NRC Form 366 (9-83)

U.S. NUCLEAR REGULATORY COMMISSION
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EXPIRES: 8/31/85

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
McGuire Nuclear Station - Unit 2	0 5 0 0 0 3 7 0	1 OF 1 4

TITLE (4): REACTOR TRIP BREAKER FAILURE DUE TO MECHANICAL FAILURE

EVENT DATE (5) MONTH	DAY	YEAR	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	REPORT DATE (7) MONTH	DAY	YEAR	OTHER FACILITIES INVOLVED (8) FACILITY NAMES	DOCKET NUMBER(S)
0 7	0 2	8 7	8 7	— 0 0 9 —	0 1	0 3	2 5	8 8		0 5 0 0 0
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OPERATING MODE (9): 3
POWER LEVEL (10): 0 0 0

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more of the following) (11)

	20.402(b)		20.405(c)	XX	50.73(a)(2)(iv)		73.71(b)
	20.405(a)(1)(i)		50.36(c)(1)		50.73(a)(2)(v)		73.71(c)
	20.405(a)(1)(ii)		50.36(c)(2)		50.73(a)(2)(vii)		OTHER (Specify in Abstract below and in Text, NRC Form 366A)
	20.405(a)(1)(iii)		50.73(a)(2)(i)		50.73(a)(2)(viii)(A)		
	20.405(a)(1)(iv)		50.73(a)(2)(ii)		50.73(a)(2)(viii)(B)		
	20.405(a)(1)(v)		50.73(a)(2)(iii)		50.73(a)(2)(x)		

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER AREA CODE	
STEVEN E. LeROY - Licensing	7 0 4	3 7 3 - 6 2 3 3

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS
B	J C	B K R	W 1 2 0	Y					

SUPPLEMENTAL REPORT EXPECTED (14)

		EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
YES (If yes, complete EXPECTED SUBMISSION DATE)	XX NO				

ABSTRACT (Limit to 1400 spaces, i.e., approximately fifteen single-space typewritten lines) (16)

At 2341 on July 2, 1987 during performance of the control rod drop timing tests, personnel detected smoke in the area of the reactor trip switchgear. The control room was notified and operators manually tripped the reactor trip breakers (RTBs). Control room status lights indicated both breakers had opened, though investigation revealed RTB 2 to be closed. The breaker could not be opened locally until an attempt was made to manually tension the breaker closure spring. The operators were not holding the feedwater isolation reset button when the breaker did open so a Train B Feedwater Isolation occurred, though it did not cause any adverse effects. The failure of the breaker has been classified as a manufacturing deficiency due to a fabrication deficiency causing the failure of a weld inside the breaker. The investigation has revealed that the breaker failed to automatically open due to a mechanical binding of the breaker. A weld failure and worn components of the breaker closure mechanism are suspected of causing the binding, but nothing conclusive has been found during the investigation at McGuire which pinpoints the cause. The breaker will undergo further inspections and tests at Westinghouse.

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INTRODUCTION:

On July 2, 1987, at 2341 during performance of the Control Rod Drop Timing tests, personnel detected smoke in the area of the Reactor Trip Switchgear [EIIS:JC]. Control room operators were notified of the smoke and manually tripped the Reactor Trip Breakers (RTB). Control room status lights indicated both breakers had apparently opened. When investigating the cause of the smoke, it was determined that the Westinghouse DS-416 RTB, installed in the 2RTB cubicle, was in the closed position. Operators made several unsuccessful attempts to locally trip the breaker. When an attempt was made to manually tension the breaker closure springs, the breaker opened. Operators were not holding the Train B Feedwater [EIIS:SJ] Isolation Reset button at the time the breaker opened which resulted in a Train B Feedwater Isolation. The breaker was removed from its cubicle for testing to determine the reason it did not open. A Bypass RTB was removed from Unit 1 1BYB cubicle and temporarily installed in the vacant Unit 2 2RTB cubicle to complete the Rod Drop Timing testing. The Control Room indicating lights for 2RTB cubicle have functioned properly during all subsequent tests.

Unit 2 was in Mode 3, Hot Standby, at the time the breaker failed to open.

The failure of the breaker has been classified as a manufacturing deficiency due to a fabrication deficiency causing the failure of a weld inside the breaker. The investigation has revealed that the breaker failed to automatically open due to a mechanical binding of the breaker. A weld failure and worn components of the breaker closure mechanism are suspected of causing the binding, but nothing conclusive has been found during the investigation at McGuire which pinpoints the cause. The breaker will undergo further inspections and tests at Westinghouse in an attempt to determine the cause of the binding.

An investigation into the cause for the apparent erroneous Control Room breaker position indicator light revealed all circuits functioning properly. No abnormalities have been discovered which would have caused an open indication when the breaker was still in the closed position. The erroneous breaker open indication in the Control Room will not be assigned a cause code until the final analysis on the breaker is completed by Westinghouse and all wires associated with the open indication light have been fully checked.

EVALUATION:

Background

There are four identical RTBs for each unit's Rod Control system. The normal alignment uses two main breakers while two bypass breakers are used to support testing and allow continuous operation of the system during periodic maintenance. Cubicles which house the breakers are labeled as RTA, RTB, BYA, and BYB. The four breakers are arranged in a series-parallel network (See Figure 1), which allows a main breaker and the opposite train bypass breaker to be deactivated and isolated for testing or maintenance. These breakers may be moved from cubicle to cubicle as required. The RTBs connect the power from the Motor/Generator Sets to the Reactor Control Rod Drive [EIIS:AA] mechanisms. When either of the two operable breakers, which are aligned in series, opens, the power is cut off to the control rod drives releasing the rods, and the Reactor is tripped.

The McGuire Unit 2 Operating License specifies that all four Reactor Trip Breakers be tested 7 days prior to unit startup and have similar testing plus time response testing every 31 days. Every 6 months, the breakers are thoroughly tested and serviced according to Westinghouse specifications. Maintenance of this fashion is also performed on all Unit 1 Reactor Trip Breakers, though not required by the Unit 1 License.

The Westinghouse DS-416 Air Circuit Breaker Inspection and Maintenance procedure provides for inspection and maintenance of the RTB and the connection hardware inside the breaker cubicle. Tests are performed on the Under Voltage (UV) trip solenoid and the Shunt trip solenoid to verify proper operation. Also, a force test is performed on the bar (trip bar) which is rotated when the breaker is tripped by either the UV trip solenoid, the Shunt trip solenoid, or the manual trip lever. A maximum trip force of less than 2 pounds to rotate the trip shaft indicates satisfactory operation. Typical values for trip force on a new breaker are in the 0.5 pound range. The breaker should trip via the UV trip solenoid when the voltage supplied to the UV coil decreases to between 28.8 volts and 14.4 volts when the UV solenoid deenergizes. This UV trip solenoid action is tested to assure it provides a minimum force of 3 pounds to rotate the trip shaft. Typical values for a new UV trip solenoid force acting on the trip shaft is in the 4 to 5 pound range.

The breaker inspection procedure is performed every 6 months for each breaker to inspect for damaged wires; tightness of the connecting nuts and bolts; the operating mechanism for binding, looseness, worn or defective parts; and cracked welds. During these inspections, the breaker is normally cycled on the order of 50 times to perform the inspection according to the Westinghouse Maintenance Program Manual for DS-416 RTBs. This procedure was last performed for breaker B-4 on December 18, 1986 and documented that no problems were found prior to placing the breaker back into service.

