UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JAN 10 1991

MEMORANDUM FOR: Thomas Murley, Director
Office of Nuclear Reactor Regulation

FROM: Eric S. Beckjord, Director
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH INFORMATION LETTER 167 : NUCLEAR PLANT AGING RESEARCH: WESTINGHOUSE DS-SERIES 480-VOLT CIRCUIT BREAKERS

The purpose of this memorandum is to transmit the results of aging research performed on Westinghouse DS-Series 480-volt circuit breakers. This research was performed by Brookhaven National Laboratory under the Nuclear Plant Aging Research (NPAR) Program. The program evaluated operating experience, laboratory testing, licensee responses to NRC Bulletin 88-01 and Generic Letter 83-28, and the Westinghouse Owners Group suggested maintenance practices for DS-416 circuit breakers.

The results of this work are reported in full in NUREG/CR-5280, Vol.1 (July 1990) and Vol.2 (November 1990), "Age-Related Degradation of Westinghouse 480-Volt Circuit Breakers." These NUREG reports received an extensive peer review, e.g., IEEE, Westinghouse, EPRI/NUMARC, national laboratories. Recommendations are made regarding maintenance practices including the frequency of maintenance. Specifically, the NUREG report recommends a method to track operating cycles imposed on each circuit breaker. This research provides a sound technical basis for developing procedures and criteria that are called for in NRC Generic Letter 83-28 and provides input to the resolution of technical issues of NRC Bulletin 88-01.

BACKGROUND

During 1970 through 1983, Westinghouse DS-416 reactor trip breakers exhibited problems with undervoltage trip attachments (UVTAs), which resulted in failure to trip on demand from the main control room. The problems came to a head when an ATWS event occurred at Salem in 1983. Consequently, Generic Letter 83-28 was issued requiring licensees to provide recommendations for improving the reliability of the reactor trip systems, including the circuit breakers. In response to pole shaft weld failures, which affected the operation of DS-416 and DS-206 breakers in reactor trip and other class 1E applications, Bulletin 88-01 was issued to require licensees to perform various inspections and measurements and report the results to the NRC. Figure 1 identifies systems affected by DS circuit breaker failures, in addition to the Reactor Protection System.

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Analysis of the licensees' responses to GL 83-28 and Bulletin 88-01 and subsequent testing and evaluation by Brookhaven National Laboratory under the auspices of the NPAR Program form the basis for the conclusions and recommendations in this Research Information Letter.

INTRODUCTION

During the period under discussion, Westinghouse issued a number of technical bulletins suggesting better maintenance and testing practices for mitigating breaker problems, and in 1986 the Westinghouse Owners Group (WOG) published a maintenance program manual for the DS-416 reactor trip breaker.

In addition to the UVTA failures, a number of age-related problems were reported in recent years. These included cracking of welds in the pole shaft levers and secondary contact brackets, non-uniform wear on the closing-cam segments, misalignment of the main roller, broken spring-release latch levers and pivot pin to trip latch, loss of clearance between moving parts, and loss of spring tension in the cell switch spring return mechanism. Most of these failures are associated with the breaker operating mechanism that is illustrated in the attached Figure 2.

Figure 3 illustrates the causes of failure that have been identified. It can be observed that many of the causes (i.e., normal operation, out of adjustment, binding, misalignment, and setpoint drift) are aging-related and that the failures are related to the mechanical operation of the breaker and not the electrical portion.

In conjunction with the operating experience analysis, a life cycle test program was conducted at BNL with the following objectives: (1) to identify the aging degradation mechanisms that might be operative, (2) to evaluate the suitability of the WOG maintenance program, and (3) to determine the expected breaker service life under normal operating conditions. A Westinghouse DS-416 low voltage power circuit breaker (circa 1981) was subjected to mechanical cycling in accordance with ANSI/IEEE C37.50 (1981). The breaker was manufactured for commercial applications, but it is identical in design, materials, and manufacturing process to a nuclear class breaker. Because of mechanical failure, the main breaker contacts were not energized electrically, but control and auxiliary power was supplied. The breaker was subjected to over 36,000 cycles over a 9-month period. Three different operating mechanisms were used during the test, and the results were surprisingly consistent and repeatable within acceptable limits.

