

2.4 Design and Construction Considerations

All internal concrete components of the CCNPP turbine building were designed in accordance with ACI-318-63.[3] The design code limited the maximum permissible design stress level to less than 50 percent of static strength, which is less than the fatigue strength of concrete (55 percent of static strength). In addition, actual concrete stresses induced by cyclic loads during normal plant operation, such as those from machine vibration, are a small portion of the combined stresses resulting from static and dynamic loads. This means that the stress range (magnitude of stress fluctuation) is also small and within the limit that yields extremely long fatigue life (> 10^7 cycles, which is equivalent to infinite life), as shown in Figure T-1.

All structural steel components in the turbine building were designed in accordance with American Institute of Steel Construction (AISC-1963) specification.[5] For the design of steel members and connections subject to repeated variation of live load stress, this specification requires that consideration be given to the number of stress cycles, the expected range of stress, and the type and location of a member or detail. For life cycles of more than $2x10^6$ loading, the maximum stress may not exceed two-thirds of the basic allowable stress provided in Sections 1.5 and 1.6 of the AISC specification, which is equivalent to 40 percent of the material yield strength.

ASTM A-36 carbon steel is typically used for all structural steel components in the turbine building. As shown in the fatigue strength curves in Figures T-2 and T-3, the fatigue limit for as-received A-36 steel is about 20 ksi at a life cycle of approximately $2x10^6$, which is about 55 percent of the material yield strength. The maximum design stresses of all steel components were limited to 40 percent of material yield strength and are less than the material fatigue limit. Again, the actual steel stresses induced by cyclic loads are a small portion of the combined stresses resulting from static and dynamic loads.

2.5 Plausibility Determination

Based on the discussion in Section 2.4, fatigue will not degrade the structural components listed in Section 2.2. Therefore, fatigue is not a plausible aging mechanism for any structural components of the turbine building.

2.6 Existing Programs

There are no existing programs at CCNPP that are designed specifically to identify or to repair the damage to structural components due to fatigue. Since fatigue is not a plausible aging mechanism that could degrade the turbine building structural components, no management program is necessary.

3.0 CONCLUSION

Some concrete components in the turbine building of CCNPP are subject to high cycles of low- level repeated load. These components were designed in accordance with ACI-318-63[3], which limits the maximum design stress to less than 50 percent of the static stress of the concrete. The concrete fatigue strength is about 55 percent of its static strength at the extremely high cycles ($>10^7$ cycles) of loading. Therefore, fatigue will not degrade any concrete component in the turbine building and requires no further evaluation.

Steel components in the turbine building subject to high-cycle ($>10^5$ cycles) loading conditions were designed in accordance with the AISC-63 specification.[5] The maximum stress in steel components and connections is smaller than the fatigue limit of steel. Fatigue degradation will have no adverse effects on the continued safety function performance during the license renewal term and requires no further evaluation for all structural steel components in the turbine building.

4.0 RECOMMENDATION

Fatigue is not a plausible aging mechanism for the structural components in the turbine building. Therefore, no further evaluation or recommendation is necessary.

5.0 REFERENCES

1. "Class I Structures License Renewal Industry Report," EPRI's Project RP-2643-27, December 1991.

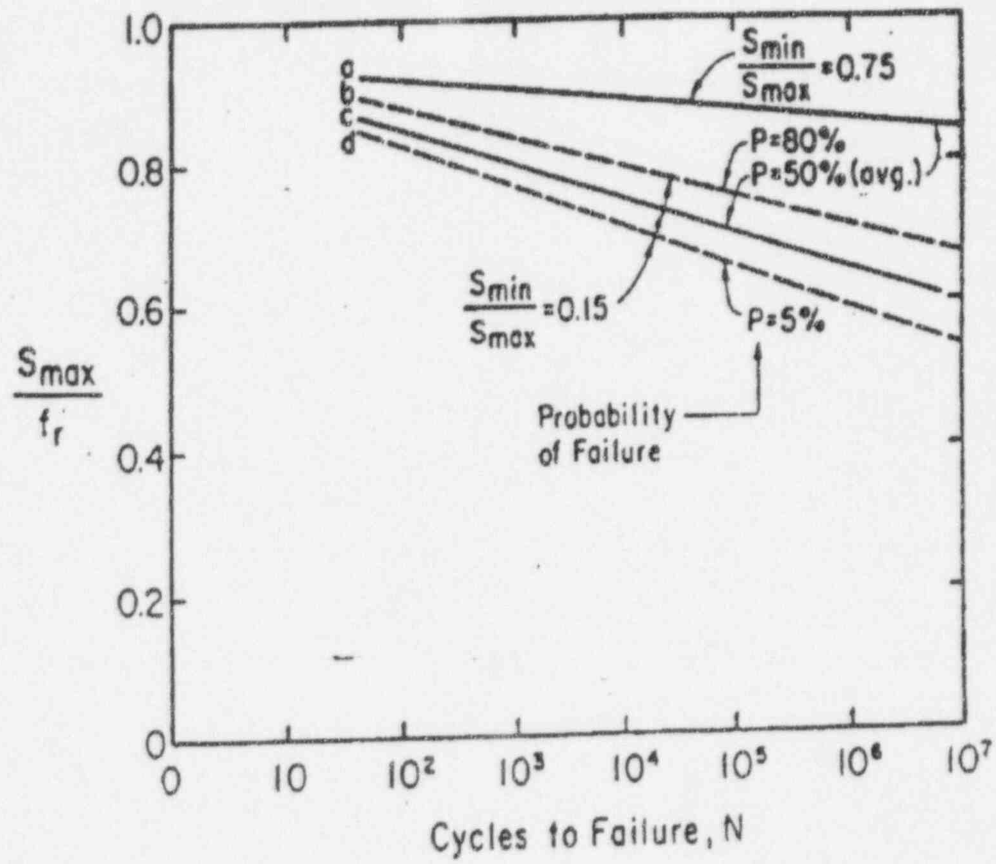
2. "Consideration for Design of Concrete Structures Subjected to Fatigue Loading," American Concrete Institute, ACI 215R-74, 1986.

