WESTINGHOUSE NON-PROPRIETARY CLASS 3

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# RELIABILITY ASSESSMENT OF CUTLER-HAMMER D26MR802A RELAYS USED AS SSPS SLAVE RELAYS

Westinghouse

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# RELIABILITY ASSESSMENT OF CUTLER-HAMMER D26MR802A RELAYS USED AS SSPS SLAVE RELAYS

June 2003

by

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## ACRONYMS

| | |
|---|---|
| AC | Alternating Current |
| CHR | Cutler-Hammer Relay |
| DC | Direct Current |
| ERP | Emergency Response Procedures |
| ESFAS | Engineered Safety Features Actuation System |
| FMEA | Failure Mode and Effects Analysis |
| FNP | Farley Nuclear Plant |
| HVAC | Heating Ventilating and Air Conditioning |
| LER | Licensee Event Report |
| IEEE | Institute of Electrical and Electronic Engineers |
| I&E | Instrumentation and Electronics |
| ND | Normally De-energized |
| NE | Normally Energized |
| NPRDS | Nuclear Plant Reliability Data System |
| NRC | Nuclear Regulatory Commission |
| NSID-TB | Nuclear Services Integration Division Technical Bulletin |
| NSD-TB | Nuclear Services Division Technical Bulletin |
| RO | Reactor Operations |
| SI | Safety Injection |
| SRT | Slave Relay Test |
| SSPS | Solid State Protection System |
| VAC | Volts Alternating Current |
| VDC | Volts Direct Current |
| WCAP | Westinghouse Commercial Atomic Power |
| WOG | Westinghouse Owners Group |

## EXECUTIVE SUMMARY

This WCAP report is one of a series of WCAP reports that provides support for extending the required surveillance test intervals of relays used as slave relays in the Solid State Protection System (SSPS). The previous WCAPs are:

- WCAP-13877 Revision 2-P-A, "Reliability Assessment of Westinghouse Type AR Relays Used as SSPS Slave Relays" (Westinghouse Proprietary Class 2C).

- WCAP-13878-P-A Rev 2, "Reliability Assessment of Potter & Brumfield MDR Series Relays" (Westinghouse Proprietary Class 2C).

The above WCAPs provide support documentation for extending the surveillance test intervals for as long as 24 months.

This WCAP report builds on the information provided in WCAP-13877 Revision 2-P-A and provides supplemental information to extend the surveillance test requirements for the Cutler-Hammer D26MR802A relay for as long as 24 months.

The methodology for this WCAP report is similar to the above NRC approved WCAPs. The supplemental information specific to the D26MR802A relay is included in this WCAP report. The relay specific information includes:

- an aging assessment,
- a failure modes and effects analysis (FEMA),
- review of the Nuclear Plant Reliability Data System (NPRDS) for Cutler-Hammer relay failures
- and a physical description and pictures of the relay.

The conclusion of this WCAP report is the same as the above WCAPs, that is, surveillance testing of relays used in SSPS slave relay applications may be extended to a refueling basis without impact or consequence to relay reliability.

# 1.0 BACKGROUND

NUREG-1366, "Improvements to Technical Specification Surveillance Requirements" was published in December 1992. This NUREG contains the combined results and recommendations from a 1983 NRC task group formed to investigate problems with surveillance testing required by Technical Specifications. The objective of these projects was to review the basis for test frequencies; to ensure that the tests promote safety and do not degrade equipment; and to review surveillance tests to ensure they do not unnecessarily burden personnel. The studies found that while some testing at power is essential to verify equipment and system operability, sufficient justification could be provided to reduce the amount of testing at power based on the following criteria:

- Safety can be significantly improved
- Equipment degradation decreased
- Unnecessary personnel burden relaxed
- In total, Operation and Maintenance (O&M) costs can be reduced

Testing of most safety-related relays meets all of the above criteria.

The WOG SRT Subgroup approached the opportunity to reduce risk of trip at power & O&M costs via extension of the SSPS slave relay test interval. Generic studies of the Type AR series relay (WCAP-13877, Reference 14.5-1) and MDR series relays (WCAP-13878, Reference 14.5-2) were performed to establish the technical basis for the necessary License Amendment Requests.

The need for the Cutler-Hammer D26M relay study is driven by the obsolescence of the AR relay's qualified mechanical latch assembly. Spare ARLA latch assemblies have not been available since the late 1970's. However, use of this alternate relay as an SSPS slave relay disqualifies the effected SSPS circuits/functions from the SRT interval extension. Thus, a technical basis equivalent to that in WCAP-13877 (Reference 14.5-1) is needed for the Cutler-Hammer D26M relay.

## 2.0 SCOPE

The scope of this analysis is limited to the Cutler-Hammer D26MR802A Type M relay when used in SSPS slave relay applications in the normally de-energized mode.

## 3.0 METHODOLOGY

The methodology used to perform a reliability assessment of the Cutler-Hammer D26MR802A Type M relay includes a Failure Modes and Effects Analysis (FMEA) and an aging assessment. In a typical, high-level FMEA (e.g., of a control system), a relay might be shown as a "subsystem" or "component". This approach simplifies considerations of relay operability to a generic level and establishes the concept that relay reliability is also generic. For the purposes of this FMEA, however, the Cutler-Hammer D26MR802A Type M relay itself is designated as the "system", allowing for a more detailed evaluation at the relay's component levels.

## 3.0 METHODOLOGY (continued)

The D26MR802A relay consists of five fundamental components. These major building blocks are : 1) the unlatching coil assembly, 2) front pole deck assembly, 3) rear pole deck assembly, 4) pick-up coil assembly and 5) mounting base.

The following steps were followed in the preparation of the FMEA:

- Design Review (Section 3.1)
- Design Development Testing Review (Section 3.2)
- Drawing Review (Section 3.3)
- Disassembly and Inspection (Section 3.4)
- Equipment Qualification Experience Review (Section 3.5)
- Failure History Review (Section 3.6)
- Generic Issues Review (Section 3.7)
- Aging Assessment Review (Section 3.8)

General guidance for the FMEA was taken from IEEE Standard 352-1987 (Reference 14-1). Results of the FMEA are presented in table format in Section 7.0 of this report. The FMEA tables identify temperature-induced age-related material degradation mechanisms applicable to the relay component materials. The FMEA also includes remarks which qualify applicability and likelihood of certain type Cutler-Hammer

## 3.0 METHODOLOGY (continued)

D26MR802A Type M relay failure modes in the SSPS application. The intent is to address the failures that may result from material degradation; this includes material degradation which can cause secondary failure mechanisms. Section 8.0 presents the aging assessment of the D26MR802A Type M relay component materials.

## 3.1 DESIGN REVIEW

The design review consisted of review of the technical data and technical data performance sheets for the D26 series relays. Part of the review (Reference 14.4-1) included review of the test results of the relays for operation to be similar to the AR series relays with the mechanical latch attachment.

The goal of using the D26M series relay is to provide an alternate relay for the AR440 and AR880 with mechanical latch used in the Solid State Protection System to operate Engineered Safety Features (ESF) devices and plant controls. The AR relay that is currently being used is an 8-pole relay with a mechanical latch. This latch was discontinued in 1970 and the replacement magnetic latch failed qualification tests and was disqualified for use as documented in Technical Bulletin 77-10 (Reference 14.3-3). The D26MR802A relay is an 8-pole relay with a mechanical latch.

## 3.1 DESIGN REVIEW (continued)

Technical Bulletin 82-03 (Reference 14.3-7) indicated that the only qualified replacement for the AR relay with a latch attachment was the MDR series relays (MDR 4121-1). These relays have coil resistance and contact ratings that are significantly different from the AR relay. This resulted in several misapplication of contacts and was documented in Technical Bulletin 92-02 (Reference 14.3-10).

The footprint of the D26M series relay is similar to the AR relay. The coil rating of the D26M series relay is slightly less than the AR relay, but closer to the AR relay than the MDR series relay. The D26M series Volt-Amp (VA) rating is less than the AR relay, which results in less heat in the cabinet. The contact loading for AC voltages are identical for the D26M and the AR series relays. The DC ratings for the contacts are 3.0 amps resistive for the AR relay and 2.0 amps resistive for the D26M series relay. This is an increase of 0.5 amps from the MDR relay.

## 3.2 DESIGN DEVELOPMENT TESTING REVIEW

It is assumed that the D26M series relays would be subjected to the same in plant environmental and operational parameters as the AR series relays. The testing of the D26M relays was based on the same series of tests that were used to test the AR relays.