Breaker Components and Operation

The RTBs at McGuire are Westinghouse DS-416, 1600 Amp, 600 Volt, three phase breakers that can be opened or closed either automatically or manually. Figure 2, Reactor Trip Breaker Shafts And Components, shows there are three main shafts inside the breaker: the pole shaft (21), the trip shaft (2), and the crank shaft (15). The crank shaft is used to tension (charge) the close spring (18) by crank shaft rotation driven by either the motor or the manual emergency charge handle (23). Rotation of the crank shaft and the connected close cam (5) is always in the counter clockwise direction. Once the close spring is charged, the spring release latch (7) holds the spring open by preventing the rotation of the close cam stop roller (6) until the spring release device (8) rotates the spring release latch down around the stop roller (6).

The pole shaft (21) supports the small angular rotation of the center pole lever (28), which ties the movement of the Y-Phase moving contact assembly (25) with the main drive link (27). Two other similar pole shaft levers (not shown) are found to the far right and left of the center pole lever. These levers operate the X-Phase and the Z-Phase moving contact assemblies in unison with the Y-Phase due to the common pole shaft. An anti-bounce lever (not shown) is similarly mounted to the pole shaft adjacent to the center pole lever and tied to the main drive link via its extended upper connecting pin. The anti-bounce lever acts as a dashpot to slow down the breaker only during opening to prevent any momentary reclosure action of the breaker. Another pole shaft lever mounted on the pole shaft (not shown) is connected to a rod which is directed upward and is attached to the bottom block of auxiliary contact switches. Two additional auxiliary contact switch blocks are stacked on top of the bottom auxiliary contact block switches for a total of three (see Figure 3). Two short rods connect the movement of the bottom auxiliary contact block with the upper two. The rods tie the movement of the pole shaft with the position of three stacked auxiliary switch blocks. Each of the three auxiliary switches contain four sets of contacts ("A finger" contacts and "B finger" contacts) for use in breaker position indication and control functions. The A finger contacts are open and, the B finger contacts are closed, when the breaker is open.

Referring to Figure 4A, when the main drive link (14) moves upward, and to the right, the connected center pole lever (9) rotates counter clockwise with the pole shaft driving the moving contact assemblies (11) (only one of three shown) forward, closing the breaker. In order for the main drive link to move upward and close the breaker, the pivot point (4) of the roller constraining link (3), tied to the trip latch (5), must be in a fixed position. This allows the opposite end of the roller constraining link, which is attached to the roller end of the main drive link, to travel upwards on the lobe on the close cam (2) during rotation. The roller constraining link prevents the main drive link from traveling down the lobe on the close cam as the cam rotates. The close cam always rotates in the counterclockwise direction.

Referring to Figures 4 and 5, the trip shaft (7) performs a function for both the closing and the opening (tripping) of the breaker. Prior to closing the breaker, the trip latch (5) is in the tripped position (See Figure 5A) and must be reset after the breaker has been opened to allow breaker closure. During the rotation of the crank shaft to charge the close spring, the trip latch moves down through the notch in the trip shaft, under the direction of the roller constraining link (3), to allow rotation of the trip shaft. The trip shaft then rotates to a position which prevents the trip latch from moving back upward through the notch in the trip shaft (See Figure 5B). When the trip shaft (7) and the trip latch (5) are in this position, the spring is charged and the cam is in the position to close the breaker (see Figure 4A). After the spring release latch (16) drops below the stop roller (1), the close springs will rotate the close cam lifting the main drive link, under the direction of the roller constraining link, closing the breaker contacts (see Figure 4B). If at any time the trip shaft is rotated to allow the upward movement of the trip latch, the breaker will open. If this action occurs while the breaker is attempting to close, the breaker will trip and remain open.

Referring to Figure 6, tripping the breaker is accomplished by any one or combination of three methods: manually at the breaker, the Under Voltage (UV) solenoid operation coil, and the Shunt trip solenoid operation coil. All three of these methods rotate the trip shaft (8) directly which trips the breaker. When the breaker is closed, the open spring (Figure 2, Component 19) and the springs loaded behind the fixed contact assemblies (not shown) maintain a clockwise rotational force on the pole shaft. The pole shaft is prevented from rotating clockwise by the tension of the roller constraining link (3) via the compression in the main drive link (10) and the center pole lever. Motion of the roller constraining link (3) is prevented by the position of the trip shaft (8) which prevents upward travel of the trip latch (1). When the trip shaft (8) is rotated allowing the trip latch (1) to move upward through the trip shaft notch, the roller constraining link allows the main drive link roller (11) to roll down the close cam, opening the breaker.

Figure 8 is provided to show a sectional view of the breaker components and to detail the components on the crank shaft.

Description of Event

On the night of July 2, 1987, the Control Rod Drop Tests were being performed. Testing had been completed for Shutdown Banks A through C. Testing was being concluded on Shutdown Bank D and the RTBs were required to be opened as directed by the test procedure. Operators opened the breakers at 2343:46 and, while holding the Feedwater Isolation Reset buttons as directed by procedure, observed the breaker position lights in the Control Room change from closed to open. The Events Recorder indicated the Train A breaker had opened, but it did not indicate a change from Closed to Open for the Train B 2RTB Breaker, unknown to the Control Room Operators. However, Operators in the Control Room did observe the illuminated Open status indicator light for the Train B 2RTB Breaker (hereafter called breaker B-4).

Operators closed the RTBs to allow continuation of the test with Shutdown (S/D) Bank E Control Rods. Operators observed the breaker position lights change from open to closed and shortly thereafter, began to withdraw S/D Bank E rods. The Events Recorder again did not show a change of breaker position for breaker B-4. As Operators were withdrawing S/D Bank E, they noticed the demand counter for this bank was not counting up from zero. The operators notified the personnel who were working with them on this test in an adjacent room which contained the RTBs. At the same time, test personnel detected smoke which appeared to be coming from the RTB cabinets and informed operators who immediately opened the RTBs (at 2345:55), while holding the Feedwater Isolation Reset buttons, and observed the status lights change from closed to open. Unknown to the Control Room Operators, the Events Recorder again did not indicate that breaker B-4 had opened.

Control Room personnel notified Supervisors to investigate the smoke and found that the breaker in 2RTB (B-4) had not tripped and was the source of the smoke. The Supervisor informed Control Room personnel that a local (manual) trip of the breaker was to be attempted, and that they should hold the Feedwater Isolation Reset button. Since the breaker was smoking, a broom stick handle was employed to make several pushes on the breaker's manual trip lever, but the lever would not move any appreciable amount. These manipulations of the local manual trip lever did not open the breaker. In an attempt to cycle the breaker, the Supervisor began to manually charge the close spring. As the close spring was being tensioned, the breaker opened at 2358:01. Due to the difficulties and long delay (approximately 12 minutes) in opening the breaker, Control Room operators were not holding the Train B Feedwater Isolation Reset button when the breaker finally opened. This resulted in a Train B Feedwater Isolation signal that was generated by the Solid State Protection System (SSPS). Closure of the Condensate Feedwater valves under the direction of the Feedwater Isolation signal did not cause adverse affects. Operators made an entry in the Unit 2 Technical Specification Action Item Logbook declaring 2RTB inoperable.

Breaker B-4 was removed from 2RTB cubicle and placed on the floor. Operators notified the Shift Engineer (Shift Technical Advisor) and the Unit 2 Coordinator of the situation. The Shift Coordinator advised operators to contact Transmissions Generation Station Support (GSS) personnel to determine if the Unit 1 Bypass Breaker from 1BYB cubicle could be used in the 2RTB cubicle replacing the failed breaker B-4.

Operators wrote a work request to investigate/repair the problem with RTB B-4. Operators also implemented the NRC Immediate Notification Requirements procedure, and informed the NRC of the breaker failure and the Feedwater Isolation (an Engineered Safety Feature actuation) at 0112. The Station Manager instructed operators not to withdraw any Unit 2 Control Rods without his permission.