3. "Building Code Requirements for Reinforced Concrete," American Concrete Institute, ACI 318-63.

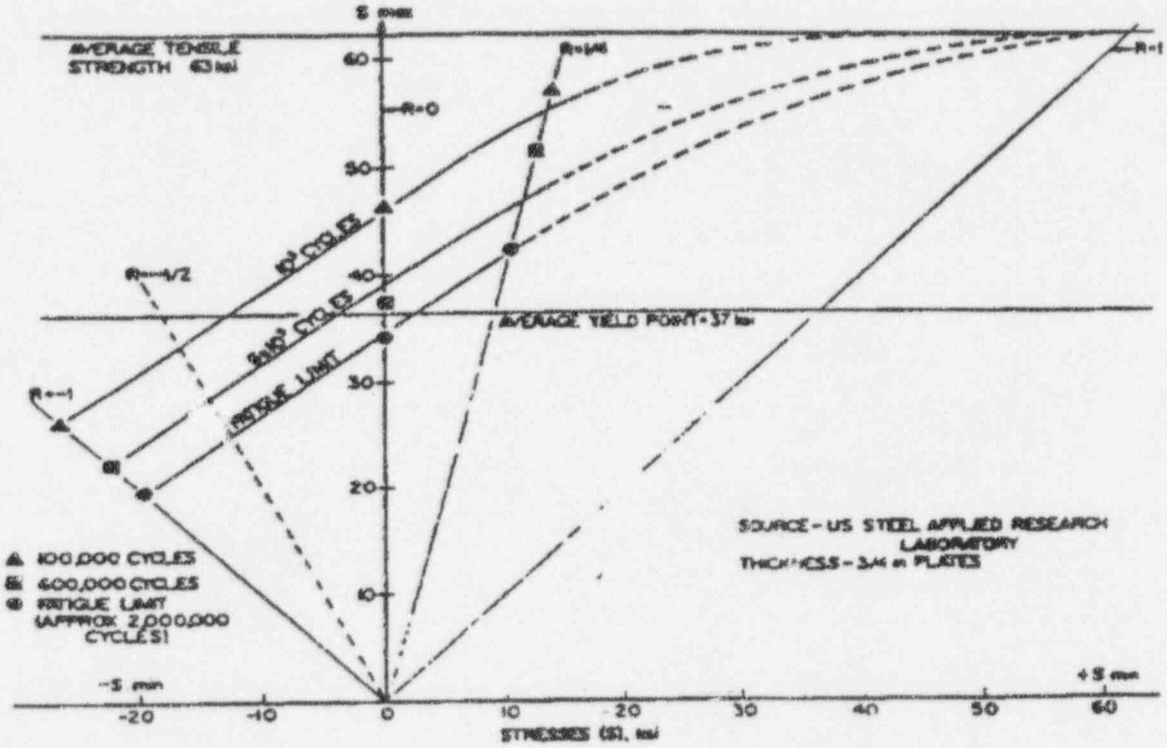
4. Civil and Structural Design Criteria for Calvert Cliffs Nuclear Power Plant, Unit No. 1 and 2, by Bechtel Power Corporation, Revision 0, August 2, 1991.

5. "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings," American Institute of Steel Construction, 1963.

6. Brockengrough, R.L., and Johnson, B.G., *Steel Design Manual*, United States Steel Corporation.



Fatigue Strength of Plain Concrete Beams
(Reference 2)



Fatigue Strength of As-Received A36
Structural Carbon Steel
(Reference 6)