ROOT CAUSE EVALUATION OF 4KV BREAKER SECONDARY CONTACT BLOCK FAILURE RCE 95-010

ATTACHMENT #1

ROOT CAUSE EVALUATION OF 4KV BREAKER SECONDARY CONTACT BLOCK FAILURE RCE 95-010

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CLARIFICATION OF PURPOSE

This report is intended to be a self-critical use of hindsight to identify all problems and the sources of those problems. The root causes identified in this report were discovered and analyzed using all information and results available at the time it was written. All such information was, of course, not available during the timeframe in which relevant actions were taken and decisions were made.

The purpose of using such a self-critical approach is to provide the most comprehensive analysis possible for identifying "lessons learned" as a basis for improving future performance. The use of an open, documented self-critical analysis program is imperative in the nuclear power industry and cannot be compromised or confused with a management prudency assessment.

Thus, this report does not attempt to make a balanced judgement of the prudency or reasonableness of any of the actions or decisions that were taken by vendors, utility management, or individual personnel based on the information that was known or available to them at the time.

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EXECUTIVE SUMMARY

At the return to service of Component Cooling Water Pump 3P026, on June 13, 1995, the control room had no indication from the breaker when the DC was turned on. The subsequent investigation determined that an electrical contact finger had broken in the stationary secondary contact block for the 4KV breaker in 3A0605.

Laboratory analysis of the failed contact block and three other contact blocks of the same vintage revealed that the root cause of failure was the use of hardened, brittle brass material in the manufacturing of the contact fingers. Cracks and work hardening were induced in the finger bends during fabrication. Mechanical cycling during removal and insertion of the breaker further hardened the material eventually causing an overload fracture.

The corrective actions for this event are identified as follows:

-Provide an operability assessment for the affected Safety Related trains.

-Issue NCR's against each Class 1E 4KV Switchgear with operability requiring checking of proper functioning after racking in the breaker.

-Ordered replacement Class 1E contact blocks from ABB with verification that the strips meet the current specification which is a softer material and not susceptible to cracking.

-Replace all Class 1E Unit 3 Train A contact blocks during the Unit 3 Cycle 8 outage in July/August 1995 and evaluate the removed contact blocks for cracking problems.

-Replace Class 1E Unit 2 Train A and B and Unit 3 Train B contact blocks during scheduled online equipment outages with full replacement complete no later then the end of the U2/3, Cycle 9 outage.

-Sent failed contact block to ABB for Part 21 evaluation.

BACKGROUND

At the return to service of Component Cooling Water Pump 3P026, on June 13, 1995, the control room had no indication from the breaker when the DC was turned on. The subsequent investigation determined that a finger in the stationary secondary contact assembly (referred hereafter as the "contact block") for the 4KV breaker in 3A0605 had broken. The contact block was removed and delivered to the Root Cause Group for failure analysis and Root Cause Evaluation. Reference NCR 95060044 and MO 95060799001. The following NCR's were written to address the operability of the Class 1E 4KV Switchgear:

NCR 95060065	Bus 2A04
NCR 95060069	Bus 2A06
NCR 95060070	Bus 3A04
NCR 95060071	Bus 3A06

The Busses are considered operable based on a seismic review, verification of contact connection when the breaker is racked in, and the fact that the fracturing of the contact block fingers only occurs when racking in/out the breakers. A detailed discussion is in the Operability Assessment section of this report.

Three (3) additional contact blocks were supplied to support the analysis. The first sample was a contact block from spare position 2A0602, removed under MO 95060832. The second sample was an unused warehouse stock unit. The third sample was removed from the Salt Water Cooling Pump 2P114, breaker location 2A0611, under MO 95061249. The 2P114 contact block was selected because there had been a relatively large number of rack in/out cycles on the breaker. All three samples are of the same manufacturing vintage as the failed unit.

EVIDENCE COLLECTION

The contact blocks were originally manufactured for ITE Metal-Clad 4KV switchgear by Brown Boveri as part number 834838-T1. The material Code for the block is 026-26208. The current vendor, ABB Power T&D Company, was contacted and they have no history of problems with the contact blocks. The specification sheet and Critical Characteristic Analysis for the contact block fingers was obtained for correlation of the laboratory analysis data. The specification sheets are in the attachments to this report.

A review of maintenance history revealed only two (2) failures in 155 breakers in the past 15 years. This includes the current failure in 3A0605 and a failure in 1990 in 3A0606 documented in NCR 90090043. The 1990 failure was considered an isolated incident.

An NPRDS search revealed no records of failed contacts on ABB breakers.

Nine utilities with ABB 4KV breakers were contacted and they have not experienced any problems with contact block finger breakage with the exception of a contact finger failure at Waterford which was caused by misalignment of the breaker when racking it in.

LABORATORY ANALYSIS AND TESTING

The contact fingers were arbitrarily numbered 1 through 12 to facilitate the analysis. These contact numbers correspond to the electrical connection numbering scheme in the following way:

Analysis Numbering	Electrical Numbering
1	5
2	7
3	13
4	14
5	3
6	1
7	6
8	9
9	10
10	15
11	4
12	2

3A0605 Contact Block

Preliminary examination of the 3A0605 contact block revealed that one of the contact fingers (#4) was fractured at the 90 degree bend at the inside end of the long section. See Figures 1, 2 and 3. The four bends in the contact fingers are designated A through D. See Figure 4. The fracture and cracks on this contact block are at bend C. Cracks were present in two other contact fingers (#9 & #10) at the same location. See Figures 5 and 6.

Scanning Electron Microscope examination (SEM) of the fracture face on contact 4 revealed a fresh intergranular fracture which is a sign of embrittled material. See Figure 10. Energy Dispersive Spectroscopy (EDS) of the contact finger surface revealed that it was silver plated. See Figure 11. EDS of the base material revealed that it was 70% copper and 30% zinc which is a 70/30 brass. See figures 12 and 13. No contamination was present on or near the fracture surface.

The fractured area of contact 4 was mounted for metallurgical cross sectioning and the sample was cross sectioned from the side into the base metal. Microhardness testing was performed on the base metal at bend B and in the straight section between bend B and the fracture area at bend C. The Rockwell Hardness, b scale, at the bend was 91. The Rockwell Hardness, b scale, in the straight area was 71. This data indicates that the bend area is hardened and embrittled in the bend area. All of the Hardness testing data is in an Attachment to this report.

Optical microscope examination of the cross sectioned fracture area on contact 4 revealed a grain structure indicative of Extra Hard temper. See Figure 7. Intergranular cracks extended into the brass from the fracture face. The fracture face was also along grain boundaries. Optical microscopy of the cross section at bend B revealed a small intergranular crack in the inner diameter of the bend. The grain structure in the bend area was characteristic of Extra Hard temper. See Figures 8 and 9. The grain structure in the straight area, away from the bend, was characteristic of Hard temper.

A mechanical fatigue test was performed on the 3A0605 Contactor Block to determine the number of insertion and removals were required to fracture the cracked fingers. A fixture was fabricated with the mating contacts to the same dimensions as on the breaker. Finger 12 fractured on the thirty-second insertion in the fixture. The finger fractured across the preexistent crack at bend C.

Optical Emission Spectrometry was performed on samples from all 12 contact fingers. The analysis confirmed that the base material was 70/30 brass in all cases. The Current ABB specification for the contact material is Alloy 230 which is an 85% copper, 15% zinc brass which is less brittle than Alloy 260, 70% copper, 30% zinc. The material specification was changed to alloy 230 in 1982. Information from the vendor on the material specification prior to 1982 was not available.

2A0602 Spare Contact Block

Optical microscope inspection of the 2A0602 contact block revealed that nine of the twelve contact fingers had cracks. The cracks were mostly on the outer diameter of bend B and D. The inner diameter of the bends could not be inspected until the fingers were removed.

The contact block was disassembled by mechanical means. First, an attempt was made to open bend D but four of the five fingers cracked at the bend during this process. It is significant that contact finger 10 was removed by opening the D bend and the finger did not crack. It was decided that the most effective way to recover the fingers was to cut them in half along the straight section. This procedure keeps the bend areas intact for inspection and analysis.

Contact 10 was subjected to several cycles of reverse bending at an original bend area and no cracks developed. The finger was cross sectioned. Examination of the microstructure revealed that the grain structure in the straight area was characteristic of Half Hard temper and the grain structure at the bend was characteristic of a less brittle material and consequently less work hardening. See Figures 14 and 15. Metallurgical examination of other fingers revealed the same Extra Hard temper condition as on the failed contact block.

Microhardness testing on contact 7 revealed a Rockwell hardness, b scale, of 72 and 94 on the straight and bent areas, respectively. Microhardness testing on contact 10 revealed a Rockwell hardness, b scale, of 76 and 90 on the straight and bent areas, respectively. Note that the Hardness numbers are similar for both contacts while contact 10 is significantly more ductile as indicated in the microstructure. Microhardness is not a sensitive indicator for slight variations in material temper.

Warehouse Contact Block

Optical microscope examination of the unused contact block obtained from the warehouse revealed cracks at the outer diameter radius of the B bend on all the contact fingers. The contact fingers were removed from the block by sawing the fingers in half at the center of the straight section. Inspection of the inner diameter of the bends revealed cracks in all the samples at the B bend.

Contacts 7 and 8 were examined in the SEM to document the surface cracks at bend B. See Figures 16 and 17. Both contacts were cross sectioned to determine the depth of the cracks and the microstructure. The inner diameter crack on contact 7 was deep, approximately one third of the thickness of the contact. See Figures 18 and 19. The grain structure at the bend was characteristic of Extra Hard temper and the grain structure in the straight area is characteristic of Hard temper. The cracks on contact 8 were shallower than those on contact 7. See Figures 20 and 21. The grain structure at the bend was characteristic of Extra Hard temper and the grain structure in the straight area is characteristic of Hard temper.

Microhardness testing on three contacts revealed the following Rockwell Hardness, b scale, data:

Contact	straight area	bend area
4	83	90
7	78.5	91.5
8	76	91.5

The material condition of the unused block is similar to that of the failure and the spare block. The unused block from the warehouse is to be of the same vintage as the blocks installed in the plant.

2A0611 Contact Block

The contact block was removed from the plant because it was installed on Salt Water Cooling Pump P114 and is considered to have a large number of insertion and removal cycles. See Figures 22 and 23.

Optical examination of the contact fingers revealed cracks on the outer diameter of the B Bend on contacts 2, 5, 6 and 11. See Figures 24 through 27.

The contact block was cycled in the test fixture 500 times and the cracks did not grow perceptibly. The test cycling was so extensive that the silver plating was scraped off the brass fingers. This test demonstrated that cracks in the fingers do not necessarily grow to fracture in the short term.

