BGE *Calvert Cliffs Nuclear Power Plant*

*License Renewal Project*

# Aging Management Review Report

**for the**

# Diesel Fuel Oil System

**(023)**

**Revision 1**

**April, 1996**

| | | | |
|---|---|---|---|
| **Prepared by:** | T. R. Hatch *(signature)*<br>**T. R. Hatch** | **Date:** | 4/30/96 |
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## Diesel Fuel Oil System Evaluation Report
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**List of Effective Sections**

**Summary of Revisions**

| Revision | Change Description |
|---|---|
| 00 | Initial Issue |
| 01 | General update for CCNPP IPA Methodology, Revision 1, and revision to component pre-evaluation and aging management review |

# 1.0 INTRODUCTION

## 1.1 Diesel Fuel Oil System Description

This section describes the scope and boundaries of the Diesel Fuel Oil 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 Diesel Fuel Oil 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 Diesel Fuel Oil System Description

The purpose of the Diesel Fuel Oil System is to provide a reliable supply of fuel oil to the emergency diesel generators, the auxiliary boilers, the SBO diesel generator, and the diesel-driven fire pump. The components of the Diesel Fuel Oil System that maintain pressure boundary of the system liquid are the focus of the aging evaluation for LCM.

The major component groups that support the pressure boundary of the system liquid function are the fuel oil tanks, valves and pipes which transport the oil.

The Diesel Fuel Oil System was determined to be within the scope of License Renewal during the System Level Scoping Process.

### 1.1.2 Diesel Fuel Oil System Boundary

The Diesel Fuel Oil System is composed of the following components:

| | |
|---|---|
| Two Diesel Fuel Oil Storage Tanks | 125,000 Gallon capacity (each). |
| Valves | Check and Hand Valves. |
| Piping | All - Carbon Steel, Pickled<br>Exposed - Painted<br>Buried - Coated & Wrapped. |

The Diesel Fuel Oil System interfaces with the following systems and components:

Emergency Diesel Generators (Suction of Fuel transfer pumps)
Auxiliary Boiler
Diesel Driven Fire Pump
SBO Diesel Generator

The boundary between the Diesel Fuel Oil System (023) and the Emergency Diesel Generator (024) is just upstream of the Y strainers installed in the suction pipe to the fuel transfer pumps.

1.1.3 Diesel Fuel Oil Intended System Functions

- Provide VA function to the power distribution system by supplying fuel oil to the EDGs during a DBE.

- To maintain the pressure boundary of the system liquid.

- To provide essential fuel oil to EDGs and FP pump diesel to ensure safe shutdown in the event of a postulated severe fire (includes isolation of nonessential aux boiler and SBO diesel fuel oil).

## 1.2 Evaluation Methods

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

Diesel Fuel Oil System components within the scope of license renewal were then evaluated using the BGE procedure for Component Pre-Evaluation to identify passive, long-lived, non-commodity components that must be evaluated for management of the effects of age-related degradation. The results of the Pre-evaluation process are presented in Section 3.0 of this report.

All components subject to aging management review are evaluated 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 these effects. The results of the Aging Management Review 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 Diesel Fuel Oil System component aging evaluation.

| Term | Description |
|---|---|
| None | |

## 1.4 System-Specific References

Several sources were used to determine Potential and Plausible ARDMs for the Diesel Fuel Oil 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 of the Diesel Fuel Oil System were utilized to verify materials, design configurations and location of components.

Table 1-1 lists the references utilized in the completion of the Diesel Fuel Oil System component aging evaluation.

**Table 1-1**
**System-Specific References**

| Document ID | Document Title | Rev | Date |
|---|---|---|---|
| - | ASME Wear Control Handbook, Peterson and Winer | - | 1980 |
| - | Component Evaluation and Program Evaluation Results for Fuel Oil Storage Tank No.21 Enclosure, Appendix E, (Part of the Component Evaluation and Program Evaluation of Four Structures) | 00 | 3/22/95 |
| - | Corrosion and Corrosion Control, An Introduction to Corrosion Science and Engineering, Uhlig, Third Edition | - | 1985 |
| - | Corrosion Engineering, Fontana and Greene | - | 1978 |
| - | Metals Handbook, 9th Edition, Vol 13, Corrosion | - | 1987 |
| - | Pre-evaluation Results for the Diesel Fuel Oil System (023) | 01 | 3/11/96 |
| 12329-0001 | Elevation, 2 - 30'-0" Dia x 24'-0" Ht, Fuel Oil Storage Tanks | 0 | 1970 |
| 12329-0003 | Roof Plan, Bottom Plan and Orientation, Fuel Oil Storage Tanks | 7 | 7/6/71 |
| 12329-0005 | Accessories for 2 - 30' x 24' Ht, Fuel Oil Storage Tanks | 5 | 6/4/92 |
| 12329-0010 | General Notes for 2 Fuel Oil Storage Tanks | 2 | 7/30/70 |
| 12503A-0015 | Piping Isometric, Fuel Oil | 7 | 12/5/90 |
| 12639A-0001 | Piping Isometric, Fuel Oil | 4F | 11/25/74 |
| 12639A-0002 | Piping Isometric, Fuel Oil | 1F | 12/3/73 |

**Table 1-1**
**System-Specific References**
**(Continued)**

| Document ID | Document Title | Rev | Date |
|---|---|---|---|
| 12639A-0003 | Piping Isometric, Fuel Oil | 6F | 11/27/74 |
| 12639A-0004 | Piping Isometric, Fuel Oil | 5F | 11/27/74 |
| 12639A-0005 | Piping Isometric, Fuel Oil | 6F | 11/25/74 |
| 12639A-0006 | Piping Isometric, Fuel Oil | 4F | 11/25/74 |
| 12639A-0007 | Piping Isometric, Fuel Oil | 5F | 11/26/74 |
| 12639A-0008 | Piping Isometric, Fuel Oil | 3F | 7/17/72 |
| 12639A-0009 | Piping Isometric, Fuel Oil | 5F | 11/26/74 |
| 60262 | Piping and Instrument Diagram - Fuel Oil Storage System (Ref's 60-736) | 28 | 6/22/94 |
| 60484 SH0001 | Fuel Oil Storage Piping Plan and Sections | 10 | 8/2/95 |
| 60484 SH0002 | Fuel Oil Storage Piping Plan and Sections | 0 | 2/20/95 |
| 60736 | Operations Drawing, Fuel Oil Storage System,Unit 1 & 2 | 32 | 8/9/95 |
| 61200 | Cathodic Protection - Containment, Unit 1 - 2, Reference Electrodes | 10 | 4/4/75 |
| 61201 | Cathodic Protection - Shallow Anode Beds and Reference Electrodes | 23 | 12/12/95 |
| 61202 | Cathodic Protection - Water & Fuel Storage Tanks | 10 | 12/12/95 |
| 61203 | Cathodic Protection - Containment Structures 1 & 2, Miscellaneous Details | 13 | 7/11/95 |
| 61406-A, 101.0 | Cathodic Protection, Installation Standard | 00 | 4/10/91 |

**Table 1-1**
**System-Specific References**
**(Continued)**

| Document ID | Document Title | Rev | Date |
|---|---|---|---|
| 61813 | Yard Tank Foundations | 05 | 3/22/88 |
| 63548 SH0007 | Yard Foundations and Structures | 04 | 10/5/73 |
| 91423 | Piping Isometric, Fuel Oil | 2 | 1/27/88 |
| 91424 | Piping Isometric, Fuel Oil | 4 | 10/10/91 |
| 92767SH HB-1 | M-600 Piping Class Sheet for HB | 54 | 12/15/95 |
| 92769HBSH HB-1 | M-601 Piping Class Summary Sheet with HB-5 (Fuel Oil) | 22 | 12/28/95 |
| 92771 | M-602 Master Valve List Sheets: | | |
| | Sht. Check-2 | 34 | 5/3/94 |
| | Sht. Gate-2 | 32 | 5/17/93 |
| | Sht. Globe-2 | 33 | 5/3/94 |
| ASTM A 105 | Forged or Rolled Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service, From 1970 Annual Book of ASTM Standards | - | 1968 |
| ASTM A 105 | Forgings, Carbon Steel, for Piping Components, From 1973 Annual Book of ASTM Standards | - | 1971 |
| ASTM A 105 | Standard Specification for Carbon Steel Forgings for Piping Applications, From 1996 World Wide STDS Service | - | 1995b |
| ASTM A 106 | Seamless Carbon Steel Pipe for High-Temperature Service, From following Annual Books of ASTM Standards | | |
| | 1970 | - | 1968 |
| | 1973 | - | 1973 |

**Table 1-1**
**System-Specific References**
**(Continued)**

| Document ID | Document Title | Rev | Date |
|---|---|---|---|
| ASTM A 106 | Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service, From 1996 World Wide STDS Service | - | 1994a |
| ASTM A 181 | Forged or Rolled Steel Pipe Flanges, Forged Fittings, and Valves and Parts for General Service, From following Annual Books of ASTM Standards | | |
| | 1970 | - | 1968 |
| | 1973 | - | 1968 |
| ASTM A 181 | Standard Specification for Carbon Steel Forgings, for General Service, From 1996 World Wide STDS Service | - | 1995a |
| | | - | |
| ASTM A 193 | Alloy-Steel Bolting Materials for High-Temperature Service, From 1970 Annual Book of ASTM Standards | - | 1969 |
| ASTM A 193 | Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service, From 1973 Annual Book of ASTM Standards | - | 1971 |
| ASTM A 193 | Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service, From 1996 World Wide STDS Service | - | 1995 |
| ASTM A 216 | Carbon-Steel Castings Suitable for Fusion Welding for High-Temperature Service, From following Annual Books of ASTM Standards | | |
| | 1970 | - | 1969 |
| | 1973 | - | 1970a |

**Table 1-1**
**System-Specific References**
**(Continued)**

| Document ID | Document Title | Rev | Date |
|---|---|---|---|
| ASTM A 216 | Standard Specification for Steel Castings , Carbon, Suitable for Fusion Welding, for High-Temperature Service, From 1996 World Wide STDS Service | - | 1993 |
| ASTM A 283 | Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality, From following Annual Books of ASTM Standards | | |
| | 1970 | - | 1967 |
| | 1973 | - | 1970a |
| ASTM A 283 | Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates, From 1996 World Wide STDS Service | - | 1993a |
| BGM-96-031 | Letter, J.Poehler to NCR Group, Molybdenum Disulfide Thread Lubricants for the RV Head and other Applications, NCR #10295 | - | 8/28/90 |
| C-96-003 | Cummins Service Information Bulletin, Microbial Contamination of Diesel Fuel, 78SIB 5-7 | - | 1978 |
| CH-1-100 | Controlled Material Management | 01 | 2/1/95 |
| CLSR | CCNPP Component Level Screening Results - System 023 | 01 | 1992 |
| CP-226 | Oil Receipt Inspection and Fuel Oil Storage Tank Surveillance (PCR 94-082) | 03 | 3/30/95 |
| CP-503 | Sampling of Oil (PCR 94-025) | 04 | 12/27/95 |

**Table 1-1**
**System-Specific References**
**(Continued)**

| Document ID | Document Title | Rev | Date |
|---|---|---|---|
| CP-927 | Determination of Water and Sediment in Oils by Centrifuge (PCR 93-087) | 02 | 9/30/93 |
| CP-955 | Determination of Water in Oils by Coulometry (PCR 93-069) | 03 | 9/26/95 |
| CP-973 | Determination of Particulate Contamination in Diesel Fuel Oil (PCR 93-095) | 03 | 2/6/96 |
| CP-996 | Determination of Microbial Growth (PCR 94-006) | 01 | 3/8/94 |
| DG-1009 | Standard Format and Content of Technical Information for Applications to Renew Nuclear Power Plant Operating Licenses, Draft NRC Regulatory Guide | - | 1990 |
| ES-014 | Summary of Ambient Environmental Service Conditions Used at CCNPP | 0 | 11/8/95 |
| ES-032 | Control of the Equipment Technical Databases (Nucleis - Master Equipment List and CCETS) | 0 | 1995 |
| FSK-MP-207 | Piping Isometric, Fuel Oil | 1 | 2/20/95 |
| FSK-MP-212 | Piping Isometric, Fuel Oil | 2 | 11/14/74 |
| FSK-MP-227 | Piping Isometric, Fuel Oil | 2 | 11/14/74 |
| FSK-MP-232 | Piping Isometric, Fuel Oil | 2 | 12/5/74 |
| FSK-MP-488 | Fuel Oil Storage Tank Trim #11 & #21, HB-5 | 1 | 8/3/72 |
| FSK-MP-899 | Piping Isometric, Fuel Oil | 4 | 8/17/76 |

**Table 1-1**
**System-Specific References**
**(Continued)**

| Document ID | Document Title | Rev | Date |
|---|---|---|---|
| FSK-MP-903 | Piping Isometric, Fuel Oil | 4 | 8/17/76 |
| FSK-MP-2667 | Piping Isometric, Fuel Oil | 0 | 11/14/74 |
| G:\PES\950103-200 | Letter, V.Spunar to Distribution, 11 Fuel Oil Storage Tank Inspection (11/1/95) | - | 1/3/96 |
| LCM 95-112 | Letter, J.Rycyna to file, Boric Acid Corrosion | - | 3/29/95 |
| LCM 96-044 | Letter, B.Tilden to file, Age Related Degradation Inspections | - | 2/15/96 |
| LCM-16 | Component Aging Management Review, LCMU Procedure | 4 | 1995 |
| LER 89-26 | Potential Emergency Diesel Generator Failure due to High Particulate Level in Fuel | 00 | 1989 |
| M-0080 | Fuel Oil Unloading Pump, Specification | 01 | 10/6/70 |
| M-216 | Specification for Field Erected Storage Tanks | 10 | 1974 |
| M-289 | Guidelines for Field Fabrication and Installation of Non-Nuclear Piping and Instrumentation | 00 | 4/22/77 |
| MN-3-100 | Painting and other Protective Coatings | 01 | 6/25/95 |
| NACE-5 | Stress Corrosion Cracking and Hydrogen Embrittlement of Iron Base Alloys, Meeting held June 12-16, 1973 | - | 1977 |
| NP-2129 | EPRI Report, Radiation Effects on Organic Materials in Nuclear Plants | - | 1981 |

**Table 1-1**
**System-Specific References**
**(Continued)**

| Document ID | Document Title | Rev | Date |
|---|---|---|---|
| NP-3137 | EPRI Report, Computer - Calculated Potential pH Diagrams to 300°C, Vol 1 | - | 1983 |
| NP-3784 | EPRI Report, A Survey of the Literature on Low-Alloy Steel Fastener Corrosion in PWR Power Plants | - | 1984 |
| NP-3944 | EPRI Report, Erosion/Corrosion in Nuclear Plant Steam Piping | - | 1985 |
| NP-5461 | EPRI Report, Component Life Estimation: LWR Structural Materials Degradation Mechanisms | - | 1987 |
| NP-5769 | EPRI Report, Degradation and Failure of Bolting in Nuclear Power Plants | - | 1988 |
| NP-5775 | EPRI Report, Environmental Effects on Components: Commentary for ASME Section III | - | 1988 |
| NP-5985 | Boric Acid Corrosion of Carbon and Low Alloy Steel Pressure Boundary Materials | - | 1988 |
| NUREG/CR-5379 | Nuclear Plant Service Water System Aging Degradation Assessment | | |
| | • Volume 1 | - | 1989 |
| | • Volume 2 | - | 1992 |
| NUREG/CR-5419 | Aging Assessment of Instrument Air Systems | - | 1990 |
| NUREG/CR-5643 | Insights Gained from Aging Research | - | 1992 |

**Table 1-1**
**System-Specific References**
**(Continued)**

| Document ID | Document Title | Rev | Date |
|---|---|---|---|
| OI-21 | Operating Instruction, Emergency Diesel Generators | 26 | 7/6/95 |
| OI-21D | Operating Instruction, Fuel Oil Storage and Supply | 0 | 8/25/95 |
| PEG-7 | Plant Engineering Section, System Walkdowns | 4 | 11/30/95 |
| PEO-0-23-2-0-M | FOST Drain Water | 02 | 8/21/95 |
| QL-2-100 | Issue Reporting and Assessment | 04 | 1/2/96 |
| TR-102204 | EPRI Report, Service (Salt) Water System Life Cycle Management Evaluation | - | 1993 |
| TS | CCNPP Technical Specification, Section 4.8.1.1.2<br>• Unit 1<br>• Unit 2 | Amend<br><br>211<br>188 | - |
| U-96-001 | BIOBOR JF Fuel Fungicide Service Bulletin No. 279 | - | 1981 |
| UFSAR | CCNPP Updated Final Safety Analysis Report | 18 | - |

# 2.0 STRUCTURES AND COMPONENTS WITHIN THE SCOPE OF LICENSE RENEWAL

## 2.1 Component Level Scoping Methodology Overview

The Diesel Fuel Oil System components were scoped in accordance with the process described in the BGE Life Cycle Management Program Methodology for Integrated Plant Assessment. 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 Diesel Fuel Oil System. These components are within the scope of license renewal.

## 2.2 Component Level Scoping Results

A total of 94 components (unique equipment identifiers), representing 13 device types in the Diesel Fuel Oil System, were designated as within the scope of license renewal. These device types are listed in Table 2-1.

The portion of the Diesel Fuel Oil System within the scope of license renewal consists of piping, components, component supports, instrumentation, and cables for the section of the system supporting fuel oil unloading, the storage of fuel, and transport of fuel to the Emergency Diesel Generators.

