21 SEP 1987

Docket Nos.: 50-369 328
and 50-370 317,318

MEMORANDUM FOR:

T. Murley*	J. Partlow	R. Capra
J. Sniezek*	F. Congel	W. Butler
F. Miraglia*	H. Miller	V. Nerses
R. Starostecki*	S. Black*	J. Stolz
S. Varga*	B. Boger*	E. Adensam
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L. Shao*	F. Schroeder	K. Jabbour
C. Rossi*	G. Holahan	A. Thadani
J. Richardson	W. Lanning	W. Troskoski

THRU: Kahtan N. Jabbour, Acting Director
Project Directorate II-3
Division of Reactor Projects - I/II

FROM: Darl S. Hood, Project Manager
Project Directorate II-3
Division of Reactor Projects - I/II

SUBJECT: NOTICE OF MEETING WITH WESTINGHOUSE REGARDING CLASS IE SWITCHGEAR MODELS DS-416, DSL-416, DS-420, DS-206 AND DSL-206

TIME & DATE: September 23, 1987
9:00 am - 4:30 pm

LOCATION: Air Rights Building
Conference Room AR 2242

PURPOSE: To discuss the technical basis for Westinghouse's recommended actions, criteria and conclusions in Enclosure 1 and related breaker failures due to inadequate welds of the pole shaft assembly at Calvert Cliffs 1 (Enclosure 2) and Sequoyah 2.

PARTICIPANTS: 1/

NRC	WESTINGHOUSE
J. Richardson	P. Morris
J. Stone	W. Bamford, et al.
D. Hood, et al.	

/S/

Darl S. Hood, Project Manager
Project Director II-3
Division of Reactor Projects I/II

cc: See next page
Enclosures:
(1) Westinghouse letter of September 11, 1986
(2) Calvert Cliffs 1 memo of September 18, 1986

1/ The meeting is open for interested members of the public to attend as observers pursuant to "Open Meeting and Statement of NRC Staff Policy," 43 Federal Register 28058, 6/28/78.

DSH	KNJ
PDII-3/DRPI/II	PDII-3/DRPI/II
DHood/rad	KJabbour
09/18/87	09/18/87

MEETING NOTICE DISTRIBUTION

Docket File
NRC PDR
L PDR
NSIC
PRC System
PD#II-3 Rdg
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W. Troskoski (MNBB 6113)
B. Kolostyak
G. Holahan
T. Murley
F. Miraglia
G. Lainas
S. Varga
EJordan
GPA/PA
VWilson
WLanning
JPartlow
ACRS (10)
OGC-Bethesda
Receptionist
(Building where mtg is being held)

NRC Participants
J. Richardson
J. Stone
D. Hood
S. McNeil
E. McKenna

bcc: Licensee/Applicant & Service List

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Duke Power Company

McGuire Nuclear Station

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The following information and recommendations are provided for your use, if you have Westinghouse Models DS-416, DSL-416, DS-420, DS-206 and DSL-206 switchgear installed in your plant in 1E service.

BACKGROUND

On July 2, 1987, it was reported that a DS-416 reactor trip breaker did not open on demand at McGuire Unit 2 during rod drop testing following a refueling outage. This malfunction was determined when plant personnel observed smoke in the vicinity of the reactor trip switchgear. Since the breaker had not opened on demand the shunt coil current was not interrupted resulting in a damaged coil. The breaker could not be tripped manually, but did trip when the manual charging handle was manipulated. During subsequent cycling on the test bench, the breaker jammed again. An inspection was conducted at the site jointly by Westinghouse, Duke Power and the NRC, during which the breaker was cycled for 37-38 times. It operated successfully each time. Visual inspection noted wear (nearly 3000 cycles of operation) and separation of the weld which attached the center pole lever to the pole shaft. The NRC issued Information Notice 87-35 on July 30, 1987 reporting this event.

INVESTIGATION RESULTS

The breaker was subsequently shipped to Westinghouse where a detailed investigation following the guidelines jointly developed by Duke Power, the NRC and Westinghouse. The breaker malfunctioned after some 130 operations.