New Contact Finger Material

In the process of reordering contact blocks for replacement of all unit 3 Train A applications during the U3C8 outage, a sample of twenty contact finger bars were obtained from ABB. Elemental analysis of the bars revealed that they were Alloy 230, 85% copper and 15% zinc in accordance with the current ABB specification. The Rockwell b scale hardness was found to be in the range of 40-60. According to the ASTM B36 Standard, the material is in the Quarter Hard temper range which is less likely to crack in the contact block application. Microstructural analysis revealed that none of the fingers had cracks in the bend area and the grain structure was characteristic of Quarter Hard in the straight area and Half Hard in the bend area. See Figures 28 through 31. Based on this analysis, production of the replacement contact blocks was authorized.

ROOT CAUSE IDENTIFICATION

The root cause of the fracturing of the finger on the 3A0605 contact block was improper material used in the finger construction. The 70/30 brass used in the older (Pre-1982) contact blocks is too brittle for the application. Examination of the other contact blocks supports the conclusion that cracks originate at the bends during fabrication due to work hardening of the brass. The variation in material hardness accounts for the degree of cracking and susceptibility to fracture during the stress of removal and insertion of the associated 4KV breakers.

IDENTIFICATION OF OTHER SUSCEPTIBLE ITEMS

This type of connector is associated with 64 Class 1E 4KV breakers in 4 buses and 91 Non-1E breakers in 8 buses in Units 2 and 3. All of the affected breakers have been identified by Station Technical.

OPERATING EXPERIENCE REVIEW

As discussed in the Evidence Collection section of the report there were no reports of failed contacts in ABB breakers in the NPRDS data base.

The manufacturer, ABB Power T&D Company, was contacted and they have no records or recollection of fractured contact fingers.

Nine power plants, with the same kind of breakers, were contacted by Station Technical. One contact failure event occurred at Waterford due to breaker misalignment during rack in. Several other plants reported breaking of the plastic frame due to breaker misalignment during racking. The plants contacted were Waterford, Vogtle, Catawba, Crystal River, Limerick, Zion, Prairie Island, Hope Creek and Beaver Valley.

10CFR21 EVALUATION

ABB Power T&D Company of Sanford, Florida is currently analyzing contact block finger material from SONGS and several other sources. As soon as the testing and data gathering are complete, ABB currently intends to issue a 10CFR Part 21 Report covering the broken and cracked contact fingers. If ABB does not issue a 10CFR Part 21 Report, than ISEG will evaluate the need to write a 1CFR Part 21 Report on the defective contact blocks discovered at SONGS.

OPERABILITY ASSESSMENT

Seismic Considerations

The control fingers are not stressed by a seismic event because the control assembly is supported firmly by the circuit breaker and cubicle. The circuit breaker is held in place firmly by its attachment to the bus and cubicle. Therefore, the control fingers do not support any seismic loads and fractures of the control fingers would not be caused by a seismic event.

All 4kv breakers contain these stationary secondary contact blocks which provide breaker control and indication.

The breakers are operable for the following reasons and under the following conditions:

Operational Considerations

The secondary contact control fingers provide power for four different functions. Control fingers 2 and 5 provide for the charging of the breaker control spring. When the breaker is racked into the operate position from the disconnected position, and the DC control power is applied, the breaker control spring will be charged. This action is quite noisy and readily apparent. If the breaker control spring has not been discharged, the charging spring motor will not be heard upon closing of the DC control power. Spring charging can be verified after the first breaker operation by either hearing the charging spring motor operate (per above) or by viewing the "SPRING CHARGED CAUTION" tag through the breaker viewing port in the lower right hand corner of the breaker cubicle door. Caution tag is located at either bottom right or left center of the circuit breakers front.

Control fingers 13 and 14 provide the green, circuit open indication. This indication is received at the local cubicle door and in the control room when the DC is turned on and the breaker open.

Control fingers 6 and 7 cause the breaker x y scheme to operate closing the breaker.

Control fingers 9 and 10 (for all breakers except the Diesel Generator breakers) provide the trip path and also provide the red indicating light when the breaker is closed. Any time the breaker is closed the red light performs the function of monitoring the breaker trip path. If the red lights are on (when the breaker is closed) the trip path is operable.

For the diesel generator breakers, the red light does not monitor the trip coil. If the red light is on (with the breaker closed) then contact fingers 14 (also used in green indicating lights) and 15 are functioning properly. And, if the Diesel Generator circuit breaker trips by operator control action at the end of its run, then secondary control fingers 9 and 10 are operating properly.

Whenever a circuit breaker is returned to service, operations as a normal routine, functions it to show operability of the equipment.

To determine that all 1E breakers presently racked into the operating position have their control springs charged, station technical inspected all breakers (through the sliding cubicle door) on 2A04, 2A06, 3A04 and 3A06 at approximately 1100 hours on 6/21/95. Each breaker racked into the energized position had its control spring charged.

Restricted Operability

1. Any time a breaker is racked out of the connected (racked in) position, to be considered operable after having been returned to the connected (racked in) position it must:

   a. Verify charging spring charges when DC is applied to breaker cubicle, or, if charging spring was not discharged, verify spring is charged after the first operation by inspection (per above).

   b. With the breaker open and DC power on, green indications lights must be observed at the proper locations.

   c. Close the breaker and observe red indicating lights at the proper locations and the load is energized.

   d. For the Diesel Generator Breakers only, red indicating lights must be illuminated at the proper locations and the diesel breaker must be tripped by operator control action at the end of the appropriate diesel run.

CORRECTIVE ACTIONS

Non-Conformance Reports have been issued against each Class 1E 4KV switchgear to require operability verification after the breaker is racked in. These NCR's are NCR 95060065 for Bus 2A04, NCR 95060069 for Bus 2A06, NCR 95060070 for Bus 3A04 and NCR 95060071 for Bus 3A06.

New contact blocks have been ordered from ABB to replace the blocks in the plant. The contact finger material has been verified to be the correct Quarter Hard 85/15 brass as discussed in the Laboratory Analysis section of the report.

All of the contact blocks in Unit 3, Train A, will be replaced during the U3C8 outage in July/August 1995. The tracking documents for this activity are the above mentioned NCR's. An MO has been written for each cubicle and each MO references the associated NCR. The removed contact blocks will be evaluated by ISEG/RCG for the degree of cracking and the results will be used to validate the overall replacement schedule.

All of the remaining old type contact blocks will be replaced in Unit 2 Train A and B and Unit 3 Train B during Scheduled Equipment outages with all the blocks being replaced no later that the end of the Cycle 9 outage on both Units.

The failed 3A0605 contact block was sent to ABB Power T&D Company for failure analysis and Part 21 evaluation.

PHOTODOCUMENTATION

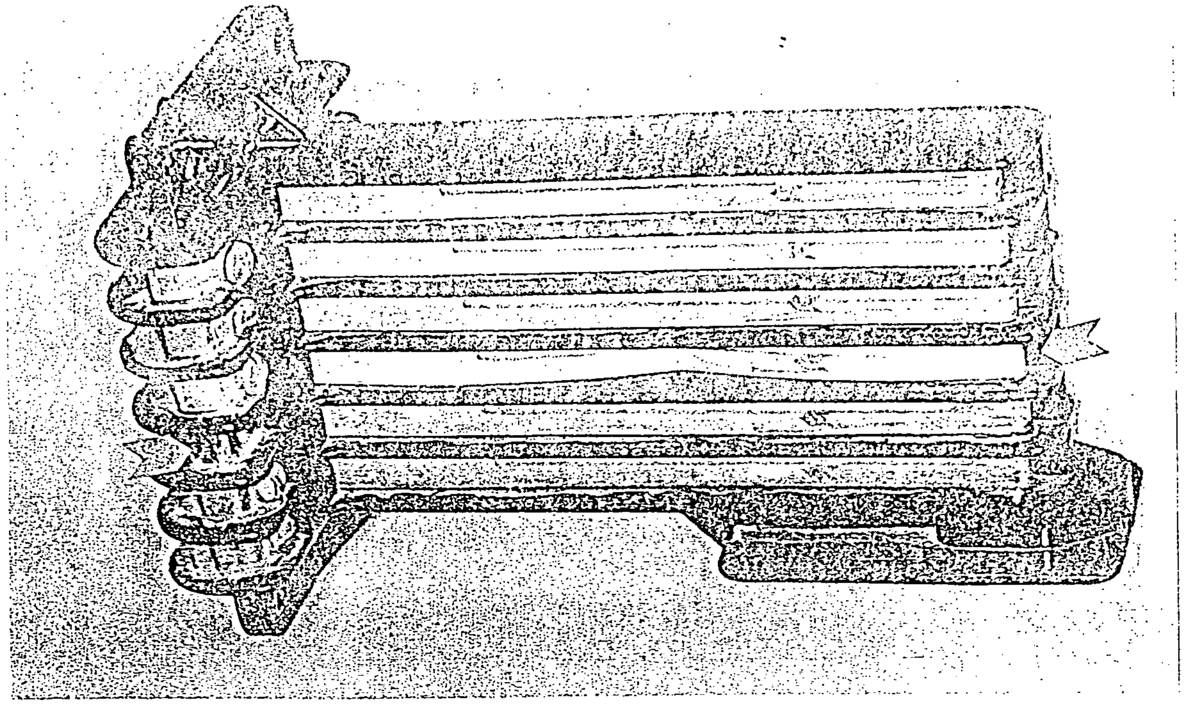

Figure 1: Optical photograph of the failed 3A0605 contact block. Note the fractured finger at location #4.