Furthermore, maintenance using the WOG maintenance manual was done at prescribed intervals during the test program.

JAN 10 1991

CONCLUSION/RECOMMENDATIONS

- The coils in the under-voltage trip attachment, shunt trip attachment, and spring release device do not age prematurely and fail because of their own operation; they are overloaded by mechanical binding.

- The key indicator for breaker degradation and subsequent maintenance is not the passage of time, but the number of cycles that the breaker experiences.

- The WOG-suggested maintenance practices are satisfactory to sustain acceptable breaker performance. The suggested frequency of maintenance is based on life cycle testing.

- The ultimate or expected life of a DS-416 breaker is 10,000 cycles. For safety-related applications a conservative factor of 2 is suggested, which results in a suggested life of 5000 cycles (approximately 20 years, assuming 250 operating cycles annually). Certain subcomponents have shorter life spans.

- Inspection on receipt of new breakers should include an examination of pole shaft welds to verify 3/16-in. fillet welds of 180° coverage.

- The lubricant recommended by Westinghouse (BR-2) for bearings and linkages collected dust and contaminants. A dry film lubricant (i.e., Neolube #2, Huron Industry) yielded better results. The lubricant (Lubriplate 130 graphite bearing grease) recommended for rubbing surfaces (cams, rollers, etc.) was not effective in reducing wear.

- A method for recording operating cycles of class 1E circuit breakers should be implemented. The installation of a counter is preferred.

- At each surveillance testing interval of 50 to 100 cycles, visual inspection should be conducted for parts vulnerable to aging.

- A maintenance inspection should be performed annually or at each refueling outage, including a complete inspection of all parts and lubrication, cleaning, and replacement as necessary.

REGULATORY IMPACT

Input to the Resolution of NRC Generic Letter 83-28

NRC Generic Letter 83-28 requires a broader scope of actions by licensees for ensuring the reactor trip system reliability than the aging study of the DS-416 breaker. Problems associated with the reactor trip breakers (or scram breakers) are one of the essential elements that should be mitigated to ensure the overall system reliability. This study provides a sound basis for developing procedures and criteria that are called for in the generic letter in the areas of equipment life estimates (Section 4.2, items 3 and 4), vendor interface (Section 2), maintenance activities (Section 4.2), and monitoring techniques (Section 4.2).

JAN 10 1991

Input to the Resolution of NRC Bulletin 88-01

Based on the results of the utility responses and the BNL testing, the pole shafts with substandard welds should be replaced or repaired to avoid any problems that could result from weld failures of the pole levers. The #3 lever weld experiences the worst stress condition under normal operation. Cracks in the #1 and #3 welds (Figure 4) start first and cause the breaker to be inoperable when they are allowed to grow to 25% of the weld length. Monitoring these two welds should be considered to avoid any problems stemming from the weld cracks.

Eric S. Beckjord, Director
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Enclosures: Figures 1-4