Refer to the results of the Diesel Fuel Oil 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**
**DFO Device Types Within Scope of License Renewal**

| Device Code | Device Description |
|---|---|
| -HB | Piping, HB |
| CKV | Check Valve |
| HV | Hand Valve |
| TK | Tank |
| BS | Basket Strainer |
| FU | Fuse |
| HS | Hand Switch |
| LS | Level Switch |
| MO | Motor |
| PUMP | Pump |
| RY | Relay |
| X | Transformer |
| XL | Indicating Lamp |

# 3.0 COMPONENT PRE-EVALUATION

## 3.1 Pre-Evaluation Method

The component pre-evaluation procedure is used to determine which components are subject to an aging management review (AMR). 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 Diesel Fuel Oil System. These function 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 Diesel Fuel Oil system components dispositioned as part of commodity evaluations include all component supports[1], all cables[1] , 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 Diesel Fuel Oil System.

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

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

**Table 3-1**
**Diesel Fuel Oil Intended System Function Disposition**

| Function Description | Function Passive |
|---|---|
| Provide VA function to the power distribution systems by supplying fuel oil to the EDGs during a DBE | No |
| To maintain the pressure boundary of the system liquid. | Yes |
| To provide essential fuel oil to EDGs and FP Pump Diesel to ensure safe shutdown in the event of a postulated severe fire (includes isolation of nonessential aux boiler and SBO diesel fuel oil) | No |

**Table 3-2**
**Summary of Diesel Fuel Oil System Device Types Requiring Aging Management Review**

| Device Code | Device Description | Components Support Passive Function ? | Components Subject to Replacement Program ? | Components Evaluated in Commodity Evaluation ? | Components Included in DFO AMR? |
|---|---|---|---|---|---|
| -HB | DFO Piping | Yes | No | No | Yes |
| CKV | Check Valve | Yes | No | No | Yes |
| HV | Hand Valve | Yes | No | No | Yes |
| TK | Tank | Yes | No | No | Yes |
| BS | Basket Strainer | No | No | No | No |
| FU | Fuse | No | No | No | No |
| HS | Hand Switch | No | No | No | No |
| LS | Level Switch | Yes | No | Yes | No |
| MO | Motor | No | No | No | No |
| PUMP | Pump | No | No | No | No |
| RY | Relay | No | No | No | No |
| X | Transformer | No | No | No | No |
| XL | Indicating Lamp | No | No | No | No |

# 4.0 COMPONENT AGING MANAGEMENT REVIEW

## 4.1 Aging Management Review Methodology Overview

The aging management review of Diesel Fuel Oil 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:

- Identify Components subject to Plausible ARDMs:

  (1) Identified potential ARDMs for Diesel Fuel Oil System components.

  (2) Grouped Diesel Fuel Oil 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 ARDMs for each component or sub-component based on:

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

- Identified methods to manage aging effects for plausible ARDMs and assessed 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

Diesel Fuel Oil System components were evaluated to identify ARDMs for which 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 Diesel Fuel Oil 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
Accumulator (Tank)

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
DOE Reports
Site OER Database

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 Diesel Fuel Oil 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. The scope of components within the aging management review for the Diesel Fuel Oil System is relatively small, and materials and environments were fairly consistent. This lead to grouping by device type and environment (buried and exposed). Within a given device type, sub-groups were developed to identify various component parts made of different materials and exposed to different environments. Component grouping is shown on Attachment 3s in Appendix A. Sub-component breakdowns are shown on Attachment 4s in Appendix A.

### 4.2.3 Plausible ARDMs

The list of potential ARDMs is utilized for a Diesel Fuel Oil 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 Diesel Fuel Oil 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. New programs were also identified.

Site programs and new programs are discussed for Diesel Fuel Oil system components and plausible ARDMs on Attachment 2s, 8s and 10s in Appendix A.

Attachment 1 in Appendix A provides a summary of Diesel Fuel Oil 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)**

| Potential ARDMs | DFO Equipment Types | | |
|---|---|---|---|
| | Pipe | Valve | Accumu |
| Cavitation Corrosion | x | x | |
| Corrosion Fatigue | x | x | |
| Creep/Shrinkage | | | |
| Crevice Corrosion | x | x | x |
| Erosion Corrosion | 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 | | | |
| MIC | x | x | x |
| Oxidation | | | |
| Particulate Wear Erosion | x | x | |
| Pitting | x | x | x |
| Radiation Damage | x | x | x |
| Rubber Degradation | x | x | x |
| Saline Water Attack | x | | |
| Selective Leaching | x | x | x |
| Stress Corrosion Cracking | x | x | x |
| Stress Relaxation | x | x | x |
| 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**

| | DFO Device Types | | | |
|---|---|---|---|---|
| PLAUSIBLE ARDMs | -HB | CKV | HV | TK |
| Cavitation Corrosion | | | | |
| Corrosion Fatigue | | | | |
| Crevice Corrosion | x | x | x | x |
| Erosion Corrosion | | | | |
| Fatigue | | | | |
| Fouling | | | | x |
| Galvanic Corrosion | | | | |
| General Corrosion | x | x | x | x |
| Hydrogen Damage | | | | |
| Intergranular Attack | | | | |
| MIC | x | | | x |
| Particulate Wear Erosion | | | | |
| Pitting | x | x | x | x |
| Radiation Damage | | | | |
| Rubber Degradation | | | | |
| 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

## Diesel Fuel Oil System
## Aging Management Review LCM-16 Attachments

### Table of Contents

**Aging Management Review Summary (Revision 1)** **System Name & No.:** Diesel Fuel Oil, 023 Date: April 26, 1998

| Device Type | Group ID | Passive Intended Functions | Grouping Attributes | Subcomponents/ Subgroups Not Subject to Aging Mgmt Review | Plausible ARDMs | Managed byExisting Programs ID | Modifications Needed | New Program Needed |
|---|---|---|---|---|---|---|---|---|
| HB | 023-HB-01 | Maintain Press Bndry Integrity. | HB Pipe (above ground) | None | Crevice Corrosion - External surfaces<br>General Corrosion - External surfaces<br>Pitting - External surfaces | MN-3-100, QL-2-100, PEG-7 | | |
| HB | 023-HB-02 | Maintain Press Bndry Integrity. | HB Pipe (buried) | None | Crevice Corrosion - External surfaces<br>General Corrosion - External surfaces<br>Pitting - External surfaces<br>MIC - External surfaces | | | Yes<br>DFO Buried Pipe Inspection Program - Inspect buried pipes to assure the pipe coating/ wrapping and cathodic protection system are adequately protecting the pipe from external ARDMs. |
| CKV | 023-CKV-01 | Maintain Press Bndry Integrity | Check Valves | Disk and Seat 023-CKV-01D | Crevice Corrosion - External surfaces<br>General Corrosion - External surfaces<br>Pitting - External surfaces | MN-3-100 QL-2-100, PEG-7 | | |

**Aging Management Review Summary (Revision 1)** **System Name & No.:** Diesel Fuel Oil, 023 Date: April 30, 1996

| Device Type | Group ID | Passive Intended Functions | Grouping Attributes | Subcomponents/ Subgroups Not Subject to Aging Mgmt Review | Plausible ARDMs | Managed byExisting Programs ID | Modifications Needed | New Program Needed |
|---|---|---|---|---|---|---|---|---|
| HV | 023-HV-01 | Maintain Press Bndry Integrity. | Hand Valves | Disk and Seat 023-HV-01D | Crevice Corrosion - External surfaces | MN-3-100 QL-2-100 PEG-7 | | |
| | | | | | General Corrosion - External surfaces | | | |
| | | | | | Pitting - External surfaces | | | |
| TK | 023-TK-01 | Maintain Press Bndry Integrity. | Tank | Stairs and Platforms 023-TK-01E | Crevice Corrosion - External exposed surfaces | MN-3-100 QL-2-100 PEG-7 | | |
| | | | | | General Corrosion - External exposed surfaces | | | |
| | | | | | Pitting - External exposed surfaces | | | |
| | | | | | Crevice Corrosion - CS internal, particularly bottom surfaces | PEO-0-023-2-O-M, CP-226 CP-973 | | Yes Tank Internal Inspection Program. -Visually Inspect the tank internal surfaces and measure tank bottom thickness to determine presence of and/or rate of significant corrosion |
| | | | | | General Corrosion - CS internal, particularly bottom surfaces | | | |
| | | | | | Pitting - CS internal, particularly bottom surfaces | | | |
| | | | | | Fouling - CS internal, particularly bottom surfaces | | | |
| | | | | | MIC - CS internal, particularly bottom surfaces | | | |

## Description of Programs Which Manage the Effects of Aging (Revision 1)

Date: April 30, 1996

System Name and Number: Diesel Fuel Oil, 023

| Program ID | Portions of System Managed By This Program & Passive Intended Function | ARDMs Managed by This Program | Description of Program |
|---|---|---|---|
| MN-3-100<br>Painting and Other Protective Coatings | Piping, Valves, and Tanks - external surfaces.<br>Passive Intended Function: Pressure Boundary Integrity | Crevice Corrosion<br>General Corrosion<br>Pitting | This program provides for assessment, prioritization and corrective action for degraded paint discovered under PEG-7 and/or QL-2-100. |
| QL-2-100<br>Issue Reporting and Assessment | Piping, Valves, and Tanks - external surfaces.<br>Passive Intended Function: Pressure Boundary Integrity | Crevice Corrosion<br>General Corrosion<br>Pitting | This procedure provides requirements for initiating, reviewing and processing of Issue Reports (IRs), and for resolution of issues. IRs are generated to document and resolve hardware and equipment deficiencies and nonconformances. Corrective actions are implemented as required to resolve the issue. |
| PEG-7<br>System Walkdowns | Piping, Valves, and Tanks - external surfaces.<br>Passive Intended Function: Pressure Boundary Integrity | Crevice Corrosion<br>General Corrosion<br>Pitting | This guideline provides direction for performance of system walkdowns, the reporting of walkdown results, and initiation of corrective action. Inspection items typically related to aging management include housekeeping (e.g., paint) and system stress or abuse (e.g., vibration, cavitation, corrrosion, leakage). Conditions adverse to quality are documented on Issue Reports in accordance with QL-2-100. |
| PEO-0-023-2-O-M<br>Drain Water from 11 & 21 FOST | Fuel Storage Tanks - internal surfaces.<br>Passive Intended Function: Pressure Boundary Integrity | Crevice Corrosion<br>General Corrosion<br>Pitting<br>Fouling<br>MIC | This procedure periodically drains water which may collect at tank bottom. This activity in combination with chemistry testing provides for detection and control of contributing environmental factors to the plausible ARDMs. If the amount of drained water or fuel chemistry is found to not meet the established standards, then corrective action is implemented as required. |
| CP-226<br>Oil Recieipt Inspection and Fuel Oil Storage Tank Surveillance | Fuel Storage Tanks - internal surfaces.<br>Passive Intended Function: Pressure Boundary Integrity | Crevice Corrosion<br>General Corrosion<br>Pitting<br>Fouling<br>MIC | This procedure controls fuel oil chemistry, including testing for presence of biologics. The procedure establishes surveillance frequencies, fuel oil specifications (e.g., viscosity, %water, particulate contamination), and corrective actions. Sampling and analysis are performed on new fuel prior to unloading from fuel trucks and on fuel in the storage tanks. |

## Description of Programs Which Manage the Effects of Aging (Revision 1)

Date: April 30, 1996

System Name and Number: Diesel Fuel Oil, 023

| Program ID | Portions of System Managed By This Program & Passive Intended Function | ARDMs Managed by This Program | Description of Program |
|---|---|---|---|
| CP-973<br>Determination of Particulate Contamination in Diesel Fuel Oil | Fuel Storage Tanks - internal surfaces.<br>Passive Intended Function: Pressure Boundary Integrity | Crevice Corrosion<br>General Corrosion<br>Pitting<br>Fouling<br>MIC | This procedure provides instructions to quantify insoluble particulate contamination in diesel fuel. Chemistry testing in accordance with this procedure and CP-226, in combination with draining of water in accordance with PEO-0-023-O-M provides for detection and control of contributing environmental factors to the plausible ARDMs. If fuel chemistry is found to not meet the established standards, then corrective action is implemented as required. |
| New Program:<br>Tank Internal Inspection Program | Fuel Storage Tanks- internal surfaces.<br>Passive Intended Function: Pressure Boundary Integrity | Crevice Corrosion<br>General Corrosion<br>Pitting<br>Fouling<br>MIC | The Tank Internals Inspection 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. The program will focus on the effects of the plausible ARDMs on tank internal surfaces. The program should visually inspect internal surfaces and measure tank bottom thickness to determine presence of and/or rate of significant corrosion. |
| New Program:<br>DFO Buried Pipe Inspection Program | External surfaces of buried portions of pipes.<br>Passive Intended Function: Pressure Boundary Integrity | Crevice Corrosion<br>General Corrosion<br>Pitting<br>MIC | The DFO Buried Pipe Inspection 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. The program will focus on the effects of the plausible ARDMs on the pipe external surfaces. The program should inspect the buried pipes to assure the pipe coating/wrapping and cathodic protection system are adequately protecting the pipe from external ARDMs. |

# Development of Aging Management Alternatives (Revision 1)

**Date:** April 26, 1996

SYSTEM NUMBER: 023

SYSTEM NAME: Diesel Fuel Oil

COMPONENT ID:

GROUP ID: 023-HB-01, 023-CKV-01
023-HV-01, 023-TK-01

| 1<br>PLAUSIBLE ARDM FROM ATTACHMENT 5 | 2<br>PLANT PROGRAM | 3<br>REASON FOR THE FORM OF AGING MANAGEMENT ALTERNATIVE CHOSEN |
|---|---|---|
| Crevice Corrosion, General Corrosion, Pitting Corrosion<br>- External surfaces not buried or located inside a building. | Periodically walkdown the DFO system to identify and correct areas where the external painted surfaces have degraded to the extent that ARDMs are challenging the pressure boundary function.<br><br>MN-3-100, Protective Coating Program<br>QL-2-100, Issue Reporting<br>PEG-7, System Walkdowns | The plausibility of the ARDMs is due to possible degradation of the external protective paint coatings due to weather and ambient conditions which are more severe than the moderate conditions found inside buildings. System Engineer Walkdown as directed by PEG-7 provides for engineer with "ownership" of the system to closely examine piping components. These walkdowns will identify and document significant coating degradation and/or presence of corrosion. PEG-7 requires initiation of an Issue Report in accordance with QL-2-100 for conditions adverse to quality, including housekeeping deficiencies (e.g. degraded paint). Issue Reports identify needed corrective action, and require completion of the work prior to closure. Procedure MN-3-100 identifies when and how to to correct the degraded condition.<br><br>This management approach provides reasonable assurance that significant degradation (i.e. degradation, which if not corrected, could eventually challenge system pressure boundary) will be identified and resolved. |
| | | |

# Development of Aging Management Alternatives (Revision 1)

**Date:** April 12, 1996

SYSTEM NUMBER: 023 SYSTEM NAME: Diesel Fuel Oil

COMPONENT ID: GROUP ID: 023-HB-02

| 1<br>PLAUSIBLE ARDM FROM ATTACHMENT 5 | 2<br>PLANT PROGRAM | 3<br>REASON FOR THE FORM OF AGING MANAGEMENT ALTERNATIVE CHOSEN |
|---|---|---|
| Crevice Corrosion<br>General Corrosion<br>Pitting Corrosion<br>MIC<br>- External surfaces buried | Inspect a representative sample of the buried pipes for signs of the plausible ARDMs prior to the period of extended operation.<br><br>DFO Buried Pipe Inspection Program (New Program) | The DFO buried pipes are protected by a coating/wrapping and an impressed cathodic protection system. However, holidays or disbonded areas of the wrapping can lead to crevice corrosion, general corrosion, pitting and MIC given a condusive environment. Since the pipe is buried (normally not inspectable) and the environmental conditions may vary, a representative sample of the buried piping will be inspected to provide assurance that the coating/wrapping and cathodic protection system are adequately protecting the pipe from external ARDMs. This management approach provides for detection by inspection, correction as needed, and identification of needed additional or future inspections. |
| | | |
| | | |
| | | |

# Development of Aging Management Alternatives (Revision 1)

**Date:** April 12, 1996

SYSTEM NUMBER: 023

SYSTEM NAME: Diesel Fuel Oil

COMPONENT ID:

GROUP ID: 023-TK-01

| 1<br>PLAUSIBLE ARDM FROM ATTACHMENT 5 | 2<br>PLANT PROGRAM | 3<br>REASON FOR THE FORM OF AGING MANAGEMENT ALTERNATIVE CHOSEN |
|---|---|---|
| Crevice Corrosion -<br>General Corrosion<br>Pitting<br>Fouling<br>MIC<br><br>CS internal, particularly bottom surfaces | Periodically drain water from the FOSTs.<br><br>PEO-0-023-2-O-M | This aging management approach provides for removal and control of a contributing environmental factor to the plausible ARDMs. Draining of any water which may collect at the tank bottom (in the sump) will minimize corrosion of the tank bottom due to plausible ARDMs. There are two primary benefits of removing water; the first is to minimize the possibility of MIC, as microbes require water to survive and multiply, and second, that typical corrosive affects of water on carbon steel will be minimized. If more than one gallon of water is drained, the operator is required to notify the shift supervisor, and the situation will be investigated to determine and correct the source of the water. |
| | Maintain fuel oil within established specifications to minimize possibility of microbe growth, buildup of sludge, and corrosive affects of plausible ARDMs.<br><br>CP-226, Oil Receipt Inspection and FOST Surveillance<br>CP-973, Determination of Particulate Contamination in Diesel Fuel Oil | This aging management approach provides for detection and control of contributing environmental factors to the plausible ARDMs. The procedures assure new and existing fuel oil chemistry meets established standards (including testing for biologics and water), thereby assuring the environment is not conducive to the plausible ARDMs. If fuel chemistry is found to not meet the established standards then corrective action is implemented as required. |
| | Inspect the internal surfaces of the tank and measure tank bottom thickness to determine presence of and/or rate of significant corrosion.<br><br>Tank Internal Inspection Program (New Program) | Draining water and chemisty testing/control of fuel oil provides a high degree of confidence that the affects of the plausible ARDMs will be minimized. However, the internal surfaces of the tank are not accessible during system walkdowns; therefore, an internal inspection will provide additional assurance that existing procedures and controls are adequately protecting tank internals. If degradation mechanisms are noted then corrective actions can be implemented. Future inspections may be scheduled if appropriate. |