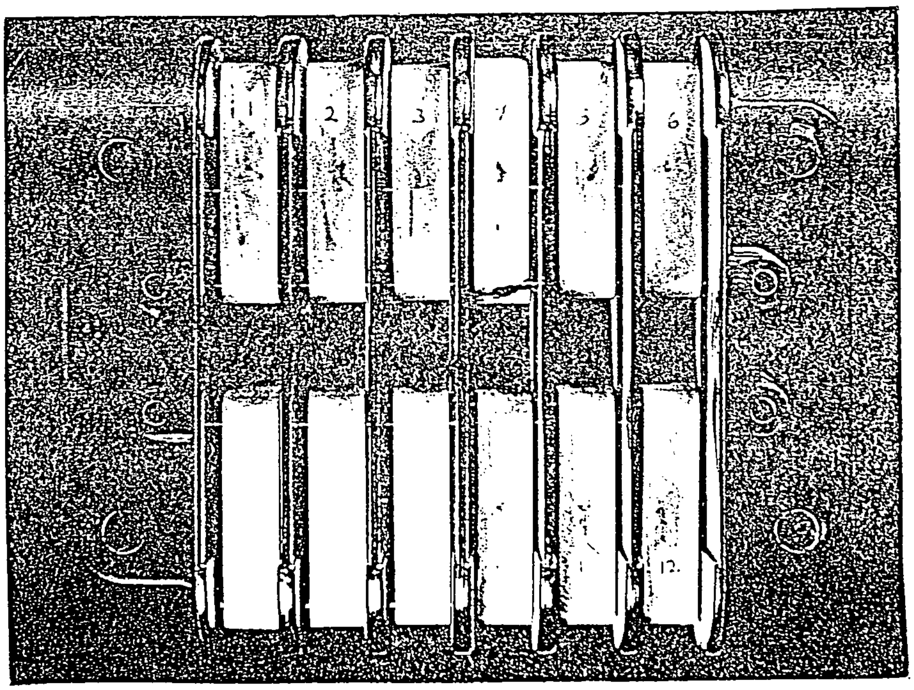

Figure 2: Optical photograph of the back of the 3A0605 contact block showing the fracture at finger #4.

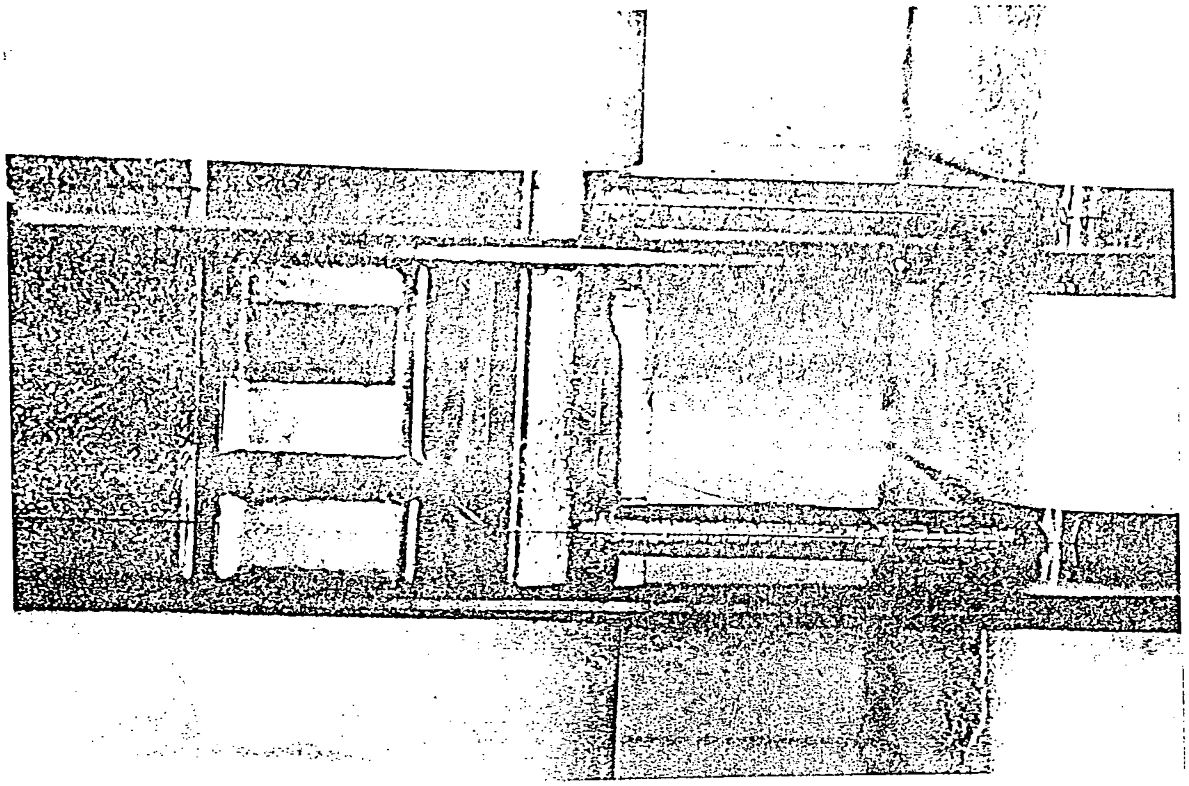

Figure 3: Optical photograph of one end of the fractured finger #4 at bend C. Crack in finger #9 is on lower right.

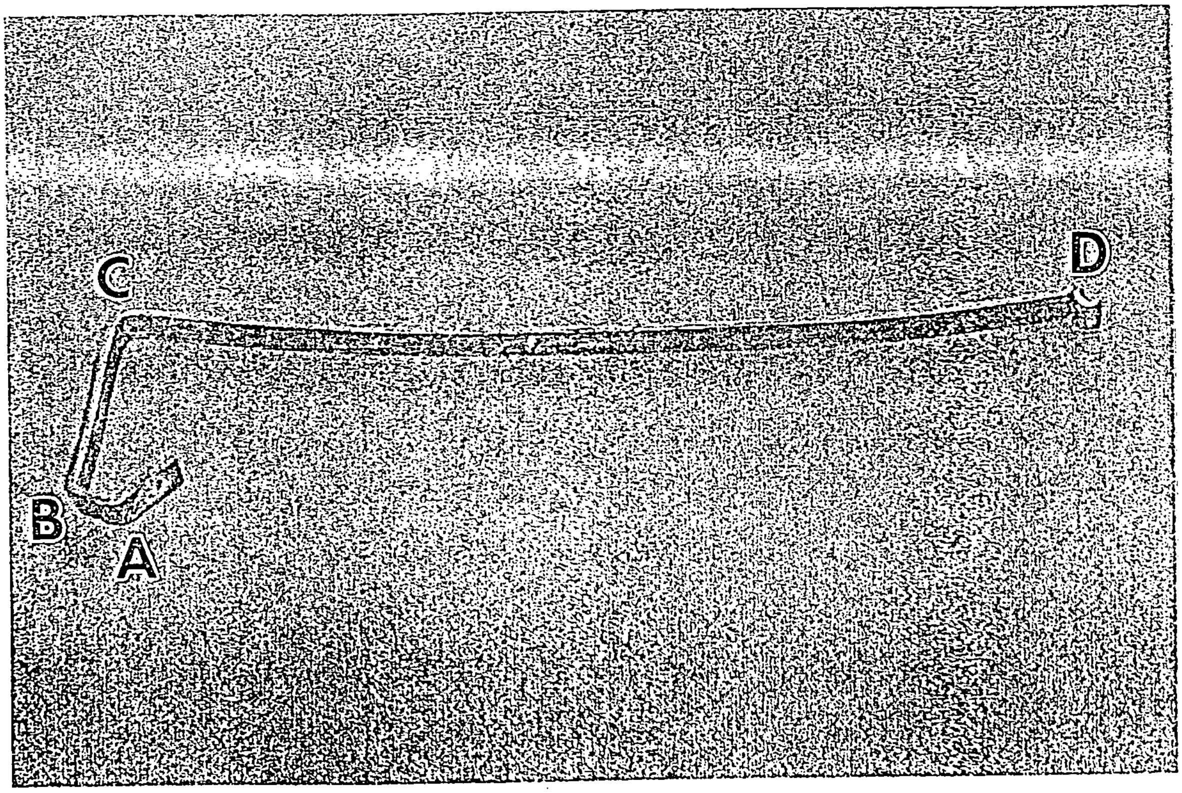

Figure 4: Optical photograph of a finger showing the labeling of the bends. Bend D was fractured during removal.

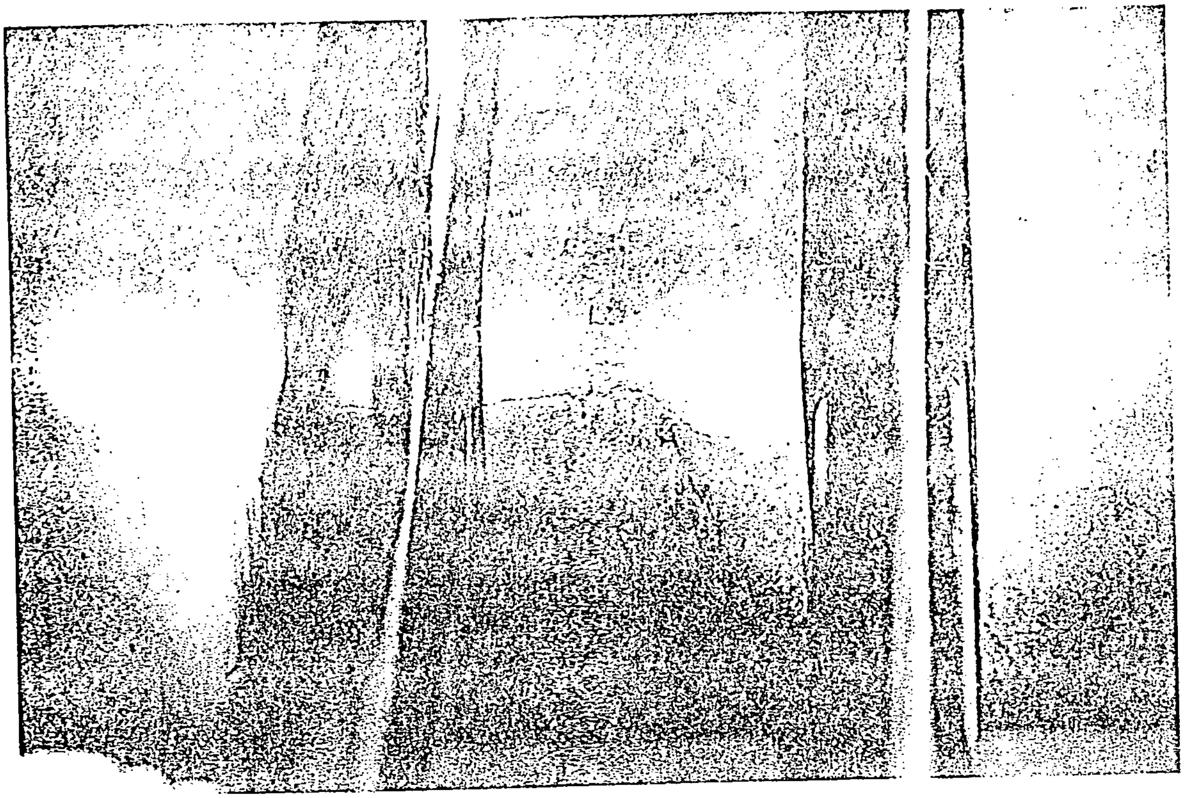

Figure 5: Optical photograph of the crack in finger #9, at bend c, on the 3A0605 contact block.

