CEOG COMBUSTION ENGINEERING OWNERS GROUP

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Revision 01

# REACTOR TRIP CIRCUIT BREAKERS SURVEILLANCE FREQUENCY EXTENSION

FINAL REPORT

CEOG TASK 787

prepared for the

C-E OWNERS GROUP

September 1994



ABB Combustion Engineering Nuclear Power

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## LEGAL NOTICE

# Executive Summary

nuclear power plant units with ABB Combustion Engineering designed Nuclear am Supply Systems (NSSS) utilize General Electric (GE) type AK-2-25 circuit eakers as reactor trip circuit breakers (RTCBs). Another 3 units use a ombination of GE Type AKR-4BE-30 and Westinghouse Type DS-206 circuit reakers. In the early-mid 1980's the performance of RTCBs was called into question by the anticipated transients without scram (ATWS) events at the Salem Nuclear Generating Station. Since that time, industry and NRC efforts to improve RTCB performance have shown significant results, such that the reliability of these circuit breakers now is better than that assumed in probabilistic risk assessments.

The Class 1E function of the RTCBs is to interrupt power to the control element drive mechanisms upon receipt of a trip signal. General Design Criteria 23 (GDC-23) requires protection systems fail into a safe state on loss of energy. To meet GDC-23, RTCBs must be actuated by a loss of control power in addition to any other means of actuation. RTCBs used in the industry generally have two means of tripping open. The shunt trip device is normally deenergized, and energizes to trip the breaker open. The undervoltage (UV) trip device is normally energized, and opens on being deenergized, thus satisfying GDC-23. The C-E reactor trip system design has always actuated both the shunt and UV trip devices on receipt of either an automatic or manual reactor trip.

Many RTCB failures are associated with reclosing the RTCB after opening it during surveillance testing or preventive maintenance. While this is more of a nuisance type of failure than a safety problem, it constitutes the largest single type of failures found in this investigation. This type of failure may be the result of overtesting the RTCBs.

This report provides justification for extending the surveillance test interval for Functional Tests of the manual trip of the RTCBs from monthly to quarterly. Also, justification is provided for an extension of the present 1 hour allowed outage time for the RTCBs. These changes affect LCO 3.3.3 (Analog), 3.3.4 (Digital), of the Improved Standard Technical Specifications, NUREG-1432, for C-E plants.

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## Executive Summary

Ten nuclear power plant units with ABB Combustion Engineering designed Nuclear Steam Supply Systems (NSSS) utilize General Electric (GE) type AK-2-25 circuit breakers as reactor trip circuit breakers (RTCBs). Another 3 units use a combination of GE Type AKR-4BE-30 and Westinghouse Type DS-206 circuit breakers. In the early-mid 1980's the performance of RTCBs was called into question by the anticipated transients without scram (ATWS) events at the Salem Nuclear Generating Station. Since that time, industry and NRC efforts to improve RTCB performance have shown significant results, such that the reliability of these circuit breakers now is better than that assumed in probabilistic risk assessments.

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Although there is still a number of RTCB problems reported in NPRDS for C-E plants, the performance is much better than it was a decade ago. With the number of RTCBs being greater at C-E NSSS plants than at the plants with other

NSSS designs, it should be expected that there would be more reported failures. Putting this in perspective, the average number of reported problems is about 0.3 per breaker per year. With 1 failure in 7-1/2 years of operation (since 1986), Appendix A calculates a failure rate of 0.6 E-4 per demand. This is better than assumed in current probabilistic risk assessments.

Previous work by the Combustion Engineering Owners Group has justified extending the surveillance interval for Functional Tests of the Reactor Protective System from monthly to quarterly. This has resulted in extending the accompanying automatic actuation of the RTCBs for this test. This has helped in reducing the number of RTCB actuations in a small way.

Although the RTCBs are locally actuated on a monthly basis, there may be some concern that a circuit breaker could go untested for a period of 3 months. To alleviate this concern, it is proposed that the manual Functional Tests of the RTCBs be performed at a staggered interval with the automatic RPS Functional Test that also actuates the RTCBs. Thus the RTCBs will continue to be tested at least once every 6 weeks, and manually actuated more frequently.

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## 1.0 INTRODUCTION

The Reactor Protective System (RPS) and Plant Protection System (PPS) of most ABB Combustion Engineering (C-E) designed nuclear steam supply systems (NSSS) utilize circuit breakers to interrupt power to the control element assembly power supplies. In the C-E protection system, these circuit breakers are variously referred to as Reactor Trip Switchgear (RTSG) and Reactor Trip Circuit Breakers (RTCBs). The term RTCB will be used in this report to refer to an individual circuit breaker, while RTSG will be used to refer to the arrangement of these breakers in a plant.

This report examines the operating history of the RTCBs, and recommends changes in surveillances to reduce overtesting, which should increase the reliability of the RTCBs, while minimizing the potential for challenges to plant systems through inadvertent scrams.

This report was prepared as an account of efforts funded by the Combustion Engineering Owners Group (CEOG). Its purpose is to provide a technical basis for altering plant technical specifications to allow for the following:

1. Extension of the surveillance test interval (STI) from monthly to quarterly for the functional test of the RTCBs.

2. Extension of the allowable outage time (AOT) for operation with an inoperable RTCB from one hour to two hours. (Also to allow plants that do not have this provision to adopt it.)

The underlying problem being addressed is overtesting of this important piece of equipment. 238 RPS circuit breaker failures (out of roughly 60,000 actuations) at CEOG plants were identified from the review of the INPO Nuclear Plant Reliability Data System (NPRDS) information dealing with circuit breaker failures in the Reactor Protective System (RPS) for plants of C-E nuclear steam supply system (NSSS) design. The majority were failures to close following testing or maintenance. The second highest category of failure deals with problems of the undervoltage trip device; this has been the subject of much consideration by the industry and the NRC, and is the major concern to be addressed by this report. In only 2 cases in about 125 operating-experience years did a RTCB actually fail to open; and in no case would the failure have prevented a successful reactor trip.

This report is divided into the following sections:

- A background section discusses: 1) the safety function of the RTCBs, and their arrangement into RTSG, 2) a brief history of the problems that have been experienced with the RTCBs, 3) industry experience with the undervoltage and shunt trip devices, 4) the surveillance testing performed on the RTCBs, and 5) the allowable outage time presently allowed.

- A discussion section addressing criteria for extending the STI and AOT for the RTCBs, and how these criteria are met.

- A conclusion section justifying the recommended STI and AOT extensions.

- A list of references (arranged as a chronological bibliography).

## 2.0 BACKGROUND

### 2.1 Description

There are three types of reactor trip switch gear systems in use on plants with a C-E designed NSSS:

1. The first generation RTSG design. This design, which is used at Palisades and Fort Calhoun Station, uses motor contactors rather than circuit breakers.

2. The second generation RTSG design. This design makes use of the General Electric AK-2-25 type breaker. The AK-2-25 type is a 600 volt, 600 amp, 3 phase, electrically operated air frame (as opposed to molded case) type circuit breaker (ACB) with shunt trip (ST) and undervoltage (UV) trip devices. This second generation is a nine breaker design as shown in Figure 1, with the ninth breaker capable of cross-tying the output of the two motor-generator (MG) sets. The ninth breaker does not operate on a reactor trip. The following C-E NSSS plants utilize this design:

   Maine Yankee (RPS)
   Calvert Cliffs Units 1 & 2 (RPS)
   Millstone Point Unit 2 (RPS)
   St. Lucie Units 1 and 2 (RPS)
   Arkansas Nuclear One - Unit 2 (PPS)
   San Onofre Units 2 & 3 (PPS)
   Waterford Unit 3 (PPS)

   Some of these plants utilize a AK-2A-25 breaker. The "AK-2A" version differs from the "AK-2" version in that the "AK-2A" has an AKD-5 interlock mechanism that prevents a breaker rackout unless the breaker is open. The AK-2-25 breaker is shown in Figure 3.

3. The System 80 PPS design. This design is used at Palo Verde Units 1, 2 and 3 and Yongwang (YGN) Units 3 & 4. This design includes only four RTCBs, as shown in Figure 2; one RTCB is actuated from each PPS output channel. Both General Electric AKR-30 type and Westinghouse DS-206 type breakers have been used. Both the GE and Westinghouse breakers are similar to the AK-2-25 breakers in that they are air frame breakers having both shunt trip and undervoltage devices. They differ from the older breakers in that they are motor operated, rather than solenoid operated, and are rated for 800 amps (the next larger frame size).

   The diversity in manufacturer feature was originally provided to improve reliability against common-mode failure, should such a concern arise. Recent concerns with the availability of the DS-206 type breaker have led to a discontinuance of its use. The DS-206 circuit breakers will be replaced with the Westinghouse DS-416 type circuit breakers.

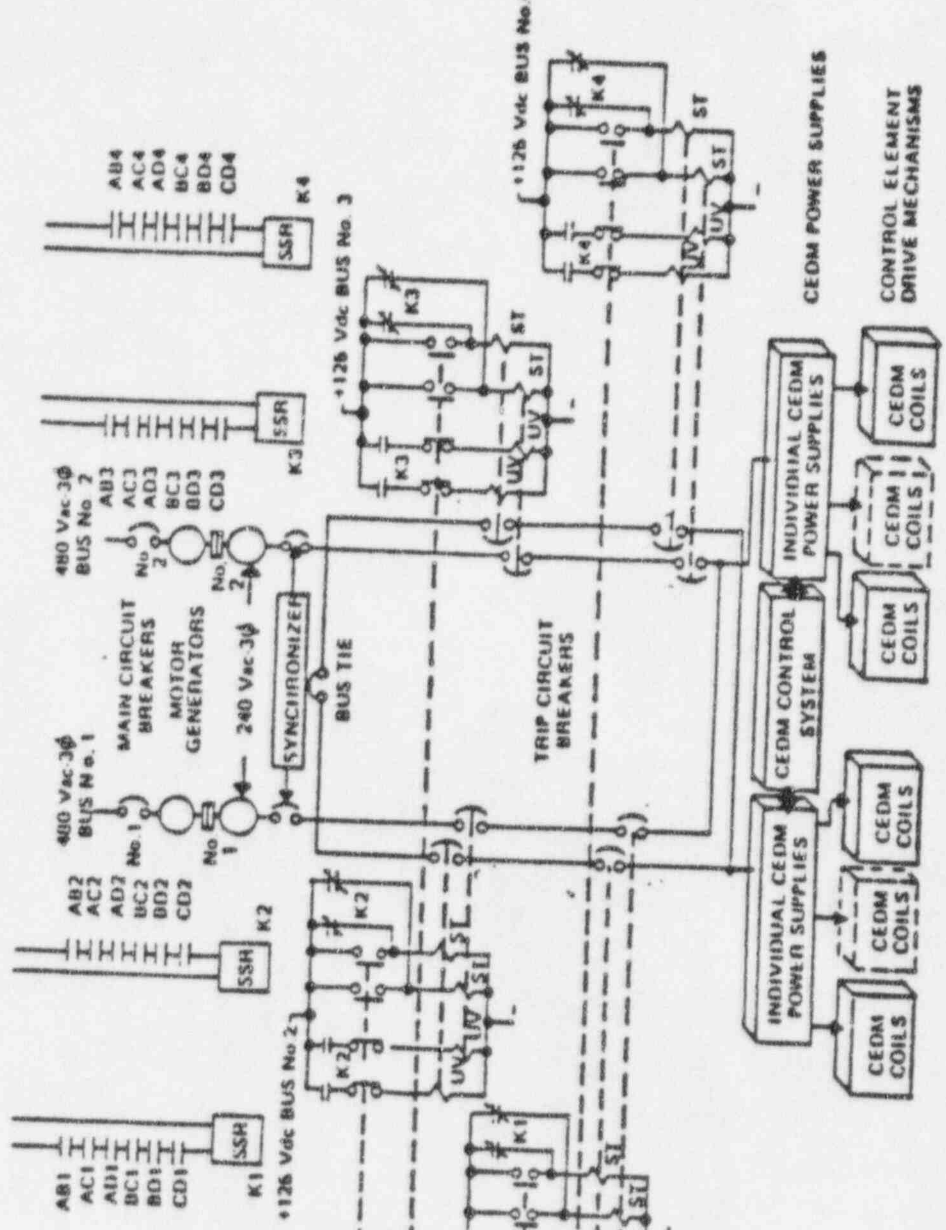


Figure 1
Second Generation Reactor Trip Switchgear Arrangement
-- Shown in an Unpowered (tripped) Condition --

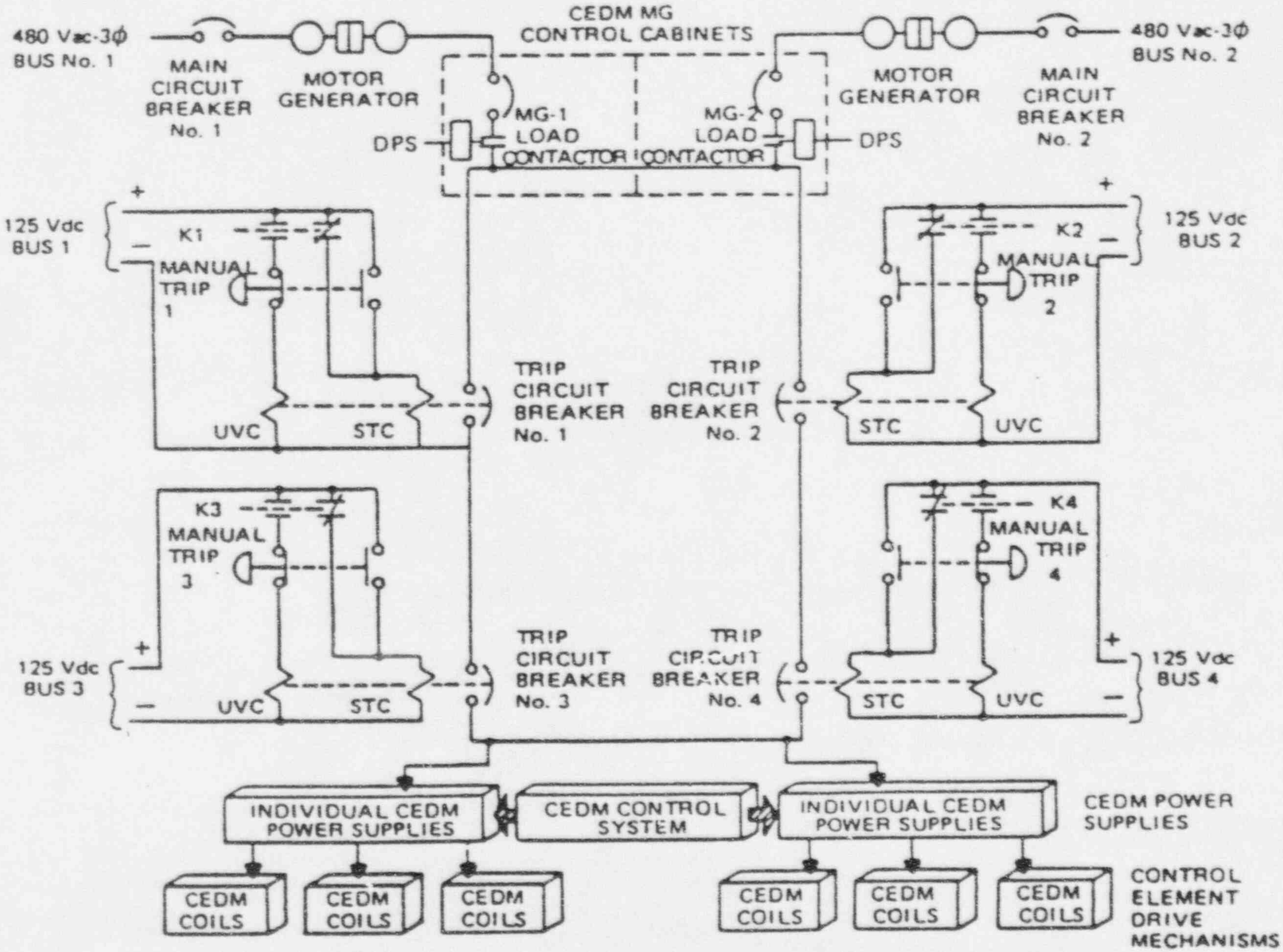


Figure 2
System 80 Reactor Trip Switchgear Arrangement
-- Shown in an Unpowered (tripped) Condition --

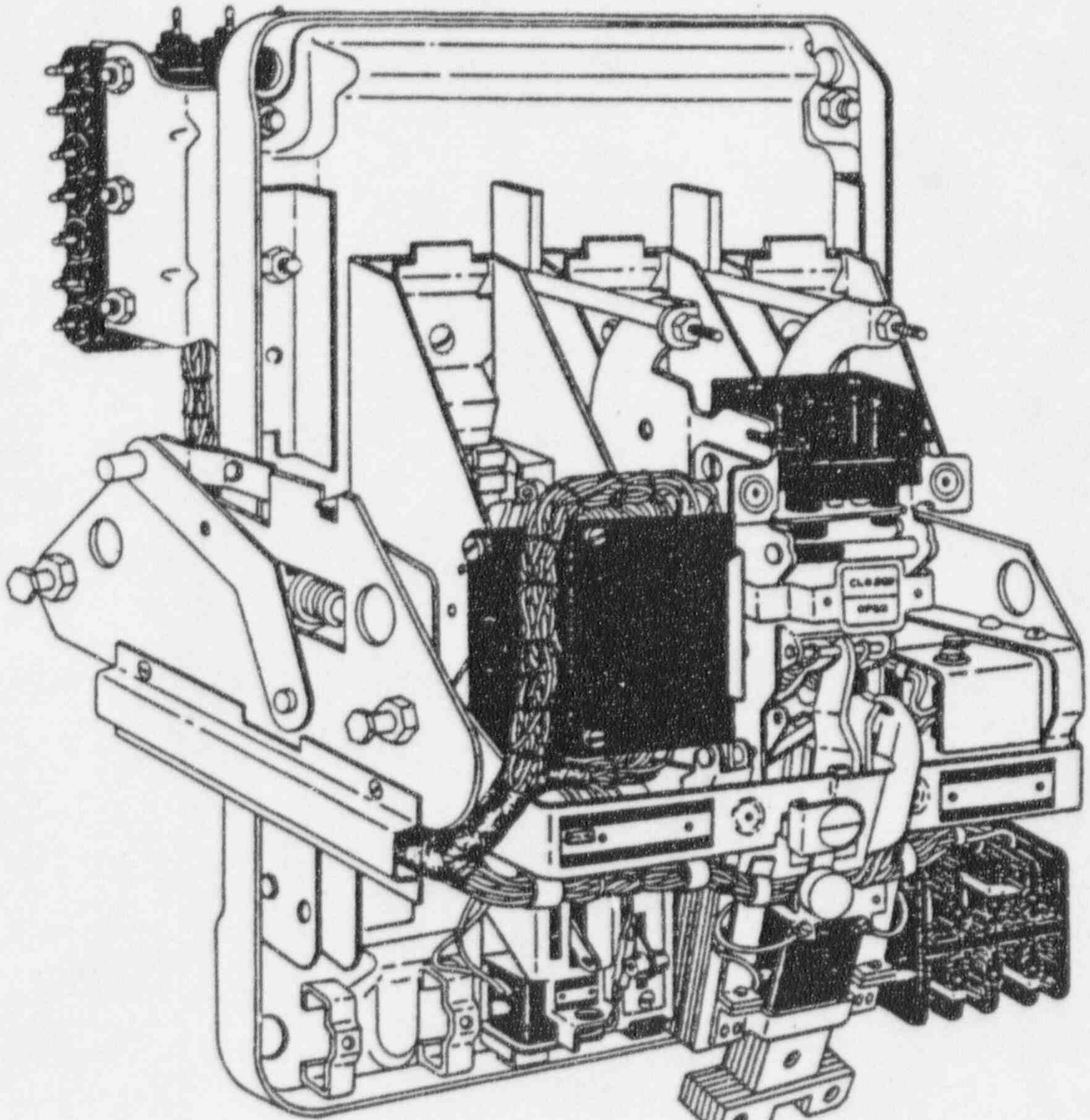

Figure 3
GE AK-2-25 Circuit Breaker
(front cover removed)

The basic RTSG design consists of nine circuit breakers which are operated in four sets of two breakers (four channels), and one breaker for the bus tie. Power input to the RTSG comes from two full capacity MG sets operated in parallel and cross-connected such that the loss of either MG set does not de-energize the CEDMs. There are two independent power supply buses, each bus powering approximately half of the CEDMs. Power is supplied from the MG sets to each bus via two redundant trip paths (trip legs). This ensures that a fault, or the opening of a RTCB in one trip leg (i.e., for testing) will not interrupt power to the CEDM buses.