McGuire Management discussed the situation with NRC personnel and at 1410 on July 3, 1987, appropriate permission was given to operators to resume Rod Drop Timing tests with the use of a Unit 1 Bypass RTB. At 1730 that same day, Rod Drop Timing tests were completed.

The problem associated with the demand counter not counting up from zero was attributed to a sticky release latch which prevented the counter wheels from moving. In no way did the demand counter problem cause or assist in the failure of breaker B-4 to open.

Description Of Breaker Inspection

GSS took breaker B-4 to their shop to begin an initial assessment to determine the cause of the failure. The breaker was cycled a total of three times during their inspection. GSS personnel closed the breaker electrically, and continuity checks of the auxiliary switch contacts used in the Shunt trip circuit indicated that they were closed. The breaker was tripped by use of the UV trip attachment and the breaker opened. The breaker was closed electrically a second time and a trip force test was performed on the trip shaft, but rotation of the trip shaft did not trip the breaker. This constituted the second failure of the breaker. Repeating what operators had previously done to open the breaker, they began to manually tension the close spring. As soon as the crank shaft (and close cam) began rotation with the manual emergency charging device the breaker jarred open. The breaker was closed electrically a third time and GSS personnel made a second attempt to perform a trip force test. On this attempt, the breaker opened successfully with a trip shaft tripping force of 1.25 pounds. Testing was stopped at 1030 on Friday, July 3, 1987, and the breaker was voluntarily quarantined until all groups concerned with the failure could be present.

On Tuesday, July 7, 1987, an NRC Inspection Team arrived on site and a meeting was held with Duke, Westinghouse, and NRC personnel at 1000 to determine a planned course of action to methodically inspect and test breaker B-4. Attention of the meeting focused on attempting to preserve any evidence which would show why the breaker failed to open. Testing of the breaker resumed on Tuesday, July 7, with Duke, NRC, and Westinghouse personnel overseeing all aspects of the inspection.

Inspections of the breaker mechanisms revealed the weld which connects the center pole lever to the pole shaft had failed. This fillet weld had cracked along the entire length of the weld. Welding is performed on only one side of the center pole lever to attach it to the pole shaft and was made approximately half way around the pole shaft. Inspections of other pole shaft levers revealed their weld lengths to be on the order of 3/8 to 3/4 the circumference of the adjoining pole shaft.

Corresponding abnormal wear markings were found at two different locations in the breaker. An indentation burr of approximately 3/32 inches long was found on the notch of the trip shaft which mated with a small wear mark on the trip latch. Subsequent testing to determine the force required to rotate the trip shaft, allowing the trip latch to pass through the notch on the trip shaft, was within acceptable limits. The second area of excessive wear was the far left side steel laminant of the four piece laminated close cam surface, which contacts the roller on the main drive link. Wear was also found on the right most steel plate of the close cam, but was not as excessive as the left most plate.

In an attempt to recreate the binding situations which had twice prevented the breaker from opening, thirty-one trips of the breaker were performed at McGuire. Several attempts were made to artificially produce a similar binding of the breaker mechanisms, but each time the breaker was directed to trip, the breaker opened successfully. During the times the breaker was closed, inspections revealed the interfaces between the main drive link top pin, main drive link, roller constraining link, the trip latch, and the center pole lever with the broken weld, were able to twist and subsequently create a binding situation. All other trip system components inspected did not reveal any abnormal conditions. The collective inspection and testing of the breaker mechanisms at McGuire was concluded on Thursday, July 9, 1987.

Inspections began on the remaining three Unit 2 RTBs on July 13, 1987. During the inspection of the breaker from cubicle 2RTA (breaker B-1), QA personnel found a questionable weld on the pole shaft lever which operates the auxiliary switch linkage. The inspector performed a liquid dye penetrant test on the weld and discovered what appeared to be a hair line crack in the weld. A force test was performed on the lever arm with a safety factor greater than 6. The lever satisfactorily passed the test, and the inspection of the breaker was complete; the breaker was cleared to return to service.

During the inspection of the breaker from cubicle 2RTB (breaker B-2), visual inspection revealed heavy wear on the left side of the close cam. The main drive link appeared to be tilted approximately 3° to the left from the lateral plane. Clearance of the mechanisms appeared to be adequate and welds were good. The same type of wear was observed on breaker B-3 and all welds were determined to be acceptable.

Description Of Breaker Indication Inspection

The Control Room indications for the Reactor Trip Breakers are comprised of a green light to indicate an Open breaker position and a red light to indicate a Closed breaker position. Operation of the green light (Open) is controlled by the breaker's auxiliary switches. These switches are operated by a connection rod to a lever on the pole shaft and by design provide a positive position indication for the breaker. The breaker main contacts position is determined by the pole shaft position. The red Control Room status indicator light for breaker Closed does not provide a positive indication of true breaker position. There is a switch contact in parallel with the light which "shorts" around the light to extinguish it when the Control Room manual trip pistol grip switch is operated.

Electrical testing performed on the B-4 breaker indicated that all switch and internal wiring were satisfactory except for the burned out Shunt trip coil. The Shunt trip coil burned out approximately 2 to 5 minutes after the coil was energized at 2341:16 but did not deenergize because of the failure of the breaker to open. This coil is not rated for continuous duty and is normally deenergized by another auxiliary switch as the main breaker contacts open. Testing of the breaker main contacts, as related to auxiliary switch contacts, revealed the main contacts must physically separate to deenergize the Shunt trip coil. The breaker main contacts must move 5/8 of an inch further open for the auxiliary switch contact to close, sending a signal to the Events Recorder indicating that the breaker had opened. The breaker main contacts move a total of approximately 3.5 inches during one operation.

The Shunt clearing contact opens well before the green light (Open) and the Events Recorder contacts. This indicates that the Shunt trip coil could not have burned out if the auxiliary switch contacts for the green light (Open) had made contact. Since both the green light (Open) and the Events Recorder operate simultaneously, this would provide printed Events Recorder data that the breaker did not open and likewise, the auxiliary switch contacts for the green light (Open) could not have made contact to directly illuminate the green light unless an external circuit wiring problem existed.

The external wiring circuits were checked for circuit polarity and determined to be correct in all cases. Circuit grounds on the 125 Volts DC battery power system were investigated. A ground was found on the positive side of the DC system but was not located inside the breaker compartment. After failed breaker B-4 was replaced with an operable breaker, the replacement breaker was cycled five times in cubicle 2RTB. During this testing, all breaker position light indicators and operations of the breaker performed correctly.

Conclusion

The failed RTB B-4 was thoroughly inspected and tested in December 1986. The inspection procedure documents that no problems were found during that inspection. Since that inspection, breaker B-4 has been cycled to satisfy the testing requirements of the Unit 2 License and during other related tests. Each time, the breaker performed as required and passed the time response tests required every 31 days without exceeding the maximum 150 millisecond opening time limit. Time response testing verified sound operation within all interacting trip components.

Preliminary investigation results obtained at McGuire concurrently with Duke, Westinghouse, and the NRC Inspection Team, could not determine a definitive reason to explain why the breaker stuck closed and failed to open. Three areas are presently considered factors which may have contributed to the failure of the breaker to open as directed: weld failure, manufacturing tolerances of the breaker components, and the cumulative effect of the high number of cycles on the breaker. The actual number of cycles the breaker had could not be determined to any degree of accuracy since the breaker was retrofitted with a counter after the initial installation. Best present estimates place the number of cycles above 3000. Closure mechanism parts, particularly the close cam, showed signs of abnormal and excessive wear, but the exact point of the binding, which resulted in the breaker failing to open, has not been determined.