## 3.3 DRAWING REVIEW

Vendor literature and drawings were reviewed to augment the subsequent disassembly and inspection effort and to verify component material types. The vendor information is included in Table 8-1, "Non-metallic Parts: D26MR802A Type M Relay Materials And Aging Data."

## 3.4 DISASSEMBLY AND INSPECTION

One D26MR802A relay was disassembled and inspected for potential items that may fail. The model chosen for disassembly is the same model that is intended to be used to replace the AR relay currently used in the SSPS.

## 3.5 EQUIPMENT QUALIFICATION EXPERIENCE REVIEW

The Westinghouse generic Equipment Qualification (EQ) programs experience, which includes the D26MR802A Type M relay, contributed significantly to the determination and assessment of failure modes that are related to temperature/age-degradation. Materials aging analysis is used to address failure modes and effects for which little data, if any, is available on which to base a quantitative analysis of reliability.

## 3.6 FAILURE HISTORY REVIEW

Failure history of Cutler-Hammer relays was gathered to:

- Establish a quantitative reliability basis specific to the SSPS slave relay applications used in normally de-energized applications;
- Demonstrate that the D26MR802A relay in normally de-energized applications in the SSPS slave application would have a greater quantitative reliability than industrial control relays used in typical commercial industrial applications reflected in sources such as IEEE Std. 500-1984 (Reference 14-2);
- Demonstrate that reliability of the D26MR802A relay in normally de-energized applications in the SSPS slave relay application is independent of the test intervals (i.e., quarterly versus "at-refueling"); and
- Facilitate comparison with the FMEA results to justify qualitatively the expectations of superior performance of the D26MR802A relay when used as SSPS slave relays in normally de-energized applications.

The Nuclear Plant Reliability Data System (NPRDS) database was searched for Cutler-Hammer D26MR802A relay failures. The NPRDS database search is further discussed in Section 9.0, “Failure Experience”.

Where available and when required, Licensee Event Reports (LERs) referenced in the NPRDS database entries were reviewed to clarify what actually happened to the relays. A number of the NPRDS entries were found to be failures of non-relay components and human errors rather than specific failure of the relay.

## 3.7 GENERIC ISSUES REVIEW

Nuclear Regulatory Commission (NRC) generic communication (i.e., Bulletins, Circulars, Information Notices) provide a broad range of lessons learned from relay failures reported in the nuclear industry. References 14.1-1 through 14.1-49 provide detailed discussion of relay failure modes and mechanisms, their effects, and root cause analyses for a variety of relays. Westinghouse Technical Bulletins, References 14.3-1 through 14.3-10 have applicability to the D26MR802A relay in the SSPS. The lessons were applied in the analysis of the D26MR802A relay as used in the SSPS slave relay application. Generic documents with direct applicability to the D26MR802A relay are discussed in Section 6.0, "Review of Generic Communications."

References 14.2-1 through 14.2-14 are NRC generic communications which discuss general problems with ESFAS.

## 3.8 AGING ASSESSMENT REVIEW

Standard approaches to relay reliability are based on empirical methods which determine a number of failures expected per number of demands (e.g., 10,000 or one million). Implicit in this statement of reliability are the premises that relays, particularly those of the industrial control type,

- operate frequently,
- will wear out before component materials are degraded by other factors of environment, and
- fail upon demand for operation.

## 3.8 AGING ASSESSMENT REVIEW (continued)

The first two premises do not apply in the case of the SSPS slave relays. The SSPS slave relays operate infrequently, most often in response to test demands. There is little likelihood that the SSPS slave relays will wear-to-failure within the current 40-year life of a nuclear plant. The third premise, which is in part derived from the other two, is the catch-all for "stand-by failures" which may arise from age-related degradation of relay materials. In the case of the SSPS slave relays, so-called stand-by failures are more likely to be the dominant failure mechanism.

The aging assessment (Section 8.0) addresses the time/temperature degradation of organic materials used in Cutler-Hammer type D26MR802A relay. The intent is to demonstrate that the age-related degradation of the relay is sufficiently slow such that detection of age-related failures is equally effective at the refueling-based test interval as it is at the quarterly test interval.

The FMEA provides a thorough failure analysis of the D26MR802A relay, its failure history and materials performance data.. In addition to the typical information found in a FMEA, this study includes the aging assessment of the D26MR802A relay.

## 4.0 DESCRIPTION OF RELAY

The D26MR802A Type M relay consists of multiple contact poles, a pick-up coil, an unlatching coil and a metal mounting base. The "A" at the end of the relay designation indicates that both the pick-up coil and the unlatching coil are rated at 120 VAC 60 cycle/100 VAC 50 cycle.

### 4.1 Major Components

The major components of the relay are the latching/unlatching assembly, front pole deck assembly, rear pole deck assembly, pick-up coil assembly and mounting base. **(See Figures 4-1 and 4-2.)** Each component is discussed below.

#### 4.1.1 Latching/Unlatching Assembly

The latching/unlatching assembly is mounted in the top most section of the relay assembly. The unlatching coil is assembled inside the latching/unlatching assembly. Two screw terminals are cast into the coil. The terminals are 180 degrees apart. The coil case is made of a red plastic type material. The material composition is discussed in Sections 5 and 8. The red color indicates that the coil voltage is rated at 120VAC 60 cycles/100 VAC 50 cycles. **(See Figures 4-1, 4-2, 4-3 and 4-4.)**

### 4.1.2 Front Pole Deck Assembly

The front pole deck assembly consists of a single piece housing and four convertible contact poles. These front contact poles are identified with an "F" stamped into the metal terminals. The "F" stamp is visible whether the contact poles are normally opened or normally closed. In addition, a green mark on the contact strip identifies the contact pole as being normally open. The front pole deck assembly is smaller than the rear pole deck assembly. This tiered design facilitates the "straight-in" use of a screwdriver to reach the contact pole terminal screws on the larger rear pole deck assembly. **(See Figures 4-1, 4-2, 4-3 and 4-7.)**

### 4.1.3 Rear Pole Deck Assembly

The rear pole deck assembly consists of a single piece housing and four convertible contact poles. These rear contact poles are identified with an "R" stamped into the metal terminals. The "R" stamp is visible whether the contact poles are normally opened or normally closed. In addition, a green mark on the contact strip identifies the contact pole as being normally open. The rear contact assembly is larger than the front contact assembly. This tiered design facilitates the "straight-in" use of a screwdriver to reach the contact pole terminal screws on the larger rear pole deck assembly. **(See Figures 4-1, 4-2, 4-3, 4-8 and 4-9.)**

### 4.1.4 Pick-up Assembly

The pick-up assembly is mounted in the base of the relay assembly. The pick-up coil is mounted in the base. Two screw terminals are cast into the coil. The terminals are adjacent to each other on the same side of the coil. The coil case is made of a red plastic type material. The material composition is discussed in Sections 5 and 8. The red color indicates that the coil voltage is rated at 120VAC 60 cycles/100 VAC 50 cycles. **(See Figures 4-1, 4-2, 4-8 and 4-10.)**

### 4.1.5 Mounting Base

The mounting base is a single piece of die cast aluminum. There are two holes in the base for mounting the relay onto existing panels or brackets. **(See Figures 4-1, 4-2, 4-3, 4-8, 4-10 and 4-11.)**

## 4.2 Sub-components

In addition to the above items, there are relay sub-components which consist of contact pole assemblies, an unlatching coil assembly, a push bar actuator assembly and a pick-up coil assembly. Each of these sub-components is discussed below.