For the System 80 design there are only four RTCBs, each RTCB corresponding to one PPS trip path output. There is thus only one trip leg, with two RTCBs, to each CEDM bus. These CEDM buses are normally tied together to permit testing and to ensure that a fault in one trip leg will not result in a spurious trip.

The Class 1-E function of the RTCBs is to open, creating a reactor trip by interrupting power to the CEDMs. There are two diverse devices in each RTCB to perform this function. The first is a shunt trip device which has an actuation coil that is normally deenergized. A RPS/PPS trip signal energizes the shunt trip device to open the RTCB. The second is an undervoltage (UV) device that has an actuation coil which is normally energized. A trip signal, or loss of voltage on a vital DC bus, will interrupt power to the undervoltage device causing it to open the RTCB. Provision of the UV device meets General Design Criterion 23. A diagram of the UV device in the energized and actuated positions is shown in Figure 4.

The RTCBs also employ an overcurrent protection feature. However, this feature is not part of the Class 1-E function of the RTCB. Other circuit breakers and fuses in the MG set power supply path provide the overcurrent protection function.

The basic RTSG design is arranged such that each of the two motor-generator (MG) sets can power all of the Control Element Drive Mechanisms (CEDMs). The two MG sets are operated in parallel, each having sufficient capacity to hold all the CEDMs in position, although one MG set may not be sufficient to hold all CEDMs and power multiple (e.g., a bank) CEA movements. The RTCBs within the RTSG are used to interrupt power from the output of the MG sets to the CEDMs. The RTCBs are controlled from the RPS/PPS and, on demand, open by either de-energizing the UV device, or energizing the shunt trip device. As such, the RTCBs are functionally a switch and are not credited with any overload or fault interruption/protection function. A manual trip both de-energizes the UV device and energizes the shunt trip device. Each of the four manual trip pushbuttons actuate two RTCBs, as shown in Figure 1. For System 80 each pushbutton actuates one RTCB, as shown in Figure 2.

The RPS/PPS generates a reactor trip signal via four trip paths. Each trip path actuates a "K" relay which opens its respective set of RTCBs. The "K" relay actuates both the shunt and undervoltage trip devices within a RTCB. Actuation of either the shunt trip device or the undervoltage device is sufficient to open the RTCB and interrupt power

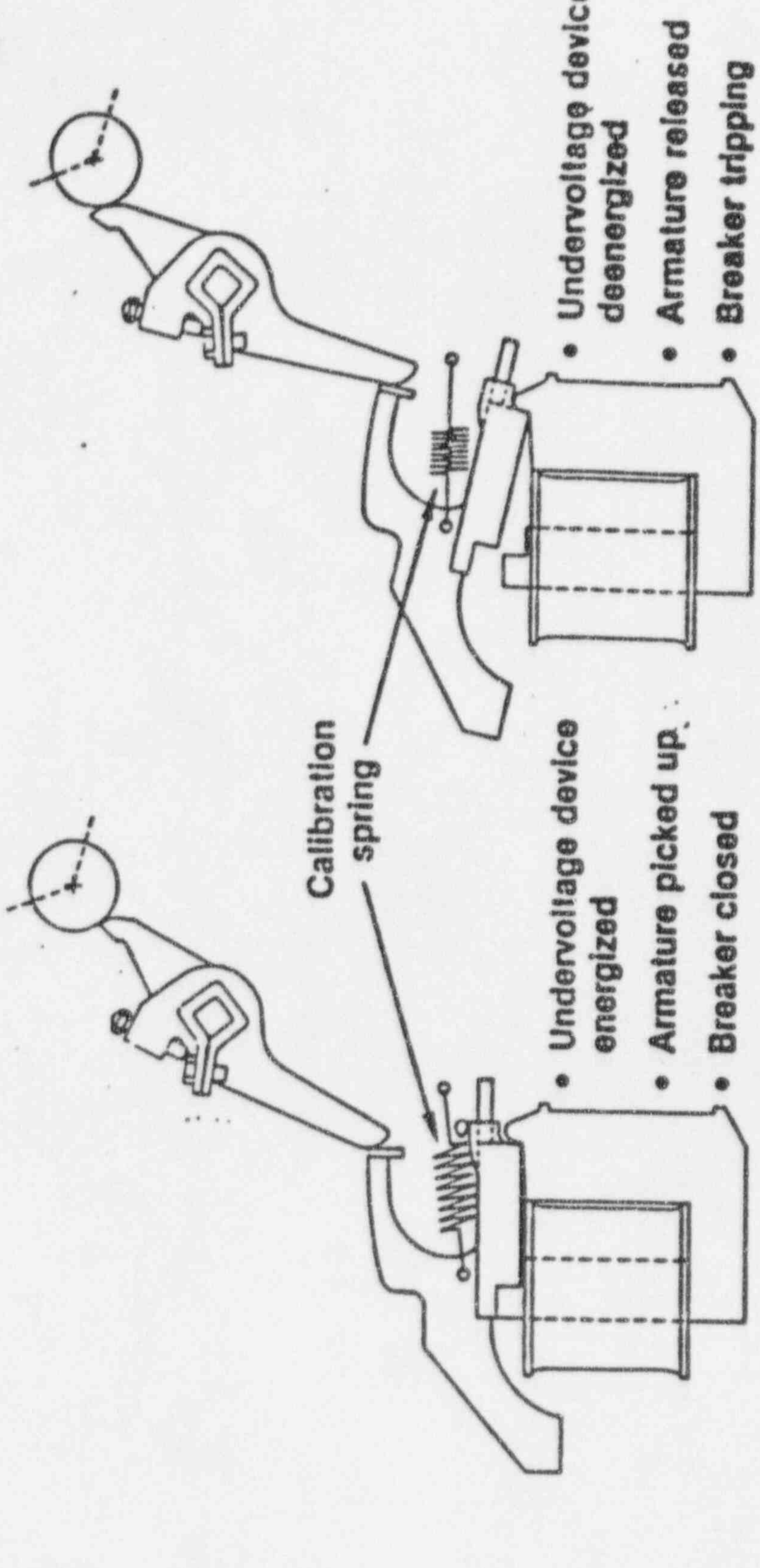


Figure 4
Undervoltage Device

from the MG sets to the CEDMs. Each "K" relay actuates one RTCB in two trip legs, so that a selective 2-out-of-4 actuation is required to generate a full reactor trip. See Figure 1. This prevents the failure of a single "K" relay from generating a spurious trip, and also permits functional testing of individual "K" relays and matrix trip paths. The System 80 design similarly requires a selective 2-out-of-4 actuation of the "K" relays, with each "K" relay actuating one RTCB. See Figure 2.

The manual trip pushbuttons bypass the "K" relay and actuate both the shunt and undervoltage trip devices. Each of the four manual trip pushbuttons opens a specific set of RTCBs corresponding with one of the "K" relays. A selective set of two pushbuttons must be actuated to generate a trip. This enables selective functional testing of the breakers by actuation of a selected pair of RTCBs (one RTCB for System 80 design) without generating a reactor trip.

## 2.2 History

Although there had been some earlier concern regarding RTCB operability (IEB 79-09, Ref. C, and IEC 81-12, Ref. E), interest peaked following the February 22 and 25, 1983 Salem ATWS events (IEB 83-01, Ref. F) and the March 3 and 8, 1983 undervoltage device failures at San Onofre Units 2 and 3 (IEB 83-04, Ref. G). IEB 83-01 dealt with failures of Westinghouse Type DB RTCBs, while IEB 83-04 dealt with failures of other types of RTCBs, primarily GE AK-2-25 and Westinghouse Type DS-416. Subsequently, IN 83-18 (Ref. H) reported on the results of RTCB tests performed to meet the requirements of these bulletins.

There has been much correspondence regarding RTCBs, and circuit breakers in general, within the nuclear industry, manufacturers, and NRC. The References (Section 5.0) give a chronological, bibliographical listing of some of the information available, starting in 1979. Following the anticipated transients without scram (ATWS) events in early 1983 at the Salem plant, the Combustion Engineering Owners Group (CEOG) formed a Reactor Trip Breaker Subcommittee to investigate performance issues of the General Electric AK-2-25 breakers used as RTCBs in C-E plants. The Babcock and Wilcox Owners Group (B&WOG) formed a similar group, which worked closely with the CEOG.

On November 3, 1983 the Commission met to discuss RTCB reliability. Shortly thereafter, the CEOG Regulatory Response Group (RRG) was activated to address this topic. The RRG met with the NRC staff on December 14, 1983 and provided a formal response to the staff's concerns on December 23, 1983 (Ref. O).

An early NRC study, Ref. AA, reported on circuit breaker performance prior to 1987. A 1992 NRC study, Ref. AG, provided a general assessment of the aging of circuit breakers. Rather than give a chronological history of RTCB performance, the following major historical topics are discussed in the next sections:

2.3 Undervoltage trip devices
2.4 Shunt trip devices
2.5 Testing and preventive maintenance

## 2.3 Undervoltage Trip Devices

The UV trip devices are the major cause of concern with RTCB operation. They are more complex than the shunt trip because they are designed to be normally energized. Being normally energized means that they operate at relatively high temperatures, and that they must rely on a spring for opening. The adjustment of this spring, and the settings at which the coil is energized and de-energized, require special attention. Being spring-actuated, they are more sensitive to the torque required to rotate the trip shaft, and related lubrication problems. Problems with sluggish and slow operation of these devices are generally remedied by cleaning and relubricating. Lubricants are discussed in References F and S.

General Electric breakers have experienced problems with both binding and excessive clearance of the armature. These clearances are pre-set and should be checked periodically as discussed in Reference I. The armatures have also been found to go to a mid-position, trip-free condition, as reported in Reference P; this primarily affects the ability to reclose.

Westinghouse breakers have experienced problems with missing retaining rings, Reference K. Occurrences of the trip paddle jamming against the armature are reported in References W and X.

Undervoltage trip devices, their problems and corrective actions are discussed in the following References:

| | |
|---|---|
| B | GE Service Advice 175.9.3, 4/2/79 (attached to IN 79-09) |
| I | GE Service Advice 175.9.3, Supp. 1, 4/15/83 |
| G | NRC IEB 83-04, 3/11/83 |
| H | NRC IN 83-18, 4/1/83 |
| J | Westinghouse 10 CFR 21 notification, 4/21/83 (DS-416 breakers) |
| M | C-E ADP Infobulletin 83-10, 8/12/83 (Westinghouse DS-206 breakers) |
| W | NRC IB 85-02, 11/5/85 (Westinghouse DB-50 breakers) |
| V | C-E ADP Infobulletin 85-06, 9/20/85 (UV device clearance adjustments) |
| AJ | NRC IN 83-09, Supp. 1, 2/2/93 (Westinghouse DB-50 breakers) |
| L | NRC GL 83-28, 7/8/83 |
| AF | NRC GL 83-28, Supp. 1, 9/18/92 |
| P | C-E ADP Infobulletin 83-13, 8/12/83, and Supp.1, 1/27/84 |
| Q | GE Service Advice 175.9.20, 3/21/84 |

## 2.4 Shunt Trip Device

The shunt trip device is simpler and more reliable than the UV device. Few failures of the shunt trip have been experienced. The 1987 McGuire Unit 2 breaker failure, Reference AA, was due to the breaker binding by wedging the main roller between the closing cam and the frame. This binding resulted in a failure of the coil to de-energize and it subsequently overheated.

The 1992 failure at Palo Verde (not strictly a shunt trip problem) was due to the breaker's main arcing contacts being misaligned, as reported in Reference AE.

In both of these events (McGuire and Palo Verde) the problem prevented the UV trip device from performing its function. These two recent events are the only complete failures of an RTCB to open since the beginning of 1986. They both occurred on Westinghouse circuit breakers, types DS-416 and DS-206, respectively. In neither event did the failure prevent a plant trip.

## 2.5 Testing and Preventive Maintenance

The basic tests conducted on the RTCBs are those required by the technical specifications, as modified by References L and AF.

The surveillance that this report is primarily concerned with extending is the CHANNEL FUNCTIONAL TEST of each RTCB. This CHANNEL FUNCTIONAL TEST includes actuation of the associated RTCBs, and is generally performed by actuating one trip pushbutton at a time to actuate its associated RTCB(s). This test is performed monthly, but an extension of the STI to quarterly was included as SR 3.3.3.1 (Analog) and SR 3.3.4.1 (Digital) of NUREG 1432 (Ref. AH).

A CHANNEL FUNCTIONAL TEST of each RPS Matrix Logic channel and RTCB channel is performed quarterly. This RPS CHANNEL FUNCTIONAL TEST includes individual actuation of each "K" relay and its associated RTCB(s). Previously this was performed monthly but an extension of the STI was justified in CEN-327 (Ref. AB). SR 3.3.3.1 (Analog) and SR 3.3.4.1 (Digital) of NUREG 1432 (Ref. AH) correspond to this test.

A CHANNEL FUNCTIONAL TEST of each RPS Manual Trip channel is currently performed once per refueling cycle. This CHANNEL FUNCTIONAL TEST includes actuation of the associated RTCBs, and is performed by depressing a set of trip pushbuttons to actuate the RTCB(s). SR 3.3.3.2 (Analog) and SR 3.3.4.3 (Digital) of NUREG 1432 (Ref. AH) correspond to this test.

An individual CHANNEL FUNCTIONAL TEST of each RTCB's undervoltage and shunt trip devices is performed once per refueling cycle. This CHANNEL FUNCTIONAL TEST includes actuation of the RTCBs. SR 3.3.3.3 (Analog) and SR 3.3.4.2 (Digital) of NUREG 1432 (Ref. AH) correspond to this test. This check is usually performed by timing the operation of the UV device and measuring its actuation. The results of these tests are trended to detect incipient failures.

The RTCBs may also be exercised during rod drop time testing following each core reload.

Testing and preventive maintenance of RTCBs are discussed in the following References:

| | |
|---|---|
| D | C-E ADP Infobulletin 81-02, 4/28/81, and Supp. 1, 11/5/81 |
| K | C-E ADP Infobulletin 83-07, 6/15/83 |
| E | NRC IEC 81-12, 7/22/81 |
| Q | GE Service Advice 175.9.20, 3/21/84 |
| S | C-E ADP Infobulletin 84-06, 6/20/84 |
| AB | CEN-327, 5/86 |
| L | NRC GL 83-28, 7/8/83 |
| AF | NRC GL 83-28, Supp. 1, 9/18/92 |
| AG | NUREG/CR-5762, 3/92 |
| AH | NUREG-1432, 12/92 |

## 2.6 Allowable Outage Time

Appendix C contains the relevant LCOs from the Improved Standard Technical Specifications for C-E Plants, NUREG-1432, Ref. AH. The Allowable Outage Time (AOT) of concern here is the 1 hour Completion Time of Required Action B.1 in LCO 3.3.3 (Analog) and Required Action B.1 of LCO 3.3.4 (Digital), as well as the 1 hour allowed in the Notes to Conditions B and C. Following expiration of this 1 hour period the plant must be shut down.

In lieu of declaring an RTCB inoperable, it is accepted practice to open the breaker or to rack it out for maintenance or testing. This places the trip leg with the affected RTCB in the de-energized state, accomplishing its safety function. In such a case, the plant is no longer considered to be in Condition B or C of the referenced LCOs (Appendix C). Testing and preventive maintenance of an RTCB can thus be conducted with the breaker racked out without placing the plant into a Technical Specification's Action.

With a RTCB open or racked out, and one trip leg open, testing of other RTCBs runs an increased risk of causing a spurious reactor trip. To meet Surveillance Requirements, testing of other RTCBs must be performed on schedule. At newer C-E plants (Waterford-3 and the three Palo Verde units), the Technical Specifications allow an inoperable RTCB to be closed for up to 1 hour to permit such testing to be performed with less risk of a spurious reactor trip. This has also been implemented in NUREG-1432 (Conditions B and C) as discussed above. Older C-E plants do not have this provision in their Technical Specifications (and it is recommended they be permitted to adopt it).

Two simple precautions can be taken during the short period in which this AOT is entered. First, the other RTCB in the same trip leg can be tested prior to entering this Action to give added assurance it will operate. Second, the operators can specifically note which manual pushbutton actuates the operable RTCB that is being relied on.

It is not often that a plant needs to invoke this 1 hour AOT, but when it is needed, 1 hour is insufficient time to test the two RTCBs in each of the other trip legs without rushing the work. It is the extension of this 1 hour AOT, and the accompanying Notes, that is discussed below.

## 3.0 DISCUSSION

NRC GL 83-28 set out the considerations necessary to achieve high reactor trip system availability:

1. uncertainty in component failure rates
2. uncertainty in common mode failure rates
3. reduced redundancy during testing
4. operator errors during testing
5. component "wear-out" caused by testing.

Additionally, one needs to look at the following:

6. the appropriateness of the testing and preventive maintenance being performed

NUREG 1366 (Ref. AI) states that overtesting is contributing to breaker failure, but that adjustment and lubrication problems are also significant. Human error has caused trips during this testing. There has been no change in the test interval since adding such diverse features as undervoltage and shunt trips, even though these features contribute to a significant increase in reliability (the C-E design has always had these features and has actuated both). NUREG-1366 states that the present allowed outage time of 2 hours for conducting testing should be increased to prevent the test from being rushed. (The actual AOT is only 1 hour, and only a few plants have been allowed this.) While these recommendations were not followed-up on in GL 93-05 (Ref. AP), the CEOG believes they are warranted.

The ATWS Rule (Ref. AQ) has also increased the overall reliability of the trip system by reducing the risk resulting from the failure of RTCBs, as noted in SECY-92-322 (Ref. AF).