The failed weld on breaker B-4 is located on the pole shaft (21) where the center pole lever (28) passes through. The majority of the weld remained on the pole shaft due to a more complete fusion of the weld to the pole shaft than to the center pole lever. Operational ability of the failed breaker was maintained during cycling due to the common top connection pin in the main drive link (27)

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and the adjacent and similar anti-bounce lever mounted on the pole shaft (21) transferring the loads. Forces opening and closing the breaker were transmitted through the anti-bounce lever and the top connection pin in the main drive link.

Investigation into the Shunt trip coil problem determined it failed sometime after the breaker B-4 was cycled at the conclusion of Control Rod Drop Timing tests of Shutdown Bank D and before rod drop testing was started on Shutdown Bank E. The Events Recorder indicated the breaker did not open during these attempted breaker cycles and the Shunt trip coil remained continuously energized in its attempt to open the breaker. Due to overheating, the Shunt trip coil burned up and shorted itself to ground. The resultant smoke is what alerted IAE and OPS personnel to the breaker problem.

The only remaining testing to be performed at McGuire is the inspection of the Unit 1 RTBs and a wire to wire resistance checkout of the external breaker Open position indicator circuits. This checkout will determine if a wiring error exists, external to the breaker, which may have caused the erroneous green light (Open) indication when the breaker failed to open.

A review of past incidents at McGuire revealed one incident in which an RTB failed to open during testing. LER 370/83-03 describes UV tests in which several different failures prevented automatic opening of the breakers under UV trip force only. These failures were attributed to bindings of the UV trip arm, lack of a gap between the trip arm and the trip shaft pin, and missing retainer rings. The breakers would open subsequently by use of the Shunt trip solenoid. Since there were no excessively worn areas, and the breakers did not bind and prevent the breaker from tripping, the failure of breaker B-4 to open is not considered recurring with respect to these past events.

Further investigation into Westinghouse breaker failures, with the assistance of the Nuclear Plant Reliability Data System (NPRDS), revealed many failures of DS-416 breakers used in various applications. Primarily, the failures were failures to close due to electrical problems in auxiliary switches and external control circuitry. However, three problems were associated with broken welds. Two occurrences at other utilities involved weld failures associated with the pole shaft. The third occurrence was associated with the secondary disconnect support bracket.

Most recently, a DS-416 Reactor Trip Breaker in use as a Bypass breaker at Catawba Nuclear Station was being inspected due to this incident at McGuire. Welds associated with the pole shaft appear to have cracks in the welds. Further information from the inspection of these welds and from the remaining breaker inspections will be included in the addendum to this report describing the results from the Westinghouse lab inspection of breaker B-4. Also, the three weld failures at other utilities will be considered by Westinghouse.

There were no personnel injuries, radiation overexposures, or releases of radioactive material as a result of this incident.

CORRECTIVE ACTIONS:

Immediate: Operators initiated a manual Reactor trip after they were alerted to smoke in the area of the breakers.

Subsequent:

1) Operators tripped breaker B-4 locally and removed it from the 2RTB cubicle.

2) The breaker was declared inoperable and secured from the Rod Drop Timing tests.

3) The NRC was notified of the failed breaker and the Feedwater Isolation (ESF Actuation).

4) All Unit 2 Reactor Trip Breakers were thoroughly inspected and a new breaker was installed as a result of the failed breaker.

5) Operators have issued a Special Order directing personnel in the Control Room to verify both Reactor Trip Breakers have opened in the time period after a Reactor trip and before reclosing the breakers. This Special Order is applicable to both units.

Planned:

1) Reactor Trip Breaker B-4 will be sent to a Westinghouse lab in Pittsburgh, Pennsylvania, and a proposed inspection with testing will be performed after Duke Power, Westinghouse, and the NRC have concurred as to what inspections and tests are to be done at the lab; Duke and NRC personnel will be present.

2) All Unit 1 RTBs will be thoroughly inspected to determine the quality of the welds in the breakers and to detect any areas of abnormal wear.

3) Operators will make a change to the Reactor Trip Procedures, to physically verify RTB status after a Reactor trip, and to maintain the status of a single breaker if it fails to open.

4) Changes will be made to procedures which involve RTB operations to physically verify the breaker status after tripping.

5) Checks will be performed on the external wiring circuits for the breaker Open indication light.

6) One new RTB of the new vintage will be installed in Unit 1, replacing an older vintage breaker, to further increase breaker reliability for Reactor trips.

SAFETY ANALYSIS:

Unit 2 was in Mode 3, Hot Standby, and had not been critical for 63 days due to a refueling outage. Control Rod Drop Timing tests were being performed which allowed only one bank of Control Rods to be withdrawn from the core at any given time. To verify that the rods of the bank being tested have all been dropped for that section of the test, both RTBs are opened ensuring all rods are at the bottom of the core prior to withdrawing another bank. In this incident, one of the RTBs failed to open, but the second redundant breaker, did open.

The failure of this breaker was discovered due to the smoke which resulted when the Shunt trip coil overheated and burned up as a result of not being reset after energizing. If the Shunt trip coil had not burned up, or if the smoke had not been noticed, the time at which the stuck closed breaker would have been discovered is not certain, assuming the condition which provided the erroneous indication in the Control Room continued to exist. It should be noted that the maximum time period a breaker could be in an unknown failed condition is 31 days due to the surveillance requirements. This condition of one breaker continuously stuck closed would not have affected the timing tests being performed since the redundant operating breaker would have performed the opening function.

Had this incident occurred in Mode 1, Power Operation, with the unit at 100% full power, the redundant RTB should have performed the opening action required to cut power to the Control Rod Drives tripping the Reactor. Postulating an incident where the stuck closed breaker condition previously existed, a failure of the second breaker would involve both RTBs failing to shut down the Reactor. This scenario of failure to shut the Reactor down is addressed by the Emergency Procedure EP/5000/11, Subcriticality. If a Reactor trip has not occurred, three Operator actions would be carried out which would cause the Control Rods to be inserted. First, Operators would begin to manually insert the Control Rods. Another Operator would go to the adjacent room which contains the Motor/Generator (M/G) sets and open the output breakers from the M/G sets and also open the supply breakers to the motors of the M/G sets. This action can be completed less than 1 minute after observing the Reactor as still critical. It should be noted that during an actual Reactor trip event, Operators in the Control Room will usually first look at the Digital Rod Position Indicator lights for confirmation that the rods have dropped after opening the RTBs. Therefore, sufficient capability to trip the Reactor would exist at all times.

The health and safety of the public were not affected by this incident.

SUPPLEMENTAL INFORMATION:

The supplemental information contained in this section will describe the results of the Westinghouse inspection of the Unit 2 Reactor Trip Breaker and the investigation into the cause for the apparent erroneous breaker position indication.

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE (3)
McGuire Nuclear Station - Unit 2	0 5 0 0 0 3 7 0	8 7	— 0 0 9	— 0 1	1 3 OF 1 4

TEXT (If more space is required, use additional NRC Form 366A's) (17)

Results Of Breaker Inspection

Westinghouse personnel performed a detailed visual inspection of the Reactor Trip Breaker. Some abnormal wear and scratch marks on the breaker side frame were found. After repeated attempts to cause the breaker to jam in the closed position, they finally succeeded and were able to identify the linkage misalignment which caused the jam. The roller attached to the main drive link normally rests on the outer laminations of the close cam. The broken weld on the center pole lever permitted lateral movement of the main drive link, which could allow the roller to move close to its tolerance limits. In the jammed position, the roller had slipped inward off the outer laminate of the cam. The force exerted by the breaker closing action induced a twisting motion which caused the roller to wedge between the close cam lamination and the side frame. Although it was established that the combination of part tolerances played a role in the jamming of the breaker, it was also concluded that the breaker would not jam unless a broken weld existed to permit the twisting action that allowed the roller to wedge.