### 4.2.1 Contact Pole Assemblies

There are two types of contact pole assemblies in the D26MR802A Type M relay i.e., the front contact pole assembly (designated as "F") and the rear contact pole assembly (designated as "R"). The front and rear contact pole assemblies are the same except for the lengths of the contact pole strips. The rear contact pole strip is longer than the front contact pole strip. The contact pole assembly consists of a housing, contacts, spring, actuator rod and spring retainer cups. The following descriptions (Sections 4.2.1.1 through 4.2.1.6) apply to both the front and rear contact pole assemblies. **(See Figures 4-2 and 4-12.)**

#### 4.2.1.1 Contact Pole Convertibility

Each of the contact poles can be changed from normally open to normally closed or from normally closed to normally open in the field. This change is accomplished by removing the contact pole from the pole deck assembly, reversing the terminal screws, rotating the contact pole 180 degrees then re-installing the contact pole into the pole deck assembly. **(See Figures 4-2 and 4-12.)**

#### 4.2.1.2 Housing

The contact pole housing consists of two pieces of plastic type material. One of the housing pieces is clear which permits inspection of the contacts. The other part of the housing is made of white plastic. The material composition is discussed in Sections 5 and 8. The housing design also keeps the contacts enclosed, thus, minimizing the possibility of dirt, insulation and wire bits from entering the housing and fouling the contacts. **(See Figures 4-2 and 4-12.)**

#### 4.2.1.3 Contacts

The contacts are located inside the contact pole housing. The movable contacts are bifurcated. The stationary contacts are solid and serrated. **(See Figures 4-2 and 4-12.)**

#### 4.2.1.4 Springs

[

]a,c **(See Figures 4-2 and 4-12.)**

#### 4.2.1.5 Actuator Rod

[

]a,c **(See Figures 4-2 and 4-12.)**

#### 4.2.1.6 Spring Retainer Cups

[

]a,c **(See Figures 4-2 and 4-12.)**

### 4.2.2 Unlatching Coil Assembly

The latching/unlatching assembly consists of an unlatching coil, a spring, a mechanical release mechanism and a housing. The latching/unlatching assembly is located at the top of the relay assembly. **(See Figures 4-1, 4-2, 4-3, 4-4, 4-5 and 4-6.)**

### 4.2.3 Push Bar Actuator Assembly

The push bar actuator changes the state of the pole contacts. [

]a,c The material composition is discussed in Sections 5 and 8. **(See Figures 4-2, 4-3, 4-8 and 4-9.)**

### 4.2.4 Pick-up Coil Assembly

The pick-up coil assembly consists of a double wound coil, aluminum mounting base, a moveable "C" shaped electromagnet and a stationary "T" shaped electromagnet. The pick-up coil is located at the bottom of the relay assembly. **(See Figures 4-1, 4-2, 4-9 and 4-10.)**

## 4.3 Relay Pick-up Operation

Energization of the pick-up coil (located in the mounting base) causes [

]a,c

(See Figure 4-6.).

a, c

[

]

### 4.3.1 Contact Pole Operation During Relay Pick-up

a, c

[ ]

### 4.4 Relay Latching/Unlatching Operation

a, c

[ ]

## 4.4 Relay Latching/Unlatching Operation (continued)

There is also a manual release lever located immediately below the unlatching coil. When this lever is moved toward the unlatching coil, the lever will perform the same unlatching action as the energized unlatching coil. [

]a,c

### 4.4.1 Contact Pole Operation During Unlatching

When the latched relay is unlatched, the springs in the normally open contact pole provides the force needed to open the contacts.

When the latched relay is unlatched, the springs in the normally closed contact pole provides the force needed to close the contacts and maintain a constant force on the closed contact.

## 4.5 Relay Operating Modes

For the purposes of this analysis, the D26MR802A latching relay is considered to have only one operating mode, that is, normally de-energized (ND).

## 4.5 Relay Operating Modes (continued)

A relay is considered to be normally de-energized (ND) if its coil is de-energized under normal plant operating conditions. A normally de-energized SSPS salve relay is, therefore, energized to perform its safety-related function. For completeness of information, a relay is considered to be normally energized (NE) if its coil is energized to maintain a desired contact position under normal plant operating conditions. A normally energized SSPS salve relay is, therefore, de-energized to perform its safety-related function.

A latching relay is normally de-energized. Typically, a latching relay is used in the control of functions where loss of power should not cause an inadvertent reset, or where a deliberate action is required to reset/terminate the function, such as Safety Injection.

## 4.6 Relay Photographs

Figures 4-1 through 4-13 show the latching D26MR802 relay. The following is a title listing of Figures 4-1 through 4-13 and parts identified on the photographs:

Figure 4-1: Complete Assembly: Side View

- Latching/Unlatching Assembly
- Front Pole Deck Assembly
- Rear Pole Deck Assembly
- Pick-up Coil Assembly and Mounting Base

## 4.6 Relay Photographs (continued)

Figure 4-2: Exploded View of Relay

- Latching/Unlatching Assembly
- Unlatching Coil
- Front Contact Pole Assembly
- Front Pole Deck Assembly
- Rear Contact Pole Assembly
- Push Bar Actuator Assembly
- Latch Shaft
- Rear Pole Deck Assembly
- Pick-up Coil
- Mounting Base

Figure 4-3: Latching/Unlatching Assembly Removed From Relay

- Latching/Unlatching Assembly
- Push Bar Actuator Assembly
- Front Contact Poles (4)
- Front Pole Deck Assembly
- Rear Pole Deck Assembly
- Mounting Base

Figure 4-4: Latching/Unlatching Assembly Disassembled

- Unlatching Coil
- Spring
- Latching/Unlatching Mechanism

## 4.6 Relay Photographs (continued)

Figure 4-5: Latching/Unlatching Mechanism – Top View

[- ][a,c]

- Mechanical Unlatch Lever

Figure 4-6: Latching/Unlatching Mechanism Components

[- ][a,c]

- Bearings (3 at 120 degrees apart)
- Grease
- Mechanical Unlatch Lever
- Spring

Figure 4-7: Front Pole Deck Assembly

- Insulators (4)
- Front Contact Pole

Figure 4-8: Rear Pole Deck Assembly With Push Bar Actuator and Pick-up Coil Assembly

- Push Bar Actuator Assembly
- Rear Contact Poles (4)
- Pick-up Coil Assembly and Mounting Base

Figure 4-9: Rear Pole Deck Assembled (Top) and Rear Pole Deck Disassembled and "T" Electromagnet (Bottom)

- "T" Electromagnet
- Push Bar Actuator Assembly
- Polyacrylic Cushion

## 4.6 Relay Photographs (continued)

Figure 4-10: Pick-up Coil Assembly (Top) and "C" Electromagnet and Pick-up Coil (Bottom)

- Pick-up Coil
- [ ][a,c]
- Mounting Base
- "C" Electromagnet

Figure 4-11: Mounting Base With "C" Electromagnet Assembly Removed (Top) and Mounting Base With "C" Electromagnet Assembly Rotated (Bottom)

- Mounting Base
- "C" Electromagnet Assembly

Figure 4-12: Front Contact Pole Assemblies (Left Side) and Rear Contact Pole Assemblies (Right Side)