### 3.1 RTCB Failure Rates

Appendix A presents a summary of NPRDS data for circuit breakers under the system code RCB (which includes all RTCB failures) for C-E units. (The information was collected in December 1993; with the latest event date being 8/21/93.) Table A-2 presents the data sorted by unit and date. Table A-3 presents the data sorted by failure type and date. The following conclusions can be drawn from the analysis presented in Appendix A:

1) There are 13 reported failures of an RTCB to open found in Tables A-2 and A-3. Of these, only one was a total failure of the breaker to open on demand (Ref. AE).

2) Based on the data, a failure rate of 0.6E-4 per demand has been experienced since 1/1/86 at C-E designed plants. This is less than the value of 5.3E-4 given for the failure of a circuit breaker to open on demand given in NUREG/CR-4639 (Ref. AR).

While the above data is based on C-E units, the whole industry experienced only 2 RTCB failures during this period. This shows that an industry failure rate less than 1E-4 (based on C-E units being less than half the total PWRs) has been experienced during this time period. This shows that the uncertainty in component failure rates is currently being controlled at an acceptably low level.

## 3.2 Common Mode Failures

While there is some opportunity for common mode failure of individual types of trip devices, the diversity of the shunt and undervoltage trip devices minimize this concern. On the C-E RTCB design both the shunt and undervoltage trip devices are actuated by either an automatic or a manual trip signal. The redundancy of trip breakers in each power supply path provides additional confidence that a trip will occur when required. Although there have been two past occurrences of individual RTCBs not opening at C-E plants (One prior to 1986, and one after), there has never been an occasion of more than one breaker failing to open by at least one trip device on a trip signal, or during testing.

## 3.3 Reduced Redundancy During Testing

As most testing is conducted with the breaker open (and frequently racked-out), or results in opening the RTCB, this is more a concern for spurious trips than for failure to trip. Only if the RTCB in test was jumpered or otherwise bypassed would there be a redundancy concern.

Likewise, testing of the RPS does not pose a loss of redundancy. A valid trip signal overrides any test signal.

Extension of the AOT would allow an inoperable RTCB to remain closed for a short period. During this time, the plant is relying on the single operable RTCB in that trip path to open if required. This has been judged acceptable for 1 hour on at least four C-E plants. Its acceptability is based on the alternative of possibly forcing the plant to shutdown for a missed surveillance versus the unlikely event of a trip occurring with the single RTCB failing on demand during this short period.

## 3.4 Operator Errors During Testing

While this was a concern in the past, improved procedures and training have led to an average trip rate of less than 2 per refueling cycle for C-E units. C-E units have met the INPO goals for trip reduction. There is a trade-off between more frequent testing giving more opportunity for operator error, and less frequent testing producing the opportunity for errors through less familiarity with the operation. It is our opinion that the difference between monthly and quarterly testing is not a major factor leading to operator error, particularly considering the simplicity of performing a manual breaker trip.

## 3.5 Component "Wear-out" Caused by Testing

Circuit breakers, while not designed to be used as "light switches," are designed for frequent on-off operation of the equipment they control. NRC IN 87-35 (Ref. AA) concluded that the breaker failure at McGuire Unit 2 was partially wear related. This failure occurred 4 years after initial criticality and the breaker had been subjected to over 2,000 cycles of operation during this period. While 500 cycles of operation per year sounds excessive, and far exceeds testing requirements, it is a representative number for a typical breaker in this application.

It is not considered good practice to leave the RTCBs closed for long periods of time. A compromise is necessary. Testing of the RTCBs once every 6 weeks, and preventive maintenance every 6 to 12 months should be adequate.

## 3.6 Appropriateness of the Testing and Preventive Maintenance Being Performed

Testing and trending along with preventive maintenance is defined by the available manufacturers' literature. When properly performed, this testing assures the reliability of the RTCBs. While overtesting may impact the frequency of preventive maintenance, this report does not discuss any relation between the frequency of preventative maintenance and the reliability of the RTCBs.

## 3.7 Time to perform testing

When all RTCBs are operable, the RPS/PPS and Manual Pushbutton Functional Tests may be performed in a methodical manner with minimal time restraints. Also, when all RTCBs are operable, one RTCB may be opened and racked out for testing and maintenance.

When an RTCB is inoperable, Functional Testing and other breaker operations becomes more difficult. Recent Technical Specifications (Waterford, Palo Verde, and NUREG-1432) allow an inoperable breaker to be reclosed for 1 hour to perform testing of other RTCBs. This provision is infrequently required, but when it is required, the allowed time is very short. If the required testing cannot be performed within this time period a forced outage may result. Alternatively, rushing to complete a test may lead to an inadvertant reactor trip.

## 4.0 CONCLUSIONS and RECOMMENDATIONS

The C-E designed reactor trip system provides redundant and diverse trip actuation (of both shunt and UV trip devices) on both automatic and manually initiated reactor trips.

The concerns with RTCB performance which arose in the early 1980s, particularly with the UV trip device, have been resolved.

Operation of the UV trip device using 125 vdc control power effectively ensures that the reactor will be tripped on loss of offsite or onsite power. As there are at least 2 independent DC buses (4 in some cases) there is no single failure that will prevent the RTCBs from being actuated. Either the affected UV devices will trip, or the remaining shunt trip devices will remain operable.

The diverse scram system installed per 10 CFR 50.62 as ATWS protection provides additional assurance that an automatic reactor trip will occur when required.

Based on the reliable performance shown by the RTCBs since 1986, the following is recommended:

1. The surveillance test interval for manual functional test of the RTCBs should be extended from monthly to quarterly. This should be staggered with the automatic RPS Functional Test such that all the RTCBs are tested once every 6 weeks.

2. The allowable outage time for closure of an inoperable RTCB to permit testing of other RTCBs should be extended from one hour to two hours.

3. A licensee applying for an extension of this surveillance interval and outage time, should review its maintenance frequency to ensure that: 1) the appropriate recommendations are being followed, and 2) the frequency of such maintenance is appropriate.

As the Class 1E function of the RTCBs is to interrupt power on an external signal, their design basis should be investigated to determine if the overcurrent protection function can be eliminated. This would simplify breaker operation and maintenance.

## 5.0 REFERENCES


A GE Instruction Manual GEI-50299E, "Power Circuit Breakers."

B GE Installation and Service Engineering - Service Advice 175.9.3 dated 4/2/79, "AK 15/25/50/75/100 Low Voltage Power Circuit Breaker with Undervoltage Trip Devices." (Attached to IN 79-09)

C NRC IE Bulletin 79-09, dated April 17, 1979, "Failures of GE Type AK-2 Circuit Breaker in Safety Related Systems."

D C-E Availability Data Program Infobulletin No. 81-02, dated April 28, 1981, "Reactor Trip Switchgear Circuit Breaker Testing and Preventative Maintenance," and Supplement 1, dated November 5, 1981.

E NRC IE Circular 81-12, dated July 22, 1981, "Inadequate Periodic Test Procedure of PWR Protection System."

F NRC IE Bulletin 83-01, dated February 25, 1983, "Failure of Reactor Trip Breakers (Westinghouse DB-50) to Open on Automatic Trip Signal."

G NRC IE Bulletin 83-04, dated March 11, 1983, "Failures of the Undervoltage Trip Function of Reactor Trip Breakers."

H NRC Information Notice 83-18, dated April 1, 1983, "Failures of the Undervoltage Trip Function of Reactor Trip Breakers."

I GE Service Advice 175.9.3, Supplement, dated April 15, 1983.

J E.P. Rahe (Westinghouse) letter NS-EPR-2753 to R.C. DeYoung (NRC), dated April 21, 1983, regarding 10CFR21 notification of potential misoperation of DS-416 reactor trip undervoltage devices.

K C-E Availability Data Program Infobulletin No. 83-07, dated June 15, 1983, "Reactor Trip Switchgear Circuit Breaker Maintenance Frequency Verification."

L NRC Generic Letter 83-28, dated July 8, 1983,"Required Actions Based on Generic Implications of Salem ATWS Events."

M C-E Availability Data Program Infobulletin No. 83-10, dated August 12, 1983,"Possible Defective Undervoltage Devices on Westinghouse DS-206 Reactor Trip Switchgear."

N NRC Memorandum from Marilyn Ley to Edward Butcher, dated December 23, 1983, "Minutes of December 14, 1983 Meeting Between NRC and CE Regulatory Response Group to Discuss the GE AK-2-25 Reactor Trip Breaker and Proposed Staff Actions."

O R.W. Wells (NU, CEOG) letter RWW-83-66 to D.G. Eisenhut (NRC), dated December 23, 1983, "Combustion Engineering Owners Group -- Regulatory Response Group Presentation Notes from December 14, 1983, NRC Meeting on Reactor Trip Breaker Reliability."

P C-E Availability Data Program Infobulletin No. 83-13, "Undervoltage Trip Device Armatures Pickup on Reactor Trip Switchgear," dated August 12, 1983, and Supplement 1, dated January 27, 1984.

Q GE Distribution Equipment Division - Service Advice 175.9.20, dated 3/21/84, "Maintenance and Upgrade of AK-25 Circuit Breakers with Undervoltage Trip Devices Used as Reactor Trip Breakers."

R Draft NRC Information Bulletin/Notice, dated April 1984, " Undervoltage Trip Attachments of Reactor Trip Breakers."

S ABB C-E Infobulletin #84-06, dated June 20, 1984, "Revitalization of RTSG Circuit Breaker Lubricant."

T "Reactor Protection System Test Interval Evaluation - Task 486," CE-NPSD-277, dated December 1984.

U NRC Generic Letter 85-58, " Failure of General Electric Type AK-2-25 Reactor Trip Breaker," dated July 17, 1985

V ABB C-E Infobulletin 85-06, "RTSG Circuit Breaker Undervoltage Device Adjustments," dated September 20, 1985.

W NRC Information Bulletin 85-02, " Undervoltage Trip Attachments of Westinghouse DB-50 Type Reactor Trip Breakers," dated November 5, 1985.

X "Report of the Reactor Trip Breaker Subcommittee of the Combustion Engineering Owner's Group," (Task 488) CE-NPSD-292, May 1985.

Y NRC Information Notice 86-105, "Potential for Loss of Reactor Trip Capability at Intermediate Power Levels," dated December 19, 1986.

Z NUREG/CR-4715, "Aging Assessment of Relays and Circuit Breakers and Systems Interactions," dated June 1987.

AA NRC Information Notice 87-35, "Reactor Trip Breaker, Westinghouse Model DS-416, Failed to Open on Manual Initiation From the Control Room," July 30, 1987; and Supplement 1 dated December 16, 1987.

AB "RPS/ESFAS Extended Test Interval Evaluation," CEOG CEN-327, dated May 1986, and Supplement 1, dated January 1989.

AC A.C. Thadani (NRC) letter to E. Sterling (CEOG), dated November 6, 1989, "NRC Evaluation of CEOG Topical Report CEN-327, 'RPS/ESFAS Extended Test Interval Evaluation'."

AD NRC GL 90-03, "Relaxation of Staff Position in Generic Letter 83-28, Item 2.2, Part 2 'Vendor Interface for Safety-Related Components," dated March 20, 1990.

AE NRC IN 92-44, "Problems With Westinghouse DS-206 and DSL-206 Type Circuit Breakers," dated June 18, 1992.

AF NRC Policy Issue (Information) SECY-92-322, dated September 18, 1992, "Relaxation of the Staff's Position in Generic Letter 83-28, Items 4.2.3 (Life Testing) and 4.2.4 (Periodic Replacement of Breakers or Components)." (Includes Supplement 1 to GL 83-28, dated October 7, 1992.)

AG NUREG/CR-5762, "Comprehensive Aging Assessment Study of Circuit Breakers and Relays," dated March 1992.

AH NUREG-1432, "Standard Technical Specifications Combustion Engineering Plants," dated September 1992.

AI NUREG-1366, "Improvements to Technical Specification Surveillance Requirements," dated December 1992.

AJ NRC Information Notice 83-09, Supplement 1, "Failure of Undervoltage Trip Attachments of Westinghouse Model DB-50 Reactor Trip Breakers, dated February 2 1993.

AK "Proposed Generic Communication; 'Line-Item Technical Specification Improvements To Reduce Testing During Power Operation'," 58 FR 16881, dated March 31, 1993.

AL Gail H. Marcus (NRC) memo to Karen M. VanDuser (NRC), dated March 8, 1993, "Associated Documents for Proposed Generic Letter on Reduced Testing Requirements for Operating Reactors."

AM NRC Information Notice 93-26, "Grease Solidification Causes Molded Case Circuit Breaker Failure to Close," dated April 7, 1993, and Supplement 1, dated January 31, 1994.

AN NRC Information Notice 93-64, "Periodic Testing and Maintenance of Molded Case Circuit Breakers," dated August 2, 1993.

AO NRC Information Notice 93-65, "Reactor Trips Caused by Breaker Testing with Fault Protection Bypassed," dated August 18, 1993.

AP NRC Generic Letter 93-05, "Line-Item Technical Specification Improvements to Reduce Surveillance Requirements for Testing During Power Operation," dated September 27, 1993.

AQ 10 CFR 50.62, "Requirements for Reduction of Risk from Anticipated Transients Without Scram (ATWS) Events for Light-water Cooled Nuclear Power Plants," dated June 26, 1984, as amended.

AR NUREG/CR-4639 (EGG-2458), Volume 5, Revision 3, "Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR) - Data Manual - Part 3: Hardware Component Failure Data (HCFD)," dated December 1990.

AS NRC Information Notice 93-26, Supplement 1, "Grease Solidification Causes Molded-Case Circuit Breaker Failure to Close," dated January 31, 1994.

# Appendix A

## Failure Data & Analysis

# APPENDIX A
## FAILURE DATA & ANALYSIS

### Introduction

Table A-1 presents a summary of the number of each type of reported failure that occurred between 1986 and mid-1993. Tables A-2 and A-3 present summaries of the INPO NPRDS data base search for failures of the Reactor Trip Circuit Breakers (RTCBs). Table A-2 is sorted by plant and date. Table A-3 is sorted by Failure Type and date. The data was obtained by searching for all circuit breaker failures on plants with a C-E designed NSSS. This set of data was then downloaded into a database and the information under NPRDS System Code RBC used (other system codes were checked and found to contain no RTCB information). The information was then summarized in a spreadsheet for analysis.

The information presented in Tables A-2 and A-3 is as follows:

PLANT — A designation of the unit at which the failure occurred.

| | |
|---|---|
| CC-1 | Calvert Cliffs Unit 1 (BG&E) |
| CC-2 | Calvert Cliffs Unit 2 (BG&E) |
| EO-ANO2 | Arkansas Nuclear One Unit 2 (Entergy Operations) |
| EO-WSES3 | Waterford Electric Station Unit 3 (Entergy Operations) |
| MY | Maine Yankee (MY) |
| MP-2 | Millstone Unit 2 (NU) |
| PV-1 | Palo Verde Unit 1 (APS) |
| PV-2 | Palo Verde Unit 2 (APS) |
| PV-3 | Palo Verde Unit 3 (APS) |
| SL-1 | St. Lucie Unit 1 (FPL) |
| SL-2 | St. Lucie Unit 2 (FPL) |
| SONGS-2 | San Onofre Nuclear Generating Station Unit 2 (SCE) |
| SONGS-3 | San Onofre Nuclear Generating Station Unit 3 (SCE) |

MODEL — Circuit breaker manufacturer or manufacturer's model number.

FAILURE DISCOVERY DATE — The date of discovery that a failure occurred, as reported in NPRDS. This is not necessarily the failure date, but rather the date that the determination was made.

FAILURE TYPE — A designation assigned (by ABB C-E) during data analysis to obtain a more consistent interpretation of the data than that supplied by the NPRDS "FAILURE MODE" reported in the next column. A three digit designation is used. The first digit represents a measure of the severity of the failure, with 1,2,3 indicating a breaker that was likely inoperable (in the technical specification sense). The second digit represents the breaker component that failed, with S designating a failure of the shunt trip device, U designating a failure of the undervoltage (UV) device, and O representing other causes than the shunt or UV trip devices, or causes that could not be determined from the available

narrative. An "*" in the third digit indicates an event judged to be a complete failure of the RTCB to open on demand.

| | |
|---|---|
| blank | Miscellaneous causes, or not an RTCB |
| 1O | Failure to open due to other causes |
| 1S | Failure to open due to malfunction of shunt trip device |
| 1U | Failure to open due to malfunction of UV device |
| 2O | Slow or erratic response due to other causes |
| 2S | Slow or erratic shunt trip device response |
| 2U | Slow or erratic UV device response or inadequate dropout voltage |
| 3U | Defective UV device |
| 4O | Failure to close due to other causes |
| 4U | Failure to close due to UV device |

FAILURE MODE The NPRDS designation for the type of failure.

| | |
|---|---|
| FC | Failure to close |
| FO | Failure to open |
| SC | Spurious closure |
| SO | Spurious opening |
| OR | Failure to operate as required |
| MO | Failure found during testing, surveillance, inspection, or maintenance |
| OP | Failure to operate properly (NPRDS info backfit only) |
| SA | Spurious Actuation |

SYSTEM A designation of the plant system in which the circuit breaker reported on is used. RTB (with or without a number/letter designation) designates a RTCB. Other systems frequently designated are the motor-generator sets.

DESCRIPTION A condensed and standardized summary of the failure, extracted from the NPRDS description, LERs, and discussion with plant staff. To the extent possible, the following information is reported: 1) part that failed, 2) cause of failure, 3) plant conditions at time of failure, and 4) detection method (testing, maintenance, observation, etc.). In some, but not all, cases the corrective action is included.

Table A-1 summarizes the failures that have been reported since 1986. 1986 is taken as a date when the improvements of GL 83-28 are assumed to have been implemented. Supplement 1 to GL 83-28 was issued in October 1992. This Supplement states that the industry experienced only one complete failure of an RTCB from the beginning of 1986 through early 1991 (IN 87-35), and only a second complete failure (IN 92-44) between 1991 and its issuance date of 10/92. No other failures are known to have been reported since this date. Both of these reported failures involved Westinghouse circuit breakers, types DS-416 and DS-206, respectively.

| TABLE A-1<br>REPORTED FAILURES - 1986 TO MID-1993 | |
|---|---|
| FAILURE TYPE | NUMBER |
| 1U: Failure to Open Due to UV Trip Device | 3 |
| 1S: Failure to open Due to Shunt Trip Device | 1 |
| 1O: Failure to open Due to other Causes | 2 |
| 2U: Slow or Erratic UV Device Response | 8 |
| 2S: Slow or Erratic Shunt Trip Device Response | 2 |
| 2O: Slow or Erratic Response Due to Other Causes | 2 |
| 3U: Defective UV Trip Device | 14 |
| 4U: Failure to Close Due to UV Trip Device | 22 |
| 4O: Failure to Close Due to Other Causes | 32 |
| : Miscellaneous causes (or not an RTCB) | 40 |
| TOTAL | 126 |

Reliability Analysis

Tables A-1 and A-3 show [1] complete failure to trip on demand since 1986. 1986 is selected as a starting point as the requirements of GL 83-28 should have been implemented by that time.

