BGE

Calvert Cliffs Nuclear Power Plant

License Renewal Project

Aging Management Review Report

for the

Main Feedwater System

(045)

Revision 1

April, 1996

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List of Effective Pages

Page	Revision	Change Description
All	0	Initial issue
All	1	General update for CCNPP IPA Methodology, Revision 1, and revision to component pre-evaluation and aging management review

1.0 INTRODUCTION

1.1 Feedwater System Description

This section describes the scope and boundaries of the Feedwater System as it was evaluated. Section 1.1.1 provides a brief synopsis of the system as described in existing plant documentation. System boundaries (as described in ES-032, Revision 0) are provided in Section 1.1.2 to clarify the extent of the Feedwater System considered in this evaluation. Section 1.1.3 is a detailed breakdown of the intended system functions within the scope of license renewal and is provided as the basis for the identification of components required to support those-intended functions.

1.1.1 Feedwater System Description

The conceptual functional requirements of the Feedwater System are:

- to transfer feedwater from the steam generator feed pump suction to the steam generators,
- to regulate the flow of feedwater to the steam generators and to maintain a constant water level in the steam generators,
- To heat the condensate received by the feed pumps,
- To provide a means for injecting chemicals into the steam generators from the chemical addition system.

The condensate booster pumps deliver the condensate to the two turbine-driven steam generator feed pumps through two parallel sets of three low pressure feedwater heaters. The steam generator feed pumps then pump the condensate through two parallel high pressure feedwater heaters to the steam generators.

The Feedwater System was determined to be within the scope of license renewal during the system level scoping process.

1.1.2 Feedwater System Boundary

The Feedwater System is comprised of the following equipment:

Pumps	turbine-driven centrifugal steam generator feed pumps (SGFP)
Valves	minimum pump recirculation flow control feedwater regulating regulating valve bypass
Pump seal water system	
Heat Exchanger	High pressure feedwater heaters
Piping	
Instrumentation	

The Feedwater System interfaces with the following systems and components:

Condensate System
Main Steam System
Chemical Addition System
Emergency Safety Features Actuation System
Extraction Steam System
Reactor Coolant System (Steam Generator)

1.1.3 Feedwater Intended System Functions

- Send signals to ESFAS and provide SG isolation
- Provide containment overpressure protection
- Prevent reverse flow from SG via check valve closure
- Maintain functionality of electrical equipment as addressed by the EQ Program
- To maintain the pressure boundary of the system
- To provide information used to assess the plant and environs condition during and following an accident
- Provide SG level indication

- To maintain electrical continuity and/or provide protection of the electrical system
- Provide signals to AFAS
- Provide signals to RPS
- Monitor steam generator level to support safe shutdown in the event of a postulated severe fire

1.2 Evaluation Methods

Feedwater System components within the scope of license renewal were identified through the use of BGE procedure for Component Level Scoping of Systems. The results of the scoping process are discussed in Section 2.0 of this report.

Feedwater System components subject to aging management review for license renewal were determined using the BGE procedure for Component Pre-Evaluation to identify passive, long-lived components that must be evaluated for management of the effects of age-related degradation. The results of the Pre-evaluation process are discussed in Section 3.0 of this report.

All components subject to aging management review are evaluated for the effects of aging in accordance with the BGE procedure for Component Aging Management Review. This procedure is performed to determine plausible aging effects and the appropriate methods to manage those effects. The results of the Aging Management Review (AMR) process are discussed in Section 4.0 of this report.

1.3 System-Specific Definitions

This section provides the definitions for any specific terms unique to the Feedwater component aging evaluation.

No terms unique to the Feedwater System were used.

1.4 System-Specific References

Several sources were used to determine potential and plausible ARDMs for the Feedwater evaluation. These sources include NRC Draft Regulatory Guide DG-1009, "Standard Format and Content of Technical Information for Applications to Renew Nuclear Power Plant Operating Licenses". Detailed drawings and other controlled documents related to the Feedwater System were utilized to verify materials, design configurations and location of components.

Table 1-1 lists the references utilized in the completion of the Feedwater System Aging Management Review for license renewal.

Table 1-1
System Specific References

Document ID	Document Title	Revision	Date
-	ANSI B31.1; Power Piping Code		1967
-	ANSI B31.7; Nuclear Power Piping Code		1969
-	ASME Boiler and Pressure Vessel Code, Section XI, Subsection IWV-2000		83S83
-	ASME Wear Control Handbook, Peterson and Winer		1980
-	CCNPP ASME Section XI Pump and Valve Test Program, Second Ten Year Interval	1	
-	CCNPP Integrated Plant Assessment Methodology	1	
-	Component Level ITLR Screening Results for the Feedwater System	1	
-	Corrosion and Corrosion Control - Uhlig and Revie	3rd Edition	1985
-	Corrosion Engineering - Fontana & Greene	3rd Edition	1978
-	Mark's Standard Handbook for Mechanical Engineers - McGraw-Hill	8th Edition	
-	Metals Handbook - ASM; Volumes 1 and 13	9th Edition	1978
-	Pre-evaluation Results for the Main Feedwater System (045)	1	
-	System Level Scoping Results	4	
10452052	Feedwater Check Valve Inspection Repetitive Task		11/10/95
10452053	Feedwater Check Valve Inspection Repetitive Task		11/10/95
12399-0002	Cast Steel Horizontal and Vertical Tilting Disk Check Valve Drawing	12	
12399-0022SH0001	Cast Steel Horizontal and Vertical Tilting Disk Check Valve Drawing	5	
12543A-01	Feedwater Piping Isometric Drawing, Unit 1	13	
12717-0002	Carbon Steel Pressure Seal Gate Valve Drawing	L	

Table 1-1
System Specific References

Document ID	Document Title	Revision	Date
13547A-20	Feedwater Piping Isometric Drawing, Unit 2	6F	
13547A-47	Feedwater Piping Isometric Drawing, Unit 2	4	
13549A-26	Feedwater Piping Isometric Drawing, Unit 2	3	
15587-0008	Vogt 3/4" Globe Valve Drawing	20	
15587-0021	Vogt 3/4" Globe Valve Drawing	5	
15587-0027	Vogt 1" Gate Valve Drawing	3	
20452043	Feedwater Check Valve Inspection Repetitive Task		11/10/95
20452044	Feedwater Check Valve Inspection Repetitive Task		11/10/95
60702SH0004	Condensate and Feedwater System Operations Drawing	28	
62702SH0004	Condensate and Feedwater System Operations Drawing	30	
6750-M-355	Equipment Specification for Thermocouple, RTD, and Thermowells	15	
92702	Special Thermowell For Thermocouples and Test Wells Drawing	3	
92767	Piping Class Sheets	58	
92771	Master Valve List	41	
CE-NPSD-634-P	Fatigue Monitoring Program For CCNPP Units 1&2		4/92
CP-0217	Specifications And Surveillance - Secondary System Chemistry Procedure	5	
DG-1009	Draft Reg. Guide - 1009, Standard Format and Content of Technical Information for Applications to Renew Nuclear Power Plants, Appendix A	Draft	12/90
FSK-MP-1003	Root Valves for Level Transmitters Drawing	5	
IR1-011-785	S/G Feedwater Nozzle/Piping Thermal Stratification Issue Report		
LCM-16	LCM Component Aging Management Review Procedure	4	

Table 1-1
System Specific References

Document ID	Document Title	Revision	Date
LCM96-044	BGE Memorandum, Subject: Age Related Degradation Inspections, dated February 15, 1996, BMT to Distribution		2/15/96
NP-2129	EPRI Report - Radiation Effects on Organic Materials in Nuclear Plants		11/81
NP-3944	EPRI Report - Erosion/Corrosion in Nuclear Plant Steam Piping		4/85
NP-5461	EPRI Report - Component Life Estimation: LWR Structural Materials Degradation Mechanisms		1987
NP-5775	EPRI Report Environmental Effects on Components: Commentary for ASME Section III		4/88
NP-5985	EPRI Report - Boric Acid Corrosion of Carbon and Low Alloy Steel Pressure Boundaries		1988
NP-6815D	EPRI Report - Detection and Control of MIC		1990
NUMARC 90-07	PWR Reactor Coolant System License Renewal Industry Report		5/92
NUREG/CR-5379	Nuclear Plant Service Water System Aging Degradation Assessment, Volume 1 and 2		6/89, 10/92
NUREG/CR-5419	Aging Assessment of Instrument Air Systems		1/90
NUREG/CR-5643	Insights Gained from Aging Research		3/92
OI-12A-1	Unit 1 Main Feedwater Operating Instructions	22	
OI-12A-2	Unit 2 Main Feedwater Operating Instructions	14	
PT-0009-204	Qualification Maintenance Requirements Sheet	0	
PT-0009-205	Qualification Maintenance Requirements Sheet	0	
TPR96-022	Technical Problem Report; Feedwater System S/G Check Valve Thermal Fatigue		3/25/96
TR-102204	EPRI Report - Service (Salt) Water System Life Cycle Management Evaluation		4/93

Table 1-1
System Specific References

Document ID	Document Title	Revision	Date
UFSAR	Updated Final Safety Analysis Report; Chapter 4 "Reactor Coolant and Associated Systems", Chapter 10 "Steam and Power Conversion Systems"	18	
VTM-D243-0001	Dresser Hancock Valves Technical Manual	0	

2.0 STRUCTURES AND COMPONENTS WITHIN THE SCOPE OF LICENSE RENEWAL

2.1 Component Level Scoping Methodology Overview

The scoping of the Feedwater System components was performed in accordance with the process described in the Calvert Cliffs Nuclear Power Plant Integrated Plant Assessment Methodology as specified in the procedure for the component level scoping of systems. The purpose of component level scoping is to identify all system components that support the intended system functions identified in Section 1.1.3 for the Feedwater System. These are the components that are within the scope of license renewal.

2.2 Component Level Scoping Results

A total of 20 device types in the Feedwater System were designated as within the scope of license renewal. These device types are listed in Table 2-1.

The portion of the Feedwater System within the scope of license renewal consists of piping, components, component supports, instrumentation, and cables for the section of the system from the feedwater isolation motor-operated valves to the steam generator feedwater nozzle and for steam generator secondary instrumentation.

Refer to the results of the Feedwater System Component Level Scoping for the list of intended functions, the list of components within the scope of license renewal, and other scoping-related details.

Table 2-1

Feedwater System Device Types Within the Scope of License Renewal

Device Type	Device Description
-DB	Class DB Piping
CKV	Check Valve
FU	Fuse
HS	Handswitch
HV	Hand Valve
I/I	Current/Current Device
JL	Power Lamp Indicator
LI	Level Indicator
LR	Level Recorder
LT	Level Transmitter
MOV	Motor Operated Valve
PI	Pressure Indicator
PT	Pressure Transmitter
RY	Relay
TE	Temperature Element
TY	Temperature Device (Relay)
X	Transformer
YX	Power Supply
ZL	Position Indicating Lamp
ZS	Position Switch

3.0 COMPONENT PRE-EVALUATION

3.1 Pre-Evaluation Methodology Overview

The component pre-evaluation procedure is used to determine which components are subject to an aging management review. This procedure is used to categorize intended system functions as active or passive, determine if the components supporting passive system functions are long-lived, and identify the set of components subject to aging management review.

The pre-evaluation also determines whether the components should be included in a commodity group AMR or the system AMR.

3.2 Pre-Evaluation Results

Table 3-1 summarizes the disposition of intended system functions for the Feedwater System as either active or passive. These functions are derived from the system functions identified and documented during the component level scoping process, which are listed in subsection 1.1.3.

Components supporting only active intended system functions (i.e., not passive components) and those that are subject to replacement based on qualified life (i.e., not long-lived components) do not require an aging management review.

Components that are evaluated as part of commodity evaluations are addressed in separate AMRs. The Feedwater System components dispositioned as part of commodity evaluations include all component supports*, all cables*, and all instrument devices that support passive functions (that are not subject to a replacement program).

Table 3-2 summarizes the disposition of the device types identified in Table 2-1 as within the scope of license renewal for the Feedwater System.

Refer to the results of the Feedwater System Component Pre-evaluation for the list of components subject to AMR and other details.

* Component supports and cables are not identified as feedwater system components in the feedwater system scoping results, but are generically included in the Component Supports and Cables Commodity AMRs, respectively.

Table 3-1
Feedwater System Intended System Function Disposition

Function Description	Function Passive?
Send signals to ESFAS and provide SG isolation	No
Provide containment overpressure protection	No
Prevent reverse flow from SG via check valve closure	No
Maintain functionality of electrical equipment as addressed by the EQ Program	No
Maintain the pressure boundary of the system	Yes
Provide information used to assess the plant and environs condition during and following an accident	No
Provide SG level indication	No
Maintain electrical continuity and/or provide protection of the electrical system	Yes
Provide signals to AFAS	No
Provide signals to RPS	No
Monitor steam generator level to support safe shutdown in the event of a postulated severe fire	No

Table 3-2

Summary of Feedwater System Device Types Requiring Aging Management Review

Device Type	Device Description	Components Support Passive Function(s)?	Components Subject to Replacement Program?	Components Evaluated in Commodity Evaluation?	Components Included in Feedwater AMR?
-DB	Class DB Piping	YES	NO	NO	YES
CKV	Check Valve	YES	NO	NO	YES
FU	Fuse	NO	NO	NO	NO
HS	Handswitch	NO	NO	NO	NO
HV	Hand Valve	YES	NO	PARTIAL	PARTIAL
I/I	Current/Current Device	NO	NO	NO	NO
JL	Power Lamp Indicator	NO	NO	NO	NO
LI	Level Indicator	NO	NO	NO	NO
LR	Level Recorder	NO	NO	NO	NO
LT	Level Transmitter	YES	PARTIAL	PARTIAL	NO
MOV	Motor Operated Valve	YES	NO	NO	YES
PI	Pressure Indicator	NO	NO	NO	NO
PT	Pressure Transmitter	YES	PARTIAL	PARTIAL	NO
RY	Relay	NO	NO	NO	NO
TE	Temperature Element	YES	NO	NO	YES
TY	Temperature Relay	NO	NO	NO	NO
X	Transformer	NO	NO	NO	NO
YX	Power Supply	NO	NO	NO	NO
ZL	Position Indicating Lamp	NO	NO	NO	NO
ZS	Position Switch	NO	NO	NO	NO

4.0 COMPONENT AGING MANAGEMENT REVIEW

4.1 Aging Management Review Methodology Overview

The aging management review of Feedwater System components was performed in accordance with the process described in the Calvert Cliffs Nuclear Power Plant Integrated Plant Assessment Methodology as specified in the procedure for the component aging management review. This procedure requires the identification of plausible age related degradation mechanisms (ARDMs) for each component subject to aging management review, unless it can be demonstrated that the effects of aging can be managed without specifying ARDMs. The effects of the ARDMs on the ability of the components to support intended functions are identified and the ability of existing plant programs to adequately manage the effects of these ARDMs is evaluated.

The review accomplished the following:

- Determination of plausible component-ARDMs combinations:

  (1) Identified potential age-related degradation mechanisms (ARDMs) for Feedwater System components.

  (2) Grouped Feedwater System components based on device type and design/operating environment attributes. Sub-component groups were also determined when necessary based on design/operating environment attributes and supported component functions.

  (3) Identified plausible age-related degradation mechanisms ARDMs for each component or sub-component based on:

  - Industry and plant information
  - Material of construction
  - Environmental service factors
  - Intended functions

- Identification of methods to manage aging effects for plausible ARDMs and assessment of current plant programs to determine whether these aging effects are adequately managed. If current programs were not adequate to manage aging effects, program modifications or new program requirements were identified.

4.2 Age-Related Degradation Mechanisms

Feedwater System components were evaluated to identify plausible ARDMs for which aging effects management activities are required to ensure that age related degradation does not affect the component intended function(s). The identification of plausible ARDMs was completed in accordance with the process discussed below.

4.2.1 Potential ARDMs

This step of the aging evaluation identifies ARDMs that are potentially detrimental to Feedwater System components. These potential ARDMs are determined on an equipment type (e.g., pipe, valve, instrument, element) basis. An ARDM is considered potential if the evaluation concludes that the ARDM could occur in generic applications of the equipment throughout the plant. The equipment types for which ARDMs were evaluated are listed below.

Pipe
Valve
Element

A list of potential component ARDMs was developed for each of the equipment types. The list was developed through review of industry documents. The following are examples of sources of ARDM information:

Draft NRC Regulatory Guide DG-1009
NUMARC Industry Reports
NRC NPAR Reports
EPRI Reports

For each ARDM on the list, a determination was made whether it was applicable (i.e., potential) to the equipment type. The applicability of the ARDM was determined on the basis of a generic component of the equipment type in service in any system in the plant.

A summary of the potential ARDMs for each of the Feedwater System equipment types is provided in Table 4-1. The specific description of each potential ARDM is included on the Attachment 7s in Appendix A.

4.2.2 Component Grouping

Similar components are grouped together for evaluation efficiency. The age-related degradation evaluation results completed for a group are applicable to each of the individual components within the group. Selection of grouping attributes was accomplished through consideration of the component characteristics that would most influence the age-related degradation that could occur. Typical grouping attributes utilized for the Feedwater System included material of construction, component specific function, and process environment. Where these attributes varied among the sub-components within a given component, a sub-group was developed to represent all similar sub-components of the parent group members. Typical sub-groups represented component pressure boundary parts and component internals. Component grouping is shown on Attachment 3s in Appendix A. Subcomponent breakdowns are shown on Attachment 4s in Appendix A.

4.2.3 Plausible ARDMs

The list of potential ARDMs is utilized for a Feedwater System component-specific identification of plausible ARDMs. The plausibility determination is made through consideration of factors that influence component susceptibility to the ARDM. The ARDMs are assessed for plausibility on the basis of:

Material of construction
Internal (process) environment
External environment
Operational conditions/effects
Affect on the passive intended function

The results of the component-specific ARDM plausibility evaluation are included in Attachment 5s and 6s in Appendix A. These results are summarized by component Device Type, in matrix form, in Table 4-2.

4.3 Methods to Manage the Effects of Aging

The methods of managing the effects of plausible age related degradation mechanisms are determined in the final step of the aging management review process. These methods are compared to current plant programs and practices to determine whether aging effects are adequately managed for the period of extended operation, or whether program revisions or new programs are required. Additionally, plant modifications may be considered as a method to manage aging effects.

Applicable aging effects management methods are determined through consideration of the specific plausible ARDM, component configuration (material of construction, geometry, service conditions, etc.), and relative significance of the aging effects for the period of extended operation.

Site programs and processes associated with the Feedwater System were reviewed to identify those that implemented the aging effects management methods determined to be necessary for the period of extended operation. These activities were reviewed with appropriate site program managers, system engineers, and others to gain concurrence on the site programs and processes that will become commitments for plant license renewal. Similarly, modifications to current programs, and requirements for new programs, were identified and reviewed with the site to gain concurrence as these will also become commitments for plant license renewal.

Site programs, modifications to programs, and new programs are related to specific Feedwater System components and plausible ARDMs on Attachments 1, 2, 8 and 10 in Appendix A.

Attachment 1 in Appendix A provides a summary of Feedwater System components (by device type) subject to aging management review, applicable passive intended function(s), plausible ARDMs, and aging effects management programs.

Table 4-1
Potential Age-Related Degradation Mechanisms (ARDMs) Summary

Potential ARDMs	Feedwater System Equipment Types		
	Pipe	Valve	Element
Cavitation Erosion	X	X	X
Corrosion Fatigue	X	X	X
Creep/Shrinkage			
Crevice Corrosion	X	X	X
Dynamic Loading	X		X
Erosion/Corrosion	X	X	X
Fatigue	X	X	X
Fouling	X	X	X
Galvanic Corrosion	X	X	X
General Corrosion	X	X	X
Hydrogen Damage	X	X	X
Intergranular Attack	X	X	X
Irradiation Embrittlement			
Microbiologically Influenced Corrosion (MIC)	X	X	X
Oxidation			
Particulate Wear Erosion	X	X	X
Pitting	X	X	X
Radiation Damage	X	X	X
Saline Water Attack	X		
Selective Leaching	X	X	X
Stress Corrosion Cracking	X	X	X
Stress Relaxation			
Thermal Damage	X	X	X
Thermal Embrittlement	X	X	X
Wear		X	X

x - indicates that the ARDM is potentially detrimental to the equipment type

Table 4-2
Plausible Age-Related Degradation Mechanisms Summary

Plausible ARDMs	Feedwater System Device Types				
	-DB	CKV	HV	MOV	TE
Cavitation Erosion					
Corrosion Fatigue	X	X			
Creep/Shrinkage					
Crevice Corrosion	X	X	X	X	X
Dynamic Loading					
Erosion/Corrosion	X	X		X	X
Fatigue	X	X			
Fouling					
Galvanic Corrosion					
General Corrosion	X	X	X	X	X
Hydrogen Damage					
Intergranular Attack					
Irradiation Embrittlement					
Microbiologically Influenced Corrosion (MIC)					
Oxidation					
Particulate Wear Erosion					
Pitting	X	X	X	X	X
Radiation Damage					
Saline Water Attack					
Selective Leaching					
Stress Corrosion Cracking					
Stress Relaxation					
Thermal Damage					
Thermal Embrittlement					
Wear					

x - indicates that the ARDM is plausible for component(s) within the Device Type

Appendix A
Feedwater System Aging Management Review Results

	Total Pages
Attachment 1, Aging Management Review Summary	1
Attachment 2, Description of Programs Which Manage the Effects of Aging	3
Equipment Type: ELEMENT	
Attachment 7, Potential ARDM List	11
Device Type: TE	
Attachment 3, Component Grouping Summary Sheet (045-TE-01)	1
Attachment 4, Sub-Component/Sub-GroupIdentification	1
Attachment 5, ARDM Matrix	1
Attachment 6, Matrix Code List	3
Equipment Type: PIPE	
Attachment 7, Potential ARDM List	10
Device Type: -DB	
Attachment 3, Component Grouping Summary Sheet (045-DB-01)	1
Attachment 3, Component Grouping Summary Sheet (045-DB-02)	1
Attachment 5, ARDM Matrix	1
Attachment 6, Matrix Code List	4
Equipment Type: VALVE	
Attachment 7, Potential ARDM List	10
Device Type: CKV	
Attachment 3, Component Grouping Summary Sheet (045-CKV-01)	1
Attachment 4, Sub-Component/Sub-GroupIdentification	1
Attachment 5, ARDM Matrix	1
Attachment 6, Matrix Code List	4
Device Type: HV	
Attachment 3, Component Grouping Summary Sheet (045-HV-01)	2
Attachment 4, Sub-Component/Sub-GroupIdentification	1
Attachment 5, ARDM Matrix	1
Attachment 6, Matrix Code List	3
Attachment 3, Component Grouping Summary Sheet (045-HV-02)	1
Attachment 4, Sub-Component/Sub-GroupIdentification	1
Attachment 5, ARDM Matrix	1
Attachment 6, Matrix Code List	3