- Front Contact Poles
- Rear Contact Poles

Figure 4-13: Gap Between "C" Electromagnet and "T" Electromagnet

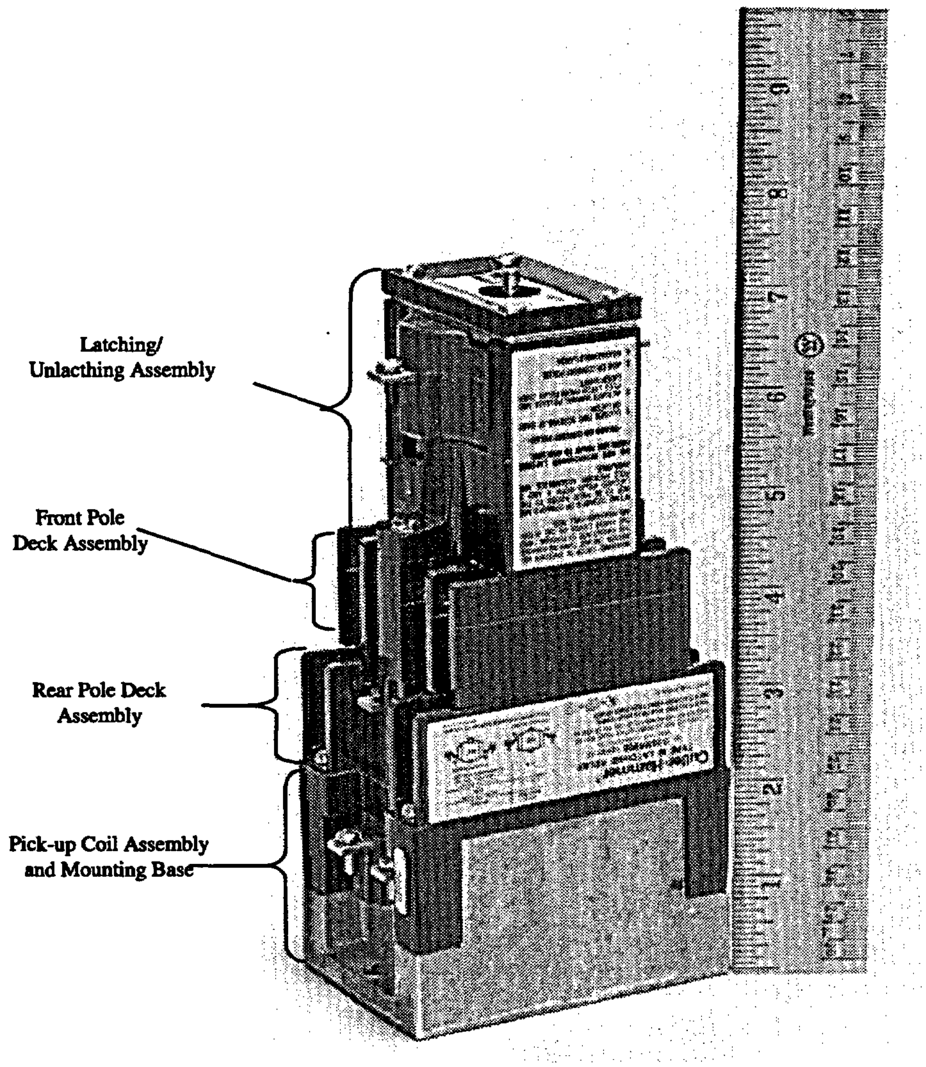


**Figure 4-1 Complete Assembly: Side View**

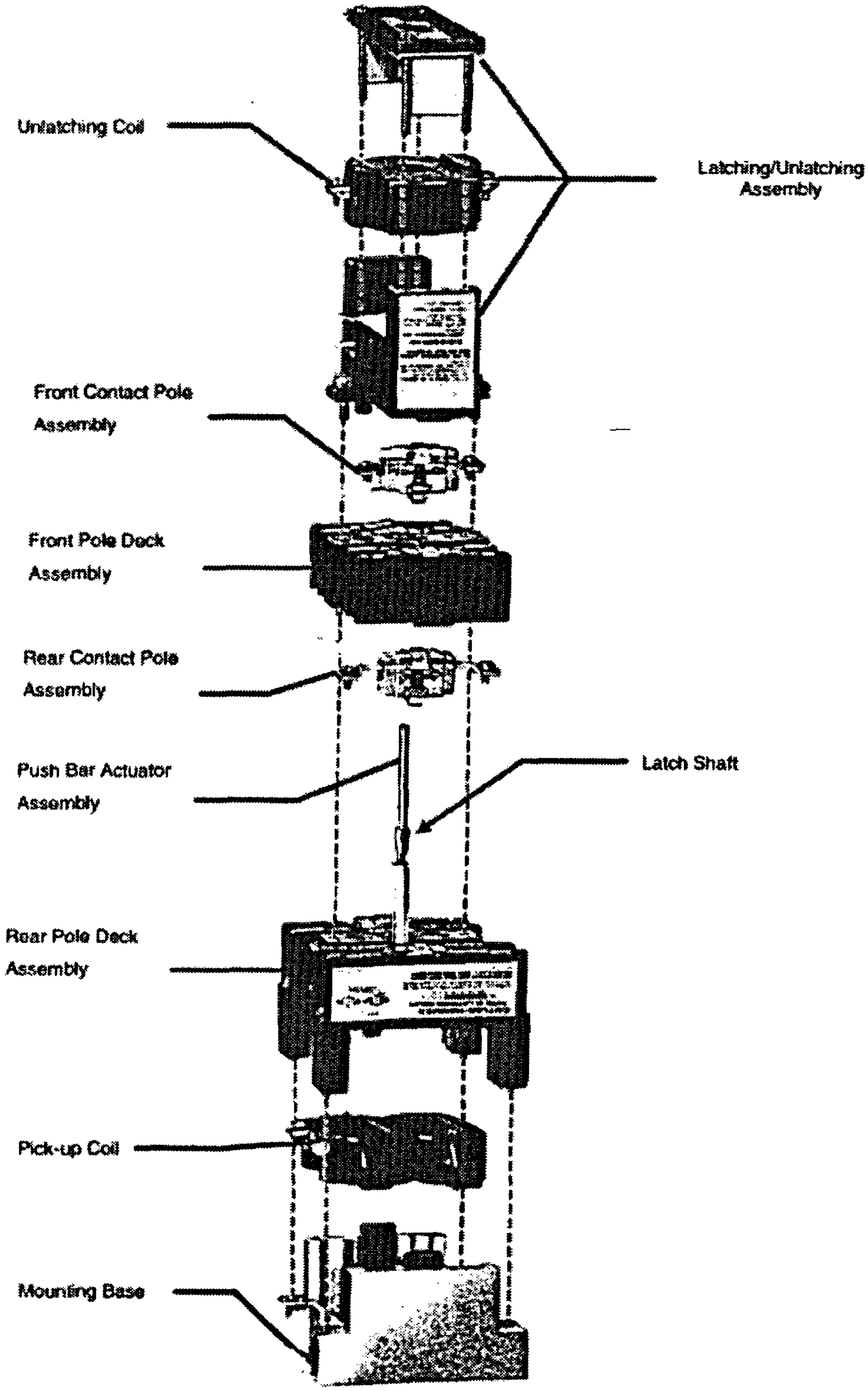


**Figure 4-2 Exploded View of Relay**

a, c

**Figure 4-3 Latching/Unlatching Assembly Removed From Relay**

a, c

Figure 4-4 Latching/Unlatching Assembly Disassembled

a, c

**Figure 4-5 Latching/Unlatching Mechanism – Top View**

a, c

**Figure 4-6 Latching/Unlatching Mechanism Components**

a, c

Figure 4-7 Front Pole Assembly

a, c

**Figure 4-8 Rear Pole Deck Assembly With Push Bar Actuator and Pick-up Coil Assembly**

a, c

**Figure 4-9 Rear Pole Deck Assembled (Top) and Rear Pole Deck Disassembled and "I" Electromagnet (Bottom)**

a, c

**Figure 4-10 Pick-up Coil Assembly (Top) and "C" Electromagnet and Pick-up Coil (Bottom)**

a, c

**Figure 4-11 Mounting Base with "C" Electromagnet Assembly Removed (Top) and Mounting Base with "C" Electromagnet Assembly Rotated (Bottom)**

a, c

Figure 4-12 Front Contact Pole Assemblies (Left Side) and Rear Contact Pole Assemblies (Right Side)

a, c

Figure 4-13 Gap Between "C" Electromagnet and "T" Electromagnet

## 5.0 D26MR802A Type M RELAY DESIGN REVIEW

The D26MR802A Type M Relay is expected to have a design life and cycle capability greatly in excess of that required for the SSPS slave relay application. The following sections summarize results of the design review.

### 5.1 DESIGN BASIS

Technical Information Publication D26 (Reference 14-3) provides information about the design characteristics of the subject relay. This report relies on Technical Information Publication D26, the Review of Generic Communications (Section 6.0), the FMEA (Section 7.0), the Aging Assessment (Section 8), the Failure Experience (Section 9.0), and the Westinghouse qualification of the D26 relay, to establish the new design basis of the relay.

### 5.2 DESIGN LIFE

Technical Information Publication for the D26 (Reference 14-3) does not provide any specified design life for the relay. However, the publication does state that the magnet assembly is designed to such that a low level noise is noticeable only after millions of operations. The SSPS slave relays have a conservative estimated duty life of 1000 cycles of operation over a forty-year plant life, based on startup testing, surveillance testing, and any valid or inadvertent trip demands.

Non-metallic materials used in the construction of the relay are listed in Table 5-1.

Further discussion of the D26MR802A relay aging and temperature endurance is deferred to Section 8.0, Aging Assessment.

## 5.3 MECHANICAL AND ELECTRICAL OPERATION

The description of the relay components and the relay operation are described in Section 4.

## 5.4 SUMMARY

The D26 relay is expected to have a cycle life capability greatly in excess of that required for the SSPS slave relay application. The maximum temperature experienced by the D26 slave relays in the SSPS cabinets will be far less than the manufacturers' rated temperature (105 °C) for reliable relay operation. The principal issue of reliability in the SSPS slave relay application is the very low cycle demand and the extended period(s) during which no demand is expected. The D26 slave relay high reliability is also supported by the Aging Assessment (Section 8.0) and other factors of relay reliability in the Conclusions of FMEA (Section 10.0).