The total number of RTCBs covered in this report is 92; counted as follows: This report covers 13 of the 15 C-E units (Palisades and Fort Calhoun are excluded as they use contactors rather than RTCBs). Of these, there are three units with 4 RTCBs (the Palo Verde units) and 10 units with 8 RTCBs (not counting cross-ties and M-G set breakers which are not RTCBs). While 126 reported failures in 7-1/2 years appears high, one must remember that this is for the 92 RTCBs included in this study, and that there have probably been on the order of 60,000 actuations of these breakers during the reported period.

The RTCB demands per refueling cycle are 39 required tests. The actual number including preventive maintenance and retesting may be double this number. Assuming an 18 month refueling cycle and 2 month outage as an average for the

13 units reported on the following number of tests will be conducted on each RTCB each refueling cycle:

| | |
|---|---|
| 18 | individual breaker monthly tests (item 13. of STS Table 4.3-1) |
| 18* | individual breaker tests due to matrix logic testing actuation of the K relay (item 12. of STS Table 4.3-1) |
| 1 | Functional Test of the Manual Trip (item 1. of STS Table 4.3-1) |
| 1 | individual test of the shunt device (item 13. note (12) of STS Table 4.3-1) |
| 1 | individual test of the UV device (item 13. note (12) of STS Table 4.3-1) |
| 39 | total individual tests required per breaker by technical specifications |

* This number is now reduced to 6 per refueling cycle for those plants that have implemented the surveillance extensions of CEN-327. For purposes of this report it is assumed that plants have not implemented this prior to the refueling cycle ending in mid-1993.

The time period from 1/1/86 through mid-1993 is 7-1/2 years or 90 months. At 90 months, 92 RTCBs, 39 required tests per RTCB, 20 months per refueling cycle, and 1 failure in this time period from Table A-3; the unreliability of the RTCBs at C-E units is **0.6 E-4** per demand. This is less than the value of 5.3 E-4 given for the failure of a circuit breaker to open on demand given in NUREG/CR-4639 (Ref. AR).

This unreliability value is presented as a conservative bounding value. It does not include the effects of scrams, maintenance, and other testing on the number of demands; which might be twice the value used. Nor does it take into account extended outages such as the MP-2 steam generator replacement, or the Calvert Cliffs extended outages in the late 1980's. It also does not account for any plant that may have implemented CEN-327 prior to mid-1993, as this is not believed to be a significant factor. It is recommended that future calculations consider these factors, as it is believed they will demonstrate even better reliability then is shown here.

Table 4.3-1 of the C-E Standard Technical Specifications (STS) is included as Appendix B, following Table A-3, for reference.

Table A-2

NPRDS RTCB Data Summary - Sorted by Plant and Date

## Table A-2
## NPRDS Reported Failures of RTCBs - By Plant & Date

| PLANT | MODEL | FAILURE DISC DATE | FAILURE TYPE | FAILURE MODE | SYSTEM | DESCRIPTION |
|---|---|---|---|---|---|---|
| CC-1 | GE AK-2A-25 | 04/20/77 | 4U | | RTB#4 | Bkr failed to close during test due to damaged UV coil. |
| CC-1 | GE AK-2A-25 | 02/28/78 | 1U | | RTB | UV trip mechanism did not trip bkr during PM due to misadjustment. |
| CC-1 | GE AK-2A-25 | 02/28/78 | | | RTB | Bkr anti-pumping function failed due to filing on relay armature. |
| CC-1 | GE AK-2A-25 | 05/03/79 | 1U | | RTB#8 | UV device would not trip bkr during PM. UV device was replaced. |
| CC-1 | GE AK-2A-25 | 09/13/81 | 4U | | RTB#7 | Bkr failed to close during test due to failed UV relay coil. |
| CC-1 | GE AK-2A-25 | 08/05/83 | 4U | | RTB#6 | Bkr would not close during test due to defective UV device. |
| CC-1 | GE AK-2A-25 | 09/19/83 | 4U | | RTB | Bkr did not close from handswitch - replaced UV device and closing coil. |
| CC-1 | GE AK-2A-25 | 12/21/83 | 2U | | RTB | UV device trip setpoint out of calibration during surveillance test. |
| CC-1 | GE AK-2A-25 | 01/27/84 | 4O | FC | RTB | Bkr would not close during test due to defect of mechanical collar. |
| CC-1 | GE AK-2A-25 | 01/30/84 | 1U | FO | RTB | Bkr failed to open on UV during test @ pwr due to binding of UV device. |
| CC-1 | GE AK-2A-25 | 03/21/84 | 4O | FC | RTB#6 | Bkr would not close during PM due to defect of closing armature. |
| CC-1 | GE AK-2A-25 | 04/05/84 | | MO | RTB | Excessive movement of closing armature unlatching mechanism. |
| CC-1 | GE AK-2A-25 | 09/26/84 | 4U | FC | RTB | UV device would not pickup during PM @ power due to alignment of armature. |
| CC-1 | GE AK-2A-25 | 01/03/85 | 2O | FO | RTB#4 | Trip times during tests were too long due to wear of front frame. |
| CC-1 | GE AK-2A-25 | 01/03/85 | 2O | FO | RTB#1 | Trip time high during test, lubricated with mobil 28 greese. |
| CC-1 | GE AK-2A-25 | 05/29/85 | | SA | RTB#3 | During Mode 6, indicator light for bkr was not lit due to blown fuse. |
| CC-1 | GE AK-2A-25 | 11/22/85 | | MO | RTB#7 | Bkr trip shaft torque was found to be too high during PM. |
| CC-1 | GE AK-2A-25 | 12/24/85 | 4O | FC | RTB#5 | Bkr did not close during PM @ pwr due to broken cutout switch. |
| CC-1 | GE AK-2A-25 | 01/23/86 | 4O | FC | RTB#2 | Failure of bkr to close due to detached springs resulted in Rx trip. |
| CC-1 | GE AK-2A-25 | 02/25/86 | 4U | FC | RTB#6 | Bkr would not close during PM @ pwr due to voltage of pickup coil. |
| CC-1 | GE AK-2A-25 | 02/25/86 | 4U | FC | RTB#3 | Bkr failed to close during test @ pwr due to UV device. |
| CC-1 | GE AK-2A-25 | 09/05/86 | 1U | FO | RTB#1 | Bkr failed to trip on UV during PM @ pwr due to inadequate armature clearanc |
| CC-1 | GE AK-2A-25 | 09/10/86 | 4U | FC | RTB#3 | UV device did not pickup following test due to incorrect air gap. |
| CC-1 | GE AK-2A-25 | 09/12/86 | 4U | FC | RTB#4 | UV device did not pickup during test @ pwr due to rivet clearance. |
| CC-1 | GE AK-2A-25 | 10/31/86 | 3U | MO | RTB#8 | During Mode 6, UV device could not be adjusted to perform as designed. |
| CC-1 | GE AK-2A-25 | 12/15/86 | 4O | FC | RTB#4 | Bkr failed to close during test @ pwr due to detached spring. |
| CC-1 | GE AK-2A-25 | 01/08/87 | 4O | FC | RTB#7 | Bkr failed to close during test due to detached operating spring. |
| CC-1 | GE AK-2A-25 | 01/19/87 | 4U | FC | RTB#8 | Bkr failed to close during test @ pwr due to armature clearance. |
| CC-1 | GE AK-2A-25 | 02/08/87 | 4U | FC | RTB#1 | Bkr failed to close during test @ Mode 1 due to open circuit in UV device. |
| CC-1 | GE AK-2A-25 | 09/30/87 | | MO | RTB#8 | Cracked retainer for closing coil was identified during PM @ power. |
| CC-1 | GE AK-2A-25 | 10/01/87 | 2U | FO | RTB#7 | Erratic UV coil response during PM @ pwr due to loose rivet. |
| CC-1 | GE AK-2A-25 | 10/04/88 | | MO | RTB#1 | Cracked closing coil noted during PM @ pwr. |
| CC-1 | GE AK-2A-25 | 11/02/88 | 3U | MO | RTB#9 | UV device was inoperative due to loose wire that was found while @ power. |

## Table A-2
## NPRDS Reported Failures of RTCBs - By Plant & Date

| PLANT | MODEL | FAILURE DISC DATE | FAILURE TYPE | FAILURE MODE | SYSTEM | DESCRIPTION |
|---|---|---|---|---|---|---|
| CC-1 | GE AK-2A-25 | 11/09/88 | | FC | RTB#3 | While @ pwr, bkr had no current to Phase B due to unknown cause. |
| CC-1 | W DS-206 | 03/27/89 | | FC | MG SET BK | MG set would not start from local switch due to defective control ckt. |
| CC-1 | GE AK-2A-25 | 03/05/90 | | MO | RTB#1 | Broken closing coil found during PM. |
| CC-1 | GE AK-2A-25 | 03/12/90 | 3U | MO | RTB | UV coil had intermittent resistance readings during PM due to aging. |
| CC-1 | GE AK-2A-25 | 04/12/90 | 1U* | FO | RTB | While shutdown, bkr failed to open on demand due to faulty UV relay. |
| CC-1 | GE AK-2A-25 | 11/25/92 | 4O | FC | RTB#3 | Bkr failed to close during Mode 3 test due to detached closing spring. |
| CC-2 | GE AK-2A-25 | 05/03/77 | 4O | | RTB#2 | Bkr was not closing properly. New UV coil was installed. |
| CC-2 | GE AK-2A-25 | 01/14/82 | 3U | FO | RTB | Calibration requirements were not met due to defective UV relay. |
| CC-2 | GE AK-2A-25 | 07/19/83 | 2U | | RTB | Trip time during test was too long due to UV device setpoint adjustments. |
| CC-2 | GE AK-2A-25 | 01/14/84 | 1S | FO | RTB | Bkr did not open during test of shunt trip device. Contacts cleaned. |
| CC-2 | GE AK-2A-25 | 02/13/84 | 3U | MO | RTB | UV relay pickup voltage was found to be low during surveillance testing. |
| CC-2 | GE AK-2A-25 | 06/27/84 | 4O | FC | RTB | Bkr would not close during test @ pwr due to loose trip shaft bearing. |
| CC-2 | GE AK-2A-25 | 10/10/84 | 2O | FO | RTB | Trip time during test @ pwr was too long due to inadequate lubrication. |
| CC-2 | GE AK-2A-25 | 12/10/84 | 2O | FO | RTB | Trip time during test @ pwr was too long due to inadequate lubrication. |
| CC-2 | GE AK-2A-25 | 01/18/85 | 2O | FO | RTB | Trip time during test @ pwr was too long due to lubrication and frame. |
| CC-2 | GE AK-2A-25 | 02/05/85 | 2O | FO | RTB#6 | Trip time during test @ pwr was too long due to dirt accumulation. |
| CC-2 | GE AK-2A-25 | 02/05/85 | 2U | FO | RTB | UV device had inadequate response during PM @ pwr due to loose armature. |
| CC-2 | GE AK-2A-25 | 02/19/85 | 2O | FO | RTB#6 | Trip time during test @ pwr was too long due to wear of front frame. |
| CC-2 | GE AK-2A-25 | 04/08/85 | 2O | FO | RTB#3 | Trip time during test @ power was too long due to cracked chasing coil. |
| CC-2 | GE AK-2A-25 | 10/12/85 | 2O | FO | RTB | Trip time during test @ power was too long due to wear of front frame. |
| CC-2 | GE AK-2A-25 | 09/30/86 | 2U | FO | RTB#7 | Intermittent UV relay response during PM @ pwr when pressure was applied. |
| CC-2 | GE AK-2A-25 | 04/17/87 | 4U | FC | RTB#3 | Bkr would not close during test due to broken lead on UV relay. |
| CC-2 | GE AK-2A-25 | 06/09/87 | 4U | FC | RTB#6 | Bkr would not close during Mode 6 test due to drift of UV device air gap. |
| CC-2 | GE AK-2A-25 | 12/03/87 | | MO | RTB#6 | Closing coil's bottom phenolic was found split during testing @ power. |
| CC-2 | GE AK-2A-25 | 03/12/88 | 4O | FC | RTB#4 | Bkr failed to close following shutdown test due to detached springs. |
| CC-2 | GE AK-2A-25 | 03/21/88 | 4O | FC | RTB#5 | Operating springs were found to be detached during shutdown testing. |
| CC-2 | GE AK-2A-25 | 05/01/88 | 3U | SA | RTB#5 | UV device failed to keep bkr opened during test @ pwr. |
| CC-2 | GE AK-2A-25 | 12/09/88 | 4O | FC | RTB#7 | Bkr would not close during test due to open circuit in cutoff switch. |
| CC-2 | GE AK-2A-25 | 01/21/89 | 4O | FC | RTB#7 | Bkr would not close during test @ pwr due to aging of control fuse. |
| CC-2 | GE AK-2A-25 | 01/21/89 | 4O | FC | RTB#8 | Bkr failed to close during test due to detached spring. |
| CC-2 | GE AK-2A-25 | 05/08/92 | | SO | MG SET BK | While @ pwr, tie bkr for MGs tripped open due to failed UV coil. |
| CC-2 | GE AK-2A-25 | 07/06/93 | 4O | FC | RTB#2 | Bkr failed to close during test @ pwr due to poor contact of fuse. |
| EO-ANO2 | GE AK-2-25 | 06/04/84 | 3U | MO | RTB | UV device air gap was found out of tolerance band during testing @ pwr. |
| EO-ANO2 | GE AK-2-25 | 12/03/85 | | MO | RTB | Local controls of bkrs could not be tested due to stuck selector switch. |
| EO-ANO2 | GE AK-2-25 | 03/26/87 | | SA | RTB | While @ pwr, bkr tripped & reclosed without being operated due to ground. |

## Table A-2
## NPRDS Reported Failures of RTCBs - By Plant & Date

| PLANT | MODEL | FAILURE DISC DATE | FAILURE TYPE | FAILURE MODE | SYSTEM | DESCRIPTION |
|---|---|---|---|---|---|---|
| EO-ANO2 | GE AK-2-25 | 01/05/89 | 2S | OR | RTB#4 | Trip time during test @ pwr was too long due to wiring installation. |
| EO-ANO2 | GE AK-2-25 | 07/10/89 | | MO | MG SET BK | UV relay coil of MG set tie bkr would not calibrate during PM @ pwr. |
| EO-ANO2 | GE AK-2-25 | 09/02/92 | 4U | FO | RTB | UV device would not adjust to acceptable setpoint during shutdown PM. |
| EO-WSES3 | GE AK-2-25 | 09/29/85 | 4U | FC | RTB | Bkr failed to reclose due to damaged trip coil. |
| EO-WSES3 | Heinemann | 01/29/87 | | FC | RTB | CEA subgroup bkr tap would not close each time bkr was shut. |
| EO-WSES3 | GE AK-2-25 | 11/06/88 | 4O | SA | RTB | Bkr failed to close following test due to broken cutoff switch. |
| EO-WSES3 | GE AK-2-25 | 03/26/89 | 4O | FC | RTB | Bkr failed to close during test @ pwr due to defective switch. |
| EO-WSES3 | GE AK-2-25 | 11/11/89 | 4O | MO | RTB | Closing coil mechanism was sticking during test due to broken clamp. |
| EO-WSES3 | GE AK-2-25 | 01/21/90 | 3U | MO | RTB | UV device air gap was too large for ensuring reset of device. |
| EO-WSES3 | GE AK-2-25 | 04/29/90 | 4O | FC | RTB | Bkr failed to close during test @ pwr due to broken switch. |
| EO-WSES3 | GE AK-2-25 | 07/24/90 | 4O | FC | RTB | Bkr failed to close during PM @ pwr due to worn switch contacts. |
| EO-WSES3 | GE AK-2-25 | 10/06/90 | 4O | FC | RTB | Bkr failed to close following test due to broken cutoff switch. |
| EO-WSES3 | GE AK-2-25 | 01/03/91 | 4O | FC | RTB | Bkr failed to close during PM @ pwr due to bent latching mechanism. |
| EO-WSES3 | GE AK-2-25 | 02/24/92 | 3U | OR | RTB | Bkr was causing ground on DC power bus due to defective UV coil device. |
| EO-WSES3 | GE AK-2-25 | 04/12/92 | 4O | FC | RTB | Bkr failed to close during test @ pwr due to lodged spring. |
| EO-WSES3 | GE AK-2-25 | 09/19/92 | 4O | FC | RTB | Bkr failed to close during test @ pwr due to broken cutoff switch. |
| EO-WSES3 | GE AK-2-25 | 12/06/92 | 4O | FC | RTB | Bkr failed to close during PM @ pwr due to broken cutoff switch. |
| MP-2 | GE AK-2A-25 | 01/18/79 | | | MG SET BK | MG set breaker tripped due to unknown cause. |
| MP-2 | GE AK-2A-25 | 07/07/79 | | | MG SET BK | MG set bkr tripped due to underfrequency trip ckt being out of cal. |
| MP-2 | GE AK-2A-25 | 09/18/79 | | | MG SET BK | MG set bkr tripped due to underfrequency trip ckt being out of cal. |
| MP-2 | GE AK-2A-25 | 10/12/79 | 4U | | RTB#4 | Bkr failed to close when UV device did not reset due to spring tension. |
| MP-2 | GE AK-2A-25 | 04/11/80 | 4O | FC | RTB | Bkr failed to close during PM due to wear of frame assembly. |
| MP-2 | GE AK-2A-25 | 01/18/81 | | | MG SET BK | MG set bkr overheated due to incorrectly sized resistor in sync. card. |
| MP-2 | GE AK-2A-25 | 02/12/88 | 4O | FC | RTB#9 | Bkr failed to close during PM due to wear of bearing & linkage. |
| MP-2 | GE AK-2A-25 | 08/19/88 | 4O | FC | RTB#7 | Bkr failed to close twice during PM due to worn parts. |
| MP-2 | GE AK-2A-25 | 04/12/89 | 4O | FC | RTB#2 | Bkr failed to close during PM due to wear of trip shaft return spring. |
| MP-2 | GE AK-2A-25 | 10/14/90 | 1S | FO | RTB#3 | Phase overload failed to trip during s/d PM due to sticking connection. |
| MP-2 | GE AK-2A-25 | 10/25/90 | 4O | FC | RTB#1 | Bkr failed to close during PM due to bent interlock arm. |
| MP-2 | GE AK-2A-25 | 03/26/93 | 4O | FC | RTB#1 | Bkr failed to close during PM @ pwr due to detached operating spring. |
| MY | GE AK-2-25 | 11/17/83 | 2O | | RTB#2 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 11/17/83 | 2O | | RTB#8 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 11/17/83 | 2O | | RTB#3 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 11/17/83 | 2O | | RTB#7 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 11/17/83 | 2O | | RTB#4 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 11/17/83 | 2O | | RTB#1 | Trip time during test was too long due to inadequate lubrication. |