**Attachment 10 Program/Activity (PA) Modifications (Revision 1)** **Date: April 30, 1996**

| **SYSTEM NUMBER:** 023 | | **SYSTEM NAME:** Diesel Fuel Oil |
|---|---|---|
| PA/TASK ID and AFFECTED PORTION | PRESENT DESCRIPTION | NEW/REVISED CORRECTIVE ACTION/RECOMMENDATION |
| Tank Internal Inspection Program<br><br>Tank, Internal Surfaces | N/A | The Tank Internals Inspection Program shall visually inspect internal surfaces and measure tank bottom thickness to determine presence of and/or rate of significant corrosion. The program shall provide appropriate inspection techniques, acceptance criteria, guidance for establishing additional and/or future inspections (if needed), and requirements for reporting of results and corrective actions. The inspection shall be coordinated with the Environmental Affairs Section. |
| DFO Buried Pipe Inspection Program<br><br>Buried Pipes, External surfaces | N/A | The DFO Buried Pipe Inspection Program shall inspect the buried pipes to assure the pipe coating/wrapping and cathodic protection system are adequately protecting the pipe from external ARDMs. The program shall provide requirements for identification of representative pipes for inspections, appropriate inspection techniques, acceptance criteria, guidance for establishing additional and/or future inspections (if needed), and requirements for reporting of results and corrective actions. |

SYSTEM: 023, Diesel Fuel Oil

EQUIPMENT TYPE: PIPE

**Potential ARDM List (Revision 1)**

Date: March 20, 1996

| ARDM | POTENTIAL | 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 piping system design prevents this ARDM from occurring (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. | [6]<br>[7]<br>[12] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: PIPE

Date: March 20, 1996

| | | | |
|---|---|---|---|
| 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]<br>[6]<br>[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]<br>[7]<br>[2] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: PIPE Date: March 20, 1996

| | | | |
|---|---|---|---|
| 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] [16] |
| 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, interstitial atomic hydrogen is combined into molecular hydrogen within the metal, causing 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). | [6] [7] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: PIPE

Date: March 20, 1996

| | | | |
|---|---|---|---|
| Hydrogen Damage (Continued) | Yes (Cont'd) | 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. Catalyst poisons or pickling inhibitors, as well as lubricants or other material containing P, S or As compounds (e.g., molybdenum disulfide lubricants) favor the entrance of atomic hydrogen into the metal lattice and should therefore be limited. | |
| 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]<br>[7]<br>[2]<br>[12] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: PIPE

Date: March 20, 1996

| | | | |
|---|---|---|---|
| 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 located outside the reactor building, where the neutron flux is not high enough to cause this ARDM to occur. | [6]<br>[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. Several forms of fungi and other microorganisms can also survive and multiply in hydrocarbon fuels.<br><br>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]<br>[7]<br>[2]<br>[14] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: PIPE

Date: March 20, 1996

| | | | |
|---|---|---|---|
| MIC (Continued) | Yes (Cont'd) | Hydrocarbon fuel fungi grow into long strings, and form larger mats or globules. They may grow though out the fuel, or at the interface area between the fuel and water bottom layer. As the fuel is agitated, for instance during filling, fungal growth is distributed throughout the fuel system. The fungus organisms need only trace amounts of minerals and water to sustain their growth, and use the fuel as their main energy/food source. Their growth chemically alters the fuel by producing sludge, acids, and other products of metabolism. When they adhere to the fuel containing surfaces the water and waste products lead to corrosion. Rubber and other tank linings, hoses and coatings may also be consumed due to their energy and trace mineral composition. | |
| 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. | [7] [12] |
| 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] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: PIPE

Date: March 20, 1996

| | | | |
|---|---|---|---|
| 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]<br>[7]<br>[2]<br>[12] |
| Radiation Damage | Yes | Non-metallics are susceptible to degradation caused by gamma radiation. | [4] |
| Rubber Degradation | Yes | Rubber can be used in specific applications of this device type. Long term exposure of rubber to water will result in water absorption and swelling, blistering, hardening, and eventual cracking. When utilized as a protective lining, moisture permeation of the rubber produces blisters beneath the lining and initiates corrosion of the lined surface. | [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. Of particular concern for structures that are inaccessible for routine inspection, and piping or other fluid components embedded in concrete. | [2] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: PIPE

Date: March 20. 1996

| | | | |
|---|---|---|---|
| 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]<br>[13] |
| 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).<br><br>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). SCC of low alloy steel and carbon steel is not considered a credible aging mechanism for typical conditions encountered in a nuclear power plant. TGSCC may be a concern in low alloy and stainless steel if aggressive chemical species (caustics, halogens, sulfates, especially if coupled with the presence of oxygen) are present. 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. | [6]<br>[7]<br>[2]<br>[12]<br>[13]<br>[15]<br>[16] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: PIPE

Date: March 20, 1996

| | | | |
|---|---|---|---|
| Stress Corrosion Cracking (Continued) | Yes (Cont'd) | 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.<br><br>Cathodic protection of buried pipes is provided to prevent SCC; however SCC can occur at areas where the coating is disbonded. The potential voltage of the pipe can result in the accumulation of alkali at the pipe surface leading to SCC. The other factors which which have a strong influence on whether SCC will occur at these locations include the chemical composition of the envirionment, the stress level (hoop stress), the nature of the metal (lower yield strength is less likely to develop SCC), the electrode potential of the metal, and the temperature (lower is less likely to develop SCC). A proven remedial measure is careful and complete protection of the pipe surface with an organic coating, which is often supplemented with a polyethylene wrap or epoxy resin coating. | |
| 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 (>700°F for typical materials). Bolted connections are most vulnerable. Relaxation of stress on packing due to stretching of gland follower studs under elevated temperatures may cause packing leakage.<br><br>Irradiation fluence levels greater than 6.0E19 increase relaxation in austenitic and nickel alloy steels. | [7] |
| Thermal Damage | Yes | Non-metallics are particularly susceptible with material dependent temperature limits. | [7]<br>[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] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: PIPE

Date: March 20, 1996

| | | | |
|---|---|---|---|
| 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] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: PIPE

Date: March 20, 1996

**Attachment 7 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 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 |
| [14] | BOIBOR JF Fuel Fungicide Service Bulletin, U.S. Borax, No. 279 |
| [15] | NACE-5, Stress Corrosion Cracking and Hydrogen Embrittlement of Iron Base Alloys, June 12-16, 1973, pages 135-139 |
| [16] | A Survey of the Literature on Low-Alloy Steel Fastener Corrosion in PWR Power Plants, EPRI Report No. NP-3784, 1984 |

Attachment 3 **Component Grouping Summary Sheet** (Revision 1) Date: 03/19/96

SYSTEM: Diesel Fuel Oil (023)

GROUP ID NUMBER: 023-HB-01

GROUP ATTRIBUTES:

1. Device Type: Pipe Line with Piping Code HB
2. Vendor:
3. Model Number:
4. Material:
5. Internal Environment:
6. External Environment: Above ground (not buried)
7. Function: Maintain System Pressure Boundary Integrity
8. Name Plate Data:

| PARAMETER | VALUE |
|---|---|
| | |
| | |

LIST OF GROUPED COMPONENTS (EQUIPMENT ID):

| | |
|---|---|
| 0-HB5-1001 | DFO System Piping* |
| 0-HB5-1002 | DFO System Piping* |
| 0-HB5-1003 | DFO System Piping* |
| 0-HB5-1004 | DFO System Piping* |
| 0-HB5-1005 | DFO System Piping* |
| 0-HB5-1006 | DFO System Piping* |
| 0-HB5-1007 | DFO System Piping |
| 0-HB5-1010 | DFO System Piping* |
| 0-HB5-1013 | DFO System Piping |
| 0-HB5-1017 | DFO System Piping |
| 0-HB5-1018 | DFO System Piping |
| 0-HB5-1019 | DFO System Piping* |
| 0-HB5-1040 | DFO System Piping* |
| 0-HB5-1056 | DFO System Piping** |
| 0-HB5-2002 | DFO System Piping* |
| 0-HB5-2004 | DFO System Piping* |
| 0-HB5-2006 | DFO System Piping*,*** |
| 0-HB5-2013 | DFO System Piping |
| 0-HB5-2040 | DFO System Piping* |

*Component has portions which are both above ground and buried. This Group addresses only the above ground portion.

**Only the portion up to valves 0HV0C-DFO-037, 051 and 151 is within the scope of this system evaluation.

***Includes short branch up to 0CKVDFO-144.

## Sub-Component/Sub-Group Identification (Revision 1)

Date: 3/27/96

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

EQUIPMENT ID: PIPE GROUP ID: 023-HB-01 DEVICE TYPE NAME: PIPE LINE WITH PIPING CODE OF "HB"

| Sub-Group ID | Sub-Component/ Name (Replacement Prgm) | Manufacturer (Source) | Material (Source) | Model Number (Source) | Passive Intended Function(s) (Source) | Subj to AMR (Y or N) |
|---|---|---|---|---|---|---|
| 023-HB-01A | PIPE (NONE) | N/A (N/A) | A-106 GR B, SMLS CARBON STEEL (92767) | N/A (N/A) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |
| 023-HB-01B | FITTINGS (NONE) | N/A (N/A) | FORGED: A-181 (92767) | N/A (N/A) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |
| 023-HB-01C | FLANGES (NONE) | N/A (N/A) | FORGED: A-181 (92767) | N/A (N/A) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |
| 023-HB-01D | BOLTS (NONE) | N/A (N/A) | BOLTS: A-193 GR B7 (92767) | N/A (N/A) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |
| 023-HB-01E | NUTS (NONE) | N/A (N/A) | NUTS: A-194 GR 2H (92767) | N/A (N/A) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |
| 023-HB-01F | WELDS (NONE) | N/A (N/A) | CS WELD MATERIAL (TYPICAL) | N/A (N/A) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |

**ARDM Matrix (Revision 1)**

SYSTEM NUMBER: 023 SYSTEM NAME: Diesel Fuel Oil
EQUIPMENT TYPE: PIPE DEVICE TYPE: HB
GROUP ID: 023-HB-01 Date: March 27, 1996

| ARDMs | 023-HB-01A Pipe | 023-HB-01B Fittings | 023-HB-01C Flanges | 023-HB-01D Bolts | 023-HB-01E Nuts | 023-HB-01F Welds |
|---|---|---|---|---|---|---|
| Cavitation Erosion | 02 | 02 | 02 | 19 | 19 | 02 |
| Corrosion Fatigue | 12 | 12 | 12 | 12 | 12 | 12 |
| Crevice Corrosion | A | A | A | A | A | A |
| Erosion Corrosion | 02 | 02 | 02 | 19 | 19 | 02 |
| Fatigue | 12 | 12 | 12 | 12 | 12 | 12 |
| Fouling | 06 | 06 | 06 | 19 | 19 | 06 |
| Galvanic Corrosion | 07 | 07 | 07 | 07 | 07 | 07 |
| General Corrosion | A | A | A | 01.3 | A | A |
| Hydrogen Damage | 03 | 03 | 03 | 03 | 03 | 03 |
| Intergranular Attack | 01.1 | 01.1 | 01.1 | 01.3 | 01.1 | 01.1 |
| MIC | 08 | 08 | 08 | 08 | 08 | 08 |
| Particulate Wear Erosion | 05 | 05 | 05 | 19 | 19 | 05 |
| Pitting | A | A | A | A | A | A |
| Radiation Damage | 01.1 | 01.1 | 01.1 | 01.3 | 01.1 | 01.1 |
| Rubber Degradation | 01.1 | 01.1 | 01.1 | 01.3 | 01.1 | 01.1 |
| Saline Water Attack | 18 | 18 | 18 | 18 | 18 | 18 |
| Selective Leaching | 01.1 | 01.1 | 01.1 | 01.3 | 01.1 | 01.1 |
| Stress Corrosion Cracking | 01.1 | 01.1 | 01.1 | 20 | 01.1 | 01.1 |
| Stress Relaxation | 04 | 04 | 04 | 04 | 04 | 04 |
| Thermal Damage | 01.1 | 01.1 | 01.1 | 01.3 | 01.1 | 01.1 |
| Thermal Embrittlement | 04 | 04 | 04 | 04 | 04 | 04 |
| Wear | 16 | 16 | 16 | 16 | 16 | 16 |

## Matrix Code List (Revision 1)

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

DEVICE TYPE: HB EQUIPMENT TYPE: PIPE

GROUP ID: 023-HB-01 Date: 3/28/96

| Code | Description | Source |
|---|---|---|
| 01 | MATERIAL IS NOT APPLICABLE TO THE ARDM. MATERIAL OF CONSTRUCTION IS NOT SUSCEPTIBLE TO THIS ARDM:<br><br>01.1 CARBON STEEL<br>01.3 ALLOY STEEL | ATTACHMENT 7<br>92767 SH HB-1 |
| 02 | PROCESS FLUID TYPE DOES NOT PERPETUATE THE ARDM. THE PROCESS FLUID IS FUEL OIL WHICH IS NORMALLY NOT FLOWING. THE SYSTEM IS PERIODICALLY OPERATED AT LOW PRESSURES AND FLOW RATES, WHICH ARE NOT THE CONDITIONS NORMALLY ASSOCIATED WITH THIS ARDM (HIGH VELOCITY AND/OR RAPID PRESSURE VARIATIONS).<br><br>ALTHOUGH THE SYSTEM OPERATING CONDITIONS MINIMIZE CAVITATION POSSIBILITY AND DURATION, THERE IS ONE PORTION OF THE SYSTEM WITH THE POTENTIAL FOR CAVITATION. DURING SYSTEM OPERATION THE UNLOADING PUMPS (WHICH ARE NOT IN LR SCOPE) MAY SEE LOW NPSH. ACCORDING TO OPERATING PROCEDURE OI-21D VALVE OHVDFO-119 (IN LR SCOPE) IS MANUALLY THROTTLED TO PREVENT CAVITATION AT THE PUMP. THIS MANUAL OPERATION ASSURES THE PUMP, THROTTLING VALVE AND DOWNSTREAM PIPING WILL NOT EXPERIENCE CAVITATION. | ATTACHMENT 7<br>UFSAR 8.4.1.2<br>92769HB SH HB-1<br>M-0080 PG 8<br>OI-21D |
| 03 | PROCESS FLUID DOES NOT PERPETUATE THE ARDM ON THE INSIDE OF THE PIPE. THE PROCESS FLUID IS FUEL OIL. THE NORMAL HYDROGEN CONCENTRATION AND LOW PRESSURES ARE NOT SUFFICIENT TO MAKE HYDROGEN ATTACK OR BLISTERING PLAUSIBLE. HYDROGEN CRACKING IS NOT A CONCERN FOR MATERIALS WITH YIELD STRESSES LESS THAN 120 KSI, WHICH IS THE CASE FOR THIS PIPE (SY=35-36 KSI) AND BOLTS (SY=105 KSI). GENERAL CORROSION, WHICH CAN LEAD TO HYDROGEN DAMAGE, IS ADDRESSED AS A SEPARATE ARDM.<br><br>THE EXTERNAL ENVIRONMENT (AIR) DOES NOT CONTAIN SUFFICIENT HYDROGEN OR PRESSURE TO MAKE THIS ARDM PLAUSIBLE. MOLY DISULPHIDE LUBRICANTS ARE PERMITTED BY PROCEDURE TO BE USED ON NON-RESTRICTED SYSTEMS SUCH AS DFO. HOWEVER, MOLY DISULFIDE LUBRICANTS REQUIRE MOISTURE AND TEMPERATURE (>150F) TO DECOMPOSE INTO HYDROGEN SULFIDE. GIVEN THE DESIGN TEMPERATURE OF 100F, ANTICIPATED AMBIENT TEMPERATURES OF LESS THAN 150F, AND DRYING EFFECTS OF WARMER TEMPERATURES, HYDROGEN DAMAGE DUE TO MOLY DISULFIDE LUBRICANTS IS NOT A CONCERN.<br><br>PIPE WELD HYDROGEN EMBRITTLEMENT IS NOT A CONCERN FOR MILD CARBON STEEL WITH A YIELD STRENGTH IN THE RANGE OF 35-40 KSI. | ATTACHMENT 7<br>METALS HANDBK VOL 13<br>ASTM A 106<br>ASTM A 181<br>ASTM A 193<br>NP-5461<br>CH-1-100<br>NP-5769<br>NP-3137<br>BGM-96-031 |
| 04 | PROCESS FLUID TEMPERATURE DOES NOT PERPETUATE THE ARDM. OPERATING TEMPERATURES MUCH LESS THAN 500°F ENSURE THIS ARDM IS NOT PLAUSIBLE (NORMALLY <100F). | ATTACHMENT 7<br>92769<br>ES-014 |