**Table 5-1**
**D26MR802A Relay**
**Non-metallic Materials, Bonding Materials and Grease**

a, c

**Table 5-1**
**D26MR802A Relay**
**Non-metallic Materials, Bonding Materials and Grease**

a, c

## 6.0 REVIEW OF GENERIC COMMUNICATIONS

Westinghouse has not issued any generic communications (e.g., Technical Bulletin, Infogram, or Nuclear Safety Advisor Letter (NSAL) in regards to the D26MR802A Type M relay. The D26MR802A relay was not sold by Westinghouse prior to June of 1998.

A search of the NPRDS database search was performed for relay failures. In particular, Cutler-Hammer relay failures were researched. A detailed description of the findings are documented in Section 9.0, "Failure Experience."

References 14.1-1 to 14.1-49 and 14.2-1 to 14.2-15 are the NRC generic communications reviewed as part of the FMEA and aging assessment of the D26MR802A Type M relay. All were reviewed with the intent of considering any relay failure modes or mechanisms identified for relays that might also apply to the D26MR802A Type M relay. References 14.3-1 to 14.3-10 are Westinghouse Technical Bulletins which are applicable to relays used in the SSPS.

I&E Bulletin 78-06 (Reference 14.1-7 ) specifically discusses failure of a Cutler-Hammer D23MRD Type M relay. The failure of this continuously energized DC relay was caused by loss of arc gap in the coil clearing contact. This failure is not applicable to the D26MR802A Type M relay because the D26MR802A relay is a normally de-energized AC relay and does not include the coil clearing contact feature.

## 7.0 FAILURE MODES AND EFFECTS RESULTS

The results of the Failure Modes and Effects Analysis (FMEA) for the Cutler-Hammer D26MR802A Type M relay are presented in Tables 7-1 through 7-6. Each table addresses a different fundamental component of the relay.

Table 7-1 is the FMEA for the relay contact pole assembly. Table 7-2 is the FMEA for the latching/unlatching assembly. Table 7-3 is the FMEA for the push bar actuator assembly. Table 7-4 is the FMEA for the pick-up coil assembly. Tables 7-5 and 7-6 are the FMEA for the front and rear pole deck assemblies, respectively.

## 7.1 FMEA TABLE FORMAT

a,b, c

**Table 7-1**
**FMEA FOR CUTLER-HAMMER D26 TYPE M RELAY CONTACT POLE ASSEMBLY**

a,b,c

**Table 7-2**
**FMEA FOR CUTLER-HAMMER D26 TYPE M RELAY LATCHING/UNLATCHING ASSEMBLY**

a,b,c

**Table 7-3**
**FMEA FOR CUTLER-HAMMER D26 TYPE M PUSH BAR ACTUATOR ASSEMBLY**

a,b,c

**Table 7-4**
**FMEA FOR CUTLER-HAMMER D26 TYPE M RELAY PICK-UP COIL ASSEMBLY**

a,b,c

**Table 7-5**
**FMEA FOR CUTLER-HAMMER D26 TYPE M RELAY FRONT POLE DECK ASSEMBLY**

a,b,c

**Table 7-6**
**FMEA FOR CUTLER-HAMMER D26 TYPE M RELAY REAR POLE DECK ASSEMBLY**

a,b,c

## 8.0 AGING ASSESSMENT

In most nuclear plant applications, and particularly for the SSPS slave relay application, aging degradation is the single greatest challenge to operability and reliability. The typical SSPS slave relay is normally de-energized, operates only in ESFAS actuation demands or during periodic testing, and is protected from the damaging effects of debris and contamination. The typical SSPS slave relay is protected from the extremes of high ambient temperature and high relative humidity by HVAC equipment in the protected areas where the SSPS is normally installed. In addition, most plants provide redundant, Class-1E-powered HVAC in the rooms where the SSPS is installed (e.g., power plant control room), further assuring minimal ambient temperature and humidity under all plant operating modes.

The aging assessment presented below addresses the time/temperature degradation of organic materials used in the D26MR802A relay. The intent is to demonstrate that the age-related degradation of the relay is sufficiently slow that failure detection is equally effective at three-month intervals and refueling-based test intervals. The recommended approach to maximizing relay reliability is to minimize test frequency, monitor and control relevant environmental factors, and determine D26MR802A slave relay replacement intervals on the basis of accurate service life predictions. These predictions should be determined specifically for the relay's service, location and environment.

Reference 14-4 contains the aging assessment of the non-metallic materials used in the construction of the D26MR802A relay. Table 8-1 and 8-2 show the predicted service life of the non-metallic materials of the D26MR802A for ESFAS applications for 20% and 0% energized duty cycles.

**Table 8-1**
**Non-metallic Parts: D26MR802A Type M Relay Materials and Aging Data**
**Relay Energized 20 %**

a,b,c

**Table 8-2**
**Non-metallic Parts: D26MR802A Type M Relay Materials and Aging Data**
**Relay Energized 0%**

a,b,c

## 9.0 FAILURE EXPERIENCE

An NPRDS database search was performed to determine if Cutler-Hammer relay model number D26MR802A had any failures recorded in the database. [

]a,c Tables 9-1 through 9-6 provide an analysis of the 61 NPRDS failures and the applicability of the failures to this analysis.

## 9.1 DESCRIPTION OF TABLES

Table 9-1 provides a list of Cutler-Hammer model numbers related to NPRDS failures and a determination if the specific model number is applicable to this analysis. Tables 9-2, 9-3 and 9-4 summarizes categories of failures such as non-relay failures, human errors and relays used in normally energized applications. Table 9-5 is an analysis of potentially bona fide relay failures. Table 9-6 is a summary of the NPRDS database search and is the bases for Tables 9-2 through 9-5. Each of the tables is discussed in further detail below.

## 9.1 DESCRIPTION OF TABLES (continued)

Table 9-1 Relay Component Applicability

a, c

Table 9-2 Summary of Non-relay Failures

a, c

Table 9-3 Summary of Relay Failures Due to Human Errors

a, c

Table 9-4 Summary of Relays Failed in Normally Energized Applications

a, c

## 9.1 DESCRIPTION OF TABLES (continued)

Table 9-5 Analysis of Potential Cutler-Hammer Relay Failures

a, c

Table 9-6 NPRDS Cutler-Hammer Relay Failures

a, c

**Table 9-1 Relay Component Applicability**

a,c

**Table 9-1 Relay Component Applicability (continued)**

a,c

**Table 9-2 Summary of Non-relay Failures**

a,c

## Table 9-2 Summary of Non-relay Failures (continued)

a,c

**Table 9-3 Summary of Relay Failures Due to Human Errors**

a,c

**Table 9-4 Summary of Failed Relays in Normally Energized Applications**

a,c

## Table 9-5 Analysis of Potential Cutler-Hammer Relay Failures

a,c

**Table 9-6 NPRDS Cutler-Hammer Relay Failures**

a,c

**Table 9-6 NPRDS Cutler-Hammer Relay Failures**

a,c

**Table 9-6 NPRDS Cutler-Hammer Relay Failures**

a,c

**Table 9-6 NPRDS Cutler-Hammer Relay Failures**

a,c

**Table 9-6 NPRDS Cutler-Hammer Relay Failures**

a,c

## Table 9-6 NPRDS Cutler-Hammer Relay Failures

a,c

## Table 9-6 NPRDS Cutler-Hammer Relay Failures

a,c

### Table 9-6 NPRDS Cutler-Hammer Relay Failures

a,c

**Table 9-6 NPRDS Cutler-Hammer Relay Failures**

a,c

### Table 9-6 NPRDS Cutler-Hammer Relay Failures

a,c

## Table 9-6 NPRDS Cutler-Hammer Relay Failures

a,c

**Table 9-6 NPRDS Cutler-Hammer Relay Failures**

a,c

**Table 9-6 NPRDS Cutler-Hammer Relay Failures**

a,c

**Table 9-6 NPRDS Cutler-Hammer Relay Failures**

a,c

## Table 9-6 NPRDS Cutler-Hammer Relay Failures

a,c

## Table 9-6 NPRDS Cutler-Hammer Relay Failures

a,c

**Table 9-6 NPRDS Cutler-Hammer Relay Failures**

a,c

## Table 9-6 NPRDS Cutler-Hammer Relay Failures

a,c

# 10.0 CONCLUSIONS OF FMEA

## 10.1 GENERAL CONCLUSIONS

Failure mechanisms dependent on age/temperature effects can be accelerated by relay operating mode or duty cycle. Even among ND relays, the duty cycle during refueling outages will affect the probability of age/temperature related failure mechanisms. Representative calculations for the D26MR802A summarized in Section 8.0 show the impact on service life for the relay with a 0 percent energized duty cycle and a 20 percent energized duty cycle. Three compounds of loctite identified in Section 8.0 indicate that the relay should be replaced more frequently than the 40 year design life of the SSPS. However, the FMEA concludes that the failure of the components associated with the parts that are bonded by the loctite are of insignificant consequence with respect to the ability of the D26MR802A relay used as an SSPS slave relay to perform the required safety function. These and other potential failure mechanisms are discussed in further detail below.