## Table A-2
## NPRDS Reported Failures of RTCBs - By Plant & Date

| PLANT | MODEL | FAILURE DISC DATE | FAILURE TYPE | FAILURE MODE | SYSTEM | DESCRIPTION |
|---|---|---|---|---|---|---|
| MY | GE AK-2-25 | 11/17/83 | 2O | | RTB#6 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 11/17/83 | 2O | | RTB#5 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 11/28/83 | 2O | | RTB#3 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 11/28/83 | 2O | | RTB#6 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 11/28/83 | 2O | | RTB#4 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 12/02/83 | 2O | | RTB#4 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 12/15/83 | 1U | | RTB#4 | Bkr would not trip on demand during test @ pwr due to defective UV leads. |
| MY | GE AK-2-25 | 12/29/83 | 2U | | RTB#6 | Bkr failed UV timing check at pwr due to inadequate clearance & torque. |
| MY | GE AK-2-25 | 01/16/84 | 2S | FO | RTB#6 | Shunt trip paddle was sticking during test @ pwr due to size of paddle. |
| MY | GE AK-2-25 | 03/21/84 | 2O | FO | RTB#1 | Trip time during test @ pwr was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 07/13/84 | 2O | FO | RTB#7 | Trip time during test was too long due to dirt in trip mechanism. |
| MY | GE AK-2-25 | 09/25/84 | 2O | FO | RTB#8 | Trip time during test @ pwr was too long due to dirt in trip mechanism. |
| MY | GE AK-2-25 | 05/21/85 | 2O | FO | RTB#6 | Trip time during test @ pwr was too long due to broken coil supports. |
| MY | GE AK-2-25 | 08/22/87 | 4U | FC | RTB#10 | Bkr failed to close during PM @ pwr due to inadequate lubrication. |
| MY | GE AK-2-25 | 08/22/87 | 2O | FO | RTB#5 | Trip time during test @ pwr was too long due to aging of breaker. |
| MY | GE AK-2-25 | 08/24/87 | 1U | FO | RTB#5 | Breaker failed to open during UV test @ pwr due to binding of closing soleno |
| MY | GE AK-2-25 | 12/31/87 | 1O | FO | RTB#1 | Sticking bkr was found during PM @ pwr due to inadequate lubrication. |
| MY | GE AK-2-25 | 09/02/88 | 4O | FC | RTB#4 | Bkr failed to close during PM @ pwr due to inadequate lubrication. |
| MY | GE AK-2-25 | 09/30/88 | 4O | FC | RTB#4 | Bkr failed to close during PM due to inadequate cleaning & lubrication. |
| MY | GE AK-2-25 | 01/12/90 | 4U | FC | RTB#4 | Bkr failed to close during PM @ pwr due to worn armature coil. |
| MY | GE AK-2-25 | 12/04/90 | 3U | MO | RTB | UV device disengaged due to inadequate installation. |
| MY | GE AK-2-25 | 02/24/93 | | MO | RTB#4 | Crack was found in paddle of cut-off switch during PM @ pwr. |
| MY | GE AK-2-25 | 02/24/93 | | MO | RTB#2 | Crack was found in paddle of cut-off switch during PM @ pwr. |
| MY | GE AK-2-25 | 02/24/93 | | MO | RTB#1 | Crack was found in paddle of cut-off switch during PM @ pwr. |
| PV-1 | GE AKR-4BE- | 12/05/88 | 3U | MO | RTB A | Broken lead on shunt trip coil during PM. |
| PV-1 | W DS-206 | 12/12/88 | | MO | RTB C | Bkr closing spring retained broke during PM @ pwr. |
| PV-1 | W DS-206 | 08/20/89 | 2O | OR | RTB C | Bkr exceeded required opening time during test @ Mode 6. |
| PV-1 | GE AKR-4BE- | 08/18/90 | 4O | FC | RTB B | Bkr failed to close following rack-in due to bent linkages. |
| PV-1 | W DS-206 | 04/08/91 | 2U | MO | RTB D | UV dropout device did not meet criteria during test @ pwr. |
| PV-1 | GE AKR-4BE- | 05/02/92 | 4O | FC | RTB A | Bkr failed to close during Mode 5 tests -damage to closing spring. |
| PV-1 | W DS-206 | 08/25/92 | 4O | FC | RTB D | Bkr would not close following rack-in after test at pwr. |
| PV-1 | GE AKR-4BE- | 12/01/92 | 2U | FO | RTB A | UV device settings out of tolerance during PM @ power. |
| PV-1 | GE AKR-4BE- | 12/14/92 | 4U | OR | RTB B | Bkr failed to close during test @ pwr due to defective UV device. |
| PV-2 | W DS-206 | 03/12/87 | | SA | RTB C | Rotary position switch on CB panel causing spurious trip @ Mode 2. |
| PV-2 | W DS-206 | 05/23/88 | | MO | RTB | Shaft welds found to have insufficient material during inspection. |

## Table A-2
## NPRDS Reported Failures of RTCBs - By Plant & Date

| PLANT | MODEL | FAILURE DISC DATE | FAILURE TYPE | FAILURE MODE | SYSTEM | DESCRIPTION |
|---|---|---|---|---|---|---|
| PV-2 | W DS-206 | 01/05/89 | 4O | FC | RTB D | Bkr failed to close during test due to damaged spring charging motor. |
| PV-2 | W DS-206 | 04/06/89 | | MO | RTB C | Closing spring retaining spring found broken during PM @ Mode 3. |
| PV-2 | GE AKR-4BE- | 10/05/90 | 4O | FC | RTB B | Breaker would not close following PM @ power. |
| PV-2 | GE AKR-4BE- | 04/11/92 | 4U | FC | RTB A | Bkr failed to close during test @ power due to defective UV device. |
| PV-2 | GE AKR-4BE- | 07/10/92 | 3U | OR | RTB B | UV device found in mid-position during inspection prior to testing. |
| PV-2 | GE AKR-4BE- | 09/01/92 | 4U | OR | RTB A | UV device did not reset following test @ power. |
| PV-2 | GE AKR-4BE- | 11/28/92 | 2U | FO | RTB A | UV device trip setpoints out of calibration during PM @ power. |
| PV-2 | GE AKR-4BE- | 02/17/93 | 4U | FC | RTB B | UV device failed to pick-up when energized during PM @ pwr. |
| PV-3 | GE AKR-4BE- | 06/27/89 | | MO | RTB A | Failure of solder joint on anti-pump relay coil found during outage PM. |
| PV-3 | GE AKR-4BE- | 03/30/92 | 4O | SO | RTB A | Bkr would not stay closed following test @ pwr. |
| PV-3 | W DS-206 | 03/31/92 | 1O* | FO | RTB C | Bkr failed to open during test @ pwr. Shaft reset springs suspected. |
| PV-3 | GE AKR-4BE- | 06/21/92 | 4O | FC | RTB B | Bkr would not close following test @ pwr. |
| PV-3 | GE AKR-4BE- | 07/08/92 | 4U | MO | RTB B | UV device armature did not reset when opened during test @ power. |
| PV-3 | W DS-206 | 08/29/92 | 2U | OR | RTB C | UV device hot drop out voltage setting slightly high during test @ power. |
| SL-1 | GE AK-2A-25 | 04/26/84 | 4O | FC | RTB#6 | Bkr failed to close during test due to dirty auxiliary contacts. |
| SL-1 | GE AK-2A-25 | 04/26/84 | 4O | FC | RTB#3 | While shutdown, bkr failed to close during test due to dirty contacts. |
| SL-1 | GE AK-2A-25 | 05/10/84 | 4O | FC | RTB#5 | Bkr failed to close during test due to dirty secondary contacts. |
| SL-1 | GE AK-2A-25 | 05/17/84 | 4U | FC | RTB#5 | Bkr would not close while at pwr due to binding of armature. |
| SL-1 | GE AK-2A-25 | 05/24/84 | 4O | FC | RTB#5 | Bkr failed to close during test due to binding of closing coil's plunger. |
| SL-1 | GE AK-2A-25 | 08/23/84 | 4O | FC | RTB#6 | Bkr failed to close during plant startup due to internal misalignment. |
| SL-1 | GE AK-2A-25 | 09/06/84 | 4U | FC | RTB#1 | Bkr failed to close during PM @ pwr due to misadjusted UV trip paddle. |
| SL-1 | GE AK-2A-25 | 06/06/85 | 3U | MO | RTB#5 | UV armature did not stroke fully during bkr closure due to binding. |
| SL-1 | GE AK-2A-25 | 06/06/85 | 4U | MO | RTB#7 | Bkr failed to fully close during test due to binding of mech. linkage. |
| SL-1 | GE AK-2A-25 | 12/13/85 | 4O | FC | RTB#1 | Bkr failed to close during outage test due to defective switch. |
| SL-1 | GE AK-2A-25 | 12/13/85 | 4O | FC | RTB#7 | Bkr failed to close during test due to damaged aux. contact coil. |
| SL-1 | GE AK-2A-25 | 04/13/86 | 4U | FC | RTB#1 | Bkr failed to close during PM @ pwr due to defective closing coil. |
| SL-1 | GE AK-2A-25 | 09/05/86 | 4O | FC | RTB#2 | Bkr failed to close during PM @ pwr due to broken support spring pin. |
| SL-1 | GE AK-2A-25 | 12/01/86 | | MO | RTB#1 | PM inspection found excessive movement of bkr internals. |
| SL-1 | GOULD | 06/21/87 | | FC | MG SET BKR | MG set bkr woudl not close due to defective relay in control circuit. |
| SL-1 | GOULD | 10/16/87 | | FC | MG SET BKR | MG set bkr would not close due to defective resistor in synch circuit. |
| SL-1 | GOULD | 08/25/88 | | SO | MG SET BKR | MG bkr tripped on voltage during rod drop test due to defective relay. |
| SL-1 | GOULD | 08/25/88 | | FC | MG SET BKR | MG set bkr would not reset during rod drop test due to defective relay. |
| SL-1 | GE AK-2A-25 | 10/06/88 | 4O | FC | RTB#7 | Bkr failed to close during test due to dirt & inadequate lubrication. |
| SL-1 | GE TJK63 | 10/12/88 | | SO | MG SET BKR | CRDM MG set tripped while @ pwr due to unknown cause. |
| SL-1 | GE AK-2A-25 | 10/05/89 | 4U | FC | RTB#2 | Bkr failed to close during PM due to misadjusted UV coil. |

# Table A-2
## NPRDS Reported Failures of RTCBs - By Plant & Date

| PLANT | MODEL | FAILURE DISC DATE | FAILURE TYPE | FAILURE MODE | SYSTEM | DESCRIPTION |
|---|---|---|---|---|---|---|
| SL-1 | GOULD | 12/15/89 | | FC | MG SET BKR | MG set bkr would not close during test due to dirty mechanism. |
| SL-1 | GE AK-2A-25 | 10/28/90 | 4O | FC | RTB#7 | Bkr failed to close during test due to inadequate set-up of latch spring. |
| SL-1 | GE AK-2A-25 | 10/28/90 | 4U | FC | RTB#3 | While shutdown, bkr failed to close during test due to shorted UV coil. |
| SL-1 | GE AK-2A-25 | 10/28/90 | 4O | FC | RTB#5 | Bkr closed intermittently on demand due to faulty control wiring. |
| SL-1 | GE AK-2A-25 | 02/07/91 | | SO | RTB#5 | Bkr tripped open due to defective relay. |
| SL-1 | GE AK-2A-25 | 12/16/91 | 4U | FC | RTB#4 | While shutdown, bkr failed to close due to defective UV coil. |
| SL-1 | GE AK-2A-25 | 12/19/91 | 4O | FC | RTB#2 | Bkr failed to close during PM due to defective closing coil. |
| SL-1 | GE TJK63 | 01/30/92 | | SO | MG SET BKR | MG set tripped due to RF signal from vibration test equipment. |
| SL-1 | GE AK-2A-25 | 11/05/92 | 4O | FC | RTB#5 | Bkr failed to close during test @ pwr due to broken cut-off switch. |
| SL-1 | GE AK-2A-25 | 03/04/93 | 4O | FC | RTB#8 | Bkr failed to close during test @ pwr due to detached spring. |
| SL-1 | GE AK-2A-25 | 06/10/93 | 4O | FC | RTB#5 | Bkr failed to close during test. Bkr was cleaned & inspected. |
| SL-1 | GE AK-2A-25 | 07/06/93 | 4O | FC | RTB#4 | Bkr failed to close during test @ pwr due to misadjusted latch switch. |
| SL-1 | GE AK-2A-25 | 08/21/93 | 3U | SO | RTB | UV relay of bkr failed erroniously in the UV condition, while @ pwr. |
| SL-2 | GE AK-2A-25 | 03/01/84 | 1U | FO | RTB#8 | Bkr would not open on demand during UV test @ pwr due to binding. |
| SL-2 | GE AK-2A-25 | 11/29/84 | 4O | FC | RTB#5 | Bkr failed to close during startup due to inadequate lubrication. |
| SL-2 | GE AK-2A-25 | 07/25/85 | 4U | FC | RTB#2 | Bkr failed to close during test @ pwr due to loose UV relay armature. |
| SL-2 | GE AK-2A-25 | 05/06/86 | 3U | MO | RTB#2 | Defective UV trip device detected during outage inspection. |
| SL-2 | GE AK-2A-25 | 04/16/89 | 4O | FC | RTB#6 | Detached trip mech. springs bound plunger during attempts to close bkr. |
| SL-2 | GE AK-2A-25 | 04/23/89 | 4U | FC | RTB#4 | Bkr failed to close during test due to defective UV relay coil. |
| SL-2 | GE AK-2A-25 | 09/07/89 | 4O | FC | RTB#5 | Bkr failed to close during test due to defective closing coil. |
| SL-2 | GE AK-2A-25 | 02/01/90 | 4O | FC | RTB#1 | Bkr failed to close during test due to unknown cause. |
| SONGS-2 | GE AK-2-25 | 10/02/83 | 2U | | RTB#4 | Trip times during tests were too long due to to pickup adjustments. |
| SONGS-2 | GE AK-2-25 | 10/03/83 | 1U | | RTB#6 | Bkr failed to open on UV during test due to unknown causes. |
| SONGS-2 | GE AK-2-25 | 10/31/83 | 3U | | RTB#4 | UV trip device armature was found in midposition due to interference. |
| SONGS-2 | GE AK-2-25 | 12/04/83 | 2U | | RTB#4 | Trip times during tests were too long due to unknown causes. |
| SONGS-2 | GE AK-2-25E | 12/04/83 | 2U | | RTB#1 | Trip times during test were too long due to unknown causes. |
| SONGS-2 | GE AK-2-25 | 12/07/83 | 4O | | RTB#3 | Installed spare bkr failed to close during test due to defective coil. |
| SONGS-2 | GE AK-2-25 | 04/16/84 | 2O | FO | RTB | Trip time during test during test was too long due to wear of bearings. |
| SONGS-2 | GE AK-2-25 | 06/28/84 | 4O | FC | RTB | Bkr failed to close during test due to normal wear. |
| SONGS-2 | GE AK-2-25 | 07/11/84 | 4O | FC | RTB | Bkr failed to remain closed during test due to worn bearings. |
| SONGS-2 | GE AK-2-25 | 02/28/85 | 2O | FO | RTB | Trip time during outage test was too long due to unknown cause. |
| SONGS-2 | GE AK-2-25 | 04/29/85 | 4O | FC | RTB | Bkr failed to close during test due to dirty contacts. |
| SONGS-2 | GE AK-2-25E | 07/04/85 | 3U | SO | RTB | UV relay operation was erratic during test due to broken lead. |
| SONGS-2 | GE AK-2-25 | 03/03/86 | 3U | MO | RTB | Low value of UV coil resistance found during PM @ pwr. |
| SONGS-2 | GE AK-2-25 | 06/23/86 | | MO | RTB | Loose fasteners found in bkr during PM @ pwr. Inadequate maintenance. |

## Table A-2
## NPRDS Reported Failures of RTCBs - By Plant & Date

| PLANT | MODEL | FAILURE DISC DATE | FAILURE TYPE | FAILURE MODE | SYSTEM | DESCRIPTION |
|---|---|---|---|---|---|---|
| SONGS-2 | GE AK-2-25E | 12/13/86 | | OR | RTB | Inadequate spring compression was caused by age & cyclic fatigue. |
| SONGS-2 | GE AK-2-25 | 08/23/87 | | MO | RTB | X-contactor relay was found damaged during PM @ pwr. |
| SONGS-2 | GE AK-2-25E | 10/07/88 | 4O | FC | RTB | Bkr failed to close during test @ pwr due to defective relay. |
| SONGS-2 | GE AK-2-25E | 03/22/89 | 2S | FO | RTB | Trip time during test @ pwr was too long due to open ckt in trip device. |
| SONGS-2 | GE AK-2-25 | 08/11/89 | | MO | RTB | Oil leak from trip device was found during PM @ pwr. |
| SONGS-2 | GE AK-2-25 | 02/07/91 | 4O | FC | RTB#1 | Bkr failed to close during test @ pwr due to binding of closing assembly. |
| SONGS-2 | GE AK-2-25 | 02/08/91 | 2U | FO | RTB | UV device failed dropout voltage check at power due to aging. |
| SONGS-3 | GE AK-2-25 | 04/25/84 | 2O | FO | RTB | Trip times during test were too long due to mechanism wear. |
| SONGS-3 | GE AK-2-25 | 05/24/84 | 2O | FO | RTB#9 | Unacceptable opening times occurred during PM @ pwr due to lubrication. |
| SONGS-3 | GE AK-2-25 | 08/29/84 | 4O | FC | RTB | Bkr failed to close during test @ pwr due to washer interference. |
| SONGS-3 | GE AK-2-25 | 02/01/85 | | MO | RTB | Loose steel lamination of closing coil was found during outage PM. |
| SONGS-3 | GE AK-2-25 | 05/10/85 | 4U | FC | RTB | UV device would not reset during PM @ pwr due to open ckt in coil. |
| SONGS-3 | GE AK-2-25E | 11/19/85 | | OR | RTB | Broken movable secondary disconnect found during PM. |
| SONGS-3 | GE AK-2-25 | 11/26/85 | 3U | MO | RTB | Defective UV coil found during outage PM. |
| SONGS-3 | GE AK-2-25E | 01/14/86 | | MO | RTB | Oil leak from trip device was found during outage PM. |
| SONGS-3 | GE AK-2-25E | 02/15/86 | | MO | RTB | Loose arc chute screws and misaligned chutes were found during outage PM. |
| SONGS-3 | GE AK-2-25E | 03/05/86 | | MO | RTB | Shutdown PM found damaged aux. switch mounting bracket. |
| SONGS-3 | GE AK-2-25 | 07/21/86 | 3U | MO | RTB | Damaged UV device coil found during PM @ pwr. |
| SONGS-3 | GE AK-2-25 | 08/13/86 | 4O | FC | RTB | Bkr failed to close during test @ pwr due to unknown cause. |
| SONGS-3 | GE AK-2-25E | 03/26/87 | | OR | RTB | Failed current transducers found during PM @ pwr. |
| SONGS-3 | GE AK-2-25 | 04/02/87 | 4U | FC | RTB | UV trip device would not reset during PM @ pwr due to unknown cause. |
| SONGS-3 | GE AK-2-25E | 04/23/87 | 4O | FC | RTB | Bkr failed to close during test @ pwr due to metal shim in closing core. |
| SONGS-3 | GE AK-2-25E | 05/02/87 | | MO | RTB | Broken coil contact found during PM @ pwr. |
| SONGS-3 | GE AK-2-25E | 05/20/87 | | OR | RTB | Failed current transducers found during PM @ pwr. |
| SONGS-3 | GE AK-2-25E | 05/27/87 | 2U | FO | RTB | Drop test of bkr failed @ pwr due to misadjusted UV trip device. |
| SONGS-3 | GE AK-2-25E | 08/18/87 | | MO | RTB | Compression spring wear-out found during PM @ pwr. |
| SONGS-3 | GE AK-2-25E | 02/17/88 | | FC | RTB | PM @ pwr found that contact springs did not meet acceptance criteria. |
| SONGS-3 | GE AK-2-25E | 01/09/89 | | OR | RTB | PM found DC ground on closed bkr due to disconnect of wires. |
| SONGS-3 | GE AK-2-25E | 10/16/89 | 3U | FO | RTB | Open ckt on UV device coil found during PM @ pwr. |
| SONGS-3 | GE AK-2-25E | 03/02/90 | 4O | FC | RTB | Bkr failed to close on demand due to damaged closing coil. |