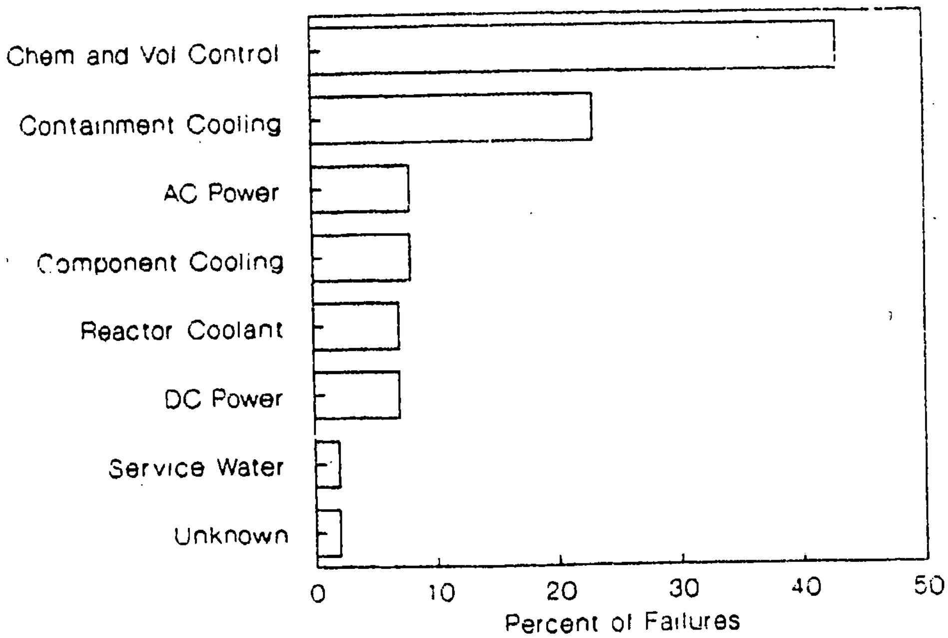
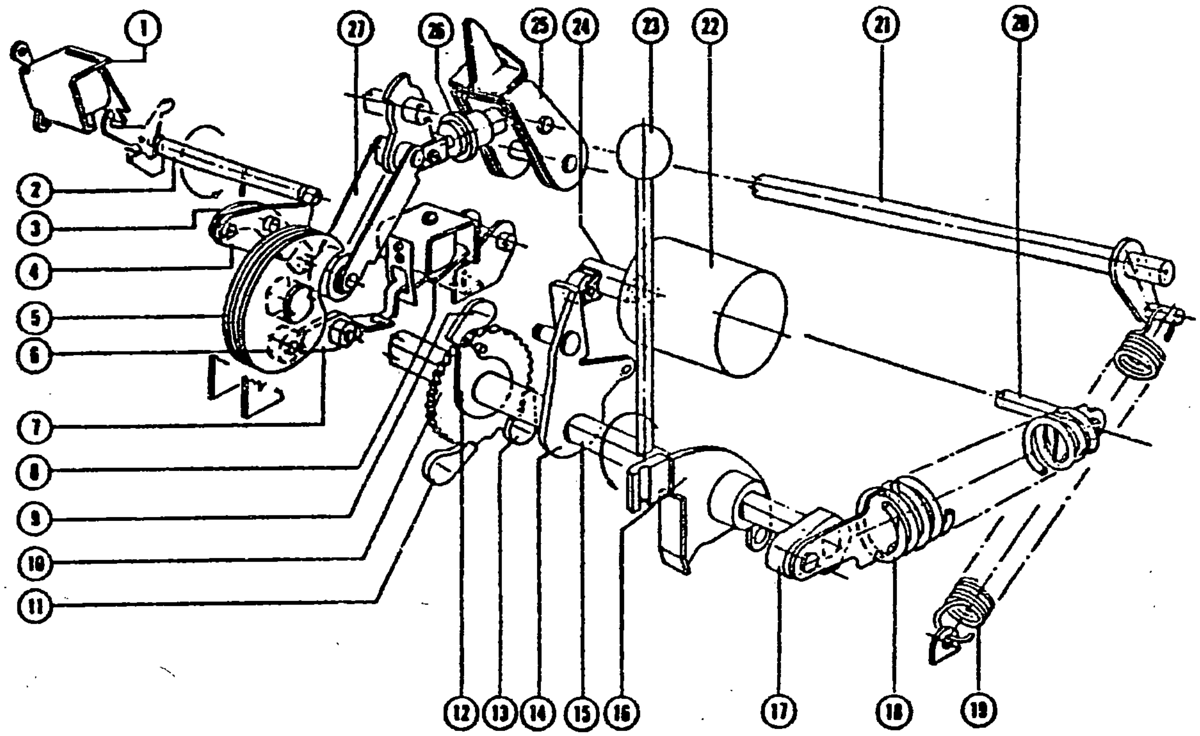


Figure 1. Systems affected



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. RATCHET 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. RESET 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

Figure 2. Arrangement of the principal parts of a completely power operated mechanism (the close spring is shown in the charged position)