Appendix A
Feedwater System Aging Management Review Results

	Total Pages
Device Type: MOV	
Attachment 3, Component Grouping Summary Sheet (045-MOV-01)	1
Attachment 4, Sub-Component/Sub-GroupIdentification	1
Attachment 5, ARDM Matrix	1
Attachment 6, Matrix Code List	4
Attachment 8, Development of Aging Management Alternatives	7
Attachment 10, Program/Activity (PA) Modifications	1

ATTACHMENT 1, AGING MANAGEMENT REVIEW SUMMARY

System Name and No.: Main Feedwater (045)

Device Type	Group ID	Passive Intended Functions	Grouping Attributes	Subcomponents/ Subgroups Not Subject to Aging Mgmt Review	Plausible ARDMs	Managed by Existing Programs ID	Modifications Needed	New Program Needed
-DB	045-DB-01	Maintain system pressure boundary	- Carbon Steel Material - Controlled environment - Water @ 435F - Subject to thermal stratification conditions	N/A	Crevice Corrosion Pitting General Corrosion	CP-0217		Yes - Age-Related Degradation Inspection Program
					Erosion Corrosion	MN-3-111 CP-0217		
					Fatigue, Corrosion Fatigue	Fatigue Monitoring Program	Yes - Commitment 01 (see Attachment 10)	
						CP-0217		
	045-DB-02	Maintain system pressure boundary	- Carbon Steel Material - Controlled environment - Water @ 435F	N/A	Crevice Corrosion Pitting General Corrosion	CP-0217		Yes - Age-Related Degradation Inspection Program
					Erosion Corrosion	MN-3-111 CP-0217		
CKV	045-CKV-01	Maintain system pressure boundary	- Carbon Steel Material - Controlled environment - Water @ 435F	045-CKV-01C Disk, and other non-pressure-retaining parts	Crevice Corrosion Pitting General Corrosion	CP-0217		Yes - Age-Related Degradation Inspection Program
					Erosion Corrosion	RepTasks 10452052, 10452053, 20452043, and 20452044 CP-0217		
					Fatigue, Corrosion Fatigue	Fatigue Monitoring Program	Yes - Commitment 01 (see Attachment 10)	
						CP-0217		
HV	045-HV-01	Maintain system pressure boundary	- Carbon Steel Material - Controlled environment - Water/Steam up to 550F - Normally open	045-HV-01D Disk, and other non-pressure-retaining parts	Crevice Corrosion Pitting General Corrosion	CP-0217		Yes - Age-Related Degradation Inspection Program
	045-HV-02	Maintain system pressure boundary	- Carbon Steel Material - Controlled environment - Water @ 4[illegible]5F - Normally closed	045-HV-01E Non-pressure-retaining internal parts	Crevice Corrosion Pitting General Corrosion	CP-0217		Yes - Age-Related Degradation Inspection Program
MOV	045-MOV-01	Maintain system pressure boundary	- Carbon Steel Material - Controlled environment - Water @ 435F - Normally open	045-MOV-01E Non-pressure-retaining internal parts	Crevice Corrosion Pitting General Corrosion	CP-0217		Yes - Age-Related Degradation Inspection Program
					Erosion Corrosion	CP-0217		Yes - Age-Related Degradation Inspection Program
TE	045-TE-01	Maintain system pressure boundary	- 2 1/4Cr-1Mo Material - Controlled environment - Water @ 435F	045-TE-01B Temperature Element	Crevice Corrosion Pitting General Corrosion	CP-0217		Yes - Age-Related Degradation Inspection Program
					Erosion Corrosion	CP-0217		Yes - Age-Related Degradation Inspection Program

ATTACHMENT 2, DESCRIPTION OF PROGRAMS WHICH MANAGE THE EFFECTS OF AGING

System Name and Number: **Main Feedwater (045)**

Program ID	Portions of System Managed By This Program & Passive Intended Function	ARDMs Managed by This Program	Description of Program
CP-0217, Chemistry Specifications and Surveillance - Secondary Systems	Feedwater System piping, valves and associated components from the feedwater isolation MOVs to the S/G nozzle, and S/G instrument root isolation valves. Passive Intended Function: Provide the system pressure retaining boundary.	Corrosion Fatigue Crevice Corrosion Erosion Corrosion General Corrosion Pitting	The Chemistry Control Program provides requirements and criteria for monitoring fluid system chemical parameters including impurity concentrations, conductivity, pH, and total solids levels. The program provides for appropriate corrective actions when out-of-specification conditions are encountered. The chemistry department procedure CP-0217 provides these requirements as applicable to the Feedwater System fluid chemistry.
MN-3-111, Erosion Corrosion Monitoring of Secondary Piping	Feedwater System piping from the feedwater isolation MOVs to the S/G nozzle. Passive Intended Function: Provide the system pressure retaining boundary.	Erosion Corrosion	The Erosion Corrosion Monitoring Program procedure (MN-3-111) provides details of the program scope (which includes the Feedwater System), criteria for classification of piping locations based on susceptibility to erosion corrosion and past inspection results, scheduling of inspections, and corrective actions when adverse conditions are found or predicted. The determination of corrective action requirements are based on calculated minimum wall thickness requirements considering all design requirements for the piping.

ATTACHMENT 2, DESCRIPTION OF PROGRAMS WHICH MANAGE THE EFFECTS OF AGING

System Name and Number: **Main Feedwater (045)**

Program ID	Portions of System Managed By This Program & Passive Intended Function	ARDMs Managed by This Program	Description of Program
Age Related Degradation Inspection Program	Feedwater System piping, valves and associated components from the feedwater isolation MOVs to the S/G nozzle, and S/G instrument root isolation valves. Passive Intended Function: Provide the system pressure retaining boundary.	Corrosion Fatigue Crevice Corrosion Erosion Corrosion General Corrosion Pitting	The Age-Related Degradation Inspection (ARDI) Program is intended to provide the additional assurance needed to conclude that the effects of plausible aging are being effectively managed for the period of extended operation. A conceptual description of the ARDI Program can be found in BGE memorandum LCM96-044 dated February 15, 1996. For the Feedwater System, the ARDI Program will be focussed on the effects of the plausible age-related degradation mechanisms and affected components identified in this AMR. The results of implementation of the ARDI Program are to be used to determine actions required to ensure that the affected components continue to support the passive intended functions identified in the AMR throughout the period of extended operation.
CCNPP Fatigue Monitoring Program	Feedwater System piping downstream of the S/G check valves to the S/G nozzle, and the S/G check valve bodies. Passive Intended Function: Provide the system pressure retaining boundary.	Fatigue Corrosion Fatigue	The CCNPP Fatigue Monitoring Program (FMP) tracks thermal fatigue usage by monitoring thermal cycles occuring at critical (bounding) locations in the plant for a specific scope of plant systems/components. The Feedwater System is not currently within the scope of the FMP. The affected piping and check valves of the Feedwater System are to be evaluated to determine whether currently monitored locations within FMP scope adequately envelope fatigue effects for these components. The FMP is to be modified, as necessary, to include these components within the scope of the program in order to ensure that fatigue effects are managed during the period of extended operation.

ATTACHMENT 2, DESCRIPTION OF PROGRAMS WHICH MANAGE THE EFFECTS OF AGING

System Name and Number: **Main Feedwater (045)**

Program ID	Portions of System Managed By This Program & Passive Intended Function	ARDMs Managed by This Program	Description of Program
S/G Check Valves Inspection for Erosion Corrosion - Repetitive Tasks 10452052, 10452053, 20452043, and 20452044	Feedwater System S/G check valves. Passive Intended Function: Provide the system pressure retaining boundary.	Erosion Corrosion	These tasks provide instructions for the inspection and thickness measurement of the S/G check valve bodies in order to determine the effects of erosion corrosion of the valves. Continued performance of these tasks ensures that the effects of erosion corrosion are managed for these check valves during the period of extended operation.

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **ELEMENT**

ARDMS	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Cavitation Erosion	Yes	Localized material erosion caused by formation and collapse of vapor bubbles in close proximity to material surface. Requires fluid (liquid) flow and pressure variations which temporarily drop the liquid pressure below the corresponding vapor pressure. Most materials are susceptible to varying degrees depending upon the severity of the environmental factors.	[6]
Corrosion Fatigue	Yes	Plant equipment operating in a corrosive environment subjected to cyclic (fatigue) loading may initiate cracks and/or fail sooner than expected based on analysis of the corrosion and fatigue loadings applied separately. Fatigue-crack initiation and growth usually follows a transgranular path, although there are some cases where intergranular cracking has been observed. In some cases, crack initiation occurs by fatigue and is subsequently dominated by corrosion advance. In other cases, a corrosion mechanism (SCC) can be responsible for crack formation below the fatigue threshold, and the fatigue mechanism can accelerate the crack propagation. Corrosion-fatigue is a potentially active mechanism in both stainless steels as well as carbon and low alloy steels.	[6]
Creep/ Shrinkage	No	Not applicable to Equipment Type. The phenomenon results in dimensional changes in metals at high temperatures and in concrete subject to long term dehydration. This ARDM is not applicable to this equipment type since proper component specification and design prevents this ARDM from occurring (i.e., system and component design standards adequately address this ARDM).	[2]
Crevice Corrosion	Yes	Crevice corrosion is intense, localized corrosion within crevices or shielded areas. It is associated with a small volume of stagnant solution caused by holes, gasket surfaces, lap joints, crevices under bolt heads, surface deposits, designed crevices for attaching thermal sleeves to safe-ends, and integral weld backing rings or back-up bars. The crevice must be wide enough to permit liquid entry and narrow enough to maintain stagnant conditions, typically a few thousandths of an inch or less. Crevice corrosion is closely related to pitting corrosion and can initiate pits in many cases as well as leading to stress corrosion cracking. In an oxidizing environment, a crevice can set up a differential aeration cell to concentrate an acid solution within the crevice. Even in a reducing environment, alternate wetting and drying can concentrate aggressive ionic species to cause pitting, crevice corrosion, intergranular attack, or stress corrosion cracking.	[5] [6] [11]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **ELEMENT**

ARDMS	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Dynamic Loading	Yes	LWR components and structures are designed to accommodate loads that are expected in service. Particular attention is given to limiting the effects of fatigue and significant plastic deformation or rupture. Experience has shown that while expected loads have been properly treated, dynamic loads not explicitly considered during design have occurred in service causing material degradation and component failure. Examples of unexpected dynamic loads are vibration, water hammer, and unstable fluid flow. Vibration dynamic loads are caused by the response of a component, system or structure to oscillating input. Possible sources of input energy include rotating equipment and fluid flow. The most serious situations arise when the input load synchronizes or nearly synchronizes with the natural frequency of the component, system, or structure. Examples of vibration-induced dynamic loading problems which have occurred in LWRs include PWR core barrel vibration, main coolant pump shaft cracking, pipe weld fatigue cracking, and steam generator and condenser tube failures. Tubes in heat exchangers tend to vibrate under the influence of crossflow velocities, possibly leading to tube or support damage. When the vibration amplitude is high enough, the tubes impact and experience thinning at mid-span; when lower, fretting damage can occur at support points. Although fatigue failure is a major concern due to vibration loads, simple loss of function may also occur in components such as bolting and valves. Flow-induced vibration has been identified as the source of many safety relief valve (SRV) failures in high energy piping systems, causing leakage, chatter, premature pop-off, fretting, galling, fatigue and possible failure to operate when required. Water hammer loads are caused by hydraulic pressure wave effects associated with rapid changes in fluid flow. These changes may be initiated by rapid valve or pump action, particularly with large differential pressure across the valve or high fluid flow capacity through the pump. In other cases, water hammer may be caused by rapid condensation of steam or liquid flashing to steam followed by condensation with enough liquid in the system to transmit the pressure wave. Unanticipated water hammer loads have caused piping support failures, deformation of piping and internals, and valve and pump damage.	[5] [6]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **ELEMENT**

ARDMS	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Erosion Corrosion	Yes	Increased rate of attack on a metal because of the relative movement between a corrosive fluid and the metal surface. Mechanical wear or abrasion can be involved, characterized by grooves, gullies, waves, holes and valleys on the metal surface. Erosion is a mechanical action of a fluid and/or particulate matter on a metal surface, without the influence of corrosion. Erosion corrosion failures can occur in a relatively short time and are sometimes unexpected, since corrosion tests are usually run under static conditions. All equipment exposed to moving fluids is vulnerable; in particular, piping (bends, tees, etc.), valves, pumps, propellers and impellers, heat exchanger tubing, turbine blades and wear plates are components which have experienced erosion corrosion. This is a serious problem in steam piping, heater drain piping, reheaters, and moisture separators due to high velocity particle impingement. Erosion corrosion has occurred in high and low pressure preheater tubes, low pressure preheaters, evaporators and feedwater heaters. Inlet tube corrosion occurs in heat exchangers, due to the turbulence of flow from the exchanger head into the smaller tubes, within the first few inches of the tube. Such corrosion has been especially evident in condenser tubes and feedwater heaters. The occurrence of erosion corrosion is highly dependent upon material of construction and the fluid flow conditions. Carbon or low alloy steels are particularly susceptible when in contact with high velocity water (single or two phase) with turbulent flow, low oxygen and fluid pH < 9.3. Maximum erosion corrosion rates are expected in carbon steel at 130-140°C (single phase) and 180°C (two phase).	[4] [5] [6]
Fatigue	Yes	Fatigue damage results from progressive, localized structural change in materials subjected to fluctuating stresses and strains. Associated failures may occur at either high or low cycles in response to various kinds of loads (e.g., Mechanical or vibrational loads, thermal cycles, or pressure cycles). Fatigue cracks initiate and propagate in regions of stress concentration that intensify strain. The fatigue life of a component is a function of several variables such as stress level, stress state, cyclic wave form, fatigue environment, and the metallurgical condition of the material. Failure occurs when the endurance limit number of cycles (for a given load amplitude) is exceeded. All materials are susceptible (with varying endurance limits) when subjected to cyclic loading. Vibration loads have also been the cause of recurring weld failures by the fatigue of small socket welds. Certain piping locations, such as charging lines, have been found to experience vibration conditions. In some cases these failures in pipe have been due to inadequately supported pipe or obturator induced vibratory loads.	[5] [6] [2]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **ELEMENT**

ARDMS	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Fouling	Yes	Unavoidable introduction of foreign substances that interact with and/or collect within system and components. Caused by failure or degradation of upstream removal process equipment, long term buildup, low flow, stagnant flow, infrequent operation, and/or contaminated inlet flow. Fouling refers to all deposits on system surfaces that increase resistance to fluid flow and/or heat transfer. Sources of fouling include the following: (1) organic films of micro-organisms and their products (microbial fouling) (2) deposits of macro-organisms such as mussels (macrobial fouling) (3) inorganic deposits, including scales, silt, corrosion products and detritus. Scales result when solubility limits for a given species are exceeded. Deposits result when coolant-borne particles drop onto surfaces due to hydraulic factors. The deposits result in reduced flow of cooling water, reduced heat transfer, and increased corrosion. Sediment deposits promote concentration cell corrosion and growth of sulfur-reducing bacteria. The bacteria can cause severe pitting after one month of service. Piping systems designed for 30 years have had their projected life reduced to five years due to under-sediment corrosion.	[8] [9] [10]
Galvanic Corrosion	Yes	Accelerated corrosion caused by dissimilar metals in contact in a conductive solution. Requires two dissimilar metals in physical or electrical contact, developed potential (material dependent), and conducting solution.	[11]
General Corrosion	Yes	Thinning (wastage) of a metal by chemical attack (dissolution) at the surface of the metal by an aggressive environment. The consequences of the damage are loss of load carrying cross-sectional area. General corrosion requires an aggressive environment and materials susceptible to that environment. An important concern for PWRs is boric acid attack of carbon steels. Borated water has been observed to leak from piping, valves, storage tanks, etc., and fall on other carbon steel components and attack the component from the outside. Wastage is not a concern for austenitic stainless steel alloys.	[6] [7] [2]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **ELEMENT**

ARDMS	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Hydrogen Damage	Yes	Two forms of hydrogen attack relevant to light water reactor materials and conditions are hydrogen blistering and hydrogen embrittlement. Both produce mechanical damage in the affected component. In each case, atomic hydrogen enters the metal, either as a result of a corrosion reaction at the surface or by cathodic polarization which results in the evolution of hydrogen gas. In blistering, molecular hydrogen within the metal causes high pressure and local damage in the form of "blistered" regions of the metal surface. Hydrogen embrittlement affects ferritic and martensitic iron-based alloys, and results in low ductility intergranular cracking (similar to stress corrosion cracking). The phenomenon of hydrogen cracking is usually manifested as delayed cracking, at or near room temperature, after stress is applied. A certain critical stress, which may take the form of weld residual stress, is required to cause cracking. Notches concentrate such stresses and tend to shorten the delay time for cracking. Cracking of welds due to hydrogen embrittlement and hydrogen-induced cracking is a common concern. This cracking is more of a problem in higher strength steels (yield strength >120 ksi). Ferritic and martensitic stainless steels, carbon steels, and other high strength alloys are susceptible. Austenitic stainless steels are relatively immune but could experience damage at sufficiently high hydrogen levels.	[5] [6]
Intergranular Attack	Yes	Intergranular Attack (IGA) is very similar to intergranular stress corrosion cracking (IGSCC) except that stress is not required for IGA. IGA is localized corrosion at or adjacent to grain boundaries, with relatively little corrosion of the material grains. It is caused by impurities in the grain boundaries, or the enrichment or depletion of alloying elements at grain boundaries, such as the depletion of chromium at austenitic stainless steel grain boundaries. A "sensitized" microstructure causes susceptibility to IGA. When austenitic stainless steels are heated into or slow cooled through the temperature range of approximately 750 to 1500°F, chromium carbides can be formed, thus depleting the grain boundaries of chromium and decreasing their corrosion resistance. High chromium ferritic stainless steels, such as Type 430, also experience susceptibility to IGA. Nickel alloys such as alloy 600 experience IGA in the presence of certain sulfur environments at high temperatures (by forming low melting sulfur compounds at grain boundaries) or when austenitic stainless steel weld filler metal is inadvertently used on Ni-Cr-Fe alloys. Susceptibility to intergranular attack (sensitization) usually develops during thermal processing such as welding or heat treatments.	[5] [6] [2] [11]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **ELEMENT**

ARDMS	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Irradiation Embrittlement	No	Not applicable to Equipment Type. The ARDM results in a decrease in steel fracture toughness due to long-term exposure to a fast flux of neutrons. High neutron fluence levels can lead to embrittlement of the reactor pressure vessel core beltline, as well as certain reactor internals and core support structures. Control of material composition to low levels of Cu and Ni (and perhaps P and Si, to some extent) is beneficial in some cases, such as the reactor pressure vessel ferritic steel. Core support structure peak fluences as high as 1.0E+21 (e > 1mev) are reached in some cases and can embrittle the austenitic stainless steels and alloy 600 material in these components. PWRs experience fluences of between 9.0E+18 and about 4.0E+19 (e > 1mev) at the vessel beltline inside surface. Safe-ends and piping outside the vessel are not expected to experience irradiation significant enough to cause problems. However, the embrittlement effects due to low flux irradiation are not well understood. This ARDM is not applicable to this equipment type since element components in the systems under evaluation are not located in areas where the neutron flux is high enough to cause this ARDM to occur.	[5] [6]
MIC	Yes	Accelerated corrosion of materials resulting from surface microbiological activity. Sulfate reducing bacteria, sulfur oxidizers, and iron oxidizing bacteria are most commonly associated with corrosion effects. Most often results in pitting followed by excessive deposition of corrosion products. Stagnant or low flow areas are most susceptible. Any system that uses untreated water, or is buried, is particularly susceptible. Consequences range from leakage to excessive differential pressure and flow blockage. Essentially all systems and most commonly-used materials are susceptible. Temperatures from about 50°F to 120°F are most conducive to MIC. Experience in virtually all large industries is common. Nuclear experience is relatively new, but also widespread. MIC is generally observed in service water applications utilizing raw untreated water. Sedimentation aggravates the problem.	[5] [6] [2]
Oxidation	No	Not applicable to Equipment Type. The ARDM results from a chemical reaction at the surface of a material when subjected to an oxidizing environment. Oxidation occurs at any temperature. Electrical components experience degradation related to oxidation and are considered separately. Oxidation generally is not considered a degradation mechanism in metals of fluid systems in mild environments since this mechanism serves to protect materials by formation of a passive layer. Other corrosion mechanisms (e.g. Corrosion fatigue, crevice corrosion, erosion corrosion, general corrosion and pitting) can result from oxidation/reduction reactions under specific aggressive mechanical and chemical environment and are addressed separately. It could be considered a degradation mechanism at high temperatures, where a more rapid reaction between metal and oxygen is likely to occur. These temperatures do not occur in power plant applications under evaluation. Therefore, oxidation is not considered a potential ARDM for element components.	[6] [11]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **ELEMENT**

ARDMS	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Particulate Wear Erosion	Yes	The loss of material caused by mechanical abrasion due to relative motion between solution and material surface. Requires high velocity fluid, entrained particles, turbulent flow regions, flow direction change, and/or impingement. Most materials are susceptible to varying degrees depending upon the severity of the environmental factors.	[6]
Pitting	Yes	A form of localized attack with greater corrosion rates at some locations than at others. Pitting can be very insidious and destructive, with sudden failures in high pressure applications (especially in tubes) occurring by perforation. This form of corrosion essentially produces "holes" of varying depth to diameter ratios in the steel. These pits are, in many cases, filled with oxide debris, especially for ferritic materials such as carbon steel. Deep pitting is more common with passive metals, such as austenitic stainless steels, than with non- passive metals. Pits are generally elongated in the direction of gravity. In many cases, erosion corrosion, fretting corrosion, and crevice corrosion can also lead to pitting. Corrosion pitting is an anodic reaction which is an autocatalytic process. That is, the corrosion process within a pit produces conditions which stimulate the continuing activity of the pit. High concentrations of impurity anions such as chlorides and sulfates tend to concentrate in the oxygen- depleted pit region, giving rise to a potentially concentrated aggressive solution in this zone. Pitting has been found on the outside diameter of tubes where sludge or tube scale was present. It can also occur at locations of relatively stagnant coolant or water, such as in carbon steel pipes for service water lines, and at crevices in stainless steel, such as at the stainless steel cladding between reactor pressure vessel closure flanges. Pitting can become passive in some metals such as aluminum.	[5] [6] [2] [11]
Radiation Damage	Yes	Non-metallics are susceptible to degradation caused by gamma radiation.	[3]
Saline Water Attack	No	Not applicable to Equipment Type. Saline Water Attack has resulted in the degradation of reinforced concrete structures. The degradation mechanism involves water seepage into the concrete resulting in a high chloride environment for the reinforcing bars. The reinforcing bars corrode resulting in expansion that leads to cracking and spalling of the concrete. Saline water attack is of particular concern for structures that are inaccessible for routine inspection, and piping or other fluid components embedded in concrete. This ARDM is not applicable to element components since elements are not constructed of nor typically installed in concrete.	[2]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **ELEMENT**