Table A-3

NPRDS RTCB Data Summary - Sorted by Failure Type and Date

Table A-3
NPRDS Reported Failures of RTCBs - By Failure Type & Date

| PLANT | MODEL | FAILURE DISC DATE | FAILURE TYPE | FAILURE MODE | SYSTEM | DESCRIPTION |
|---|---|---|---|---|---|---|
| CC-1 | GE AK-2A-25 | 02/23/78 | | | RTB | Bkr anti-pumping function failed due to filing on relay armature. |
| MP-2 | GE AK-2A-25 | 01/18/79 | | | MG SET BK | MG set breaker tripped due to unknown cause. |
| MP-2 | GE AK-2A-25 | 07/07/79 | | | MG SET BK | MG set bkr tripped due to underfrequency trip ckt being out of cal. |
| MP-2 | GE AK-2A-25 | 09/18/79 | | | MG SET BK | MG set bkr tripped due to underfrequency trip ckt being out of cal. |
| MP-2 | GE AK-2A-25 | 01/18/81 | | | MG SET BK | MG set bkr overheated due to incorrectly sized resistor in sync. card. |
| CC-1 | GE AK-2A-25 | 04/05/84 | | MO | RTB | Excessive movement of closing armature unlatching mechanism. |
| SONGS-3 | GE AK-2-25 | 02/01/85 | | MO | RTB | Loose steel lamination of closing coil was found during outage PM. |
| CC-1 | GE AK-2A-25 | 05/29/85 | | SA | RTB#3 | During Mode 6, indicator light for bkr was not lit due to blown fuse. |
| SONGS-3 | GE AK-2-25E | 11/19/85 | | OR | RTB | Broken movable secondary disconnect found during PM. |
| CC-1 | GE AK-2A-25 | 11/22/85 | | MO | RTB#7 | Bkr trip shaft torque was found to be too high during PM. |
| EO-ANO2 | GE AK-2-25 | 12/03/85 | | MO | RTB | Local controls of bkrs could not be tested due to stuck selector switch. |
| SONGS-3 | GE AK-2-25E | 01/14/86 | | MO | RTB | Oil leak from trip device was found during outage PM. |
| SONGS-3 | GE AK-2-25E | 02/15/86 | | MO | RTB | Loose arc chute screws and misaligned chutes were found during outage PM. |
| SONGS-3 | GE AK-2-25E | 03/05/86 | | MO | RTB | Shutdown PM found damaged aux. switch mounting bracket. |
| SONGS-2 | GE AK-2-25 | 06/23/86 | | MO | RTB | Loose fasteners found in bkr during PM @ pwr. Inadequate maintenance. |
| SL-1 | GE AK-2A-25 | 12/01/86 | | MO | RTB#1 | PM inspection found excessive movement of bkr internals. |
| SONGS-2 | GE AK-2-25E | 12/13/86 | | OR | RTB | Inadequate spring compression was caused by age & cyclic fatigue. |
| EO-WSES3 | Heinemann | 01/29/87 | | FC | RTB | CEA subgroup bkr tap would not close each time bkr was shut. |
| PV-2 | W DS-206 | 03/12/87 | | SA | RTB C | Rotary position switch on CB panel causing spurious trip @ Mode 2. |
| EO-ANO2 | GE AK-2-25 | 03/26/87 | | SA | RTB | While @ pwr, bkr tripped & reclosed without being operated due to ground. |
| SONGS-3 | GE AK-2-25E | 03/26/87 | | OR | RTB | Failed current transducers found during PM @ pwr. |
| SONGS-3 | GE AK-2-25E | 05/02/87 | | MO | RTB | Broken coil contact found during PM @ pwr. |
| SONGS-3 | GE AK-2-25E | 05/20/87 | | OR | RTB | Failed current transducers found during PM @ pwr. |
| SL-1 | GOULD | 06/21/87 | | FC | MG SET BK | MG set bkr woudl not close due to defective relay in control circuit. |
| SONGS-3 | GE AK-2-25E | 08/18/87 | | MO | RTB | Compression spring wear-out found during PM @ pwr. |
| SONGS-2 | GE AK-2-25 | 08/23/87 | | MO | RTB | X-contactor relay was found damaged during PM @ pwr. |
| CC-1 | GE AK-2A-25 | 09/30/87 | | MO | RTB#8 | Cracked retainer for closing coil was identified during PM @ power. |
| SL-1 | GOULD | 10/16/87 | | FC | MG SET BK | MG set bkr would not close due to defective resistor in synch circuit. |
| CC-2 | GE AK-2A-25 | 12/03/87 | | MO | RTB#6 | Closing coil's bottom phenolic was found split during testing @ power. |
| SONGS-3 | GE AK-2-25E | 02/17/88 | | FC | RTB | PM @ pwr found that contact springs did not meet acceptence criteria. |
| PV-2 | W DS-206 | 05/23/88 | | MO | RTB | Shaft welds found to have insufficient material during inspection. |
| SL-1 | GOULD | 08/25/88 | | FC | MG SET BK | MG set bkr would not reset during rod drop test due to defective relay. |
| SL-1 | GOULD | 08/25/88 | | SO | MG SET BK | MG bkr tripped on voltage during rod drop test due to defective relay. |

## Table A-3
## NPRDS Reported Failures of RTCBs - By Failure Type & Date

| PLANT | MODEL | FAILURE DISC DATE | FAILURE TYPE | FAILURE MODE | SYSTEM | DESCRIPTION |
|---|---|---|---|---|---|---|
| CC-1 | GE AK-2A-25 | 10/04/88 | | MO | RTB#1 | Cracked closing coil noted during PM @ pwr. |
| SL-1 | GE TJK63 | 10/12/88 | | SO | MG SET BK | CRDM MG set tripped while @ pwr due to unknown cause. |
| CC-1 | GE AK-2A-25 | 11/09/88 | | FC | RTB#3 | While @ pwr, bkr had no current to Phase B due to unknown cause. |
| PV-1 | W DS-206 | 12/12/88 | | MO | RTB C | Bkr closing spring retained broke during PM @ pwr. |
| SONGS-3 | GE AK-2-25E | 01/09/89 | | OR | RTB | PM found DC ground on closed bkr due to disconnect of wires. |
| CC-1 | W DS-206 | 03/27/89 | | FC | MG SET BK | MG set would not start from local switch due to defective control ckt. |
| PV-2 | W DS-206 | 04/06/89 | | MO | RTB C | Closing spring retaining spring found broken during PM @ Mode 3. |
| EO-ANO2 | GE AK-2-25 | 07/10/89 | | MO | MG SET BK | UV relay coil of MG set tie bkr would not calibrate during PM @ pwr. |
| SONGS-2 | GE AK-2-25 | 08/11/89 | | MO | RTB | Oil leek from trip device was found during PM @ pwr. |
| SL-1 | GOULD | 12/15/89 | | FC | MG SET BK | MG set bkr would not close during test due to dirty mechanism. |
| CC-1 | GE AK-2A-25 | 03/05/90 | | MO | RTB#1 | Broken closing coil found during PM. |
| SL-1 | GE AK-2A-25 | 02/07/91 | | SO | RTB#5 | Bkr tripped open due to defective relay. |
| SL-1 | GE TJK63 | 01/30/92 | | SO | MG SET BK | MG set tripped due to RF signal from vibration test equipment. |
| CC-2 | GE AK-2A-25 | 05/08/92 | | SO | MG SET BK | While @ pwr, tie bkr for MGs tripped open due to failed UV coil. |
| MY | GE AK-2-25 | 02/24/93 | | MO | RTB#1 | Crack was found in paddle of cut-off switch during PM @ pwr. |
| MY | GE AK-2-25 | 02/24/93 | | MO | RTB#2 | Crack was found in paddle of cut-off switch during PM @ pwr. |
| MY | GE AK-2-25 | 02/24/93 | | MO | RTB#4 | Crack was found in paddle of cut-off switch during PM @ pwr. |
| PV-8 | GE AKR-4BE- | 06/27/89 | | MO | RTB A | Failure of solder joint on anti-pump relay coil found during outage PM. |
| MY | GE AK-2-25 | 12/31/87 | 1O | FO | RTB#1 | Sticking bkr was found during PM @ pwr due to inadequate lubrication. |
| PV-3 | W DS-206 | 03/31/92 | 1O* | FO | RTB C | Bkr failed to open during test @ pwr. Shaft reset springs suspected. |
| CC-2 | GE AK-2A-25 | 01/14/84 | 1S | FO | RTB | Bkr did not open during test of shunt trip device. Contacts cleaned. |
| MP-2 | GE AK-2A-25 | 10/14/90 | 1S | FO | RTB#3 | Phase overload failed to trip during s/d PM due to sticking connection. |
| CC-1 | GE AK-2A-25 | 02/28/78 | 1U | | RTB | UV trip mechanism did not trip bkr during PM due to misadjustment. |
| CC-1 | GE AK-2A-25 | 05/03/79 | 1U | | RTB#8 | UV device would not trip bkr during PM. UV device was replaced. |
| SONGS-2 | GE AK-2-25 | 10/03/83 | 1U | | RTB#6 | Bkr failed to open on UV during test due to unknown causes. |
| MY | GE AK-2-25 | 12/15/83 | 1U | | RTB#4 | Bkr would not trip on demand during test @ pwr due to defective UV leads. |
| CC-1 | GE AK-2A-25 | 01/30/84 | 1U | FO | RTB | Bkr failed to open on UV during test @ pwr due to binding of UV device. |
| SL-2 | GE AK-2A-25 | 03/01/84 | 1U | FO | RTB#8 | Bkr would not open on demand during UV test @ pwr due to binding. |
| CC-1 | GE AK-2A-25 | 09/05/86 | 1U | FO | RTB#1 | Bkr failed to trip on UV during PM @ pwr due to inadequate armature clearanc |
| MY | GE AK-2-25 | 08/24/87 | 1U | FO | RTB#5 | Breaker failed to open during UV test @ pwr due to binding of closing soleno |
| CC-1 | GE AK-2A-25 | 04/12/90 | 1U | FO | RTB | While shutdown, bkr failed to open on demand due to faulty UV relay. |
| MY | GE AK-2-25 | 11/17/83 | 2O | | RTB#4 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 11/17/83 | 2O | | RTB#2 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 11/17/83 | 2O | | RTB#5 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 11/17/83 | 2O | | RTB#3 | Trip time during test was too long due to inadequate lubrication. |

## Table A-3
## NPRDS Reported Failures of RTCBs - By Failure Type & Date

| PLANT | MODEL | FAILURE DISC DATE | FAILURE TYPE | FAILURE MODE | SYSTEM | DESCRIPTION |
|---|---|---|---|---|---|---|
| MY | GE AK-2-25 | 11/17/83 | 2O | | RTB#1 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 11/17/83 | 2O | | RTB#6 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 11/17/83 | 2O | | RTB#7 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 11/17/83 | 2O | | RTB#8 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 11/28/83 | 2O | | RTB#3 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 11/28/83 | 2O | | RTB#4 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 11/28/83 | 2O | | RTB#6 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 12/02/83 | 2O | | RTB#4 | Trip time during test was too long due to inadequate lubrication. |
| MY | GE AK-2-25 | 03/21/84 | 2O | FO | RTB#1 | Trip time during test @ pwr was too long due to inadequate lubrication. |
| SONGS-2 | GE AK-2-25 | 04/16/84 | 2O | FO | RTB | Trip time during test during test was too long due to wear of bearings. |
| SONGS-3 | GE AK-2-25 | 04/25/84 | 2O | FO | RTB | Trip times during test were too long due to mechanism wear. |
| SONGS-3 | GE AK-2-25 | 05/24/84 | 2O | FO | RTB#9 | Unacceptable opening times occurred during PM @ pwr due to lubrication. |
| MY | GE AK-2-25 | 07/13/84 | 2O | FO | RTB#7 | Trip time during test was too long due to dirt in trip mechanism. |
| MY | GE AK-2-25 | 09/25/84 | 2O | FO | RTB#8 | Trip time during test @ pwr was too long due to dirt in trip mechanism. |
| CC-2 | GE AK-2A-25 | 10/10/84 | 2O | FO | RTB | Trip time during test @ pwr was too long due to inadequate lubrication. |
| CC-2 | GE AK-2A-25 | 12/10/84 | 2O | FO | RTB | Trip time during test @ pwr was too long due to inadequate lubrication. |
| CC-1 | GE AK-2A-25 | 01/03/85 | 2O | FO | RTB#4 | Trip times during tests were too long due to wear of front frame. |
| CC-1 | GE AK-2A-25 | 01/03/85 | 2O | FO | RTB#1 | Trip time high during test, lubricated with mobil 28 grease. |
| CC-2 | GE AK-2A-25 | 01/18/85 | 2O | FO | RTB | Trip time during test @ pwr was too long due to lubrication and frame. |
| CC-2 | GE AK-2A-25 | 02/05/85 | 2O | FO | RTB#6 | Trip time during test @ pwr was too long due to dirt accumulation. |
| CC-2 | GE AK-2A-25 | 02/19/85 | 2O | FO | RTB#6 | Trip time during test @ pwr was too long due to wear of front frame. |
| SONGS-2 | GE AK-2-25 | 02/28/85 | 2O | FO | RTB | Trip time during outage test was too long due to unknown cause. |
| CC-2 | GE AK-2A-25 | 04/08/85 | 2O | FO | RTB#3 | Trip time during test @ power was too long due to cracked chasing coil. |
| MY | GE AK-2-25 | 05/21/85 | 2O | FO | RTB#6 | Trip time during test @ pwr was too long due to broken coil supports. |
| CC-2 | GE AK-2A-25 | 10/12/85 | 2O | FO | RTB | Trip time during test @ power was too long due to wear of front frame. |
| MY | GE AK-2-25 | 08/22/87 | 2O | FO | RTB#5 | Trip time during test @ pwr was too long due to aging of breaker. |
| PV-1 | W DS-206 | 08/20/89 | 2O | OR | RTB C | Bkr exceeded required opening time during test @ Mode 6. |
| MY | GE AK-2-25 | 01/16/84 | 2S | FO | RTB#6 | Shunt trip paddle was sticking during test @ pwr due to size of paddle. |
| EO-ANO2 | GE AK-2-25 | 01/05/89 | 2S | OR | RTB#4 | Trip time during test @ pwr was too long due to wiring installation. |
| SONGS-2 | GE AK-2-25E | 03/22/89 | 2S | FO | RTB | Trip time during test @ pwr was too long due to open ckt in trip device. |
| CC-2 | GE AK-2A-25 | 07/19/83 | 2U | | RTB | Trip time during test was too long due to UV device setpoint adjustments. |
| SONGS-2 | GE AK-2-25 | 10/02/83 | 2U | | RTB#4 | Trip times during tests were too long due to to pickup adjustments. |
| SONGS-2 | GE AK-2-25 | 12/04/83 | 2U | | RTB#4 | Trip times during tests were too long due to unknown causes. |
| SONGS-2 | GE AK-2-25E | 12/04/83 | 2U | | RTB#1 | Trip times during test were too long due to unknown causes. |
| CC-1 | GE AK-2A-25 | 12/21/83 | 2U | | RTB | UV device trip setpoint out of calibration during surveillance test. |

## Table A-3
## NPRDS Reported Failures of RTCBs - By Failure Type & Date

| PLANT | MODEL | FAILURE DISC DATE | FAILURE TYPE | FAILURE MODE | SYSTEM | DESCRIPTION |
|---|---|---|---|---|---|---|
| MY | GE AK-2-25 | 12/29/83 | 2U | | RTB#6 | Bkr failed UV timing check at pwr due to inadequate clearance & torque. |
| CC-2 | GE AK-2A-25 | 02/05/85 | 2U | FO | RTB | UV device had inadequate response during PM @ pwr due to loose armature. |
| CC-2 | GE AK-2A-25 | 09/30/86 | 2U | FO | RTB#7 | Intermittent UV relay response during PM @ pwr when pressure was applied. |
| SONGS-3 | GE AK-2-25E | 05/27/87 | 2U | FO | RTB | Drop test of bkr failed @ pwr due to misadjusted UV trip device. |
| CC-1 | GE AK-2A-25 | 10/01/87 | 2U | FO | RTB#7 | Erratic UV coil response during PM @ pwr due to loose rivet. |
| SONGS-2 | GE AK-2-25 | 02/08/91 | 2U | FO | RTB | UV device failed dropout voltage check at power due to aging. |
| PV-1 | W DS-206 | 04/08/91 | 2U | MO | RTB D | UV dropout device did not meet criteria during test @ pwr. |
| PV-3 | W DS-206 | 08/29/92 | 2U | OR | RTB C | UV device hot drop out voltage setting slightly high during test @ power. |
| PV-2 | GE AKR-4BE- | 11/28/92 | 2U | FO | RTB A | UV device trip setpoints out of calibration during PM @ power. |
| PV-1 | GE AKR-4BE- | 12/01/92 | 2U | FO | RTB A | UV device settings out of tolerance during PM @ power. |
| CC-2 | GE AK-2A-25 | 01/14/82 | 3U | FO | RTB | Calibration requirements were not met due to defective UV relay. |
| SONGS-2 | GE AK-2-25 | 10/31/83 | 3U | | RTB#4 | UV trip device armature was found in midposition due to interference. |
| CC-2 | GE AK-2A-25 | 02/13/84 | 3U | MO | RTB | UV relay pickup voltage was found to be low during surveillance testing. |
| EO-ANO2 | GE AK-2-25 | 06/04/84 | 3U | MO | RTB | UV device air gap was found out of tolerance band during testing @ pwr. |
| SL-1 | GE AK-2A-25 | 06/06/85 | 3U | MO | RTB#5 | UV armature did not stroke fully during bkr closure due to binding. |
| SONGS-2 | GE AK-2-25E | 07/04/85 | 3U | SO | RTB | UV relay operation was erratic during test due to broken lead. |
| SONGS-3 | GE AK-2-25 | 11/26/85 | 3U | MO | RTB | Defective UV coil found during outage PM. |
| SONGS-2 | GE AK-2-25 | 03/03/86 | 3U | MO | RTB | Low value of UV coil resistance found during PM @ pwr. |
| SL-2 | W AK-2A-25 | 05/06/86 | 3U | MO | RTB#2 | Defective UV trip device detected during outage inspection. |
| SONGS-3 | GE AK-2-25 | 07/21/86 | 3U | MO | RTB | Damaged UV device coil found during PM @ pwr. |
| CC-1 | GE AK-2A-25 | 10/31/86 | 3U | MO | RTB#8 | During Mode 6, UV device could not be adjusted to perform as designed. |
| CC-2 | GE AK-2A-25 | 05/01/88 | 3U | SA | RTB#5 | UV device failed to keep bkr opened during test @ pwr. |
| CC-1 | GE AK-2A-25 | 11/02/88 | 3U | MO | RTB#9 | UV device was inoperative due to loose wire that was found while @ power. |
| PV-1 | GE AKR-4BE- | 12/05/88 | 3U | MO | RTB A | Broken lead on shunt trip coil during PM. |
| SONGS-3 | GE AK-2-25E | 10/16/89 | 3U | FO | RTB | Open ckt on UV device coil found during PM @ pwr. |
| EO-WSES3 | GE AK-2-25 | 01/21/90 | 3U | MO | RTB | UV device air gap was too large for ensuring reset of device. |
| CC-1 | GE AK-2A-25 | 03/12/90 | 3U | MO | RTB | UV coil had intermittent resistance readings during PM due to aging. |
| MY | GE AK-2-25 | 12/04/90 | 3U | MO | RTB | UV device disengaged due to inadequate installation. |
| EO-WSES3 | GE AK-2-25 | 02/24/92 | 3U | OR | RTB | Bkr was causing ground on DC power bus due to defective UV coil device. |
| PV-2 | GE AKR-4BE- | 07/10/92 | 3U | OR | RTB B | UV device found in mid-position during inspection prior to testing. |
| SL-1 | GE AK-2A-25 | 08/21/93 | 3U | SO | RTB | UV relay of bkr failed erroniously in the UV condition, while @ pwr. |
| CC-2 | GE AK-2A-25 | 05/03/77 | 4O | | RTB#2 | Bkr was not closing properly. New UV coil was installed. |
| MP-2 | GE AK-2A-25 | 04/11/80 | 4O | FC | RTB | Bkr failed to close during PM due to wear of frame assembly. |
| SONGS-2 | GE AK-2-25 | 12/07/83 | 4O | | RTB#3 | Installed spare bkr failed to close during test due to defective coil. |
| CC-1 | GE AK-2A-25 | 01/27/84 | 4O | FC | RTB | Bkr would not close during test due to defect of mechanical collar. |

