U.S. NUCLEAR REGULATORY COMMISSION

REGION III

AUGMENTED INSPECTION TEAM

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Facility:	Clinton Power Station
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Inspectors:	G. Wright, Chief Reactor Projects Branch 4 S. Alexander, Special Inspection Branch, NRR S. Campbell, Senior Resident Inspector Davis-Besse, R-III Z. Falevits, Senior Reactor Inspector, R-III J. Knox, Electrical Engineering Branch, NRR T. Tella, Senior Reactor Inspector, R-III

G. Wright, Team Leader, Chief
Reactor Projects Branch 4

J. Jacobson, Acting Deputy Director
Division of Reactor Safety

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Report Details

1.0 Introduction

1.1 Purpose and Scope of the Inspection

The NRC has established a policy in NRC Inspection Manual Chapter 0325 to provide for the timely, thorough, and systematic inspection of significant operational events at nuclear power plants. This includes the use of an Augmented Inspection Team (AIT) to determine the causes, conditions and circumstances about an event, and to communicate its findings, safety concerns, and recommendations to NRC management. On July 22, 1997, main feed circuit breaker to Bus 1A1 failed to open. On August 5, 1997, the circuit breaker for the RHR Pump "A" also failed to open. Two similar breaker failures within a short time was considered a significant event and therefore, the NRC (1) dispatched an AIT to Clinton Power Station (CPS) on August 5, 1997, to review the circumstances surrounding the circuit breaker failures and (2) issued Confirmatory Action Letter (CAL) No. RIII-97-009 to the licensee. These breaker failures were of particular concern because they occurred within a short period and, because of the poor maintenance history at CPS, they represented a potential common mode failure.

The AIT consisted of six NRC inspectors and included specialists from NRR and RIII. The AIT Charter (Appendix A) directed the team to conduct fact finding, to determine the sequence of events associated with the breaker failures, to evaluate the performance of personnel involved in the event, and to assess the licensee's response to the event, including their root cause for the failed RHR Pump A breaker.

The AIT was on-site from August 5-15, 1997. An entrance meeting was held with the licensee on August 6, 1997, at CPS. A public exit meeting was held at CPS on August 20, 1997. At the exit meeting, the AIT provided its conclusion that the August 5, 1997, RHR Pump A circuit breaker failure was caused by inadequate and inappropriate preventive maintenance and a failure of the corrective action program to identify, evaluate, and correct issues associated with circuit breakers (see Section 7 for details).

1.2 Inspection Methodology

Following an initial briefing by licensee personnel during the entrance meeting on August 6, 1997, the AIT monitored the licensee's investigation into the breaker failure and independently inspected available information on the RHR Pump A breaker. The licensee contracted independent engineering consultants and vendor representatives to help in the root cause determination. These specialists, with electrical maintenance and operations personnel from CPS, comprised the licensee's Special Investigation Team (SIT). The SIT was tasked to develop and implement a systematic approach to the investigation in the root cause determination for the failed breaker.

AIT members independently reviewed breaker maintenance procedures, condition reports, the Westinghouse breaker technical manual, control room logs, and maintenance work requests (MWRs) associated with the breakers to determine their maintenance and operational history. The AIT interviewed members of the licensee's training, engineering, electrical maintenance, and operations departments responsible for training electricians, performing maintenance on the breaker, and operating the breaker. A list of persons contacted is contained in Appendix B.

The AIT also reviewed records and documents concerning the licensee's determination of the event's safety significance, root cause analyses, and internal investigations of the event. A list of documents reviewed is contained in Appendix C.

2.0 Narrative Description of the Breaker Failure Events

2.1 Failure of the Reserve Auxiliary Transformer (RAT) Main Feed Circuit Breaker to Division 1 Bus 1A1

According to the record of the licensee's event critique, operator logs, MWR remarks and interviews with CPS staff, the following events occurred on the afternoon of July 22, 1997, after a Division 2 Emergency Diesel Generator surveillance run.

Just after 1:00 p.m., CPS control room operators were transferring the power supply for Division 1 4.16-kV Bus 1A1 from the Reserve Auxiliary Transformer (RAT) to the Emergency Reserve Auxiliary Transformer (ERAT). The operator closed the ERAT feed breaker switch, which automatically paralleled across and closed the ERAT feed breaker to Bus 1A1. The operator allowed the ERAT breaker control switch to return to "AUTO," which should have automatically tripped open the RAT breaker. As expected, the red "breaker-closed" position indicating light for the RAT breaker went out, but the green "breaker-open" light for the RAT breaker did not come on. Also, an expected "auto breaker trip" annunciator signal was not received. These indications signified that the RAT breaker had failed to trip open, which was further confirmed by the operators noting that ammeters indicated there was load on both the RAT and ERAT powering Bus 1A1. At 1:11 p.m., the RAT breaker failed to open on a second attempt. At this time, the RAT and ERAT were both supplying power to Bus 1A1.

At 1:12 p.m., the licensee sent an operator to the Division 1 switchgear. The operator observed smoke coming from the upper portion of the RAT main feed breaker cubicle and immediately informed the control room. The control room notified the fire brigade at 1:14 p.m. who, upon arrival in the switchgear room, reported no fire in the cubicle. The licensee later determined that when the breaker failed to open, the designated auxiliary "a" contact did not de-energize the trip coil as it would normally. The trip coil, being designed only for momentary energization, had overheated and opened, terminating the over-temperature condition which had produced the smoke. The RAT breaker again failed to open on a third attempt at about 1:15 p.m.

Operators assessed impact on electrical loads and plant conditions with a loss of Bus 1A1 and decided to de-energize the bus in order to safely deal with the RAT breaker. The operators removed the major loads from Bus 1A1, including residual heat removal (RHR) Pump A (1:11 p.m.) and the reactor water cleanup pump (1:35 p.m.). RHR Pump B was placed into operation (2:07 p.m.) to maintain core cooling. The ERAT breaker was then opened.

CPS electricians and engineers then opened the RAT breaker cubicle door and observed the blackened condition of the trip coil, indicating it had severely overheated. The trip trigger below the trip coil was not fully down and reset, indicating that the trip mechanism was unla[illegible], and the breaker mechanical position indication was intermediate, i.e., only partially open. The licensee did not continue investigation of the RAT breaker until Bus 1A1 was fully de-energized at 5:58 p.m. by opening the 345-kV line supply breaker to the RAT in the switchyard.

Electricians documented the as-found conditions of the RAT breaker on MWR D75608. Following the completion of the visual inspection of the breaker, an electrician confirmed that the trip mechanism was unlatched by manually lifting the trip trigger, with no results. He then lifted the closing trigger which initiated a closing operation; however, with the trip mechanism unlatched, the breaker started to close then tripped free, as should occur with the breaker in its current condition. The Bus 1A1 RAT breaker was subsequently removed from its cubicle for further examination.

The licensee held a critique at 6:00 a.m., on July 23, 1997, to gather facts regarding the failure of Bus 1A1 RAT main feed breaker to open on demand. The critique was documented in Critique Report EM 97-015 and the breaker failure was documented in Condition Report (CR) 1-97-07-222. The licensee sent the failed breaker to Westinghouse & Cutler-Hammer Aftermarket Product Center in Greenwood, South Carolina, to investigate the cause of the failure. Representatives from CPS traveled to Greenwood to help in the investigation.

2.2 Failure of RHR Pump A Circuit Breaker

Division 1 RHR Pump A had been placed in the shutdown cooling (SDC) mode on August 2, 1997, to maintain core cooling. On August 5, 1997, at 3:59 a.m., Division 2 RHR Pump B was started and placed in the SDC mode to secure Division 1 equipment for the purposes of conducting surveillance tests. After the operators placed RHR Pump B in the SDC mode, an operator in training, under the direction of control room personnel, shut the discharge valve for RHR Pump A. The trainee then attempted to stop RHR Pump A by opening the circuit breaker to the pump. When the trainee turned the control room hand switch to open the breaker, as expected, the red "breaker-closed" position indicating light for the RHR Pump A breaker went out, but the green "breaker-open" light did not come on. In addition, control room indicators for pump flow and motor current did not fall to zero as expected. These indications meant that the pump had not stopped. When the trainee released the hand switch, the red "breaker-closed" light illuminated. A licensed reactor operator then attempted to stop RHR Pump A and experienced the same results. RHR Pump A discharge valve was immediately reopened to prevent overheating the pump (which placed both Divisions 1 and 2 in SDC mode). The licensee estimated that RHR Pump A operated for approximately 10 seconds with its discharge valve closed.