ARDMS	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Selective Leaching	Yes	The removal of one element from a solid alloy by corrosion processes. The most common example is the selective removal of zinc in brass alloys (dezincification). Similar processes occur in other alloy systems in which aluminum, iron, cobalt, chromium, and other elements are removed. There are two types, layer-type and plug-type. Layer-type is a uniform attack whereas plug-type is extremely localized leading to pitting. Overall dimensions do not change appreciably. If a piece of equipment is covered by debris or surface deposits and/or not inspected closely, sudden unexpected failure may occur in high pressure applications due to the poor strength of the remaining material. Requires susceptible materials and corrosive environment. Materials particularly susceptible include zinc, aluminum, carbon and nickel. Environmental conditions include high temperature, stagnant aqueous solution, and porous inorganic scale. Acidic solutions and oxygen aggravate the mechanism.	[11] [12]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: Main Feedwater System (045) Equipment Type: ELEMENT

ARDMS	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Stress Corrosion Cracking	Yes	Selective corrosive attack along or across material grain boundaries. Four particular mechanisms are known to exist: (1) Intergranular (IGSCC), between the material grain boundaries. (2) Transgranular (TGSCC), across the material grains along certain crystallographic planes. (3) Irradiation Assisted (IASCC), between the material grains after an incubation neutron dose which sensitizes the material. (4) Interdendritic (IDSCC), between the dendrite interfaces. SCC requires applied or residual tensile stress, susceptible materials (such as austenitic stainless steels, alloy 600, alloy x-750, SAE 4340, and ASTM A289), and oxygen and/or ionic species (e.g., Chlorides/sulfates). Common sources of residual stress include thermal processing and stress risers created during surface finishing, fabrication, or assembly. The heat input during welding can result in a localized sensitized region which is susceptible to SCC. IGSCC is a concern in stainless steel piping depending on material condition and process fluid chemistry and also is a potential concern in valve internals (PH steel). While operating experience with carbon steel piping shows no evidence of environmentally assisted cracking, laboratory studies do indicate a susceptibility to SCC. Screening tests on SA106b and SA333GR6 indicate that severe combinations of cyclic applied stress and high temperature oxygenated water can result in environmentally enhanced cracking. TGSCC may be a concern in stainless steel if aggressive chemical species (caustics, halogens, sulfates, especially if coupled with the presence of oxygen) are present. TGSCC was thought to be inactive in low alloy steel, however, recent data suggests that the mechanism may operate. IASCC is a potential concern only for reactor vessel internals and other stainless steel components, such as control rods, which are subject to very high neutron fluence levels. A fast neutron incubation fluence of at least 1.0E+20 is generally required to sensitize the material. IDSCC is a potential concern in stainless steel weld metal deposits based on microstructure and delta ferrite content. This mechanism is inactive in carbon and low alloy steel. Ammonia grooving in brass components can occur when the concentration of ammonia is greater than a few ppm. It is found most often in feedwater heaters that contain admiralty brass tubes and where morpholine, which breaks down into ammonia, is used to increase the pH of the condensate.	[5] [6] [2]
Stress Relaxation	Yes	Stress Relaxation occurs under conditions of constant strain where part of the elastic strain is replaced with plastic strain. A material loaded to an initial stress may experience a reduction in stress over time at high temperatures. Bolted connections are most vulnerable. Relaxation of stress on packing due to stretching of gland follower studs under elevated temperatures may cause packing leakage.	[6]
Thermal Damage	Yes	Non-metallics are particularly susceptible with material dependent temperature limits.	[6] [2]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **ELEMENT**

ARDMS	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Thermal Embrittlement	Yes	Loss of material fracture toughness caused by thermally induced changes in the formation and distribution of alloying constituents. Requires high temperature 500°F to 700°F for metallic components. Ferrite containing stainless steels are susceptible as are materials with grain boundary segregation of impurities.	[6]
Wear	Yes	Wear results from relative motion between two surfaces (adhesive wear), from the influence of hard, abrasive particles (abrasive wear - see particulate erosion) or fluid stream (erosion), and from small, vibratory or sliding motions under the influence of a corrosive environment (fretting). In addition to material loss from the above wear mechanisms, impeded relative motion between two surfaces held in intimate contact for extended periods may result from galling/self-welding. Motions may be linear, circular, or vibratory in inert or corrosive environments. The most common result of wear is damage to one or both surfaces involved in the contact. Wear most typically occurs in components which experience considerable relative motion such as valves and pumps, in components which are held under high loads with no motion for long periods (valves, flanges), or in clamped joints where relative motion is not intended but occurs due to a loss of clamping force (e.g., Tubes in supports, valve stems in seats, springs against tubes). Wear may proceed at an ever-increasing rate as worn surfaces moving past one another will often do so with much higher contact stresses than the surfaces of the original geometry. Fretting is a wear phenomenon that occurs between tight-fitting surfaces subjected to a cyclic, relative motion of extremely small amplitude. Fretting is frequently accompanied by corrosion. Common sites for fretting are in joints that are bolted, keyed, pinned, press fit or riveted; in oscillating bearings, couplings, spindles, and seals; in press fits on shafts; and in universal joints. Under fretting conditions, fatigue cracks may be initiated at stresses well below the endurance limit of nonfretted specimens.	[1]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **ELEMENT**

Reference List

Source	Title
[1]	ASME Wear Control Handbook, Peterson and Winer, 1980
[2]	Standard Format and Content of Technical Information for Applications to Renew Nuclear Power Plant Operating Licenses, Draft NRC Regulatory Guide No. DG-1009, December 1990
[3]	Radiation Effects on Organic Materials in Nuclear Plants, EPRI Report No. NP-2129, November 1981
[4]	Erosion/Corrosion in Nuclear Plant Steam Piping, EPRI Report No. NP-3944, 1985
[5]	Component Life Estimation: LWR Structural Materials Degradation Mechanisms, EPRI Report No. NP-5461, 1987
[6]	Environmental Effects on Components: Commentary for ASME Section III, EPRI Report No. NP-5775, April 1988
[7]	Boric Acid Corrosion of Carbon and Low Alloy Steel Pressure Boundary Materials, EPRI Report No. NP-5985, 1988
[8]	Nuclear Plant Service Water System Aging Degradation Assessment, NUREG/CR-5379, Volume 1 and 2, June 1989 and October 1992
[9]	Aging Assessment of Instrument Air Systems, NUREG/CR-5419, January 1990
[10]	Insights Gained from Aging Research, NUREG/CR-5643, March 1992
[11]	Corrosion Engineering, Fontana and Greene, 1978
[12]	Corrosion and Corrosion Control, An Introduction to Corrosion Science and Engineering, Uhlig, Third Edition, 1985

ATTACHMENT 3, COMPONENT GROUPING SUMMARY SHEET

SYSTEM: Main Feedwater
GROUP ID NUMBER: 045-TE-01
GROUP ATTRIBUTES:

1. Device Type: TE
2. Vendor: NA
3. Model Number: NA
4. Material: 2 1/4 Cr - 1 Mo Steel
5. Internal Environment: Controlled chemistry water at up to 435F
6. External Environment: Climate controlled atmospheric air (Auxiliary Bldg.)
7. Function: Maintain system pressure boundary
8. Name Plate Data:

PARAMETER	VALUE
System Temperature	up to 435F
System Pressure	</= 1300 psig
Material of Construction	ASTM A182 - F22 (2 1/4 Cr - 1 Mo steel)

LIST OF GROUPED COMPONENTS (EQUIPMENT ID):

Equipment ID	Description	Equipment ID	Description
1TE4516	11 FW S/G INL TEMP ELMNT		
1TE4517	12 FW S/G INL TEMP ELMNT		

ATTACHMENT 4, SUBCOMPONENT/SUB-GROUP IDENTIFICATION

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater

EQUIPMENT ID: NA GROUP ID: 045-TE-01

Sub-Group ID	Sub-Component/Name (Replacement Pgm)	Manufacturer (Source)	Material (Source)	Model Number (Source)	Passive Intended Function(s) (Source)	Subject to AMR (Y or N)
045-TE-01A	Thermowell (None)	Bechtel (92702) (6750-M-355)	2 1/4 Cr - ASTM A182, F22 (92702) (6750-M-355)	NA (NA)	Maintain system pressure boundary (CLSR)	Y
045-TE-01B	Thermocouple (None)	NA (NA)	NA (NA)	NA (NA)	None (non pressure retaining) (NA)	N

ATTACHMENT 5, ARDM MATRIX

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: ELEMENT DEVICE TYPE: TE
GROUP ID (if applicable): 045-TE-01

	GROUP OR SUB GROUP ID			
ARDMs	045-TE-01A	NA	NA	NA
CAVITATION EROSION	1			
CORROSION FATIGUE	2			
CREVICE CORROSION	A			
DYNAMIC LOADING	3			
EROSION CORROSION	B			
FATIGUE	4			
FOULING	5			
GALVANIC CORROSION	6			
GENERAL CORROSION	C			
HYDROGEN DAMAGE	7			
INTERGRANULAR ATTACK	8			
MIC	9			
PARTICULATE WEAR EROSION	10			
PITTING	A			
RADIATION DAMAGE	11			
SELECTIVE LEACHING	12			
STRESS CORROSION CRACKING	13			
STRESS RELAXATION	14			
THERMAL DAMAGE	11			
THERMAL EMBRITTLEMENT	15			
WEAR	16			

ATTACHMENT 6, MATRIX CODE LIST

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: ELEMENT DEVICE TYPE: TE
GROUP ID (if applicable): 045-TE-01

CODE	DESCRIPTION	SOURCE
1	The feedwater system fluid flow conditions, pressure and temperature do not result in cavitation at the thermowell. The flow is relatively steady and the pressure is much greater than the vapor pressure at system temperature. Therefore, cavitation erosion is not plausible.	[5], [9]
2	Control of system chemistry results in limited corrosion, and fatigue is not plausible for the thermowells. Therefore, corrosion fatigue is not plausible.	[5]
3	Normal service loads for the feedwater system do not result in significant vibration or other dynamic loading conditions. The system pressure and flowrate are normally maintained steady. The stiffness of the thermowell eliminates flow induced vibration. Based on these considerations, dynamic loading effects are not plausible.	[1], [4], [5], [9], [13]
4	The source of thermal cycling for the piping in which these thermowells are installed are plant start-ups/shutdowns and secondary plant transients. Thermal growth of the thermowell is unrestrained, therefore, no thermal stresses are created. Additionally, vibrational effects are not ocurring (see 3. above). Based on these considerations, fatigue of the thermowell is not plausible.	[5], [8], [9], [13]
5	Fouling does not affect the component function. The component intended function is to maintain the pressure boundary integrity only. Due to the control of feedwater chemistry, fouling (including contamination and sedimentation) is not expected. Any fouling or sedimentation will not have an affect on the intended function.	[5], [10]
6	The thermowell material is Cr-Mo steel and the surrounding piping is carbon steel. The feedwater system water chemistry is controlled to minimize conductivity. The anodic material (carbon steel piping) surface area is large relative to the thermowell. Based on low conductivity electrolyte, and large anode surface area, the effects of galvanic corrosion are insignificant and will not affect the piping (or thermowell) intended function. Therefore, galvanic corrosion is not plausible.	[6], [7], [10], [13]
7	The thermowell is not fabricated from the high strength steel susceptible to hydrogen embrittlement and cracking. Therefore, this ARDM is not plausible.	[5]
8	Carbon and low alloy steel material is not susceptible to intergranular attack.	[5]
9	Microbiologically influenced corrosion is not plausible due to the chemical conditions and temperature of the working fluid in the system. The source for feedwater is demineralized water, and organic contaminants are avoided through feedwater/condensate chemistry control. Additionally, normal feedwater temperature is above 200F making MIC not possible.	[5], [10]
10	Control of feedwater chemistry ensures essentially no particulate matter in the feedwater flowstream. Therefore, particulate wear erosion is not plausible.	[10]
11	The thermal damage and radiation damage ARDMs affect non-metallics only. There are no non-metallic materials in these thermowells.	[2], [5]
12	The Cr-Mo steel material is not susceptible to selective leaching. Therefore, this ARDM is not plausible.	[6], [11]
13	Control of feedwater chemistry (particularly oxygen concentration) prevents the environment necessary for SCC of alloy steel material. Therefore, this ARDM is not plausible.	[5], [10]
14	There are no prestressed parts to the thermowell assembly, therefore, stress relaxation is not plausible.	[13]
15	The feedwater system operating temperature of ~ 435F max. is not sufficient to result in embrittlement. Thermal embrittlement of low alloy steels requires temperatures greater than 650F.	[9], [12]

ATTACHMENT 6, MATRIX CODE LIST

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: ELEMENT DEVICE TYPE: TE
GROUP ID (if applicable): 045-TE-01

CODE	DESCRIPTION	SOURCE
16	There are no moving parts in the thermowell assembly. Therefore, wear is not plausible.	[13]
A	Crevice corrosion and pitting can occur in areas of the thermowell assembly that are not exposed to the general flowstream such as in the area of the half-coupling attachment to the main piping, and other crevices. These areas may comprise small localized volumes of stagnant solution for which fluid chemistry may deviate from bulk system chemistry. Higher concentrations of impurities may exist in these crevices due to out-of-specification system chemistry during shutdown conditions and due to the stagnant flow conditions of the crevice. The resulting degradation is highly localized pits or cracks. The control of feedwater/condensate system fluid chemistry significantly limits the effects of crevice corrosion and pitting. The effects of crevice corrosion and pitting can not be dismissed due to the potential for crevice locations and potentially high impurity concentrations in the system during shutdown conditions. Management of the effects of crevice corrosion and pitting should consist of: 1) maintenance of the current system chemistry control program, and 2) subjecting a representative sample of thermowell applications (from components in this group or representative applications in other portions of the plant) to an inspection to determine the extent of localized degradation.	[5], [6], [10]
B	Erosion corrosion is plausible due to high velocity, high energy fluid flow conditions. The effects of erosion corrosion include potentially rapid wall thinning to the point of pressure boundary failure. The control of feedwater system fluid chemistry limits the rate and the effects of erosion corrosion. The feedwater system is monitored routinely for the effects of erosion corrosion by the plant erosion corrosion monitoring program. Management of the effects of erosion corrosion of the thermowell components should consist of: 1) maintaining the current system chemistry control program, and 2) subjecting a representative sample of thermowell applications (from components in this group or representative applications in other portions of the plant) to an inspection to determine the extent of erosion corrosion.	[3], [5], [9], [10]
C	General corrosion of the thermowells is plausible due to exposure of components to potentially corrosive medium during shutdown periods and, to a lesser extent, during operation. The rate of general corrosion is low due to the chromium content of the alloy steel material, however, exposure to high oxygen concentrations during shutdown conditions could result in general corrosion. The effects of general corrosion is wall thinning over a relatively large area and could result in pressure boundary failure if extensive. The control of feedwater/condensate system fluid chemistry significantly limits the effects of general corrosion. Management of the effects of general corrosion should consist of: 1) maintenance of the current system chemistry control program, and 2) subjecting a representative sample of thermowell applications (from components in this group or representative applications in other portions of the plant) to an inspection to determine the extent of general corrosion (i.e., wall thinning).	[5], [6], [7], [10]

ATTACHMENT 6, MATRIX CODE LIST

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: ELEMENT DEVICE TYPE: TE
GROUP ID (if applicable): 045-TE-01

Reference List

Source	Title
[1]	Standard Format and Content of Technical Information for Applications to Renew Nuclear Power Plant Operating Licenses, Draft NRC Regulatory Guide No. DG-1009, December 1990
[2]	Radiation Effects on Organic Materials in Nuclear Plants, EPRI Report No. NP-2129, November 1981
[3]	Erosion/Corrosion in Nuclear Plant Steam Piping, EPRI Report No. NP-3944, 1985
[4]	Component Life Estimation: LWR Structural Materials Degradation Mechanisms, EPRI Report No. NP-5461, 1987
[5]	Environmental Effects on Components: Commentary for ASME Section III, EPRI Report No. NP-5775, April 1988
[6]	Corrosion Engineering, Fontana and Greene, 1978
[7]	Corrosion and Corrosion Control, An Introduction to Corrosion Science and Engineering, Uhlig, Third Edition, 1985
[8]	Drawing 60702, Sheet 4, Rev. 28; Condensate and Feedwater System, Unit 1
[9]	UFSAR, Rev. 18; Chapter 4 - Reactor Coolant and Associated Systems, Chapter 10 - Steam and Power Conversion Systems
[10]	CP-217, Rev. 5; Chemistry Specifications and Surveillance - Secondary System
[11]	Marks' Standard Handbook for Mechanical Engineers, 8th Edition, McGraw-Hill
[12]	Metals Handbook, 9th Edition, Volumes 1 and 13, ASM
[13]	Drawing 92702, Rev. 3; Special Thermowell for Thermocouples and Test Wells

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **PIPE**

ARDM	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Cavitation Erosion	Yes	Localized material erosion caused by formation and collapse of vapor bubbles in close proximity to material surface. Requires fluid (liquid) flow and pressure variations which temporarily drop the liquid pressure below the corresponding vapor pressure. Most materials are susceptible to varying degrees depending upon the severity of the environmental factors.	[6]
Corrosion Fatigue	Yes	Plant equipment operating in a corrosive environment subjected to cyclic (fatigue) loading may initiate cracks and/or fail sooner than expected based on analysis of the corrosion and fatigue loadings applied separately. Fatigue-crack initiation and growth usually follows a transgranular path, although there are some cases where intergranular cracking has been observed. In some cases, crack initiation occurs by fatigue and is subsequently dominated by corrosion advance. In other cases, a corrosion mechanism (SCC) can be responsible for crack formation below the fatigue threshold, and the fatigue mechanism can accelerate the crack propagation. Corrosion-fatigue is a potentially active mechanism in both stainless steels as well as carbon and low alloy steels.	[6]
Creep/ Shrinkage	No	Not applicable to Equipment Type. The phenomenon results in dimensional changes in metals at high temperatures and in concrete subject to long term dehydration. This ARDM is not applicable to this equipment type since proper piping system design prevents this ARDM from occuring (i.e., piping design standards adequately address this ARDM).	[2]
Crevice Corrosion	Yes	Crevice corrosion is intense, localized corrosion within crevices or shielded areas. It is associated with a small volume of stagnant solution caused by holes, gasket surfaces, lap joints, crevices under bolt heads, surface deposits, designed crevices for attaching thermal sleeves to safe-ends, and integral weld backing rings or back-up bars. The crevice must be wide enough to permit liquid entry and narrow enough to maintain stagnant conditions, typically a few thousandths of an inch or less. Crevice corrosion is closely related to pitting corrosion and can initiate pits in many cases as well as leading to stress corrosion cracking. In an oxidizing environment, a crevice can set up a differential aeration cell to concentrate an acid solution within the crevice. Even in a reducing environment, alternate wetting and drying can concentrate aggressive ionic species to cause pitting, crevice corrosion, intergranular attack, or stress corrosion cracking.	[5] [6] [11]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **PIPE**

ARDM	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Dynamic Loading	Yes	LWR components and structures are designed to accommodate loads that are expected in service. Particular attention is given to limiting the effects of fatigue and significant plastic deformation or rupture. Experience has shown that while expected loads have been properly treated, dynamic loads not explicitly considered during design have occurred in service causing material degradation and component failure. Examples of unexpected dynamic loads are vibration, water hammer, and unstable fluid flow. Vibration dynamic loads are caused by the response of a component, system or structure to oscillating input. Possible sources of input energy include rotating equipment and fluid flow. The most serious situations arise when the input load synchronizes or nearly synchronizes with the natural frequency of the component, system, or structure. Examples of vibration-induced dynamic loading problems which have occurred in LWRs include PWR core barrel vibration, main coolant pump shaft cracking, pipe weld fatigue cracking, and steam generator and condenser tube failures. Tubes in heat exchangers tend to vibrate under the influence of crossflow velocities, possibly leading to tube or support damage. When the vibration amplitude is high enough, the tubes impact and experience thinning at mid-span; when lower, fretting damage can occur at support points. Although fatigue failure is a major concern due to vibration loads, simple loss of function may also occur in components such as bolting and valves. Flow-induced vibration has been identified as the source of many safety relief valve (SRV) failures in high energy piping systems, causing leakage, chatter, premature pop-off, fretting, galling, fatigue and possible failure to operate when required. Water hammer loads are caused by hydraulic pressure wave effects associated with rapid changes in fluid flow. These changes may be initiated by rapid valve or pump action, particularly with large differential pressure across the valve or high fluid flow capacity through the pump. In other cases, water hammer may be caused by rapid condensation of steam or liquid flashing to steam followed by condensation with enough liquid in the system to transmit the pressure wave. Unanticipated water hammer loads have caused piping support failures, deformation of piping and internals, and valve and pump damage.	[5] [6]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: Main Feedwater System (045) Equipment Type: PIPE

ARDM	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Erosion Corrosion	Yes	Increased rate of attack on a metal because of the relative movement between a corrosive fluid and the metal surface. Mechanical wear or abrasion can be involved, characterized by grooves, gullies, waves, holes and valleys on the metal surface. Erosion is a mechanical action of a fluid and/or particulate matter on a metal surface, without the influence of corrosion. Erosion corrosion failures can occur in a relatively short time and are sometimes unexpected, since corrosion tests are usually run under static conditions. All equipment exposed to moving fluids is vulnerable; in particular, piping (bends, tees, etc.), valves, pumps, propellers and impellers, heat exchanger tubing, turbine blades and wear plates are components which have experienced erosion corrosion. This is a serious problem in steam piping, heater drain piping, reheaters, and moisture separators due to high velocity particle impingement. Erosion corrosion has occurred in high and low pressure preheater tubes, low pressure preheaters, evaporators and feedwater heaters. Inlet tube corrosion occurs in heat exchangers, due to the turbulence of flow from the exchanger head into the smaller tubes, within the first few inches of the tube. Such corrosion has been especially evident in condenser tubes and feedwater heaters. The occurrence of erosion corrosion is highly dependent upon material of construction and the fluid flow conditions. Carbon or low alloy steels are particularly susceptible when in contact with high velocity water (single or two phase) with turbulent flow, low oxygen and fluid pH < 9.3. Maximum erosion corrosion rates are expected in carbon steel at 130-140°C (single phase) and 180°C (two phase).	[4] [5] [6]
Fatigue	Yes	Fatigue damage results from progressive, localized structural change in materials subjected to fluctuating stresses and strains. Associated failures may occur at either high or low cycles in response to various kinds of loads (e.g., Mechanical or vibrational loads, thermal cycles, or pressure cycles). Fatigue cracks initiate and propagate in regions of stress concentration that intensify strain. The fatigue life of a component is a function of several variables such as stress level, stress state, cyclic wave form, fatigue environment, and the metallurgical condition of the material. Failure occurs when the endurance limit number of cycles (for a given load amplitude) is exceeded. All materials are susceptible (with varying endurance limits) when subjected to cyclic loading. Vibration loads have also been the cause of recurring weld failures by the fatigue of small socket welds. Certain piping locations, such as charging lines, have been found to experience vibration conditions. In some cases these failures in pipe have been due to inadequately supported pipe or obturator induced vibratory loads.	[5] [6] [2]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **PIPE**

