50-317/318

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

November 20, 1996

ORGANIZATION: Baltimore Gas and Electric Company

SUBJECT: SUMMARY OF MEETING WITH BALTIMORE GAS AND ELECTRIC COMPANY (BGE) ON BGE LICENSE RENEWAL ACTIVITIES

On October 24, 1996, the Nuclear Regulatory Commission (NRC) staff met with representatives of BGE in Rockville, Maryland, to provide comments to BGE on the implementation of their IPA System and Commodity Report template in the areas of scoping and intended function for three sample reports: 1) Main Feedwater, the Auxiliary Building (Structures report), and Component Supports. The staff's comments provided to BGE during this meeting summarize the results of the staff's site visit on October 17, 1996 to BGE offices at Calvert Cliffs Nuclear Power Plant. During this site visit, the staff, in addition to reviewing the implementation of the BGE template in the area of scoping and intended function, reviewed the BGE site documentation to determine if the references to site documentation in the reports were sufficient and to determine if additional on-site information should be provided in the reports. A list of meeting attendees is provided in Attachment 1, and Attachment 2 is a copy of the staff's comment matrix provided during the meeting.

During the October 24, 1996 meeting the staff presented BGE with the attached matrix of comments and stated that the checks in the matrix represented an area where the staff believed the template was adequately implemented such that the staff had sufficient information to begin review; a check with a footnote denoted an area which was generally adequate but additional clarification would be helpful; and no check indicated an area where the staff believed the template implementation did not provide sufficient information for the staff to begin its review. The areas where information was deemed to be insufficient in the reports included 1) Listing of SCs, 2) Conceptual Boundaries for the Auxilary Building and Component Supports, and 3) Design Loading Conditions associated with intended functions.

For listing of SCs, the staff stated that the identification in the report of SCs subject to review must enable the staff to readily determine from onsite drawings or lists, whether a particular SC is subject to review or not. Specifically, the staff stated that indicating "all" or "all except" for a particular component or component type inside a stated boundary would enable the staff to identify the SCs subject to AMR. As an example, the staff stated

DF01

that if the feedwater report clarified that all supports within the stated aging management review (AMR) boundary were subject to review and if the Auxilary Building report provided the staff the exceptions to the structural component types requiring a review, the reports would be sufficient regarding the list of SCs issue. BGE agreed to provide this clarification. Based on this agreement, the staff stated that no additional staff examination of this issue at the template level is necessary.

For Conceptual Boundaries, the staff stated that a more clear description of the boundary of the Auxilary building and component supports was essential for it to be able to comprehend where BGE's review was focused. BGE agreed to provide a better description of the interfaces of structures and delineate where any common interface components are reviewed. For component supports BGE agreed to discuss the review of anchor bolts and baseplates and to better describe how the component supports for all the systems subject to review are included in an aging management review. Based on these agreements, the staff stated that no additional staff review of this issue at the template level is necessary.

For Design Loading conditions, the staff stated that the sample reports did not contain adequate description of design loading conditions, stress allowables, and loading combinations to adequately define the SCs intended function that must be maintained. BGE explained that their aging management programs are designed with alert values set conservatively such that design margins of the SCs are not reduced and therefore the intended functions would be maintained under all design conditions. BGE stated that the information the staff desires is overly burdensome and unnecessary. BGE suggested that the appropriate place in the license renewal review for the staff to focus is in the aging management demonstration for SCs where the bases for a program's alert values are presented demonstrating that the SC will not be degraded beyond its design basis. The staff stated that it would consider this approach in connection with its review of Section II of the template implementation --Aging Management Demonstration.

At the end of the meeting, BGE delivered to the staff samples of the template implementation for Section II of the template for Main Feedwater, the Auxilary Building, and Component Supports. These samples are contained in Attachment 3. BGE stated that these samples address the issue of operating experience, corrective action, as well as address the issue of ensuring that the design basis is maintained. The staff stated that it would review these samples in

conjunction with another site visit beginning November 7 such that final comments on the issue of intended function, operating experience, and corrective action can be provided by November 14, 1996.

John P. Moulton, Project Manager
License Renewal Project Directorate
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Attachments:
1. Attendance List
2. Staff's Comment Matrix
3. BGE Section 2 Template Samples

cc: See next page

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Original Signed By:

John P. Moulton, Project Manager
License Renewal Project Directorate
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Attachments:
1. Attendance List
2. Staff's Comment Matrix
3. BGE Section 2 Template Samples

cc: See next page

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Baltimore Gas & Electric Company

Calvert Cliffs Nuclear Power Plant
Unit Nos. 1 and 2

cc:

President
Calvert County Board of
Commissioners
175 Main Street
Prince Frederick, Md 20678

D. A. Brune, Esquire
General Counsel
Baltimore Gas and Electric Company
P.O. Box 1475
Baltimore, MD 21203

Jay E. Silberg, Esquire
Shaw, Pittman, Potts and Trowbridge
2300 N Street, NW
Washington, DC 20037

Mr. Terrence J. Camilleri, Director, NRM
Calvert Cliffs Nuclear Power Plant
1650 Calvert Cliffs Parkway
Lusby, MD 20657-4702

Resident Inspector
c/o U.S. Nuclear Regulatory
Commission
P.O. Box 287
St. Leonard, MD 20685

Mr. Richard I. McLean
Administrator - Radioecology
Department of Natural Resources
580 Taylor Avenue
Tawes State Office Building
B3
Annapolis, MD 21401

Regional Administrator, Region I
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406

Mr. Joseph H. Walter, Chief Engineer
Public Service Commission of
Maryland
Engineering Division
6 St. Paul Centre
Baltimore, MD 21202-6806

Kristen A. Burger, Esquire
Maryland People's Counsel
6 St. Paul Centre
Suite 2101
Baltimore, MD 21202-1631

Patricia T. Birnie, Esquire
Co-Director
Maryland Safe Energy Coalition
P.O. Box 33111
Baltimore, MD 21218

Mr. Robert E. Denton
Vice President - Nuclear Energy
Baltimore Gas and Electric Company
Calvert Cliffs Nuclear Power Plant
1650 Calvert Cliffs Parkway
Lusby, MD 20657-4702

Mr. Larry Bell
NRC Technical Training Center
5700 Brainerd Road
Chattanooga, TN 37411-4017

ATTENDANCE LIST
NRC MEETING WITH BALTIMORE GAS AND ELECTRIC
October 24, 1996

	NAME	ORGANIZATION
1.	John Moulton	NRC/NRR/DRPM/PDLR
2.	Barth Doroshuk	BGE/Life Cycle Mgmt.
3.	Dennis DiBello	BGE/LCM
4.	Don Shaw	BGE/LCM
5.	Barry Tilden	BGE/LCM
6.	Sam Lee	NRC/NRR/DRPM/PDLR
7.	Hai-Boh Wang	NRC/NRR/DRPM/PDLR
8.	Scott Newberry	NRC/NRR/DRPM/PDLR
9.	Raj Anand	NRC/NRR/DRPM/PDLR
10.	P. T. Kuo	NRC/NRR/DRPM/PDLR
11.	Steve Hoffman	NRC/NRR/DRPM/PDLR
12.	M. Banic	NRR/DE
13.	H. L. Brammer	NRR/DE
14.	Tricia Heroux	EPRI
15.	Bob Prato	NRC/NRR/DRPM/PDLR
16.	Winston Liu	NRC/NRR/DRPM/PDLR
17.	Christopher Regan	NRC/NRR/DRPM/PDLR
18.	Paul Shemanski	NRC/NRR/DRPM/PDLR
19.		
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ATTACHMENT 1

Attachment 2

ATTACHMENT (2)

STAFF COMMENTS ON OCTOBER 10, 1996 SCOPING/FUNCTION SAMPLES

October 24, 1996

Template/Report	Feedwater	Aux. Building	Component Supports
I. Scoping			
A. SSC Description			
General Description	✓	✓	✓
Conceptual Boundaries	✓		
Commodity make-up	n/a	n/a	✓
B. SCs and Intended Functions			
What is in scope	✓	✓	✓
Why is it in scope	✓	✓	✓
Simplified drawing	✓		
SCs covered elsewhere	✓[1]	✓	[4]
List of SCs	[2]	[2]	[5]
SC Intended functions	[3]	[3]	[3]
Any unique SCs included	n/a	✓	n/a

BGE Deliverables to NRC

October 24, 1996

1. Feedwater System License Renewal Technical Report, section on Feedwater Piping, written for LR Technical Report Template parts II., III., and IV.

2. Structures License Renewal Technical Report, section on Steel Components, written for LR Technical Report Template parts II., III., and IV.

3. Component Supports License Renewal Technical Report, section on Piping Supports, written for LR Technical Report Template parts II., III., and IV.

ATTACHMENT (3)

5.8.2 Aging Management

The following provides a discussion of the results of the aging management review for the Feedwater System scope. Hereafter, discussion of the Feedwater System is limited to the scope of components subject to an aging management review and not included in the scope of any commodity evaluation.