After observing the condition it was found that the jamming could be repeated by manually forcing the close cam and main drive link into a unique constrained position. The breaker did not assume this unique position on its own through about thirty subsequent operations.

The scenario at McGuire can be explained as follows: The roller attached to the main drive link normally rests on the outer close cam laminations. The broken weld permitted lateral movement of the main drive link which moved the roller close to its tolerance limits. In the jammed position, the roller had slipped 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 stacking of part tolerances played a part in the jamming of the breaker, it was also concluded that the breaker would not jam unless a broken weld was present to permit the twisting action that allowed the roller to wedge.

Subsequent evaluation of the broken weld revealed that the weld had about 25% fusion. The mechanism producing the weld separation was low cycle fatigue with the fatigue striations indicating separation after about 2,500 cycles (consistent with Duke's estimate of operating cycles). A conservatively calculated load on the weld was determined to be 10,000 psi. The designed weld strength is 35,000 psi giving a "safety factor" of 3.5.

POTENTIAL SAFETY IMPACT

Westinghouse considers this malfunction of the DS-416 Reactor Trip Breaker to be a random occurrence. DS-416 breakers have operated through many thousands of cycles without any malfunction similar to that reported at McGuire. Despite the quality of the weld in the McGuire breaker, it performed for about 3,000 cycles confirming that the weld as designed is conservative. It was also evident that while it is necessary to have a weld separation to initiate the occurrence it also requires other part tolerances to be near maximum.

For these reasons, Westinghouse does not recommend that any immediate actions be taken. This, however, does not preclude recommended actions in line with normal surveillance and maintenance practices.

RECOMMENDED ACTIONS

Primary attention has been focused on the weld separation with contributing factors from tolerance build-up. Because Westinghouse performed a random inspection of the pole shafts (welds) during manufacture and because one instance of the roller rubbing the side frame surfaced during the investigation Westinghouse recommends the following actions for 1E applications of DS-416 switchgear:

A. Short Term Inspection (Next Surveillance)

Weld Inspection (On Three Pole Lever Welds)

This inspection may be performed with the breaker disconnected and racked out fully on the cell rails, or on a bench, as is suitable to the user. Minimum tools are - small mirror, fillet gauge (1/8" and 3/16"), flash light, screwdriver, socket wrench and long handled pliers.

Procedure

1. Trip the breaker if energized and closed. Rack it out on cell rails fully extended, or transfer to bench.

2. Remove front panel.

3. Disconnect motor leads, and the link for the auxiliary switches.

4. Remove the top cover towards the front of the breaker, making sure that wires in the harness are not damaged.

5. Inspect the weld(s) visually to the criteria given below.

6. Reinstall all items removed or disconnected.

Criteria and Actions

1. Weld Separation

   Action: If separated welds are found, remove from service as main or bypass breaker.

2. Cracked Weld

   For checking the presence of weld cracking, exclude the ends which may show evidence of cold start.

   Action: If cracks are found, use only as bypass breaker until weld condition can be corrected.

3. Size and Length of Weld

Exclusive of the ends of the weld, which may show evidence of cold start, the weld should have at least 3/16" fillet for 90° continuously around the pole shaft. If the fillet is under 3/16", then the weld must be at least 1/8" fillet for 120° continuously around the pole shaft. Either size weld provides a "safety factor" in excess of 1.5.

Action: If dimensions are not met, use only as bypass breaker until weld condition can be corrected.

B. Long Term Inspection (Next Refueling)

1. Examine Welds for Separation, Cracks or Size

Inspect remainder of pole shaft welds with the exception of stop levers which do not perform a safety function. Replace pole shaft if necessary.

2. Alignment of Breaker Mechanism

Refer to Figure 1. This tolerance check should be performed on the bench with the closing springs disconnected from the cam-shaft (common shaft going through the close cam).