Subsequent evaluation of the broken weld revealed that the weld had fused originally for only about 15% of its total length. Complete separation of the weld was due to low cycle fatigue, striations indicating that the separation occurred after about 2,500 cycles.

Westinghouse personnel consider this malfunction to be a random occurrence. Breakers of this type have operated through many thousands of cycles without malfunction. Westinghouse personnel also consider that the weld failure at 2,500 cycles is not inconsistent with the breaker design and also that weld failure will be gradual over many breaker cycles so that periodic weld inspection will be able to identify a problem before failure occurs.

Description Of Breaker Indication Inspection

The testing performed at the time of this incident could not identify any problem with the breaker indication wiring that would cause an erroneous open indication. This testing is documented in Licensee Event Report 370/87-09. Westinghouse personnel determined during their investigation of the breaker that there were no wiring problems internal to the breaker that would cause an erroneous open indication. IAE personnel performed many wiring tests subsequent to this event. These tests included: 1) Verifying that the wiring was terminated correctly at the breaker, and elsewhere; 2) Testing all wiring for continuity and resistance to verify good connections and absence of grounds; 3) Visually inspecting all switch contacts and electrically testing for continuity; and, 4) Dynamically testing the breaker for proper time/electrical response to verify that all circuits were functioning properly. IAE personnel could not find any problems or discrepancies anywhere in the circuit which could have caused the open indication for the jammed breaker.

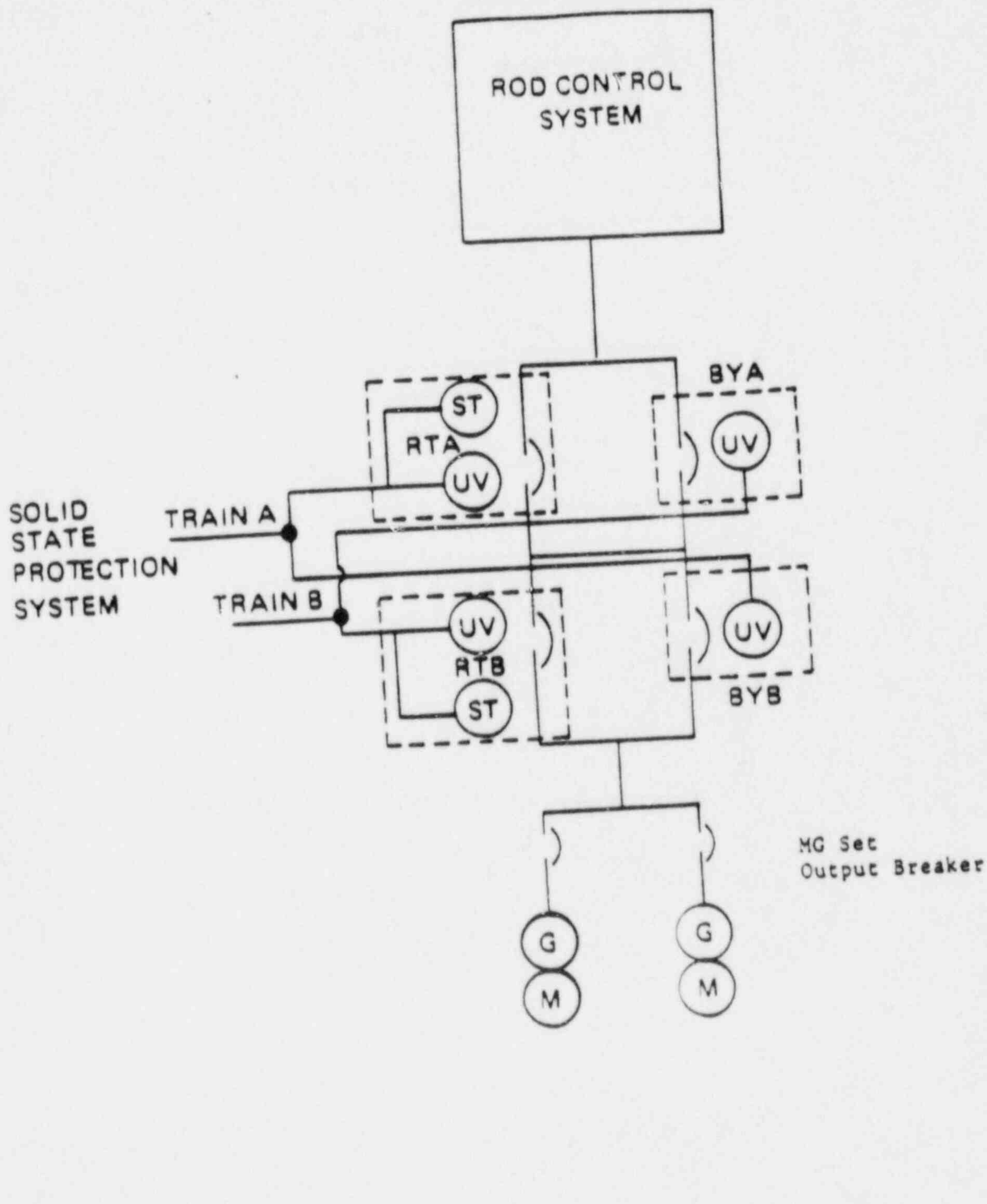
CORRECTIVE ACTIONS:

Subsequent: All McGuire Reactor Trip Breakers have been replaced with new breakers that have been inspected according to Westinghouse recommendations.

Planned: Transmissions personnel will incorporate new inspection criteria into procedure MP/0/A/2001/06, Westinghouse DS-416 Air Circuit Breaker Inspection and Maintenance. This inspection criteria was recommended by Westinghouse and includes a thorough examination of all wear surfaces and the weld on the center pole lever at each maintenance interval.