## 10.2 RELAY BINDING

The relay binding failure mode is of particular concern for the SSPS slave relays. This failure mode is defined generally as a mechanical condition which prevents the relay from changing state on demand. Relay binding is postulated to occur in the D26MR802A relays due to the following failure mechanisms.

1. The mechanical release mechanism does not release on demand, or
2. excessive friction between moving and stationary components.

Excessive friction between stationary and moving relay components results from several potential root causes. Increased friction between components may be caused by normal wear, age-related degradation of component materials, or dirt or debris entering the relay. Routine wear is not postulated to result in excessive friction or binding of the relays. Given the low cycle life demands for SSPS slave relays, relay wear degradation is minimal. This is because of the very low number of relay operating cycles expected over the plant life (e.g., 1000) versus the designed and test-demonstrated capability of the relay (i.e., 10,000,000).

[

]a,c

## 10.3 Core Magnet Assembly Shading Coil Adhesive

a, c

## 10.4 Pull Rod

a, c

## 10.5 CONTACTS

Failure modes and effects postulated for the relay contacts are generic to all relay types. Those reflected in Table 7-1 (see "Contacts") are not unique to the D26 type relay. Most relay contact failures are a result of misapplication of the relay and not due to the relay design.

The fusing of relay contacts most commonly results from relay misapplication. This failure mechanism is the direct result of contacts experiencing currents in excess of their maximum rating (60 Amps making; 6 Amps breaking). For the purposes of this evaluation, it is assumed that most cases of excessive contact loading have been resolved. Confidence is affirmed by:

- Very few contact failures have been reported.
- Factory acceptance testing and plant start-up testing have identified no significant design flaws.
- Good housekeeping prevails at the SSPS cabinet locations.
- High temperature and high relative humidity is not a concern due to plant heating, ventilation and air-conditioning systems.
- It is also assumed that a contact loading analysis in accordance with the SER contained in Reference 14.5-1 has been or will be performed to ensure that the D26M relay contacts are acceptable for their intended application.

Therefore, the probability of contact failure in SSPS slave relays is significantly less than that for industrial applications of control relays.

## 10.6 LATCH ATTACHMENT

For SSPS slave relays equipped with a latch, latch operation is not critical to the initiation of the safety function performed by the relay. A failure to latch will not prevent successful automatic ESFAS actuation(s). The purpose of the latch on SSPS slave relays is to maintain the ESFAS function until reset by the operator. The actuation circuitry is configured to provide continuous energization of the slave relays as long as a valid actuation signal exists. No failure of the latch attachment will prevent ESFAS actuation.

Failure of the latch to make may have consequence only when the trip condition is reset, and prior to operator actions to reset individual functions (e.g., SI). In most cases, the signal is sealed-in by other circuit components. For these, the postulated latch failure may not be of consequence. Where the latching slave relay is the sole seal in, inadvertent reset may result in an increase in accident consequences.

Failure of an SSPS slave relay to unlatch is not a failure to perform its automatic safety function. A failure to unlatch on demand is readily detectable. For example, SI reset is performed manually by the operator as directed by the Emergency Response Procedures (ERP). The ERPs also direct the operator to verify that SI reset has occurred. If a given SI relay fails to reset, other measures can be taken, with a small penalty in time.

Latch coils are normally de-energized and have the same insulation material as the relay coil. Furthermore, latch coil energizations are exclusively of momentary duration precluding the possibility that self-heating is a factor in latch coil life or reliability. It is concluded that these postulated failure modes/mechanisms for the latch coils used on SSPS slave relays are highly improbable over the 40 year plant life.

## 10.7 OTHER FACTORS

The following subsections address environmental factors postulated to cause certain relay failures or accelerate failure mechanisms which are time/temperature-dependent. Conditions in typical industrial areas are discussed and compared to conditions in nuclear plant areas where the SSPS is installed. Extreme or damaging forms of these environs exist in many industries, but are virtually absent from the normal operating conditions of most nuclear plant "mild" environment areas.

### 10.7.1 Dirt, Debris and Contamination

Among the challenges to reliability of industrial control relays are adverse effects of dirt, debris and contamination. In typical industrial applications these factors may, at times, represent the greatest challenge to relay operability. Ultimately, adverse effects of dirt, debris, and contamination (e.g., mining applications) will lead to some of the failure modes described in Section 7.0.

Large accumulations of dust may foul contacts or increase friction between moving parts of the relay. Contact fouling may contribute directly and indirectly to high contact resistance. Dust "flashing" on contact closure/energization will leave carbon residue. The effect can be additive with successive operations. Extreme cases of flashing will "pit" the contact surface. Pitting, alone, will degrade contact performance reducing the effective contact surface and or increasing contact resistance. Pitting can also increase the potential for contact corrosion. In particularly dirty environments, contact fusing will eventually result from increasing contact resistance and abrasive degradation of the contact surface.

Debris (e.g., foreign material chips, loose screws) may become lodged in the relay, preventing mechanical movement.

Chemical contamination (e.g., oil, corrosive chemistry) may be the result of inadvertent spray from adjacently mounted equipment or processes. The degradation process is similar to that described above for large accumulations of dust.. Again, the leading concern is for degradation of the relay contacts, though in general, other relay components and materials may be equally vulnerable.

Typical industrial environments provide significant opportunity for the above mechanisms to occur in extreme. This is not the case in nuclear power plants. Housekeeping conditions in nuclear plant control rooms are exceptional by comparison to most primary industry or mining operations. The SSPS is located in or adjacent to the main control rooms where environmental conditions generally are milder than the shipping/storage conditions specified by the vendors. While these nuclear plant areas are not "dust-free", there are no large accumulations of dust or dirt as might be expected near lathes or on mining equipment. Periodic inspection of the SSPS cabinets typically include housekeeping checks, with cleaning performed as needed.

The SSPS cabinets are normally required to be closed at all times, except during authorized surveillance. This requirement arises from seismic qualification requirements and concern for "missile" damage by flying debris during a seismic event. Even during plant surveillance, access to the cabinets is subject to procedural control. Furthermore there are no sources of missiles or inadvertent chemical/oil spray (as might result from rupture of a hydraulic cylinder or hose) in nuclear plant control rooms.

The SSPS cabinets have good defense to sources of dust, debris and contamination. The SSPS is located in plant areas where dust is minimal and where debris and contamination are non-existent. Random, non-time dependent failure modes associated with dirt, debris and contamination are considered to have a very low probability. For this reason, the SSPS slave relays are expected to perform with above average reliability.

### 10.7.2 High Ambient Temperature

Temperature-induced aging degradation of materials is minimized by temperature controls in the SSPS cabinet locations. Furthermore plants provide climate control (i.e., heating, ventilation, and air-conditioning; HVAC) with Class 1E powered redundant systems. Table 8-1 of Reference 14.5-1 lists the ambient temperature ranges for plants which responded to the WOG survey. Westinghouse recommends a 40 year shelf life for type AR relays when stored at or below 120 °F. Normal ambient temperatures in SSPS cabinet areas are well within the specified shelf life conditions.

Extensive temperature monitoring efforts for the Farley Nuclear Plant (FNP) spanning (date 1992 to date 1993) are summarized in Table 8-2 of Reference 14.5-1. These data are considered to be typical of domestic nuclear plants. As such, the FNP data is used in the aging assessment calculations.

### 10.7.3 High Relative Humidity

High relative humidity will accelerate corrosion of relay contacts, especially in applications where there are few and infrequent operations of normally open relay contacts. Room heating and air-conditioning in the SSPS cabinet locations minimizes relative humidity. In general, nuclear plant environmental controls maintain the relative humidity in the main control room and adjacent equipment rooms at non-condensing levels. Thus, it is expected that corrosion of SSPS slave relay contacts should be at a minimum throughout their service life. This is demonstrated by the few reported cases of contact replacements cited for the SSPS slave relays.