Feedwater System - Materials and Environment

The large bore Feedwater System main line piping is seamless carbon steel and the small bore drain and instrument tap piping is seamless carbon steel with forged fittings. Piping joints are butt-welded for large bore piping and socket welded for small bore piping. [M600, Sys Dwg, UFSAR Ch. 10.2, M600C] Some segments have been replaced with chromium-molybdenum (Cr-Mo) alloy steel to increase resistance to erosion-corrosion; however, for the purposes of the aging-management demonstration, no distinction is made between it and carbon steel.

The Feedwater System valves consist of the steam generator feedwater header check valves, feedwater isolation motor operated gate valves (MOVs), and small hand operated gate and globe valves for feedwater header drain and steam generator instrumentation root isolation service. The valves are constructed of cast or forged carbon steel material. [FW AMR Report] Modifications are planned (or completed) to install replacement check valves made of Cr-Mo. [DES]

The steam generator feedwater inlet temperature instruments are installed in thermowells in the main feedwater piping. The thermowells are fabricated of alloy steel material and are welded to the piping via a carbon steel half-coupling fitting. [FW AMR Report]

The internal environment for the Feedwater System components during power generation is chemically treated, demineralized, high pressure water that increases in temperature with plant power level from 100F or less to approximately 435F at full power. The system is subjected to thermal cycling during plant power increases and decreases, and in the event of plant transients such as step power changes or trips. The horizontal segment of Feedwater System piping adjacent to the steam generator inlet nozzle is subject to thermal stratification effects at hot standby and low power levels, which can result in large, rapid thermal transients in the piping. [IR1-711-785] System flowrates and fluid velocities are high at full power conditions. Except for certain infrequent severe transients described in UFSAR Chapter 14, the system bulk fluid is subcooleds water [UFSAR Ch. 10.2, Sys Desc 32] During plant shutdown conditions, the system may be drained or maintained full of water.

The external environment for the system components is ambient atmospheric air in either the auxiliary building or the containment building. This environment is a climate controlled atmosphere with moderate temperatures and humidity and not considered to be aggressive to component external surfaces. [FW AMR Report] Thermal insulation further minimizes contact of component external surfaces with the ambient atmosphere.

Feedwater System - Age-related Degradation Mechanisms

The aging management review performed for the Feedwater System included a review of potential age-related degradation mechanisms (ARDM) to determine any that may result in aging effects that could affect the ability of a component to perform its intended function. The list of ARDMs considered to be potential for Feedwater System components is given in Table 5.8-2. The table also indicates which ARDMs were determined to affect the ability of a component to perform its intended function considering the period of extended operation. These are the ARDMs considered to be plausible, in accordance with the IPA Methodology, for which the effects of aging must be demonstrated to be adequately managed so that the component intended function(s) will be maintained consistent with the CLB for the period of extended operation. Plausible ARDMs, and certain non-plausible ARDMs, are discussed further below.

TABLE 5.8-2

POTENTIAL AND PLAUSIBLE ARDMs

Potential ARDMs	Component Types					Not Plausible for System
	Piping	Check Valve	Hand Valve	MOV	Temperature Element	
Cavitation Erosion						x
Corrosion Fatigue						x
Crevice Corrosion	✓	✓	✓	✓	✓	
Dynamic Loading						x
Erosion Corrosion	✓	✓		✓	✓	
Fatigue	✓					
Fouling						x
Galvanic Corrosion						x
General Corrosion	✓	✓	✓	✓	✓	
Hydrogen Damage						x
Intergranular Attack						x
MIC						x
Particulate Wear Erosion						x
Pitting	✓	✓	✓	✓	✓	
Radiation Damage						x
Saline Water Attack						x
Selective Leaching						x
Stress Corrosion Cracking						x
Thermal Damage						x
Thermal Embrittlement						x
Wear						x

✓ - indicates plausible ARDM determination

The following discussion of corrosion combines the results of the AMR Report for the crevice corrosion, general corrosion and pitting corrosion ARDMs.

Piping - Corrosion - Aging Mechanism

Carbon steel is susceptible to general and localized (crevice and pitting) corrosion mechanisms in a water environment. The rate and nature of these corrosion mechanisms is particularly dependent on the local water chemistry conditions. Long-term repeated exposure to these mechanisms may result in localized pitting and/or general area material loss, especially in stagnant areas (crevices, dead legs) that, if left unmitigated, could eventually result in loss of the pressure retaining capability under CLB design loading conditions.

Therefore, general corrosion and crevice corrosion/pitting were determined to be plausible ARDMs for which aging effects must be managed for certain areas of the MFW system. [FW AMR Report]

Piping - Corrosion - Methods to Manage Aging

Mitigation: The effects of corrosion cannot be completely prevented but they can be mitigated by preventing, or minimizing, the exposure of the carbon steel piping material to an aggressive environment.

Maintaining a feedwater environment of purified water with a controlled pH and with dissolved oxygen and other impurities maintained at low levels during normal plant operation results in limited corrosion reactions and the formation of a passive oxide layer (magnetite) that protects the pipe interior surface by minimizing bare metal exposure to the water environment. [metals handbook]

Discovery: Although periods of shutdown may be brief and infrequent, they may result in a short term aggressive environment due to the introduction of oxygen and other impurities during system maintenance activities. System flush and prompt restoration of system chemistry to established bounds can minimize the resultant corrosion. The corrosion that does occur can be discovered and monitored through inspections of the internal surfaces and measurement of the wall thickness.

Crevices and stagnant flow areas may exist where localized fluid chemistry could be outside of the specified limits for varying periods of time. The corrosion that does occur will be limited by the limited impurity inventory and can be discovered and monitored through inspections of the piping.

Piping - Corrosion - Aging Management Programs

Mitigation: The CCNPP chemistry program is based on references 1 through 6 and limits are established for critical system chemistry parameters based on current industry standards. The concentration of dissolved oxygen is maintained at very low levels through the addition of oxygen scavenging chemicals during power and shutdown modes. [CP-0217] At power, non-condensable gases are also removed from the system by extraction in the main condenser. The concentration of impurities, such as chlorides, sodium, and sulfates, are maintained at very low levels by passing a portion of the fluid flowstream through demineralizers and filtration units. [UFSAR Ch. 10.2] An elevated system fluid pH is maintained, through addition of chemicals to the flowstream. [CP-0217]

The Feedwater System water quality is sampled on a daily basis (some parameters are sampled continuously at power) to confirm that the control processes are effective. In addition, the system is sampled for the concentration of corrosion products weekly as confirmation of program effectiveness. Specific actions are taken when the limits are exceeded, including power reduction and plant shutdown if conditions warrant. [CP-0217]

The CCNPP Chemistry Program is subject to internal assessment activity both within the Chemistry Department and through the site performance assessment group. The secondary systems Chemistry

Program is recognized through these assessments as maintaining highly effective secondary chemistry controls and aggressively pursuing continuous improvements through monitoring industry initiatives and trends in the area of secondary systems corrosion control. [Op Exp Reports] The program is also subject to frequent external assessments by INPO, NRC, and others.

Discovery: For non-stagnant areas where local chemistry will not differ significantly from the system bulk fluid chemistry, erosion corrosion is expected to be the predominant corrosion mechanism. Feedwater piping is subject to periodic inspection of wall thickness as discussed later for erosion corrosion.

In order to verify that no significant corrosion is occurring in the Feedwater System piping from adverse fluid chemistry in stagnant or crevice areas of the system, a new plant program will be developed to provide requirements for inspections of representative piping locations. The program is considered an Age-Related Degradation Inspection (ARDI) Program as defined in the CCNPP IPA Methodology.

The elements of the ARDI program will include:

- determination of the examination sample size based on plausible aging effects;
- identification of inspection locations in the system/component based on plausible aging effects and consequences of loss of component intended function;
- determination of examination techniques that would be effective considering the aging effects for which the component is examined;
- methods for interpretation of examination results;
- methods for resolution of adverse examination findings, including consideration of all design loadings required by the Current Licensing Basis and specification of required corrective actions; and
- evaluation of the need for follow-up examinations to monitor the progression of any age-related degradation.

For Feedwater System piping, this inspection program will focus on the issue of corrosion of carbon steel piping materi in the feedwater environment in areas of low flow and/or known crevices.

<u>Piping - Corrosion - Demonstration of Aging Management</u>

Based on the factors presented above, the following conclusions can be reached with respect to corrosion of Feedwat System piping:

- The Feedwater System piping provides the system pressure retaining boundary and integrity must be maintained under CLB design conditions.
- Corrosion is plausible for this piping, is affected by the local chemistry, and results in material loss which can lead to loss of pressure retaining boundary integrity.
- The CCNPP Chemistry Program provides controls for system bulk fluid chemistry in order to minimize the overall effects of corrosion but localized corrosion may be more limiting than general corrosion in areas of low flow velocity.
- Inspections for erosion-corrosion will monitor general and localized corrosion mechanisms in areas subject to flow; however erosion-corrosion predictions of wall thickness may not be conservative for localized corrosion in stagnant areas.
- To provide additional assurance that localized corrosion is not significant in stagnant and low-flow areas, the Feedwater System piping will be included in the scope of an ARDI Program and

inspections will be performed and appropriate corrective action will be taken if significant corrosion is encountered.

- Therefore, there is reasonable assurance that the effects of localized corrosion in low-flow areas will be managed in order to maintain the piping pressure boundary integrity, consistent with the CLB, during the period of extended operation.