At 4:13 a.m., the licensee dispatched operators, electricians and engineers to the Division 1 Switchgear (Bus 1A1) to determine the actual breaker position and condition. Unlike the Bus 1A1 RAT main feed breaker event, the personnel dispatched to Division 1 switchgear did not observe smoke from the RHR Pump A breaker cubicle. The licensee later determined that with a different control circuit, the RHR Pump A breaker's trip coil was de-energized upon releasing the hand switch; hence it did not severely overheat and smoke.

Personnel at the switchgear noted that the red "breaker-closed" local position, indicating light on the cubicle door, was illuminated. After the door to the breaker cubicle was opened, the licensee determined that the breaker was not fully open, but in the intermediate position. This determination was based on the trip trigger not being reset, the mechanical position indicator showing the breaker to be partially open, and the mechanism-operated cubicle (MOC) switch operating lever being almost horizontal instead of at a 45° up angle (normal breaker-open position) or 45° down (breaker closed position). Realizing that a potential safety hazard existed with Bus 1A1 still energized, the licensee discontinued the breaker investigation until the bus could be de-energized.

The licensee then developed procedures to remove electrical loads and de-energize Bus 1A1. At 7:49 a.m., with Bus 1A1 stripped and the Division 1 diesel and RAT main feed breaker locked out, the control room operators opened Bus 1A1 ERAT feed breaker to de-energize Bus 1A1. However, the RHR Pump A breaker undervoltage relay dropped out upon de-energizing the bus and because the fuses for control power to the breaker had not been removed, the breaker's trip coil energized again. This action did not open the breaker.

The licensee conducted a critique at 9:00 a.m., on August 5, 1997, to gather facts on the failure of the breaker to open on demand. The licensee documented the critique in Critique Report EM 97-016 and the breaker failure was documented in CR 1-97-08-045. The breaker was quarantined to preserve its as-found condition until the licensee formed its SIT and the NRC dispatched the AIT.

The AIT observed the SIT's development, execution and documentation of its troubleshooting plan, which included the in situ internal examination of the breaker with a video boroscope. The plan included provisions for using a training breaker similar to the failed breaker for testing examination techniques prior to performance on the failed breaker. The examination also included manipulation of the trip trigger, tripping latch and trip cam to verify the trip mechanism was unlatched; checks of various electrical components (e.g., trip coil winding resistance and breaker pole/contact resistance); and careful removal of the breaker from its cubicle. Despite extensive efforts to remove the breaker without disturbing its as-found condition, the RHR Pump A breaker fell open while being pulled from its cubicle on August 11, 1997. The SIT continued its failure analysis, which culminated in the presentation by the SIT of its root cause evaluation on August 14, 1997.

3.0 Explanation of Circuit Breaker Operation (See Figures 1 and 2)

The circuit breakers that failed at CPS were Westinghouse Type DHP, 4.7-kV-rated, air-magnetic circuit breakers. DHP breakers of various current ratings are used in both safety-related (Divisions 1 and 2) and non-safety-related portions of the 4.16-kV electrical distribution system at CPS.

3.1 Closing Operation

Each breaker has three poles or phases, "A"(left), "B"(center) and "C"(right) when facing the front of the breaker. Each phase has one pair of arcing contacts and two pairs of main contacts. The moving contacts are mounted on moving arms (one for each of the three poles or phases in the breaker) connected to the load side of each pole by an electrically conducting hinge. The breaker's contact operating linkages and the mechanism close the main and arcing contacts by releasing the energy stored in a closing spring by a charging motor and a rachet mechanism. This is accomplished either electrically or manually. An operator can electrically close the breaker by energizing the closing (spring release) coil locally (by a hand control switch on the breaker cubicle door) or remotely (by a hand control switch in the control room). The breaker can also be closed electrically by automatic signals such as emergency core cooling system actuation signals or load sequencer signals for the emergency diesel generator. An operator can manually close the breaker by lifting a device on the front of the breaker called a closing trigger. This is the same component lifted by the closing coil (also known as a magnet or solenoid) during electrical operation. The breaker's closing spring is recharged by the motor immediately after each closing operation. This ratchet mechanism can be operated by hand, using an accessory handle to charge the closing spring, for maintenance, if the charging motor is inoperative, or if 125-Vdc control power is not available to the breaker.

3.2 Opening Operation

The main and arcing contacts of the breaker are opened normally by the energy stored in the opening springs (which act on the moving contact arm drive linkages) and the kickout springs (that act directly on the moving contact arms themselves). The opening energy is stored in the springs by the action of the closing operation, i.e., some of the energy that is expended by the closing spring in closing the breaker goes into storing energy in the springs used to open the breaker.

Similar to the closing function, the opening operation may be initiated (i.e., the breaker may be tripped) manually or electrically. Manual tripping is accomplished by lifting the trip trigger on the front of the breaker by hand. This same trip trigger is lifted by the trip coil in electrical operation in response to local or remote hand control switches or automatic signals such as from protective relays, interlocks, or load shedding functions. Lifting of the trip trigger unlatches the tripping mechanism which releases the mechanical lock on the contact operating mechanism. This allows the contacts to move with the force of the opening springs (during the entire opening operation) and the kickout springs (used to disengage the main and arcing contacts at the beginning of the opening stroke).

3.3 Failure Mechanism

In order to understand the August 5, 1997, failure of RHR Pump A breaker to open it must be realized that once the trip latch mechanism is unlatched and the moving contact arm linkages collapse, the opening forces supplied by the springs must exceed the system resistances to open the breaker. In-situ boroscopic inspection of RHR Pump A circuit breaker identified three significant items: the moving contacts were in various stages of opening, the trip mechanism had unlatched with the moving arm linkages collapsed, and no foreign material was identified impeding the breaker's ability to open.

Testing on the failed breaker revealed the available opening forces did not exceed the system resistances, causing the breaker to fail in a partially open condition. The largest contribution to the forces opposing opening came from the main and arcing contacts. Additional testing of the failed RHR Pump A breaker confirmed that the degraded condition of the contact surfaces created excessive friction between the moving and stationary contact surfaces. The increased friction significantly increased the force necessary to open the breaker. The contact degradation was directly attributable to inappropriate and inadequate maintenance. Further inspection and testing of the RHR Pump A breaker revealed that the C-phase kickout spring was loose, slightly bent, and slightly short in length; significantly reducing the force it was able to provide to open the C-phase contacts.

Other sources of friction that resist opening in the moving contact arm operating linkages or mechanism that had a relatively lower contribution included the following:

- contact arm hinges,
- the upper and lower contact arm operating rod pins,
- and the pole shaft bearings,

with minor contributions by the:

- main link pin,
- the cam follower roller,
- the main link return spring,
- the restraining link pins and the trip cam (primarily its pivot pin).

In addition, during the opening sequence, the contact arm operating mechanism drives the puffer and auxiliary switch linkages which both normally retard the opening operation to a small degree. Tests and examination of the failed RHR Pump A breaker established that although some of these components may not have been properly maintained (mainly lubrication), they did not figure significantly as sources of the excessive friction that contributed to the failure.

As noted earlier, it was established through testing and examination that the RHR breaker's trip mechanism functioned properly to release the breaker into the so-called "trip free" condition. Had this not occurred, the moving contacts would not have disengaged at all.

3.4 Conclusion

The principal mechanical (proximate) causes of the August 5, 1997, failure of the RHR Pump A breaker to open when operated were excessive main and arcing contact friction coupled with insufficient opening force, primarily due to a degraded kickout spring on "C" phase. The possible root cause of these conditions was inadequate and inappropriate maintenance by the licensee and inadequate corrective action exacerbated by weak maintenance guidance from the breaker manufacturer.