Figure 6: Optical photograph of the crack in finger #12, at bend c, on the 3A0605 contact block.

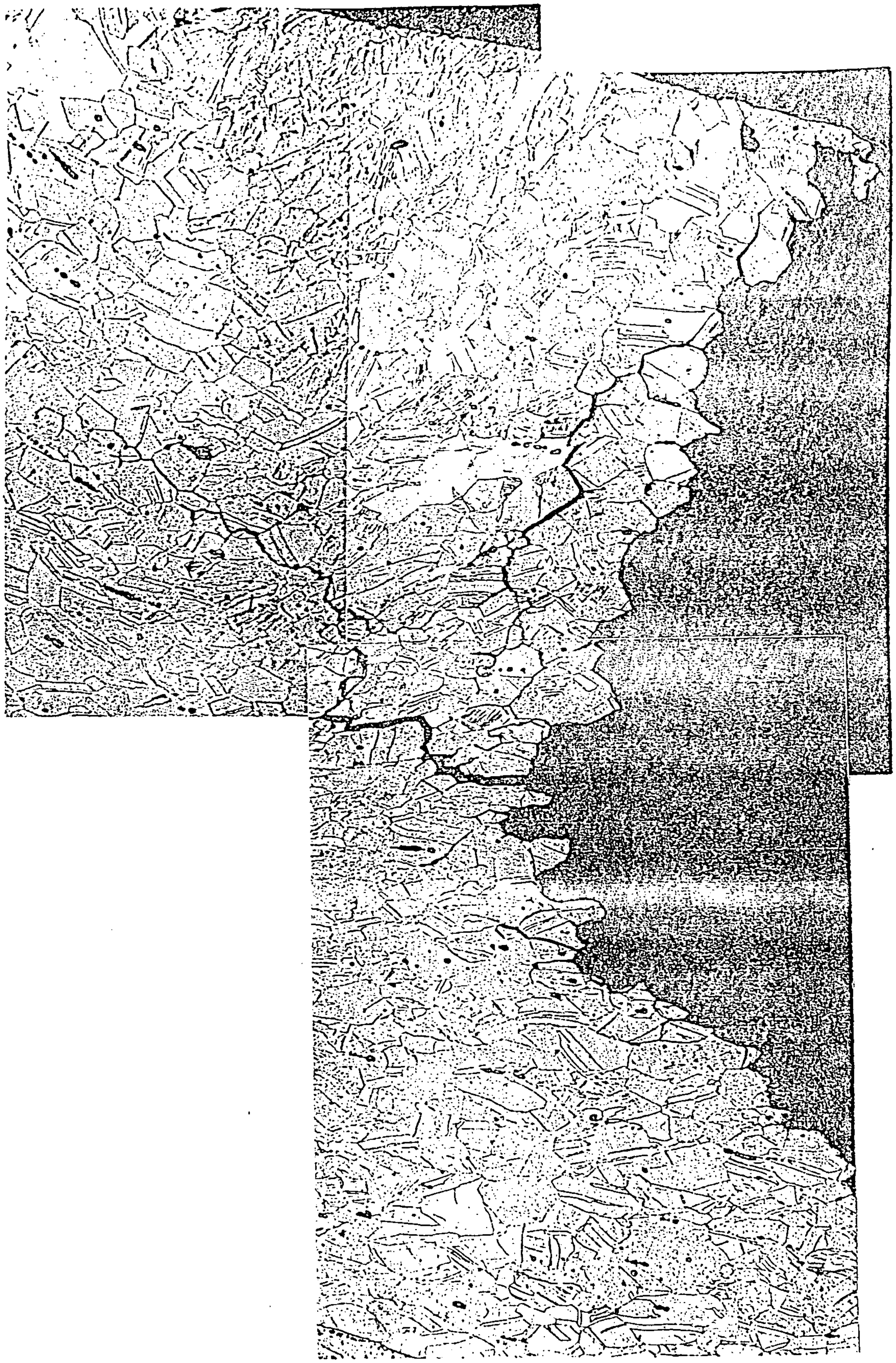

Figure 7: Optical Micrograph of a cross section of one side of the finger #4 fracture showing the intergranular cracks and extra hard temper grain structure. Mag:200X

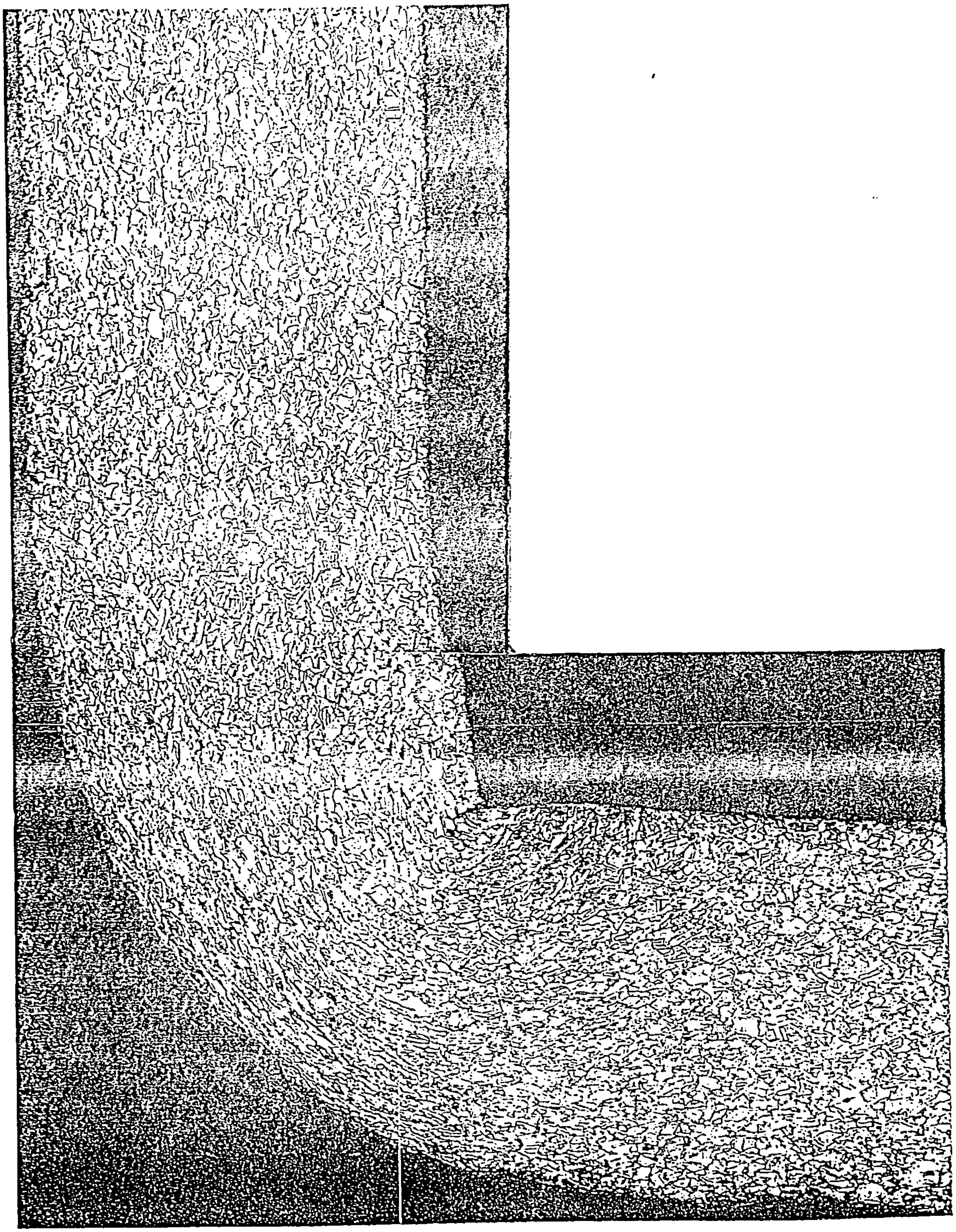

Figure 8: Optical Micrograph of finger #4 cross section at bend B showing a crack at the inner diameter and the extra hard temper grain structure at the bend. Mag:50X

Figure 9: Close-up of the inner diameter crack in finger 4, bend B in Figure 8. Mag:400X

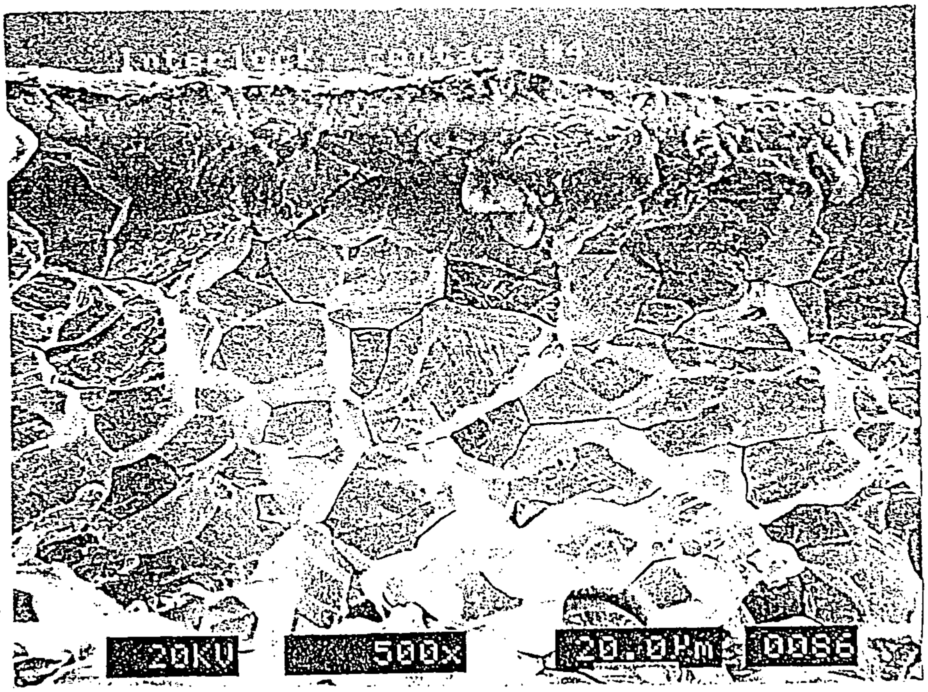

Figure 10: Scanning Electron Microscope (SEM) photograph of the fracture face on finger 4 showing the intergranular structure.