Piping - Erosion Corrosion - Aging Mechanism

Based on the material and environment of the Feedwater System, erosion corrosion of internal surfaces was determined to be a plausible ARDM for which the effects of aging must be managed. [FW AMR Report] Erosion corrosion can result in material loss in areas with an adverse geometry that causes disturbances in the flowstream such as bends, tees, valves and localized internal surface irregularities. High velocity, turbulent flow erodes the metal surface, usually the protective passive corrosion film, and exposes fresh metal to corrode. This process can result in significant wall thickness reduction in a period of time much less than the Period of Extended Operation, especially for carbon steel. If left unmitigated, erosion corrosion can reduce the component wall thickness and could result in loss of the pressure retaining capability under CLB design loading conditions.

Piping - Erosion Corrosion - Methods to Manage Aging

Mitigation: The effects of erosion corrosion can be mitigated by selecting resistant materials and by maintaining optimal fluid chemistry conditions. Certain fluid chemistry parameters, such as dissolved oxygen concentration and fluid pH level, can be controlled, or optimized, to minimize the effects of erosion corrosion. However erosion corrosion can not be completely prevented.

Discovery: The effects of erosion corrosion can be discovered through measurement and monitoring of piping wall thickness. Measurements at susceptible locations can be used to assess the need for measurements at less susceptible locations. Based on piping geometry and fluid flow conditions, areas of the system most likely to experience erosion corrosion can be determined and pipe wall thickness can be measured directly using non-destructive examination techniques. The measurements must be performed on a frequency that is sufficient to ensure that minimum wall thickness requirements will be met until at least the next examination is performed.

Piping - Erosion Corrosion - Aging Management Programs

Mitigation: The CCNPP Chemistry Program discussed above for corrosion specifically considers erosion corrosion. The limits for impurity concentration and fluid pH are set to minimize erosion corrosion while also minimizing other forms of corrosion in the secondary system.

Discovery: The Main Feedwater System is subject to inspections of pipe wall thickness under the CCNPP erosion-corrosion program. This program is based on References 7 and 8 and meets the intent of the Nuclear Management and Resources Council (now NEI) guidelines per NUREG-1344, Appendix A as described in Reference 9. Provisions of the Erosion Corrosion program include

- Identification, categorization, prioritization, and scheduling of inspection points based on susceptibility and consequences of failure
- NDE methods to be used for measuring wall thickness
- classification and disposition of inspection results, including calculation of erosion-corrosion rates and conservatively predicting the time at which the component will reach the minimum wall thickness
- scheduling of pipe replacement such that wall thickness remains above the minimum wall thickness

- base-line wall thickness measurements of replacement pipe.
- The minimum wall thickness calculated is as required by the original construction code and ensures the piping intended function will be maintained under all design loadings required by the CLB.

As a result, the erosion corrosion program engineers determine areas of the system that are susceptible to erosion corrosion through consideration of piping geometry, fluid velocity, and fluid energy level (e.g., pressure and temperature). For susceptible areas of the Feedwater System, the minimum allowable pipe wall thickness is calculated and compared to measured pipe wall thickness. The measured pipe wall thickness is trended on a frequency sufficient to ensure no monitored piping wall thickness will be reduced to below calculated minimum allowable wall thickness prior to the next scheduled inspection.

Pipe wall thickness measurements are made through the use of non-destructive examination techniques (usually UT). In the event of unacceptable measured thickness, immediate corrective actions are taken. These actions may include analysis of the existing condition in order to determine the suitability of the component for service, considering all design basis loading conditions, or replacement of the piping component. [MN-3-111, superseded by MN-3-202]

Components that are replaced due to erosion corrosion, including those made of Cr-Mo, are also subject to additional examinations. A component remains within the scope of the program, and is subject to continuing inspection, until it can be shown that degradation due to erosion corrosion no longer could prevent the piping from performing its intended function. [MN-3-202] Industry techniques and methods, such as the EPRI CHEC software, are evaluated and used for use in determining susceptible areas and for detecting piping wall thickness degradation in order to enhance Erosion Corrosion Program effectiveness.

Pipe wall thickness is also sampled periodically in areas not expected to be susceptible to erosion corrosion and discovery of unexpected degradation requires additional wall thickness examinations of similar components in similar environments. [MN-3-202]

The CCNPP erosion corrosion program has been in place for many years and has been effective in preventing unexpected failures of Feedwater System piping. It is subject to frequent internal and external assessments, including NRC, INPO, and others. The Erosion Corrosion Program has demonstrated its effectiveness through discovery and trending of pipe wall thinning due to erosion corrosion in the Feedwater System and some pipe segments have been replaced due to erosion corrosion degradation. [M-600C, communication with FW Sys Engr, E/C Pgm Mgr]

<u>Piping - Erosion Corrosion - Demonstration of Aging Management</u>

Based on the factors presented above, the following conclusions can be reached with respect to erosion corrosion of Feedwater System piping:

- The Feedwater System piping provides the system pressure retaining boundary and integrity must be maintained under CLB design conditions.
- Erosion corrosion is plausible for much of this piping and results in pipe wall thinning which can lead to loss of pressure retaining boundary integrity.
- The CCNPP Chemistry Program provides controls for system fluid chemistry in order to minimize the effects of erosion corrosion. While degradation is not entirely prevented, the rate, and therefore the predictions of when minimum wall thickness will be reached, depend on the system chemistry.
- The CCNPP Erosion Corrosion Program monitors the effects of erosion corrosion through measurement of pipe wall thickness on a frequency dependent upon the rate of degradation. The

program requires the performance of corrective actions prior to pipe wall thinning to below minimum required wall thickness established by the original construction code.

- Wall thickness is sampled for areas not expected to be susceptible and the implications of unexpected results for similar locations is assessed.
- Therefore, there is reasonable assurance that the effects of erosion corrosion will be managed in order to maintain the piping pressure boundary integrity under all design loadings required by the CLB during the period of extended operation.

Conclusion

The programs discussed for the Feedwater System are listed in the following table. These programs are (or will be for new programs) administratively controlled by a formal review and approval process. As demonstrated above, these programs will manage the aging mechanisms and their effects such that the intended functions of the components of the Feedwater System will be maintained, consistent with the CLB, during the period of extended operation.

The analysis/assessment, corrective action, and confirmation/documentation process for license renewal is in accordance with QL-2, "Corrective Actions Program." QL-2 is pursuant to Appendix B and covers all structures and components subject to aging management review.

Table 5.8-3

LIST OF AGING MANAGEMENT PROGRAMS FOR THE FEEDWATER SYSTEM

Program	Credited As
CCNPP Chemistry Program Procedure "Specifications and Surveillance - Secondary Systems" CP-0217	Mitigate the effects of corrosion of Feedwater System piping and components during normal operation
CCNPP Chemistry Program Procedure "Plant Layup and Equipment Preservation" CH-1-104	Mitigate the effects of corrosion of Feedwater System piping and components during shutdown conditions
CCNPP Erosion Corrosion Program Procedure "Erosion/Corrosion Monitoring of Secondary Piping" MN-3-202	Management of the effects of erosion corrosion of Feedwater System piping
CCNPP Preventive Maintenance Program MN-1-102	Management of the effects of erosion corrosion of the Feedwater System steam generator check valves
Age-Related Degradation Inspection (ARDI) Program (new)	Management of the effects of corrosion of Feedwater System piping and components, and erosion corrosion of feedwater isolation MOVs and temperature element thermowells

Table 5.8-4

LIST OF REFERENCES FOR THE FEEDWATER SYSTEM

1. ANSI N45.2.1 (02/26/73), Cleaning of Fluid Systems and Associated Components During Construction Phase of Nuclear Power Plants
2. U. S. Nuclear Regulatory Guide 1.37 (03/16/73), Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plants
3. INPO 88-021, Revision 1, September 1991, Guidelines for Chemistry at Nuclear Power Stations
4. INPO 85-021, June 1985, Control of Chemicals in Nuclear Power Plants
5. EPRI NP-6239, 5405-2, Final Report December 1988, PWR Secondary Water Chemistry Guidelines, Revision 2
6. EPRI TR-102134, Projects 2493, 5401, Final Report, May 1993, PWR Secondary Water Chemistry Guidelines, Revision 3
7. EPRI NP-3944, Erosion/Corrosion in Nuclear Plant Steam Piping: Causes and Inspection Program Guidelines, April 1985
8. NRC Generic Letter 89-08, Erosion/Corrosion Induced Pipe Wall Thinning
9. G. C. Creel reply to NRC Generic Letter 89-08, February 26, 1990, affirming Materials Engineering and Analysis (ME&A) Implementing Procedure (IP) 5.05, Secondary System Piping Erosion/Corrosion Inspection Program, was fully implemented.
10. CCNPP Feedwater System Aging Management Review Report, Revision 1.
11. CCNPP Updated Final Safety Analysis Report, Revision 19.
12. CCNPP Technical Procedure CP-0217, "Specifications and Surveillance: Secondary Chemistry", Revision 5.
13. CCNPP Administrative Procedure CH-1-104, "Plant Layup and Equipment Preservation", Revision 0.
14. CCNPP Administrative Procedure MN-3-202, "Erosion/Corrosion Monitoring of Secondary Piping", Revision 1.
15. CCNPP Administrative Procedure MN-1-102, "Preventive Maintenance Program", Revision 4.