Procedure

1. Remove front panel of the breaker.
2. Disconnect the closing springs from the cam shaft. The other end may be left undisturbed.
3. De-energize control powers to the breakers, if wired to power supplies. Breakers should be open with springs discharged.
4. Restrain the UVTA with a wire loop so that the breaker is not in a trip-free mode.
5. Simulate manual charge of the closing springs to the charged position, to turn the close cam to the "Ready to Close" position.

6. With pressure applied to roller as indicated in Figure 1, slowly turn the closing cam manually by the spring charging handle. (Note: To release the cam to turn, depress both manual trip and close buttons simultaneously.) Continue to turn the cam until the breaker contacts reach the closed position.

   At this time, the maximum lateral play of the roller is in effect.

7. Through the front of the breaker, sight the close cam, the roller and the side frames. Using a flashlight, check to see that -

   a. roller is making contact with the two outer laminates of the close cam. It is not required to be centrally placed.

   b. there is visible gap between the side frame and the roller side at each end of the mechanism.

   If either of the two checks are not satisfactory, contact Westinghouse.

8. Reinstall all components removed.

Other Switchgear Models

Other switchgear models which utilize the identical pole shaft and mechanism should also be inspected.

1. DSL-416 and DS-420

   Inspection schedule should be identical to that outlined above for DS-416.

2. DS-206 and DSL-206

   Since the stresses on these welds are considerably less than those on the DS-416 application, (resulting in a much larger "safety factor"), it is recommended that all the above inspections be accomplished at the utilities' convenience in a time frame not to exceed the next refueling outage.

CONCLUSIONS

Westinghouse believes that the above actions are prudent and when accomplished on a one-time basis will provide assurance that a similar circumstance will not be repeated.

Sincerely,

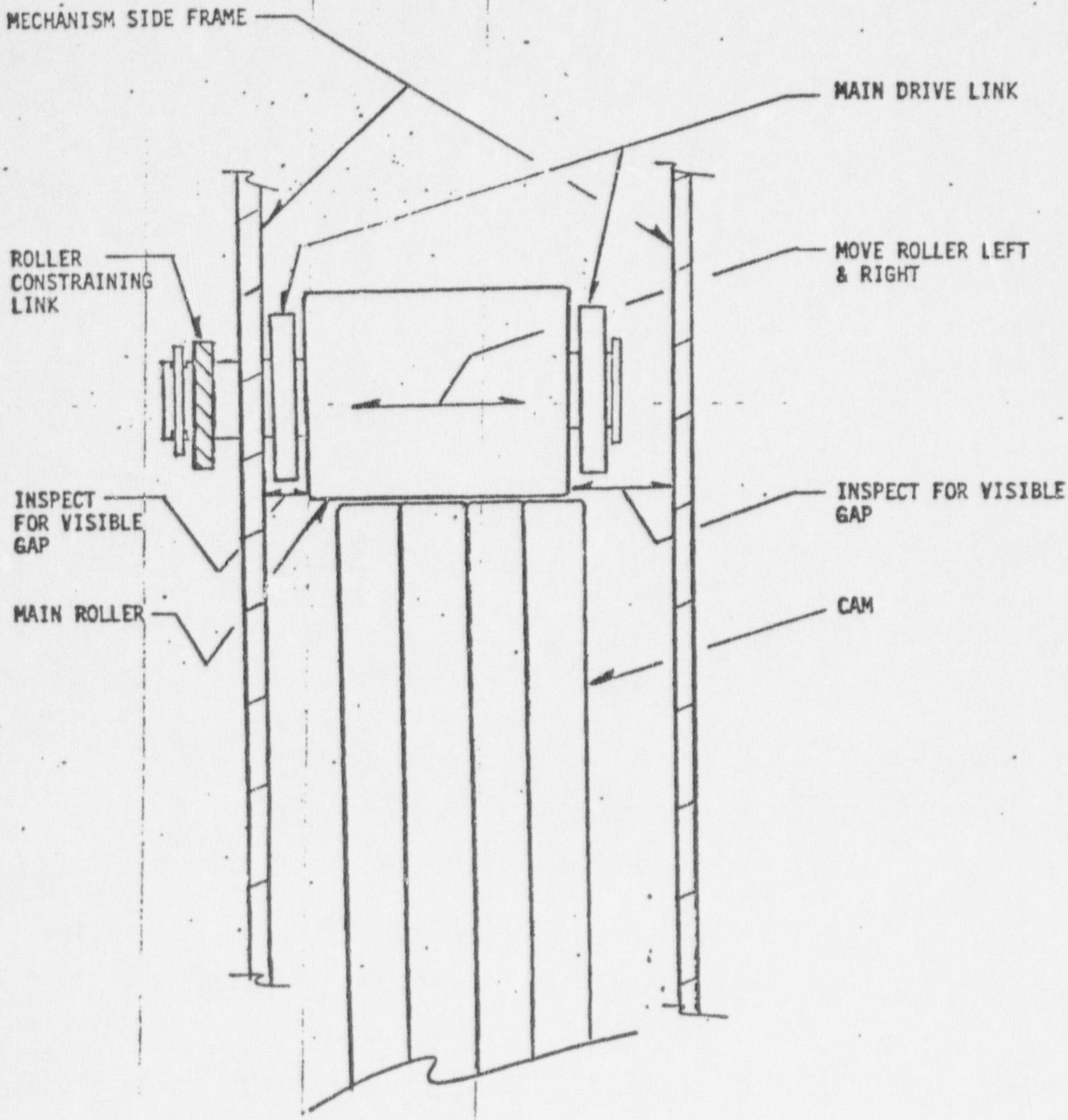
H. C. Walls, Manager
Mid-America Region
Projects Department