4.0 RAT Main Feed and RHR Pump A Breaker Histories and Previous RHR A Breaker Failures and Root Cause Evaluations

a. Inspection Scope

The AIT reviewed the history of the RAT and RHR breakers to identify conditions which may have contributed to the July 22 and August 5 failures.

b. Observations and Findings

4.1 History of the Failed DHP Breakers at CPS

4.1.1 Bus 1A1 RAT Main Feed Breaker

The breaker used for the RAT main feed was purchased from Westinghouse in 1977 and received at CPS on July 10, 1979. CPS commenced commercial operation on August 29, 1986. The last full preventive maintenance (PM) was performed on the breaker on July 20, 1993. Recent major corrective maintenance on the breaker was to clean and inspect it and rework the motor cutoff switch and levering-in device (MWR D75429), begun on May 9, 1997. On May 23, 1997, the breaker was racked in and on May 24, cycled three times as a post-maintenance functional check. Between June 3 and July 2, 1997, the breaker was closed and opened about nine times.

4.1.2 RHR Pump A Breaker

RHR Pump A breaker was also purchased in 1977 and received on site July 10, 1979. The last full PM on the RHR Pump A breaker was initiated on June 21, 1993, and completed March 27, 1996. Recent major work on June 9, 1997, included cleaning and inspecting, and rework of the motor cutoff switch and levering-in device (MWR D63306). On July 26, 1997, as part of the corrective action for the failure of the Bus 1A1 RAT main feed breaker, the licensee checked and adjusted (as required) the latch check switch (MWR D75611) on this and other DHP breakers. The RHR Pump A breaker was racked out and back in for this job. Between June 12 and August 2, 1997, when the RHR Pump A was started in SDC mode for the last time prior to its failure to open, the breaker was cycled open and closed about nine times.

4.2 Previous RHR Pump A Failures and Root Cause Evaluation

The AIT reviewed MWRs for the RHR Pump A breaker from 1985 to the present. The AIT identified the following RHR Pump A breaker failures, causes, and corrective actions from the MWRs that were reviewed:

MWR B18632, performed in November 1985, attributed a failure of the breaker to close electrically during testing to binding of the linkage that operates the closing spring charging motor cutoff switch due to dirt. The MWR indicated that the condition was corrected by cleaning the linkage. The AIT's review of the MWR could not conclude that dirt alone would cause the switch to malfunction; mechanical misalignment or faulty switch internals (a problem with earlier vintage switches) could have been a contributing cause. It appeared that either the diagnosis was not adequately described or was incomplete. The MWR also stated that a CR was initiated to determine if this failure/root cause was a generic problem; the licensee was unable to produce the CR. This MWR had no apparent bearing on the recent failure of RHR Pump A breaker.

MWR C28360 (July 1988) concerned a broken internal ceramic piece on the Phase C arc chute. The MWR indicated that the probable cause for the broken arc chute was a material defect. This material defect had no relation to the failure of the RHR Pump A breaker.

MWR D01719 (June 1989) concerned problems with a bent piece of sheet metal near the "secondary contact block lever" (more correctly called the secondary "disconnect" block lever). The MWR also discussed a problem with a primary disconnect finger cluster. None of the problems had any apparent bearing on the RHR Pump A failure.

MWR D04509 (August 1990) stated that the breaker tripped after closure was attempted from the main control room during surveillance of RHR Pump A. The MWR noted a similar failure of the breaker to close two days earlier which had been corrected by cycling the breaker in and out of the cubicle. The MWR determined the cause of the failure to be a misadjustment of the latch check switch contact in the closing circuit. The failure was thought to have been corrected by adjusting the latch check switch, but the failure recurred. The MWR also noted trouble racking the breaker back into the cubicle. It was determined to be caused by a loose racking mechanism. The racking mechanism was tightened to correct the problem.

The AIT questioned the diagnosis of the failure to close, which attributed the breaker's tripping open upon closing to latch check switch adjustment. The MWR indicated that a closing operation was initiated and that the breaker tripped free. The latch check switch is a permissive for energizing the closing coil. It is supposed to be closed only when the trip trigger is almost fully reset, thus, ensuring that the closing coil cannot be energized if the tripping mechanism is not latched, otherwise the breaker would trip free on attempting to close. However, if the latch check switch was misadjusted such that it was open, a closing operation never would have been initiated. If the latch check switch was misadjusted such that it was closed, even with the trip trigger not reset, it might have allowed a closing operation to be initiated when it should not have, but it would be the trip trigger not being reset that caused the trip, not the latch check switch. Therefore, the AIT noted (and the licensee agreed in later discussions) that the MWR diagnosis was incomplete and that there was another reason, e.g., sticking or misadjustment of the trip trigger or tripping latch, that actually caused the breaker to go trip free on closing. This MWR had no apparent bearing on the recent breaker failure.

MWR D03344, performed in June 1993, noted questionable operation of truck-operated cubicle (TOC) switch. There was also information indicating unsatisfactory condition of a refurbished replacement breaker, but nothing with a direct bearing to the August 5 failure.

c. <u>Conclusions</u>

The AIT was not able to definitively conclude that the problem described in the above MWRs did not bear on the RHR Pump A breaker's failure to open. While the documentation suggests no connection, after reviewing the MWRs and subsequent discussions with the licensee, the AIT concluded that the actual causes for specific equipment failures were not always correctly established and completely or accurately documented in MWRs. The AIT also noted a great deal of variability (and some inaccuracy) in the terminology used to describe breaker operation and components. This information raises questions regarding the effectiveness of training for individuals who work on breakers. As discussed in NRC Inspection Report No. 50-461/97003, a formalized process for establishing root cause, generic implication, and continued operability of equipment had not been effectively established.

Bus 1A1 RAT main feed breaker MWRs were not reviewed because the AIT was unable to compare root causes for past failures with the recent July 22, 1997, failure because the licensee had not determined a root cause for the July 22, 1997, failure.

5.0 Review of CPS Maintenance on Westinghouse Breakers

a. Inspection Scope

The AIT reviewed the preventive maintenance procedural guidance, vendor recommendations, and preventive maintenance performance on the RAT and RHR breakers to identify problems which could have caused the breaker failures.

b. Observations and Findings

5.1 Review of the PM and Testing Procedures

The AIT reviewed recent PMs for the RAT Main Feed breaker to Bus 1A1 and RHR Pump A breaker. These PMs were conducted under Tasks PEMRHA002 (the RAT main feed breaker), dated July 20, 1993, and PEMRHA501 (RHR Pump A breaker), dated March 22, 1996, using Procedure 8410.01, "Westinghouse DHP 6900 V, 4160-kV V Power Circuit Breaker," Revisions 15 (for the 1A1 Main Feed breaker) and 16 (for RHR Pump A breaker). The following preventive maintenance was performed under these procedures:

- Breaker Cubicle Inspection
- Circuit Breaker Inspection
- Contact Inspection and Adjustment
- Tripping Latch Clearance Adjustment
- Holding Pawl Adjustment
- Lubrication
- Testing
- Breaker Restoration

Less than a year after the PM on the RHR Pump A breaker was complete, the NRC conducted an Engineering and Technical Support and Startup Readiness Inspection from January 6 through March 7, 1997. The findings from this inspection were documented in

Inspection Report No. 50-461/97003 issued May 5, 1997. The report concluded that the licensee had failed to identify, trend, address and correct recurring problems related to 480 V, 4.16-kV, and 6.9-kV circuit breakers. These problems resulted from 17 years of inadequate breaker maintenance, which included use of unapproved lubricants and unapproved solvents that caused grease hardening. The hardened grease resulted in binding of various breaker components and subsequent breaker failures. The inspection report also noted inadequate procedures and/or failure to follow procedures contributed to breaker material condition deficiencies.