## Matrix Code List (Revision 1)

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

DEVICE TYPE: HB EQUIPMENT TYPE: PIPE

GROUP ID: 023-HB-01 Date: 3/28/96

| Code | Description | Source |
|---|---|---|
| 05 | PROCESS FLUID FLOW RATE DOES NOT PERPETUATE THE ARDM. RELATIVELY LOW FLOW VELOCITIES ARE NOT LIKELY TO ENTRAIN DAMAGING PARTICULATES. THE CLEAN SYSTEM CONTAINS INSIGNIFICANT PARTICULATE MATTER. | ATTACHMENT 7<br>CP-226<br>UFSAR 8.4.1.2<br>M-0080 PG8 |
| 06 | PROCESS FLUID CHEMISTRY AND ENVIRONMENT DO NOT PERPETUATE THE ARDM:<br><br>FOULING IS NOT PLAUSIBLE. THE FLUID IS FUEL OIL. THE STORAGE TANK FUEL IS TESTED FOR THE PRESENCE OF BIOLOGICS AND IS TREATED WITH A CORROSIVE INHIBITOR. THE SYSTEM TAKES SUCTION ABOVE THE BOTTOM OF THE FUEL OIL TANKS (THE LOWEST NOZZLE BEING 8" ABOVE THE TANK BOTTOM), WHICH MINIMIZES CARRY OF SLUDGE INTO THE PIPES. THE FUEL OIL ITSELF KEEPS CORROSION PRODUCTS TO A MINIMUM ON THE INSIDE SURFACE OF THE PIPES. THEREFORE, THIS ARDM IS NOT PLAUSIBLE ON THE PIPE INTERNALS. FOULING IS NOT A CONCERN FOR PIPE EXTERNALS. | ATTACHMENT 7<br>M-216<br>CP-226<br>12329-0005 |
| 07 | MATERIAL SELECTION/SEPARATION DOES NOT PERPETUATE THE ARDM. MATERIALS USED THROUGHOUT THE SYSTEM GENERALLY HAVE LOW POTENTIAL DIFFERENCES AND, WHERE APPROPRIATE, ARE SEPARATED BY APPROPRIATE TRANSITION MATERIALS. | ATTACHMENT 7<br>92767 |
| 08 | PROCESS FLUID CHEMISTRY AND ENVIRONMENT DO NOT PERPETUATE THE ARDM:<br><br>MIC IS NOT PLAUSIBLE. THE FLUID IS FUEL OIL. THE STORAGE TANK FUEL IS TESTED QUARTERLY FOR THE PRESENCE OF BIOLOGICS. THE SYSTEM TAKES SUCTION ABOVE THE BOTTOM OF THE FUEL OIL TANKS, WHERE HISTORICALLY SLUDGE AND MICROBE GROWTH HAS OCCURRED. THIS MINIMIZES THE POSSIBILITY OF TRANSFERRING MICROBES INTO THE PIPING SYSTEM ITSELF. WATER INTRODUCED TO THE TANK TENDS TO SINK TO THE BOTTOM AND IS PERIODICALLY DRAINED, THEREBY PREVENTING WATER FROM BEING DRAWN INTO THE SYSTEM PIPING. THE FUEL IS REGULARLY TESTED TO ASSURE THE FUEL CONTAINS LESS THAN 0.05% WATER BY VOLUME. THE LACK OF WATER IN THE SYSTEM PIPES PREVENTS SIGNIFICANT MICROBIOLOGICAL GROWTH. THEREFORE, THIS ARDM IS NOT PLAUSIBLE FOR THE PIPE INTERNALS. MIC IS ALSO NOT PLAUSIBLE FOR PIPE EXTERNALS. THE LACK OF CONSISTENT STAGNANT WATER ON EXPOSED PIPE SURFACES PREVENTS SIGNIFICANT MICROBIOLOGICAL GROWTH. | ATTACHMENT 7<br>M-216<br>CP-226<br>12329-0005 |
| 12 | SERVICE LOADING AMPLITUDES/FREQUENCIES DO NOT PERPETUATE THE ARDM. THE SYSTEM IS NOT CYCLED FREQUENTLY AND OPERATES AT LOW PRESSURE AND TEMPERATURES MAKING THIS ARDM NOT PLAUSIBLE. | ATTACHMENT 7<br>92769HB SH HB-1<br>OI-21,OI-21D |

## Matrix Code List (Revision 1)

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

DEVICE TYPE: HB EQUIPMENT TYPE: PIPE

GROUP ID: 023-HB-01 Date: 3/28/96

| Code | Description | Source |
|---|---|---|
| 16 | WEAR IS NOT A PLAUSIBLE ARDM SINCE THE SUBCOMPONENTS ARE DESIGNED TO ELIMINATE ANY RELATIVE MOTION BETWEEN THE PARTS. THE SUBCOMPONENTS ARE DESIGNED SO THEY ARE NOT ADJACENT TO OTHER SUBCOMPONENTS OR THEY ARE RESTRAINED SUCH THAT THERE IS NOT RELATIVE MOTION. | ATTACHMENT 7<br>92767SH HB-1<br>DFO PIPING ISOS (SEE AMR REPORT TABLE 1-1) |
| 18 | COMPONENT MATERIAL AND ENVIRONMENT DO NOT PERPETUATE THE ARDM:<br><br>SALINE WATER ATTACK IS NOT A PLAUSIBLE ARDM. THE PIPE IS NOT EMBEDDED IN CONCRETE, AND THE FLUID IS FUEL OIL. | ATTACHMENT 7<br>DFO PIPING ISOS (SEE AMR REPORT TABLE 1-1) |
| 19 | COMPONENT ENVIRONMENT DOES NOT PERPETUATE THE ARDM. THE SUBCOMPONENTS TYPICALLY ARE NOT EXPOSED TO THE PROCESS FLUID WHICH MAKES THE ARDM NON-PLAUSIBLE. | ATTACHMENT 7 |
| 20 | COMPONENT MATERIAL AND ENVIRONMENT DO NOT PERPETUATE THE ARDM:<br><br>BOLTING MATERIAL IS A193 GR B7, WHICH IS RESISTANT TO MOST FORMS OF STRESS CORROSION CRACKING, PARTICULARLY CHLORIDE STRESS CORROSION CRACKING. THE INDUSTRY ISSUE RELATING TO STRESS CORROSION CRACKING PROMOTED BY BORIC ACID AND DECOMPOSITION OF THREAD LUBRICANTS CONTAINING MOLY-DISULFIDE DOES NOT APPLY TO THIS SYSTEM, AS THE SYSTEM DOES NOT CONTAIN BORIC ACID. | ATTACHMENT 7<br>LCM 95-112 |
| A | THE ARDM IS PLAUSIBLE BECAUSE THE EXTERNAL CARBON STEEL AND ALLOY FASTENER MATERIALS ARE EXPOSED TO HUMID, MOIST OR WET ENVIRONMENTS. SUN AND WEATHER WILL DETERIORATE THE PROTECTIVE PAINT COATING OF THE EXPOSED PIPES AND LEAD TO ACCELERATED CORROSION MECHANISMS OF STEEL COMPONENTS EXPOSED TO MOISTURE. SOME PIPES ARE PROTECTED FROM DIRECT AFFECTS OF SUN AND WEATHER BY A CONCRETE ENCLOSURE OR PIT COVER. HOWEVER, THE STEEL SURFACES ARE STILL EXPOSED TO CHANGES IN HUMIDITY AND TEMPERATURES, REQUIRING THE PROTECTION OF PAINT.<br><br>AGING MANAGEMENT RECOMMENDATIONS FOR PIPE EXTERNALS:<br><br>(1) PERIODICALLY INSPECT PAINT AND REPAIR AS REQUIRED.<br><br>GENERAL, CREVICE AND PITTING CORROSION ARE NOT PLAUSIBLE FOR PIPE INTERNALS. THE FLUID IS FUEL OIL. IT IS TESTED AND TREATED WITH CORROSIVE INHIBITOR. THE FUEL DOES NOT CONTAIN SUFFICIENT OXYGEN TO PRODUCE A CONCENTRATION CELL. WATER INTRODUCED TO THE TANK TENDS TO SINK TO THE BOTTOM, PREVENTING WATER FROM BEING DRAWN INTO THE SYSTEM PIPING. THE FUEL IS REGULARLY TESTED TO ASSURE THE FUEL CONTAINS LESS THAN 0.05% WATER BY VOLUME. THE LACK OF WATER IN THE SYSTEM PIPES PREVENTS SIGNIFICANT CORROSION OF THE CARBON STEEL PIPES DUE TO WATER. | ATTACHMENT 7<br>CP-226<br>PEO-0-023-2-0 |

Attachment 3 **Component Grouping Summary Sheet** (Revision 1) Date: 03/19/96

SYSTEM: Diesel Fuel Oil (023)

GROUP ID NUMBER: 023-HB-02

GROUP ATTRIBUTES:

1. Device Type: Pipe Line with Piping Code HB
2. Vendor:
3. Model Number:
4. Material: Coated and Wrapped
5. Internal Environment:
6. External Environment: Buried in Ground
7. Function: Maintain System Pressure Boundary Integrity
8. Name Plate Data:

| PARAMETER | VALUE |
|---|---|
| | |
| | |

LIST OF GROUPED COMPONENTS (EQUIPMENT ID):

| | |
|---|---|
| 0-HB5-1001 | DFO System Piping* |
| 0-HB5-1002 | DFO System Piping* |
| 0-HB5-1003 | DFO System Piping* |
| 0-HB5-1004 | DFO System Piping* |
| 0-HB5-1005 | DFO System Piping* |
| 0-HB5-1006 | DFO System Piping* |
| 0-HB5-1010 | DFO System Piping* |
| 0-HB5-1019 | DFO System Piping* |
| 0-HB5-1040 | DFO System Piping* |
| 0-HB5-2002 | DFO System Piping* |
| 0-HB5-2004 | DFO System Piping* |
| 0-HB5-2006 | DFO System Piping* |
| 0-HB5-2040 | DFO System Piping* |

*Component has portions which are both above ground and buried. This Group addresses only the buried portion.

## Sub-Component/Sub-Group Identification (Revision 1)

Date: 3/27/96

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

EQUIPMENT ID: PIPE GROUP ID: 023-HB-02 DEVICE TYPE NAME: PIPE LINE WITH PIPING CODE OF "HB"

| Sub-Group ID | Sub-Component/ Name (Replacement Prgm) | Manufacturer (Source) | Material (Source) | Model Number (Source) | Passive Intended Function(s) (Source) | Subj to AMR (Y or N) |
|---|---|---|---|---|---|---|
| 023-HB-02A | PIPE (NONE) | N/A (N/A) | A-106 GR B, SMLS CARBON STEEL (92767) | N/A (N/A) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |
| 023-HB-02B | FITTINGS (NONE) | N/A (N/A) | FORGED: A-181 (92767) | N/A (N/A) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |
| 023-HB-02C | WELDS (NONE) | N/A (N/A) | CS WELD MATERIAL (TYPICAL) | N/A (N/A) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |

**ARDM Matrix (Revision 1)**

SYSTEM NUMBER: 023 SYSTEM NAME: Diesel Fuel Oil
EQUIPMENT TYPE: PIPE DEVICE TYPE: HB
GROUP ID: 023-HB-02 Date: March 20, 1996

| **ARDMs** | 023-HB-02A Pipe | 023-HB-02B Fittings | 023-HB-02C Welds |
|---|---|---|---|
| Cavitation Erosion | 02 | 02 | 02 |
| Corrosion Fatigue | 12 | 12 | 12 |
| Crevice Corrosion | A | A | A |
| Erosion Corrosion | 02 | 02 | 02 |
| Fatigue | 12 | 12 | 12 |
| Fouling | 06 | 06 | 06 |
| Galvanic Corrosion | 07 | 07 | 07 |
| General Corrosion | A | A | A |
| Hydrogen Damage | 03 | 03 | 03 |
| Intergranular Attack | 01.1 | 01.1 | 01.1 |
| MIC | A | A | A |
| Particulate Wear Erosion | 05 | 05 | 05 |
| Pitting | A | A | A |
| Radiation Damage | 01.1 | 01.1 | 01.1 |
| Rubber Degradation | 01.1 | 01.1 | 01.1 |
| Saline Water Attack | 18 | 18 | 18 |
| Selective Leaching | 01.1 | 01.1 | 01.1 |
| Stress Corrosion Cracking | 08 | 08 | 08 |
| Stress Relaxation | 04 | 04 | 04 |
| Thermal Damage | 01.1 | 01.1 | 01.1 |
| Thermal Embrittlement | 04 | 04 | 04 |
| Wear | 16 | 16 | 16 |

## Matrix Code List (Revision 1)

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

DEVICE TYPE: HB EQUIPMENT TYPE: PIPE

GROUP ID: 023-HB-02 Date: 3/28/96

| Code | Description | Source |
|---|---|---|
| 01 | MATERIAL IS NOT APPLICABLE TO THE ARDM. MATERIAL OF CONSTRUCTION IS NOT SUSCEPTIBLE TO THIS ARDM:<br><br>01.1 CARBON STEEL | ATTACHMENT 7<br>92767 SH HB-1 |
| 02 | PROCESS FLUID TYPE DOES NOT PERPETUATE THE ARDM. THE PROCESS FLUID IS FUEL OIL WHICH IS NORMALLY NOT FLOWING. THE SYSTEM IS PERIODICALLY OPERATED AT LOW PRESSURES AND FLOW RATES, WHICH ARE NOT THE CONDITIONS NORMALLY ASSOCIATED WITH THIS ARDM (HIGH VELOCITY AND/OR RAPID PRESSURE VARIATIONS).<br><br>ALTHOUGH THE SYSTEM OPERATING CONDITIONS MINIMIZE CAVITATION POSSIBILITY AND DURATION, THERE IS ONE PORTION OF THE SYSTEM WITH THE POTENTIAL FOR CAVITATION. DURING SYSTEM OPERATION THE UNLOADING PUMPS (WHICH ARE NOT IN LR SCOPE) MAY SEE LOW NPSH. ACCORDING TO OPERATING PROCEDURE OI-21D VALVE OHVDFO-119 (IN LR SCOPE) IS MANUALLY THROTTLED TO PREVENT CAVITATION AT THE PUMP. THIS MANUAL OPERATION ASSURES THE PUMP, THROTTLING VALVE AND DOWNSTREAM PIPING WILL NOT EXPERIENCE CAVITATION. | ATTACHMENT 7<br>UFSAR 8.4.1.2<br>92769HB SH HB-1<br>M-0080 PG 8<br>OI-21D |
| 03 | PROCESS FLUID DOES NOT PERPETUATE THE ARDM ON THE INSIDE OF THE PIPE. THE PROCESS FLUID IS FUEL OIL. THE NORMAL HYDROGEN CONCENTRATION AND LOW PRESSURES ARE NOT SUFFICIENT TO MAKE HYDROGEN ATTACK OR BLISTERING PLAUSIBLE. HYDROGEN CRACKING IS NOT A CONCERN FOR MATERIALS WITH YIELD STRESSES LESS THAN 120 KSI, WHICH IS THE CASE FOR THIS PIPE (YS= 35-36 KSI). GENERAL CORROSION, WHICH CAN LEAD TO HYDROGEN DAMAGE, IS ADDRESSED AS A SEPARATE ARDM.<br><br>THE EXTERNAL ENVIRONMENT (SAND, AIR, ETC...) DOES NOT CONTAIN SUFFICIENT HYDROGEN OR PRESSURE TO MAKE THIS ARDM PLAUSIBLE.<br><br>PIPE WELD HYDROGEN EMBRITTLEMENT IS NOT A CONCERN FOR MILD CARBON STEEL WITH A YIELD STRENGTH IN THE RANGE OF 35-40 KSI. | ATTACHMENT 7<br>METALS HANDBK VOL 13<br>NP-5461<br>ASTM A 106<br>ASTM A 181 |
| 04 | PROCESS FLUID TEMPERATURE DOES NOT PERPETUATE THE ARDM. OPERATING TEMPERATURES MUCH LESS THAN 500°F ENSURE THIS ARDM IS NOT PLAUSIBLE (NORMALLY <100F). | ATTACHMENT 7<br>92769<br>ES-014 |
| 05 | PROCESS FLUID FLOW RATE DOES NOT PERPETUATE THE ARDM. RELATIVELY LOW FLOW VELOCITIES ARE NOT LIKELY TO ENTRAIN DAMAGING PARTICULATES. THE CLEAN SYSTEM CONTAINS INSIGNIFICANT PARTICULATE MATTER. | ATTACHMENT 7<br>CP-226<br>UFSAR 8.4.1.2<br>M-0080 PG8 |