Figure 1

Reactor Trip Breaker Arrangement



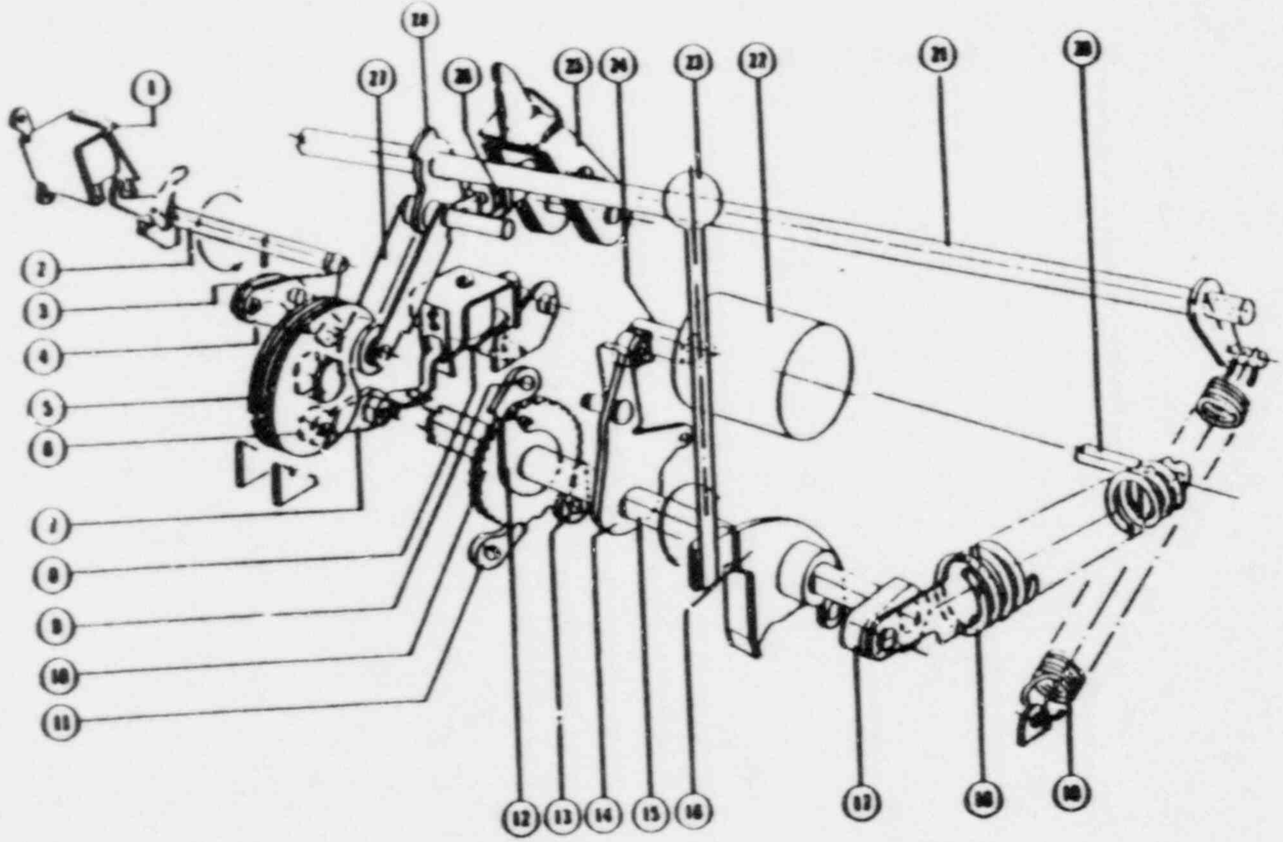


Figure 2

Reactor Trip Breaker Shafts And Components

1. SHUNT TRIP DEVICE
2. TRIP SHAFT
3. ROLLER CONSTRAINING LINK
4. TRIP LATCH
5. CLOSE CAM
6. STOP ROLLER
7. SPRING RELEASE LATCH
8. SPRING RELEASE DEVICE
9. OSCILLATOR PAWL
10. RACHET WHEEL
11. HOLD PAWL
12. DRIVE PLATE
13. EMERGENCY CHARGE PAWL
14. OSCILLATOR
15. CRANK SHAFT
16. EMERGENCY CHARGE DEVICE
17. CRANK ARM
18. CLOSING SPRING
19. TRIP/OPEN SPRING
20. CLOSING SPRING ANCHOR
21. POLE SHAFT
22. MOTOR
23. EMERGENCY CHARGE HANDLE
24. MOTOR CRANK AND HANDLE
25. MOVING CONTACT ASSEMBLY
26. INSULATING LINK
27. MAIN DRIVE LINK
28. CENTER POLE LEVER