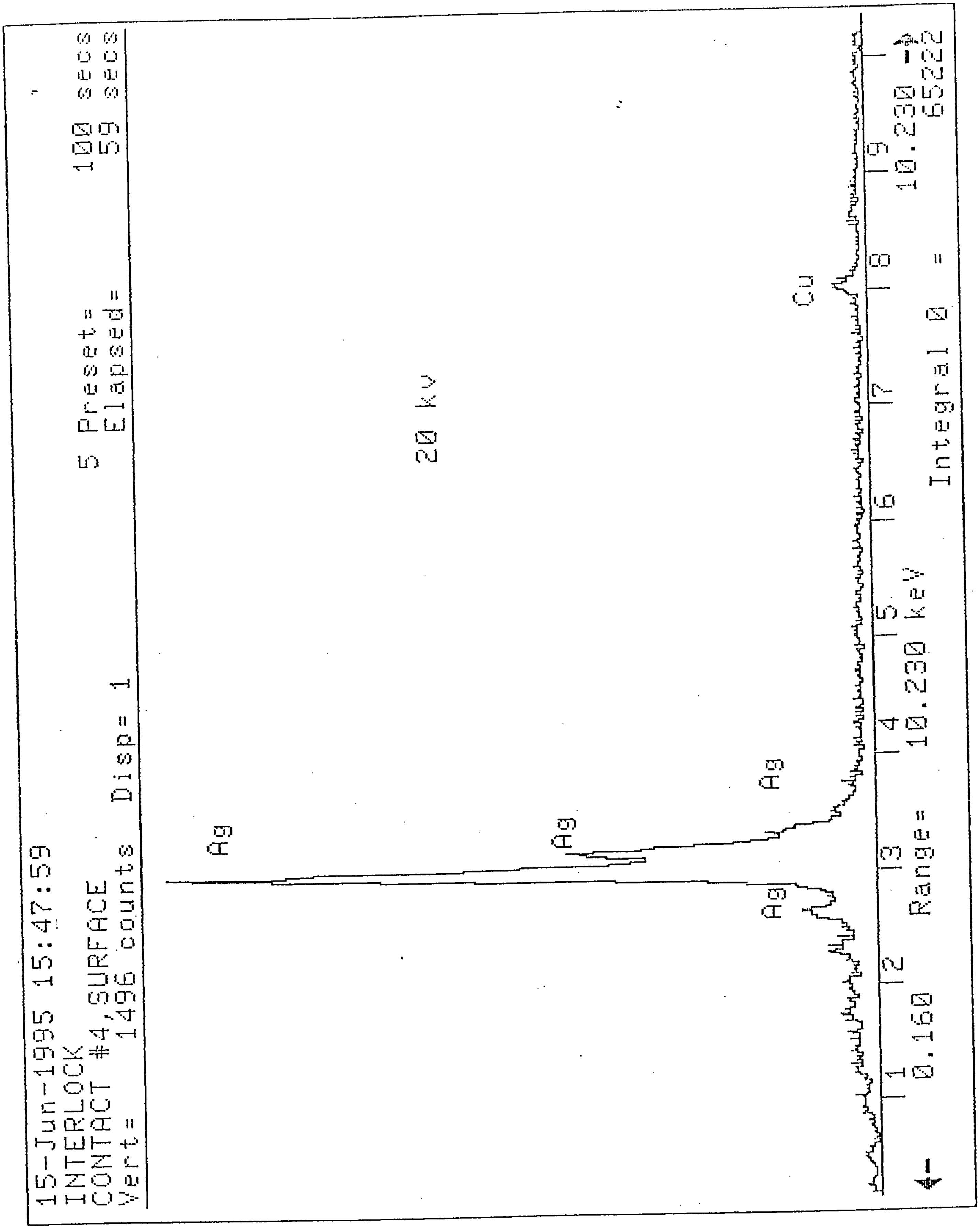

Figure 11: Energy Dispersive spectrum (EDS) showing the elemental composition of the plating on the surface of finger #4, contact block 3A0605.

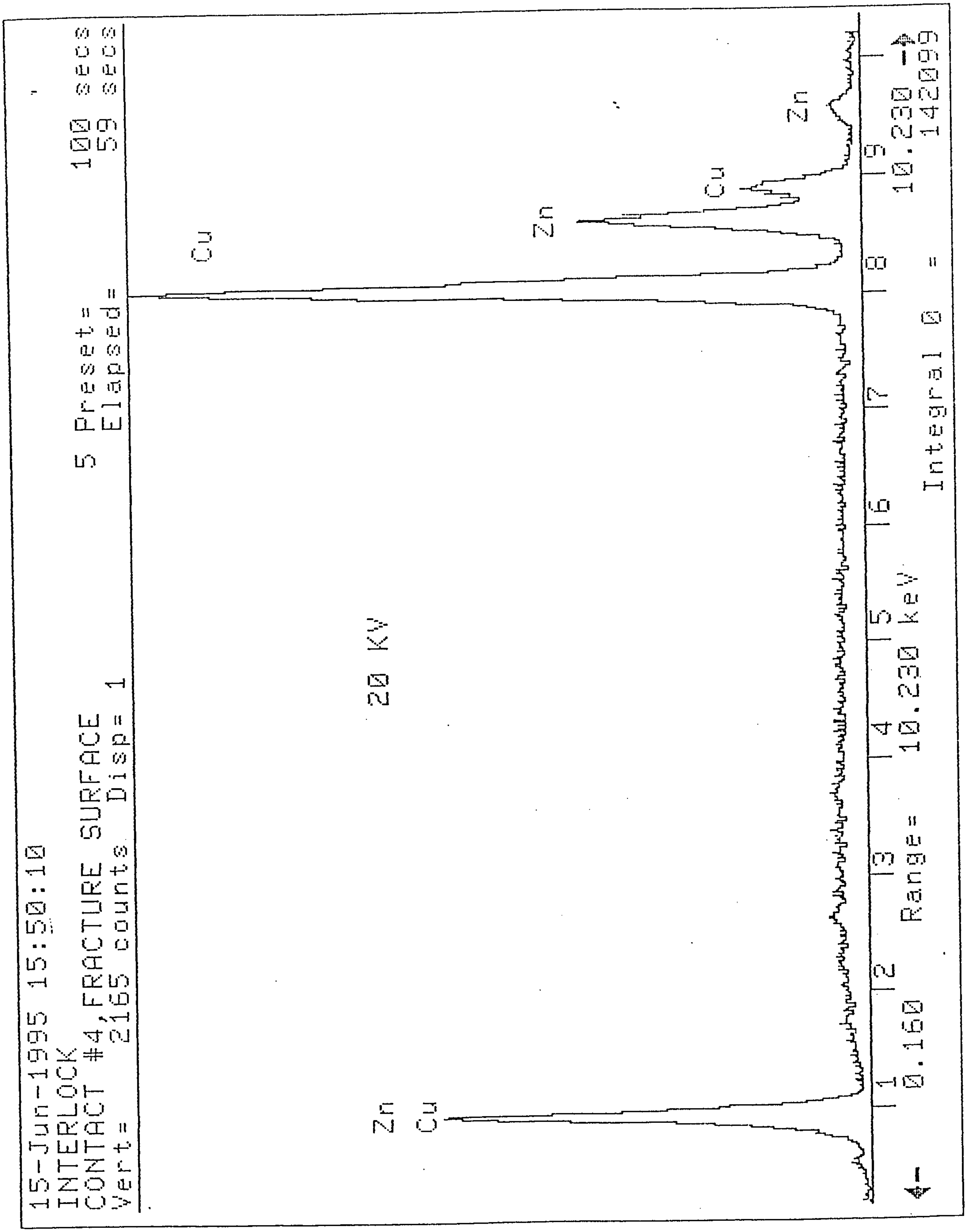

Figure 12: EDS of the base metal of 3A0605, finger #4 showing copper and zinc are present.

15-Jun-1995 15:53:37 CONTACT #4,FRACTURE

Accelerating voltage	20.0 KeV
Beam - sample incidence angle	60.0 degrees
Xray emergence angle	29.0 degrees
Xray - window incidence angle	1.5 degrees

STANDARDLESS EDS ANALYSIS
(ZAF CORRECTIONS VIA MAGIC V)

ELEMENT & LINE	WEIGHT PERCENT	ATOMIC PERCENT*	PRECISION 2 SIGMA	K-RATIO**
Cu KA	69.19	69.79	0.69	0.6959
Zn KA	30.81	30.21	0.54	0.3093
TOTAL	100.00			

ITERATIONS 4

*NOTE: ATOMIC PERCENT is normalized to 100

**NOTE: K-RATIO = K-RATIO x R
where R = reference(standard)/reference(sample)

NORMALIZATION FACTOR: 1.000

Figure 13: Table of copper and zinc elemental percentages in the EDS spectrum in figure 12. The material is 70/3 brass.

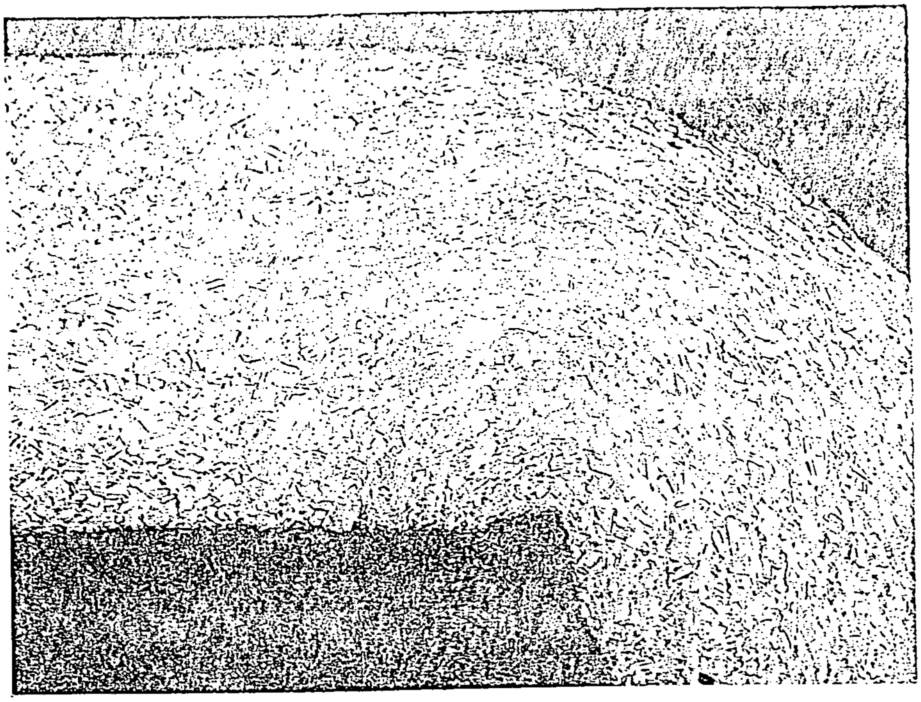

Figure 14: Optical micrograph of bend C on finger #10 from the spare 2A0602 contact block. The grain structure shows why this finger was more ductile than the others. Compare to Figure 8. Mag:50X