## Matrix Code List (Revision 1)

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

DEVICE TYPE: HB EQUIPMENT TYPE: PIPE

GROUP ID: 023-HB-02 Date: 3/28/96

| Code | Description | Source |
|---|---|---|
| 06 | PROCESS FLUID CHEMISTRY AND ENVIRONMENT DO NOT PERPETUATE THE ARDM:<br><br>FOULING IS NOT PLAUSIBLE. THE FLUID IS FUEL OIL. THE STORAGE TANK FUEL IS TESTED FOR THE PRESENCE OF BIOLOGICS AND IS TREATED WITH A CORROSIVE INHIBITOR. THE SYSTEM TAKES SUCTION ABOVE THE BOTTOM OF THE FUEL OIL TANKS (THE LOWEST NOZZLE BEING 8" ABOVE THE TANK BOTTOM), WHICH MINIMIZES CARRY OF SLUDGE INTO THE PIPES. THE FUEL OIL ITSELF KEEPS CORROSION PRODUCTS TO A MINIMUM ON THE INSIDE SURFACE OF THE PIPES. THEREFORE, THIS ARDM IS NOT PLAUSIBLE ON THE PIPE INTERNALS. FOULING IS NOT A CONCERN FOR PIPE EXTERNALS. | ATTACHMENT 7<br>92767<br>M-216<br>CP-226<br>12329-0005 |
| 07 | MATERIAL SELECTION/SEPARATION DOES NOT PERPETUATE THE ARDM. MATERIALS USED THROUGHOUT THE SYSTEM GENERALLY HAVE LOW POTENTIAL DIFFERENCES AND, WHERE APPROPRIATE, ARE SEPARATED BY APPROPRIATE TRANSITION MATERIALS. THE BURIED PIPE IS PROTECTED BY AN IMPRESSED CATHODIC PROTECTION SYSTEM. | ATTACHMENT 7<br>61201,92767<br>61406SH0004SEC101.2 |
| 08 | COMPONENT MATERIAL AND STRESSES DO NOT PERPETUATE THE ARDM. THE MATERIAL IS MILD CARBON STEEL WITH YIELD STRENGTH OF 35-36 KSI, WHICH IS NORMALLY NOT AFFECTED BY SCC. THE MECHANISM OF CATHODIC PROTECTION INDUCED SCC AT DISBONDED WRAPPING LOCATIONS IS A FUNCTION OF SEVERAL ITEMS INCLUDING PIPE MATERIAL AND STRESS. INDUSTRY EXPERIENCE AND TESTING SHOWS SCC IS LESS LIKELY TO OCCUR WHEN YIELD STRENGTHS ARE LOW, AND ALMOST NEVER OCCUR FOR MATERIALS WITH THIS LOW OF A YIELD STRENGTH. GIVEN THE DESIGN PRESSURE OF 35 PSIG AND MAX OPERATING PRESSURE OF 25 PSIG, THE PIPING HOOP STRESSES ARE NEGLIGIBLE (APPROXIMATELY 350 PSI). BASED ON THESE CONDITIONS THE ARDM IS NOT CONSIDERED PLAUSIBLE FOR PIPE EXTERNALS.<br><br>MILD CARBON STEEL INTERNALS EXPOSED TO FUEL OIL ARE NOT CONDITIONS CONDUSIVE TO SCC.. | ATTACHMENT 7<br>NACE-7 PGS 101,136-138<br>9276SH HB-1<br>ASTM A 106<br>ASTM A 181 |
| 12 | SERVICE LOADING AMPLITUDES/FREQUENCIES DO NOT PERPETUATE THE ARDM. THE SYSTEM IS NOT CYCLED FREQUENTLY AND OPERATES AT LOW PRESSURE AND TEMPERATURES MAKING THIS ARDM NOT PLAUSIBLE. | ATTACHMENT 7<br>92769HB SH HB-1<br>OI-21,OI-21D |
| 16 | WEAR IS NOT A PLAUSIBLE ARDM SINCE THE SUBCOMPONENTS ARE DESIGNED TO ELIMINATE ANY RELATIVE MOTION BETWEEN THE PARTS. THE DFO PIPING IN THIS GROUP IS BURIED, THEREBY ELIMINATING RELATIVE MOTION. | ATTACHMENT 7<br>92767SH HB-1<br>DFO PIPING ISOS (SEE AMR REPORT TABLE 1-1) |
| 18 | COMPONENT MATERIAL AND ENVIRONMENT DO NOT PERPETUATE THE ARDM:<br><br>SALINE WATER ATTACK IS NOT A PLAUSIBLE ARDM. THE PIPE IS NOT EMBEDDED IN CONCRETE, AND THE FLUID IS FUEL OIL. | ATTACHMENT 7<br>DFO PIPING ISOS (SEE AMR REPORT TABLE 1-1) |

## Matrix Code List (Revision 1)

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

DEVICE TYPE: HB EQUIPMENT TYPE: PIPE

GROUP ID: 023-HB-02 Date: 3/28/96

| Code | Description | Source |
|---|---|---|
| A | CREVICE CORROSION, GENERAL CORROSION, MIC AND PITTING ARE COMMON ARDMS FOR BURIED PIPE. SOIL RESISTIVITY (OR CONDUCTIVITY); CHLORIDE AND SULFATE PRESENCE; OXYGEN CONTENT AND SOIL AERATION; pH; MOISTURE CONTENT OF THE SOIL AND WET/DRY CYCLES; AND MICROBE ACTIVITY AFFECT THESE MECHANISMS. SPECIFIC INFORMATION CONCERNING THESE ATTRIBUTES ALONG THE BURIED DFO PIPE RUNS IS NOT READILY AVAILABLE. THE PIPING IS PROTECTED PER STANDARD INDUSTRY PRACTICE WITH AN EXTERNAL COATING AND WRAPPING, AND WITH AN IMPRESSED CATHODIC PROTECTION SYSTEM.<br><br>AGING MANAGEMENT RECOMMENDATIONS:<br><br>(1) CONFIRM THROUGH REGULAR INSPECTIONS THAT THE PROTECTIVE COATING AND CATHODIC PROTECTION SYSTEM FOR DFO BURIED PIPING ARE ADEQUATELY PROTECTING THE PIPE FROM THE PLAUSIBLE ARDMS.<br><br>ARDMS PLAUSIBLE FOR PIPE EXTERNAL SURFACES ARE NOT PLAUSIBLE FOR INTERNAL SURFACES; THEREFORE INTERNAL SURFACES NEED NOT BE INSPECTED. THE FOLLOWING PROVIDES A BASIS FOR EACH ARDM:<br><br>GENERAL, CREVICE AND PITTING CORROSION: THE FLUID IS FUEL OIL. IT IS TESTED AND TREATED WITH CORROSIVE INHIBITOR. THE FUEL DOES NOT CONTAIN SUFFICIENT OXYGEN TO PRODUCE A CONCENTRATION CELL. WATER INTRODUCED TO THE TANK TENDS TO SINK TO THE BOTTOM AND IS DRAINED PERIODICALLY, THEREBY PREVENTING WATER FROM BEING DRAWN INTO THE SYSTEM PIPING. THE FUEL IS REGULARLY TESTED TO ASSURE THE FUEL CONTAINS LESS THAN 0.05% WATER BY VOLUME. THE LACK OF WATER IN THE SYSTEM PIPES PREVENTS SIGNIFICANT CORROSION OF THE CARBON STEEL INTERNAL SURFACES DUE TO WATER.<br><br>MIC: THE FLUID IS FUEL OIL. THE STORAGE TANK FUEL IS TESTED QUARTERLY FOR THE PRESENCE OF BIOLOGICS. THE SYSTEM TAKES SUCTION ABOVE THE BOTTOM OF THE FUEL OIL TANKS, WHERE HISTORICALLY SLUDGE AND MICROBE GROWTH HAS OCCURRED. THIS MINIMIZES THE POSSIBILITY OF TRANSFERRING MICROBES INTO THE PIPING SYSTEM ITSELF. WATER INTRODUCED TO THE TANK TENDS TO SINK TO THE BOTTOM AND IS PERIODICALLY DRAINED, THEREBY PREVENTING WATER FROM BEING DRAWN INTO THE SYSTEM PIPING. THE FUEL IS REGULARLY TESTED TO ASSURE THE FUEL CONTAINS LESS THAN 0.05% WATER BY VOLUME. THE LACK OF WATER IN THE SYSTEM PIPES PREVENTS SIGNIFICANT MICROBIOLOGICAL GROWTH. THEREFORE, THIS ARDM IS NOT PLAUSIBLE FOR THE PIPE INTERNALS. | ATTACHMENT 7,<br>CORROSION AND CORROSION CONTROL (UHLIG),<br>CORROSION ENGINEERING (FONTANA),<br>CP-226,<br>PEO-0-023-2-0,<br>U-96-001(BIOBOR),<br>C-96-003 (CUMMINS)<br>12329-0005 |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: VALVE

Date: March 27, 1996

| ARDM | POTENTIAL | 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] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: VALVE

Date: March 27, 1996

| | | | |
|---|---|---|---|
| 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]<br>[6]<br>[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]<br>[7]<br>[2] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: VALVE

Date: March 27, 1996

| | | | |
|---|---|---|---|
| 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] [15] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: VALVE

Date: March 27, 1996

| | | | |
|---|---|---|---|
| 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, interstitial atomic hydrogen is combined into molecular hydrogen within the metal, causing 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. Catalyst poisons or pickling inhibitors, as well as lubricants or other material containing P, S or As compounds (e.g., molybdenum disulfide lubricants) favor the entrance of atomic hydrogen into the metal lattice and should therefore be limited. | [6]<br>[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]<br>[7]<br>[2]<br>[12] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: VALVE

Date: March 27, 1996

| | | | |
|---|---|---|---|
| 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 valve components are located outside the reactor building, where the neutron flux is not high enough to cause this ARDM to occur. | [6]<br>[7] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: VALVE Date: March 27, 1996

| | | | |
|---|---|---|---|
| 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. Several forms of fungi and other microorganisms can also survive and multiply in hydrocarbon fuels.<br><br>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. Hydrocarbon fuel fungi grow into long strings, and form larger mats or globules. They may grow though out the fuel, or at the interface area between the fuel and water bottom layer. As the fuel is agitated, for instance during filling, fungal growth is distributed throughout the fuel system. The fungus organisms need only trace amounts of minerals and water to sustain their growth, and use the fuel as their main energy/food source. Their growth chemically alters the fuel by producing sludge, acids, and other products of metabolism. When they adhere to the fuel containing surfaces the water and waste products lead to corrosion. Rubber and other tank linings, hoses and coatings may also be consumed due to their energy and trace mineral composition. | [6]<br>[7]<br>[2]<br>[14] |
| 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]<br>[12] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: VALVE

Date: March 27, 1996

| | | | |
|---|---|---|---|
| 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]<br>[7]<br>[2]<br>[12] |
| Radiation Damage | Yes | Non-metallics are susceptible to degradation caused by gamma radiation. | [4] |
| Rubber Degradation | Yes | Rubber can be used in specific applications of this device type. Long term exposure of rubber to water will result in water absorption and swelling, blistering, hardening, and eventual cracking. When utilized as a protective lining, moisture permeation of the rubber produces blisters beneath the lining and initiates corrosion of the lined surface. | [3] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: VALVE

Date: March 27, 1996

| | | | |
|---|---|---|---|
| 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. 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] |
| 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]<br>[13] |
| 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). | [6]<br>[7]<br>[2]<br>[12]<br>[13]<br>[15] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: VALVE

Date: March 27, 1996

| | | | |
|---|---|---|---|
| Stress Corrosion Cracking (Continued) | Yes (Cont'd) | 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). SCC of low alloy steel and carbon steel is not considered a credible aging mechanism for typical conditions encountered in a nuclear power plant. TGSCC may be a concern in low alloy and stainless steel if aggressive chemical species (caustics, halogens, sulfates, especially if coupled with the presence of oxygen) are present. 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.<br><br>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. | |
| 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 (>700°F for typical materials). Bolted connections are most vulnerable. Relaxation of stress on packing due to stretching of gland follower studs under elevated temperatures may cause packing leakage.<br><br>Irradiation fluence levels greater than 6.0E19 increase relaxation in austenitic and nickel alloy steels. | [7] |
| Thermal Damage | Yes | Non-metallics are particularly susceptible with material dependent temperature limits. | [7]<br>[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] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: VALVE

Date: March 27, 1996

| | | | |
|---|---|---|---|
| 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 anotner 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] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: VALVE

Date: March 27, 1996

**Attachment 7 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 |
| [14] | BOIBOR JF Fuel Fungicide Service Bulletin, U.S. Borax, No. 279 |
| [15] | A Survey of the Literature on Low-Alloy Steel Fastener Corrosion in PWR Power Plants, EPRI Report No. NP-3784, 1984 |

Attachment 3 **Component Grouping Summary Sheet** (Revision 1) Date: 04/11/96

SYSTEM: Diesel Fuel Oil (023)

GROUP ID NUMBER: 023-CKV-01

GROUP ATTRIBUTES:

1. Device Type: Check Valve
2. Vendor:
3. Model Number: Marks 223 and 238
4. Material:
5. Internal Environment:
6. External Environment:
7. Function: Maintain System Pressure Boundary Integrity
8. Name Plate Data:

| PARAMETER | VALUE |
|---|---|
| | |
| | |

LIST OF GROUPED COMPONENTS (EQUIPMENT ID):

| | |
|---|---|
| 0CKV11-DFO-123* | Engine FO CKV |
| 0CKV11-DFO-136* | Engine FO CKV |
| 0CKV12-DFO-123* | Engine FO CKV |
| 0CKV12-DFO-136* | Engine FO CKV |
| 0CKV21-DFO-123* | Engine FO CKV |
| 0CKV21-DFO-136* | Engine FO CKV |
| 0CKVDFO-144 | Emergency Suction CKV |
| 0CKVDFO-146 | Number 1 Header CKV |
| 0CKVDFO-148 | Number 2 Header CKV |

* Valves are located inside Diesel Generator building.

## Sub-Component/Sub-Group Identification (Revision 1)

Date: 4/11/96

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

EQUIPMENT ID: VALVE GROUP ID: 023-CKV-01 DEVICE TYPE NAME: CHECK VALVE

| Sub-Group ID | Sub-Component/ Name (Replacement Prgm) | Manufacturer (Source) | Material (Source) | Model Number (Source) | Passive Intended Function(s) (Source) | Subj to AMR (Y or N) |
|---|---|---|---|---|---|---|
| 023-CKV-01A | BODY/BONNET (NONE) | N/A (N/A) | CAST A216 GR WCB OR FORGED A105 CARBON STEEL (92771) | MARK 223 AND 238 (60736) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |
| 023-CKV-01B | BOLTS (NONE) | N/A (N/A) | BOLTS: A-193 GR B7 (TYPICAL) | MARKS 223 AND 238 (60736) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |
| 023-CKV-01C | NUTS (NONE) | N/A (N/A) | NUTS: A-194 GR 2H (TYPICAL) | MARKS 223 AND 238 (60736) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |
| 023-CKV-01D | DISK & SEAT (NA) | N/A (N/A) | N/A (N/A) | N/A (N/A) | NONE. NO LR INTENDED FUNCTION. COMPONENT IN LR SCOPE FOR PRESSURE BOUNDARY ONLY. (CLSR) | N |

**ARDM Matrix (Revision 1)**

SYSTEM NUMBER: 023 SYSTEM NAME: Diesel Fuel Oil
EQUIPMENT TYPE: VALVE DEVICE TYPE: CKV
GROUP ID: 023-CKV-01 Date: March 27, 1996

| ARDMs | 023-CKV-01A Body | 023-CKV-01B Bolts | 023-CKV-01C Nuts |
|---|---|---|---|
| Cavitation Erosion | 02 | 19 | 19 |
| Corrosion Fatigue | 12 | 12 | 12 |
| Crevice Corrosion | A | A | A |
| Erosion Corrosion | 02 | 19 | 19 |
| Fatigue | 12 | 12 | 12 |
| Fouling | 06 | 19 | 19 |
| Galvanic Corrosion | 07 | 07 | 07 |
| General Corrosion | A | 01.3 | A |
| Hydrogen Damage | 03 | 03 | 03 |
| Intergranular Attack | 01.1 | 01.3 | 01.1 |
| MIC | 08 | 08 | 08 |
| Particulate Wear Erosion | 05 | 19 | 19 |
| Pitting | A | A | A |
| Radiation Damage | 01.1 | 01.3 | 01.1 |
| Rubber Degradation | 01.1 | 01.3 | 01.1 |
| Selective Leaching | 01.1 | 01.3 | 01.1 |
| Stress Corrosion Cracking | 01.1 | 18 | 01.1 |
| Stress Relaxation | 04 | 04 | 04 |
| Thermal Damage | 01.1 | 01.3 | 01.1 |
| Thermal Embrittlement | 04 | 04 | 04 |
| Wear | 16 | 16 | 16 |

**Matrix Code List (Revision 1)**

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

DEVICE TYPE: CKV EQUIPMENT TYPE: VALVE

GROUP ID: 023-CKV-01 Date: 4/12/96

| Code | Description | Source |
|---|---|---|
| 01 | MATERIAL IS NOT APPLICABLE TO THE ARDM. MATERIAL OF CONSTRUCTION IS NOT SUSCEPTIBLE TO THIS ARDM:<br><br>01.1 CARBON STEEL<br>01.3 ALLOY STEEL | ATTACHMENT 7<br>92771 |
| 02 | PROCESS FLUID TYPE DOES NOT PERPETUATE THE ARDM. THE PROCESS FLUID IS FUEL OIL WHICH IS NORMALLY NOT FLOWING. THE SYSTEM IS PERIODICALLY OPERATED AT LOW PRESSURES AND FLOW RATES, WHICH ARE NOT THE CONDITIONS NORMALLY ASSOCIATED WITH THIS ARDM (HIGH VELOCITY AND/OR RAPID PRESSURE VARIATIONS). | ATTACHMENT 7<br>UFSAR 8.4.1.2<br>92769HB SH HB-1<br>M-0080 PG 8 |
| 03 | PROCESS FLUID DOES NOT PERPETUATE THE ARDM ON THE INSIDE OF THE VALVE. THE PROCESS FLUID IS FUEL OIL. THE NORMAL HYDROGEN CONCENTRATION AND LOW PRESSURES ARE NOT SUFFICIENT TO MAKE HYDROGEN ATTACK OR BLISTERING PLAUSIBLE. HYDROGEN CRACKING IS NOT A CONCERN FOR MATERIALS WITH YIELD STRESSES LESS THAN 120 KSI, WHICH IS THE CASE FOR THE VALVE BODY (YS=36 KSI) AND THE BOLTS (YS=105 KSI). GENERAL CORROSION, WHICH CAN LEAD TO HYDROGEN DAMAGE, IS ADDRESSED AS A SEPARATE ARDM.<br><br>THE EXTERNAL ENVIRONMENT (AIR) DOES NOT CONTAIN SUFFICIENT HYDROGEN OR PRESSURE TO MAKE THIS ARDM PLAUSIBLE. MOLY DISULPHIDE LUBRICANTS ARE PERMITTED BY PROCEDURE TO BE USED ON NON-RESTRICTED SYSTEMS SUCH AS DFO. HOWEVER, MOLY DISULFIDE LUBRICANTS REQUIRE MOISTURE AND TEMPERATURE (>150F) TO DECOMPOSE INTO HYDROGEN SULFIDE. GIVEN THE DESIGN TEMPERATURE OF 100F, ANTICIPATED AMBIENT TEMPERATURES OF LESS THAN 150F, AND DRYING EFFECTS OF WARMER TEMPERATURES, HYDROGEN DAMAGE DUE TO MOLY DISULFIDE LUBRICANTS IS NOT A CONCERN.<br><br>WELD HYDROGEN EMBRITTLEMENT IS NOT A CONCERN FOR MILD CARBON STEEL WITH A YIELD STRENGTH IN THE RANGE OF 36-40 KSI. | ATTACHMENT 7<br>METALS HANDBK VOL 13<br>ASTM A 216<br>ASTM A 105<br>ASTM A 193<br>NP-5461<br>CH-1-100<br>NP-5769<br>NP-3137<br>BGE-96-031 |
| 04 | PROCESS FLUID TEMPERATURE DOES NOT PERPETUATE THE ARDM. OPERATING TEMPERATURES LESS THAN 500°F ENSURE THIS ARDM IS NOT PLAUSIBLE (NORMALLY <100F). | ATTACHMENT 7<br>92769<br>ES-014 |
| 05 | PROCESS FLUID FLOW RATE DOES NOT PERPETUATE THE ARDM. RELATIVELY LOW FLOW VELOCITIES ARE NOT LIKELY TO ENTRAIN DAMAGING PARTICULATES. THE CLEAN SYSTEM CONTAINS INSIGNIFICANT PARTICULATE MATTER. | ATTACHMENT 7<br>CP-226<br>UFSAR 8.4.1.2<br>M-0080 PG8 |