Attachment - Figure 1
HT/3277G

cc: G. J. Pliml
F. G. Lentine
E. J. Fuerst
J. A. Usem W

T. A. Rieck
J. A. Johnson W
D. L. Farrar
J. Marianyi WOG Rep.

FIGURE 1



FRONT VIEW

POWER OPERATED (STORED ENERGY) MECHANISM

ENCLOSURE 2

Calvert Cliffs

September 18, 1986

To: J. P. McVicker

From: D. A. Wright

Subject: CCNPP 480 Volt Breaker No. 52-1108 - NCR 3894

During routine maintenance of the subject breaker, it was discovered that the weldment connecting the center pole lever arm to the pole shaft was broken. The pole shaft with the broken weldment and a pole shaft removed from another breaker were sent to the Materials Engineering and Analysis Unit (ME&AU) for evaluation.

A visual examination of the failed breaker indicates that the failure occurred on Arm No. 3 shown in Figure No. 1. At higher magnification, shown in Figure No. 2, it is observed that the fillet weld separated from the lever arm at all but a small area at the start of the weld. The fillet weld remained attached to the pole shaft side along its entire length.

Examination of the separated surface reveals that approximately 70 percent of the weld had not fused to the lever arm. These unfused areas have a flat, smooth and relatively featureless surface. The remaining 30 percent represents the areas that fractured during operation of the breaker. Macroscopic examination of the fractured areas reveals a rough woody texture characteristic of an overload fracture in a weld. All fractured areas have a similar appearance and there is no evidence of beach marks indicative of a fatigue fracture. Therefore, we assume that the fracture of the fused areas was the result of overload. Since the cyclic operating loads of this breaker are assumed to be consistent the failure most probably occurred during the first cycle(s) of operation. The failed lever arm was connected to the anti-rotational lever arm beside it, therefore, the load was transferred to this lever arm after the failure and the breaker continued to operate.

A measurement of the fillet legs indicates that the leg on the pole shaft side was 0.30 inch and the leg on the lever arm side was 0.10 inch. This mismatch of leg sizes of 3 to 1 and lack of fusion on the lever arm side indicates an improper welding technique in manufacture. We suspect from the weld morphology and spatter that these arms were welded to the pole shaft in production using Gas Metal Arc Welding (GMAW) process. It appears that the welder did not properly position the electrode in the joint. The electrode was positioned more toward the pole shaft resulting in leg mismatch and lack of fusion on the lever arm side (see Figure No. 3).