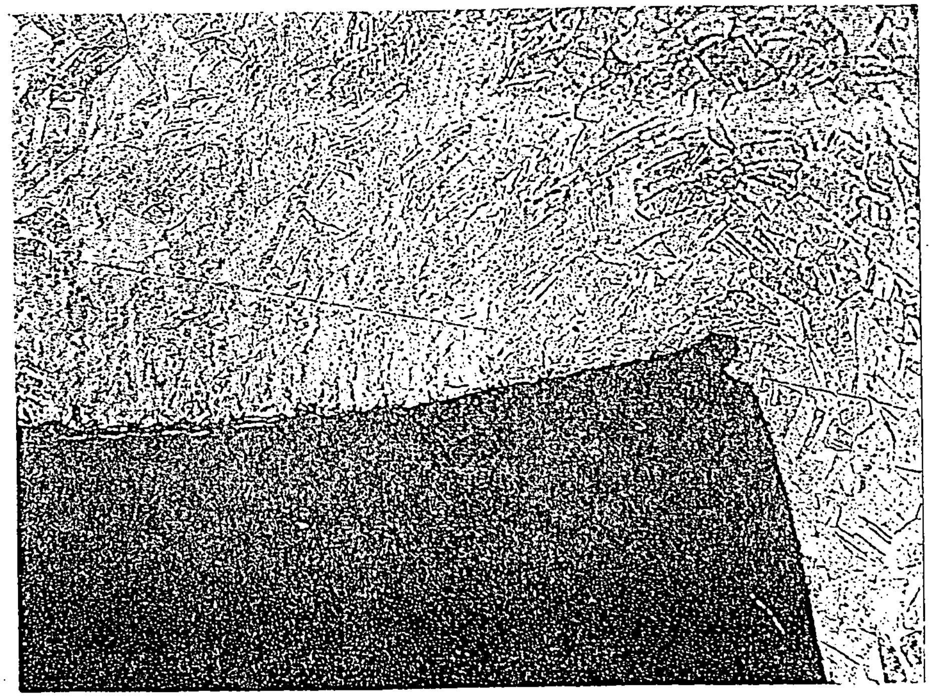

Figure 15: Close-up of the grain structure at the bend area of figure 14. The larger gains are a less hard temper than the cracked fingers. Mag: 200X

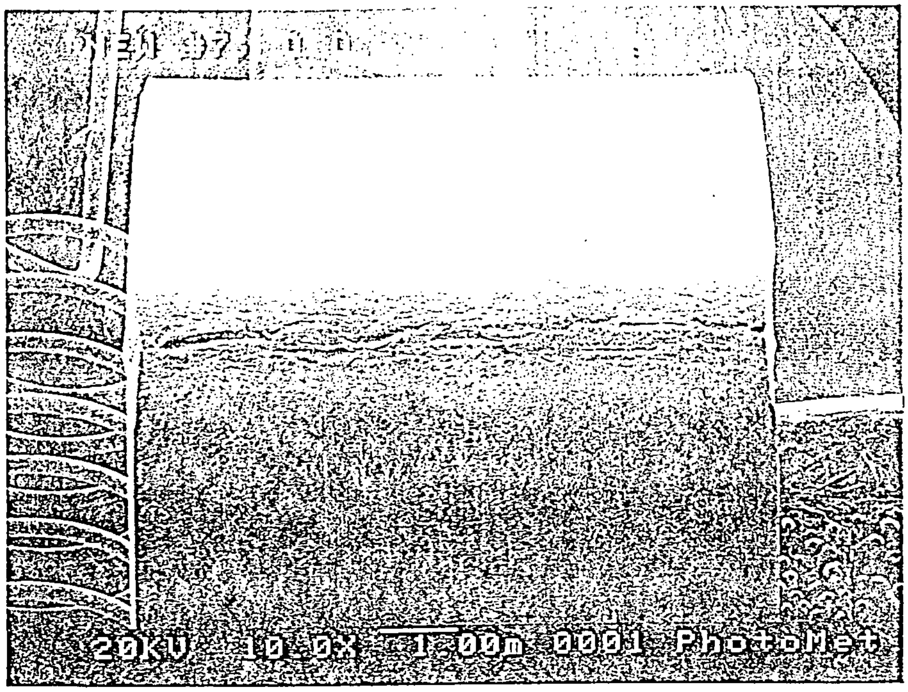

Figure 16: SEM photograph of contact finger #7 from the warehouse contact block showing the cracks at bend B.

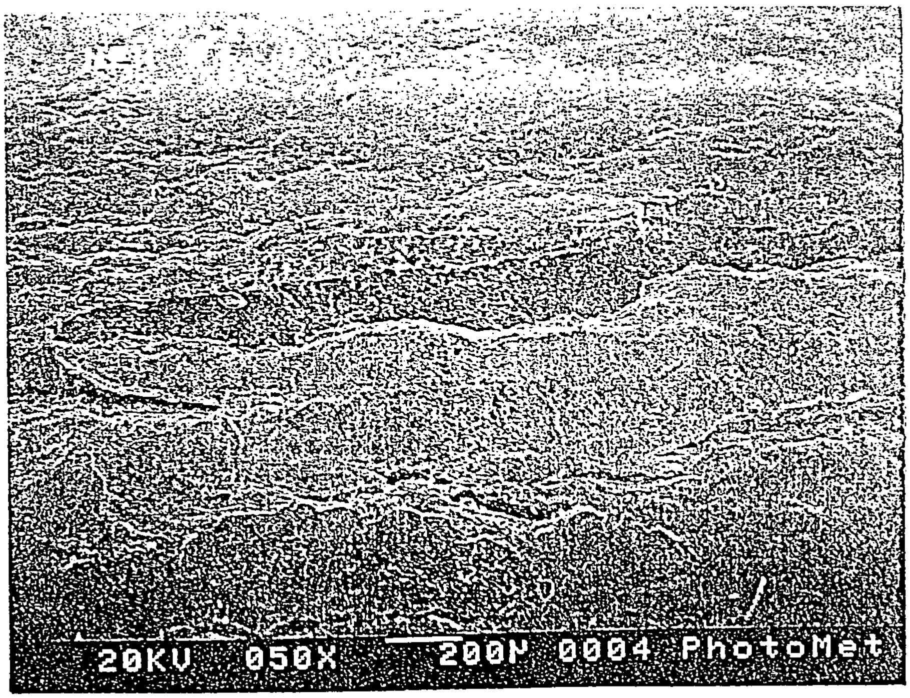

Figure 17: Close-up of the cracks in Contact #7, bend B, in Figure 16.

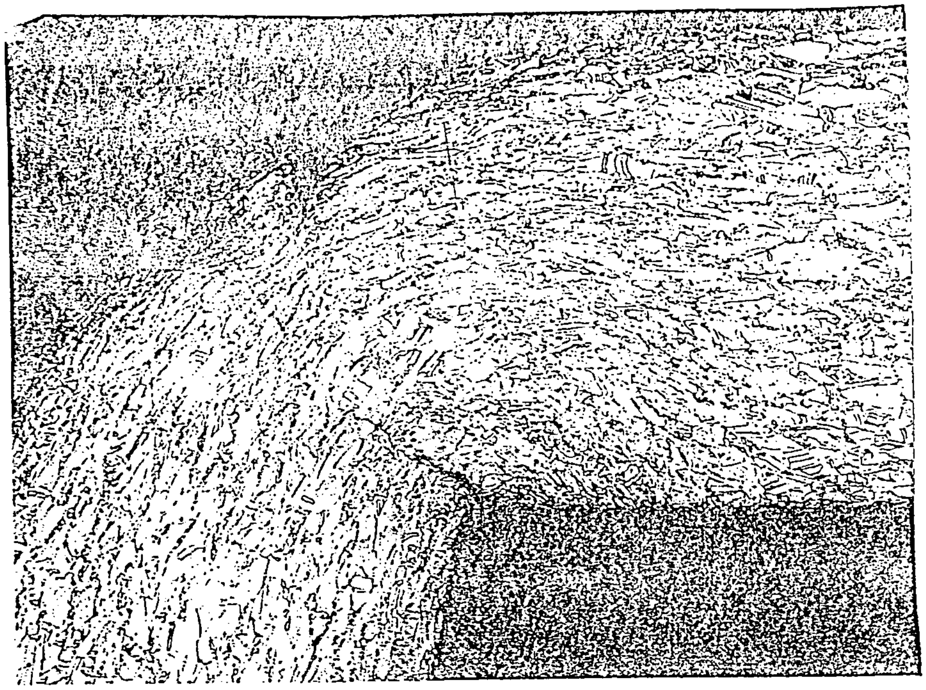

Figure 18: Optical micrograph of the cross section of contact finger #7, bend b, showing the depth of the cracks. Mag:50X

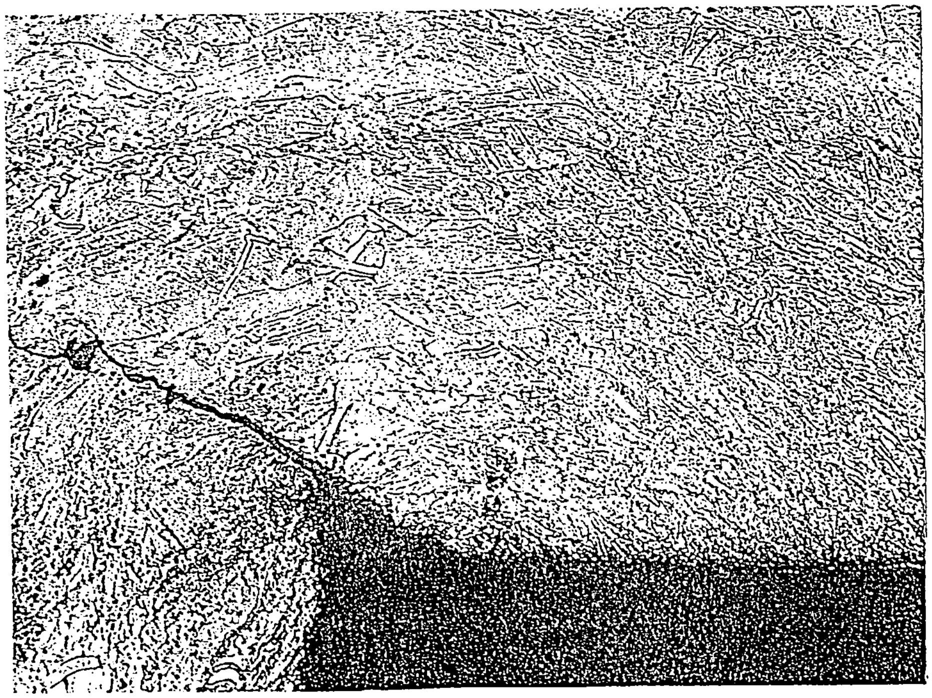

Figure 19: Close-up of the inner diameter crack in finger #7, bend B, in Figure 18. Mag:200X