APPENDIX A

TECHNICAL INFORMATION

7.1.2 Aging Management

The potential and plausible age-related degradation mechanisms (ARDMs) for structural components affected are identified in Table 7.1-3. The table is divided into two parts, Structural Type Components and Systems Type Components, because the ARDMs differ for structures versus systems. Based upon environment, design and the results of inspection, a number of these mechanisms were determined to be not plausible. [AMRRs]

TABLE 7.1-3:
STRUCTURES POTENTIAL AND PLAUSIBLE ARDMs
(by structure number listed below table)

ARDM	Potential	Plausible	Components Affected
Structural Type Components (Concrete, Structural Steel, Architectural, Unique)			
Freeze-Thaw	1, 2, 3, 5, 6	X	
Leaching of Calcium Hydroxide	1, 2, 3, 4, 5, 6	X	
Aggressive Chemical Attack on Concrete	1, 2, 3, 4, 5, 6	1, 2, 3, 4	Ground Floor/Slabs, Basemats, Foundations, and Walls (below-grade portions only); Intake Structure Fluid Retaining Walls and Slabs
Reactions with Aggregates	1, 2, 3, 4, 5, 6	X	
Corrosion of Embedded Steel/rebar	1, 2, 3, 4, 5, 6	1, 2, 3, 4	Ground Floor/Slabs, Basemats, Foundations, and Walls (below-grade portions only); Intake Structure Fluid Retaining Walls and Slabs
Abrasion and Cavitation	3	X	
Cracking of Masonry Block Walls	2	X	
Settlement	1, 2, 3, 4, 5, 6	X	
Corrosion of Steel	1, 2, 3, 4, 5, 6	1, 2, 3, 4, 5, 6	Steel Components (* in Table 7.1-1)
Corrosion of Liner	1, 2	1, 2	Liners
Corrosion of Tendons	1	1	Post Tensioning System
Prestress Losses	1	1	Post Tensioning System
Weathering	1, 2, 3, 4, 5, 6	2, 3, 4, 5, 6	Caulking and Sealants, Expansion Joints
Elevated Temperature	1, 2	X	
Irradiation	1, 2	X	
Fatigue	1, 2, 3, 4	X	
System Type Components			
General corrosion/oxidation	1	1	EQ Electrical/Mechanical Penetrations, Personnel Airlocks, Equipment Hatch
Pitting/Crevice Corrosion	1	X	
IASCC	1	X	
SCC/IGSCC/IGA	1	X	
Microbiologically Influenced Corrosion	1	X	
Thermal Aging	1	X	
Stress Relaxation	1	X	

1	**Containment Structure**	**3**	**Intake Structure**	**5**	**FOST #21 Enclosure**
2	**Auxiliary Building**	**4**	**Turbine Building**	**6**	**CST #12 Enclosure**

X - not plausible

APPENDIX A

TECHNICAL INFORMATION

The following ARDMs were determined to be not plausible for CCNPP based on site specific justification: Freeze-Thaw, Leaching of Calcium Hydroxide, and Settlement. These non-plausibility determinations are discussed below:

Freeze-Thaw was determined to be not plausible. The CCNPP site is located in the geographic region considered subject to severe weathering conditions. Although freeze-thaw cycles can degrade concrete components that are exposed to cold temperatures and moisture, concrete components subject to aging management review were constructed with specific design features[1] to maximize their resistance to freeze-thaw. Based on these features freeze-thaw was determined to be not plausible for CCNPP. The not plausible conclusion is supported by a walkdown inspection of the Unit 1 containment structure, performed in 1992, which found no indication of the freeze-thaw effect. This finding represents over 20 years of environmental exposure conditions and further substantiates the conclusion that freeze-thaw is not a plausible aging mechanism and will not have any impact on structural integrity for these structural components. [AMRRs]

Leaching of Calcium Hydroxide was determined to be not plausible. Concrete surfaces are exposed to rain water and humidity above-grade and groundwater below-grade. By design, no ponding is allowed to occur on above-grade concrete surfaces. Without ponding, there is insufficient hydraulic pressure to leach out the calcium hydroxide. Below-grade concrete could be subjected to sufficient hydraulic pressure due to groundwater, however, the concrete mix was designed for low permeability and high compressive strength which provides the best protection against leaching. Based on these features leaching of calcium hydroxide was determined to be not plausible for CCNPP. This conclusion for above-grade concrete is supported by a 1992 walkdown inspection. During that inspection only minor traces of calcium hydroxide leaching marks were detected on the concrete structures. These indications were judged to have no impact on structural integrity. [AMRRs]

Settlement was determined to be not plausible. CCNPP's structures are situated on Miocene soil, which is exceptionally dense and will support heavy foundation loads. Additionally, the structural load on the containment basemat is about the same as the removed earth weight. When the overburden was removed there was a slight uplift of the soil. This uplift was resettled to approximately the same compaction when the load of the structure was added during construction. Therefore, the soil bearing stress is well below its ultimate bearing capacity, and the maximum long-term settlement is predicted to be 1/2 inch. Most of the predicted 1/2 inch settlement is in terms of uniform settlement which has no adverse effect on the structure. In addition, for the containment the groundwater table is maintained by the dewatering system which minimizes any changes to the site conditions that could affect settlement. Therefore, settlement is not a plausible aging mechanism for the structural components. [AMRRs]

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[1] "ACI 318 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." [AMRR]

APPENDIX A

TECHNICAL INFORMATION

The following paragraphs provide the demonstration that the effects of the plausible aging mechanisms identified in Table 7.1-3 are adequately managed such that there will be reasonable assurance that the intended functions will be maintained consistent with the current licensing basis (CLB) during the period of extended operations. Hereafter, the aging management review of Structures is limited to the scope of Structural Type Components and Systems Type Components subject to an aging management review and not included in the scope of any commodity evaluation.

Structures Environments and Materials of Construction

The following defines the environment and materials of construction for structures by dividing them into the categories of external above and below-grade and internal:

External Above-grade Environmental Conditions - The above-grade portion of structures are exposed to the atmosphere. There is no heavy industry nearby CCNPP to add chemicals to the atmosphere but, due to the close proximity of the Chesapeake Bay the concrete could be exposed to an environment containing chloride ions.

Concrete and coated steel are exposed to the external environmental conditions.

External Below-grade Environmental Conditions - The below-grade portions of structures are comprised of reinforced concrete in contact with soil and groundwater. The pH of groundwater was documented at construction to be 7.5 and has been recently confirmed to be in the same pH range.

The ground area around the containments has a groundwater dewatering system that was installed during construction to maintain a stable groundwater level at the 10 foot elevation.

The concrete fluid retaining walls of the intake structure are in contact with the Chesapeake Bay water which is an environment containing chloride ions.

Internal Environmental Conditions

For the purposes of this aging evaluation, the internal environmental conditions for the tank enclosures, which are open to the atmosphere, are conservatively considered to be the same as the external environment. For the remaining structures the specific internal environment is described below:

Containment Structure - The maximum design ambient air temperature is 120°F for normal startup, and shutdown operation. The design ambient air pressure is 14.7 psia. Ambient air pressure is limited to -1.0 to +1.8 psig during normal plant operation. The design ambient air relative humidity during normal plant operation is 50% at 120°F and 14.7 psia. These represent the normal service conditions which contribute to the aging stressors of the containment.

Both concrete and coated steel are exposed to the internal environmental conditions.

Auxiliary Building, Intake Structure, Turbine Building - Ambient temperatures are controlled by plant ventilation systems as specified in UFSAR, Chapter 9. The plant ventilation systems are designed to provide minimum (winter) and maximum (summer) building air temperatures as specified in UFSAR, Chapter 9, Table 9-18. Certain areas are maintained by safety related ventilation systems. These areas are maintained by design, at, or below the maximum design temperature identified in UFSAR, Chapter 9, Table 9-18, during UFSAR, Chapter 14 events. The remaining areas of the auxiliary building, turbine building and, intake structure are ventilated by non-safety related (NSR) ventilation systems and are maintained at or below the maximum design temperatures. [UFSAR]

UFSAR, Appendix 10A, Section 10A.3.20 and Section 10A.4.1.20 define the pressure as 0 psig. General plant areas are at atmospheric pressure. Certain Auxiliary Building areas are maintained positive or negative to the ambient air pressure with respect to surrounding areas by the ventilation system for control of airborne releases. [UFSAR]

There are no design humidity requirements for these structures. The UFSAR documents that expected conditions are based on the design of the heating and ventilation system only.

Both concrete and coated steel are exposed to the internal environmental conditions.

The results of the aging evaluation on Steel components is presented below:

Steel Components - Corrosion of Steel - Aging Mechanisms

Corrosion of Steel was determined to be plausible for steel components (items marked with an asterisk in Table 7.1-2).

Steel components are located in both internal and external environments and are therefore subject to varying levels of humid conditions. Exposed 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, by alternating wetting and drying, or by other surface actions, the oxidation rate will diminish rapidly with time. Chlorides increase the rate of corrosion by increasing the electrochemical activity.