A nondestructive examination (NDE) was performed on all pole shaft to lever arm welds for both pole shaft assemblies sent to ME&AU. The NDE consisted of visual examination and wet fluorescent magnetic particle examination. Results of these examinations are shown in NDE Report No. 85-1445 included as Attachment No. 1, and are summarized as follows:

1. Visual examination indicates that in general the starts of the welds are not fused properly to the lever arm side.

2. Visual examination also indicates that in general a fillet leg mismatch exists.

3. Magnetic particle examination indicates that with the exception of the start, the welds appear to be fused to the lever arm side.

The condition of the unfailed welds were probably adequate for intended service, however, flaws present including the failed weld indicates that there was inadequate control of welding during production.

To further investigate the problem of welder technique a section was removed from the center of all unfailed welds. The sections were ground to a 240 grit finish and the welds were macroetched with ammonium persulfate to reveal the depth of fusion. Depth of fusion measurements were made for all sections and the results recorded in Table No. 1. A photograph representative of welds examined is shown in Figure No. 4. These results reveal that the depth of fusion on the pole shaft was significantly greater than the depth of fusion on the lever arm. It is important to note that the depth of fusion does not determine the adequacy of the joint. If complete fusion is present the joint is adequate. The results indicate that the welder's technique was poor, but in most cases there was adequate fusion outside of the start of the weld.

We conclude from the analysis that the failure was caused by lack of fusion of the weld as a result of improper welding technique. Inspection of the welds on both assemblies sent to ME&AU indicates a potential exists that more failures may have occurred or will occur on the pole shaft assemblies now in service. ME&AU recommends that provisions be made to nondestructively examine and/or repair all breakers that are now operating with similar pole shaft assemblies. We believe the most efficient fix would be to fillet weld the backside of the joint. For more details on weld repair contact R. E. Cantrell on 787-5505.

D. A. Wright
Materials Engineer

Approved
R. B. Pond, Jr.
Principal Metallurgist

DAW/paw

Attachments

cc: C. H. Cruse
J. A. Crunkleton
G. R. Fuhrman
W. J. Lippold
K. A. Pickering
T. L. Sydnor