## Matrix Code List (Revision 1)

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

DEVICE TYPE: CKV EQUIPMENT TYPE: VALVE

GROUP ID: 023-CKV-01 Date: 4/12/96

| Code | Description | Source |
|---|---|---|
| 06 | PROCESS FLUID CHEMISTRY AND ENVIRONMENT DO NOT PERPETUATE THE ARDM:<br><br>FOULING IS NOT PLAUSIBLE. THE FLUID IS FUEL OIL. THE STORAGE TANK FUEL IS TESTED FOR THE PRESENCE OF BIOLOGICS AND IS TREATED WITH A CORROSIVE INHIBITOR. THE SYSTEM TAKES SUCTION ABOVE THE BOTTOM OF THE FUEL OIL TANKS (THE LOWEST NOZZLE BEING 8" ABOVE THE TANK BOTTOM), WHICH MINIMIZES CARRY OF SLUDGE INTO THE PIPES. THE FUEL OIL ITSELF KEEPS CORROSION PRODUCTS TO A MINIMUM ON THE INSIDE SURFACE OF THE VALVES. THEREFORE, THIS ARDM IS NOT PLAUSIBLE ON THE VALVE INTERNALS. FOULING IS NOT A CONCERN FOR VALVE EXTERNALS. | ATTACHMENT 7<br>M-216<br>CP-226<br>12329-0005 |
| 07 | MATERIAL SELECTION/SEPARATION DOES NOT PERPETUATE THE ARDM. MATERIALS USED THROUGHOUT THE SYSTEM GENERALLY HAVE LOW POTENTIAL DIFFERENCES AND, WHERE APPROPRIATE, ARE SEPARATED BY APPROPRIATE TRANSITION MATERIALS. | ATTACHMENT 7<br>92771 |
| 08 | PROCESS FLUID CHEMISTRY AND ENVIRONMENT DO NOT PERPETUATE THE ARDM:<br><br>MIC IS NOT PLAUSIBLE. THE FLUID IS FUEL OIL. THE STORAGE TANK FUEL IS TESTED QUARTERLY FOR THE PRESENCE OF BIOLOGICS. THE SYSTEM TAKES SUCTION ABOVE THE BOTTOM OF THE FUEL OIL TANKS, WHERE HISTORICALLY SLUDGE AND MICROBE GROWTH HAS OCCURRED. THIS MINIMIZES THE POSSIBILITY OF TRANSFERRING MICROBES INTO THE PIPING SYSTEM ITSELF. WATER INTRODUCED TO THE TANK TENDS TO SINK TO THE BOTTOM AND IS PERIODICALLY DRAINED, THEREBY PREVENTING WATER FROM BEING DRAWN INTO THE SYSTEM PIPING. THE FUEL IS REGULARLY TESTED TO ASSURE THE FUEL CONTAINS LESS THAN 0.05% WATER BY VOLUME. THE LACK OF WATER IN THE SYSTEM PIPES PREVENTS SIGNIFICANT MICROBIOLOGICAL GROWTH. THEREFORE, THIS ARDM IS NOT PLAUSIBLE FOR THE VALVE INTERNALS. MIC IS ALSO NOT PLAUSIBLE FOR VALVE EXTERNALS. THE LACK OF CONSISTENT STAGNANT WATER ON EXPOSED PIPE SURFACES PREVENTS SIGNIFICANT MICROBIOLOGICAL GROWTH. | ATTACHMENT 7<br>CP-226<br>PEO-0-023-2-0-M<br>U-96-001(BIOBOR)<br>C-96-003 (CUMMINS) |
| 12 | SERVICE LOADING AMPLITUDES/FREQUENCIES DO NOT PERPETUATE THE ARDM. THE SYSTEM IS NOT CYCLED FREQUENTLY AND OPERATES AT LOW PRESSURE AND TEMPERATURES MAKING THIS ARDM NOT PLAUSIBLE. | ATTACHMENT 7<br>92769HB SH HB-1<br>OI-21,OI-21D |
| 16 | WEAR IS NOT A PLAUSIBLE ARDM SINCE THE PRESSURE BOUNDARY SUBCOMPONENTS ARE DESIGNED TO ELIMINATE ANY RELATIVE MOTION BETWEEN THE PARTS. THE BODY, BOLTS AND NUTS ARE ASSEMBLED INTO ONE RIGID PRESSURE BOUNDARY COMPONENT. THERE IS NO RELATIVE MOVEMENT BETWEEN THESE PARTS. THE MOVEMENT OF THE PLUG WILL CAUSE LIMITED INTERNAL WEAR OVER TIME. HOWEVER, THE FUNCTION TO PREVENT REVERSE FLOW WILL REQUIRE CORRECTIVE ACTION LONG BEFORE THE PB INTEGRITY FUNCTION IS CHALLENGED. | ATTACHMENT 7<br>92771 |

## Matrix Code List (Revision 1)

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

DEVICE TYPE: CKV EQUIPMENT TYPE: VALVE

GROUP ID: 023-CKV-01 Date: 4/12/96

| Code | Description | Source |
|---|---|---|
| 18 | COMPONENT MATERIAL AND ENVIRONMENT DO NOT PERPETUATE THE ARDM:<br><br>A193 GR B7 BOLTING MATERIAL IS RESISTANT TO MOST FORMS OF STRESS CORROSION CRACKING, PARTICULARLY CHLORIDE STRESS CORROSION CRACKING. THE INDUSTRY ISSUE RELATING TO STRESS CORROSION CRACKING PROMOTED BY BORIC ACID AND DECOMPOSITION OF THREAD LUBRICANTS CONTAINING MOLY-DISULFIDE DOES NOT APPLY TO THIS SYSTEM, AS THE SYSTEM DOES NOT CONTAIN BORIC ACID. | ATTACHMENT 7<br>LCM 95-112 |
| 19 | COMPONENT ENVIRONMENT DOES NOT PERPETUATE THE ARDM. THE SUBCOMPONENTS TYPICALLY ARE NOT EXPOSED TO THE PROCESS FLUID WHICH MAKES THE ARDM NON-PLAUSIBLE. | ATTACHMENT 7 |
| A | THE ARDM IS PLAUSIBLE BECAUSE THE EXTERNAL CARBON STEEL AND ALLOY FASTENER MATERIALS ARE EXPOSED TO HUMID, MOIST OR WET ENVIRONMENTS. THE VALVES ARE PROTECTED FROM DIRECT AFFECTS OF SUN AND WEATHER BY A CONCRETE ENCLOSURE OR PIT WITH A COVER. HOWEVER, THE STEEL SURFACES ARE STILL EXPOSED TO CHANGES IN HUMIDITY AND TEMPERATURES, REQUIRING THE PROTECTION OF PAINT.<br><br>AGING MANAGEMENT RECOMMENDATIONS:<br><br>(1) PERIODICALLY INSPECT PAINT AND REPAIR AS REQUIRED.<br><br>GENERAL, CREVICE AND PITTING CORROSION ARE NOT PLAUSIBLE FOR EXTERNAL SURFACES OF VALVES LOCATED INSIDE THE DIESEL GENERATOR BUILDING. THESE VALVES ARE MARKED WITH AN "*" ON ATTACHMENT 3. THE DIESEL GENERATOR BUILDING PROVIDES PROTECTION FROM WEATHER, AND THE VENTILATION SYSTEM MAINTAINS MODERATE AMBIENT CONDITIONS WHICH WILL NOT CAUSE SIGNIFICANT DEGRADATION OF THE PAINT OR EXPOSED CARBON STEEL SURFACES.<br><br>GENERAL, CREVICE AND PITTING CORROSION ARE NOT PLAUSIBLE FOR VALVE INTERNALS. THE FLUID IS FUEL OIL. IT IS TESTED AND TREATED WITH CORROSIVE INHIBITOR. THE FUEL DOES NOT CONTAIN SUFFICIENT OXYGEN TO PRODUCE A CONCENTRATION CELL. WATER INTRODUCED TO THE TANK TENDS TO SINK TO THE BOTTOM AND IS DRAINED PERIODICALLY, PREVENTING WATER FROM BEING DRAWN INTO THE SYSTEM PIPING. THE FUEL IS REGULARLY TESTED TO ASSURE THE FUEL CONTAINS LESS THAN 0.05% WATER BY VOLUME. THE LACK OF WATER IN THE SYSTEM PIPES PREVENTS SIGNIFICANT CORROSION OF THE CARBON STEEL VALVES DUE TO WATER. | ATTACHMENT 7<br>CP-226<br>PEO-0-023-2-0<br>60484 SH0001<br>63548 SH0007<br>UFSAR 9.8.2.3 |

Attachment 3 **Component Grouping Summary Sheet** (Revision 1) Date: 04/12/96

SYSTEM: Diesel Fuel Oil (023)

GROUP ID NUMBER: 023-HV-01

GROUP ATTRIBUTES:

1. Device Type: Hand Valve
2. Vendor:
3. Model Number: Marks 19, 29 and 130
   (Ref. 60736,60484,FSK-MP-488,Critical Design Criteria)
4. Material:
5. Internal Environment:
6. External Environment:
7. Function: Maintain System Pressure Boundary Integrity
8. Name Plate Data:

| PARAMETER | VALUE |
|---|---|
| | |
| | |

LIST OF GROUPED COMPONENTS (EQUIPMENT ID):

| | |
|---|---|
| 0HV0C-DFO-037 | Fuel Oil Xfer Line Isol to SBO Bldg |
| 0HV0C-DFO-054 | Fuel Oil Xfer Line Sample Connection |
| 0HV0C-DFO-151 | Portable Pump Connection |
| 0HV11-DFO 121* | Engine FO Isolation |
| 0HV11-DFO 122* | Engine FO Isolation |
| 0HV12-DFO 121* | Engine FO Isolation |
| 0HV12-DFO 122* | Engine FO Isolation |
| 0HV21-DFO 121* | Engine FO Isolation |
| 0HV21-DFO 122* | Engine FO Isolation |
| 0HVDFO-100 | 11 FOST to #1 Header |
| 0HVDFO-101 | 11 FOST Fill & #2 Header |
| 0HVDFO-102 | 11 FOST Fill to Aux Boilers Isolation |
| 0HVDFO-1020 | LS 6402 Root |
| 0HVDFO-1022 | LS 6402 Root |
| 0HVDFO-1024 | LS 6400 Root |
| 0HVDFO-1026 | LS 6400 Root |
| 0HVDFO-103 | 11 FOST Lo Point Drain & Sample |
| 0HVDFO-1031 | LS 6403 Root |
| 0HVDFO-1033 | LS 6403 Root |
| 0HVDFO-1035 | LS 6405 Root |
| 0HVDFO-1037 | LS 6405 Root |
| 0HVDFO-106 | 21 FOST to #1 Header |
| 0HVDFO-107 | 21 FOST Fill & #2 Header |
| 0HVDFO-108 | 21 FOST to Aux Boilers Isolation |
| 0HVDFO-109 | 21 FOST Lo Point Drain & Sample |
| 0HVDFO-115 | Unloading Bypass & Fill |

Attachment 3 **Component Grouping Summary Sheet** (Revision 1) Date: 04/12/96

SYSTEM: Diesel Fuel Oil (023)

GROUP ID NUMBER: 023-HV-01

| | |
|---|---|
| 0HVDFO-119 | FO Unloading Pump Discharge |
| 0HVDFO-128 | Portable Pump Connection Isolation |
| 0HVDFO-129 | Portable Pump Connection Isolation |
| 0HVDFO-133 | Aux Steam Generator Supply |
| 0HVDFO-135* | Aux Steam Generator FO PP Supply |
| 0HVDFO-145 | 11 FOST to #1 Header B/U |
| 0HVDFO-147 | 11 FOST to #2 Header B/U |
| 0HVDFO-149* | Aux Blr Emergency Shutoff |
| 0HVDFO-166 | Aux Boiler Header Drain |

* Valves are located inside Diesel Generator or Turbine buildings.

DF3HV01.DOC

**Sub-Component/Sub-Group Identification (Revision 1)**

Date: 4/11/96

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

EQUIPMENT ID: VALVE GROUP ID: 023-HV-01 DEVICE TYPE NAME: MANUAL VALVE

| Sub-Group ID | Sub-Component/ Name (Replacement Prgm) | Manufacturer (Source) | Material (Source) | Model Number (Source) | Passive Intended Function(s) (Source) | Subj to AMR (Y or N) |
|---|---|---|---|---|---|---|
| 023-HV-01A | BODY/BONNET (NONE) | N/A (N/A) | CAST A216 GR WCB OR FORGED A105 CARBON STEEL (92771) | MARKS 19,29,130 (SEE ATTACH 3) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |
| 023-HV-01B | BOLTS (NONE) | N/A (N/A) | BOLTS: A-193 GR B7 (TYPICAL) | MARKS 19,29,130 (SEE ATTACH 3) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |
| 023-HV-01C | NUTS (NONE) | N/A (N/A) | NUTS: A-194 GR 2H (TYPICAL) | MARKS 19,29,130 (SEE ATTACH 3) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |
| 023-HV-01D | DISK & SEAT (NA) | N/A (N/A) | N/A (N/A) | N/A (N/A) | NONE. NO LR INTENDED FUNCTION. COMPONENT IN LR SCOPE FOR PRESSURE BOUNDARY ONLY. (CLSR) | N |
| 023-HV-01E | STEM (NONE) | N/A (N/A) | ALLOY STEEL (TYPICAL) | MARKS 19,29,130 (SEE ATTACH 3) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |

**ARDM Matrix (Revision 1)**

SYSTEM NUMBER: 023 SYSTEM NAME: Diesel Fuel Oil
EQUIPMENT TYPE: VALVE DEVICE TYPE: HV
GROUP ID: 023-HV-01 Date: March 27, 1996

| **ARDMs** | 023-HV-01A Body | 023-HV-01B Studs | 023-HV-01C Nuts | 023-HV-01E Stem |
|---|---|---|---|---|
| Cavitation Erosion | 02 | 19 | 19 | 02 |
| Corrosion Fatigue | 12 | 12 | 12 | 12 |
| Crevice Corrosion | A | A | A | A |
| Erosion Corrosion | 02 | 19 | 19 | 02 |
| Fatigue | 12 | 12 | 12 | 12 |
| Fouling | 06 | 19 | 19 | 06 |
| Galvanic Corrosion | 07 | 07 | 07 | 07 |
| General Corrosion | A | 01.3 | A | A |
| Hydrogen Damage | 03 | 03 | 03 | 03 |
| Intergranular Attack | 01.1 | 01.3 | 01.1 | 01.3 |
| MIC | 08 | 08 | 08 | 08 |
| Particulate Wear Erosion | 05 | 19 | 19 | 05 |
| Pitting | A | A | A | A |
| Radiation Damage | 01.1 | 01.3 | 01.1 | 01.3 |
| Rubber Degradation | 01.1 | 01.3 | 01.1 | 01.3 |
| Selective Leaching | 01.1 | 01.3 | 01.1 | 01.3 |
| Stress Corrosion Cracking | 01.1 | 18 | 01.1 | 01.3 |
| Stress Relaxation | 04 | 04 | 04 | 04 |
| Thermal Damage | 01.1 | 01.3 | 01.1 | 01.3 |
| Thermal Embrittlement | 04 | 04 | 04 | 04 |
| Wear | 16 | 16 | 16 | 15 |