ARDM	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Fouling	Yes	Unavoidable introduction of foreign substances that interact with and/or collect within system and components. Caused by failure or degradation of upstream removal process equipment, long term buildup, low flow, stagnant flow, infrequent operation, and/or contaminated inlet flow. Fouling refers to all deposits on system surfaces that increase resistance to fluid flow and/or heat transfer. Sources of fouling include the following: (1) organic films of micro-organisms and their products (microbial fouling) (2) deposits of macro-organisms such as mussels (macrobial fouling) (3) inorganic deposits, including scales, silt, corrosion products and detritus. Scales result when solubility limits for a given species are exceeded. Deposits result when coolant-borne particles drop onto surfaces due to hydraulic factors. The deposits result in reduced flow of cooling water, reduced heat transfer, and increased corrosion. Sediment deposits promote concentration cell corrosion and growth of sulfur-reducing bacteria. The bacteria can cause severe pitting after one month of service. Piping systems designed for 30 years have had their projected life reduced to five years due to under-sediment corrosion.	[8] [9] [10]
Galvanic Corrosion	Yes	Accelerated corrosion caused by dissimilar metals in contact in a conductive solution. Requires two dissimilar metals in physical or electrical contact, developed potential (material dependent), and conducting solution.	[11]
General Corrosion	Yes	Thinning (wastage) of a metal by chemical attack (dissolution) at the surface of the metal by an aggressive environment. The consequences of the damage are loss of load carrying cross-sectional area. General corrosion requires an aggressive environment and materials susceptible to that environment. An important concern for PWRs is boric acid attack of carbon steels. Borated water has been observed to leak from piping, valves, storage tanks, etc., and fall on other carbon steel components and attack the component from the outside. Wastage is not a concern for austenitic stainless steel alloys.	[6] [7] [2]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **PIPE**

ARDM	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Hydrogen Damage	Yes	Two forms of hydrogen attack relevant to light water reactor materials and conditions are hydrogen blistering and hydrogen embrittlement. Both produce mechanical damage in the affected component. In each case, atomic hydrogen enters the metal, either as a result of a corrosion reaction at the surface or by cathodic polarization which results in the evolution of hydrogen gas. In blistering, molecular hydrogen within the metal causes high pressure and local damage in the form of "blistered" regions of the metal surface. Hydrogen embrittlement affects ferritic and martensitic iron-based alloys, and results in low ductility intergranular cracking (similar to stress corrosion cracking). The phenomenon of hydrogen cracking is usually manifested as delayed cracking, at or near room temperature, after stress is applied. A certain critical stress, which may take the form of weld residual stress, is required to cause cracking. Notches concentrate such stresses and tend to shorten the delay time for cracking. Cracking of welds due to hydrogen embrittlement and hydrogen-induced cracking is a common concern. This cracking is more of a problem in higher strength steels (yield strength >120 ksi). Ferritic and martensitic stainless steels, carbon steels, and other high strength alloys are susceptible. Austenitic stainless steels are relatively immune but could experience damage at sufficiently high hydrogen levels.	[5] [6]
Intergranular Attack	Yes	Intergranular Attack (IGA) is very similar to intergranular stress corrosion cracking (IGSCC) except that stress is not required for IGA. IGA is localized corrosion at or adjacent to grain boundaries, with relatively little corrosion of the material grains. It is caused by impurities in the grain boundaries, or the enrichment or depletion of alloying elements at grain boundaries, such as the depletion of chromium at austenitic stainless steel grain boundaries. A "sensitized" microstructure causes susceptibility to IGA. When austenitic stainless steels are heated into or slow cooled through the temperature range of approximately 750 to 1500°F, chromium carbides can be formed, thus depleting the grain boundaries of chromium and decreasing their corrosion resistance. High chromium ferritic stainless steels, such as Type 430, also experience susceptibility to IGA. Nickel alloys such as alloy 600 experience IGA in the presence of certain sulfur environments at high temperatures (by forming low melting sulfur compounds at grain boundaries) or when austenitic stainless steel weld filler metal is inadvertently used on Ni-Cr-Fe alloys. Susceptibility to intergranular attack (sensitization) usually develops during thermal processing such as welding or heat treatments.	[5] [6] [2] [11]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **PIPE**

ARDM	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Irradiation Embrittlement	No	Not applicable to Equipment Type. The ARDM results in a decrease in steel fracture toughness due to long-term exposure to a fast flux of neutrons. High neutron fluence levels can lead to embrittlement of the reactor pressure vessel core beltline, as well as certain reactor internals and core support structures. Control of material composition to low levels of Cu and Ni (and perhaps P and Si, to some extent) is beneficial in some cases, such as the reactor pressure vessel ferritic steel. Core support structure peak fluences as high as 1.0E+21 (e > 1mev) are reached in some cases and can embrittle the austenitic stainless steels and alloy 600 material in these components. PWRs experience fluences of between 9.0E+18 and about 4.0E+19 (e > 1mev) at the vessel beltline inside surface. Safe-ends and piping outside the vessel are not expected to experience irradiation significant enough to cause problems. However, the embrittlement effects due to low flux irradiation are not well understood. This ARDM is not applicable to this equipment type since piping components are not located in areas where the neutron flux is high enough to cause this ARDM to occur.	[5] [6]
MIC	Yes	Accelerated corrosion of materials resulting from surface microbiological activity. Sulfate reducing bacteria, sulfur oxidizers, and iron oxidizing bacteria are most commonly associated with corrosion effects. Most often results in pitting followed by excessive deposition of corrosion products. Stagnant or low flow areas are most susceptible. Any system that uses untreated water, or is buried, is particularly susceptible. Consequences range from leakage to excessive differential pressure and flow blockage. Essentially all systems and most commonly-used materials are susceptible. Temperatures from about 50°F to 120°F are most conducive to MIC. Experience in virtually all large industries is common. Nuclear experience is relatively new, but also widespread. MIC is generally observed in service water applications utilizing raw untreated water. Sedimentation aggravates the problem.	[5] [6] [2]
Oxidation	No	Not applicable to Equipment Type. The ARDM results from a chemical reaction at the surface of a material when subjected to an oxidizing environment. Oxidation occurs at any temperature. Electrical components experience degradation related to oxidation and are considered separately. Oxidation generally is not considered a degradation mechanism in metals of fluid systems in mild environments since this mechanism serves to protect materials by formation of a passive layer. Other corrosion mechanisms (e.g. Corrosion fatigue, crevice corrosion, erosion corrosion, general corrosion and pitting) can result from oxidation/reduction reactions under specific aggressive mechanical and chemical environment and are addressed separately. It could be considered a degradation mechanism at high temperatures, where a more rapid reaction between metal and oxygen is likely to occur. These temperatures do not occur in power plant applications under evaluation. Therefore, oxidation is not considered a potential ARDM for piping.	[6] [11]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **PIPE**

ARDM	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Particulate Wear Erosion	Yes	The loss of material caused by mechanical abrasion due to relative motion between solution and material surface. Requires high velocity fluid, entrained particles, turbulent flow regions, flow direction change, and/or impingement. Most materials are susceptible to varying degrees depending upon the severity of the environmental factors.	[6]
Pitting	Yes	A form of localized attack with greater corrosion rates at some locations than at others. Pitting can be very insidious and destructive, with sudden failures in high pressure applications (especially in tubes) occurring by perforation. This form of corrosion essentially produces "holes" of varying depth to diameter ratios in the steel. These pits are, in many cases, filled with oxide debris, especially for ferritic materials such as carbon steel. Deep pitting is more common with passive metals, such as austenitic stainless steels, than with non- passive metals. Pits are generally elongated in the direction of gravity. In many cases, erosion corrosion, fretting corrosion, and crevice corrosion can also lead to pitting. Corrosion pitting is an anodic reaction which is an autocatalytic process. That is, the corrosion process within a pit produces conditions which stimulate the continuing activity of the pit. High concentrations of impurity anions such as chlorides and sulfates tend to concentrate in the oxygen- depleted pit region, giving rise to a potentially concentrated aggressive solution in this zone. Pitting has been found on the outside diameter of tubes where sludge or tube scale was present. It can also occur at locations of relatively stagnant coolant or water, such as in carbon steel pipes for service water lines, and at crevices in stainless steel, such as at the stainless steel cladding between reactor pressure vessel closure flanges. Pitting can become passive in some metals such as aluminum.	[5] [6] [2] [11]
Radiation Damage	Yes	Non-metallics are susceptible to degradation caused by gamma radiation.	[3]
Saline Water Attack	Yes	Saline Water Attack has resulted in the degradation of reinforced concrete structures. The degradation mechanism involves water seepage into the concrete resulting in a high chloride environment for the reinforcing bars. The reinforcing bars corrode resulting in expansion that leads to cracking and spalling of the concrete. Saline water attack is of particular concern for structures that are inaccessible for routine inspection, and piping or other fluid components embedded in concrete.	[2]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **PIPE**

ARDM	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Selective Leaching	Yes	The removal of one element from a solid alloy by corrosion processes. The most common example is the selective removal of zinc in brass alloys (dezincification). Similar processes occur in other alloy systems in which aluminum, iron, cobalt, chromium, and other elements are removed. There are two types, layer-type and plug-type. Layer-type is a uniform attack whereas plug-type is extremely localized leading to pitting. Overall dimensions do not change appreciably. If a piece of equipment is covered by debris or surface deposits and/or not inspected closely, sudden unexpected failure may occur in high pressure applications due to the poor strength of the remaining material. Requires susceptible materials and corrosive environment. Materials particularly susceptible include zinc, aluminum, carbon and nickel. Environmental conditions include high temperature, stagnant aqueous solution, and porous inorganic scale. Acidic solutions and oxygen aggravate the mechanism.	[11] [12]
Stress Corrosion Cracking	Yes	Selective corrosive attack along or across material grain boundaries. Four particular mechanisms are known to exist: (1) Intergranular (IGSCC), between the material grain boundaries. (2) Transgranular (TGSCC), across the material grains along certain crystallographic planes. (3) Irradiation Assisted (IASCC), between the material grains after an incubation neutron dose which sensitizes the material. (4) Interdendritic (IDSCC), between the dendrite interfaces. SCC requires applied or residual tensile stress, susceptible materials (such as austenitic stainless steels, alloy 600, alloy x-750, SAE 4340, and ASTM A289), and oxygen and/or ionic species (eg., Chlorides/sulfates). Common sources of residual stress include thermal processing and stress risers created during surface finishing, fabrication, or assembly. The heat input during welding can result in a localized sensitized region which is susceptible to SCC. IGSCC is a concern in stainless steel piping depending on material condition and process fluid chemistry and also is a potential concern in valve internals (PH steel). While operating experience with carbon steel piping shows no evidence of environmentally assisted cracking, laboratory studies do indicate a susceptibility to SCC. Screening tests on SA106b and SA333GR6 indicate that severe combinations of cyclic applied stress and high temperature oxygenated water can result in environmentally enhanced cracking. TGSCC may be a concern in stainless steel if aggressive chemical species (caustics, halogens, sulfates, especially if coupled with the presence of oxygen) are present. TGSCC was thought to be inactive in low alloy steel, however, recent data suggests that the mechanism may operate. IASCC is a potential concern only for reactor vessel internals and other stainless steel components, such as control rods, which are subject to very high neutron fluence levels. A fast neutron incubation fluence of at least 1.0E+20 is generally required to sensitize the material. IDSCC is a potential concern in stainless steel weld metal deposits based on microstructure and delta ferrite content. This mechanism is inactive in	[5] [6] [2]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: Main Feedwater System (045) Equipment Type: PIPE

ARDM	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
		carbon and low alloy steel. Ammonia grooving in brass components can occur when the concentration of ammonia is greater than a few ppm. It is found most often in feedwater heaters that contain admiralty brass tubes and where morpholine, which breaks down into ammonia, is used to increase the pH of the condensate.	
Thermal Damage	Yes	Non-metallics are particularly susceptible with material dependent temperature limits.	[6] [2]
Thermal Embrittlement	Yes	Loss of material fracture toughness caused by thermally induced changes in the formation and distribution of alloying constituents. Requires high temperature 500°F to 700°F for metallic components. Ferrite containing stainless steels are susceptible as are materials with grain boundary segregation of impurities.	[6]
Wear	No	Not applicable to equipment type. There are no moving parts in this equipment type.	[1]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **PIPE**

Reference List

Source	Title
[1]	ASME Wear Control Handbook, Peterson and Winer, 1980
[2]	Standard Format and Content of Technical Information for Applications to Renew Nuclear Power Plant Operating Licenses, Draft NRC Regulatory Guide No. DG-1009, December 1990
[3]	Radiation Effects on Organic Materials in Nuclear Plants, EPRI Report No. NP-2129, November 1981
[4]	Erosion/Corrosion in Nuclear Plant Steam Piping, EPRI Report No. NP-3944, 1985
[5]	Component Life Estimation: LWR Structural Materials Degradation Mechanisms, EPRI Report No. NP-5461, 1987
[6]	Environmental Effects on Components: Commentary for ASME Section III, EPRI Report No. NP-5775, April 1988
[7]	Boric Acid Corrosion of Carbon and Low Alloy Steel Pressure Boundary Materials, EPRI Report No. NP-5985, 1988
[8]	Nuclear Plant Service Water System Aging Degradation Assessment, NUREG/CR-5379, Volume 1 and 2, June 1989 and October 1992
[9]	Aging Assessment of Instrument Air Systems, NUREG/CR-5419, January 1990
[10]	Insights Gained from Aging Research, NUREG/CR-5643, March 1992
[11]	Corrosion Engineering, Fontana and Greene, 1978
[12]	Corrosion and Corrosion Control, An Introduction to Corrosion Science and Engineering, Uhlig, Third Edition, 1985

ATTACHMENT 3, COMPONENT GROUPING SUMMARY SHEET

SYSTEM: Main Feedwater (045)
GROUP ID NUMBER: 045-DB-01
GROUP ATTRIBUTES:

1. Device Type: -DB
2. Vendor: NA
3. Model Number: NA
4. Material: Carbon Steel
5. Internal Environment: Controlled chemistry water at 435F (normal operation)
6. External Environment: Climate controlled atmospheric air (Containment Bldg.)
7. Function: Maintain system pressure boundary
8. Name Plate Data:

PARAMETER	VALUE
System Temperature	Variable from ambient (70F) when shutdown to 435F when operating (subject to thermal transient conditions due to thermal stratification near S/G nozzle at HSB, plant start-up / shutdown, and operational transients)
System Pressure	</= 1300 psig
Materials of Construction	Carbon Steel - seamless ASTM A-106 piping, cast steel ASTM A-234 fittings (alternate material for 1-DB1-1018, -1019 piping and fittings: Cr-Mo per M600C)
Joints	Butt welded, except socket welded for 2" and smaller branch lines

LIST OF GROUPED COMPONENTS (EQUIPMENT ID):

Equipment ID	Description	Equipment ID	Description
1-DB1-1018	FW SYSTEM PIPING	2-DB1-2018	FW SYSTEM PIPING
1-DB1-1019	FW SYSTEM PIPING	2-DB1-2019	FW SYSTEM PIPING

ATTACHMENT 3, COMPONENT GROUPING SUMMARY SHEET

SYSTEM: Main Feedwater (045)
GROUP ID NUMBER: 045-DB-02
GROUP ATTRIBUTES:

1. Device Type: -DB
2. Vendor: NA
3. Model Number: NA
4. Material: Carbon Steel
5. Internal Environment: Controlled chemistry water at 435F (normal operation)
6. External Environment: Climate controlled atmospheric air (Auxiliary Bldg.)
7. Function: Maintain system pressure boundary
8. Name Plate Data:

PARAMETER	VALUE
System Temperature	Variable from ambient (70F) when shutdown to 435F when operating (subject to thermal transient conditions due to plant start-up / shutdown and operational transients)
System Pressure	</= 1300 psig
Materials of Construction	Carbon Steel - seamless ASTM A-106 piping, cast steel ASTM A-234 fittings (alternate material for 1-DB3-1001, -1002 piping and fittings: Cr-Mo per M600C)
Joints	Butt welded, except socket welded for 2" and smaller branch lines

LIST OF GROUPED COMPONENTS (EQUIPMENT ID):

Equipment ID	Description	Equipment ID	Description
1-DB3-1001	FW SYSTEM PIPING	2-DP3-2001	FW SYSTEM PIPING
1-DB3-1002	FW SYSTEM PIPING	2-DB3-2002	FW SYSTEM PIPING

ATTACHMENT 5, ARDM MATRIX

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: PIPE DEVICE TYPE: -DB
GROUP ID (if applicable): NA

	GROUP OR SUB GROUP ID			
ARDMs	045-DB-01	045-DB-02	NA	NA
CAVITATION EROSION	1	1		
CORROSION FATIGUE	A	2		
CREVICE CORROSION	B	B		
DYNAMIC LOADING	3	3		
EROSION CORROSION	C	C		
FATIGUE	D	4		
FOULING	5	5		
GALVANIC CORROSION	6	6		
GENERAL CORROSION	E	E		
HYDROGEN DAMAGE	7	7		
INTERGRANULAR ATTACK	8	8		
MIC	9	9		
PARTICULATE WEAR EROSION	10	10		
PITTING	B	B		
RADIATION DAMAGE	11	11		
SALINE WATER ATTACK	12	12		
SELECTIVE LEACHING	13	13		
STRESS CORROSION CRACKING	14	14		
THERMAL DAMAGE	11	11		
THERMAL EMBRITTLEMENT	15	15		

Component Aging Management Review

ATTACHMENT 6, MATRIX CODE LIST

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: PIPE DEVICE TYPE: -DB
GROUP ID (if applicable): NA

CODE	DESCRIPTION	SOURCE
1	The feedwater system fluid flow conditions, pressure and temperature do not result in cavitation conditions in the piping. The flow is relatively steady and the pressure is much greater than the vapor pressure at system temperature. Therefore, cavitation erosion is not plausible.	[5], [11]
2	Control of system chemistry results in limited corrosion, and thermal fatigue for this piping is conservatively bounded by design code requirements (see Code 4 below). Therefore, corrosion fatigue is not plausible.	[5]
3	Normal service loads for feedwater piping do not result in significant vibration or other dynamic loading conditions. The system pressure is normally maintained steady. The transient effects of abnormal conditions, such as water hammer, are not considered routine and do not result in cumulative degradation of the piping. Based on these considerations, the effects of dynamic loading are negligible and will not affect the piping function.	[1], [4], [5],[10], [11]
4	The feedwater piping components in this group are far removed from the S/G, and are not subject to rapid thermal transient conditions associated with the S/G feedwater nozzle/piping thermal stratification conditions. The source of thermal cycling for the piping in this group is plant start-ups/shutdowns and secondary plant transients. These thermal cycles are conservatively enveloped by the design code requirements associated with this piping (ANSI B31.7/B31.1 rules for calculating allowable stress range for expansion stresses) which allow 7000 full temperature range cycles before applying additional stress limitations. The code requirements conservatively envelope expected plant thermal transients through the period of extended operation, therefore, thermal fatigue is not considered plausible for this group of piping components.	[5], [8], [9], [11], [12], [13], [19], [20]
5	Fouling does not affect the component function. The component intended function is to maintain the pressure boundary integrity only. Due to the control of feedwater chemistry, fouling (including contamination and sedimentation) is not expected. Any fouling or sedimentation will not have an affect on the intended function.	[5], [16]
6	Piping material is all carbon steel (with potentially Cr-Mo steel also) and water chemistry is controlled. Therefore, the required galvanic cell and electrolyte are not present, and galvanic corrosion is not plausible.	[6], [16]
7	The piping is not fabricated from the high strength steel susceptible to hydrogen embrittlement and cracking. Therefore, this ARDM is not plausible.	[5]
8	Carbon steel material is not susceptible to intergranular attack.	[5]
9	Microbiologically influenced corrosion is not plausible due to the chemical conditions and temperature of the working fluid in the system. The source for feedwater is demineralized water, and organic contaminants are avoided through feedwater/condensate chemistry control. Additionally, normal feedwater temperature is above 200F making MIC not possible.	[5], [16]
10	Control of feedwater chemistry ensures essentially no particulate matter in the feedwater flowstream. Therefore, particulate wear erosion is not plausible.	[16]
11	The thermal damage and radiation damage ARDMs affect non-metallics only. There are no non-metallic materials in these piping groups.	[2], [5]
12	The effects of saline water attack is potentially applicable only to piping in contact with concrete and exposed to moisture (i.e., embedded pipe). There is no embedded pipe in these piping groups of components.	[1], [11]
13	The carbon steel piping material is not susceptible to selective leaching. Therefore, this ARDM is not plausible.	[6], [17]

ATTACHMENT 6, MATRIX CODE LIST

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: PIPE DEVICE TYPE: -DB
GROUP ID (if applicable): NA

CODE	DESCRIPTION	SOURCE
14	Control of feedwater chemistry (particularly oxygen concentration) prevents the environment necessary for SCC of carbon steel material. Therefore, this ARDM is not plausible.	[5], [16]
15	The feedwater system operating temperature of ~ 435F max. is not sufficient to result in embrittlement. Thermal embrittlement of plain carbon and low alloy steels requires temperatures greater than 650F .	[5], [11]
A	Corrosion fatigue is plausible due to the combination of fatigue and corrosion mechanisms affecting this piping. It is characterized by accelerated crack propagation at susceptible locations due to mechanism synergy's and can lead to component failure prior to predicted failure due to corrosion or fatigue effects alone. Control of feedwater chemistry minimizes the corrosive effects of the fluid environment and monitoring the fatigue effects of thermal cycles provides predictability of degradation. An evaluation of feedwater system piping thermal fatigue should be performed to ensure that plant components that are currently monitored for the effects of fatigue are bounding for the feedwater piping. Additionally, the system fluid chemistry should continue to be controlled to minimize conditions conducive to corrosion.	[5], [14], [16], [18]
B	Crevice corrosion and pitting can occur in areas of the piping system that are not exposed to the general flowstream such as areas of lack of complete penetration in butt welds, clearances at socket weld fit-ups, and other crevices. These areas may comprise small localized volumes of stagnant solution for which fluid chemistry may deviate from bulk system chemistry. Higher concentrations of impurities may exist in these crevices due to out-of-specification system chemistry during shutdown conditions and due to the stagnant flow conditions of the crevice. The resulting degradation is highly localized pits or cracks. The control of feedwater/condensate system fluid chemistry significantly limits the effects of crevice corrosion and pitting. Additionally, controls over piping fit-up and welding quality during construction limit the locations of potential crevices in the large bore piping. Most susceptible locations for crevices are the small bore branch piping (drains and instrumentation taps) where socket welding creates potential crevices by design of the joint. The effects of crevice corrosion and pitting can not be dismissed due to the potential for crevice locations and potentially high impurity concentrations in the system during shutdown conditions. Management of the effects of crevice corrosion and pitting should consist of: 1) maintenance of the current system chemistry control program, and 2) subjecting a representative sample of piping locations (from piping in these groups or representative piping in other portions of the plant) to an inspection to determine the extent of localized degradation occurring in the feedwater piping.	[5], [6], [16]
C	Erosion corrosion is plausible due to high velocity, high energy fluid flow conditions. The effects of erosion corrosion include potentially rapid pipe wall thinning to the point of pressure boundary failure. The control of feedwater system fluid chemistry limits the rate and effects of erosion corrosion. The feedwater system is monitored routinely for the effects of erosion corrosion by the plant erosion corrosion monitoring program. The chemistry control program and the erosion corrosion monitoring program should be continued through the period of extended operation in order to manage the effects of erosion corrosion.	[3], [5], [11], [16]