File No.: 86-30-038

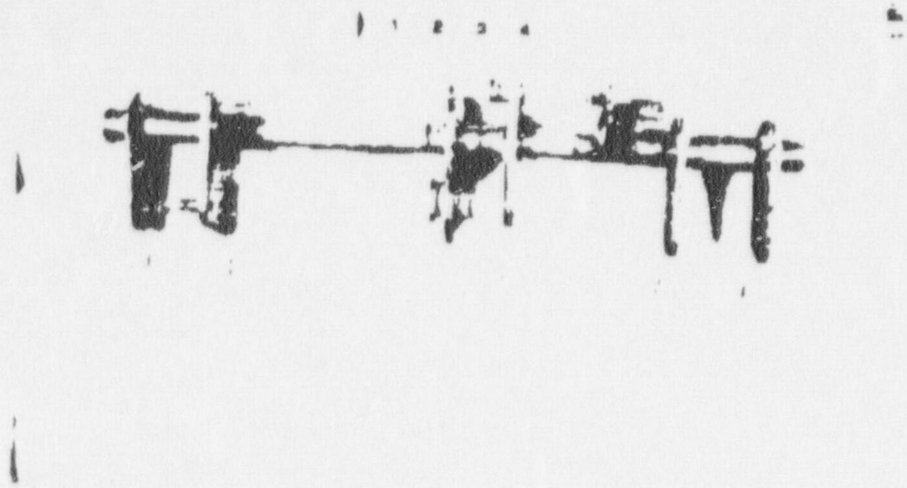


Figure No. 1 Photograph of Pole Shaft Assembly

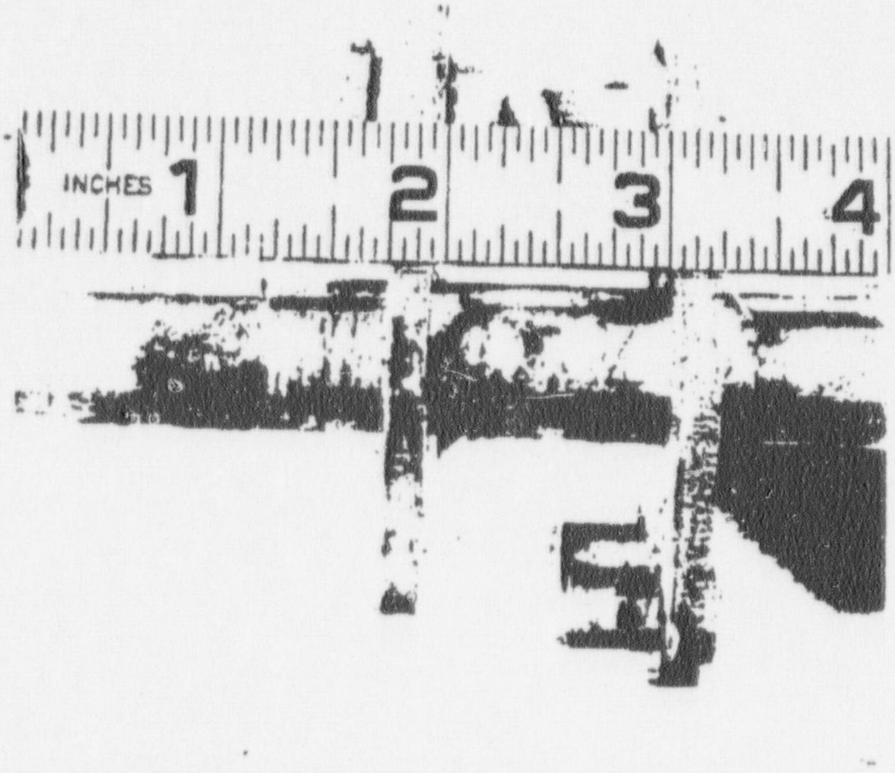


Figure No. 2 Higher Magnification of Arm No. 3 Showing Separation of Weld from the Lever Arm

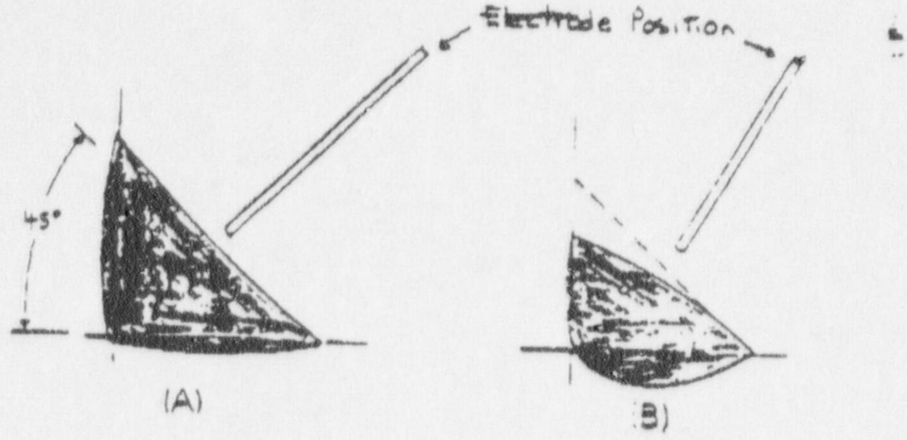


Figure No. 3 Fillet Weld Profiles Showing Acceptable (A) and Unacceptable (B) Profiles