In response to Inspection Report No. 50-461/97003 findings, the licensee developed an inspection and testing plan on April 23, 1997, to inspect, partially clean, and conduct reduced control voltage opening and closing timing testing on selected Westinghouse and General Electric breakers. Specific to Westinghouse breakers, the plan checked for industry related problems (e.g., cracked levering-in devices and motor cutoff switch failures) and to assess the use of unapproved lubricants and degraded lubricants. The licensee wrote MWRs D75429 (the RAT main feed breaker) and D63306 (RHR Pump A breaker) to perform the CPS inspection plan for inspecting, cleaning and re-lubricating only the accessible areas in the breakers. The AIT reviewed these MWRs and determined this work was not a full breaker PM. The MWRs used portions of Revision 17 to Procedure CPS 8410.01 to perform limited cleaning of Division 1 breakers only. The program was completed for the RHR and RAT breakers on May 5 and 9, 1997, respectively. The inspection plan was limited in scope in that the licensee decided not to clean and inspect Division 2 breakers. CPS thought that a reduced control voltage test of Division 2 breakers was adequate to prove functionality rather than performing additional breaker maintenance. The AIT noted the inspection program was not based on a comprehensive review of recommended maintenance and industry experience against CPS' current PM program requirements.

The AIT reviewed Tasks PEMRHA002 and PEMRHA501 which conducted the last full PM on RHR and RAT breakers and MWRs D75429 and D63306 that cleaned the breakers. The AIT then compared these tasks, MWRs and Revisions 15, 16 and 17 of Procedure CPS 8410.01 with the Westinghouse technical manual, Instruction Book (IB) 32-253-4B, "Instructions for Porcel-line Type DHP Magnetic Air Circuit Breakers," to assess consistency with the vendor manual. Although, the licensee used an earlier version of the vendor manual, IB 32-253-4A, which had been outdated since 1989, the different manual revisions (4A and 4B) provided similar instructions regarding lubrication. The AIT assessment of the vendor's manual is documented in Section 5.2 below. The AIT identified that these work documents generally included most of the vendor's recommendations. There were however exceptions, most notably CPS' PM procedure CPS 8410.01 did not include the vendor recommendation for lubricating the main and arcing contact surfaces (Point 4 of Figure 2).

The vendor's manual stated that lubrication of the contact surfaces (Point 4 of Figure 2) at normal maintenance intervals would be beneficial. However, the licensee overlooked this recommendation while developing their breaker maintenance procedures. Compounding the omission was the fact that previous CPS maintenance practices of using files, plastic scouring pads, and unapproved solvents on the main contacts may have removed lubricant applied at the factory. Lubrication of the upper and lower contact operating rod pins (Points 1 and 2 of Figure 2) was not mentioned in the vendor's manual or CPS' maintenance procedures. The vendor manual stated that lubrication of the moving hinge contact point (Point 3 of Figure 2) was unnecessary unless the contacts were replaced and that lubrication of the pole shaft roller bearings (Point 5 of Figure 2) should not normally be required because these bearings were packed at the factory with a "top grade slow oxidizing grease that should last for many years." The manual further stated these bearings should remain undisturbed unless the breaker exhibited sluggishness or evidence of dirt existed. The vendor's manual also recommended that the roller bearings should be cleaned and relubricated if the parts were dismantled for some reason. Although the vendor manual described routine lubrication points, its use of wording such as "beneficial" and "for many years" did not emphasize or ascribe appropriate level of importance to these actions.

Besides lubrication of these areas, the maintenance procedures did not include a measurement of force and length of the opening, compression and kickout springs for degradation and kickout spring alignment. As mentioned above (in Section 3.0), these springs provide the forces needed to open the breaker. The vendor manual excluded a check of the springs, therefore, CPS did not include it in their procedures.

5.2 Adequacy of Vendor Technical Guidance

The team concluded that the vendor technical guidance and recommendations were not sufficiently thorough or clear in a number of areas. The latest revision of the technical manual (Revision 4B), effective in 1989, contained most of the same deficiencies as Revision 4A. Westinghouse had not incorporated into revision 4B, technical guidance from a Westinghouse letter to CPS in January 1987, which described a method that differed from the technical manual on how the trip latch and trip cam adjusting screw were to be adjusted. In addition to various technical errors in diagrams and text, particularly in the area of lubrication, the vendor's manual omitted several points that should have been lubricated (some with light machine oil, some with Molykote BR2). Further, the manual was weak in its recommended lubrication of sliding electrical parts, most notably the main and arcing contacts with graphite grease. While the manual did require complete inspection, lubrication, cleaning, and adjustment at a minimum of every three years, it did not explicitly call for complete breaker refurbishment.

5.3 Interviews of Maintenance and Operation Personnel

To determine if operating and/or maintenance activities contributed to the two breaker failures, the AIT interviewed individuals responsible for operating and maintaining the RAT main feed and RHR Pump A breakers. The SIT and the AIT interviewed the individual who last operated the RHR Pump A breaker. During the interview, the operator described how he racked-in the breaker before placing RHR Pump A in service on August 2, 1997. From his description, the AIT and the SIT determined that the breaker was racked-in properly and this activity did not contribute to the breaker failure.

Electricians interviewed by the AIT indicated they did not lubricate Points 1, 2, 3, 4, and 5 of Figure 2. The electricians stated that during routine breaker maintenance they had used plastic scouring pads and files to dress the contacts as necessary (i.e., when pits or burrs were found). The electricians also indicated that the main contacts were not lubricated with conductive grease following maintenance. Further, the electricians stated that while they had not recently used unapproved solvents, such as Freon, on the breaker main contacts, unapproved solvents had been used on these areas in the past.

c. Conclusion

The AIT concluded the vendor's manual was weak and did not, in all cases, provide appropriate guidance for proper maintenance of the breakers and did not effectively assist the licensee in developing comprehensive effective preventive maintenance procedures. Even though the vendor manual was weak, the AIT considered it sufficient (if used in conjunction with other industry material and maintenance practices) for the licensee to have established a good PM program. However, CPS had not critically evaluated the vendor manual in developing its PM procedures and failed to include steps to inspect and lubricate Points 1, 2, 3, and 4 shown on Figure 2. These omissions were compounded by previous maintenance practices e.g., using unapproved solvents and abrasives, which had the effect of eliminating the original lubrication on the main contacts. Also, these PMs failed to verify opening and kickout springs for degradation plus a check of the kickout springs for proper alignment. Even after deficiencies were identified during the conduct of Inspection Report No. 50-461/97003, CPS was not proactive in assessing and revising the PM procedures or in developing a special inspection procedure. This lack of action resulted in missing several opportunities to correct the material condition of the breakers. The AIT believes that the breaker failures would have been prevented had more comprehensive procedures been developed to perform acceptable PMs.

6.0 Root Cause Investigation and Evaluation of the Failed Breakers

a. Inspection Scope

The AIT reviewed the licensee's root cause evaluations for the RAT and RHR breakers to assess completeness and accuracy of the evaluations.

b. Observations and Findings

6.1 Root Cause Investigation of RAT Main Feed Breaker to Bus 1A1 by Cutler-Hammer

6.1.1 Inspection

The AIT reviewed the July 28, 1997, letter to IP from Westinghouse Nuclear Services Division, Repair and Replacement Services. The letter reported the preliminary findings from the examination and testing of the CPS RAT breaker inspected at the Westinghouse Cutler-Hammer, Greenwood, South Carolina, manufacturing plant on July 25, 1997. The letter stated that the Greenwood facility performed the failure analysis on the DHP breaker, Shop Order No. 01YN005B4, Serial No. 2, according to the instructions in IP Purchase Order No. 705276. The letter stated that the failure analysis steps to be performed, per the purchase order, were approved by representatives of both IP and Cutler-Hammer.

6.1.2 Vendor Findings

According to the letter, the Greenwood facility performed the following investigations:

(1) The facility did a visual inspection upon receipt and noted only that the opening coil had apparently failed as evidenced by its blackened discoloration and that the coil was open.

(2) The facility cycled the breaker without failure and reported that it operated freely and concluded this was "evidence of good preventive maintenance."

(3) The facility checked the main contacts for wear, alignment, synchronization and penetration and found these parameters were good although the main contacts, had wider gaps than "outlined" in Westinghouse vendor manual I.B. 32-253-4B. The wider gap would reduce contact friction.

(4) The facility replaced the open-coil tripping solenoid and the discolored closing coil.