ATTACHMENT 6, MATRIX CODE LIST

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: PIPE DEVICE TYPE: -DB
GROUP ID (if applicable): NA

CODE	DESCRIPTION	SOURCE
D	Fatigue due to thermal cycling of the feedwater piping in this group (low-cycle fatigue) is plausible due to thermal stratification of the piping adjacent to the S/G nozzle during hot stand-by and low power operating conditions. The resulting high number of thermal cycles to which the piping is subjected could result in fatigue damage accumulation to the point of crack initiation and propagation. An evaluation of feedwater system piping thermal fatigue should be performed to ensure that plant components that are currently monitored for the effects of fatigue are bounding for the feedwater piping.	[5], [14], [15]
E	General corrosion of the feedwater system piping is plausible due to exposure of carbon steel materials to corrosive medium during shutdown periods and, to a lessor extent, during operation. The rate of general corrosion is low after the initial build-up of the protective corrosion film (magnetite). Exposure to high oxygen concentrations during shutdown and potential removal and re-creation of the corrosion film result in general corrosion. The effects of general corrosion is pipe wall thinning over a relatively large area and could result in pressure boundary failure if extensive. The control of feedwater/condensate system fluid chemistry significantly limits the effects of general corrosion. Management of the effects of general corrosion should consist of: 1) maintenance of the current system chemistry control program, and 2) subjecting a representative sample of piping locations (from piping in these groups or representative piping in other portions of the plant) to an inspection to determine the extent of general degradation occurring in the feedwater piping. Portions of the feedwater system piping inspected for the effects of erosion corrosion are thereby managed for the effects of general corrosion (i.e., wall thinning).	[5], [6], [7], [16]

ATTACHMENT 6, MATRIX CODE LIST

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: PIPE DEVICE TYPE: -DB
GROUP ID (if applicable): NA

Reference List

Source	Title
[1]	Standard Format and Content of Technical Information for Applications to Renew Nuclear Power Plant Operating Licenses, Draft NRC Regulatory Guide No. DG-1009, December 1990
[2]	Radiation Effects on Organic Materials in Nuclear Plants, EPRI Report No. NP-2129, November 1981
[3]	Erosion/Corrosion in Nuclear Plant Steam Piping, EPRI Report No. NP-3944, 1985
[4]	Component Life Estimation: LWR Structural Materials Degradation Mechanisms, EPRI Report No. NP-5461, 1987
[5]	Environmental Effects on Components: Commentary for ASME Section III, EPRI Report No. NP-5775, April 1988
[6]	Corrosion Engineering, Fontana and Greene, 1978
[7]	Corrosion and Corrosion Control, An Introduction to Corrosion Science and Engineering, Uhlig, Third Edition, 1985
[8]	Drawing 60702, Sheet 4, Rev. 28; Condensate and Feedwater System, Unit 1
[9]	Drawing 62702, Sheet 4, Rev. 30; Condensate and Feedwater System, Unit 2
[10]	OI-12A-1, Rev. 22/OI-12A-2, Rev. 14; Feedwater System Operating Instructions
[11]	UFSAR, Rev. 18; Chapter 4 - Reactor Coolant and Associated Systems, Chapter 10 - Steam and Power Conversion Systems
[12]	ANSI B31.1, 1967; Power Piping Code
[13]	ANSI B31.7, 1969; Nuclear Power Piping Code
[14]	CE-NPSD-634-P, April 1992; Fatigue Monitoring Program for CCNPP Units 1 and 2
[15]	IR1-011-785 ; S/G Feedwater Nozzle/Piping Thermal Stratification Issue Report
[16]	CP-217, Rev. 5; Chemistry Specifications and Surveillance - Secondary System
[17]	Marks' Standard Handbook for Mechanical Engineers, 8th Edition, McGraw-Hill
[18]	Metals Handbook, 9th Edition, Volumes 1 and 13, ASM
[19]	Drawing 12543A-01, Rev. 13; Feedwater Piping Isometric, Unit 1
[20]	Drawing 13547A-20, Rev. 6F; 13547A-47, Rev. 4; 13549A-26, Rev. 3; Feedwater Piping Isometric, Unit 2

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **VALVE**

ARDM	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Cavitation Erosion	Yes	Localized material erosion caused by formation and collapse of vapor bubbles in close proximity to material surface. Requires fluid (liquid) flow and pressure variations which temporarily drop the liquid pressure below the corresponding vapor pressure. Most materials are susceptible to varying degrees depending upon the severity of the environmental factors.	[7]
Corrosion Fatigue	Yes	Plant equipment operating in a corrosive environment subjected to cyclic (fatigue) loading may initiate cracks and/or fail sooner than expected based on analysis of the corrosion and fatigue loadings applied separately. Fatigue-crack initiation and growth usually follows a transgranular path, although there are some cases where intergranular cracking has been observed. In some cases, crack initiation occurs by fatigue and is subsequently dominated by corrosion advance. In other cases, a corrosion mechanism (SCC) can be responsible for crack formation below the fatigue threshold, and the fatigue mechanism can accelerate the crack propagation. Corrosion-fatigue is a potentially active mechanism in both stainless steels as well as carbon and low alloy steels.	[7]
Creep/ Shrinkage	No	Not applicable to Equipment Type. The phenomenon results in dimensional changes in metals at high temperatures and in concrete subject to long term dehydration. This ARDM is not applicable to this equipment type since proper component specification and design prevents this ARDM from occuring (i.e., system and component design standards adequately address this ARDM).	[2]
Crevice Corrosion	Yes	Crevice corrosion is intense, localized corrosion within crevices or shielded areas. It is associated with a small volume of stagnant solution caused by holes, gasket surfaces, lap joints, crevices under bolt heads, surface deposits, designed crevices for attaching thermal sleeves to safe-ends, and integral weld backing rings or back-up bars. The crevice must be wide enough to permit liquid entry and narrow enough to maintain stagnant conditions, typically a few thousandths of an inch or less. Crevice corrosion is closely related to pitting corrosion and can initiate pits in many cases as well as leading to stress corrosion cracking. In an oxidizing environment, a crevice can set up a differential aeration cell to concentrate an acid solution within the crevice. Even in a reducing environment, alternate wetting and drying can concentrate aggressive ionic species to cause pitting, crevice corrosion, intergranular attack, or stress corrosion cracking.	[6] [7] [12]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **VALVE**

ARDM	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Erosion Corrosion	Yes	Increased rate of attack on a metal because of the relative movement between a corrosive fluid and the metal surface. Mechanical wear or abrasion can be involved, characterized by grooves, gullies, waves, holes and valleys on the metal surface. Erosion is a mechanical action of a fluid and/or particulate matter on a metal surface, without the influence of corrosion. Erosion corrosion failures can occur in a relatively short time and are sometimes unexpected, since corrosion tests are usually run under static conditions. All equipment exposed to moving fluids is vulnerable; in particular, piping (bends, tees, etc.), valves, pumps, propellers and impellers, heat exchanger tubing, turbine blades and wear plates are components which have experienced erosion corrosion. This is a serious problem in steam piping, heater drain piping, reheaters, and moisture separators due to high velocity particle impingement. Erosion corrosion has occurred in high and low pressure preheater tubes, low pressure preheaters, evaporators and feedwater heaters. Inlet tube corrosion occurs in heat exchangers, due to the turbulence of flow from the exchanger head into the smaller tubes, within the first few inches of the tube. Such corrosion has been especially evident in condenser tubes and feedwater heaters. The occurrence of erosion corrosion is highly dependent upon material of construction and the fluid flow conditions. Carbon or low alloy steels are particularly susceptible when in contact with high velocity water (single or two phase) with turbulent flow, low oxygen and fluid $pH < 9.3$. Maximum erosion corrosion rates are expected in carbon steel at 130-140°C (single phase) and 180°C (two phase).	[5] [6] [7]
Fatigue	Yes	Fatigue damage results from progressive, localized structural change in materials subjected to fluctuating stresses and strains. Associated failures may occur at either high or low cycles in response to various kinds of loads (e.g., Mechanical or vibrational loads, thermal cycles, or pressure cycles). Fatigue cracks initiate and propagate in regions of stress concentration that intensify strain. The fatigue life of a component is a function of several variables such as stress level, stress state, cyclic wave form, fatigue environment, and the metallurgical condition of the material. Failure occurs when the endurance limit number of cycles (for a given load amplitude) is exceeded. All materials are susceptible (with varying endurance limits) when subjected to cyclic loading. Vibration loads have also been the cause of recurring weld failures by the fatigue of small socket welds. Certain piping locations, such as charging lines, have been found to experience vibration conditions. In some cases these failures in pipe have been due to inadequately supported pipe or obturator induced vibratory loads.	[6] [7] [2]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **VALVE**

ARDM	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Fouling	Yes	Unavoidable introduction of foreign substances that interact with and/or collect within system and components. Caused by failure or degradation of upstream removal process equipment, long term buildup, low flow, stagnant flow, infrequent operation, and/or contaminated inlet flow. Fouling refers to all deposits on system surfaces that increase resistance to fluid flow and/or heat transfer. Sources of fouling include the following: (1) organic films of micro-organisms and their products (microbial fouling) (2) deposits of macro-organisms such as mussels (macrobial fouling) (3) inorganic deposits, including scales, silt, corrosion products and detritus. Scales result when solubility limits for a given species are exceeded. Deposits result when coolant-borne particles drop onto surfaces due to hydraulic factors. The deposits result in reduced flow of cooling water, reduced heat transfer, and increased corrosion. Sediment deposits promote concentration cell corrosion and growth of sulfur-reducing bacteria. The bacteria can cause severe pitting after one month of service. Piping systems designed for 30 years have had their projected life reduced to five years due to under-sediment corrosion.	[9] [10] [11]
Galvanic Corrosion	Yes	Accelerated corrosion caused by dissimilar metals in contact in a conductive solution. Requires two dissimilar metals in physical or electrical contact, developed potential (material dependent), and conducting solution.	[12]
General Corrosion	Yes	Thinning (wastage) of a metal by chemical attack (dissolution) at the surface of the metal by an aggressive environment. The consequences of the damage are loss of load carrying cross-sectional area. General corrosion requires an aggressive environment and materials susceptible to that environment. An important concern for PWRs is boric acid attack of carbon steels. Borated water has been observed to leak from piping, valves, storage tanks, etc., and fall on other carbon steel components and attack the component from the outside. Wastage is not a concern for austenitic stainless steel alloys.	[7] [8] [2]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **VALVE**

ARDM	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Hydrogen Damage	Yes	Two forms of hydrogen attack relevant to light water reactor materials and conditions are hydrogen blistering and hydrogen embrittlement. Both produce mechanical damage in the affected component. In each case, atomic hydrogen enters the metal, either as a result of a corrosion reaction at the surface or by cathodic polarization which results in the evolution of hydrogen gas. In blistering, molecular hydrogen within the metal causes high pressure and local damage in the form of "blistered" regions of the metal surface. Hydrogen embrittlement affects ferritic and martensitic iron-based alloys, and results in low ductility intergranular cracking (similar to stress corrosion cracking). The phenomenon of hydrogen cracking is usually manifested as delayed cracking, at or near room temperature, after stress is applied. A certain critical stress, which may take the form of weld residual stress, is required to cause cracking. Notches concentrate such stresses and tend to shorten the delay time for cracking. Cracking of welds due to hydrogen embrittlement and hydrogen-induced cracking is a common concern. This cracking is more of a problem in higher strength steels (yield strength >120 ksi). Ferritic and martensitic stainless steels, carbon steels, and other high strength alloys are susceptible. Austenitic stainless steels are relatively immune but could experience damage at sufficiently high hydrogen levels.	[6] [7]
Intergranular Attack	Yes	Intergranular Attack (IGA) is very similar to intergranular stress corrosion cracking (IGSCC) except that stress is not required for IGA. IGA is localized corrosion at or adjacent to grain boundaries, with relatively little corrosion of the material grains. It is caused by impurities in the grain boundaries, or the enrichment or depletion of alloying elements at grain boundaries, such as the depletion of chromium at austenitic stainless steel grain boundaries. A "sensitized" microstructure causes susceptibility to IGA. When austenitic stainless steels are heated into or slow cooled through the temperature range of approximately 750 to 1500°F, chromium carbides can be formed, thus depleting the grain boundaries of chromium and decreasing their corrosion resistance. High chromium ferritic stainless steels, such as Type 430, also experience susceptibility to IGA. Nickel alloys such as alloy 600 experience IGA in the presence of certain sulfur environments at high temperatures (by forming low melting sulfur compounds at grain boundaries) or when austenitic stainless steel weld filler metal is inadvertently used on Ni-Cr-Fe alloys. Susceptibility to intergranular attack (sensitization) usually develops during thermal processing such as welding or heat treatments.	[6] [7] [2] [12]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **VALVE**

ARDM	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Irradiation Embrittlement	No	Not applicable to Equipment Type. The ARDM results in a decrease in steel fracture toughness due to long-term exposure to a fast flux of neutrons. High neutron fluence levels can lead to embrittlement of the reactor pressure vessel core beltline, as well as certain reactor internals and core support structures. Control of material composition to low levels of Cu and Ni (and perhaps P and Si, to some extent) is beneficial in some cases, such as the reactor pressure vessel ferritic steel. Core support structure peak fluences as high as 1.0E+21 (e > 1mev) are reached in some cases and can embrittle the austenitic stainless steels and alloy 600 material in these components. PWRs experience fluences of between 9.0E+18 and about 4.0E .9 (e > 1mev) at the vessel beltline inside surface. Safe-ends and piping outside the vessel are not expected to experience irradiation significant enough to cause problems. However, the embrittlement effects due to low flux irradiation are not well understood. This ARDM is not applicable to this equipment type since valve components are not located in areas where the neutron flux is high enough to cause this ARDM to occur.	[6] [7]
MIC	Yes	Accelerated corrosion of materials resulting from surface microbiological activity. Sulfate reducing bacteria, sulfur oxidizers, and iron oxidizing bacteria are most commonly associated with corrosion effects. Most often results in pitting followed by excessive deposition of corrosion products. Stagnant or low flow areas are most susceptible. Any system that uses untreated water, or is buried, is particularly susceptible. Consequences range from leakage to excessive differential pressure and flow blockage. Essentially all systems and most commonly-used materials are susceptible. Temperatures from about 50°F to 120°F are most conducive to MIC. Experience in virtually all large industries is common. Nuclear experience is relatively new, but also widespread. MIC is generally observed in service water applications utilizing raw untreated water. Sedimentation aggravates the problem.	[6] [7] [2]
Oxidation	No	Not applicable to Equipment Type. The ARDM results from a Chemical reaction at the surface of a material when subjected to an oxidizing environment. Oxidation occurs at any temperature. Electrical components experience degradation related to oxidation and are considered separately. Oxidation generally is not considered a deradation mechanism in metals of fluid systems in mild environments since this mechanism serves to protect materials by formation of a passive layer. Other corrosion mechanisms (e.g. Corrosion fatigue, crevice corrosion, erosion corrosion, general corrosion and pitting) can result from oxidation/reduction reactions under specific aggressive mechanical and chemical environment and are addressed separately. It could be considered a degradation mechanism at high temperatures, where a more rapid reaction between metal and oxygen is likely to occur. These temperatures do not occur in power plant applications under evaluation. Therefore, oxidation is not considered a potential ARDM for valve components.	[7] [12]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **VALVE**

ARDM	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Particulate Wear Erosion	Yes	The loss of material caused by mechanical abrasion due to relative motion between solution and material surface. Requires high velocity fluid, entrained particles, turbulent flow regions, flow direction change, and/or impingement. Most materials are susceptible to varying degrees depending upon the severity of the environmental factors.	[7]
Pitting	Yes	A form of localized attack with greater corrosion rates at some locations than at others. Pitting can be very insidious and destructive, with sudden failures in high pressure applications (especially in tubes) occurring by perforation. This form of corrosion essentially produces "holes" of varying depth to diameter ratios in the steel. These pits are, in many cases, filled with oxide debris, especially for ferritic materials such as carbon steel. Deep pitting is more common with passive metals, such as austenitic stainless steels, than with non- passive metals. Pits are generally elongated in the direction of gravity. In many cases, erosion corrosion, fretting corrosion, and crevice corrosion can also lead to pitting. Corrosion pitting is an anodic reaction which is an autocatalytic process. That is, the corrosion process within a pit produces conditions which stimulate the continuing activity of the pit. High concentrations of impurity anions such as chlorides and sulfates tend to concentrate in the oxygen- depleted pit region, giving rise to a potentially concentrated aggressive solution in this zone. Pitting has been found on the outside diameter of tubes where sludge or tube scale was present. It can also occur at locations of relatively stagnant coolant or water, such as in carbon steel pipes for service water lines, and at crevices in stainless steel, such as at the stainless steel cladding between reactor pressure vessel closure flanges. Pitting can become passive in some metals such as aluminum.	[6] [7] [2] [12]
Radiation Damage	Yes	Non-metallics are susceptible to degradation caused by gamma radiation.	[4]
Saline Water Attack	No	Not applicable to Equipment Type. Saline Water Attack has resulted in the degradation of reinforced concrete structures. The degradation mechanism involves water seepage into the concrete resulting in a high chloride environment for the reinforcing bars. The reinforcing bars corrode resulting in expansion that leads to cracking and spalling of the concrete. Saline water attack is of particular concern for structures that are inaccessible for routine inspection, and piping or other fluid components embedded in concrete. This ARDM is not applicable to valve components since valves are not constructed of nor typically installed in concrete.	[2]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **VALVE**

ARDM	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Selective Leaching	Yes	The removal of one element from a solid alloy by corrosion processes. The most common example is the selective removal of zinc in brass alloys (dezincification). Similar processes occur in other alloy systems in which aluminum, iron, cobalt, chromium, and other elements are removed. There are two types, layer-type and plug-type. Layer-type is a uniform attack whereas plug-type is extremely localized leading to pitting. Overall dimensions do not change appreciably. If a piece of equipment is covered by debris or surface deposits and/or not inspected closely, sudden unexpected failure may occur in high pressure applications due to the poor strength of the remaining material. Requires susceptible materials and corrosive environment. Materials particularly susceptible include zinc, aluminum, carbon and nickel. Environmental conditions include high temperature, stagnant aqueous solution, and porous inorganic scale. Acidic solutions and oxygen aggravate the mechanism.	[12] [13]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: Main Feedwater System (045) Equipment Type: VALVE

ARDM	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Stress Corrosion Cracking	Yes	Selective corrosive attack along or across material grain boundaries. Four particular mechanisms are known to exist: (1) Intergranular (IGSCC), between the material grain boundaries. (2) Transgranular (TGSCC), across the material grains along certain crystallographic planes. (3) Irradiation Assisted (IASCC), between the material grains after an incubation neutron dose which sensitizes the material. (4) Interdendritic (IDSCC), between the dendrite interfaces. SCC requires applied or residual tensile stress, susceptible materials (such as austenitic stainless steels, alloy 600, alloy x-750, SAE 4340, and ASTM A289), and oxygen and/or ionic species (eg., Chlorides/sulfates). Common sources of residual stress include thermal processing and stress risers created during surface finishing, fabrication, or assembly. The heat input during welding can result in a localized sensitized region which is susceptible to SCC. IGSCC is a concern in stainless steel piping depending on material condition and process fluid chemistry and also is a potential concern in valve internals (PH steel). While operating experience with carbon steel piping shows no evidence of environmentally assisted cracking, laboratory studies do indicate a susceptibility to SCC. Screening tests on SA106b and SA333GR6 indicate that severe combinations of cyclic applied stress and high temperature oxygenated water can result in environmentally enhanced cracking. TGSCC may be a concern in stainless steel if aggressive chemical species (caustics, halogens, sulfates, especially if coupled with the presence of oxygen) are present. TGSCC was thought to be inactive in low alloy steel, however, recent data suggests that the mechanism may operate. IASCC is a potential concern only for reactor vessel internals and other stainless steel components, such as control rods, which are subject to very high neutron fluence levels. A fast neutron incubation fluence of at least 1.0E+20 is generally required to sensitize the material. IDSCC is a potential concern in stainless steel weld metal deposits based on microstructure and delta ferrite content. This mechanism is inactive in carbon and low alloy steel. Ammonia grooving in brass components can occur when the concentration of ammonia is greater than a few ppm. It is found most often in feedwater heaters that contain admiralty brass tubes and where morpholine, which breaks down into ammonia, is used to increase the pH of the condensate.	[6] [7] [2]
Stress Relaxation	Yes	Stress Relaxation occurs under conditions of constant strain where part of the elastic strain is replaced with plastic strain. A material loaded to an initial stress may experience a reduction in stress over time at high temperatures. Bolted connections are most vulnerable. Relaxation of stress on packing due to stretching of gland follower studs under elevated temperatures may cause packing leakage.	[7]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **VALVE**

ARDM	POTENTIAL (YES/NO)	DESCRIPTION/JUSTIFICATION	SOURCE
Thermal Damage	Yes	Non-metallics are particularly susceptible with material dependent temperature limits.	[7] [2]
Thermal Embrittlement	Yes	Loss of material fracture toughness caused by thermally induced changes in the formation and distribution of alloying constituents. Requires high temperature 500°F to 700°F for metallic components. Ferrite containing stainless steels are susceptible as are materials with grain boundary segregation of impurities.	[7]
Wear	Yes	Wear results from relative motion between two surfaces (adhesive wear), from the influence of hard, abrasive particles (abrasive wear - see particulate erosion) or fluid stream (erosion), and from small, vibratory or sliding motions under the influence of a corrosive environment (fretting). In addition to material loss from the above wear mechanisms, impeded relative motion between two surfaces held in intimate contact for extended periods may result from galling/self-welding. Motions may be linear, circular, or vibratory in inert or corrosive environments. The most common result of wear is damage to one or both surfaces involved in the contact. Wear most typically occurs in components which experience considerable relative motion such as valves and pumps, in components which are held under high loads with no motion for long periods (valves, flanges), or in clamped joints where relative motion is not intended but occurs due to a loss of clamping force (e.G., Tubes in supports, valve stems in seats, springs against tubes). Wear may proceed at an ever- increasing rate as worn surfaces moving past one another will often do so with much higher contact stresses than the surfaces of the original geometry. Fretting is a wear phenomenon that occurs between tight-fitting surfaces subjected to a cyclic, relative motion of extremely small amplitude. Fretting is frequently accompanied by corrosion. Common sites for fretting are in joints that are bolted, keyed, pinned, press fit or riveted; in oscillating bearings, couplings, spindles, and seals; in press fits on shafts; and in universal joints. Under fretting conditions, fatigue cracks may be initiated at stresses well below the endurance limit of nonfretted specimens.	[1]