## Matrix Code List (Revision 1)

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

DEVICE TYPE: HV EQUIPMENT TYPE: VALVE

GROUP ID: 023-HV-01 Date: 4/12/96

| Code | Description | Source |
|---|---|---|
| 01 | MATERIAL IS NOT APPLICABLE TO THE ARDM. MATERIAL OF CONSTRUCTION IS NOT SUSCEPTIBLE TO THIS ARDM:<br><br>01.1 CARBON STEEL<br>01.3 ALLOY STEEL | ATTACHMENT 7<br>92771 |
| 02 | PROCESS FLUID TYPE DOES NOT PERPETUATE THE ARDM. THE PROCESS FLUID IS FUEL OIL WHICH IS NORMALLY NOT FLOWING. THE SYSTEM IS PERIODICALLY OPERATED AT LOW PRESSURES AND FLOW RATES, WHICH ARE NOT THE CONDITIONS NORMALLY ASSOCIATED WITH THIS ARDM (HIGH VELOCITY AND/OR RAPID PRESSURE VARIATIONS).<br><br>ALTHOUGH THE SYSTEM OPERATING CONDITIONS MINIMIZE CAVITATION POSSIBILITY AND DURATION, THERE IS ONE PORTION OF THE SYSTEM WITH THE POTENTIAL FOR CAVITATION. DURING SYSTEM OPERATION THE UNLOADING PUMPS (WHICH ARE NOT IN LR SCOPE) MAY SEE LOW NPSH. ACCORDING TO OPERATING PROCEDURE OI-21D VALVE OHVDFO-119 (IN LR SCOPE) IS MANUALLY THROTTLED TO PREVENT CAVITATION AT THE PUMP. THIS MANUAL OPERATION ASSURES THE PUMP, THROTTLING VALVE AND DOWNSTREAM PIPING WILL NOT EXPERIENCE CAVITATION. | ATTACHMENT 7<br>UFSAR 8.4.1.2<br>92769HB SH HB-1<br>M-0080 PG 8<br>OI-21D |
| 03 | PROCESS FLUID DOES NOT PERPETUATE THE ARDM ON THE INSIDE OF THE VALVE. THE PROCESS FLUID IS FUEL OIL. THE NORMAL HYDROGEN CONCENTRATION AND LOW PRESSURES ARE NOT SUFFICIENT TO MAKE HYDROGEN ATTACK OR BLISTERING PLAUSIBLE. HYDROGEN CRACKING IS NOT A CONCERN FOR MATERIALS WITH YIELD STRESSES LESS THAN 120 KSI, WHICH IS THE CASE FOR THE VALVE BODY (YS=36 KSI) AND THE BOLTS (YS=105 KSI). GENERAL CORROSION, WHICH CAN LEAD TO HYDROGEN DAMAGE, IS ADDRESSED AS A SEPARATE ARDM.<br><br>THE EXTERNAL ENVIRONMENT (AIR) DOES NOT CONTAIN SUFFICIENT HYDROGEN OR PRESSURE TO MAKE THIS ARDM PLAUSIBLE. MOLY DISULPHIDE LUBRICANTS ARE PERMITTED BY PROCEDURE TO BE USED ON NON-RESTRICTED SYSTEMS SUCH AS DFO. HOWEVER, MOLY DISULFIDE LUBRICANTS REQUIRE MOISTURE AND TEMPERATURE (>150F) TO DECOMPOSE INTO HYDROGEN SULFIDE. GIVEN THE DESIGN TEMPERATURE OF 100F, ANTICIPATED AMBIENT TEMPERATURES OF LESS THAN 150F, AND DRYING EFFECTS OF WARMER TEMPERATURES, HYDROGEN DAMAGE DUE TO MOLY DISULFIDE LUBRICANTS IS NOT A CONCERN.<br><br>WELD HYDROGEN EMBRITTLEMENT IS NOT A CONCERN FOR MILD CARBON STEEL WITH A YIELD STRENGTH IN THE RANGE OF 36-40 KSI. | ATTACHMENT 7<br>METALS HANDBK VOL 13<br>ASTM A 216<br>ASTM A 105<br>ASTM A 193<br>NP-5461<br>CH-1-100<br>NP-5769<br>NP-3137<br>BGM-96-031 |
| 04 | PROCESS FLUID TEMPERATURE DOES NOT PERPETUATE THE ARDM. OPERATING TEMPERATURES LESS THAN 500°F ENSURE THIS ARDM IS NOT PLAUSIBLE (NORMALLY <100F). | ATTACHMENT 7<br>92769<br>ES-014 |

## Matrix Code List (Revision 1)

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

DEVICE TYPE: HV EQUIPMENT TYPE: VALVE

GROUP ID: 023-HV-01 Date: 4/12/96

| Code | Description | Source |
|---|---|---|
| 05 | PROCESS FLUID FLOW RATE DOES NOT PERPETUATE THE ARDM. RELATIVELY LOW FLOW VELOCITIES ARE NOT LIKELY TO ENTRAIN DAMAGING PARTICULATES. THE CLEAN SYSTEM CONTAINS INSIGNIFICANT PARTICULATE MATTER. | ATTACHMENT 7<br>CP-226<br>UFSAR 8.4.1.2<br>M-0080 PG8 |
| 06 | PROCESS FLUID CHEMISTRY AND ENVIRONMENT DO NOT PERPETUATE THE ARDM:<br><br>FOULING IS NOT PLAUSIBLE. THE FLUID IS FUEL OIL. THE STORAGE TANK FUEL IS TESTED FOR THE PRESENCE OF BIOLOGICS AND IS TREATED WITH A CORROSIVE INHIBITOR. THE SYSTEM TAKES SUCTION ABOVE THE BOTTOM OF THE FUEL OIL TANKS (THE LOWEST NOZZLE BEING 8" ABOVE THE TANK BOTTOM), WHICH MINIMIZES CARRY OF SLUDGE INTO THE PIPES. THE FUEL OIL ITSELF KEEPS CORROSION PRODUCTS TO A MINIMUM ON THE INSIDE SURFACE OF THE VALVES. THEREFORE, THIS ARDM IS NOT PLAUSIBLE ON THE VALVE INTERNALS. FOULING IS NOT A CONCERN FOR VALVE EXTERNALS. | ATTACHMENT 7<br>M-216<br>CP-226<br>12329-0005 |
| 07 | MATERIAL SELECTION/SEPARATION DOES NOT PERPETUATE THE ARDM. MATERIALS USED THROUGHOUT THE SYSTEM GENERALLY HAVE LOW POTENTIAL DIFFERENCES AND, WHERE APPROPRIATE, ARE SEPARATED BY APPROPRIATE TRANSITION MATERIALS. | ATTACHMENT 7<br>92771 |
| 08 | PROCESS FLUID CHEMISTRY AND ENVIRONMENT DO NOT PERPETUATE THE ARDM:<br><br>MIC IS NOT PLAUSIBLE. THE FLUID IS FUEL OIL. THE STORAGE TANK FUEL IS TESTED QUARTERLY FOR THE PRESENCE OF BIOLOGICS. THE SYSTEM TAKES SUCTION ABOVE THE BOTTOM OF THE FUEL OIL TANKS, WHERE HISTORICALLY SLUDGE AND MICROBE GROWTH HAS OCCURRED. THIS MINIMIZES THE POSSIBILITY OF TRANSFERRING MICROBES INTO THE PIPING SYSTEM ITSELF. WATER INTRODUCED TO THE TANK TENDS TO SINK TO THE BOTTOM AND IS PERIODICALLY DRAINED, THEREBY PREVENTING WATER FROM BEING DRAWN INTO THE SYSTEM PIPING. THE FUEL IS REGULARLY TESTED TO ASSURE THE FUEL CONTAINS LESS THAN 0.05% WATER BY VOLUME. THE LACK OF WATER IN THE SYSTEM PIPES PREVENTS SIGNIFICANT MICROBIOLOGICAL GROWTH. THEREFORE, THIS ARDM IS NOT PLAUSIBLE FOR THE VALVE INTERNALS. MIC IS ALSO NOT PLAUSIBLE FOR VALVE EXTERNALS. THE LACK OF CONSISTENT STAGNANT WATER ON EXPOSED PIPE SURFACES PREVENTS SIGNIFICANT MICROBIOLOGICAL GROWTH. | ATTACHMENT 7<br>CP-226<br>PEO-0-023-2-0-M<br>U-96-001(BIOBOR)<br>C-96-003 (CUMMINS) |
| 12 | SERVICE LOADING AMPLITUDES/FREQUENCIES DO NOT PERPETUATE THE ARDM. THE SYSTEM IS NOT CYCLED FREQUENTLY AND OPERATES AT LOW PRESSURE AND TEMPERATURES MAKING THIS ARDM NOT PLAUSIBLE. | ATTACHMENT 7<br>92769HB SH HB-1<br>OI-21,OI-21D |

## Matrix Code List (Revision 1)

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

DEVICE TYPE: HV EQUIPMENT TYPE: VALVE

GROUP ID: 023-HV-01 Date: 4/12/96

| Code | Description | Source |
|---|---|---|
| 15 | ARDMS DO NOT SIGNIFICANTLY AFFECT COMPONENT FUNCTION.<br><br>WEAR DOES NOT SIGNIFICANTLY AFFECT COMPONENT INTENDED FUNCTION. VALVE OPERATION RESULTS IN STEM/PACKING CONTACT IN RELATIVE MOTION AND POTENTIALLY ABRASIVE WEAR. IF PACKINGS LEAK, IT WILL BE MINOR (MINIMAL IMPACT ON INTENDED FUNCTION) AND DETECTABLE DURING VALVE OPERATION/INSPECTION. | ATTACHMENT 7<br>92771 |
| 16 | WEAR IS NOT A PLAUSIBLE ARDM SINCE THE PRESSURE BOUNDARY SUBCOMPONENTS ARE DESIGNED TO ELIMINATE ANY RELATIVE MOTION BETWEEN THE PARTS. THE BODY, BOLTS AND NUTS ARE ASSEMBLED INTO ONE RIGID PRESSURE BOUNDARY COMPONENT. THERE IS NO RELATIVE MOVEMENT BETWEEN THESE PARTS. | ATTACHMENT 7<br>92771 |
| 18 | COMPONENT MATERIAL AND ENVIRONMENT DO NOT PERPETUATE THE ARDM:<br><br>BOLTING MATERIAL IS A193 GR B7, WHICH IS RESISTANT TO MOST FORMS OF STRESS CORROSION CRACKING, PARTICULARLY CHLORIDE STRESS CORROSION CRACKING. THE INDUSTRY ISSUE RELATING TO STRESS CORROSION CRACKING PROMOTED BY BORIC ACID AND DECOMPOSITION OF THREAD LUBRICANTS CONTAINING MOLY-DISULFIDE DOES NOT APPLY TO THIS SYSTEM, AS THE SYSTEM DOES NOT CONTAIN BORIC ACID. | ATTACHMENT 7<br>LCM 95-112 |
| 19 | COMPONENT ENVIRONMENT DOES NOT PERPETUATE THE ARDM. THE SUBCOMPONENTS TYPICALLY ARE NOT EXPOSED TO THE PROCESS FLUID WHICH MAKES THE ARDM NON-PLAUSIBLE. | ATTACHMENT 7 |

## Matrix Code List (Revision 1)

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

DEVICE TYPE: HV EQUIPMENT TYPE: VALVE

GROUP ID: 023-HV-01 Date: 4/12/96

| Code | Description | Source |
|---|---|---|
| A | THE ARDM IS PLAUSIBLE BECAUSE THE EXTERNAL CARBON STEEL AND ALLOY FASTENER MATERIALS ARE EXPOSED TO HUMID, MOIST OR WET ENVIRONMENTS. SUN AND WEATHER WILL DETERIORATE THE PROTECTIVE PAINT COATING OF THE EXPOSED VALVES AND LEAD TO ACCELERATED CORROSION MECHANISMS OF STEEL COMPONENTS EXPOSED TO MOISTURE. SOME VALVES ARE PROTECTED FROM DIRECT AFFECTS OF SUN AND WEATHER BY A CONCRETE ENCLOSURE. HOWEVER, THE STEEL SURFACES ARE STILL EXPOSED TO CHANGES IN HUMIDITY AND TEMPERATURES, REQUIRING THE PROTECTION OF PAINT.<br><br>AGING MANAGEMENT RECOMMENDATIONS:<br><br>(1) PERIODICALLY INSPECT PAINT AND REPAIR AS REQUIRED.<br><br>GENERAL, CREVICE AND PITTING CORROSION ARE NOT PLAUSIBLE FOR EXTERNAL SURFACES OF VALVES LOCATED INSIDE THE DIESEL GENERATOR OR TURBINE BUILDINGS. THESE VALVES ARE MARKED WITH AN "*" ON ATTACHMENT 3. THESE BUILDINGS PROVIDE PROTECTION FROM WEATHER, AND THE VENTILATION SYSTEMS MAINTAIN MODERATE AMBIENT CONDITIONS WHICH WILL NOT CAUSE SIGNIFICANT DEGRADATION OF THE PAINT OR EXPOSED CARBON STEEL SURFACES.<br><br>GENERAL, CREVICE AND PITTING CORROSION ARE NOT PLAUSIBLE FOR VALVE INTERNALS. THE FLUID IS FUEL OIL. IT IS TESTED AND TREATED WITH CORROSIVE INHIBITOR. THE FUEL DOES NOT CONTAIN SUFFICIENT OXYGEN TO PRODUCE A CONCENTRATION CELL. WATER INTRODUCED TO THE TANK TENDS TO SINK TO THE BOTTOM AND IS DRAINED PERIODICALLY, PREVENTING WATER FROM BEING DRAWN INTO THE SYSTEM PIPING. THE FUEL IS REGULARLY TESTED TO ASSURE THE FUEL CONTAINS LESS THAN 0.05% WATER BY VOLUME. THE LACK OF WATER IN THE SYSTEM PIPES PREVENTS SIGNIFICANT CORROSION OF THE CARBON STEEL VALVES DUE TO WATER. | ATTACHMENT 7<br>CP-226<br>PEO-0-023-2-0<br>USFAR 9.8.2.3<br>ES-014<br>60484SH0001 |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: ACCUMU

Date: March 27, 1996

| ARDM | POTENTIAL | DESCRIPTION/JUSTIFICATION | SOURCE |
|---|---|---|---|
| Cavitation Erosion | No | Not applicable to equipment type. Cavitation erosion is 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. Vented tanks are not subject to such flow and pressure variations. | [7] |
| Corrosion Fatigue | No | Not applicable to equipment type. 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. However, since tanks are not subjected to pressure and flow oscillations, or to significant temperature fluctuations, they are not subject to this ARDM. | [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] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: ACCUMU

Date: March 27, 1996

| | | | |
|---|---|---|---|
| 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] |
| Erosion Corrosion | No | Not applicable to equipment type. Erosion corrosion is 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. 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). This ARDM is therefore not applicable to tanks as flow into or out of a tank is relatively infrequent and flow rates are low. | [5] [6] [7] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: ACCUMU

Date: March 27, 1996

| | | | |
|---|---|---|---|
| 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]<br>[7]<br>[2] |
| 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]<br>[10]<br>[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] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: ACCUMU

Date: March 27, 1996

| | | | |
|---|---|---|---|
| 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]<br>[8]<br>[2]<br>[16] |
| 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, interstitial atomic hydrogen is combined into molecular hydrogen within the metal, causing 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. Catalyst poisons or pickling inhibitors, as well as lubricants or other material containing P, S or As compounds (e.g., molybdenum disufide lubricants) favor the entrance of atomic hydrogen into the metal lattice and should therefore be limited. | [6]<br>[7] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: ACCUMU

Date: March 27, 1996

| | | | |
|---|---|---|---|
| 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] |
| 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 these tank components are located outside the reactor building, where the neutron flux is not high enough to cause this ARDM to occur. | [6] [7] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: ACCUMU

Date: March 27, 1996

| | | | |
|---|---|---|---|
| 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. Several forms of fungi and other microorganisms can also survive and multiply in hydrocarbon fuels.<br><br>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. Hydrocarbon fuel fungi grow into long strings, and form larger mats or globules. They may grow though out the fuel, or at the interface area between the fuel and water bottom layer. As the fuel is agitated, for instance during filling, fungal growth is distributed throughout the fuel system. The fungus organisms need only trace amounts of minerals and water to sustain their growth, and use the fuel as their main energy/food source. Their growth chemically alters the fuel by producing sludge, acids, and other products of metabolism. When they adhere to the fuel containing surfaces the water and waste products lead to corrosion. Rubber and other tank linings, hoses and coatings may also be consumed due to their energy and trace mineral composition. | [6]<br>[7]<br>[2]<br>[14] |
| 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 these tank components. | [7]<br>[12] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: ACCUMU

Date: March 27, 1996

| | | | |
|---|---|---|---|
| Particulate Wear Erosion | No | Not applicable to equipment type. Particulate wear erosion is 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. This ARDM is therefore not applicable to tanks as flow into or out of a tank is relatively infrequent and flow rates are low. | [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]<br>[7]<br>[2]<br>[12] |
| Radiation Damage | Yes | Non-metallics are susceptible to degradation caused by gamma radiation. | [4] |
| Rubber Degradation | Yes | Rubber can be used in specific applications of this device type. Long term exposure of rubber to water will result in water absorption and swelling, blistering, hardening, and eventual cracking. When utilized as a protective lining, moisture permeation of the rubber produces blisters beneath the lining and initiates corrosion of the lined surface. | [3] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: ACCUMU

Date: March 27, 1996

| | | | |
|---|---|---|---|
| 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. 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 tank components since tanks are not constructed of nor typically installed in concrete. | [2] |
| 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]<br>[13] |
| 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). | [6]<br>[7]<br>[2]<br>[12]<br>[13]<br>[15]<br>[16] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: ACCUMU

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| | | | |
|---|---|---|---|
| Stress Corrosion Cracking (Continued) | Yes (Cont'd) | 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). SCC of low alloy steel and carbon steel is not considered a credible aging mechanism for typical conditions encountered in a nuclear power plant. TGSCC may be a concern in low alloy and stainless steel if aggressive chemical species (caustics, halogens, sulfates, especially if coupled with the presence of oxygen) are present. 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.<br><br>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.<br><br>Cathodic protection of buried pipes is provided to prevent SCC; however SCC can occur at areas where the coating is disbonded. The potential voltage of the pipe can result in the accumulation of alkali at the pipe surface leading to SCC. The other factors which which have a strong influence on whether SCC will occur at these locations include the chemical composition of the envirionment, the stress level (hoop stress), the nature of the metal (lower yield strength is less likely to develop SCC), the electrode potential of the metal, and the temperature (lower is less likely to develop SCC). A proven remedial measure is careful and complete protection of the pipe surface with an organic coating, which is often supplemented with a polyethylene wrap or epoxy resin coating.. | |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: ACCUMU Date: March 27, 1996

| | | | |
|---|---|---|---|
| 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 (>700°F for typical materials).. Bolted connections are most vulnerable. Relaxation of stress on packing due to stretching of gland follower studs under elevated temperatures may cause packing leakage.<br><br>Irradiation fluence levels greater than 6.0E19 increase relaxation in austenitic and nickel alloy steels. | [7] |
| Thermal Damage | Yes | Non-metallics are particularly susceptible with material dependent temperature limits. | [7]<br>[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 | No | Not applicable to equipment type. 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. This ARDM is not applicable to tanks as there are no moving parts. | [1] |