(5) The facility electrically operated the breaker at minimum, nominal, and maximum control voltage and found the results satisfactory.

(6) Timing was checked using the interval method and the facility found the opening interval longer than normal.

(7) The facility replaced the opening and kickout springs.

(8) Timing tests were performed after spring replacement and after puffer and hinge bolt were adjusted

(9) The facility dismantled the breaker and inspected individual parts. They found pole shaft bearings in good condition, but some drying lubricant was found, notably on parts not specified in the Westinghouse vendor's manual to be lubricated.

The letter concluded that "Part replacement and mechanism tear down did not provide evidence that would identify a particular cause for the in service failure." Cutler-Hammer found no evidence of a mechanical deficiency, a generic problem with the breaker or the existing preventive maintenance program. The report, stated that no cause of failure had been determined, however, mechanism parts would be measured to determine if replacement would be recommended.

6.1.3 AIT Findings From Review of Westinghouse Preliminary Report

Based on a review of the preliminary letter and discussion with the SIT, the AIT identified the following:

(1) The breaker was received by the Cutler-Hammer (facility) in a condition where the as-found condition was altered or lost through removing the breaker from its

cubicle and repetitive cycling of the breaker on site. Had the as-found condition been preserved, it might have facilitated an accurate or conclusive identification of the cause(s) of the breaker's failure.

(2) The facility did not appear to recognize the delicate force balance (opening spring forces versus resistive forces) nature of the breaker dynamics and were looking for a more noticeable failure. They therefore drew no inference from subtle anomalies (or recognized the potential for a cumulative effect or synergism) such as the contact condition, puffer adjustment, dried lubricant, or slower than a minimum required opening interval, etc.

(3) The facility measured opening and closing intervals, as opposed to the design parameters, as stated in the vendor's manual, of moving contact arm speed on closing and 17-millisecond contact separation on opening. The opening interval was found long, but the facility did not recognize this as an indicator of the degraded condition, i.e., potential excessive opening resistance.

(4) The facility replaced the opening and kickout springs, but did not measure the as-found free length and spring constant and the as-found adjustment of kickout springs that affects compression.

(5) The facility performed timing tests after spring replacement and after puffer and hinge bolt adjustments but did not make direct force measurements.

(6) No special significance was attributed to the rough condition of the main contacts. Through interviews with the individual who accompanied the breaker to the Cutler-Hammer facility the AIT learned that the main contacts were in a similar condition to those of the breaker for RHR Pump A.

6.2 Root Cause Investigation and Evaluation of RHR Pump A Breaker

6.2.1 Scope

To evaluate the licensee's plans, plan implementation, the root cause evaluation, and proposed corrective action, the AIT reviewed the following documents:

- licensee's written troubleshooting plan and failure analysis documents,
- the chart of possible causes,
- the associated maintenance work requests and test procedures,
- breaker maintenance Procedure, CPS 8410.01, Revisions 14, 17, and 18, and the associated Checklist, CPS 8410.01C001, Revision 14,
- a summary of the maintenance history of the failed RHR Pump A breaker and selected MWRs in detail,
- the CPS-approved and in use editions of the Westinghouse DHP technical manual, I.B. 32-253-4A, dated September 1978,

- Westinghouse's January 21, 1987 letter to CPS modifying the procedure for checking the trip latch roller-to-trip trigger clearance,

- and the current edition of the breaker vendor technical manual, I.B. 32-253-4B, dated January 1989 (which had not incorporated the new trip latch roller adjustment guidance in the 1987 Westinghouse letter).

The AIT attended several meetings conducted by the SIT, operations briefings, and licensee management briefings. The SIT simulated their proposed inspection activities using a DHP breaker of a model similar to, but older design than, the failed RHR Pump A breaker. These simulations were observed by the AIT. The training breaker and a similar (non-safety-related) breaker in the plant with a slightly larger current rating were examined by AIT members for comparison with the failed RHR Pump A breaker. The AIT observed the examination and testing of the failed RHR Pump A breaker in the plant, and interviewed SIT members and personnel involved with troubleshooting activities of the RHR Pump A breaker. The failed RHR Pump A breaker was examined by AIT members after the completion of the licensee's initial troubleshooting, including manual slow closing (without latching) and manipulation of the moving contact arms. Finally, the AIT reviewed the licensee's root cause evaluation prepared by its principal contractor in this effort. Subsequent to the onsite portion of the inspection, the AIT reviewed several revisions of the licensee's proposed procedure for full examination and testing of the failed RHR Pump A breaker and released the quarantine on the breaker at appropriate points. The AIT also reviewed the proposed procedure for interim condition assessment and restoration of the remaining safety related DHP breakers.

6.2.2 Observation

1. Troubleshooting Plan and Analyses

The licensee intended the troubleshooting plan to be comprehensive. The plan was developed to rule out non-contributing factors and to try to preserve the as-found condition of the failed breaker. Possible non-contributing factors included mechanical binding of the breaker internals (interference in the tripping mechanisms, debris/interference obstructing the main moving contact blades) and electrical component anomalies (electrical shorts, high resistances, tripping coil failures) on the breaker circuitry. However, as these possibilities were eliminated, the plan appeared to concentrate on assessing friction factors including:

- main and arcing contacts,

- moving contact arm hinge pins,

- and upper and lower main contact operating rod pins

and did not initially consider others. The decision to not evaluate these items was based on the conditions of the corresponding components in the RAT main feed breaker for Bus 1A1 that had failed in July 1997, including:

- pole shaft bearings,
- main link pin and cam follower roller,
- and restraining link pins.

The plan also initially failed to account for the possibility that the components supplying the opening forces could have contributed to the failure. Specifically, the plan did not investigate whether the kickout and opening springs physical properties e.g., spring constant and free length, were consistent with design values. Existing conditions could be different from those specified by the manufacturer, thus providing less than the design value of opening force.

2. <u>Implementation/Execution of the Plan</u>

Before removing the breaker from the switchgear cubicle, the SIT developed a plan to perform a boroscopic examination of the breaker internals to check for mechanical interference. After reviewing the plan, the AIT released the quarantine for the examination. The boroscopic inspection did not identify any mechanical interference inside the breaker. The examination revealed that Phase A moving main contacts were disengaged from the stationary main contacts, but Phase A moving arcing contact was just touching its stationary on one side. Phase B main and arcing contacts were slightly engaged with minimal penetration. The main and arcing contacts for Phase C had the most engagement and penetration of the three phases. It appeared that the Phase C contacts were holding the breaker in the intermediate position. Pole resistance readings confirmed the observed contact positions. Phase A had the highest resistance of about 1100 micro-ohms, Phase B had a reading between 900 and 1000 micro-ohms and Phase C had the lowest reading of approximately 800 micro-ohms. The presence of a resistance reading on Phase A confirmed that Phase A arcing contact carried the Phase A load current of RHR Pump A motor after the breaker failed to fully open. Chart recorder printouts and interviews with operators on shift on August 5, 1997, confirmed no observed change, in pump motor current or pump flow. Loss of one phase would have noticeably affected pump flow and pump motor current readings.

3. <u>AIT Observations of Plan Implementation</u>

With few exceptions, the SIT carefully carried out the plan. In one instance, the technician performing a detailed procedural step, first performed the step out of sequence. The technician tried to depress the tripping latch before first raising the trip trigger per procedure, he was unable to do so (as expected) and initially misinterpreted this result as a stuck tripping latch. An AIT member closely observing this phase of troubleshooting questioned the sequence of events. When the proper test sequence, i.e., holding the trip trigger in the trip position (necessary, but not specified in the procedure) was directed by the supervisor (system engineer), the technician was able to depress the trip latch roller. He accomplished this without the breaker opening, thus confirming that the opening operation of the contacts was not being hindered by any binding of the tripping latch on the top of the trip cam.