Since exposed steel is subject to corrosion in humid environments, corrosion of steel is plausible for these structural steel component types.

Left unmitigated, long term corrosion can reduce steel thickness, which compromises the structural capability of the steel components. Reduced steel thickness caused by corrosion of steel could lead to degraded functions for structural and/or functional support, shelter/protection, missile barrier, rated fire barrier, or flooding protection.

APPENDIX A

TECHNICAL INFORMATION

Steel Components - Corrosion of Steel - Methods to Manage Aging

A method to mitigate the effects of corrosion of steel is to provide exposed steel surfaces with protective coatings. Coatings serve as a protective layer, preventing moisture and oxygen from directly contacting the steel surfaces, and thus mitigating the effects of the ARDM by reducing the rate of corrosion. This rate of corrosion depends on the exposed environment and the condition of the coatings.

Visual observation serves as a discovery method to identify a degraded protective coating that could lead to corrosion of steel. Degraded paint coatings can lead to exposed steel and subsequently corrosion of the underlying steel. Steel will only corrode if the coating breaks down and allows moisture and oxygen to come in contact with the exposed steel. Coatings degrade slowly over many years allowing the degraded conditions to be detected visually during normal plant operations. Coatings which are blistered, chalky, or showing rust stains have degraded to the point where the steel is exposed to moisture and oxygen. Surface rust of steel components has no effect on the steel component's ability to perform its intended structural function during any design loading condition.

Structural steel components are located in both accessible and inaccessible areas. The aging management method differs based on the location. Visual observation of the coatings' condition is an effective method to identify these conditions in a timely manner for routinely accessible areas. For those areas not routinely accessible, additional effort must occur to either make these areas accessible (such as scaffolding) or to identify similar coatings in accessible areas and monitor their condition as a representative sample of the condition of coatings in inaccessible locations.

Steel Components - Corrosion of Steel - Aging Management Program

For CCNPP all exposed steel surfaces were provided with protective coatings during construction. These coatings have various life expectancies depending on surface preparation, type of coating, and service conditions. At CCNPP only approved coatings are used for specific applications. Surface cleaning and preparation are specified to maximize the coating life.

CCNPP's method to mitigate the effects of corrosion of steel is to maintain the protective coatings applied during original construction. The Painting and Other Protective Coatings Program, MN-3-100, based on references 14-21, controls painting and coating activities at CCNPP. Differing levels of control exist depending on the location of the components, with the highest controls applied to items inside containment and the lowest applied to "balance of plant" items. The coatings inside containment are checked for proper thickness when applied. Every outage the condition of coatings is inspected and evaluated for corrective action. Outside containment the controls over application standards and measurements vary and activities to ensure the coatings remain intact are provided by other programs as described below.

For accessible areas, discovery of degraded coatings for structural steel components is accomplished by a number of activities, including periodic documented inspections by assigned systems engineers. These walkdowns, conducted in accordance with a Plant Engineering Guideline entitled "System Walkdowns," have the following characteristics:

- Walkdowns are conducted at periodic intervals, as set by Plant Engineering Guideline, based on system performance, operating conditions, etc.
- Walkdowns are performed by an assigned system engineer who is familiar with the interface of his system to the surrounding structure. Any signs of degraded coatings would be detected by this individual.
- To assist the system engineer in detecting such conditions, the "System Walkdown" guideline contains a checklist on which to document conditions observed during the walkdown.
- The Plant Engineering Guideline on System Walkdowns requires that any unusual condition observed during the system engineers walkdown be recorded on the walkdown sheet and assistance obtained from design engineering in evaluating the impact of the unusual condition. Conditions that warrant further action are documented on an issue report and the site corrective action program tracks the status of corrective actions.

By maintaining the coatings of the external surfaces of the structural steel, corrosion of structural steel will be mitigated. Coatings which are determined not to be effective in preventing corrosion of the structural steel are replaced at the earliest opportunity (such as repainting structural steel for operating equipment the next time it is shutdown.). Since the degradation of the underlying steel is slow and localized to the surface, there is reasonable assurance that the intended function of the structural steel will not be effected before the coating is repaired.

For inaccessible areas, the aging of structural steel is not expected to be different from that of structural steel in the nearby accessible areas. If the coatings are the same type and the same environmental conditions exist then it is reasonable to expect that if the nearby accessible coatings remain intact, the inaccessible coatings are also intact. To provide additional assurance that deterioration of structural steel protective coatings are not progressing differently, inaccessible structural steel locations will be subject to an age-related degradation inspection in accordance with the CCNPP IPA Methodology. The age-related degradation inspection will include the following:

- Identification of inaccessible locations
- Selection of representative structural steel components for inspection
- Development of an inspection sample size
- Use of appropriate inspection techniques
- Requirements for reporting of results and corrective actions if aging concerns are identified

<u>Steel Components - Corrosion of Steel - Aging Management Demonstration</u>

Based on the factors presented above, the following conclusions can be reached with respect to corrosion of steel components:

- Steel components provide functions for structural and/or functional support, shelter/protection, missile barrier, rated fire barrier, or flooding protection.
- Corrosion was determined to be plausible for steel components.
- Steel corrodes in the presence of moisture and oxygen. Coatings mitigate the effects of corrosion by providing a protective layer, preventing moisture and oxygen from contacting the steel.
- Coatings were specified during original construction and are maintained through the site coatings program.

- Discovery of any protective coating degradation in accessible areas is accomplished by a number of activities, including periodic documented inspections by assigned system engineers.
- Discovery of any protective coating degradation in inaccessible areas is accomplished by either making these areas accessible (such as scaffolding) or to identify similar coatings in accessible areas and monitor their condition as a representative sample of the condition of coatings in inaccessible locations.
- Therefore, there is reasonable assurance that structural and/or functional support, shelter/protection, rated fire barrier, or flooding protection functions provided by steel components will be maintained, consistent with the CLB during the period of extended operations.

Conclusion

The programs discussed for structures are listed in the following table. These pr. grams are administratively controlled by a formal review and approval process. As demonstrated above, these programs will manage the aging mechanisms and their effects such that the intended functions of the structures will be maintained, consistent with the CLB, during the period of extended operations.

The analysis/assessment, corrective action, and confirmation/documentation process for license renewal is in accordance with QL-2, "Corrective Actions Program." QL-2, is pursuant to Appendix B and covers all structures and components subject to aging management review."

TABLE 7.1-4

LIST OF AGING MANAGEMENT PROGRAMS FOR STRUCTURES

Program	Credited as:	Developmental References
Plant Engineering Guideline on System Walkdowns	Administrative controls for periodic inspection which manage the effects of corrosion of steel for accessible steel components.	
CCNPP's Protective Coating and Painting Program MN-3-100	Administrative controls for periodic inspection which mitigate and manage the effects of corrosion of steel for accessible steel components.	14 - 21
Age-related degradation inspection (ARDI) program (new) to investigate inaccessible steel locations	Management of the effects of corrosion of steel for inaccessible steel components.	new

APPENDIX A

TECHNICAL INFORMATION

TABLE 7.1-5

LIST OF REFERENCES FOR STRUCTURES

1. CCNPP Updated Final Safety Analysis Report, Revision 19.

2. "Aging Management Review Report for the Containment System (059)," Revision 3, May 1996

3. "Aging Management Review Report for the Containment Structure (059)," Revision 1, May 1996

4. "Aging Management Review Report for the Intake Structure ," Revision 2, May 1996

5. "Aging Management Review Report for the Turbine Building," Revision 2, May 1996

6. "Aging Management Review Report for the Auxiliary Building," Revision 2, May 1996

7. "Aging Management Review Report for the Fuel Oil Storage Tank No. 21 Enclosure," Revision 2, May 1996

8. "Aging Management Review Report for the Condensate Storage Tank No. 12 Enclosure," Revision 2, May 1996

9. "Examination of the Unit 1 Containment Structure - Calvert Cliffs Nuclear Power Plant," August 1992.

10. "Examination of Condensate Storage Tank #12 Enclosure - Calvert Cliffs Nuclear Power Plant," September 21, 1994.

11. "Examination of Fuel Oil Storage Tank #21 Enclosure - Calvert Cliffs Nuclear Power Plant," September 21, 1994.

12. "Examination of Intake Structure - Calvert Cliffs Nuclear Power Plant," October 24, 1994.

13. "Examination of Auxiliary Feedwater Pump Rooms - Calvert Cliffs Nuclear Power Plant," October 27, 1994.