Figure 3

Reactor Trip Breaker With Front Panel Removed

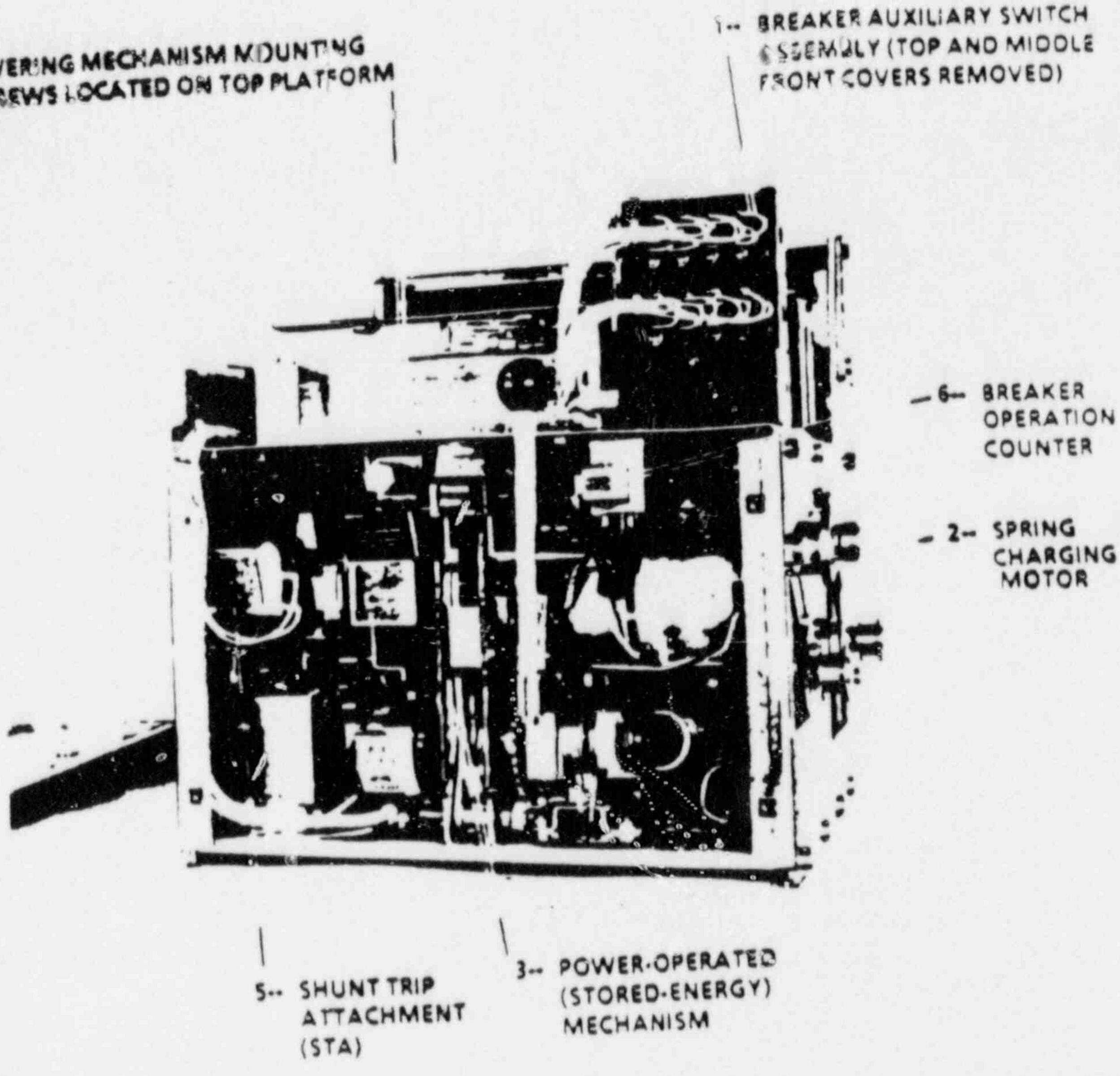


Figure 4

Breaker Open Going Closed Action

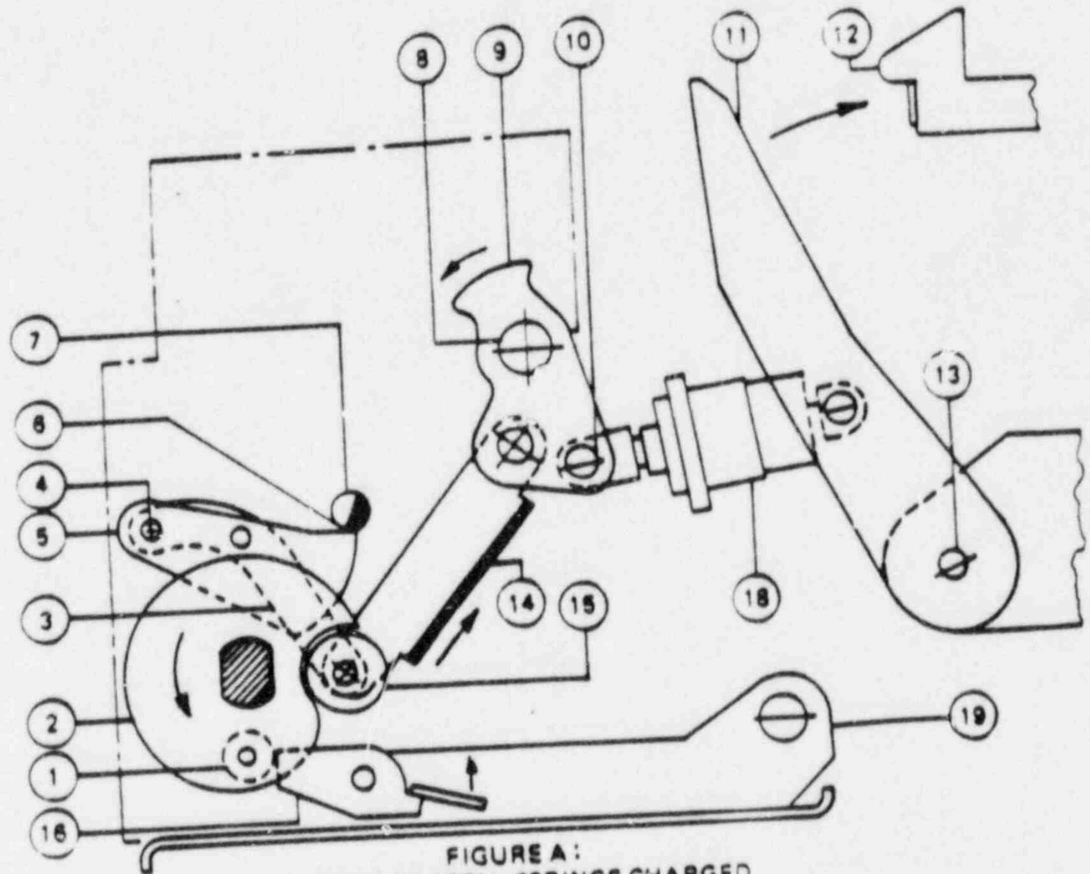


FIGURE A:
BREAKER OPEN–SPRINGS CHARGED

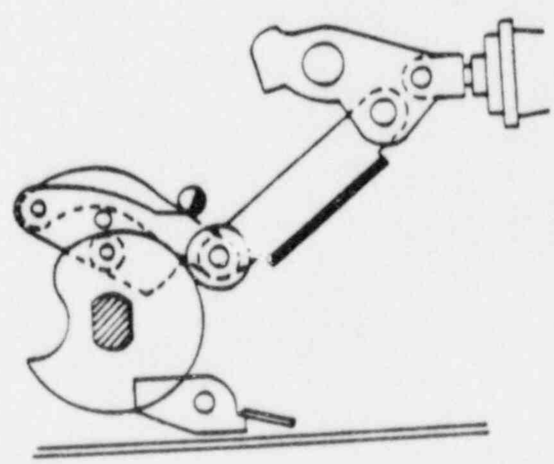


FIGURE B:
BREAKER CLOSED–SPRINGS DISCHARGED

Figure 5

Trip Shaft Latch Details

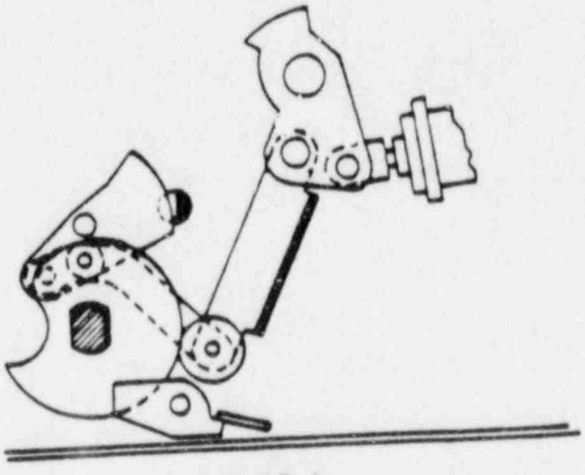


FIGURE A:
BREAKER OPEN—SPRINGS DISCHARGED

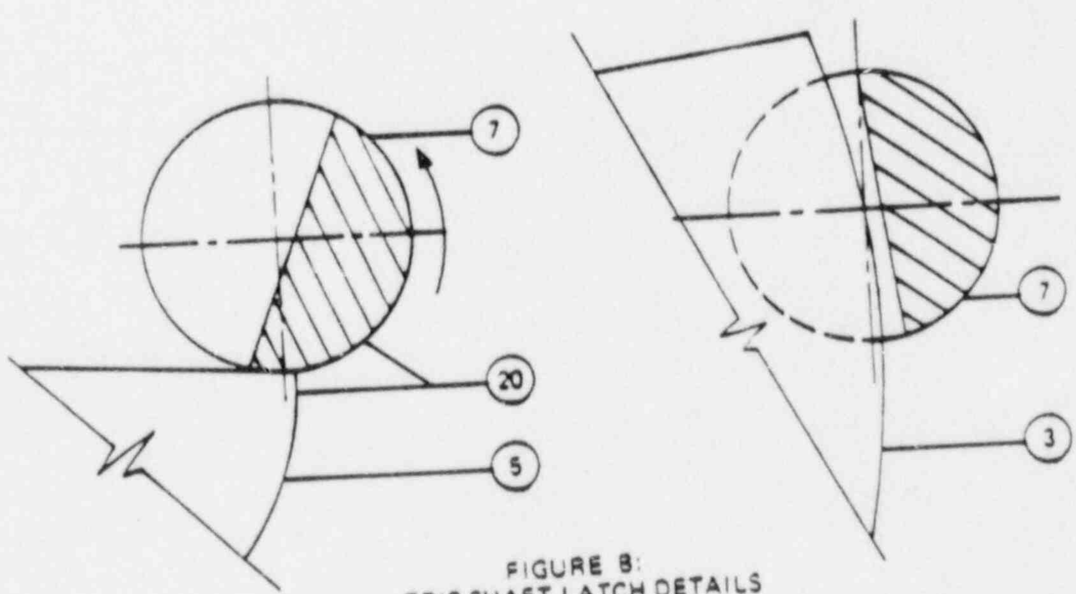


FIGURE B:
TRIP SHAFT LATCH DETAILS

TRIP LATCH HELD
(RESET)

TRIP LATCH RELEASED
(TRIPPED)