The AIT also observed that the SIT had not adequately prepared for some planned evolutions. For example, the digital low-resistance ohmmeter, used for the individual pole resistance tests, apparently had not been functionally checked beforehand. As a result, after several unsuccessful attempts to measure pole resistance on Phases A and B, which initially indicated open, the digital low-resistance ohmmeter fuses were found blown. Also, it was not initially realized that the grounding jumpers, installed for an added measure of personnel safety, would have to be removed during the pole resistance tests. Removal of these straps would separate the phases electrically and avoid erroneously measuring parallel resistances. In addition, the SIT experienced difficulty setting up the video equipment to record and display the boroscope video examination.

6.2.3 SIT Conclusion

On August 14, 1997, the SIT presented the root cause for RHR Pump A breaker failure to open on demand to IP management and the AIT members. The SIT concluded that the breaker failed to trip open because the available spring force (F_{spring}) for opening was not sufficient to overcome the sum of ($\sum$) the resistive forces ($F_{resistances}$).

The spring forces necessary to open the breaker included the kickout, opening, and perhaps a small contribution from the buffer springs (although this was not initially considered at all by the SIT). The frictional forces considered by the SIT were the upper and lower pole operating rod pins, the moving contact arm hinge, and the moveable and stationary main and arcing contacts (Points 1, 2, 3, and 4 of Figure 2) respectively.

The as-found lubrication at Points 1 and 2 was gummy, indicating an unacceptable lubricant, and containing bright metal chips from metallic wear. Acceptable lubricant was found on Point 3. The SIT found mechanical wear on the main contacts, Point 4. The SIT concluded that larger opening forces (F_{spring}) to open the breaker were necessary to overcome increased frictional forces created by the mechanical wear on the contacts.

Finally, the SIT found the stationary contacts misaligned, indicating that the moving contacts did not squarely strike and enter the stationary contacts. The SIT concluded that misalignment of stationary contacts was a contributing factor in the mechanical binding of the contacts in the failed breaker opening. The SIT stated its position that the required spring force to account for misalignment may not have been considered in the breaker design.

The AIT noted that failing to properly adjust the contacts would cause the misalignment. The AIT found, after reviewing maintenance procedures, that appropriate instructions were included to perform this adjustment and concluded that the licensee had not properly adjusted these contacts during previous PMs.

The SIT attributed the failure also to the following contributing causes:

- The vendor either did not specify or vaguely specified in its manual the lubrication requirements of Points 1, 2, 3 and 4.
- The vendor did not include sufficient spring force to overcome $\sum F_{resistances}$ in the breaker design.
- CPS staff contributed to the breaker failure because of a history of unacceptable breaker maintenance practices. These practices included the use of unapproved

solvents on the main contacts, which removed the lubricant applied at the factory (and not replacing it) and not adequately controlling lubricants used on the breakers.

- CPS failed to track, trend and investigate breaker failures to address the problem adequately.

c. Conclusion

The licensee's failure analysis of the RAT main feed to Bus 1A1 breaker was inadequate. As-found conditions immediately after the failure were not preserved and, as far as reported in the preliminary report, insufficient measurements and measurements of limited effectiveness had, up to that time, been employed at Cutler-Hammer. This appeared to be due to a failure to recognize the subtleties of the cumulative effects of minor degradations that may not be individually significant.

The licensee's failure analysis of the RHR Pump A breaker failure was significantly improved over the analysis for the RAT breaker. The RHR breaker failure analysis was based on a systematic approach and was designed to maintain as-found conditions and to identify as much information as possible before moving the breaker. This approach provided valuable information on determining the root cause of the failure. While AIT involvement was necessary to ensure a thorough evaluation, the licensee's SIT development and implementation of the investigation program was successful in identifying the root cause of the failure.

7.0 Summary of AIT Findings and Conclusions

Adequacy of the Proposed Failed Breaker Examination and Testing Procedure

The procedure for initial breaker examination and testing was adequate. However, later phases were not as comprehensive and required prompting by the AIT to cover all the sources of potential problems in the breaker including some sources of friction and the opening force potential weaknesses.

Conclusions

The AIT reviewed the history of the RHR Pump A breaker, the history of breaker maintenance in general, the licensee's response to NRC Inspection Report No. 50-461/97003, the licensee's response to the July 22, 1997, breaker failure, and the licensee response to the August 5, 1997, failure. Based on these reviews the AIT concluded the August 5, 1997, breaker failure was caused by:

1. inadequate and inappropriate maintenance activities;

2. failure to adequately assess the findings in NRC Inspection Report No. 50-461/97003;

3. inadequate corrective action for the findings in Inspection Report No. 50-461/97003;

4. failure to perform an adequate root cause evaluation and implement effective corrective action for the July 22, 1997, breaker failure.

In addition, the AIT concluded that the failure to properly maintain the safety related electrical circuit breakers introduced a common mode failure into at least all 4.16-kV Westinghouse electrical circuit breakers at CPS.

Maintenance on breakers over their life has not been consistent with vendor recommendations (see NRC Inspection Report No. 50-461/97003) for frequency or scope of preventive maintenance. In this case, the most significant item was failure to adequately maintain and lubricate the main and arcing contacts (both moving and stationary). Further, there has been a history at CPS of using unapproved cleaning agents which could have led to the removal or contamination of existing lubrication.

Inspection Report No. 50-461/97003 identified a number of items associated with breaker maintenance and corrective actions for past breaker failures. CPS' assessment of that inspection report did not effectively address the scope of the potential problems and therefore did not identify and implement effective corrective actions. Specifically, CPS failed to identify that the main and arcing contacts were not being lubricated and, therefore, did not include a specific check for contact condition in their short term corrective actions.

CPS' response to the July 22, 1997, breaker failure did not appropriately integrate the failure and historical problems with breakers into a comprehensive investigation plan. The breaker's as-found condition was not preserved and the breaker was cycled several times prior to sending it to the vendor for additional inspection. Even though the breaker was sent to the vendor, the scope of work authorized by CPS did not provide a comprehensive assessment of the breaker. CPS' and the vendor's lack of understanding of the breakers operation also contributed to the poor evaluation of the failure. For example, the condition of the main and arcing contacts was observed; however, no significance was placed on their condition.

The AIT also evaluated CPS' investigation into the August 5, 1997, breaker failure and concluded that overall the methodology was a significant improvement over that used for the July 22, 1997, breaker failure. The licensee took prudent action in quarantining RHR Pump A breaker to preserve the as found condition of the breaker following its failure. Contracted engineering consultants and industry experts comprising the SIT provided guidance to the licensee to inspect the breaker methodically and determine a possible root cause.

The SIT determined that the primary cause for the breaker failure was that available opening forces were insufficient to overcome the system's resistances. At this point however, the SIT appeared to focus on the system resistances associated with the main contact blades and did not initially consider all potential sources of system resistance, e.g., the potential contribution from pole shaft bearing. Further, the SIT did not consider the opening forces during their initial investigation. Specifically, the SIT did not initially consider the kick-out and opening springs as being potential contributors to the failure. AIT discussions with the SIT regarding these issues resulted in a more complete evaluation being conducted.

The SIT's final determination, that lack of appropriate maintenance of the main and arcing contacts combined with a short and bent kick out spring were the causes of the August 5, 1997, RHR Pump A breaker failure was consistent with the AIT's independent evaluation.

8.0 Exit Meeting

The AIT met with licensee representatives (denoted below) during a public exit meeting on August 20, 1997. During this meeting, the AIT discussed the purpose of the inspection, the inspection methodology, and presented the team's findings and conclusions. The team also discussed the likely informational content of the inspection report regarding documents or processes reviewed by the team during their inspection activities. No priopMetary information was identified.

Personnel Participating in the Exit Meeting

IP Company

J. Cook, Senior Vice President
W. Romberg, Assistant Vice President
P. Yocum, Plant Manager, CPS
R. Phares, Manager, Nuclear and Performance Improvement
D. Thompson, Manager, Nuclear Station Engineering Department
M. Stickney, Supervisor, Regulatory Interface

U.S. Nuclear Regulatory Commission

A. Beach, Regional Administrator, RIII
J. Caldwell, Deputy Regional Administrator, RIII
G. Grant, Director, Director, Division of Reactor Projects, Region III
G. Wright, AIT Leader and Acting Chief, Reactor Projects Branch 4, Region III
T. Pruett, Senior Resident Inspector, CPS
K Stoedter, Resident Inspector, CPS
S. Campbell, AIT Member and Senior Resident Inspector, Davis-Besse Plant
Z. Falevits, AIT Member and Senior Reactor Engineer, Region III

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION III
801 WARRENVILLE ROAD
LISLE, ILLINOIS 60532-4351

APPENDIX A

August 8, 1997

MEMORANDUM FOR: Geoffrey C. Wright, Team Leader, Augmented Inspection Team (AIT), Clinton Power Station

FROM: A. Bill Beach, Regional Administrator, RIII

SUBJECT: CLINTON AIT CHARTER - REVISION 1

This revision is being issued to clarify aspects of the Charter.