## 11.0 BASIS FOR ASSESSING SLAVE RELAY RELIABILITY

Standard sources of relay reliability typically base the reliability of relays on numbers of failures per accumulated cycles of operation. For industrial control relays, reliability is assessed on the number of failures expected per 10,000, 100,000, or 1 million relay operations, as recommended in the National Relay Manufacturers Association (NRMA) Handbook. These bases are derived from expectations that industrial control relays will accumulate 10,000 to over a million cycles of operation over their service life, and that failure, when it ultimately occurs, will be the result of wear. Furthermore, some applications of industrial control relays may demand 10,000 to a million cycles of operation in a single year.

Based on the WOG survey data shown in Section 9.0 of Reference 14.5-1, the type AR relays have a relatively low failure-per-hour rate when used as the SSPS slave relays in domestic nuclear plants. For the 10 plants contributing data, the time-based failure rate is 4.4E-08 failures per hour of service collectively for 1, 3 and 18 month test intervals for the type AR slave relays. This is two orders of magnitude less than the 3.1E-06 best estimate for failures per hour of service for 120 to 199 volt AC control relays recommended in IEEE-500-1984 (Reference 14-2). Statistically, this is a favorable comparison since there are far fewer AR relays and service hours for AR relays, documented in Reference 14.5-1, than relays in general, documented in IEEE-500-1984. Considering the relatively low temperature, low duty cycles and absence of other conditions which challenge relay operability, it is anticipated that the type AR relay and the replacement D26MR802A relay hourly failure rate would be significantly less if more relay data were available.

While the Westinghouse type AR and the D26MR802A relays are industrial control type relays, service in the SSPS slave relay application is not typical of industrial control relay applications. Both relays are designed for millions of operations. However, SSPS slave relays are estimated to perform approximately 1000 operations within a 40-year service life in nuclear power plant. It can be concluded that the standard references for industrial control relay reliability have little relevance to the SSPS slave relay application. That is, it is very unlikely that the SSPS slave relays will be degraded by factors of wear or frequent operational stress. It is more likely that the SSPS slave relays will experience component degradation due to the effects of temperature and age, and that failures will occur as isolated random events over the majority of their service life.

Thus, it is proposed that the reliability of SSPS slave relays should be assessed on the basis of their resistance to temperature-induced and aging-related degradation. The aging assessment, Section 8.0, demonstrates that the degradation of SSPS slave relays requires substantial time, given the mild temperature environments which prevail in the typical SSPS location, and the absence of other environmental challenges to relay operation and reliability. Furthermore, the rate of degradation is sufficiently slow that testing at a three-month interval is no more likely to detect significant changes in the SSPS slave relays than testing at an 18 to 24 month interval.

## 12.0 ANALYSIS SUMMARY

In the absence of high ambient temperatures, significant accumulations of dirt and debris, and sources of contamination, no failure modes have been identified that would be accelerated or catalyzed in the normally de-energized type AR relays nor would be expected in the replacement D26MR802A relay. Of the valid failures reported for type AR relays (Reference 14.5-1) and the D26MR802A relay, few constitute a concern for a failure of an SSPS slave relay to perform its primary safety related function.

The FMEA (Section 7.0) cites failure mechanisms which are postulated due to the degradation of the relay materials. However, conditions in the SSPS output relay cabinet are sufficiently mild that the time dependent failure modes are not likely to occur within the 40-year plant life. Furthermore, the very slow rate of degradation in material properties is equally insignificant at the three-month or refueling (18 - 24 month) intervals.

## 13.0 CONCLUSION

Based on the reliability assessment of the type AR SSPS slave relay contained in Reference 14.5-1 and the supplemental reliability assessment of the D26MR802A replacement relay contained in this report, the assumed initial quarterly test interval supported by WCAP-10271-P-A Supplement 2 Rev 1 (Reference 14.5-3) is overly conservative. Slave relay testing may be extended to a refueling basis without impact or consequence to relay reliability.

## 14.0 REFERENCES


14-1 IEEE Standard 352-1987, "IEEE Guide for General Principles of Reliability Analysis of Nuclear Power Generating Stations Safety Systems"

14-2 IEEE Standard 500-1984, "Guide to the Collection and Presentation of Electrical, Electronic, and Sensing Component Reliability Data for Nuclear-Power Generating Stations"

14-3 CUTLER-HAMMER AC AND DC RELAYS – D26 Type M Multipole Relay – Technical Information Publication D26 (10/1/87)

14-4 RRS/EMPE(02)-345, "Temperature Study For Cutler Hammer Relays Model D26MR802A", Revision 0, Westinghouse Proprietary Class 2


## 14.1 GENERIC COMMUNICATIONS ON RELAYS


14.1-1 RO Bulletin 74-12, "Incorrect Coils in Westinghouse Type SG Relays at Trojan", 10/21/74

14.1-2 I&E Bulletin 76-02, "Relay Coil Failures - GE Type HFA, HGA, HKA, HMA Relays", 3/12/76

14.1-3 I&E Bulletin 76-03, "Relay Malfunctions - GE Type STD Relays", 3/15/76

14.1-4 I&E Bulletin 76-05, "Relay Failures - Westinghouse BFD Relays", (Not Dated)

14.1-5 I&E Bulletin 77-02, "Potential Failure Mechanism in Certain Westinghouse AR Relays with Latch Attachments", 9/12/77

14.1-6 I&E Bulletin 78-01, "Flammable Contact-Arm Retainers in GE CR120A Relays", 1/16/78

14.1-7 I&E Bulletin 78-06, "Defective Cutler-Hammer, Type M Relays with DC Coils", 5/31/78

## 14.1 GENERIC COMMUNICATIONS ON RELAYS (continued)

14.1-8 I&E Bulletin 79-25, "Failures of Westinghouse BFD Relays in Safety-Related Systems", 11/2/79; includes excepts from Westinghouse letter TS-E-412, December 6, 1978.

14.1-9 I&E Bulletin 80-19 Revision 1, "Failures of Mercury-Wetted Matrix Relay in Reactor Protective Systems of Operating Nuclear Power Plants Designed by Combustion Engineering", 8/13/80

14.1-10 I&E Bulletin 84-02, "Failures of General Electric Type HFA Relays in use in Class 1E Safety Systems", 3/12/84

14.1-11 I&E Bulletin 88-03, "Inadequate Latch Engagement in HFA Type Latching Relays Manufactured By General Electric (GE) Company", 3/10/88

14.1-12 I&E Circular 76-02, "Relay Failures Westinghouse BF (ac) and BFD (dc) Relays", 8/18/76

14.1-13 I&E Circular 79-20, "Failure of GTE Sylvania Relay, Type PM Bulletin 7305, Catalog 5U12-11-AC with 1 120V AC Coil", 9/24/79

14.1-14 I&E Circular 80-01, "Service Advice for General Electric Induction Disc Relays", 1/17/8

14.1-15 I&E Notice 81-01, "Possible Failure of General Electric Type HFA Relays", 1/16/81

## 14.1 GENERIC COMMUNICATIONS ON RELAYS (continued)

14.1-16 I&E Notice 82-02, "Westinghouse NBFD Relay Failures in Reactor Protection Systems at Certain Nuclear Power Plants", 1/27/82

14.1-17 I&E Notice 82-04, "Potential Deficiency of Certain Agastat E-7000 Series Time-Delay Relays", 3/10/82

14.1-18 I&E Notice 82-13, "Failures of General Electric Type HFA Relays", 5/10/82

14.1-19 I&E Notice 82-48, "Failures of Agastat CR 0095 Relay Sockets", 12/3/82

14.1-20 I&E Notice 82-50, "Modification of Solid State AS Undervoltage Relays Type ITE-27", 12/20/82

14.1-21 I&E Notice 82-54, "Westinghouse NBFD Relays Failures in Reactor Protection Systems, 12/27/82

14.1-22 I&E Notice 82-55, "Seismic Qualification of Westinghouse AR Relay With Latch Attachments Used In Westinghouse Solid State Protection System", 12/28/82

14.1-23 I&E Notice 83-19, "General Electric Type HFA Contact Gap and Wipe Setting Adjustments", 3/5/83

## 14.1 GENERIC COMMUNICATIONS ON RELAYS (continued)

14.1-24 I&E Notice 83-38, "Defective Heat Sink Adhesive and Seismically Induced Chatter in relays Within Printed Circuit Cards", 6/13/83