SYSTEM: 023, Diesel Fuel Oil

**Potential ARDM List (Revision 1)**

EQUIPMENT TYPE: ACCUMU Date: March 27, 1996

**Attachment 7 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 |
| [14] | BOIBOR JF Fuel Fungicide Service Bulletin, U.S. Borax, No. 279 |
| [15] | NACE-5, Stress Corrosion Cracking and Hydrogen Embrittlement of Iron Base Alloys, June 12-16, 1973, pages 135-139 |
| [16] | A Survey of the Literature on Low-Alloy Steel Fastener Corrosion in PWR Power Plants, EPRI Report No. NP-3784, 1984 |

Attachment 3 **Component Grouping Summary Sheet** (Revision 1) Date: 03/08/96

SYSTEM: Diesel Fuel Oil (023)

GROUP ID NUMBER: 023-TK-01

GROUP ATTRIBUTES:

1. Device Type: Tank
2. Vendor:
3. Model Number:
4. Material:
5. Internal Environment:
6. External Environment:
7. Function: Maintain System Pressure Boundary Integrity
8. Name Plate Data:

| PARAMETER | VALUE |
|---|---|
| | |
| | |

LIST OF GROUPED COMPONENTS (EQUIPMENT ID):

0TKFOSTWG11 11 Fuel Oil Storage Tank
0TKFOSTWG21 21 Fuel Oil Storage Tank

**Sub-Component/Sub-Group Identification (Revision 1)**

Date: 3/15/96

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

EQUIPMENT ID: ACCUMU GROUP ID: 023-TK-01 DEVICE TYPE NAME: TANK

| Sub-Group ID | Sub-Component/ Name (Replacement Prgm) | Manufacturer (Source) | Material (Source) | Model Number (Source) | Passive Intended Function(s) (Source) | Subj to AMR (Y or N) |
|---|---|---|---|---|---|---|
| 023-TK-01A | SHELL, INTERNAL (NONE) | PITTSBURGH-DES MOINES (12329-0001) | CARBON STEEL, A283 GR C (SPEC 6750 M-216) | NA (NA) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |
| 023-TK-01B | NOZZLES/PENETRATIONS (NONE) | PITTSBURGH-DES MOINES (12329-0001) | CARBON STEEL (SPEC 6750 M-216) | NA (NA) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |
| 023-TK-01C | ANCHOR BOLTS/NUTS (NONE) | PITTSBURGH-DES MOINES (12329-0001) | CARBON STEEL (TYPICAL) | NA (NA) | STRUCTURAL SUPPORT FOR PB. (CLSR) | Y |
| 023-TK-01D | MANWAY BOLTS/NUTS (NONE) | PITTSBURGH-DES MOINES (12329-0001) | CARBON STEEL (TYPICAL) | NA (NA) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |
| 023-TK-01E | STAIRS/PLATFORMS (NONE) | PITTSBURGH-DES MOINES (12329-0001) | CARBON STEEL (SPEC 6750 M-216) | NA (NA) | NONE. NO LR INTENDED FUNCTION. COMPONENT IN LR SCOPE FOR PRESSURE BOUNDARY ONLY. (CLSR) | N |
| 023-TK-01F | SHELL SIDE AND ROOF, EXTERNAL (NONE) | PITTSBURGH-DES MOINES (12329-0001) | CARBON STEEL, A283 GR C (SPEC 6750 M-216) | NA (NA) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |
| 023-TK-01G | SHELL BOTTOM, EXTERNAL (NONE) | PITTSBURGH-DES MOINES (12329-0001) | CARBON STEEL, A283 GR C (SPEC 6750 M-216) | NA (NA) | MAINTAIN PRESSURE BOUNDARY INTEGRITY (CLSR) | Y |

**ARDM Matrix (Revision 1)**

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL
EQUIPMENT TYPE: ACCUMU DEVICE TYPE: TANK
GROUP ID: 023-TK-01 Date March 27, 1996

| ARDMs | 023-TK-01A Shell Internal | 023-TK-01B Penetrations | 023-TK-01C Anchor Bolts/Nuts | 023-TK-01D Manway Bolts/Nuts | 023-TK-01F Shell External Exposed | 023-TK-01G Shell Bottom External |
|---|---|---|---|---|---|---|
| Crevice Corrosion | A | A | B | B | B | 18 |
| Fatigue | 12 | 12 | 12 | 12 | 12 | 12 |
| Fouling | A | A | 19 | 19 | 19 | 18 |
| Galvanic Corrosion | 07 | 07 | 07 | 07 | 07 | 07 |
| General Corrosion | A | A | B | B | B | 18 |
| Hydrogen Damage | 03 | 03 | 03 | 03 | 03 | 03 |
| Intergranular Attack | 01.1 | 01.1 | 01.1 | 01.1 | 01.1 | 01.1 |
| MIC | A | A | 06 | 06 | 06 | 06 |
| Pitting | A | A | B | B | B | 18 |
| Radiation Damage | 01.1 | 01.1 | 01.1 | 01.1 | 01.1 | 01.1 |
| Rubber Degradation | 01.1 | 01.1 | 01.1 | 01.1 | 01.1 | 01.1 |
| Selective Leaching | 01.1 | 01.1 | 01.1 | 01.1 | 01.1 | 01.1 |
| Stress Corrosion Cracking | 17 | 17 | 17 | 17 | 17 | 18 |
| Stress Relaxation | 04 | 04 | 04 | 04 | 04 | 04 |
| Thermal Damage | 01.1 | 01.1 | 01.1 | 01.1 | 01.1 | 01.1 |
| Thermal Embrittlement | 04 | 04 | 04 | 04 | 04 | 04 |

## Matrix Code List (Revision 1)

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

DEVICE TYPE: TK EQUIPMENT TYPE: ACCUMU

GROUP ID: 023-TK-01 Date: 3/28/96

| Code | Description | Source |
|---|---|---|
| 01 | MATERIAL IS NOT APPLICABLE TO THE ARDM. MATERIAL OF CONSTRUCTION IS NOT SUSCEPTIBLE TO THIS ARDM:<br><br>01.1 CARBON STEEL | ATTACHMENT 7<br>M-216<br>12329-0010 |
| 03 | PROCESS FLUID DOES NOT PERPETUATE THE ARDM ON THE INSIDE OF THE TANK. THE PROCESS FLUID IS FUEL OIL. THE NORMAL HYDROGEN CONCENTRATION AND LOW PRESSURES ARE NOT SUFFICIENT TO MAKE HYDROGEN ATTACK OR BLISTERING PLAUSIBLE. HYDROGEN CRACKING IS NOT A CONCERN FOR MATERIALS WITH YIELD STRESSES LESS THAN 120 KSI, WHICH IS THE CASE FOR THE MATERIALS IN THIS TANK. GENERAL CORROSION, WHICH CAN LEAD TO HYDROGEN DAMAGE, IS ADDRESSED AS A SEPARATE ARDM.<br><br>THE EXTERNAL SURFACE ENVIRONMENT (AIR) DOES NOT CONTAIN SUFFICIENT HYDROGEN OR PRESSURE TO MAKE THIS ARDM PLAUSIBLE. MOLY DISULPHIDE LUBRICANTS ARE PERMITTED BY PROCEDURE TO BE USED ON NON-RESTRICTED SYSTEMS SUCH AS DFO. HOWEVER, MOLY DISULFIDE LUBRICANTS REQUIRE MOISTURE AND TEMPERATURE (>150F) TO DECOMPOSE INTO HYDROGEN SULFIDE. GIVEN THE DESIGN TEMPERATURE OF 100F, HYDROGEN DAMAGE DUE TO MOLY DISULFIDE LUBRICANTS IS NOT A CONCERN.<br><br>WELD HYDROGEN EMBRITTLEMENT IS NOT A CONCERN FOR MILD CARBON STEEL WITH A YIELD STRENGTH IN THE RANGE OF 30-40 KSI. | ATTACHMENT 7<br>METALS HANDBK VOL 13<br>M-216<br>NP-5461<br>CH-1-100<br>NP-5769<br>NP-3137<br>BGM-96-031<br>ASTM A 283 |
| 04 | PROCESS FLUID TEMPERATURE DOES NOT PERPETUATE THE ARDM. OPERATING TEMPERATURES MUCH LESS THAN 500°F ENSURE THIS ARDM IS NOT PLAUSIBLE (NORMALLY <100F). | ATTACHMENT 7<br>92769<br>ES-014 |
| 06 | ENVIRONMENT DOES NOT PERPETUATE THE ARDM:<br><br>MIC IS NOT PLAUSIBLE FOR EXPOSED TANK EXTERNALS. THE LACK OF CONSISTENT STAGNANT WATER PREVENTS SIGNIFICANT MICROBIOLOGICAL GROWTH. THIS IS ALSO TRUE FOR THE EXTERNAL SURFACE OF THE TANK BOTTOM. BOTH TANKS SIT ON 3" OF OIL SOAKED COMPACTED SAND. THE OUTER RING IS SEALED TO PREVENT WATER FROM GETTING UNDER THE TANK. THEREFORE, GIVEN THE LACK OF WATER UNDER THE TANK, MIC IS NOT A CONCERN. | ATTACHMENT 7<br>61813<br>M-216 |
| 07 | MATERIAL SELECTION/SEPARATION DOES NOT PERPETUATE THE ARDM. MATERIALS USED THROUGHOUT THE SYSTEM GENERALLY HAVE LOW POTENTIAL DIFFERENCES AND, WHERE APPROPRIATE, ARE SEPARATED BY APPROPRIATE TRANSITION MATERIALS. THE TANK BOTTOMS ARE ALSO PROTECTED BY A CATHODIC PROTECTION SYSTEM AND ARE COATED WITH A MATERIAL WHICH PROVIDES GALVANIC PROTECTION. | ATTACHMENT 7<br>61201<br>61202<br>92767<br>61406SH0004SEC101.2<br>M-216 |

**Matrix Code List (Revision 1)**

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

DEVICE TYPE: TK EQUIPMENT TYPE: ACCUMU

GROUP ID: 023-TK-01 Date: 3/28/96

| Code | Description | Source |
|---|---|---|
| 12 | SERVICE LOADING AMPLITUDES/FREQUENCIES DO NOT PERPETUATE THE ARDM. THE SYSTEM IS NOT CYCLED FREQUENTLY AND OPERATES AT LOW PRESSURE AND TEMPERATURES MAKING THIS ARDM NOT PLAUSIBLE. THE TANK IS NOT SUBJECT TO CONTINUOUS OR HIGH AMPLITUDE DYNAMIC LOADS. | ATTACHMENT 7<br>92769HB SH HB-1<br>OI-21,OI-21D |
| 17 | COMPONENT MATERIAL AND ENVIRONMENT DO NOT PERPETUATE THE ARDM.<br><br>TANK INTERNALS AND EXPOSED EXTERNALS ARE NOT SUSCEPTIBLE TO SCC AS THE MATERIAL IS MILD CARBON STEEL WITH MINIMAL STRESS, AND IS EXPOSED TO FUEL OIL OR AIR. THESE ARE NOT CONDITIONS WHICH INDUCE SCC OF CARBON STEEL. | ATTACHMENT 7<br>NACE-5 PGS 59,137-138 |
| 18 | COMPONENT MATERIAL AND ENVIRONMENT DO NOT PERPETUATE THE ARDM.<br><br>THE TANK BOTTOMS ARE PROTECTED FROM ALL FORMS OF EXTERNAL CORROSION BY SEVERAL DESIGN FEATURES: THE BOTTOMS ARE COATED WITH ONE COAT OF BITUMASTIC SUPERBLACK, WHICH PROVIDES GALVANIC PROTECTION. ALL WELD SEAMS ARE COVERED WITH A STRIP OF NO-OX-ID ASBESTOS STRIPS. THE TANKS ARE SET ON A 3" LAYER OF OIL SOAKED COMPACTED SAND. THE OUTER EDGE OF THE TANKS ARE ANCHORED TO A CONCRETE RING. ANY VOIDS BETWEEN THE TANK BOTTOMS AND THE CONCRETE RING WERE FILLED WITH GROUT AND THEN THE JOINT WAS SEALED WITH A FIBRATED COLD PLASTIC COAL TAR PITCH FLASHING. TANK #21 IS LOCATED INSIDE A BUILDING WITH THE BOTTOM AT ELEVATION 46', THEREBY PROTECTING THE TANK FROM DIRECT WEATHER AND GROUND WATER. TANK #11 IS LOCATED OUTSIDE AT ELEVATION 46', WELL ABOVE THE GROUND WATER LEVEL. THIS DESIGN ASSURES THE BOTTOM OF BOTH TANKS IS PROTECTED FROM CORROSIVE ENVIRONMENTS. THE TANK BOTTOMS ARE ALSO PROTECTED BY AN IMPRESSED CATHODIC PROTECTION SYSTEM.<br><br>THE PROTECTIVE FEATURES OF THE DESIGN WERE DEMONSTRATED ADEQUATE FOR OUTDOOR TANK #11 BY AN INTERNAL TANK INSPECTION PERFORMED ON 11/1/95. THE INSPECTION INCLUDED A SERIES OF UT MEASUREMENTS OF THE 1/4 INCH BOTTOM PLATES, WHICH SHOWED A MINIMUM THICKNESS OF 0.251 INCHES. THIS INSPECTION DEMONSTRATES THAT THE TANK BOTTOM IS ADEQUATELY PROTECTED FROM CORROSION EFFECTS. | ATTACHMENT 7<br>M-216<br>12329-0010<br>61813<br>UFSAR 2.7.3.2<br>61201<br>61202<br>G:\PES\950103-200<br>12329-0003 |
| 19 | COMPONENT ENVIRONMENT DOES NOT PERPETUATE THE ARDM. THE SUBCOMPONENTS TYPICALLY ARE NOT EXPOSED TO THE PROCESS FLUID WHICH MAKES THE ARDM NON-PLAUSIBLE. | ATTACHMENT 7 |

## Matrix Code List (Revision 1)

SYSTEM NUMBER: 023 SYSTEM NAME: DIESEL FUEL OIL

DEVICE TYPE: TK EQUIPMENT TYPE: ACCUMU

GROUP ID: 023-TK-01 Date: 3/28/96

| Code | Description | Source |
|---|---|---|
| A | TANK INTERNAL SURFACES:<br><br>CREVICE, FOULING, GENERAL, MIC AND PITTING ARDMS ARE PLAUSIBLE BECAUSE INTERNAL CARBON STEEL MATERIAL OF CONSTRUCTION IS EXPOSED TO FUEL OIL POTENTIALLY CONTAMINATED WITH WATER AND BIOLOGICS. WATER WILL GENERALLY COLLECT AT THE TANK BOTTOM. MECHANISMS ARE COMPOUNDED BY PRESENCE OF SLUDGE/DEPOSITS AT BOTTOM OF TANK (THIS IS A PROBLEM THAT HAS BEEN REPORTED AT CCNPP).<br><br>AGING MANAGEMENT RECOMMENDATIONS:<br><br>A. OPERATIONS CHECK FOR AND REMOVAL OF WATER (THROUGH SUMP DRAIN).<br>B. CONTROL OF FUEL OIL CHEMISTRY, INCLUDING SAMPLING FOR BIOLOGICS.<br>C. INTERNAL TANK INSPECTIONS, INCLUDING NDE THICKNESS MEASUREMENTS OF BOTTOM PLATE. | ATTACHMENT 7<br>LER 89-26 |
| B | TANK EXTERNAL EXPOSED SUFACES<br><br>CREVICE, GENERAL AND PITTING ARDMS ARE PLAUSIBLE BECAUSE THE EXTERNAL CARBON STEEL MATERIAL OF CONSTRUCTION IS EXPOSED TO HUMID, MOIST OR WET ENVIRONMENTS. SUN AND WEATHER WILL DETERIORATE THE PROTECTIVE PAINT COATING OF THE #11 TANK AND LEAD TO ACCELERATED CORROSION MECHANISMS OF CARBON STEEL COMPONENTS EXPOSED TO MOISTURE. THE #12 TANK IS PROTECTED FROM DIRECT AFFECTS OF SUN AND WEATHER BY A CONCRETE ENCLOSURE. HOWEVER, THE CARBON STEEL SURFACES ARE STILL EXPOSED TO CHANGES IN HUMIDITY AND TEMPERATURE, REQUIRING THE PROTECTION OF PAINT. THE EMBEDDED PORTION OF THE ANCHOR BOLTS HAS BEEN EVALUATED TO BE ADEQUATELY PROTECTED FROM CORROSION BY THE QUALITY OF THE CONCRETE (REF COMPONENT EVALUATION AND PROGRAM EVALUATION RESULTS FOR FUEL OIL STORAGE TANK #21 ENCLOSURE, APPENDIX E - THIS IS JUDGED TO BE APPLICABLE TO THE TANK #11 FOUNDATION RING).<br><br>AGING MANAGEMENT RECOMMENDATIONS:<br><br>(1) PERIODICALLY INSPECT PAINT AND REPAIR AS REQUIRED. | ATTACHMENT 7 |