On August 5, 1997, a 4.16kV Westinghouse circuit breaker failed to open on demand while the licensee was shifting from the 'A' RHR pump to the 'B' RHR pump. This breaker failure, when viewed with previous repetitive Westinghouse circuit breaker failures and the licensee's failure to clearly identify breaker malfunction root cause(s), raises concerns regarding the operability of vital safety-related components. Current analyses of past failures indicates that one potential causal factor involves generic implications for proper breaker operation. Based on discussions with the Offices of Nuclear Reactor Regulation (NRR) and Analysis and Evaluation of Operational Data (AEOD) regarding repetitive breaker failures, Region III has decided, with NRR concurrence, to conduct an AIT in accordance with Management Directive (MD) 8.3. Part I of MD 8.3 states that an AIT may result from events involving repetitive failures affecting safety-related equipment and involving potential adverse generic implications.

Attached for your implementation is an AIT Charter for the inspection of the circumstances associated with the breaker failure. The objectives of the team are to identify and communicate the facts surrounding the breaker failure as well as any generic issues, and to document the findings and conclusions of the onsite inspection. The inspection should begin on August 6, 1997, and be completed within approximately one week. The report should be ready for regional management's signature within approximately two weeks from the end of the inspection.

Please contact me if you have any questions regarding these objectives or the enclosed Charter.

Attachment: AIT Charter

See Attached Distribution:

Distribution:

cc w/attachment:
G. M. Tracy, EDO
J. E. Rosenthal, AEOD
D. F. Ross, AEOD
G. E. Grant, RIII
J. A. Grobe, RIII
K. E. Perkins, RIV
S. J. Collins, NRR
A. E. Chaffee, NRR
G. H. Marcus, NRR
J. B. Hopkins, NRR
S. A. Richards, NRR
J. A. Calvo, NRR

AUGMENTED INSPECTION TEAM (AIT) CHARTER

AIT formation, per MD 8.3, was based on the staff's need to fully understand the causes, consequences and generic implications of repetitive Westinghouse 4.16kV breaker failures involving various safety-related systems.

The Augmented Inspection Team (AIT) is to perform an inspection to accomplish the following:

1. Establish a chronology of events associated with the breaker failure including initiating activities, identification of the problem, and subsequent equipment troubleshooting and testing.

2. Review previous Westinghouse 4.16kV breaker failures, analyze factual information and evidence related to the failures, and evaluate the licensee's actions in identifying root causes.

3. Evaluate the adequacy of the licensee's Westinghouse 4.16kV breaker Preventive Maintenance (PM) Program including past PM's performed on such breakers and identify any aspects of breaker PM that could contribute to the breaker failures. Include in the review, breaker maintenance and testing procedures and vendor manuals to determine whether maintenance activities correspond to recommended vendor practices.

4. Interview plant personnel and evaluate maintenance worker training in performing 4.16kV breaker maintenance activities and operator training in placing 4.16kV breakers in operation, including their ability to properly perform breaker racking operations, to identify any contributing factors to the breaker failure.

5. Review the adequacy of the licensee's program for determining the root cause of the breaker failures. Observe and evaluate troubleshooting, testing, and analysis of quarantined equipment.

Appendix B - Persons Contacted

Licensee Management

J. Cook, Senior Vice President
W. Romberg, Assistant Vice President
P. Yocum, Plant Manager, CPS
R. Phares, Manager, Nuclear and Performance Improvement
D. Thompson, Manager, Nuclear Station Engineering Department
M. Stickney, Supervisor, Regulatory Interface

Special investigation Team (Root Cause Analysis)

S. Eisenhart	Performance Improvement Inc. (team leader)
J. Canning	CR Electrical Distribution Services
J. Roy	CR Electrical Distribution Services
A. Storms	Storms Advisory Services
L. Demick	Demick Associates, Inc.
V. Torres	Westinghouse
S. Richitelli	Cutler-Hammer
D. Wheatley	Illinois Power - Independent Analysis Group
D. Lukach	Illinois Power - Nuclear Station Engineering
F. Taylor	Illinois Power - Electrical Maintenance
G. Smith	Illinois Power - Electrical Maintenance
L. Lehman	Illinois Power - Audio/Visual

Special Investigation Team (Corrective Action)

M. Stickney	Illinois Power - Team Leader
D. Lukach	Illinois Power - Nuclear Station Engineering
D. Wheatley	Illinois Power - Independent Analysis Group
G. Reed	Illinois Power - Operations
F. Taylor	Illinois Power - Quality Assurance
L. Lehman	Illinois Power - Audio/Visual
J. Canning	CR Electrical Distribution
J. Roy	CR Electrical Distribution
L. Demick	Demick and Associates
H. Estrada	Independent

Electrical Maintenance

J. Bopp	North American - Electrician
M. Calandrillo	Illinois Power - Electrician
J. Celey	Illinois Power - Electrician
G.Englehart	Illinois Power - Electrician

Electrical Maintenance (continued)