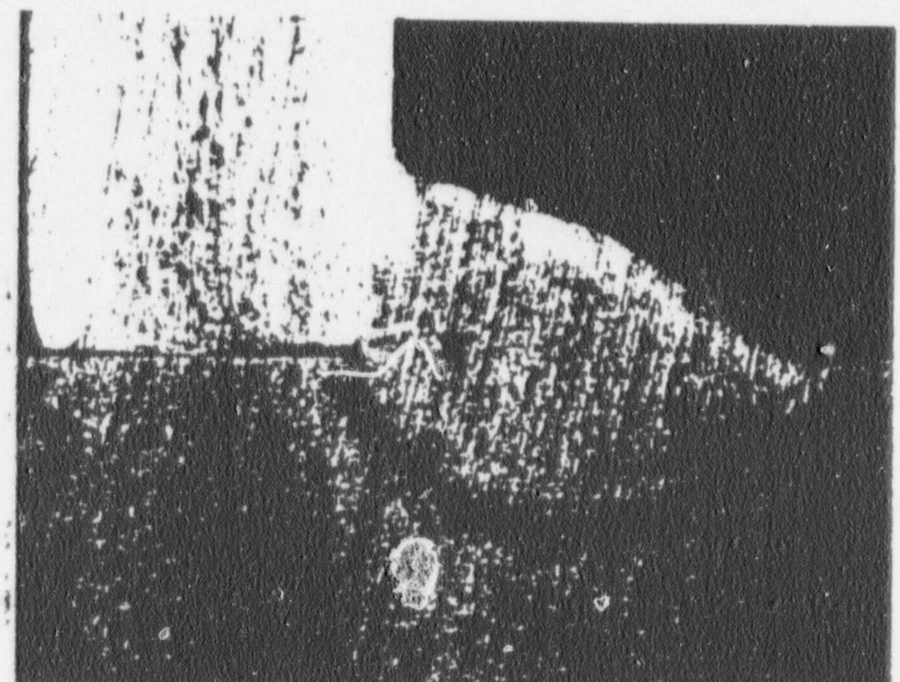


Figure No. 4 A Fillet Weld Profile Representative of the Macroetched Cross Sections

Attachment No. 1

No. 851445

NONDESTRUCTIVE TESTING REPORT

M. R. No. 5870-2003 / NCR#3894

Q. C. Call No. 86-3780

W. A. T. No. NA

System No. 2C-1-030-NDCG1

Plant Calvert Cliffs Unit 1 Date September 5, 1986

Component Breaker Pole Shafts

Component Location FSRC Materials Eng. and Analysis Lab MT Room

Area Examined Pole Shaft Attachments Fillet welds and Approx. 1 inch on either side of Fillet

Material Ferromagnetic Mat'l Temp. 75 F Procedure No. 5.102 Rev. 3

Surface Condition Wire Brushed Clean Grounded

☐ Visual (V.T.) Data Sheet No.

☐ Ultrasonics (U.T.) Data Sheet No. Calibration Record No.

☐ Eddy Current (E.T.) Data Sheet No. Calibration Record No.

☐ Radiography (R.T.) Data Sheet No. Technique Sheet No.

☑ Magnetic Particles (M.T.) Data Sheet No. 85-1445 A,B Standard No. Pie Gauge

Method: ☑ Continuous ☐ Residual / Current: ☑ AC ☐ DC ☐ HWDC

Equipment: ☑ Coil ☐ Yoke ☐ Prods ☐ Central Conductor ☑ Head Shot

☐ Perm. Magnet

Particles: ☐ Dry ☑ Wet / ☐ Visible ☑ Fluorescent / Color: Yellow-Green

☐ Liquid Penetrant (P.T.) Data Sheet No.

Penetrant Type: ☐ Solvent Removable ☐ Water Washable ☐ Post Emulsified

☐ Visible ☐ Fluorescent / Penetrant – Developer Brand Name:

Developer Type: ☐ Dry ☐ Wet ☐ Nonaqueous

Cleaner – Evaporation Time

Penetrant – Dwell Time

Development Time

	BATCH NO.
Penetrant	
Developer	
Cleaner	

No. Items Examined: 11 welds No. Items Accepted: 1 weld No. Items Rejected: 10 welds.