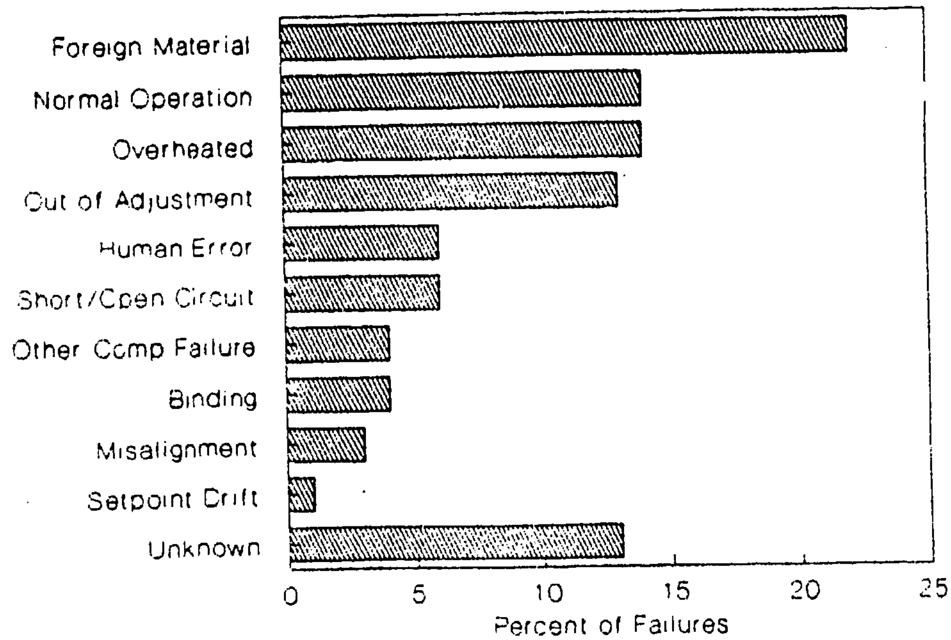


Figure 3. Failure cause

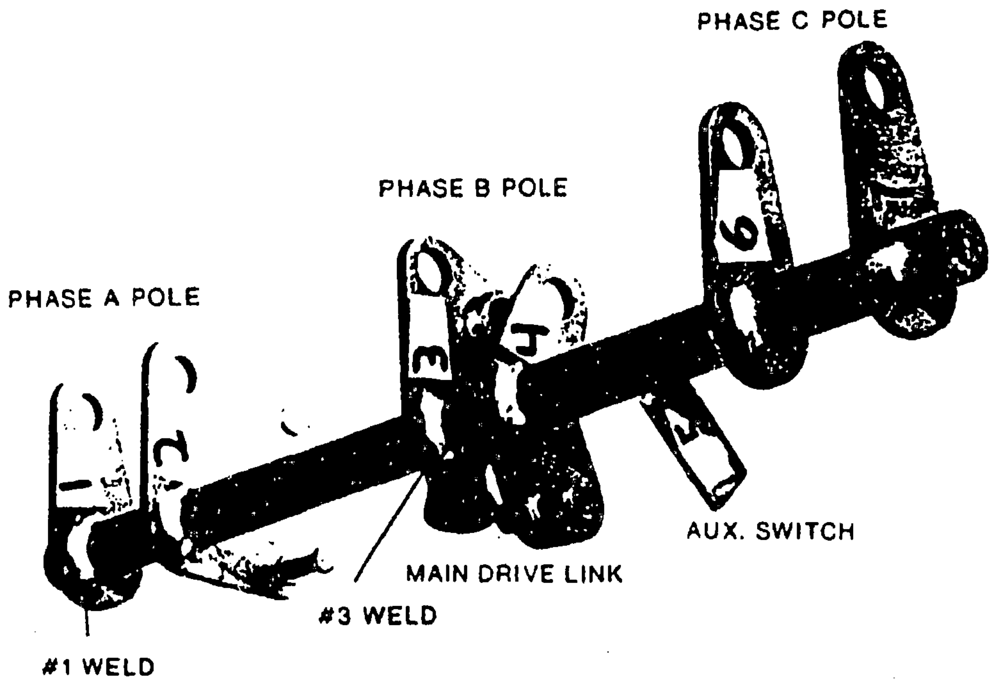


Figure 4. Pole Shaft with Seven Levers Welded on to it