14. USNRC Regulatory Guide 1.54, Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants

15. ANSI N101.2 - 1972, Protective Coatings (Paints) for Light Water Nuclear Reactor Containment Facilities

16. ANSI N101.4 - 1972, Quality Assurance for Protective Coatings Applied to Nuclear Facilities

17. ASTM D3843 - 89, Standard Practice for Quality Assurance for Protective Coatings Applied to Nuclear Facilities

18. ASTM D5144 -91, Standard Guide for Use of Protective Coatings Standards in Nuclear Power Plants

19. ASTM D5163.91, Standard Guide for Establishing Procedures to Monitor the Performance of Safety-related Coatings in an Operating Nuclear Power Plant

20. Manual on Maintenance Coatings for Nuclear Power Plants, ASTM Manual Series: MNL 8

21. Steel Structures Painting Manual (SSPC), Volume 1 and 2 prepared by Steel Structures Painting Council, Pittsburgh, PA

7.6.2 Aging Management

The potential age-related degradation mechanisms (ARDMs) for component supports are identified in Table 7.6-3. Those ARDMs identified as plausible for a group of supports are noted by a check mark (✓) in the appropriate column. Those ARDMs which were evaluated but determined to be not plausible for a particular group of supports are marked "not plausible." Those ARDMs which were not evaluated for a group of supports because they are not applicable to the group are marked N/A. Those that were evaluated but were determined to be not plausible for any group of supports in this commodity evaluation are listed in a note to the table.

Where ARDMs were determined to be plausible, an aging management strategy was selected which involves both methods to mitigate the effects of the plausible ARDMs and methods to discover their effects. For component supports, discovery methods involve two separate but complementary sets of activities. The first set of activities consists of baseline walkdowns or inspections which are conducted one time to determine whether the plausible ARDMs are actually occurring for the supports potentially affected. The second set of activities involves follow-on actions which occur repetitively. The nature of the follow-on actions is dictated by the results of the baseline inspection or walkdowns. For example, if no evidence is found that the plausible ARDM is occurring during the baseline inspection, the follow-on actions credited may consist of periodic documented walkdowns by system engineers to ensure that this condition continues. If evidence of significant aging is found for certain groups during the baseline activities, follow-on actions consist of aging management activities that are formulated to address the condition discovered during the baseline inspection. Baseline and follow-on activities are discussed in more detail under each component support group heading.

Piping Supports

A wide variety of piping support types are installed in systems within the scope of license renewal depending on the design requirements of individual piping configurations. During the Aging Management Review, those piping supports which contain threaded fasteners in their load bearing path were evaluated separately from those without such fasteners. Within each of these types, supports inside containment were evaluated separately from those outside since the environment in containment is typically more severe for aging and provides fewer opportunities for routine discovery of degraded conditions. Tables 7.6-2 and 3 show the resulting four groups of piping supports. Even though the AMR determined that different piping support types are subject to different aging mechanisms, with few exceptions all types of piping supports were determined to be subject to the same aging effects and these effects are managed in a similar manner. Therefore, piping supports of all types are addressed in this section and any discussion which only applies to a particular type is noted as such.

Piping Supports - Materials and Environment. Piping supports are constructed of structural steel. Piping supports are located inside the containment buildings and inside other climate controlled buildings.

Inside Containment:

- The maximum design ambient air temperature is 120°F for normal, startup, and shutdown operation.
- The design ambient air pressure is 14.7 psia. Ambient air pressure is limited to -1.0 to +1.8 psig during normal plant operation.
- The design ambient air relative humidity during normal plant operation is 50% at 120°F and 14.7 psia.

TABLE 7.6-3

POTENTIAL AND PLAUSIBLE ARDMs FOR COMPONENT SUPPORTS

Potential ARDMs	Component Types for Which ARDM is Plausible							
	Piping Supports				Cable Raceway Supports		HVAC Ducting Supports	
	Spring Hangers, Constant Load Supports, Sway Struts, Rod Hangers, and Snubber Supports Outside Containment	Spring Hangers, Constant Load Supports, Sway Struts, Rod Hangers, and Snubber Supports Inside Containment	Piping Frames Outside Containment	Piping Frames Inside Containment	Channel, Clamp, and Other Supporting Styles Outside Containment	Channel, Clamp, and Other Supporting Styles Inside Containment	Rod Hanger, Trapeze Supports Outside Containment	Rod Hanger, Trapeze Supports Inside Containment
General Corrosion of Steel	✓	✓	✓	✓	✓	✓	✓	✓
Elastomer Hardening	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Loading Due to Rotating/ Reciprocating Machinery	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Loading Due to Hydraulic Vibration or Water Hammer	✓	✓	not plausible	not plausible	N/A	N/A	N/A	N/A
Loading Due to Thermal Expansion of Piping/ Component	✓ *	✓ *	not plausible	not plausible	N/A	N/A	N/A	N/A
Other Loading (Abuse, Impacts, Accidents)	✓	not plausible	✓	not plausible	✓	not plausible	✓	not plausible

Note: Not plausible for entire commodity group:
- radiation embrittlement of steel
- grout/concrete local deterioration
- stress corrosion cracking of high strength bolting
- thermal effects on steel
- lead anchor creep

* not plausible for snubbers

TABLE 7.6-3 (continued)

POTENTIAL AND PLAUSIBLE ARDMs FOR COMPONENT SUPPORTS

Potential ARDMs	Equipment Support Types for Which ARDM is Plausible											
	Anchorage Including Elastomer Vibration Isolators	Electrical Cabinet Anchorage Outside Containment	Electrical Cabinet Anchorage Inside Containment	Electrical Equip. (load bearing insulation material)	Equipment Frames (Instruments & batteries on racks) Outside Containment	Equipment Frames (Instruments on racks) Inside Containment	Frames and Saddles (Tanks & Heat Exchangers Outside Containment	Frames and Saddles (Tanks & Heat Exchangers Inside Containment	Metal Spring Isolators & Fixed Bases Outside Containment	Metal Spring Isolators & Fixed Bases Inside Containment	LOCA Restraints	Ring Foundation for Flat-bottom Vertical Tanks
General Corrosion of Steel	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Elastomer Hardening	✓	N/A	N/A	✓	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Loading Due to Rotating/ Reciprocating Machinery	not plausible	N/A	N/A	N/A	N/A	N/A	N/A	N/A	✓	✓	✓	N/A
Loading Due to Hydraulic Vibration or Water Hammer	N/A	N/A	N/A	N/A	N/A	N/A	✓	✓	N/A	N/A	✓	N/A
Loading Due to Thermal Expansion of Piping/ Component	N/A	N/A	N/A	N/A	N/A	N/A	✓	✓	N/A	N/A	not plausible	✓
Other Loading (Abuse, Impacts, Accidents)	✓	✓	not plausible	✓	✓	not plausible	✓	not plausible	✓	not plausible	not plausible	✓

Note: Not plausible for entire commodity group:

- radiation embrittlement of steel
- grout/concrete local deterioration
- stress corrosion cracking of high strength bolting
- thermal effects on steel
- lead anchor creep

In the other buildings:

- Ambient temperatures are controlled by plant ventilation systems as specified in UFSAR Chapter 9. The plant ventilation systems are designed to provide minimum (winter) and maximum (summer) building air temperatures as specified in UFSAR, Table 9-18. Certain areas are maintained by safety related ventilation systems. The remaining areas are ventilated by non-safety related ventilation systems and are maintained at or below the maximum design temperatures.
- General plant areas are at atmospheric pressure. Certain Auxiliary Building areas are maintained positive or negative to the ambient air pressure for control of airborne radiological releases.
- There are no design humidity requirements for these areas.

Piping Supports - Plausible Aging Mechanisms and Effects on Intended Functions. As shown in Table 7-6.3, general corrosion, loading due to hydraulic vibration, loading due to thermal expansion and other loading (abuse, impacts, accidents) are the ARDMs considered to be plausible for piping supports.

General corrosion is plausible for all piping supports because normal humidity levels in the plant could result in moisture coming into contact with the structural steel supports. During the plausibility determination, no credit is taken for the protective coating applied to these supports; however, this protective coating plays an important role in the aging management approach for piping supports.

Loading due to hydraulic vibration and thermal expansion is considered plausible for spring hangers, constant load supports, sway struts and rod hangers because these types of supports have threaded fasteners in the load bearing path which could be loosened by such loading. Piping supports are designed to accommodate a broad range of loading conditions. However, over time loading could result in degraded support conditions.

For snubber supports, loading due to thermal expansion was determined to be not plausible because, by design, snubbers do not restrict movement due to thermal expansion. Loading due to hydraulic vibration was determined to be plausible for snubber supports because snubbers do restrict this type of movement.

Piping supports without threaded fasteners in the load bearing path are only allowed in applications where loading due to hydraulic vibration and thermal expansion are small relative to other design loads. Therefore, loading due to thermal expansion and hydraulic vibration were determined to be not plausible for this type of support.

Other loading (abuse, impacts, accidents) was determined to be a plausible ARDM for all piping supports outside of containment. Piping systems inside containment are accessible for a much shorter time period than similar systems outside of containment. Additionally, containment closeout inspections prior to restart are designed to discover any degraded conditions of piping supports inside containment prior to operating the system at power. Consequently, this ARDM was determined to be not plausible for piping supports of all types inside containment.

Stress corrosion cracking (SCC) of support bolting was determined to be not plausible, both inside and outside of containment. Industry experience has shown that high strength bolting (i.e. those with yield strength greater than 150 KSI) installed in some NSSS applications inside containment could be subject to stress corrosion cracking in a humid environment. However, BGE concludes that there is no high strength bolting installed in piping support applications at CCNPP for the following reasons:

- Industry experience with SCC of high strength bolting in a humid environment has shown that such high strength bolting is likely to fail in a matter of months after installation.
- Such failures would have been discovered and corrected during the routine plant operations and maintenance activities including the baseline discovery activities discussed in the following paragraphs.
- Additionally, plant construction practices would have made it highly unlikely that high strength bolting would be installed in such applications during plant construction even though equipment specifications typically did not place an upper limit on bolting strength.
- Current design standards for piping supports do contain guidance on bolting materials to be used for piping supports.