## Table A-3
## NPRDS Reported Failures of RTCBs - By Failure Type & Date

| PLANT | MODEL | FAILURE DISC DATE | FAILURE TYPE | FAILURE MODE | SYSTEM | DESCRIPTION |
|---|---|---|---|---|---|---|
| CC-1 | GE AK-2A-25 | 03/21/84 | 40 | FC | RTB#6 | Bkr would not close during PM due to defect of closing armature. |
| SL-1 | GE AK-2A-25 | 04/26/84 | 40 | FC | RTB#6 | Bkr failed to close during test due to dirty auxiliary contacts. |
| SL-1 | GE AK-2A-25 | 04/26/84 | 40 | FC | RTB#3 | While shutdown, bkr failed to close during test due to dirty contacts. |
| SL-1 | GE AK-2A-25 | 05/10/84 | 40 | FC | RTB#5 | Bkr failed to close during test due to dirty secondary contacts. |
| SL-1 | GE AK-2A-25 | 05/24/84 | 40 | FC | RTB#5 | Bkr failed to close during test due to binding of closing coil's plunger. |
| CC-2 | GE AK-2A-25 | 06/27/84 | 40 | FC | RTB | Bkr would not close during test @ pwr due to loose trip shaft bearing. |
| SONGS-2 | GE AK-2-25 | 06/28/84 | 40 | FC | RTB | Bkr failed to close during test due to normal wear. |
| SONGS-2 | GE AK-2-25 | 07/11/84 | 40 | FC | RTB | Bkr failed to remain closed during test due to worn bearings. |
| SL-1 | GE AK-2A-25 | 08/23/84 | 40 | FC | RTB#6 | Bkr failed to close during plant startup due to internal misalignment. |
| SONGS-3 | GE AK-2-25 | 08/29/84 | 40 | FC | RTB | Bkr failed to close during test @ pwr due to washer interference. |
| SL-2 | GE AK-2A-25 | 11/29/84 | 40 | FC | RTB#5 | Bkr failed to close during startup due to inadequate lubrication. |
| SONGS-2 | GE AK-2-25 | 04/29/85 | 40 | FC | RTB | Bkr failed to close during test due to dirty contacts. |
| SL-1 | GE AK-2A-25 | 12/13/85 | 40 | FC | RTB#7 | Bkr failed to close during test due to damaged aux. contact coil. |
| SL-1 | GE AK-2A-25 | 12/13/85 | 40 | FC | RTB#1 | Bkr failed to close during outage test due to defective switch. |
| CC-1 | GE AK-2A-25 | 12/24/85 | 40 | FC | RTB#5 | Bkr did not close during PM @ pwr due to broken cutout switch. |
| CC-1 | GE AK-2A-25 | 01/23/86 | 40 | FC | RTB#2 | Failure of bkr to close due to detached springs resulted in Rx trip. |
| SONGS-3 | GE AK-2-25 | 08/13/86 | 40 | FC | RTB | Bkr failed to close during test @ pwr due to unknown cause. |
| SL-1 | GE AK-2A-25 | 09/05/86 | 40 | FC | RTB#2 | Bkr failed to close during PM @ pwr due to broken support spring pin. |
| CC-1 | GE AK-2A-25 | 12/15/86 | 40 | FC | RTB#4 | Bkr failed to close during test @ pwr due to detached spring. |
| CC-1 | GE AK-2A-25 | 01/08/87 | 40 | FC | RTB#7 | Bkr failed to close during test due to detached operating spring. |
| SONGS-3 | GE AK-2-25E | 04/23/87 | 40 | FC | RTB | Bkr failed to close during test @ pwr due to metal shim in closing core. |
| MP-2 | GE AK-2A-25 | 02/12/88 | 40 | FC | RTB#9 | Bkr failed to close during PM due to wear of bearing & linkage. |
| CC-2 | GE AK-2A-25 | 03/12/88 | 40 | FC | RTB#4 | Bkr failed to close following shutdown test due to detached springs. |
| CC-2 | GE AK-2A-25 | 03/21/88 | 40 | FC | RTB#5 | Operating springs were found to be detached during shutdown testing. |
| MP-2 | GE AK-2A-25 | 08/19/88 | 40 | FC | RTB#7 | Bkr failed to close twice during PM due to worn parts. |
| MY | GE AK-2-25 | 09/02/88 | 40 | FC | RTB#4 | Bkr failed to close during PM @ pwr due to inadequate lubrication. |
| MY | GE AK-2-25 | 09/30/88 | 40 | FC | RTB#4 | Bkr failed to close during PM due to inadequate cleaning & lubrication. |
| SL-1 | GE AK-2A-25 | 10/06/88 | 40 | FC | RTB#7 | Bkr failed to close during test due to dirt & inadequate lubrication. |
| SONGS-2 | GE AK-2-25E | 10/07/88 | 40 | FC | RTB | Bkr failed to close during test @ pwr due to defective relay. |
| EO-WSES3 | GE AK-2-25 | 11/06/88 | 40 | SA | RTB | Bkr failed to close following test due to broken cutoff switch. |
| CC-2 | GE AK-2A-25 | 12/09/88 | 40 | FC | RTB#7 | Bkr would not close during test due to open circuit in cutoff switch. |
| PV-2 | W DS-206 | 01/05/89 | 40 | FC | RTB D | Bkr failed to close during test due to damaged spring charging motor. |
| CC-2 | GE AK-2A-25 | 01/21/89 | 40 | FC | RTB#7 | Bkr would not close during test @ pwr due to aging of control fuse. |
| CC-2 | GE AK-2A-25 | 01/21/89 | 40 | FC | RTB#8 | Bkr failed to close during test due to detached spring. |
| EO-WSES3 | GE AK-2-25 | 03/26/89 | 40 | FC | RTB | Bkr failed to close during test @ pwr due to defective switch. |

## Table A-3
## NPRDS Reported Failures of RTCBs - By Failure Type & Date

| PLANT | MODEL | FAILURE DISC DATE | FAILURE TYPE | FAILURE MODE | SYSTEM | DESCRIPTION |
|---|---|---|---|---|---|---|
| MP-2 | GE AK-2A-25 | 04/12/89 | 4O | FC | RTB#2 | Bkr failed to close during PM due to wear of trip shaft return spring. |
| SL-2 | GE AK-2A-25 | 04/16/89 | 4O | FC | RTB#6 | Detached trip mech. springs bound plunger during attempts to close bkr. |
| SL-2 | GE AK-2A-25 | 09/07/89 | 4O | FC | RTB#5 | Bkr failed to close during test due to defective closing coil. |
| EO-WSES3 | GE AK-2-25 | 11/11/89 | 4O | MO | RTB | Closing coil mechanism was sticking during test due to broken clamp. |
| SL-2 | GE AK-2A-25 | 02/01/90 | 4O | FC | RTB#1 | Bkr failed to close during test due to unknown cause. |
| SONGS-3 | GE AK-2-25E | 03/02/90 | 4O | FC | RTB | Bkr failed to close on demand due to damaged closing coil. |
| EO-WSES3 | GE AK-2-25 | 04/29/90 | 4O | FC | RTB | Bkr failed to close during test @ pwr due to broken switch. |
| EO-WSES3 | GE AK-2-25 | 07/24/90 | 4O | FC | RTB | Bkr failed to close during PM @ pwr due to worn switch contacts. |
| PV-1 | GE AKR-4BE- | 08/18/90 | 4O | FC | RTB B | Bkr failed to close following rack-in due to bent linkages. |
| PV-2 | GE AKR-4BE- | 10/05/90 | 4O | FC | RTB B | Breaker would not close following PM @ power. |
| EO-WSES3 | GE AK-2-25 | 10/06/90 | 4O | FC | RTB | Bkr failed to close following test due to broken cutoff switch. |
| MP-2 | GE AK-2A-25 | 10/25/90 | 4O | FC | RTB#1 | Bkr failed to close during PM due to bent interlock arm. |
| SL-1 | GE AK-2A-25 | 10/28/90 | 4O | FC | RTB#7 | Bkr failed to close during test due to inadequate set-up of latch spring. |
| SL-1 | GE AK-2A-25 | 10/28/90 | 4O | FC | RTB#5 | Bkr closed intermittently on demand due to faulty control wiring. |
| EO-WSES3 | GE AK-2-25 | 01/03/91 | 4O | FC | RTB | Bkr failed to close during PM @ pwr due to bent latching mechanism. |
| SONGS-2 | GE AK-2-25 | 02/07/91 | 4O | FC | RTB#1 | Bkr failed to close during test @ pwr due to binding of closing assembly. |
| SL-1 | GE AK-2A-25 | 12/19/91 | 4O | FC | RTB#2 | Bkr failed to close during PM due to defective closing coil. |
| PV-3 | GE AKR-4BE- | 03/30/92 | 4O | SO | RTB A | Bkr would not stay closed following test @ pwr. |
| EO-WSES3 | GE AK-2-25 | 04/12/92 | 4O | FC | RTB | Bkr failed to close during test @ pwr due to lodged spring. |
| PV-1 | GE AKR-4BE- | 05/02/92 | 4O | FC | RTB A | Bkr failed to close during Mode 5 tests -damage to closing spring. |
| PV-3 | GE AKR-4BE- | 06/21/92 | 4O | FC | RTB B | Bkr would not close following test @ pwr. |
| PV-1 | W DS-206 | 08/25/92 | 4O | FC | RTB D | Bkr wou'd not close following rack-in after test at pwr. |
| EO-WSES3 | GE AK-2-25 | 09/19/92 | 4O | FC | RTB | Bkr failed to close during test @ pwr due to broken cutoff switch. |
| SL-1 | GE AK-2A-25 | 11/05/92 | 4O | FC | RTB#5 | Bkr failed to close during test @ pwr due to broken cut-off switch. |
| CC-1 | GE AK-2A-25 | 11/25/92 | 4O | FC | RTB#3 | Bkr failed to close during Mode 3 test due to detached closing spring. |
| EO-WSES3 | GE AK-2-25 | 12/06/92 | 4O | FC | RTB | Bkr failed to close during PM @ pwr due to broken cutoff switch. |
| SL-1 | GE AK-2A-25 | 03/04/93 | 4O | FC | RTB#8 | Bkr failed to close during test @ pwr due to detached spring. |
| MP-2 | GE AK-2A-25 | 03/26/93 | 4O | FC | RTB#1 | Bkr failed to close during PM @ pwr due to detached operating spring. |
| SL-1 | GE AK-2A-25 | 06/10/93 | 4O | FC | RTB#5 | Bkr failed to close during test. Bkr was cleaned & inspected. |
| SL-1 | GE AK-2A-25 | 07/06/93 | 4O | FC | RTB#4 | Bkr failed to close during test @ pwr due to misadjusted latch switch. |
| CC-2 | GE AK-2A-25 | 07/06/93 | 4O | FC | RTB#2 | Bkr failed to close during test @ pwr due to poor contact of fuse. |
| CC-1 | GE AK-2A-25 | 04/20/77 | 4U | | RTB#4 | Bkr failed to close during test due to damaged UV coil. |
| MP-2 | GE AK-2A-25 | 10/12/79 | 4U | | RTB#4 | Bkr failed to close when UV device did not reset due to spring tension. |
| CC-1 | GE AK-2A-25 | 09/13/81 | 4U | | RTB#7 | Bkr failed to close during test due to failed UV relay coil. |
| CC-1 | GE AK-2A-25 | 08/05/83 | 4U | | RTB#6 | Bkr would not close during test due to defective UV device. |

## Table A-3
## NPRDS Reported Failures of RTCBs - By Failure Type & Date

| PLANT | MODEL | FAILURE DISC DATE | FAILURE TYPE | FAILURE MODE | SYSTEM | DESCRIPTION |
|---|---|---|---|---|---|---|
| CC-1 | GE AK-2A-25 | 09/19/83 | 4U | | RTB | Bkr did not close from handswitch - replaced UV device and closing coil. |
| SL-1 | GE AK-2A-25 | 05/17/84 | 4U | FC | RTB#5 | Bkr would not close while at pwr due to binding of armature. |
| SL-1 | GE AK-2A-25 | 09/06/84 | 4U | FC | RTB#1 | Bkr failed to close during PM @ pwr due to misadjusted UV trip paddle. |
| CC-1 | GE AK-2A-25 | 09/26/84 | 4U | FC | RTB | UV device would not pickup during PM @ power due to alignment of armature. |
| SONGS-3 | GE AK-2-25 | 05/10/85 | 4U | FC | RTB | UV device would not reset during PM @ pwr due to open ckt in coil. |
| SL-1 | GE AK-2A-25 | 06/06/85 | 4U | MO | RTB#7 | Bkr failed to fully close during test due to binding of mech. linkage. |
| SL-2 | GE AK-2A-25 | 07/25/85 | 4U | FC | RTB#2 | Bkr failed to close during test @ pwr due to loose UV relay armature. |
| EO-WSES3 | GE AK-2-25 | 09/29/85 | 4U | FC | RTB | Bkr failed to reclose due to damaged trip coil. |
| CC-1 | GE AK-2A-25 | 02/25/86 | 4U | FC | RTB#3 | Bkr failed to close during test @ pwr due to UV device. |
| CC-1 | GE AK-2A-25 | 02/25/86 | 4U | FC | RTB#6 | Bkr would not close during PM @ pwr due to voltage of pickup coil. |
| SL-1 | GE AK-2A-25 | 04/13/86 | 4U | FC | RTB#1 | Bkr failed to close during PM @ pwr due to defective closing coil. |
| CC-1 | GE AK-2A-25 | 09/10/86 | 4U | FC | RTB#3 | UV device did not pickup following test due to incorrect air gap. |
| CC-1 | GE AK-2A-25 | 09/12/86 | 4U | FC | RTB#4 | UV device did not pickup during test @ pwr due to rivet clearance. |
| CC-1 | GE AK-2A-25 | 01/19/87 | 4U | FC | RTB#8 | Bkr failed to close during test @ pwr due to armature clearance. |
| CC-1 | GE AK-2A-25 | 02/08/87 | 4U | FC | RTB#1 | Bkr failed to close during test @ Mode 1 due to open circuit in UV device. |
| SONGS-3 | GE AK-2-25 | 04/02/87 | 4U | FC | RTB | UV trip device would not reset during PM @ pwr due to unknown cause. |
| CC-2 | GE AK-2A-25 | 04/17/87 | 4U | FC | RTB#3 | Bkr would not close during test due to broken lead on UV relay. |
| CC-2 | GE AK-2A-25 | 06/09/87 | 4U | FC | RTB#6 | Bkr would not close during Mode 6 test due to drift of UV device air gap. |
| MY | GE AK-2-25 | 08/22/87 | 4U | FC | RTB#10 | Bkr failed to close during PM @ pwr due to inadequate lubrication. |
| SL-2 | GE AK-2A-25 | 04/23/89 | 4U | FC | RTB#4 | Bkr failed to close during test due to defective UV relay coil. |
| SL-1 | GE AK-2A-25 | 10/05/89 | 4U | FC | RTB#2 | Bkr failed to close during PM due to misadjusted UV coil. |
| MY | GE AK-2-25 | 01/12/90 | 4U | FC | RTB#4 | Bkr failed to close during PM @ pwr due to worn armature coil. |
| SL-1 | GE AK-2A-25 | 10/28/90 | 4U | FC | RTB#3 | While shutdown, bkr failed to close during test due to shorted UV coil. |
| SL-1 | GE AK-2A-25 | 12/16/91 | 4U | FC | RTB#4 | While shutdown, bkr failed to close due to defective UV coil. |
| PV-2 | GE AKR-4BE- | 04/11/92 | 4U | FC | RTB A | Bkr failed to close during test @ power due to defective UV device. |
| PV-3 | GE AKR-4BE- | 07/08/92 | 4U | MO | RTB B | UV device armature did not reset when opened during test @ power. |
| PV-2 | GE AKR-4BE- | 09/01/92 | 4U | OR | RTB A | UV device did not reset following test @ power. |
| EO-ANO2 | GE AK-2-25 | 09/02/92 | 4U | FO | RTB | UV device would not adjust to acceptable setpoint during shutdown PM. |
| PV-1 | GE AKR-4BE- | 12/14/92 | 4U | OR | RTB B | Bkr failed to close during test @ pwr due to defective UV device. |
| PV-2 | GE AKR-4BE- | 02/17/93 | 4U | FC | RTB B | UV device failed to pick-up when energized during PM @ pwr. |

# Appendix B

## C-E Standard Technical Specifications (NUREG 0212)

## Table 3.3-1 and Table 4.3-1

## TABLE 3.3-1

## REACTOR PROTECTIVE INSTRUMENTATION

| FUNCTIONAL UNIT | TOTAL NO. OF CHANNELS | CHANNELS TO TRIP | MINIMUM CHANNELS OPERABLE | APPLICABLE MODES | ACTION |
|---|---|---|---|---|---|
| 1. Manual Reactor Trip | 2 | 1 | 2 | 1, 2 | 1 |
| | 2 | 1 | 2 | 3*, 4*, 5* | 8 |
| 2. Linear Power Level - High | 4 | 2 | 3 | 1, 2 | 2# |
| 3. Logarithmic Power Level-High | | | | | |
| a. Startup and Operating | 4 | 2(a)(d) | 3 | 1, 2 | 2#, 3# |
| | 4 | 2 | 3 | 3*, 4*, 5* | 8 |
| b. Shutdown | 4 | 0 | 2 | 3, 4, 5 | 3 |
| 4. Pressurizer Pressure - High | 4 | 2 | 3 | 1, 2 | 2# |
| 5. Pressurizer Pressure - Low | 4 | 2(b) | 3 | 1, 2 | 2# |
| 6. Containment Pressure - High | 4 | 2 | 3 | 1, 2 | 2# |
| 7. Steam Generator Pressure - Low | 4/SG | 2/SG | 3/SG | 1, 2 | 2# |
| 8. Steam Generator Level - Low | 4/SG | 2/SG | 3/SG | 1, 2 | 2# |
| 9. Local Power Density - High | 4 | 2(c)(d) | 3 | 1, 2 | 2# |
| 10. DNBR - Low | 4 | 2(c)(d) | 3 | 1, 2 | 2# |
| 11. Steam Generator Level - High | 4/SG | 2/SG | 3/SG | 1, 2 | 2# |
| 12. Reactor Protection System Logic | 4 | 2 | 3 | 1, 2 | 4 |
| | | | | 3*, 4*, 5* | 8 |
| 13. Reactor Trip Breakers | 4 | 2(f) | 3 | 1, 2 | 4 |
| | | | | 3*, 4*, 5* | 8 |
| 14. Core Protection Calculators | 4 | 2(c)(d) | 3 | 1, 2 | 2#, 3# and 7 |
| 15. CEA Calculators | 2 | 1 | 2(e) | 1, 2 | 6 and 7 |
| 16. Reactor Coolant Flow-Low | 4/SG | 2/SG | 3/SG | 1, 2 | 2#, 3# |
| 17. Loss of Load | 4 | 2 | 3 | 1(g) | 2#, 3# |

TABLE 3.3-1 (Continued)

TABLE NOTATION

*With the protective system trip breakers in the closed position, the CEA drive system capable of CEA withdrawal, and fuel in the reactor vessel.