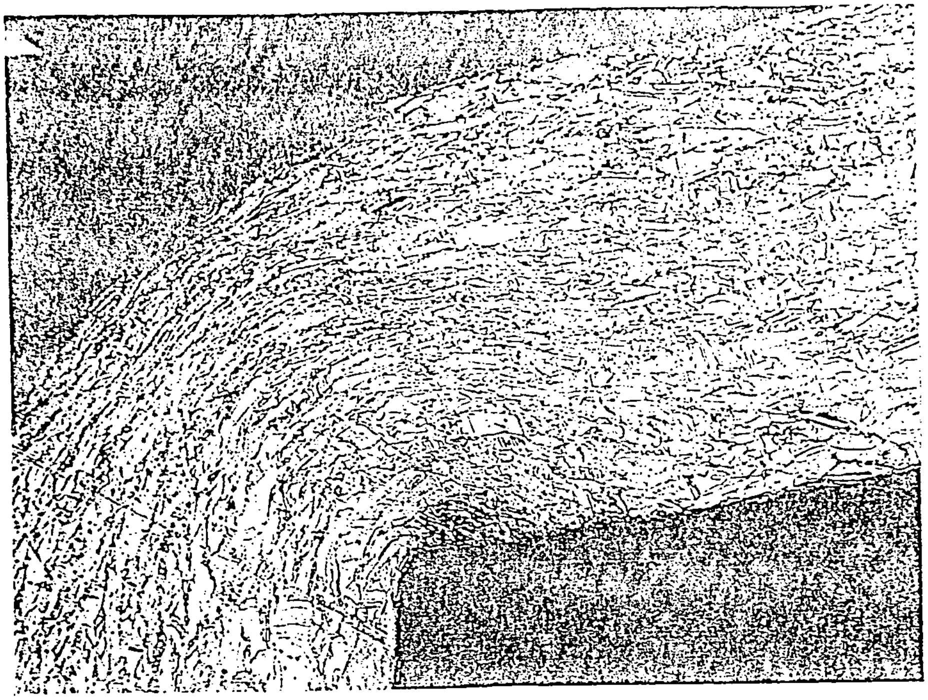

Figure 20: Optical micrograph of the cross section of contact finger #8, bend b, showing the depth of the cracks. Mag:50X

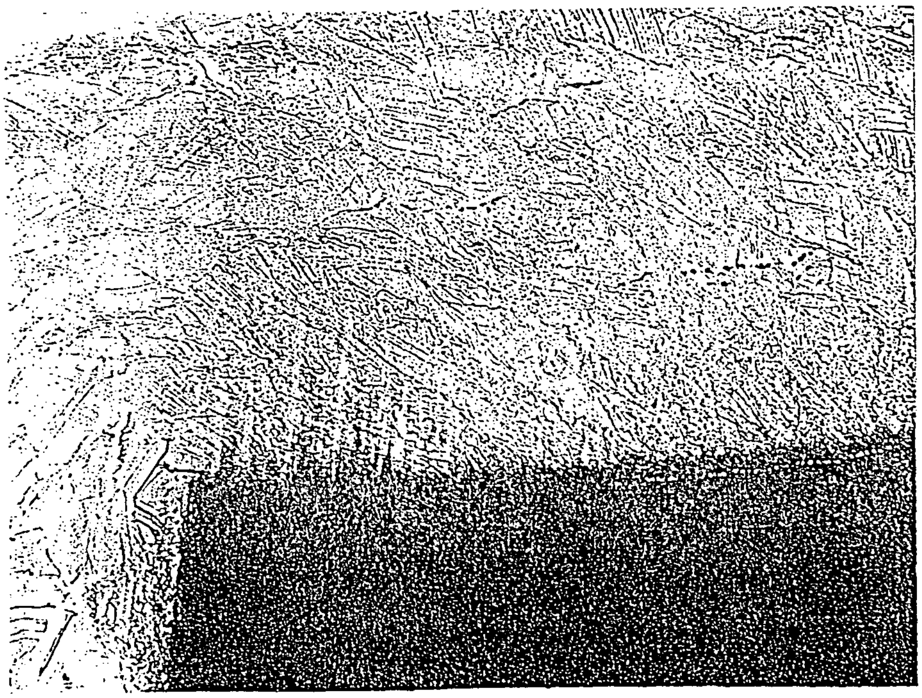

Figure 21: Close-up of the inner diameter crack in finger #8, bend B, in Figure 20. Mag:200X

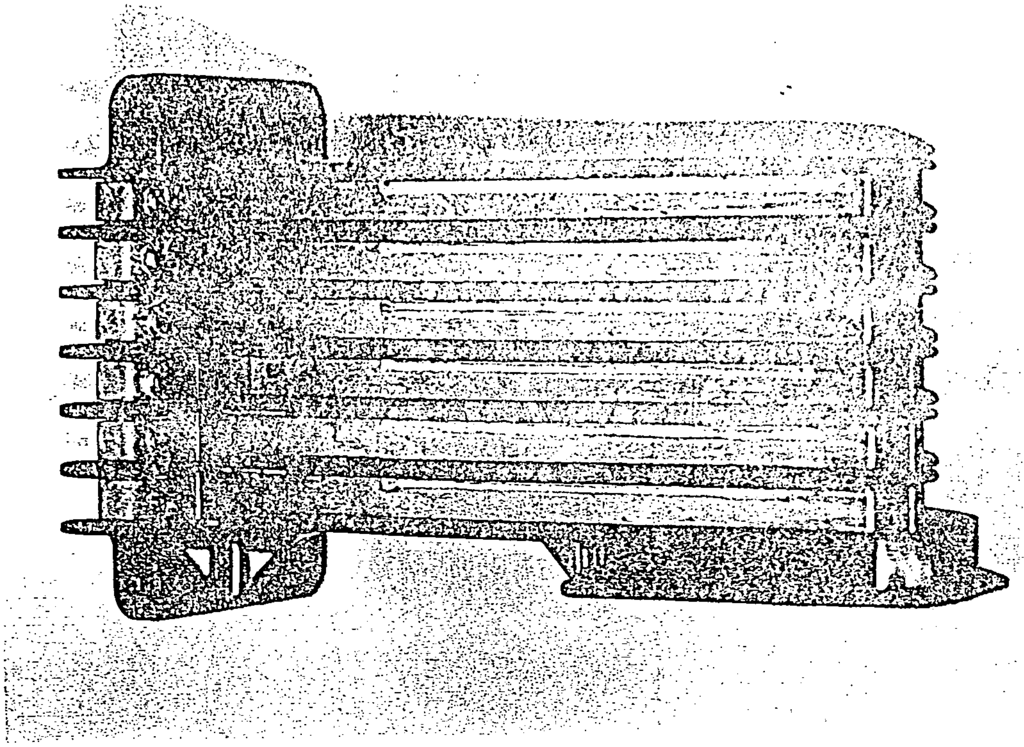

Figure 22: Optical photograph of the 2A0611 contact block after removal from the P114 breaker.

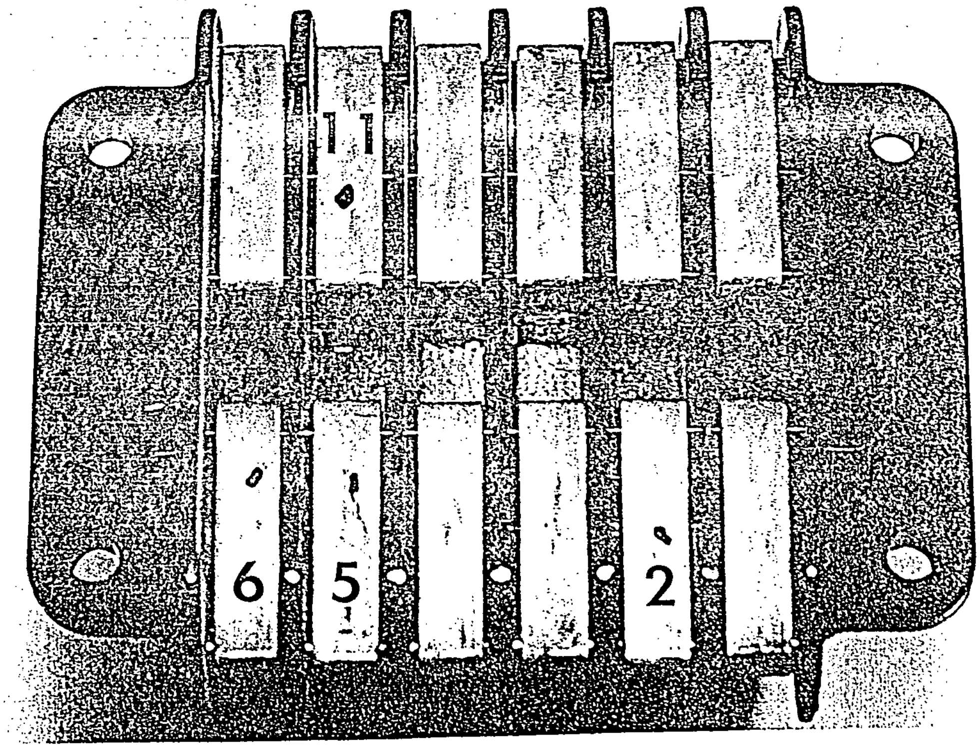

Figure 23: Optical photograph of back of the 2A0611 contact block showing the location of the cracked fingers.