K. Trone Illinois Power - Supervisor, Electrical Maintenance

Operations

D. Livingstone Illinois Power - Non-Licensed Operator

Electrical Maintenance Training

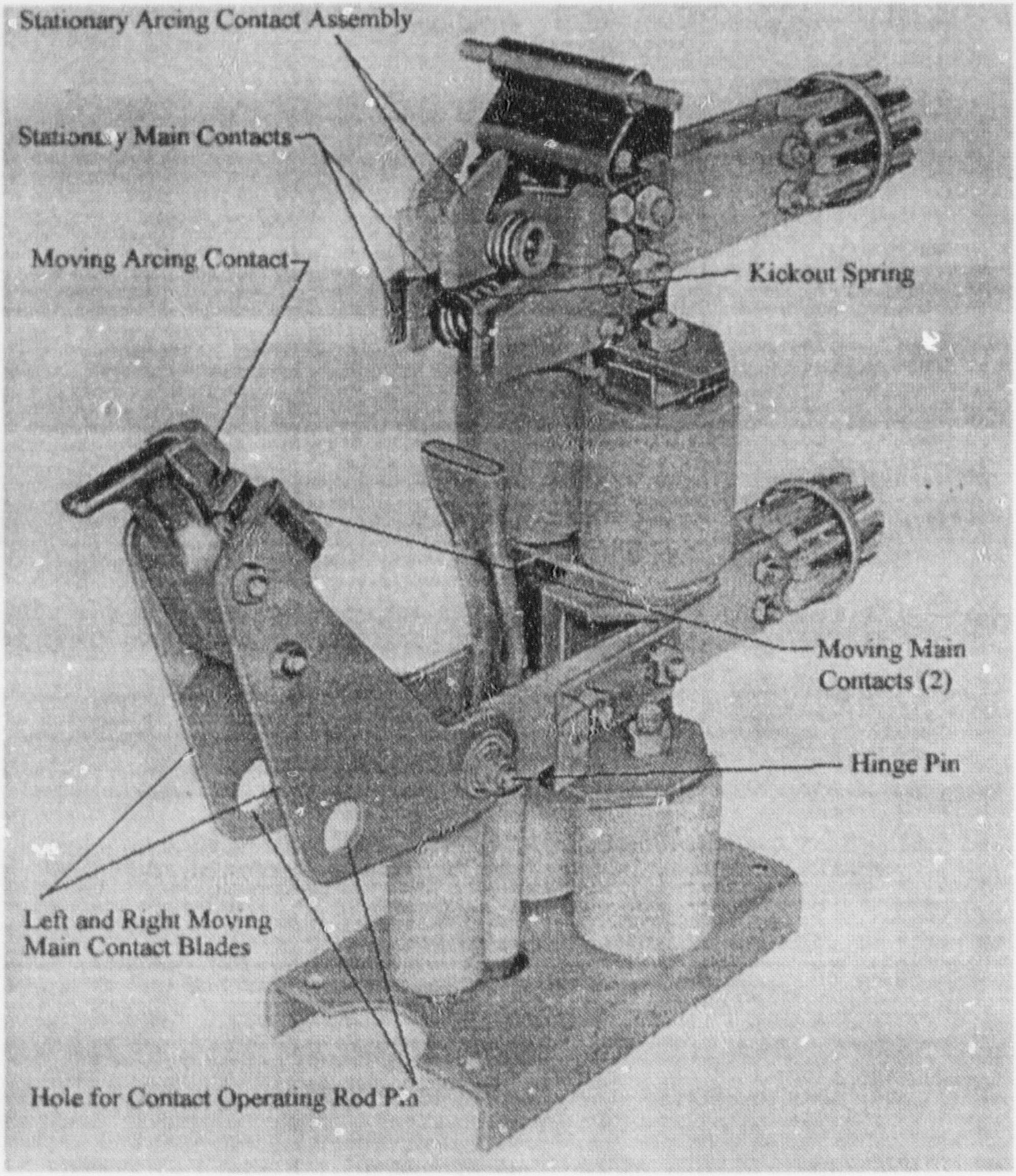
Harley Fishel Training Administrator

Appendix C - Documents Reviewed

MWR D75611	Check and Adjust Breaker Latch Check Switches
MWR B18632	RHR Breaker Failure to Close - Clean Linkage
MWR C28360	Repair RHR Pump Breaker Phase C Internal Ceramic Piece
MWR D01719	Repair RHR Pump A Breaker Bent Sheet Metal
MWR D04509	Repair RHR Pump Breaker Misadjusted Latch Check Switch
MWR D03344	Replace RHR Pump Breaker TOC Switches
PERMRHA002	Preventive Maintenance Task on RAT Main Feed Breaker
PERMRHA501	Preventive Maintenance Task on RHR Pump Breaker
Procedure 8410.01	Westinghouse DHP6900V, 4.16-kV Power Circuit Breaker Maintenance, Revisions 14, 15, 16 and 17
MWR D75427	Clean and Inspect RAT Main Feed Breaker, May 9, 1997
MWR D63306	Clean and Inspect RHR Pump A Breaker, May 5, 1997
Westinghouse Technical Manual	IB-32-253-4A, 1978 and 4B, 1989, "Instructions for Porcel-Line Type DHP Magnetic Air Circuit Breakers"
Westinghouse Preliminary Report	DHP Breaker Failure Analysis Illinois Power Company Clinton Power Plant Shop Order 014N005B4, Serial #2"
Critique Report EM97-015	Critique of RAT Main Feed Breaker Failure
Critique Report EM97-016	Critique of RHR Pump A Breaker Failure
Condition Report 1-97-07-222	Failure of RAT Main Feed Breaker
Condition Report 1-97-08-045	Failure of RHR Pump A Breaker

Appendix D - Acronyms and Intialisms

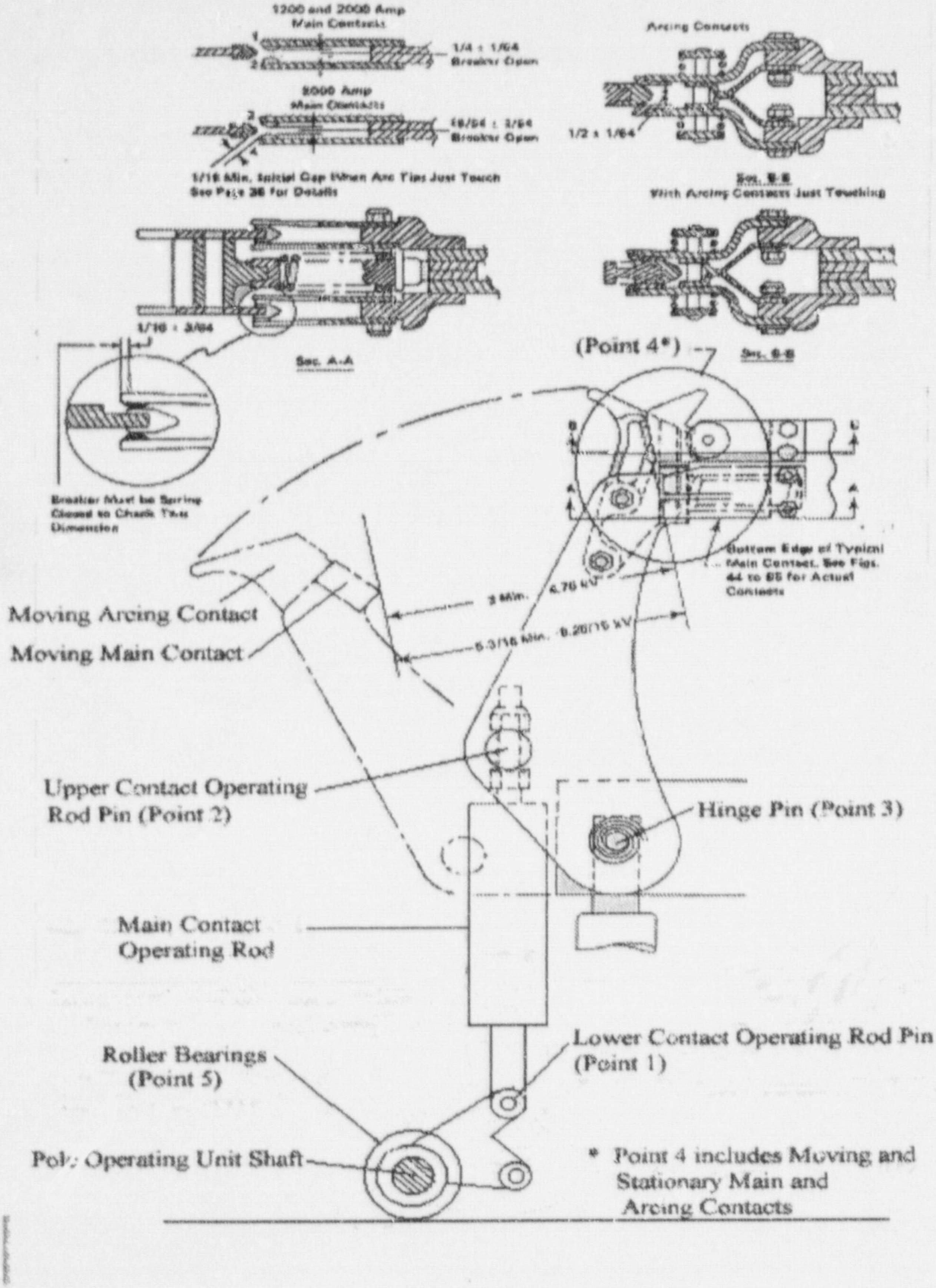
AEOD	Analysis of Events and Operational Data
AIT	Augmented Inspection Team
CPS	Clinton Power Station
CR	Condition Report
EDO	Executive Director for Operation
ERAT	Emergency Reserve Auxiliary Transformer
I.B.	Instruction Booklet
IP	Illinois Power
kV	kilo-Volts
MD	Management Directive
MOC	Mechanism Operated Cubicle
MWR	Maintenance Work Request
NRC	Nuclear Regulatory Commission
NRR	Nuclear Reactor Regulation
PM	Preventive Maintenance
RAT	Reserve Auxiliary Transformer
RHR	Residual Heat Removal
SC	South Carolina
SDC	Shutdown Cooling
SIT	Special Investigation Team
TOC	Truck Operated Cubicle
V	Volts
Vac	Volts alternating current
Vdc	Volts direct current



POLE UNIT ASSEMBLY

(3 ASSEMBLIES PER BREAKER)

FIGURE 1



CONTACT ASSEMBLY (FIGURE 2)