#The provisions of Specification 3.0.4 are not applicable.

(a) Trip may be manually bypassed above $(10^{-4})$% of RATED THERMAL POWER; bypass shall be automatically removed when THERMAL POWER is less than or equal to $(10^{-4})$% of RATED THERMAL POWER.

(b) Trip may be manually bypassed below (400) psia; bypass shall be automatically removed whenever pressurizer pressure is greater than or equal to 500 psia.

(c) Trip may be manually bypassed below $(10^{-4})$% of RATED THERMAL POWER; bypass shall be automatically removed when THERMAL POWER is greater than or equal to $(10^{-4})$% of RATED THERMAL POWER. During testing pursuant to Special Test Exception 3.10.3, trip may be manually bypassed below (1)% of RATED THERMAL POWER; bypass shall be automatically removed when THERMAL POWER is greater than or equal to (1)% of RATED THERMAL POWER.

(d) Trip may be bypassed during testing pursuant to Special Test Exception 3.10.3.

(e) See Special Test Exception 3.10.2.

(f) Each channel shall be comprised of two trip breakers; actual trip logic shall be one-out-of-two taken twice.

(g) Trip may be bypassed below (55%) RATED THERMAL POWER.

ACTION STATEMENTS

ACTION 1 - With the number of channels OPERABLE one less than required by the Minimum Channels OPERABLE requirement, restore the inoperable channel to OPERABLE status within 48 hours or be in at least HOT STANDBY within the next 6 hours and/or open the protective system trip breakers.

ACTION 2 - With the number of channels OPERABLE one less than the Total Number of Channels, STARTUP and/or POWER OPERATION may continue provided the inoperable channel is placed in the bypassed or tripped condition within 1 hour. If the inoperable channel is bypassed, the desirability of maintaining this channel in the bypassed condition shall be reviewed in accordance with Specification 6.5.1.6k. The channel shall be returned to OPERABLE status no later than during the next COLD SHUTDOWN.

## TABLE 3.3-1 (Continued)

## ACTION STATEMENTS

With a channel process measurement circuit that affects multiple functional units inoperable or in test, bypass or trip all associated functional units as listed below:

| Process Measurement Circuit | Functional Unit Bypassed |
|---|---|
| 1. Linear Power (Subchannel or Linear) | Linear Power Level - High<br>Local Power Density - High<br>DNBR - Low |
| 2. Pressurizer Pressure - High | Pressurizer Pressure - High<br>Local Power Density - High<br>DNBR - Low |
| 3. Containment Pressure - High | Containment Pressure - High (RPS)<br>Containment Pressure - High (ESF) |
| 4. Steam Generator Pressure - Low | Steam Generator Pressure - Low<br>Steam Generator ΔP 1 and 2 (EFAS 1 and 2) |
| 5. Steam Generator Level | Steam Generator Level - Low<br>Steam Generator Level - High<br>Steam Generator ΔP (EFAS) |
| 6. Core Protection Calculator | Local Power Density - High<br>DNBR - Low |

ACTION 3 - With the number of channels OPERABLE one less than the Minimum Channels OPERABLE requirement, STARTUP and/or POWER OPERATION may continue provided the following conditions are satisfied:

a. Verify that one of the inoperable channels has been bypassed and place the other channel in the tripped condition within 1 hour, and

b. All functional units affected by the bypassed/tripped channel shall also be placed in the bypassed/tripped condition as listed below:

| Process Measurement Circuit | Functional Unit Bypassed/Tripped |
|---|---|
| 1. Linear Power (Subchannel or Linear) | Linear Power Level - High<br>Local Power Density - Hith<br>DNBR - Low |

ACTION STATEMENTS

| | | |
|---|---|---|
| 2. | Pressurizer Pressure - High | Pressurizer Pressure - High<br>Local Power Density - High<br>DNBR - Low |
| 3. | Containment Pressure - High | Containment Pressure - High (RPS<br>Containment Pressure - High (ESF |
| 4. | Steam Generator Pressure - Low | Steam Generator Pressure - Low<br>Steam Generator ΔP 1 and 2 (EFAS 1 and 2) |
| 5. | Steam Generator Level | Steam Generator Level - Low<br>Steam Generator Level - High<br>Steam Generator ΔP (EFAS) |
| 6. | Core Protection Calculator | Local Power Density - High<br>DNBR - Low |

STARTUP and/or POWER OPERATION may continue until the performance of the next required CHANNEL FUNCTIONAL TEST. Subsequent STARTUP and/or POWER OPERATION may continue if one channel is restored to OPERABLE status and the provisions of ACTION 2 are satisfied.

ACTION 4 - With the number of channels OPERABLE one less than required by the Minimum Channels OPERABLE requirement, suspend all operations involving positive reactivity changes.

ACTION 5 - With the number of channels OPERABLE one less than required by the Minimum Channels OPERABLE requirement, be in at least HOT STANDBY within 6 hours (however, one channel may be bypassed for up to 1 hour for surveillance testing per Specification 4.3.1.1).

ACTION 6 - a. With one CEAC inoperable, operation may continue for up to 7 days provided that at least once per 4 hours, each CEA is verified to be within 7 inches (indicated position) of all other CEAs in its group.

b. With both CEACs inoperable, operation may continue provided that:

1. Within 1 hour the margins required by Specification 3.2.1 and 3.2.4 are increased and maintained at a value equivalent to greater than or equal to 19% of RATED THERMAL POWER,

TABLE 3.3-1 (Continued)

ACTION STATEMENTS

2. Within 4 hours:

   a) All full length and part length CEA groups are withdrawn to and subsequently maintained at the "Fall Out" position, except during surveillance testing pursuant to the requirements of Specification 4.1.3.1.2 or for control when CEA group 6 may be inserted no further than 127.5 inches withdrawn.

   b) The "RSPT/CEAC Inoperable" addressable constant in the CPCs is set to the inoperable status.

   c) The Control Element Drive Mechanism Control System (CEDMCS) is placed in and subsequently maintained in the "Off" mode except during CEA group 6 motion permitted by a) above, when the CEDMCS may be operated in either the Manual Group" or "Manual Individual" mode.

3. At least once per 4 hours, all full length and part length CEAs are verified fully withdrawn except during surveillance testing prusuant to Specification 4.1.3.1.2 or during insertion of CEA group 6 as permitted by 1. a) above, then verify at least once per 4 hours that the inserted CEAs are aligned within 7 inches (indicated position) of all other CEAs in its group.

ACTION 7 - With three or more auto restarts of one non-bypassed calculator during a 12-hour interval, demonstrate calculator OPERABILITY by performing a CHANNEL FUNCTIONAL TEST within the next 24 hours.

ACTION 8 - With the number of OPERABLE channels one less than the Minimum Channels OPERABLE requirement restore the inoperable channel to OPERABLE status within 48 hours or open the reactor trip breakers within the next hour.



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TABLE 4.3-1

REACTOR PROTECTIVE INSTRUMENTATION SURVEILLANCE REQUIREMENTS

| FUNCTIONAL UNIT | CHANNEL CHECK | CHANNEL CALIBRATION | CHANNEL FUNCTIONAL TEST | MODES FOR WHICH SURVEILLANCE IS REQUIRED |
|---|---|---|---|---|
| 1. Manual Reactor Trip | N.A. | N.A. | R | 1, 2, 3*, 4*, 5* |
| 2. Linear Power Level - High | S | D(2,4), M(3,4), Q(4), R(10) | M | 1, 2 |
| 3. Logarithmic Power Level - High | S | R(4)(10) | M and S/U(1) | 1, 2, 3, 4, 5 |
| 4. Pressurizer Pressure - High | S | R | M | 1, 2 |
| 5. Pressurizer Pressure - Low | S | R | M | 1, 2 |
| 6. Containment Pressure - High | S | R | M | 1, 2 |
| 7. Steam Generator Pressure - Low | S | R | M | 1, 2 |
| 8. Steam Generator Level - Low | S | R | M | 1, 2 |
| 9. Local Power Density - High | S | D(2,4), R(4,5, 10) | M, R(6) | 1, 2 |
| 10. DNBR - Low | S | S(7), D(2,4), M(8), R(4,5, 10) | M, R(6) | 1, 2 |
| 11. Steam Generator Level - High | S | R | M | 1, 2 |
| 12. Reactor Protection System Logic | N.A. | N.A. | M | 1, 2, 3*, 4*, 5* |

TABLE 4.3-1 (Continued)

REACTOR PROTECTIVE INSTRUMENTATION SURVEILLANCE REQUIREMENTS

| FUNCTIONAL UNIT | CHANNEL CHECK | CHANNEL CALIBRATION | CHANNEL FUNCTIONAL TEST | MODES FOR WHICH SURVEILLANCE IS REQUIRED |
|---|---|---|---|---|
| 13. Reactor Trip Breakers | N.A. | N.A. | M,(12) | 1, 2, 3*, 4*, 5* |
| 14. Core Protection Calculators | S | D(2,4),R(4,5, 10) | M(11),R(6) | 1, 2 |
| 15. CEA Calculators | S | R | M,R(6) | 1, 2 |
| 16. Reactor Coolant Flow-Low | S | R | M | 1, 2 |
| 17. Loss of Load | S | N.A. | M | 1(9) |



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TABLE 4.3-1 (Continued)

TABLE NOTATION

* - With reactor trip breakers in the closed position and the CEA drive system capable of CEA withdrawal.

(1) - Each startup or when required with the reactor trip breakers closed and the CEA drive system capable of rod withdrawal, if not performed in the previous 7 days.

(2) - Heat balance only (CHANNEL FUNCTIONAL TEST not included), above 15% of RATED THERMAL POWER; adjust the Linear Power Level signals and the CPC addressable constant multipliers to make the CPC delta T power and CPC nuclear power calculations agree with the calorimetric calculation if absolute difference is greater than 2%. During PHYSICS TESTS, these daily calibrations may be suspended provided these calibrations are performed upon reaching each major test power plateau and prior to proceeding to the next major test power plateau.

(3) - Above 15% of RATED THERMAL POWER, verify that the linear power subchannel gains of the excore detectors are consistent with the values used to establish the shape annealing matrix elements in the Core Protection Calculators.

(4) - Neutron detectors may be excluded from CHANNEL CALIBRATION.

(5) - After each fuel loading and prior to exceeding 70% of RATED THERMAL POWER, the incore detectors shall be used to determine the shape annealing matrix elements and the Core Protection Calculators shall use these elements.

(6) - This CHANNEL FUNCTIONAL TEST shall include the injection of simulated process signals into the channel as close to the sensors as practicable to verify OPERABILITY including alarm and/or trip functions.

(7) - Above 70% of RATED THERMAL POWER, verify that the total RCS flow rate as indicated by each CPC is less than or equal to the actual RCS total flow rate determined by either using the reactor coolant pump differential pressure instrumentation (conservatively compensated for measurement uncertainties) or by calorimetric calculations (conservatively compensated for measurement uncertainties) and if necessary, adjust the CPC addressable constant flow coefficients such that each CPC indicated flow is less than or equal to the actual flow rate. The flow measurement uncertainty may be included in the BERR1 term in the CPC and is equal to or greater than 4%.

(8) - Above 70% of RATED THERMAL POWER, verify that the total RCS flow rate as indicated by each CPC is less than or equal to the actual RCS total flow rate determined by calorimetric calculations (conservatively compensated for measurement uncertainties).

(9) - Above 55% of RATED THERMAL POWER.

(10) - Detector plateau curves shall be obtained, evaluated, and compared to manufacturer's data.

(11) - The monthly CHANNEL FUNCTIONAL TEST shall include verification that the correct values of addressable constants are installed in each OPERABLE CPC per Specification 2.2.2.

(12) - At least once per 18 months and following maintenance or adjustment of the reactor trip breakers, the CHANNEL FUNCTIONAL TEST shall include independent verification of the undervoltage and shunt trips.

## Appendix C

## NUREG-1432 RPS Logic and Trip Initiation LCOs

## 3.3 INSTRUMENTATION

### 3.3.3 Reactor Protective System (RPS) Logic and Trip Initiation (Analog)

LCO 3.3.3 Six channels of RPS Matrix Logic, four channels of RPS Initiation Logic, [four] channels of reactor trip circuit breakers (RTCBs), and [four] channels of Manual Trip shall be OPERABLE.

APPLICABILITY: MODES 1 and 2,
MODES 3, 4, and 5, with any RTCBs closed and any control element assemblies capable of being withdrawn.

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. ---------NOTE---------<br>This action also applies when three Matrix Logic channels are inoperable due to a common power source failure de-energizing three matrix power supplies.<br>---------------------<br><br>One Matrix Logic channel inoperable. | A.1 Restore channel to OPERABLE status. | 48 hours |

(continued)

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | | COMPLETION TIME |
|---|---|---|---|
| B. ---------NOTE--------- RTCBs associated with one inoperable channel may be closed for up to 1 hour for the performance of an RPS CHANNEL FUNCTIONAL TEST. --------------------- One channel of Manual Trip, RTCBs, or Initiation Logic inoperable in MODE 1 or 2. | B.1 | Open the affected RTCBs. | 1 hour |
| C. ---------NOTE--------- RTCBs associated with one inoperable channel may be closed for up to 1 hour for the performance of an RPS CHANNEL FUNCTIONAL TEST. --------------------- One channel of Manual Trip, RTCBs, or Initiation Logic inoperable in MODE 3, 4, or 5. | C.1 | Open all RTCBs. | 48 hours |
| D. Two channels of RTCBs or Initiation Logic affecting the same trip leg inoperable. | D.1 | Open the affected RTCBs. | Immediately |

(continued)

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| E. Required Action and associated Completion Time of Condition A, B, or D not met.<br><br>OR<br><br>One or more Functions with two or more Manual Trip, Matrix Logic, Initiation Logic, or RTCB channels inoperable for reasons other than Condition A or D. | E.1 Be in MODE 3.<br><br>AND<br><br>E.2 Open all RTCBs. | 6 hours<br><br><br><br>6 hours |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| SR 3.3.3.1 | Perform a CHANNEL FUNCTIONAL TEST on each RPS Logic channel and RTCB channel. | [92] days |
| SR 3.3.3.2 | Perform a CHANNEL FUNCTIONAL TEST on each RPS Manual Trip channel. | Once within 7 days prior to each reactor startup |
| [SR 3.3.3.3 | Perform a CHANNEL FUNCTIONAL TEST, including separate verification of the undervoltage and shunt trips, on each RTCB. | [18] months] |

## 3.3 INSTRUMENTATION

### 3.3.4 Reactor Protective System (RPS) Logic and Trip Initiation (Digital)

LCO 3.3.4 Six channels of RPS Matrix Logic, four channels of RPS Initiation Logic, [four channels of reactor trip circuit breakers (RTCBs),] and four channels of Manual Trip shall be OPERABLE.

APPLICABILITY: MODES 1 and 2,
MODES 3, 4, and 5, with any RTCBs closed and any control element assemblies capable of being withdrawn.

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. ---------NOTE--------- This action also applies when three Matrix Logic channels are inoperable due to a common power source failure de-energizing three matrix power supplies. --------------------- One Matrix Logic channel inoperable. | A.1 Restore channel to OPERABLE status. | 48 hours |

(continued)

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| B. ---------NOTE--------- RTCBs associated with one inoperable channel may be closed for up to 1 hour for the performance of an RPS CHANNEL FUNCTIONAL TEST. --------------------- One channel of Manual Trip, RTCBs, or Initiation Logic inoperable in MODE 1 or 2. | B.1 Open the affected RTCBs. | 1 hour |
| C. ---------NOTE--------- RTCBs associated with one inoperable channel may be closed for up to 1 hour for the performance of an RPS CHANNEL FUNCTIONAL TEST. --------------------- One channel of Manual Trip, RTCBs, or Initiation Logic inoperable in MODE 3, 4, or 5. | C.1 Open all RTCBs. | 48 hours |
| D. Two channels of RTCBs or Initiation Logic affecting the same trip leg inoperable. | D.1 Open the affected RTCBs. | Immediately |

(continued)

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| E. Required Action and associated Completion Time of Condition A, B, or D not met.<br><br>OR<br><br>One or more Functions with more than one Manual Trip, Matrix Logic, Initiation Logic, or RTCB channel inoperable for reasons other than Condition A or D. | E.1 Be in MODE 3.<br><br>AND<br><br>E.2 Open all RTCBs. | 6 hours<br><br><br><br>6 hours |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| SR 3.3.4.1 | Perform a CHANNEL FUNCTIONAL TEST on each RPS Logic channel and RTCB channel. | [92] days |
| SR 3.3.4.2 | Perform a CHANNEL FUNCTIONAL TEST, including separate verification of the undervoltage and shunt trips, on each RTCB. | [18] months |
| SR 3.3.4.3 | Perform a CHANNEL FUNCTIONAL TEST on each RPS Manual Trip channel. | Once within 7 days prior to each reactor startup |