Because there is no high strength bolting in piping support applications, SCC was determined to be not plausible for piping supports.

The effects of general corrosion on piping supports would be a loss of support material and consequently a reduction in component support strength if the ARDM were allowed to progress unmanaged. The effects of loading due to hydraulic vibrations, thermal expansion and other loading would initially be loosened threaded fasteners in the load bearing path of the support. If these mechanisms were left unmanaged, the effects could progress to the point of reducing the amount of support afforded to the piping and/or allowing excessive motion of the supported piping. This failure of the piping supports' intended function could, in turn, lead to failure of the piping pressure boundary under design basis loading conditions.

Piping Supports - Methods to Manage the ARDMs. Methods to manage aging of the piping supports are discussed in two categories: (1) Mitigation measures are activities which reduce the likelihood or rate of the ARDMs. (2) Discovery techniques are those that can reasonably detect the effects of aging prior to loss of intended function.

To mitigate the effects of general corrosion, the conditions on the external surfaces of the piping supports must be controlled. Significant rates of corrosion related ARDMs only occur when the piping supports come into contact with moisture. Preventing direct and prolonged contact between metal surfaces and moisture is an effective mitigation technique for general corrosion.

For discovery, the effects of the general corrosion are detectable by visual techniques. Because much of the external metal surfaces of the piping supports are covered by a protective coating, observing that significant degradation has not occurred to this coating is an effective method to ensure that corrosion has not affected the intended function of the piping supports. Coatings degrade slowly over time, allowing visual detection during normal operations. Because the coating does not contribute to the intended function of the supports, observing the coating for

degradation provides an alert condition which can trigger corrective action at the onset of degradation of the support itself, long before degradation affects the support's ability to withstand the most limiting design loading conditions.

The effects of excessive loading from thermal expansion, hydraulic vibrations or other loading (abuses, impacts, accidents) are observable initially in the form of loosened threaded fasteners in the load bearing path of the support, again at the onset of degradation.

Therefore, adequate discovery techniques for piping support aging need to include both a visual observation of the general condition of the supports to address general corrosion and examination of the piping supports for loose parts, loosened fasteners and adequate tightness of bolting to address the loading-related ARDMs.

Piping Supports - Identification and Description of Aging Management Programs. Mitigation and discovery methods are implemented in CCNPP programs to manage the effects of aging on the intended function of piping supports. The plant programs described below apply to all piping supports within the scope of license renewal with the exceptions noted.

To mitigate general corrosion, a combination of plant programs ensures that the external metal surfaces of the piping supports are not in contact with a moist, aggressive environment for extended periods of time.

- The "Paint and Preservation Program" (based on references 10 through 18) controls painting and coating activities at CCNPP. Differing levels of control exist, with the highest controls applied to items inside the Containment buildings and the lowest being applied to the "balance of plant" items. The coatings inside containment are checked for proper thickness when applied. Every outage the condition of the coatings is visually inspected and evaluated for corrective action. Outside Containment, controls exist for application standards, measurement, etc. but activities to ensure the coatings remain intact are left to other programs, such as those described next. [MN-3-100]

- The "Control of Shift Activities" (based on references 2 and 19 through 33) and "Ownership of Plant Operating Spaces" (based on reference 34) programs ensure that aggressive conditions such as pooled water are not allowed to remain for extended time periods.

    - Control of Shift Activities directs plant operators to inspect their entire operating spaces twice per shift and to report any deficiency (When shutdown, the containment is inspected once per shift.) The procedure lists detailed acceptance criteria, including items such as oil/water leakage, floor drains/gratings clear, normal temperature and humidity for the area, etc.

    - The Ownership of Plant Operating Spaces program assigns all plant areas to an "owner." Owners are required to periodically inspect their space for deficiencies defined in the procedure, including paint, rust, and missing supports.

    - Official assessments of programs such as these that contribute to the plant's "housekeeping" (including NRC comments) have been historically noted as effective

in identifying deficiencies in plant areas.[NO-1-200][NO-1-107][Fourth Quarter Safety Performance Evaluation - 1995]

For discovery, as discussed previously, the level of aging management activity needed for each category of component supports is determined based on the condition observed during a baseline walkdown of a representative sample of supports of each category. Therefore, discovery activities are discussed in two categories, baseline activities and follow-on aging management activities. The as-found condition during the baseline walkdown dictates the level of follow-on aging management needed for the support type.

Baseline Walkdowns (for 12 of the 20 supported systems) - Completed in-service inspection activities serve as an adequate baseline activity to document the condition of piping supports for 12 of the 20 systems within the scope of license renewal which contain these types of supports. (The ISI program is described in more detail later, under Follow-on Activities.) The ASME Section XI ISI for component supports includes a visual examination of a prescribed sampling of piping supports in the 12 systems covered by this program. The visual examination contains the following elements which would detect the effects of excessive general corrosion in a timely manner:

1) a visual examination to determine the general mechanical and structural condition of the support, and
2) a check for loose parts, debris, abnormal corrosion products, wear, erosion, corrosion and loss of integrity of bolted or welded connections.

ASME Section XI ISI includes the following additional elements, which are performed during the visual examination, that ensure that excessive loading, regardless of its cause, is discovered in a timely manner:

1) measurement of clearances,
2) detection of physical displacement,
3) structural adequacy of supporting elements,
4) connections between load-carrying structural members, and
5) tightness of bolting.

ASME Section XI ISI contains acceptance criteria which require corrective action if the effects of significant aging are discovered. These acceptance criteria are set at levels such that the corrective actions taken will ensure that the piping supports remain capable of performing their intended function under all design loading conditions.

Baseline Walkdowns (8 non-ISI systems) - Eight of the systems within the scope of license renewal that contain piping supports are not subject to ASME Section XI ISI inspections. These systems are:

Well and Pretreated Water	Plant Heating
Fire Protection	Demineralized Water and Condensate Storage
Compressed Air	NSSS Sampling System
Diesel Fuel Oil	Condensate System

Due to the diversity in loading conditions affecting piping systems, a conclusion could not be reached that the piping systems which are inspected by the ISI activities are fully representative of those that have not been inspected by this baseline activity. Therefore, additional sampling baseline walkdowns will be performed.

These walkdowns will consist of a sampling of the supports within the scope of license renewal for the eight systems listed above. The sample approach will be comparable to the approach required by ASME Section XI for piping supports of ASME Class 3 systems. The additional walkdowns will execute those steps of the ASME Section XI ISI inspections which are relied upon to detect general corrosion and loading due to excessive thermal expansion, hydraulic vibration or other loading as described above. These walkdowns will document the condition of the piping supports within the scope of license renewal and within this component support type for the eight systems listed above. Once these additional walkdowns are completed, an adequate baseline condition assessment will have been completed for the entire group of supports.

Follow-on Activities (for 12 of the 20 supported systems) - Based on the results of baseline inspections completed per the existing ISI requirements, it was determined that continuing ASME Section XI ISI inspections into the period of extended operations will also serve as an adequate follow-on activity for those piping systems subject to that program.

ASME Section XI ISI (based on references 2, 32, and 35 through 39) requires inspections of piping supports at periodic intervals such that all piping supports of code class systems are inspected on a sampling basis once per inspection interval. Inspection intervals are established based on the requirements of an established industry code (i.e. ASME Section XI). The current inspection interval for CCNPP is 10 years.

Follow-on Activities (8 non-ISI systems) - For piping supports not covered by ISI requirements, the results of the additional baseline walkdowns described above will determine the extent of aging management practices needed for these supports. If the baseline walkdowns reveal no significant effects of aging, then the follow-on activities for aging management of these piping supports will be system engineer walkdowns of their assigned systems. These walkdowns, conducted in accordance with a Plant Engineering Guideline entitled "System Walkdowns," have the following characteristics:

- Walkdowns are conducted at periodic intervals, as set by the Plant Engineering Guideline, based on system performance, operating conditions, etc.
- Walkdowns are performed by the assigned system engineer, who is familiar with the system and its condition. Signs of corrosion or effects of excessive loading would be detected by this individual.
- To assist the system engineer in detecting such conditions, the "System Walkdown" guideline contains a checklist, which contains items related to aging of piping supports, on which to document conditions observed during the walkdown.
- As a further aid to systems engineers conducting these walkdowns, a Design Engineering Standard entitled "Piping Support Inspections" has been prepared to detail acceptable and unacceptable conditions of piping supports. Excerpts from this

standard are included in the system walkdown guideline as an attachment to aid the system engineer.

- The Plant Engineering Guideline on System Walkdowns requires that any unusual condition observed during the system engineer's walkdown of piping supports be recorded on the walkdown sheet and assistance obtained from design engineering in evaluating the impact of the unusual condition. Conditions that warrant further action are documented on an issue report and the site corrective action program tracks the status of corrective actions.