ATTACHMENT 7, POTENTIAL ARDM LIST

System: **Main Feedwater System (045)** Equipment Type: **VALVE**

Reference List

Source	Title
[1]	ASME Wear Control Handbook, Peterson and Winer, 1980
[2]	Standard Format and Content of Technical Information for Applications to Renew Nuclear Power Plant Operating Licenses, Draft NRC Regulatory Guide No. DG-1009, December 1990
[3]	Service (Salt) Water System Life Cycle Management Evaluation, EPRI Report No. TR-102204, April 1993
[4]	Radiation Effects on Organic Materials in Nuclear Plants, EPRI Report No. NP-2129, November 1981
[5]	Erosion/Corrosion in Nuclear Plant Steam Piping, EPRI Report No. NP-3944, 1985
[6]	Component Life Estimation: LWR Structural Materials Degradation Mechanisms, EPRI Report No. NP-5461, 1987
[7]	Environmental Effects on Components: Commentary for ASME Section III, EPRI Report No. NP-5775, April 1988
[8]	Boric Acid Corrosion of Carbon and Low Alloy Steel Pressure Boundary Materials, EPRI Report No. NP-5985, 1988
[9]	Nuclear Plant Service Water System Aging Degradation Assessment, NUREG/CR-5379, Volume 1 and 2, June 1989 and October 1992
[10]	Aging Assessment of Instrument Air Systems, NUREG/CR-5419, January 1990
[11]	Insights Gained from Aging Research, NUREG/CR-5643, March 1992
[12]	Corrosion Engineering, Fontana and Greene, 1978
[13]	Corrosion and Corrosion Control, An Introduction to Corrosion Science and Engineering, Uhlig, Third Edition, 1985

ATTACHMENT 3, COMPONENT GROUPING SUMMARY SHEET

SYSTEM: Main Feedwater (045)
GROUP ID NUMBER: 045-CKV-01
GROUP ATTRIBUTES:

1. Device Type: CKV
2. Vendor: ROCKWELL-EDWARD VALVES
3. Model Number: Fig. 970Y/Fig. 970(WCC)NTY
4. Material: Cast Carbon Steel
5. Internal Environment: Controlled chemistry water at 435F (normal operation)
6. External Environment: Climate controlled atmospheric air (Containment Building)
7. Function: Maintain system pressure boundary
8. Name Plate Data:

PARAMETER	VALUE
System Temperature	Variable from ambient (70F) when shutdown to ~435F when operating (subject to temperature cycles associated with plant start-up / shutdown and operational transients)
System Pressure	</= 1300 psig
Materials of Construction	BODY/COVER: Cast/Forged Carbon Steel - ASTM A216, Grade WCB or WCC/ASTM A105 (alternate material for valves: Cr-Mo alloy steel - see MCR 93-045-027-00 for details)

LIST OF GROUPED COMPONENTS (EQUIPMENT ID):

Equipment ID	Description	Equipment ID	Description
1CKVFW-130	12 SG FW HDR CKV	2CKVFW-130	22 SG FW HDR CKV
1CKVFW-133	11 SG FW HDR CKV	2CKVFW-133	21 SG FW HDR CKV

ATTACHMENT 4, SUBCOMPONENT/SUB-GROUP IDENTIFICATION

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater

EQUIPMENT ID: NA GROUP ID: 045-CKV-01

Sub-Group ID	Sub-Component/Name (Replacement Pgm)	Manufacturer (Source)	Material (Source)	Model Number (Source)	Passive Intended Function(s) (Source)	Subject to AMR (Y or N)
045-CKV-01A	Body, Cover, Drain Ass'y (None)	Rockwell (NA)	Carbon Steel, Forged or Cast (12399-0002; 12399-0022SH0001)	Fig. 970Y; Fig. 970(WCC)NTY (12399-0002; 12399-0022SH0001)	Maintain system pressure boundary (CLSR)	Y
045-CKV-01B	Pressure Seal Bolting (None)	Rockwell (NA)	AISI 416 Stainless Steel; or ASTM A193, Gr. B7 Alloy Steel (12399-0002; 12399-0022SH0001)	Fig. 970Y; Fig. 970(WCC)NTY (12399-0002; 12399-0022SH0001)	Maintain system pressure boundary (CLSR)	Y
045-CKV-01C	Disk/seat, other non-pressure retaining parts (NA)	Rockwell (NA)	Various (NA)	NA (NA)	None (Prevents reverse flow from S/G) (NA)	N

ATTACHMENT 5, ARDM MATRIX

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: VALVE DEVICE TYPE: CKV
GROUP ID (if applicable): 045-CKV-01

	GROUP OR SUB GROUP ID			
ARDMs	045-CKV-01A (Body/Cover)	045-CKV-01B (Bolting)		
CAVITATION EROSION	1	16		
CORROSION FATIGUE	J	16		
CREVICE CORROSION	A	16		
EROSION CORROSION	B	16		
FATIGUE	K	17		
FOULING	4	16		
GALVANIC CORROSION	5	16		
GENERAL CORROSION	C	16		
HYDROGEN DAMAGE	6	16		
INTERGRANULAR ATTACK	7	16		
MIC	8	16		
PARTICULATE WEAR EROSION	9	16		
PITTING	A	16		
RADIATION DAMAGE	10	10		
SELECTIVE LEACHING	11	16		
STRESS CORROSION CRACKING	12	16		
STRESS RELAXATION	13	13		
THERMAL DAMAGE	10	10		
THERMAL EMBRITTLEMENT	14	14		
WEAR	15	15		

ATTACHMENT 6, MATRIX CODE LIST

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: VALVE DEVICE TYPE: CKV
GROUP ID (if applicable): 045-CKV-01

CODE	DESCRIPTION	SOURCE
1	The feedwater system fluid flow conditions, pressure and temperature do not result in cavitation at these check valves. The flow is relatively steady and the pressure is much greater than the vapor pressure at system temperature. Therefore, cavitation erosion is not plausible.	[5], [11]
4	Fouling does not affect the component function. The component intended function is to maintain the pressure boundary integrity only. Due to the control of feedwater chemistry, fouling (including contamination and sedimentation) is not expected. Any fouling or sedimentation will not have an affect on the intended function.	[5], [16]
5	The check valve materials of construction are primarily carbon steel (with potentially Cr-Mo steel also) and water chemistry is controlled to minimize conductivity. Therefore, the required galvanic cell and electrolyte are not present, and galvanic corrosion is not plausible.	[6], [16]
6	The check valve is not fabricated from the high strength steel susceptible to hydrogen embrittlement and cracking. Therefore, this ARDM is not plausible.	[5]
7	Carbon steel material is not susceptible to intergranular attack.	[5]
8	Microbiologically influenced corrosion is not plausible due to the chemical conditions and temperature of the working fluid in the system. The source for feedwater is demineralized water, and organic contaminants are avoided through feedwater/condensate chemistry control. Additionally, normal feedwater temperature is above 200F making MIC not possible.	[5], [16]
9	Control of feedwater chemistry ensures essentially no particulate matter in the feedwater flowstream. Therefore, particulate wear erosion is not plausible.	[16]
10	The thermal damage and radiation damage ARDMs affect non-metallics only. There are no non-metallic pressure retaining materials in these check valves.	[2], [5]
11	Carbon steel materials are not susceptible to selective leaching. Therefore, this ARDM is not plausible.	[6], [11], [17]
12	Control of feedwater chemistry (particularly oxygen concentration) prevents the environment necessary for SCC of carbon steel material. Therefore, this ARDM is not plausible.	[5], [16]
13	Stress relaxation requires constant strain at temperatures greater than 700F. The maximum temperature to which the check valves are exposed is ~ 435F. Therefore, stress relaxation of pressure seal bolting (or other pressure retaining parts) is not plausible.	[5], [11]
14	The feedwater system operating temperature of ~ 435F max. is not sufficient to result in thermal embrittlement. Thermal embrittlement of low carbon or alloy steels requires temperatures greater than 650F.	[11], [18]
15	Surfaces of the check valves pressure retaining boundary subject to wear are hard-faced with a corrosion resistant inlay to prevent degradation. Based on this protective surface treatment and limited relative motion of pressure retaining parts, wear is not plausible.	[14], [19]
16	The check valve pressure seal bolting is exposed to the containment atmosphere and is not exposed to the feedwater system fluid flowstream. This environment is not conducive to significant corrosion of the stainless steel or alloy steel bolting. Therefore, the corrosion and erosion mechanisms are not plausible.	[5], [8], [9]
17	Bolting pre-load and cover-to-body joint design limit the effects of fatigue. Fatigue is not plausible for the pressure seal bolting.	[17]

ATTACHMENT 6, MATRIX CODE LIST

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: VALVE DEVICE TYPE: CKV
GROUP ID (if applicable): 045-CKV-01

CODE	DESCRIPTION	SOURCE
A	Crevice corrosion and pitting can occur in areas of the check valves that are not exposed to the general flowstream such as at the valve cover-to-body interface, the valve body drain pipe, and other crevices. These areas may comprise small localized volumes of stagnant solution for which fluid chemistry may deviate from bulk system chemistry. Higher concentrations of impurities may exist in these crevices due to out-of-specification system chemistry during shutdown conditions and due to the stagnant flow conditions of the crevice. The resulting degradation is highly localized pits or cracks. The control of feedwater/condensate system fluid chemistry significantly limits the effects of crevice corrosion and pitting. The effects of crevice corrosion and pitting can not be dismissed due to the potential for crevice locations and potentially high impurity concentrations in the system during shutdown conditions. Management of the effects of crevice corrosion and pitting should consist of: 1) maintenance of the current system chemistry control program, and 2) subjecting a representative sample of valves (from valves in this group or representative components in other portions of the plant) to an inspection to determine the extent of localized degradation occurring in the feedwater check valves.	[5], [6], [16]
B	Erosion corrosion is plausible due to high velocity, high energy fluid flow conditions. The effects of erosion corrosion include potentially rapid component wall thinning to the point of pressure boundary failure. The control of feedwater system fluid chemistry limits the rate and effects of erosion corrosion. The feedwater system check valves have experienced valve body erosion in service, and are monitored periodically for the effects of erosion corrosion by specific inspections during refueling outages. The chemistry control program and these inspections should be continued through the period of extended operation in order to manage the effects of erosion corrosion.	[3], [5], [11], [15], [16]
C	General corrosion of the feedwater check valves is plausible due to exposure of the carbon steel materials to corrosive medium during shutdown periods and, to a lesser extent, during operation. The rate of general corrosion is low after the initial build-up of the protective corrosion film (magnetite). Exposure to high oxygen concentrations during shutdown and potential removal and re-creation of the corrosion film result in general corrosion. The effect of general corrosion is component wall thinning over a relatively large area and could result in pressure boundary failure if extensive. The control of feedwater/condensate system fluid chemistry significantly limits the effects of general corrosion. Management of the effects of general corrosion should consist of: 1) maintenance of the current system chemistry control program, and 2) subjecting a representative sample of valves (from valves in this group or representative components in other portions of the plant) to an inspection to determine the extent of general corrosion occurring in the feedwater check valves.	[5], [6], [7], [16]
J	The ARDM is plausible due to the combination of fatigue and corrosion mechanisms affecting these valves. It is characterized by accelerated crack propagation at susceptible locations due to mechanism synergies and can lead to component failure. Aging management recommendations include maintenance of system chemistry, and cycle counting in the fatigue monitoring program.	[5] Note 1

ATTACHMENT 6, MATRIX CODE LIST

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: VALVE DEVICE TYPE: CKV
GROUP ID (if applicable): 045-CKV-01

CODE	DESCRIPTION	SOURCE
K	The ARDM is plausible due to thermal effects, mainly during reactor startup. It is characterized by crack propagation at susceptible locations due to thermal cycling which could lead to component failure. The aging management recommendation is cycle counting in the fatigue monitoring program.	[1], [4], [5], [22] Note 1

Notes:

1. The evaluation results for fatigue, and corrosion fatigue, of these check valves is unchanged from the results of the Feedwater System Evaluation Report, Revision 0. There is technical justification that fatigue, and thus corrosion fatigue, are not plausible for these valves and this is documented in Technical Problem Report (TPR) 96-022. The aging evaluation results are unchanged here in order to be consistent with the License Renewal Application Technical Report for the Feedwater System. Additionally, the conclusion that fatigue, and corrosion fatigue, are plausible is conservative from a nuclear safety standpoint. The effects of fatigue will be evaluated as part of the aging effects management program for the check valves (see Attachment 8/10).

ATTACHMENT 6, MATRIX CODE LIST

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: VALVE DEVICE TYPE: CKV
GROUP ID (if applicable): 045-CKV-01

Reference List

Source	Title
[1]	Standard Format and Content of Technical Information for Applications to Renew Nuclear Power Plant Operating Licenses, Draft NRC Regulatory Guide No. DG-1009, December 1990
[2]	Radiation Effects on Organic Materials in Nuclear Plants, EPRI Report No. NP-2129, November 1981
[3]	Erosion/Corrosion in Nuclear Plant Steam Piping, EPRI Report No. NP-3944, 1985
[4]	Component Life Estimation: LWR Structural Materials Degradation Mechanisms, EPRI Report No. NP-5461, 1987
[5]	Environmental Effects on Components: Commentary for ASME Section III, EPRI Report No. NP-5775, April 1988
[6]	Corrosion Engineering, Fontana and Greene, 1978
[7]	Corrosion and Corrosion Control, An Introduction to Corrosion Science and Engineeri _, Uhlig, Third Edition, 1985
[8]	Drawing 60702, Sheet 4, Rev. 28; Condensate and Feedwater System, Unit 1
[9]	Drawing 62702, Sheet 4, Rev. 30; Condensate and Feedwater System, Unit 2
[10]	OI-12A-1, Rev. 22/OI-12A-2, Rev. 14; Feedwater System Operating Instructions
[11]	UFSAR, Rev. 18; Chapter 4 - Reactor Coolant and Associated Systems, Chapter 10 - Steam and Power Conversion Systems
[12]	ANSI B31.1, 1967; Power Piping Code
[13]	ANSI 331.7, 1969; Nuclear Power Piping Code
[14]	Drawings 12399-02, Rev. 12; 12399-22, sheet 1, Rev. 5; Fig. 970Y Check Valve Assembly
[15]	Repetitive Tasks 10452052, 10452053, 20452043, 20452044; Feedwater Check Valve Inspections
[16]	CP-217, Rev. 5; Chemistry Specifications and Surveillance - Secondary System
[17]	Marks' Standard Handbook for Mechanical Engineers, 8th Edition, McGraw-Hill
[18]	Metals Handbook, 9th Edition, Volumes 1 and 13, ASM
[19]	ASME Wear Control Handbook, Peterson and Winer, 1980
[20]	Drawing 12543A-01, Rev. 13; Feedwater Piping Isometric, Unit 1
[21]	Drawing 13547A-20, Rev. 6F; 13547A-47, Rev. 4; 13549A-26, Rev. 3; Feedwater Piping Isometric, Unit 2
[22]	CE-NPSD-634-P, April 1992; Fatigue Monitoring Program for CCNPP Units 1 and 2

ATTACHMENT 3, COMPONENT GROUPING SUMMARY SHEET

SYSTEM: Main Feedwater (045)
GROUP ID NUMBER: 045-HV-01
GROUP ATTRIBUTES:

1. Device Type: HV
2. Vendor: Various
3. Model Number: Various
4. Material: Carbon Steel
5. Internal Environment: Controlled chemistry water/steam at up to 550F
6. External Environment: Climate controlled atmospheric air (Containment Bldg)
7. Function: Maintain system pressure boundary
8. Name Plate Data:

PARAMETER	VALUE
System Temperature	up to 550F
System Pressure	</= 1300 psig
Material of Construction	Cast or Forged Carbon Steel w/ CR 13 trim
Normal Operating Position	Open
Valve Type	Globe (Mark # 110H, 130)

LIST OF GROUPED COMPONENTS (EQUIPMENT ID):

Equipment ID	Description	Equipment ID	Description
1HVFW-1501	LT-1113A ROOT	2HVFW-1501	1113A-LT & 1013A-PT ROOT
1HVFW-1502	LT-1113A ROOT	2HVFW-1502	1113A-LT & 1013-PT ROOT
1HVFW-1503	LT-1113A ROOT	2HVFW-1503	1113A-LT ROOT
1HVFW-1504	LT-1113A ROOT	2HVFW-1504	1113-LT ROOT
1HVFW-1521	LT-1113B ROOT	2HVFW-1521	1105-LT, 1113B-LT & 1013-
1HVFW-1522	LT-1113B ROOT	2HVFW-1522	1105-LT, 1113B-LT & 1013B
1HVFW-1523	LT-1113B ROOT	2HVFW-1523	1105-LT & 1113B-LT ROOT
1HVFW-1524	LT-1113B ROOT	2HVFW-1524	1105-LT & 1113B-LT ROOT
1HVFW-1541	LT-1113C ROOT	2HVFW-1541	1113C-LT ROOT
1HVFW-1542	LT-1113C ROOT	2HVFW-1542	1113C-LT ROOT
1HVFW-1543	LT-1113C ROOT	2HVFW-1543	1113C-LT & 1013C-PT ROOT
1HVFW-1544	LT-1113C ROOT	2HVFW-1544	1113C-LT & 1013C-PT ROOT
1HVFW-1561	LT-1113D ROOT	2HVFW-1561	1111-LT, 1113D-LT & 1013D
1HVFW-1562	LT-1113D ROOT	2HVFW-1562	1111-LT, 1113D-LT & 1013D
1HVFW-1563	LT-1113D ROOT	2HVFW-1563	1111-LT & 1113D-LT ROOT
1HVFW-1564	LT-1113D ROOT	2HVFW-1564	1111-LT & 1113D-LT ROOT
1HVFW-1587	1-LT-1114A ROOT VLV	2HVFW-1587	1114A-LT ROOT
1HVFW-1588	1-LT-1114A ROOT VLV	2HVFW-1588	1114A-LT ROOT
1HVFW-1596	1-LT-1114B ROOT VLV	2HVFW-1596	1114B-LT ROOT
1HVFW-1597	1-LT-1114B ROOT VLV	2HVFW-1597	1114B-LT ROOT

ATTACHMENT 3, COMPONENT GROUPING SUMMARY SHEET

Equipment ID	Description	Equipment ID	Description
1HVFW-1601	LT-1123A ROOT	2HVFW-1601	1023A-PT & 1123A-LT ROOT
1HVFW-1602	LT-1123A ROOT	2HVFW-1602	1023A-PT & 1123A-LT ROOT
1HVFW-1603	LT-1123A ROOT	2HVFW-1603	1123A-LT ROOT
1HVFW-1604	LT-1123A ROOT	2HVFW-1604	1123A-LT ROOT
1HVFW-1621	LT-1123B ROOT	2HVFW-1621	1023B-PT, 1106-LT & 1123B
1HVFW-1622	LT-1123B ROOT	2HVFW-1622	1023B-PT, 1106-LT & 1123B
1HVFW-1623	LT-1123B ROOT	2HVFW-1623	1106-LT & 1123B-LT ROOT
1HVFW-1624	LT-1123B ROOT	2HVFW-1624	1106-LT & 1123B-LT ROOT
1HVFW-1641	LT-1123C ROOT	2HVFW-1641	1123C-LT ROOT
1HVFW-1642	LT-1123C ROOT	2HVFW-1642	1123C-LT ROOT
1HVFW-1643	LT-1123C ROOT	2HVFW-1643	1023C-PT & 1123C-LT ROOT
1HVFW-1644	LT-1123C ROOT	2HVFW-1644	1023C-PT & 1123C-LT ROOT
1HVFW-1661	LT-1123D ROOT	2HVFW-1661	1023D-PT 1121-LT & 1123D-
1HVFW-1662	LT-1123D ROOT	2HVFW-1662	1023D-PT, 1121-LT & 1123D
1HVFW-1663	LT-1123D ROOT	2HVFW-1663	1023C-PT & 1123C-LT ROOT
1HVFW-1664	LT-1123D ROOT	2HVFW-1664	1023C-PT & 1123C-LT ROOT
1HVFW-1687	1-LT-1124A ROOT VLV	2HVFW-1687	1124A-LT ROOT
1HVFW-1688	1-LT-1124A ROOT VLV	2HVFW-1688	1123-LT ROOT
1HVFW-1696	1-LT-1124B ROOT VLV	2HVFW-1696	1123B-LT ROOT
1HVFW-1697	1-LT-1124B ROOT VLV	2HVFW-1697	1124B-LT ROOT
1HVFW-1705	1-LT-1114C ROOT VLV	2HVFW-1705	1114C-LT ROOT
1HVFW-1706	1-LT-1114C ROOT VLV	2HVFW-1706	1114C-LT ROOT
1HVFW-1714	1-LT-1114D ROOT VLV	2HVFW-1714	1114D-LT ROOT
1HVFW-1715	1-LT-1114D ROOT VLV	2HVFW-1715	1114D-LT ROOT
1HVFW-1805	1-LT-1124C ROOT VLV	2HVFW-1805	1124C-LT ROOT
1HVFW-1806	1-LT-1124C ROOT VLV	2HVFW-1806	1124C-LT ROOT
1HVFW-1814	1-LT-1124D ROOT VLV	2HVFW-1814	1123D-LT ROOT
1HVFW-1815	1-LT-1124D ROOT VLV	2HVFW-1815	1123D-LT ROOT

ATTACHMENT 4, SUBCOMPONENT/SUB-GROUP IDENTIFICATION

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater

EQUIPMENT ID: NA GROUP ID: 045-HV-01

Sub-Group ID	Sub-Component/Name (Replacement Pgm)	Manufacturer (Source)	Material (Source)	Model Number (Source)	Passive Intended Function(s) (Source)	Subject to AMR (Y or N)
045-HV-01A	Body, Bonnet (None)	Various (NA)	Carbon Steel, Forged or Cast (92771SH-GLB-1) (VTM-D240-0001) (15587-0008) (15587-0021)	Mark 110H, 130 (FSK-MP-1003)	Maintain system pressure boundary (CLSR)	Y
045-HV-01B	Stem (None)	Various (NA)	13% Chrome, ASTM A182, F6 or similar (VTM-D240-0001) (15587-0008) (15587-0021)	Mark 110H, 130 (FSK-MP-1003)	Maintain system pressure boundary (CLSR)	Y
045-HV-01C	Body/Bonnet Bolting (for bolted bonnet valves) (None)	Various (N/A)	Carbon or Alloy Steel (VTM-D240-0001) (15587-0008) (15587-0021)	Mark 110H, 130 (FSK-MP-1003)	Maintain system pressure boundary (CLSR)	Y
045-HV-01D	Disk, other non-pressure retaining parts (NA)	Various (NA)	NA (NA)	NA (NA)	None (Normally open) (NA)	N

ATTACHMENT 5, ARDM MATRIX

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: VALVE DEVICE TYPE: HV
GROUP ID (if applicable): 045-HV-01