14.1-25 I&E Notice 83-63, "Potential Failures of Westinghouse Electric Corporation Type SA-1 Differential Relays", 9/26/83

14.1-26 I&E Notice 83-63 Supplement 1, "Potential Failures of Westinghouse Electric Corporation Type SA-1 Differential Relays", 2/15/84

14.1-27 I&E Notice 84-20, "Service Life of Relays in Safety-Related Systems", 3/21/84

14.1-28 I&E Notice 85-49, "Relay Calibration Problem", 7/1/85

14.1-29 I&E Notice 85-82, "Diesel Generator Differential Protection Relay Not Seismically Qualified", 10/18/85

14.1-30 NRC Information Notice 87-66, "Inappropriate Application of Commercial Grade Components", 12/31/87

14.1-31 NRC Information Notice 88-14, "Potential Problems With Electrical Relays", 4/18/88

14.1-32 NRC Information Notice 88-45, "Problems in Protective Relay and Circuit Breaker Coordination", 7/7/88

14.1-33 NRC Information Notice 88-58, "Potential Problems With ASEA Brown Boveri ITE-51L Time-Over Current Relays", 8/8/88

14.1-34 NRC Information Notice 88-69, "Movable Contact Finger Binding in HFA Relays Manufactured by General Electric (GE)", 8/19/88

## 14.1 GENERIC COMMUNICATIONS ON RELAYS (continued)

14.1-35 NRC Information Notice 88-69 Supplement 1, "Movable Contact Finger Binding in HFA Relays Manufactured by General Electric (GE)", 9/29/88

14.1-36 NRC Information Notice 88-83, "Inadequate Testing of Relay Contacts in Safety-Related Logic Systems", 10/19/88

14.1-37 NRC Information Notice 88-88, "Degradation of Westinghouse ARD Relays", 11/16/88

14.1-38 NRC Information Notice 88-88 Supplement 1, "Degradation of Westinghouse ARD Relays", 5/31/89

14.1-39 NRC Information Notice 88-98, "Electrical Relay Degradation Caused by Oxidation of Contact Surfaces", 12/19/88

14.1-40 NRC Information Notice 90-57, "Substandard, Refurbished Potter & Brumfield Relays Misrepresented as New", 9/5/90

14.1-41 NRC Information Notice 90-57, Supplement 1, "Substandard, Refurbished Potter & Brumfield Relays Misrepresented as New", 11/27/91

14.1-42 NRC Information Notice 91-45, "Possible Malfunction of Westinghouse ARD, BFD, and NBFD Relays, and A200 DC and DPC 250 Magnetic Contactors", 7/5/91

14.1-43 NRC Information Notice 92-04, "Potter & Brumfield Model MDR Rotary Relay Failures", 1/6/92

14.1-44 NRC Information Notice 92-05, "Potential Coil Insulation Breakdown in ABB RXMH2 Relays", 1/8/92

14.1-45 NRC Information Notice 92-19, "Misapplication of Potter & Brumfield MDR Rotary Relays", 3/2/92

14.1-46 NRC Information Notice 92-24, "Distributor Modification to Certain Commercial-Grade Agastat Electrical Relays", 3/30/92

## 14.1 GENERIC COMMUNICATIONS ON RELAYS (continued)

14.1-47 NRC Information Notice 92-27, "Thermally Induced Accelerated Aging and Failure of ITE/Gould AC Relays Used in Safety-Related Applications", 4/3/92

14.1-48 NRC Information Notice 92-45, "Incorrect Relay Used in Emergency Diesel Generator Output Breaker Control Circuitry", 6/22/92

14.1-49 NRC Information Notice 92-77, "Questionable Selection and Review to Determine Suitability of Electropneumatic Relays for Certain Applications", 11/17/92

## 14.2 GENERIC COMMUNICATIONS RELATED TO ESFAS SYSTEMS

14.2-1 I&E Bulletin 77-03, "On-Line Testing of Westinghouse Solid State Protection System (SSPS)", 9/12/77 (Cites Westinghouse Technical Bulletin NSD-TB-77-11.)

14.2-2 I&E Bulletin 80-06, "Engineered Safety Feature (ESF) Reset Controls", 3/13/80

14.2-3 I&E Notice 79-04, "Degradation of Engineered Safety Features"

14.2-4 I&E Notice 81-10, "Inadvertent Containment Spray Due to Personnel Error", 3/25/81

14.2-5 I&E Notice 81-15, "Degradation of Automatic ECCS Actuation Capability by Isolation of Instrument Lines"

14.2-6 I&E Notice 82-10, "Following Up Symptomatic Repairs to Assure Resolution of the Problem", 3/31/82

14.2-7 I&E Notice 82-19, "Loss of High Head Safety Injection Emergency Boration and Reactor Coolant Makeup Capability", 6/18/82

## 14.2 GENERIC COMMUNICATIONS RELATED TO ESFAS SYSTEMS (continued)

14.2-8 I&E Notice 84-37, "Use of Lifted Leads and Jumpers During Maintenance or Surveillance Testing", 5/10/84

14.2-9 I&E Notice 84-39, "Inadvertent Isolation of Containment Spray Systems", 5/25/84

14.2-10 I&E Notice 85-18, "Failures of Undervoltage Output Circuit Boards in the Westinghouse Designed Solid State Protection System", 3/7/85

14.2-11 I&E Notice 85-18 Supplement 1, "Failures of Undervoltage Output Circuit Boards in the Westinghouse Designed Solid State Protection System", 9/10/91

14.2-12 I&E Notice 85-23, "Inadequate Surveillance and Postmaintenance and Postmodification System Testing", 3/22/85

14.2-13 I&E Notice 85-51, "Inadvertent Loss or Improper Actuation of Safety-Related Equipment, 7/10/85

14.2-14 I&E Notice 87-01, "RHR Valve Misalignment Causes Degradation of ECCS in PWRs", 1/6/87

## 14.3 WESTINGHOUSE TECHNICAL BULLETINS

14.3-1 NSD-TB-76-2, February 18, 1976, "BFD Relays", System(s): Reactor Protection System.

14.3-2 NSD-TB-76-16, November 22, 1976, "BFD & NBFD Relays", System(s): Relay Reactor Protection Systems, Relay Engineered Safeguards Systems.

14.3-3 NSD-TB-77-10, July 21, 1977, "AR Relays with Latch Attachments", System(s): Solid State Protection System (SSPS) and Auxiliary Safeguards Cabinets (ASG).

## 14.3 WESTINGHOUSE TECHNICAL BULLETINS (continued)

14.3-4 NSD-TB-79-05, August 14, 1979, "NBFD Relays", System(s): Relay Reactor Protection System, and Relay Engineered Safeguards Systems.

14.3-5 NSD-TB-81-14, December 7, 1981, "BFD (NBFD) Relays", System(s): Reactor Protection and Safeguard Systems.

14.3-6 NSD-TB-81-14, Rev. 1, January 15, 1982, "BFD (NBFD) Relays", System(s): Reactor Protection and Safeguard Systems.

14.3-7 NSD-TB-82-03, June 24, 1982, "AR Relays with Latch Attachments", System(s): Solid State Protection System and Auxiliary Safeguards Cabinets.

14.3-8 NSD-TB-82-03, Rev. 1, December 14, 1982, "AR Relays with Latch Attachments", System(s): Solid State Protection System and Auxiliary Safeguards Cabinets.

14.3-9 NSID-TB-85-16, July 31, 1985, "SSPS Undervoltage Output Driver Card", System(s): Solid State Protection System (SSPS).

14.3-10 NSD-TB-92-02, Rev. 0, January 24, 1992, "Misapplied Relay Contacts", System(s): Solid State Protection System (SSPS).

## 14.4 WESTINGHOUSE DRAWING

14.4-1 [ ][a,b,c]

## 14.5 WESTINGHOUSE WCAP

14.5-1 WCAP-13877 Revision 2-P-A, "Reliability Assessment of Westinghouse Type AR Relays Used as SSPS Slave Relays ", Westinghouse Proprietary Class 2C

14.5-2 WCAP-13878-P-A Rev 2, "Reliability Assessment of Potter & Brumfield MDR Series Relays", Westinghouse Proprietary Class 2C

14.5-3 WCAP-10271-P-A Supplement 2 Rev 1, "Evaluation of Surveillance Frequencies and Out of Service Times for the Engineered Safety Features Actuation System", Westinghouse Proprietary Class 2