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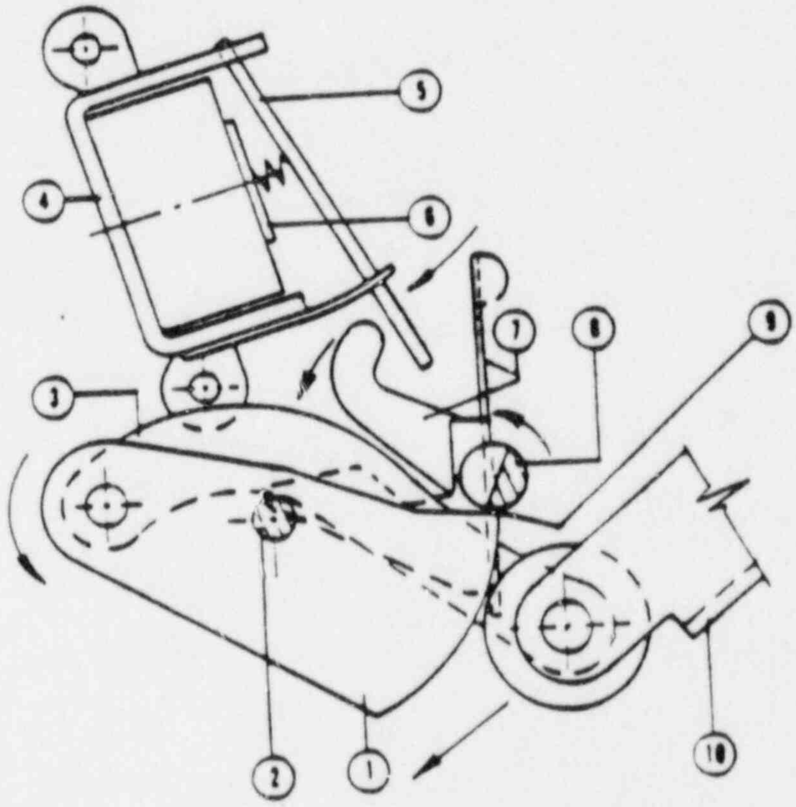
Figure 6

Breaker Component Trip Action

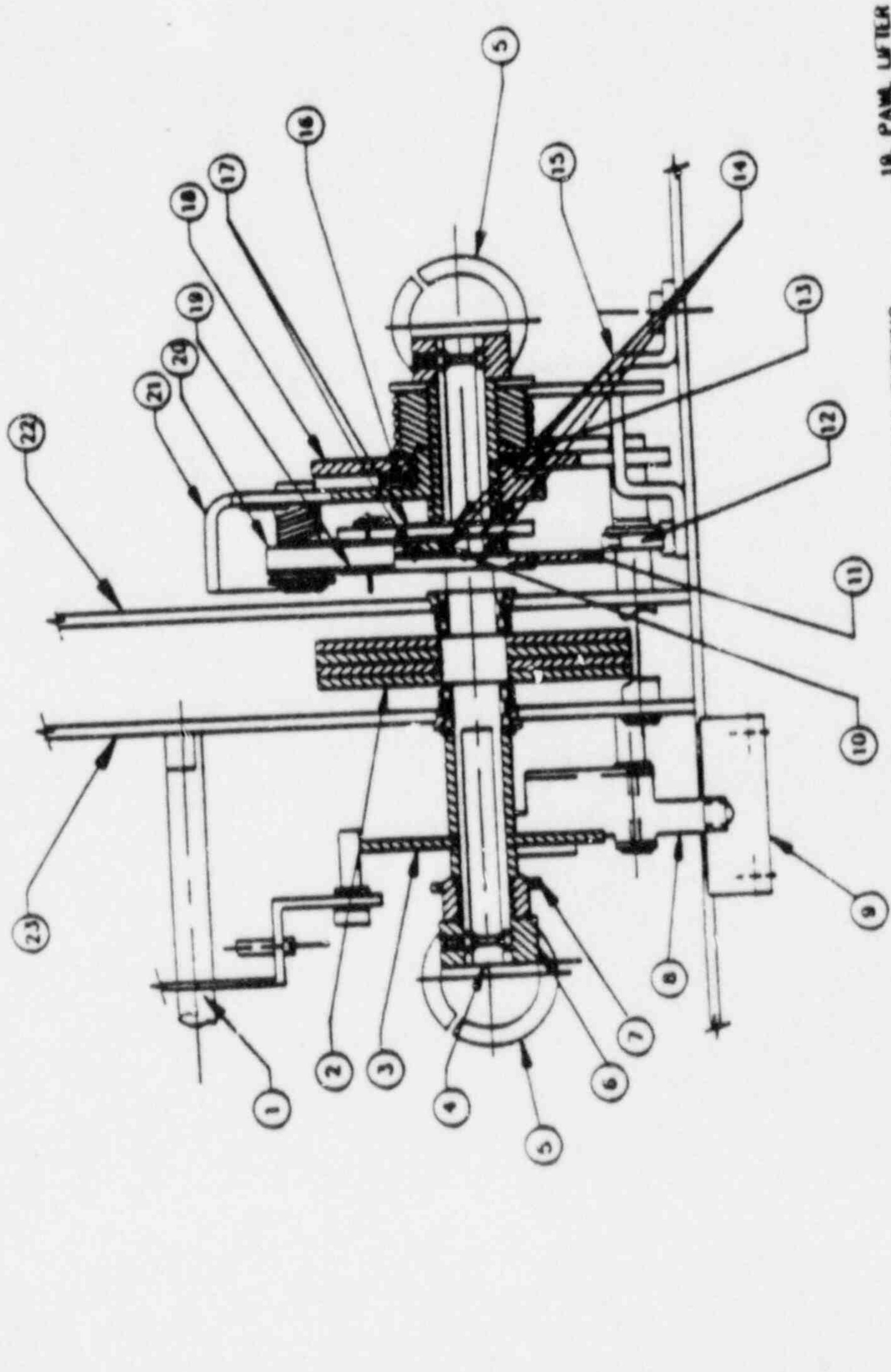


STA/BREAKER
INTERACTION

1. TRIP LATCH
2. TRIP LATCH PIVOT PIN
3. ROLLER CONSTRAINING LINK
4. SHUNT TRIP DEVICE
5. SHUNT TRIP ARMATURE
6. SHUNT TRIP COIL
7. TRIP SHAFT LEVER
8. TRIP SHAFT
9. TRIP SHAFT LATCH SURFACE
10. MAIN DRIVE LINK
11. MAIN DRIVE LINK ROLLER

Figure 7

Sectional View Of Breaker Components



1. TRIP SHAFT
2. CLOSE CAM
3. MOTOR CUT-OFF SWITCH CAM
4. CRANK SHAFT
5. CLOSING SPRING
6. CRANK ARM
7. SPRING CHARGE INDICATOR
8. MOTOR CUT-OFF SWITCH LEVER
9. MOTOR CUT-OFF SWITCH
10. RATCHET BUSHING
11. RATCHET WHEEL
12. HOLD PAWL
13. OSCILLATOR BUSHING
14. SPACERS (3)
15. STOP BRACKET
16. THRUST BEARING AND RACES
17. DRIVE PLATES (2)
18. EMERGENCY CHARGE DRIVE
19. PAWL LIFTER
20. OSCILLATOR PAWL
21. OSCILLATOR
22. MECHANISM SIDE FRAME, RIGHT HAND
23. MECHANISM SIDE FRAME, LEFT HAND

M87018E

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NUCLEAR PRODUCTION

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March 25, 1988

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555

Subject: McGuire Nuclear Station, Unit 2
Docket No. 50-370
LER 370/87-09-01

Gentlemen:

On August 3, 1987, Duke submitted Licensee Event Report 370/87-09 reporting a reactor trip breaker failure at McGuire. In that report Duke stated that Westinghouse would perform further inspections and testing of the reactor trip breaker and report the findings, and the findings would then be submitted to NRC. Accordingly, pursuant to 10CFR 50.73 Sections (a)(1) and (d), attached is revised Licensee Event Report 370/87-09-01 which provides the additional information beginning on page 12 of 14. This report is being submitted in accordance with 10CFR 50.73(a)(2)(iv). This event is considered to be of no significance with respect to the health and safety of the public.

Very truly yours,

Hal B. Tucker

Hal B. Tucker

SEL/249/jgc

Attachment

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