ARDMs	GROUP OR SUB GROUP ID			
	045-HV-01A (Body/Bonnet)	045-HV-01B (Stem)	045-HV-01C (Bolting)	NA
CAVITATION EROSION	1	1	16	
CORROSION FATIGUE	2	2	16	
CREVICE CORROSION	A	18	16	
EROSION CORROSION	1	1	16	
FATIGUE	3	3	17	
FOULING	4	4	16	
GALVANIC CORROSION	5	5	16	
GENERAL CORROSION	B	18	16	
HYDROGEN DAMAGE	6	6	16	
INTERGRANULAR ATTACK	7	7	16	
MIC	8	8	16	
PARTICULATE WEAR EROSION	9	9	16	
PITTING	A	18	16	
RADIATION DAMAGE	10	10	10	
SELECTIVE LEACHING	11	11	16	
STRESS CORROSION CRACKING	12	12	16	
STRESS RELAXATION	13	13	13	
THERMAL DAMAGE	10	10	10	
THERMAL EMBRITTLEMENT	14	14	14	
WEAR	15	15	15	

Component Aging Management Review

ATTACHMENT 6, MATRIX CODE LIST

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: VALVE DEVICE TYPE: HV
GROUP ID (if applicable): 045-HV-01

CODE	DESCRIPTION	SOURCE
1	These valves are not in the feedwater system flow stream. Therefore, cavitation erosion and erosion corrosion are not plausible.	[2], [5], [6], [7]
2	Control of system chemistry results in limited corrosion, and thermal fatigue is not plausible for these hand valves. Therefore, corrosion fatigue is not plausible.	[2]
3	These hand valves are 3/4" and 1" globe type valves that serve as instrumentation root isolation valves off the steam generator secondary shell. These small valves are not subject to significant alternating stress levels in response to temperature cycles. Therefore, thermal fatigue is not considered plausible for these hand valves.	[2], [5], [6], [7]
4	Fouling does not affect the component function. The component intended function is to maintain the pressure boundary integrity only. Due to the control of feedwater chemistry, fouling (including contamination and sedimentation) is not expected. Any fouling or sedimentation will not have an affect on the intended function.	[2], [8]
5	The hand valve materials of construction are carbon steel with chromium steel trim. Feedwater system and steam generator water chemistry is controlled to minimize fluid conductivity. Based on the relatively large anode (CS parts) surface area, and low conductivity electrolyte, galvanic corrosion is not plausible.	[3], [8]
6	The valves are not fabricated from the high strength steel susceptible to hydrogen embrittlement and cracking. Therefore, this ARDM is not plausible.	[2]
7	The carbon steel material of the valve body is not susceptible to intergranular attack. The chromium steel stem could be susceptible if sensitized, however, the stems are not welded and sensitization is unlikely. Also, the feedwater environment is not sufficiently oxidizing to result in significant IGA. Therefore, IGA is not plausible for the valve materials.	[2], [4], [8]
8	Microbiologically influenced corrosion is not plausible due to the chemical conditions and temperature of the working fluid in the system. The source for feedwater is demineralized water, and organic contaminants are avoided through feedwater/condensate chemistry control. Additionally, normal feedwater temperature is above 200F making MIC not possible.	[2], [8]
9	Control of feedwater chemistry ensures essentially no particulate matter in the feedwater flowstream. Therefore, particulate wear erosion is not plausible.	[8]
10	The thermal damage and radiation damage ARDMs affect non-metallics only. There are no non-metallic pressure retaining materials in these valves.	[1], [2]
11	Carbon and chromium steel materials are not susceptible to selective leaching. Therefore, this ARDM is not plausible.	[3], [7], [9]
12	Control of feedwater chemistry (particularly oxygen concentration) prevents the environment necessary for SCC of carbon and alloy steel material. Therefore, this ARDM is not plausible.	[2], [8]
13	Stress relaxation requires constant strain at temperatures greater than 700F. The maximum temperature to which these valves are exposed is ~ 550F. Therefore, stress relaxation of bonnet bolting (or other pressure retaining parts) is not plausible.	[2], [7]
14	The temperature to which these valves are exposed (~ 550F max.) is not sufficient to result in thermal embrittlement. Thermal embrittlement of low carbon or alloy steels requires temperatures greater than 650F.	[7], [10]
15	There is typically no relative motion between pressure retaining parts of these hand valves. Therefore, wear is not plausible.	[11]

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: VALVE DEVICE TYPE: HV
GROUP ID (if applicable): 045-HV-01

CODE	DESCRIPTION	SOURCE
16	The vaive bonnet bolting is exposed to the containment atmosphere and is not exposed to the feedwater system fluid flowstream. This environment is not conducive to significant corrosion of the carbon or alloy steel bolting. Therefore, the corrosion and erosion mechanisms are not plausible.	[2], [5], [6]
17	Bolting pre-load limits the effects of fatigue. Fatigue is not plausible for the bonnet bolting.	[9]
18	The chromium content in the stem material results in resisitance to general corrosion, pitting and crevice corrosion, particularly in the controlled chemistry feedwater environment. Additionally, limited pitting and corrosion of the stem (in the area of the packing, which is the most aggressive area for corrosion) would not affect the pressure boundary function of the sub-component. Therefore, general corrosion, pitting and crevice corrosion are not plausible for the valve stem.	[2], [4], [8]
A	Crevice corrosion and pitting can occur in areas of the hand valves that are not exposed to the general flowstream such as at the valve body-to-bonnet interface, the valve body-to-seat ring interface, and other crevices. These areas may comprise small localized volumes of stagnant solution for which fluid chemistry may deviate from bulk system chemistry. Higher concentrations of impurities may exist in these crevices due to out-of-specification system chemistry during shutdown conditions and due to the stagnant flow conditions of the crevice. The resulting degradation is highly localized pits or cracks. The control of feedwater/condensate system fluid chemistry significantly limits the effects of crevice corrosion and pitting. The effects of crevice corrosion and pitting can not be dismissed due to the potential for crevice locations and potentially high impurity concentrations in the system during shutdown conditions. Management of the effects of crevice corrosion and pitting should consist of: 1) maintenance of the current system chemistry control program, and 2) subjecting a representative sample of valves (from valves in this group or representative components in other portions of the plant) to an inspection to determine the extent of localized degradation occurring in the feedwater hand valves.	[2], [3], [8]
B	General corrosion of the feedwater hand valves is plausible due to exposure of the carbon steel materials to a potentially corrosive medium during shutdown periods and, to a lesser extent, during operation. The rate of general corrosion is low after the initial build-up of the protective corrosion film (magnetite). Exposure to high oxygen concentrations during shutdown can result in general corrosion. The effect of general corrosion is component wall thinning over a relatively large area and could result in pressure boundary failure if extensive. The control of feedwater/condensate system fluid chemistry significantly limits the effects of general corrosion. Management of the effects of general corrosion should consist of: 1) maintenance of the current system chemistry control program, and 2) subjecting a representative sample of valves (from valves in this group or representative components in other portions of the plant) to an inspection to determine the extent of general corrosion occurring in the feedwater hand valves.	[2], [3], [4], [8]

ATTACHMENT 6, MATRIX CODE LIST

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: VALVE DEVICE TYPE: HV
GROUP ID (if applicable): 045-HV-01

Reference List

Source	Title
[1]	Radiation Effects on Organic Materials in Nuclear Plants, EPRI Report No. NP-2129, November 1981
[2]	Environmental Effects on Components: Commentary fo ASME Section III, EPRI Report No. NP-5775, April 1988
[3]	Corrosion Engineering, Fontana and Greene, 1978
[4]	Corrosion and Corrosion Control, An Introduction to Corrosion Science and Engineering, Uhlig, Third Edition, 1985
[5]	Drawing 60702, Sheet 4, Rev. 28; Condensate and Feedwater System, Unit 1
[6]	Drawing 62702, Sheet 4, Rev. 30; Condensate and Feedwater System, Unit 2
[7]	UFSAR, Rev. 18; Chapter 4 - Reactor Coolant and Associated Systems, Chapter 10 - Steam and Power Conversion Systems
[8]	CP-217, Rev. 5; Chemistry Specifications and Surveillance - Secondary System
[9]	Marks' Standard Handbook for Mechanical Engineers, 8th Edition, McGraw-Hill
[10]	Metals Handbook, 9th Edition, Volumes 1 and 13, ASM
[11]	ASME Wear Control Handbook, Peterson and Winer, 1980

ATTACHMENT 3, COMPONENT GROUPING SUMMARY SHEET

SYSTEM: Main Feedwater (045)
GROUP ID NUMBER: 045-HV-02
GROUP ATTRIBUTES:

1. Device Type: HV
2. Vendor: Various
3. Model Number: Various
4. Material: Carbon Steel
5. Internal Environment: Controlled chemistry water at up to 435F
6. External Environment: Climate controlled atmospheric air (Containment Bldg)
7. Function: Maintain system pressure boundary
8. Name Plate Data:

PARAMETER	VALUE
System Temperature	up to 435F
System Pressure	</= 1300 psig
Normal Operating Position	Closed
Valve Type	Gate (Mark # 7)

LIST OF GROUPED COMPONENTS (EQUIPMENT ID):

Equipment ID	Description	Equipment ID	Description
1HVFW-220	11 SG FW HDR DRAIN	2HVFW-220	21 SG FW HDR DRAIN
1HVFW-222	12 SG FW HDR DRAIN	2HVFW-223	22 SG FW HDR DRAIN

ATTACHMENT 4, SUBCOMPONENT/SUB-GROUP IDENTIFICATION

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater

EQUIPMENT ID: NA GROUP ID: 045-HV-02

Sub-Group ID	Sub-Component/Name (Replacement Pgm)	Manufacturer (Source)	Material (Source)	Model Number (Source)	Passive Intended Function(s) (Source)	Subject to AMR (Y or N)
045-HV-02A	Body, Bonnet (None)	Various (NA)	Carbon Steel, Forged or Cast (92771SH-GATE-1) (VTM-D243-0001) (15587-0027)	Mark 7 (60702SH0004) (62702SH0004)	Maintain system pressure boundary (CLSR)	Y
045-HV-02B	Stem (None)	Various (NA)	13% Chrome, ASTM A182 Gr. F6 or similar (VTM-D243-0001) (15587-0027)	Mark 7 (60702SH0004) (62702SH0004)	Maintain system pressure boundary (CLSR)	Y
045-HV-02C	Body/Bonnet Bolting (for bolted bonnet valves) (None)	Various (N/A)	Carbon or Alloy Steel (VTM-D243-0001) (15587-0027)	Mark 7 (60702SH0004) (62702SH0004)	Maintain system pressure boundary (CLSR)	Y
045-HV-02D	Disk and Seat (None)	Various (NA)	13% Chrome, ASTM A182 Gr. F6 or similar (VTM-D243-0001) (15587-0027)	Mark 7 (60702SH0004) (62702SH0004)	Maintain system pressure boundary (SR to NSR boundary) (CLSR)	Y
045-HV-02E	Other non-pressure retaining parts (NA)	Various (NA)	NA (NA)	NA (NA)	None (Normally open) (NA)	N

ATTACHMENT 5, ARDM MATRIX

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: VALVE DEVICE TYPE: HV
GROUP ID (if applicable): 045-HV-02

ARDMs	GROUP OR SUB GROUP ID			
	045-HV-02A (Body/Bonnet)	045-HV-02B (Stem)	045-HV-02C (Bolting)	045-HV-02D (Disk/Seat)
CAVITATION EROSION	1	1	16	1
CORROSION FATIGUE	2	2	16	2
CREVICE CORROSION	A	18	16	18
EROSION CORROSION	1	1	16	1
FATIGUE	3	3	17	3
FOULING	4	4	16	4
GALVANIC CORROSION	5	5	16	5
GENERAL CORROSION	B	18	16	18
HYDROGEN DAMAGE	6	6	16	6
INTERGRANULAR ATTACK	7	7	16	7
MIC	8	8	16	8
PARTICULATE WEAR EROSION	9	9	16	9
PITTING	A	18	16	18
RADIATION DAMAGE	10	10	10	10
SELECTIVE LEACHING	11	11	16	11
STRESS CORROSION CRACKING	12	12	16	12
STRESS RELAXATION	13	13	13	13
THERMAL DAMAGE	10	10	10	10
THERMAL EMBRITTLEMENT	14	14	14	14
WEAR	15	15	15	15

ATTACHMENT 6, MATRIX CODE LIST

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: VALVE DEVICE TYPE: HV
GROUP ID (if applicable): 045-HV-02

CODE	DESCRIPTION	SOURCE
1	These valves are not in the feedwater system flow stream. Therefore, cavitation erosion and erosion corrosion are not plausible.	[2], [5], [6], [7]
2	Control of system chemistry results in limited corrosion, and thermal fatigue is not plausible for these hand valves. Therefore, corrosion fatigue is not plausible.	[2]
3	These hand valves are 1" gate type valves that serve as drain isolation valves off the main feedwater piping. These small valves are not subject to significant alternating stress levels in response to temperature cycles. Therefore, thermal fatigue is not considered plausible for these hand valves.	[2], [5], [6], [7]
4	Fouling does not affect the component function. The component intended function is to maintain the pressure boundary integrity only. Due to the control of feedwater chemistry, fouling (including contamination and sedimentation) is not expected. Any fouling or sedimentation will not have an affect on the intended function.	[2], [8]
5	The hand valve materials of construction are carbon steel with chromium steel trim. Feedwater system water chemistry is controlled to minimize fluid conductivity. Based on the relatively large anode (CS parts) surface area, and low conductivity electrolyte, galvanic corrosion is not plausible.	[3], [8]
6	The valves are not fabricated from the high strength steel susceptible to hydrogen embrittlement and cracking. Therefore, this ARDM is not plausible.	[2]
7	The carbon steel material of the valve body is not susceptible to intergranular attack. The chromium steel trim could be susceptible if sensitized, however, the stem and disk are not welded and sensitization is unlikely. Also, the feedwater environment is not sufficiently oxidizing to result in significant IGA. Therefore, IGA is not plausible for the valve materials.	[2], [4], [8]
8	Microbiologically influenced corrosion is not plausible due to the chemical conditions and temperature of the working fluid in the system. The source for feedwater is demineralized water, and organic contaminants are avoided through feedwater/condensate chemistry control. Additionally, normal feedwater temperature is above 200F making MIC not possible.	[2], [8]
9	Control of feedwater chemistry ensures essentially no particulate matter in the feedwater flowstream. Therefore, particulate wear erosion is not plausible.	[8]
10	The thermal damage and radiation damage ARDMs affect non-metallics only. There are no non-metallic pressure retaining materials in these valves.	[1], [2]
11	Carbon and chromium steel materials are not susceptible to selective leaching. Therefore, this ARDM is not plausible.	[3], [7], [9]
12	Control of feedwater chemistry (particularly oxygen concentration) prevents the environment necessary for SCC of carbon and alloy steel material. Therefore, this ARDM is not plausible.	[2], [8]
13	Stress relaxation requires constant strain at temperatures greater than 700F. The maximum temperature to which these valves are exposed is ~ 435F. Therefore, stress relaxation of bonnet bolting (or other pressure retaining parts) is not plausible.	[2], [7]
14	The temperature to which these valves are exposed (~ 435F max.) is not sufficient to result in thermal embrittlement. Thermal embrittlement of low carbon or alloy steels requires temperatures greater than 650F.	[7], [10]
15	There is typically no relative motion between pressure retaining parts of these hand valves. The valves are not operated (opened / closed) often and no significant seating surface wear is expected. Therefore, wear is not plausible.	[11], [12]

ATTACHMENT 6, MATRIX CODE LIST

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: VALVE DEVICE TYPE: HV
GROUP ID (if applicable): 045-HV-02

CODE	DESCRIPTION	SOURCE
16	The valve bonnet bolting is exposed to the containment atmosphere and is not exposed to the feedwater system fluid flowstream. This environment is not conducive to significant corrosion of the carbon or alloy steel bolting. Therefore, the corrosion and erosion mechanisms are not plausible.	[2], [5], [6]
17	Bolting pre-load limits the effects of fatigue. Fatigue is not plausible for the bonnet bolting.	[9]
18	The chromium content in the trim material results in resisitance to general corrosion, pitting and crevice corrosion, particularly in the controlled chemistry feedwater environment. Additionally, limited pitting and corrosion of the trim (in the area of the packing, which is the most aggressive area for corrosion) would not affect the pressure boundary function of the sub-component. Therefore, general corrosion, pitting and crevice corrosion are not plausible for the valve trim.	[2], [4], [8]
A	Crevice corrosion and pitting can occur in areas of the hand valves that are not exposed to the general flowstream such as at the valve body-to-bonnet interface, the valve body-to-seat ring interface, and other crevices. These areas may comprise small localized volumes of stagnant solution for which fluid chemistry may deviate from bulk system chemistry. Higher concentrations of impurities may exist in these crevices due to out-of-specification system chemistry during shutdown conditions and due to the stagnant flow conditions of the crevice. The resulting degradation is highly localized pits or cracks. The control of feedwater/condensate system fluid chemistry significantly limits the effects of crevice corrosion and pitting. The effects of crevice corrosion and pitting can not be dismissed due to the potential for crevice locations and potentially high impurity concentrations in the system during shutdown conditions. Management of the effects of crevice corrosion and pitting should consist of: 1) maintenance of the current system chemistry control program, and 2) subjecting a representative sample of valves (from valves in this group or representative components in other portions of the plant) to an inspection to determine the extent of localized degradation occurring in the feedwater hand valves.	[2], [3], [8]
B	General corrosion of the feedwater hand valves is plausible due to exposure of the carbon steel materials to a potentially corrosive medium during shutdown periods and, to a lesser extent, during operation. The rate of general corrosion is low after the initial build-up of the protective corrosion film (magnetite). Exposure to high oxygen concentrations during shutdown can result in general corrosion. The effect of general corrosion is component wall thinning over a relatively large area and could result in pressure boundary failure if extensive. The control of feedwater/condensate system fluid chemistry significantly limits the effects of general corrosion. Management of the effects of general corrosion should consist of: 1) maintenance of the current system chemistry control program, and 2) subjecting a representative sample of valves (from valves in this group or representative components in other portions of the plant) to an inspection to determine the extent of general corrosion occurring in the feedwater hand valves.	[2], [3], [4], [8]

ATTACHMENT 6, MATRIX CODE LIST

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: VALVE DEVICE TYPE: HV
GROUP ID (if applicable): 045-HV-02

Reference List

Source	Title
[1]	Radiation Effects on Organic Materials in Nuclear Plants, EPRI Report No. NP-2129, November 1981
[2]	Environmental Effects on Components: Commentary for ASME Section III, EPRI Report No. NP-5775, April 1988
[3]	Corrosion Engineering, Fontana and Greene, 1978
[4]	Corrosion and Corrosion Control, An Introduction to Corrosion Science and Engineering, Uhlig, Third Edition, 1985
[5]	Drawing 60702, Sheet 4, Rev. 28; Condensate and Feedwater System. Unit 1
[6]	Drawing 62702, Sheet 4, Rev. 30; Condensate and Feedwater System. Unit 2
[7]	UFSAR, Rev. 18; Chapter 4 - Reactor Coolant and Associated Systems, Chapter 10 - Steam and Power Conversion Systems
[8]	CP-217, Rev. 5; Chemistry Specifications and Surveillance - Secondary System
[9]	Marks' Standard Handbook for Mechanical Engineers, 8th Edition, McGraw-Hill
[10]	Metals Handbook, 9th Edition, Volumes 1 and 13, ASM
[11]	ASME Wear Control Handbook, Peterson and Winer, 1980
[12]	OI-12A-1, Rev. 22/OI-12A-2, Rev. 14; Feedwater System Operating Instructions

ATTACHMENT 3, COMPONENT GROUPING SUMMARY SHEET

SYSTEM: Main Feedwater (045)
GROUP ID NUMBER: 045-MOV-01
GROUP ATTRIBUTES:

1. Device Type: MOV
2. Vendor: Velan
3. Model Number: B20-2A5PS-02TS
4. Material: Carbon Steel
5. Internal Environment: Controlled chemistry water at up to 435F
6. External Environment: Climate controlled atmospheric air (Auxiliary Bldg)
7. Function: Maintain system pressure boundary
8. Name Plate Data:

PARAMETER	VALUE
System Temperature	Variable from ambient (70F) when shutdown to ~435F when operating (subject to temperature cycles associated with plant start-up / shutdown and operational transients)
System Pressure	</= 1300 psig
Normal Operating Position	Open
Valve Type	Motor Operated Gate

LIST OF GROUPED COMPONENTS (EQUIPMENT ID):

Equipment ID	Description	Equipment ID	Description
1MOV4516VLV	11 SG FW ISOL	2MOV4516VLV	21 SG FW ISOL
1MOV4517VLV	12 SG FW ISOL	2MOV4517VLV	22 SG FW ISOL

ATTACHMENT 4, SUBCOMPONENT/SUB-GROUP IDENTIFICATION

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater

EQUIPMENT ID: NA GROUP ID: 045-MOV-01

Sub-Group ID	Sub-Component/Name (Replacement Pgm)	Manufacturer (Source)	Material (Source)	Model Number (Source)	Passive Intended Function(s) (Source)	Subject to AMR (Y or N)
045-MOV-01A	Body, Bonnet (None)	Velan (12717-0002)	Carbon Steel w/ Stellited wear surfaces (12717-0002)	Fig. # B20-2A5PS-2TS (12717-0002)	Maintain system pressure boundary (CLSR)	Y
045-MOV-01B	Stem (None)	Velan (12717-0002)	410 SS (12717-0002)	Fig. # B20-2A5PS-2TS (12717-0002)	Maintain system pressure boundary (CLSR)	Y
045-MOV-01C	Wedge, Seat Ring (None)	Velan (12717-0002)	Carbon Steel w/ Stellited wear surfaces (12717-0002)	Fig. # B20-2A5PS-2TS (12717-0002)	Maintain system pressure boundary (SR to NSR boundary) (CLSR)	Y
045-MOV-01D	Body/Bonnet Bolting (None)	Velan (12717-0002)	Carbon or Alloy Steel (12717-0002)	Fig. # B20-2A5PS-2TS (12717-0002)	Maintain system pressure boundary (CLSR)	Y
045-MOV-01E	Non-pressure retaining parts (NA)	Velan (12717-0002)	Various (12717-0002)	Fig. # B20-2A5PS-2TS (12717-0002)	None (Non-pressure retaining) (NA)	N

ATTACHMENT 5, ARDM MATRIX

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: VALVE DEVICE TYPE: MOV
GROUP ID (if applicable): 045-MOV-01