Follow-on Activities (snubbers) - For snubber supports an additional follow-on aging management activity is credited. Although the snubbers themselves are determined to be active components in the license renewal rule, the hardware that connects the snubber to the pipe/component and to the structural member are considered passive. Plant Technical Specification 4.7.8.1 requires periodic surveillance of snubbers to ensure functionality. The periodicity is based on past results and is in accordance with a table in the Technical Specifications. Many of the steps of this surveillance address the functionality of the active snubber and are not credited as aging management activities in the context of the license renewal rule. However, several steps of the surveillance also address the passive snubber supports. The surveillance requires verification that snubber installation exhibits no signs of detachment from foundation or supporting structures including clamps, welds, Hilti bolts, general condition of concrete as well as steps to verify that the pipe clamp/rod eye bracket is in satisfactory condition and the snubber is properly aligned. Any abnormal condition discovered during this surveillance must be reported and resolved in accordance with the site issue reporting and corrective action process.

Piping Supports - Demonstration. Based on the factors presented above, the following conclusions can be reached with respect to the piping supports for piping systems within the scope of license renewal:

- Piping supports associated with piping in the scope of license renewal are themselves considered to be within the scope of license renewal because failure of these supports could lead to failure of the supported component.
- General corrosion, loading due to hydraulic vibration, loading due to thermal expansion and other loading (abuse, impacts, accidents) were determined to be plausible ARDMs for piping supports. The effects of these ARDMs are loss of strength of the piping support and loosened threaded fasteners in the load bearing path. These effects, if left unmanaged, could lead to loss of the intended function of the piping supports and ultimately to failure of the supported piping under normal or more severe loading conditions.
- General corrosion is mitigated by applying coatings to component supports, then periodically examining the supports for degradation of that coating or conditions that could accelerate degradation..
- Baseline discovery programs include elements which would enable these activities to discover the effect of all plausible aging mechanisms and to determine the appropriate level of follow-on aging management activities. All piping supports within the scope of license renewal have either been inspected under the existing ASME Section XI In-Service Inspection program baseline activity or will be inspected using similar techniques and standards to establish a baseline condition for license renewal. The baseline activities

conducted to date for a wide range of piping systems have revealed no significant aging effects which require more specialized aging management practices.

- Follow-on discovery activities include ASME Section XI In-Service Inspections, System Engineer Walkdowns and the Snubber Surveillance Inspections. These activities include elements which would ensure discovery of the effects of all plausible aging mechanisms and require corrective action and actions to prevent recurrence of problem conditions as appropriate. All piping supports within the scope of license renewal are subject to one or more of these follow-on discovery activities.
- The discovery aging management activities (Section XI inspections, additional baseline walkdowns of selected piping systems, system engineer walkdowns and snubber surveillances) detect and correct any adverse effects of general corrosion and loading-related ARDMs well before these ARDMs would have an impact on the intended support function of the piping supports under all design loading conditions.
- Therefore, there is reasonable assurance that the effects of aging will be adequately managed such that the piping supports will be capable of performing their structural support function consistent with the CLB during the period of extended operations.

<u>Conclusion</u>

The programs discussed for aging management of component supports are listed in the following table. These programs are administratively controlled by a formal review and approval process. As demonstrated above, these programs will manage the effects of aging such that the intended function of the Component Supports within the scope of license renewal will be maintained, consistent with the CLB, during the period of extended operations.

The analysis/assessment, corrective action, and confirmation/documentation process for license renewal is in accordance with QL-2, "Corrective Actions Program." QL-2 is pursuant to Appendix B and covers all structures and components subject to aging management review.

Table 7.6-4
List of Aging Management Programs for Component Supports

Program Name	Credited As
Control of Shift Activities and Ownership of Plant Spaces	Mitigation program to ensure that environments which might accelerate aging of component supports are not allowed to be present for extended time period.
Section XI In Service Inspection of Piping Supports	Baseline discovery activity for all piping systems within the scope of license renewal except the eight systems mentioned.
Additional Baseline Walkdowns of the portions of eight piping systems within the scope of license renewal.	Baseline discovery activity for the in-scope portions of the Well and Pretreated Water, Fire Protection, Compressed Air, Diesel Fuel Oil, Plant Heating, Demineralized Water and Condensate Storage, NSSS Sampling, and Condensate Systems
Section XI In Service Inspection of Piping Supports	Follow-on discovery activity for those systems covered by this program.
Plant Engineering Guideline on System Walkdowns	Follow-on discovery activity for those piping systems not covered by the Section XI ISI program.
Snubber Surveillance Procedure	Follow-on discovery activity for snubber supports within the scope of this commodity evaluation.

REFERENCES

1. "Calvert Cliffs Nuclear Power Plant Units 1 and 2, Aging Management Review of Component Supports," September 1995

2. CCNPP Updated Final Safety Analysis Report, Revision 19

3. Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant equipment Dated February 1992, copyright Seismic Qualification Utility Group (SQUG), Revision 2, corrected February 14, 1992

4. ASME Boiler and Pressure Vessel Code Section XI, "Rules for In-Service Inspection of Nuclear Power Plant Components," 1983 edition with Addenda through Summer 1983

5. PEG-7, "Plant Engineering Section Guideline, System Walkdowns," Revision 4, November 1995

6. STP-M-12-1, "Unit 1 Accessible Snubber Visual Inspection," Revision 12, January 3, 1996

7. STP-M-12-2, "Unit 2 Accessible Snubber Visual Inspection," Revision 14, January 3, 1996

8. STP-M-13-1, "Unit 1 Inaccessible Snubber Visual Inspection," Revision 15, January 3, 1996

9. STP-M-13-2, "Unit 2 Snubber Inspection (Inaccessible)," Revision 13, January 3, 1996

10. USNRC Regulatory Guide 1.54, Quality Assurance

11. Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants

12. ANSI N101.2 - 1972, Protective Coatings (Paints) for Light Water Nuclear Reactor Containment Facilities

13. ANSI N101.4 - 1972, Quality Assurance for Protective Coatings Applied to Nuclear Facilities

14. ASTM D3843 - 89, Standard Practice for Quality Assurance for Protective Coatings Applied to Nuclear Facilities

15. ASTM D5144 -91, Standard Guide for Use of Protective Coatings Standards in Nuclear Power Plants

16. ASTM D5163.91, Standard Guide for Establishing Procedures to Monitor the Performance of Safety-related Coatings in an Operating Nuclear Power Plant

17. Manual on Maintenance Coatings for Nuclear Power Plants, ASTM Manual Series: MNL 8

18. Steel Structures Painting Manual (SSPC), Volume 1 and 2 prepared by Steel Structures Painting Council, Pittsburgh,

19. CFR 50.54, Conditions of Licenses

20. CFR 50, Appendix R

21. CFR 55, Operator's Licenses

22. PR-1-100, Preparation and Control of Calvert Cliffs Administrative Procedures

23. INPO 84-021 (OP-204), Conduct of Operations

REFERENCES

1. "Calvert Cliffs Nuclear Power Plant Units 1 and 2, Aging Management Review of Component Supports," September 1995
2. CCNPP Updated Final Safety Analysis Report, Revision 19
3. Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant equipment Dated February 1992, copyright Seismic Qualification Utility Group (SQUG), Revision 2, corrected February 14, 1992
4. ASME Boiler and Pressure Vessel Code Section XI, "Rules for In-Service Inspection of Nuclear Power Plant Components," 1983 edition with Addenda through Summer 1983
5. PEG-7, "Plant Engineering Section Guideline, System Walkdowns," Revision 4, November 1995
6. STP-M-12-1, "Unit 1 Accessible Snubber Visual Inspection," Revision 12, January 3, 1996
7. STP-M-12-2, "Unit 2 Accessible Snubber Visual Inspection," Revision 14, January 3, 1996
8. STP-M-13-1, "Unit 1 Inaccessible Snubber Visual Inspection," Revision 15, January 3, 1996
9. STP-M-13-2, "Unit 2 Snubber Inspection (Inaccessible)," Revision 13, January 3, 1996
10. USNRC Regulatory Guide 1.54, Quality Assurance
11. Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants
12. ANSI N101.2 - 1972, Protective Coatings (Paints) for Light Water Nuclear Reactor Containment Facilities
13. ANSI N101.4 - 1972, Quality Assurance for Protective Coatings Applied to Nuclear Facilities
14. ASTM D3843 - 89, Standard Practice for Quality Assurance for Protective Coatings Applied tc Nuclear Facilities
15. ASTM D5144 -91, Standard Guide for Use of Protective Coatings Standards in Nuclear Power Plants
16. ASTM D5163.91, Standard Guide for Establishing Procedures to Monitor the Performance of Safety-related Coatings in an Operating Nuclear Power Plant
17. Manual on Maintenance Coatings for Nuclear Power Plants, ASTM Manual Series: MNL 8
18. Steel Structures Painting Manual (SSPC), Volume 1 and 2 prepared by Steel Structures Painting Council, Pittsburgh,
19. CFR 50.54, Conditions of Licenses
20. CFR 50, Appendix R
21. CFR 55, Operator's Licenses
22. PR-1-100, Preparation and Control of Calvert Cliffs Administrative Procedures
23. INPO 84-021 (OP-204), Conduct of Operations