No. Items with Recordable Indications 0

Remarks: See Attached Data Sheets

Examiner [signature] Level II Report Reviewer [signature] Date 9/8/86

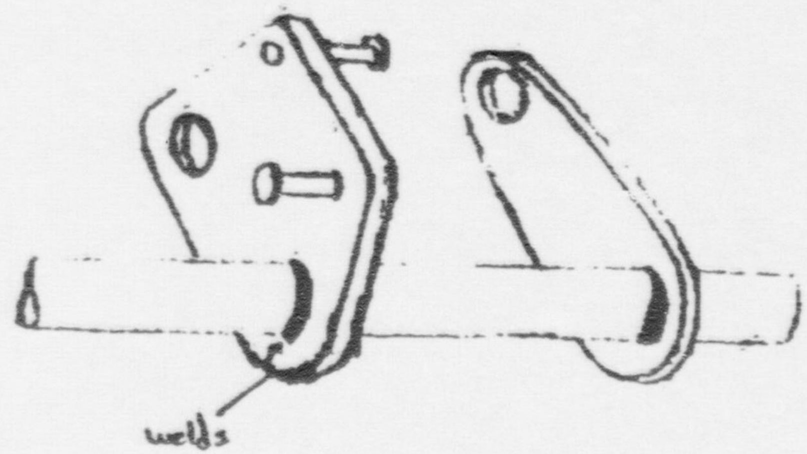
Report and Attachment Received by [signature] Date 9/5/86

CC-8001 Rev. 10/82

Attachment No. 1

NE# 5B70-2003
QC# 86-3780

Electrical Pole Shaft



Attachment No. 1

No. 85-1445-6

NDE DATA SHEET

M. R. No. 5B70-2003

NDE Report No. 85-1445-

Procedure No. 5.102

Rev. 3

Breaker Pole Shafts

Visual examination performed prior to magnetic particles examination. ...ck of fusion was noted at the start of eight of the ten welds ...amined.

Each pole shaft has six welds. they are fillets approx. 1/4 inch in size and are located on one side of each attachment.

There is undercut at the toe of the welds. The undercut was removed by grinding to reveal no fusion problem beyond the start of the weld. In order to perform a valid examination the welds must be prepared by grinding and the weld starting points must be dressed.

Attachment No. 1

No. 85-1445-B

NDE DATA SHEET

M. R. No. 5B70-2003 Procedure No. 5.102

NDE Report No. 85-1445 Rev. 3

Breaker Pole Shaft

Visual Examination

1). Lack of fusion was noted visually in eight of ten welds examined. This Lack of fusion is at the start of each of the eight welds.

2). Cracks were detected in two welds, at the start of each weld

Magnetic Particles

1). Magnetic Particles examination was performed before any weld preparation. It was noted that a indication was detected at the toe of the welds. This is undercut.

2). In order to determine if there was a valid indication in the undercut area the welds had to be ground.

3). After grinding another Mag. particle examination was performed with no reportable indication noted in that area.

4). The Lack of fusion noted at the weld starts was also removed from several of the attachments and mag. particle examined. Cracks were detected.

Conclusion

1). The starts and undercut need to be removed from and welds that will be examined in the future.

2). Where Lack of fusion at the starts are found visually until the weld can be prepared for mag particle Testing it will be considered rejectable.

[signature] 9-8-86
Examiner Date

CC-0810 Rev. 7/77

Table No. 1 Depth of Fusion Measurements

Arm	Depth of Fusion Pole Side (mm)	Depth of Fusion Lever Arm Side (mm)
1	2.40	0.1
2	2.0	0.5
3	2.25	1.0
4	2.25	1.0
5	2.0	0.3
6	2.0	1.0
1*	1.5	0.3
2*	1.5	0.2
4*	2.25	0.4
5*	1.0	0.2
6*	1.5	0.4