ARDMs	GROUP OR SUB GROUP ID			
	045-MOV-01A (Body/Cover)	045-MOV-01B (Stem)	045-MOV-01C (Wedge, Seat)	045-MOV-01D (Bolting)
CAVITATION EROSION	1	1	1	16
CORROSION FATIGUE	2	2	2	16
CREVICE CORROSION	A	A	A	16
EROSION CORROSION	B	B	B	16
FATIGUE	3	3	3	17
FOULING	4	4	4	16
GALVANIC CORROSION	5	5	5	16
GENERAL CORROSION	C	C	C	16
HYDROGEN DAMAGE	6	6	6	16
INTERGRANULAR ATTACK	7	7	7	16
MIC	8	8	8	16
PARTICULATE WEAR EROSION	9	9	9	16
PITTING	A	A	A	16
RADIATION DAMAGE	10	10	10	10
SELECTIVE LEACHING	11	11	11	16
STRESS CORROSION CRACKING	12	12	12	16
STRESS RELAXATION	13	13	13	13
THERMAL DAMAGE	10	10	10	10
THERMAL EMBRITTLEMENT	14	14	14	14
WEAR	15	15	18	15

ATTACHMENT 6, MATRIX CODE LIST

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: VALVE DEVICE TYPE: MOV
GROUP ID (if applicable): 045-MOV-01

CODE	DESCRIPTION	SOURCE
1	The feedwater system fluid flow conditions, pressure and temperature do not result in cavitation at the feedwater isolation valves. The flow is relatively steady and the pressure is much greater than the vapor pressure at system temperature. Therefore, cavitation erosion is not plausible.	[3], [8]
2	Control of system chemistry results in limited corrosion, and thermal fatigue is not plausible for these valves. Therefore, corrosion fatigue is not plausible.	[3]
3	The feedwater isolation valves are far removed from the S/G, and are not subject to rapid thermal transient conditions associated with the S/G feedwater nozzle/piping thermal stratification conditions. The sources of thermal cycling for the MOVs are plant start-ups/shutdowns and secondary plant transients. Thermal fatigue effects result from thermal expansion stresses due to temperature cycles and is primarily a problem for piping systems. Based on the limited number of temperature cycles and relatively low thermal stresses developed in the valve body, thermal fatigue is not considered plausible for these valves.	[3], [6], [7], [8], [14], [15]
4	Fouling does not affect the component function. The component intended function is to maintain the pressure boundary integrity only. Due to the control of feedwater chemistry, fouling (including contamination and sedimentation) is not expected. Any fouling or sedimentation will not have an affect on the intended function.	[3], [10]
5	The valve materials of construction are carbon steel with a stainless steel stem. Feedwater system water chemistry is controlled to minimize fluid conductivity. Based on the large anode (CS parts) surface area and low conductivity electrolyte, galvanic corrosion is not plausible.	[4], [9], [10]
6	The valves (and subcomponents) are not fabricated from the high strength steel susceptible to hydrogen embrittlement and cracking. Therefore, this ARDM is not plausible.	[3]
7	Carbon steel and martensitic SS material are not susceptible to intergranular attack.	[3]
8	Microbiologically influenced corrosion is not plausible due to the chemical conditions and temperature of the working fluid in the system. The source for feedwater is demineralized water, and organic contaminants are avoided through feedwater/condensate chemistry control. Additionally, normal feedwater temperature is above 200F making MIC not possible.	[3], [10]
9	Control of feedwater chemistry ensures essentially no particulate matter in the feedwater flowstream. Therefore, particulate wear erosion is not plausible.	[10]
10	The thermal damage and radiation damage ARDMs affect non-metallics only. There are no non-metallic pressure retaining materials in these valves.	[1], [3]
11	Carbon and alloy steel materials are not susceptible to selective leaching. Therefore, this ARDM is not plausible.	[4], [8], [11]
12	Control of feedwater chemistry (particularly oxygen concentration) prevents the environment necessary for SCC of carbon steel material. Also, the 410SS stem material is not in a highly stressed application. Therefore, this ARDM is not plausible.	[3], [5], [10]
13	Stress relaxation requires constant strain at temperatures greater than 700F. The maximum temperature to which the check valves are exposed is ~ 435F. Therefore, stress relaxation of pressure seal bolting (or other pressure retaining parts) is not plausible.	[3], [8]
14	The feedwater system operating temperature of ~ 435F max. is not sufficient to result in thermal embrittlement. Thermal embrittlement of low carbon or alloy steels requires temperatures greater than 650F.	[8], [12]

ATTACHMENT 6, MATRIX CODE LIST

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: VALVE DEVICE TYPE: MOV
GROUP ID (if applicable): 045-MOV-01

CODE	DESCRIPTION	SOURCE
15	Surfaces of the MOVs pressure retaining boundary that are subject to wear are hard-faced with a wear and corrosion resistant material (Stellite #6) to prevent degradation. Based on this protective surface treatment and limited relative motion of pressure retaining parts, wear is not plausible.	[9], [13]
16	The valve pressure seal bolting is exposed to the auxiliary building atmosphere and is not exposed to the feedwater system fluid flowstream. This environment is not conducive to significant corrosion of the carbon or alloy steel bolting. Therefore, the corrosion and erosion mechanisms are not plausible.	[3], [6], [7]
17	Bolting pre-load and cover-to-body joint design limit the effects of fatigue. Fatigue is not plausible for the pressure seal bolting.	[11]
18	Wear of the MOV seating surfaces can occur due to valve cycling. Excessive wear can result in significant leakage through the valve seat. However, the valve seating surfaces are hard-faced with Stellite #6 to minimize the effects of wear. In addition, these valves are classified as IST Category B (leakage through the seat is inconsequential to valve function) and, as such, are not subject to seat leakage testing requirements. Therefore, limited seating surface wear will not affect the function of the feedwater isolation valves, and wear is not a plausible ARDM.	[9], [13], [16], [17]
A	Crevice corrosion and pitting can occur in areas of the feedwater isolation valves that are not exposed to the general flowstream such as at the valve cover-to-body interface, the valve body-to-seat ring interface, and other crevices. These areas may comprise small localized volumes of stagnant solution for which fluid chemistry may deviate from bulk system chemistry. Higher concentrations of impurities may exist in these crevices due to out-of-specification system chemistry during shutdown conditions and due to the stagnant flow conditions of the crevice. The resulting degradation is highly localized pits or cracks. The control of feedwater/condensate system fluid chemistry significantly limits the effects of crevice corrosion and pitting. The effects of crevice corrosion and pitting can not be dismissed due to the potential for crevice locations and potentially high impurity concentrations in the system during shutdown conditions. Management of the effects of crevice corrosion and pitting should consist of: 1) maintenance of the current system chemistry control program, and 2) subjecting a representative sample of valves (from valves in this group or representative components in other portions of the plant) to an inspection to determine the extent of localized degradation occurring in the feedwater isolation valves.	[3], [4], [10]
B	Erosion corrosion is plausible due to high velocity, high energy fluid flow conditions. The effects of erosion corrosion include potentially rapid component wall thinning to the point of pressure boundary failure. The control of feedwater system fluid chemistry limits the effects of erosion corrosion. Management of the effects of erosion corrosion should consist of: 1) maintenance of the current system chemistry control program, and 2) subjecting a representative sample of the valves (from valves in this group or representative components in other portions of the plant) to an inspection to determine the extent of erosion corrosion occurring in the feedwater isolation valves.	[2], [3], [8], [10]

ATTACHMENT 6, MATRIX CODE LIST

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: VALVE DEVICE TYPE: MOV
GROUP ID (if applicable): 045-MOV-01

CODE	DESCRIPTION	SOURCE
C	General corrosion of the feedwater isolation valves is plausible due to exposure of the carbon steel materials to potentially corrosive medium during shutdown periods and, to a lesser extent, during operation. The rate of general corrosion is low after the initial build-up of the protective corrosion film (magnetite). Exposure to high oxygen concentrations during shutdown and potential removal and re-creation of the corrosion film result in general corrosion. The effect of general corrosion is component wall thinning over a relatively large area and could result in pressure boundary failure if extensive. The control of feedwater/condensate system fluid chemistry significantly limits the effects of general corrosion. Management of the effects of general corrosion should consist of: 1) maintenance of the current system chemistry control program, and 2) subjecting a representative sample of valves (from valves in this group or representative components in other portions of the plant) to an inspection to determine the extent of general corrosion occurring in the feedwater isolation valves.	[3], [4], [5], [10]

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
EQUIPMENT TYPE: VALVE DEVICE TYPE: MOV
GROUP ID (if applicable): 045-MOV-01

Reference List

Source	Title
[1]	Radiation Effects on Organic Materials in Nuclear Plants, EPRI Report No. NP-2129, November 1981
[2]	Erosion/Corrosion in Nuclear Plant Steam Piping, EPRI Report No. NP-3944, 1985
[3]	Environmental Effects on Components: Commentary for ASME Section III, EPRI Report No. NP-5775, April 1988
[4]	Corrosion Engineering, Fontana and Greene, 1978
[5]	Corrosion and Corrosion Control, An Introduction to Corrosion Science and Engineering, Uhlig, Third Edition, 1985
[6]	Drawing 60702, Sheet 4, Rev. 28; Condensate and Feedwater System, Unit 1
[7]	Drawing 62702, Sheet 4, Rev. 30; Condensate and Feedwater System, Unit 2
[8]	UFSAR, Rev. 18; Chapter 4 - Reactor Coolant and Associated Systems, Chapter 10 - Steam and Power Conversion Systems
[9]	Drawing 12717-02, Rev. L; Pressure Seal Gate Valve Assembly
[10]	CP-217, Rev. 5; Chemistry Specifications and Surveillance - Secondary System
[11]	Marks' Standard Handbook for Mechanical Engineers, 8th Edition, McGraw-Hill
[12]	Metals Handbook, 9th Edition, Volumes 1 and 13, ASM
[13]	ASME Wear Control Handbook, Peterson and Winer, 1980
[14]	Drawing 12543A-01, Rev. 13; Feedwater Piping Isometric, Unit 1
[15]	Drawing 13547A-20, Rev. 6F; 13547A-47, Rev. 4; 13549A-26, Rev. 3; Feedwater Piping Isometric, Unit 2
[16]	ASME Boiler and Pressure Vessel Code, Section XI "Rules for Inservice Inspection of Nuclear Power Plant Components", Subsection IWV-2000; 1983 ed. w/ Summer '83 addenda
[17]	CCNPP ASME Section XI Pump and Valve Test Program, Second Ten Year Interval, Revision 1

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
COMPONENT ID: NA GROUP ID: 045-DB-01

1 PLAUSIBLE ARDM FROM ATTACHMENT 5	2 PLANT PROGRAM	3 REASON FOR THE FORM OF AGING MANAGMENT ALTERNATIVE CHOSEN
Crevice Corrosion, Pitting, General Corrosion, Corrosion Fatigue	Control system fluid chemistry in order to minimize the concentration of corrosive impurities (chlorides, sulfates, oxygen): **CP-0217, Chemistry Specifications and Surveillance - Secondary Systems**	Control of fluid chemistry prevents a corrosive environment for Feedwater System components.
	Determine the extent of degradation due to the effects of crevice corrosion, pitting, and general corrosion through inspection of representative plant components prior to the period of extended operations: **Age-Related Degradation Inspection Program (new program)**	The occurrence of crevice corrosion, pitting and general corrosion are expected to be limited and may not affect the intended function of the Feedwater System components due to the control of fluid chemistry. Inspections of representative plant components will provide assurance that significant corrosion is not occurring, or will result in initiation of appropriate corrective action if significant corrosion is occuring.
Erosion Corrosion	Monitor Feedwater System piping for the effects of erosion corrosion: **MN-3-111, Erosion Corrosion Monitoring of Secondary Piping**	An erosion corrosion monitoring program is effective in determining a rate of degradation and preventing erosion corrosion from affecting the component intended function.
	Control system fluid chemistry in order to minimize the concentration of corrosive impurities (chlorides, sulfates, oxygen) and optimize fluid pH: **CP-0217, Chemistry Specifications and Surveillance - Secondary Systems**	Control of fluid chemistry prevents a corrosive environment for Feedwater System components, and limits the rate and effects of erosion corrosion.
Fatigue, Corrosion Fatigue	Monitor the effects of thermal fatigue: **CCNPP Fatigue Monitoring Program (with modifications)**	Tracking and monitoring the fatigue status of Feedwater System components will ensure that fatigue threshholds are not exceeded and that fatigue cracks are prevented or controlled. Through control of corrosion and monitoring of thermal fatigue effects, corrosion fatigue is also managed such that the effects will not prevent the component intended function.

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
COMPONENT ID: NA GROUP ID: 045-DB-02

1 PLAUSIBLE ARDM FROM ATTACHMENT 5	2 PLANT PROGRAM	3 REASON FOR THE FORM OF AGING MANAGMENT ALTERNATIVE CHOSEN
Crevice Corrosion, Pitting, General Corrosion	Control system fluid chemistry in order to minimize the concentration of corrosive impurities (chlorides, sulfates, oxygen): **CP-0217, Chemistry Specifications and Surveillance - Secondary Systems**	Control of fluid chemistry prevents a corrosive environment for Feedwater System components.
	Determine the extent of degradation due to the effects of crevice corrosion, pitting, and general corrosion through inspection of representative plant components prior to the period of extended operations: **Age-Related Degradation Inspection Program (new program)**	The occurrence of crevice corrosion, pitting and general corrosion are expected to be limited and may not affect the intended function of the Feedwater System components due to the control of fluid chemistry. Inspections of representative plant components will provide assurance that significant corrosion is not occurring, or will result in initiation of appropriate corrective action if significant corrosion is occuring.
Erosion Corrosion	Monitor Feedwater System piping for the effects of erosion corrosion: **MN-3-111, Erosion Corrosion Monitoring of Secondary Piping**	An erosion corrosion monitoring program is effective in determining a rate of degradation and preventing erosion corrosion from affecting the component intended function.
	Control system fluid chemistry in order to minimize the concentration of corrosive impurities (chlorides, sulfates, oxygen) and optimize fluid pH: **CP-0217, Chemistry Specifications and Surveillance - Secondary Systems**	Control of fluid chemistry prevents a corrosive environment for Feedwater System components, and limits the rate and effects of erosion corrosion.

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
COMPONENT ID: NA GROUP ID: 045-CKV-01

1 PLAUSIBLE ARDM FROM ATTACHMENT 5	2 PLANT PROGRAM	3 REASON FOR THE FORM OF AGING MANAGMENT ALTEPNATIVE CHOSEN
Crevice Corrosion, Pitting, General Corrosion, Corrosion Fatigue	Control system fluid chemistry in order to minimize the concentration of corrosive impurities (chlorides, sulfates, oxygen): **CP-0217, Chemistry Specifications and Surveillance - Secondary Systems**	Control of fluid chemistry prevents a corrosive environment for Feedwater System components.
	Determine the extent of degradation due to the effects of crevice corrosion, pitting, and general corrosion through inspection of representative plant components prior to the period of extended operations: **Age-Related Degradation Inspection Program (new program)**	The occurrence of crevice corrosion, pitting and general corrosion are expected to be limited and may not affect the intended function of the Feedwater System components due to the control of fluid chemistry. Inspections of representative plant components will provide assurance that significant corrosion is not occurring, or will result in initiation of appropriate corrective action if significant corrosion is occuring.
Erosion Corrosion	Monitor the Feedwater System S/G check valves for the effects of erosion corrosion: **Special Inspections of Feedwater Header Steam Generator Check Valves - Repetitive Tasks 10452052, 10452053, 20452043, and 20452044**	An erosion corrosion monitoring program is effective in determining a rate of degradation and preventing erosion corrosion from affecting the component intended function.
	Control system fluid chemistry in order to minimize the concentration of corrosive impurities (chlorides, sulfates, oxygen) and optimize fluid pH: **CP-0217, Chemistry Specifications and Surveillance - Secondary Systems**	Control of fluid chemistry prevents a corrosive environment for Feedwater System components, and limits the rate and effects of erosion corrosion.
Fatigue, Corrosion Fatigue	Monitor the effects of thermal fatigue: **CCNPP Fatigue Monitoring Program (with modifications)**	Tracking and monitoring the fatigue status of Feedwater System components will ensure that fatigue threshholds are not exceeded and that fatigue cracks are prevented or controlled. Through control of corrosion and monitoring of thermal fatigue effects, corrosion fatigue is also managed such that the effects will not prevent the component intended function.

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
COMPONENT ID: NA GROUP ID: 045-HV-01

1 PLAUSIBLE ARDM FROM ATTACHMENT 5	2 PLANT PROGRAM	3 REASON FOR THE FORM OF AGING MANAGMENT ALTERNATIVE CHOSEN
Crevice Corrosion, Pitting, General Corrosion	Control system fluid chemistry in order to minimize the concentration of corrosive impurities (chlorides, sulfates, oxygen): **CP-0217, Chemistry Specifications and Surveillance - Secondary Systems**	Control of fluid chemistry prevents a corrosive environment for Feedwater System components.
	Determine the extent of degradation due to the effects of crevice corrosion, pitting, and general corrosion through inspection of representative plant components prior to the period of extended operations: **Age-Related Degradation Inspection Program (new program)**	The occurrence of crevice corrosion, pitting and general corrosion are expected to be limited and may not affect the intended function of the Feedwater System components due to the control of fluid chemistry. Inspections of representative plant components will provide assurance that significant corrosion is not occurring, or will result in initiation of appropriate corrective action if significant corrosion is occuring.

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
COMPONENT ID: NA GROUP ID: 045-HV-02

1 PLAUSIBLE ARDM FROM ATTACHMENT 5	2 PLANT PROGRAM	3 REASON FOR THE FORM OF AGING MANAGMENT ALTERNATIVE CHOSEN
Crevice Corrosion, Pitting, General Corrosion	Control system fluid chemistry in order to minimize the concentration of corrosive impurities (chlorides, sulfates, oxygen): **CP-0217, Chemistry Specifications and Surveillance - Secondary Systems**	Control of fluid chemistry prevents a corrosive environment for Feedwater System components.
	Determine the extent of degradation due to the effects of crevice corrosion, pitting, and general corrosion through inspection of representative plant components prior to the period of extended operations: **Age-Related Degradation Inspection Program (new program)**	The occurrence of crevice corrosion, pitting and general corrosion are expected to be limited and may not affect the intended function of the Feedwater System components due to the control of fluid chemistry. Inspections of representative plant components will provide assurance that significant corrosion is not occurring, or will result in initiation of appropriate corrective action if significant corrosion is occuring.

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
COMPONENT ID: NA GROUP ID: 045-MOV-01

1 PLAUSIBLE ARDM FROM ATTACHMENT 5	2 PLANT PROGRAM	3 REASON FOR THE FORM OF AGING MANAGMENT ALTERNATIVE CHOSEN
Crevice Corrosion, Pitting, General Corrosion	Control system fluid chemistry in order to minimize the concentration of corrosive impurities (chlorides, sulfates, oxygen): **CP-0217, Chemistry Specifications and Surveillance - Secondary Systems**	Control of fluid chemistry prevents a corrosive environment for Feedwater System components.
	Determine the extent of degradation due to the effects of crevice corrosion, pitting, and general corrosion through inspection of representative plant components prior to the period of extended operations: **Age-Related Degradation Inspection Program (new program)**	The occurrence of crevice corrosion, pitting and general corrosion are expected to be limited and may not affect the intended function of the Feedwater System components due to the control of fluid chemistry. Inspections of representative plant components will provide assurance that significant corrosion is not occurring, or will result in initiation of appropriate corrective action if significant corrosion is occuring.
Erosion Corrosion	Control system fluid chemistry in order to minimize the concentration of corrosive impurities (chlorides, sulfates, oxygen) and optimize fluid pH: **CP-0217, Chemistry Specifications and Surveillance - Secondary Systems**	Control of fluid chemistry prevents a corrosive environment for Feedwater System components, and limits the rate and effects of erosion corrosion.
	Determine the extent of degradation due to the effects of erosion corrosion through inspection of representative plant components prior to the period of extended operations: **Age-Related Degradation Inspection Program (new program)**	The occurrence of erosion corrosion is expected to be limited and may not affect the intended function of the Feedwater System MOVs due to the control of fluid chemistry and non-conducive flow geometry of the valve. Inspections of representative plant components will provide assurance that significant erosion corrosion is not occurring, or will result in initiation of appropriate corrective action if significant erosion corrosion is occuring.

SYSTEM NUMBER: 045 SYSTEM NAME: Main Feedwater
COMPONENT ID: NA GROUP ID: 045-TE-01

1 PLAUSIBLE ARDM FROM ATTACHMENT 5	2 PLANT PROGRAM	3 REASON FOR THE FORM OF AGING MANAGMENT ALTERNATIVE CHOSEN
Crevice Corrosion, Pitting, General Corrosion	Control system fluid chemistry in order to minimize the concentration of corrosive impurities (chlorides, sulfates, oxygen): **CP-0217, Chemistry Specifications and Surveillance - Secondary Systems**	Control of fluid chemistry prevents a corrosive environment for Feedwater System components.
	Determine the extent of degradation due to the effects of crevice corrosion, pitting, and general corrosion through inspection of representative plant components prior to the period of extended operations: **Age-Related Degradation Inspection Program (new program)**	The occurrence of crevice corrosion, pitting and general corrosion are expected to be limited and may not affect the intended function of the Feedwater System components due to the control of fluid chemistry. Inspections of representative plant components will provide assurance that significant corrosion is not occurring, or will result in initiation of appropriate corrective action if significant corrosion is occuring.
Erosion Corrosion	Control system fluid chemistry in order to minimize the concentration of corrosive impurities (chlorides, sulfates, oxygen) and optimize fluid pH: **CP-0217, Chemistry Specifications and Surveillance - Secondary Systems**	Control of fluid chemistry prevents a corrosive environment for Feedwater System components, and limits the rate and effects of erosion corrosion.
	Determine the extent of degradation due to the effects of erosion corrosion through inspection of representative plant components prior to the period of extended operations: **Age-Related Degradation Inspection Program (new program)**	The occurrence of erosion corrosion is expected to be limited and may not affect the intended function of the Feedwater System thermowells due to the control of fluid chemistry and thermowell material of construction. Inspections of representative plant components will provide assurance that significant erosion corrosion is not occurring, or will result in initiation of appropriate corrective action if significant erosion corrosion is occuring.

ATTACHMENT 10, PROGRAM/ACTIVITY (PA) MODIFICATIONS

SYSTEM NUMBER: 045 **SYSTEM NAME:** Main Feedwater

PA/TASK ID and AFFECTED PORTION	PRESENT DESCRIPTION	NEW/REVISED CORRECTIVE ACTION/RECOMMENDATION
Age-Related Degradation Inspection (ARDI) Program	New Program	The ARDI Program must provide requirements for identification of representative plant components for inspection based on the results of this aging management review, the inspection sample size, appropriate inspection techniques, and requirements for reporting of results and corrective actions. Reference BGE Memorandum LCM96-044, dated 2-15-96, for further information.
CCNPP Fatigue Monitoring Program (FMP) - Scope of program portion; Commitment 01	The FMP currently excludes the Main Feedwater System from the scope of the program.	An evaluation of the Feedwater System piping and components (for which thermal fatigue is plausible) is required in order to determine whether current fatigue monitoring practice envelopes fatigue effects on Feedwater components. The FMP must be modified, as necessary, to monitor appropriate plant components such that the thermal fatigue effects of Feedwater components are bounded and managed.