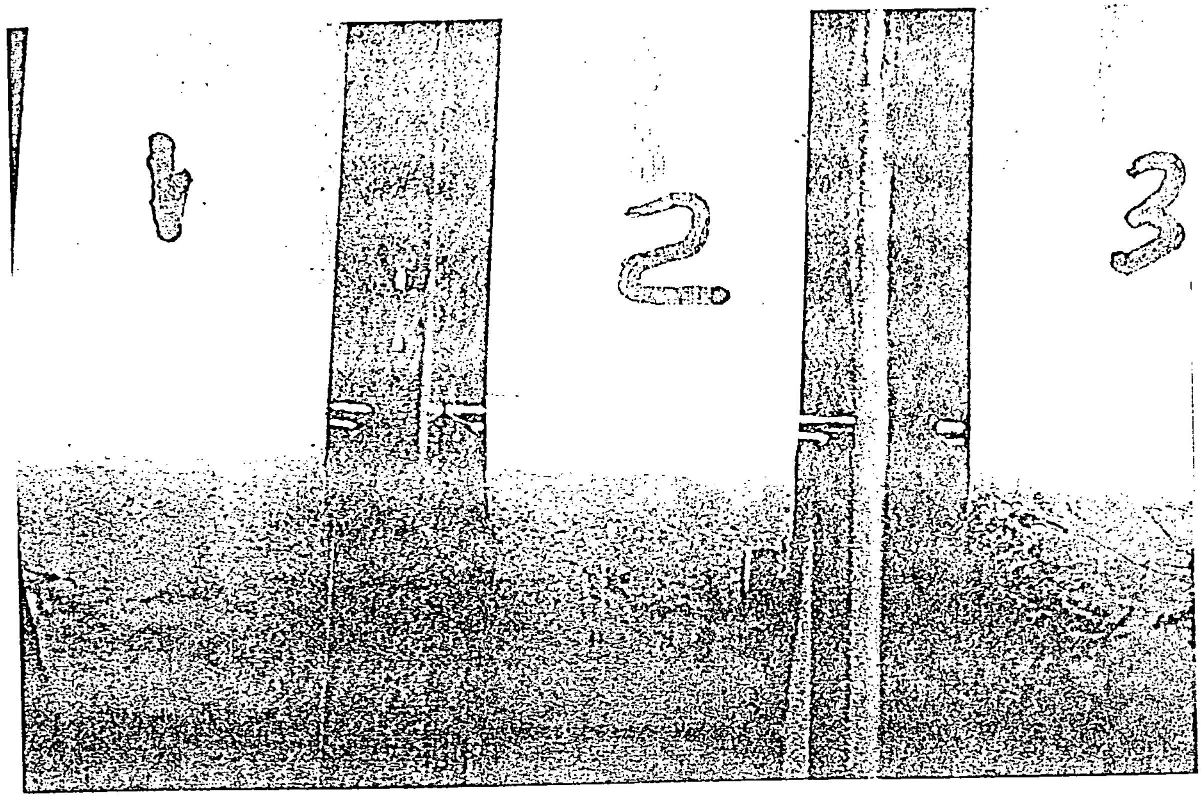

Figure 24: Close-up of the crack in finger #2, bend B, in contact block 2A0611.

Figure 25: Close-up of the crack in finger #5, bend B, in contact block 2A0611.

Figure 26: Close-up of the crack in finger #6, bend B, in contact block 2A0611.

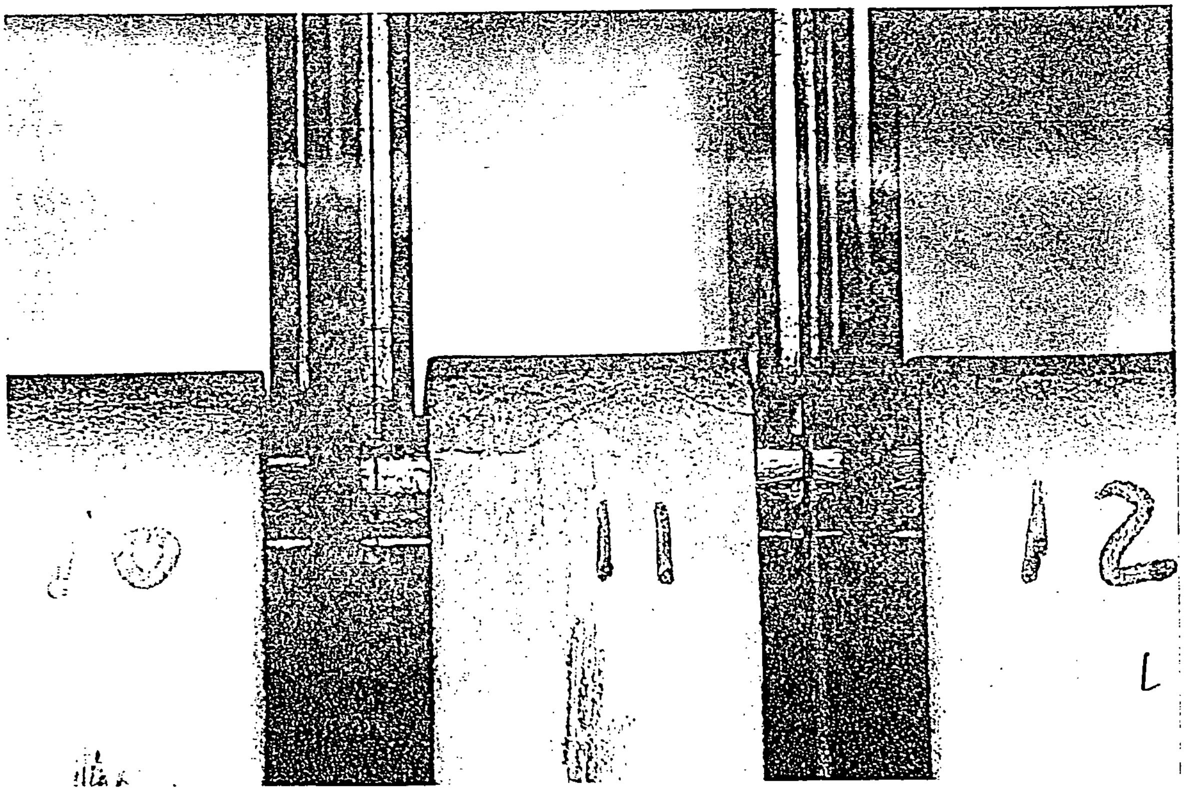

Figure 27: Close-up of the crack in finger #11, bend B, in contact block 2A0611.

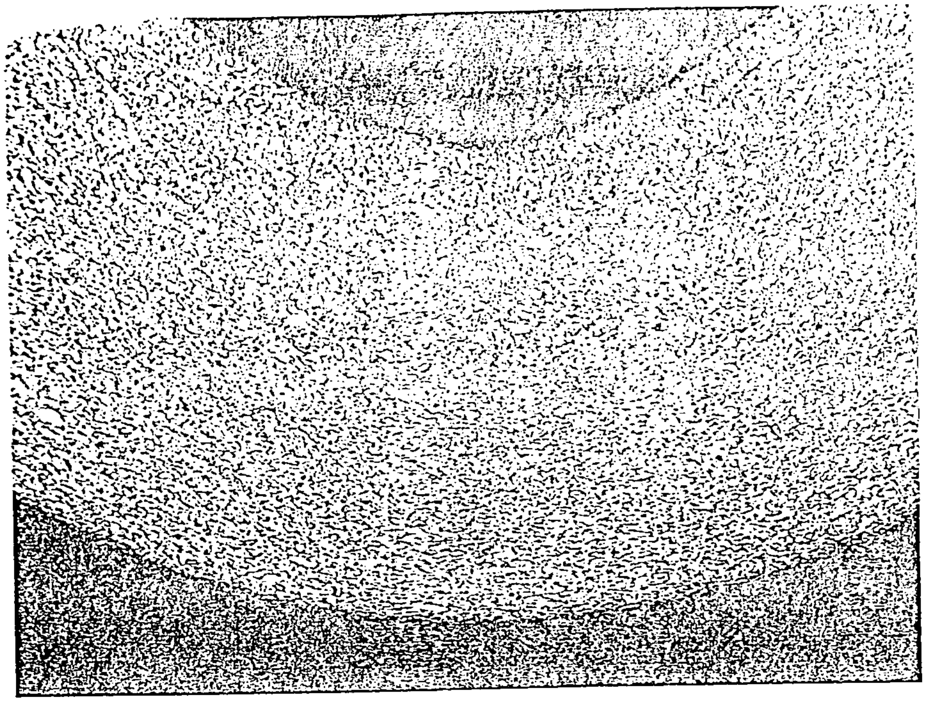

Figure 28: Cross sectional micrograph of the new contact finger material in the bend area showing a grain structure indicative of Half Hard temper. Mag:50X

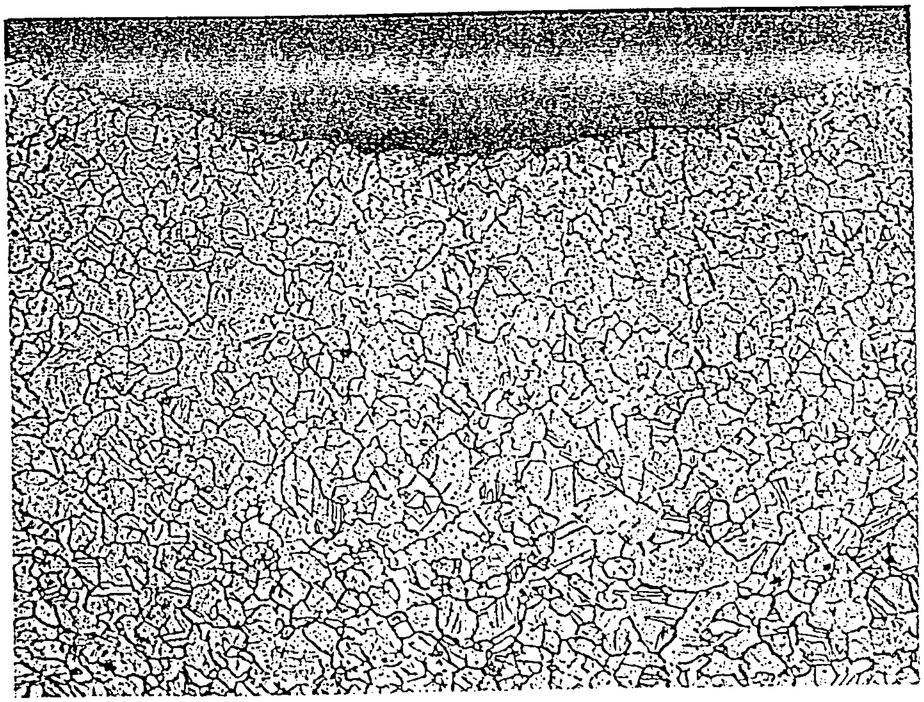

Figure 29: Magnified view of the new material at the bend area showing the absence of cracks. Mag:200X

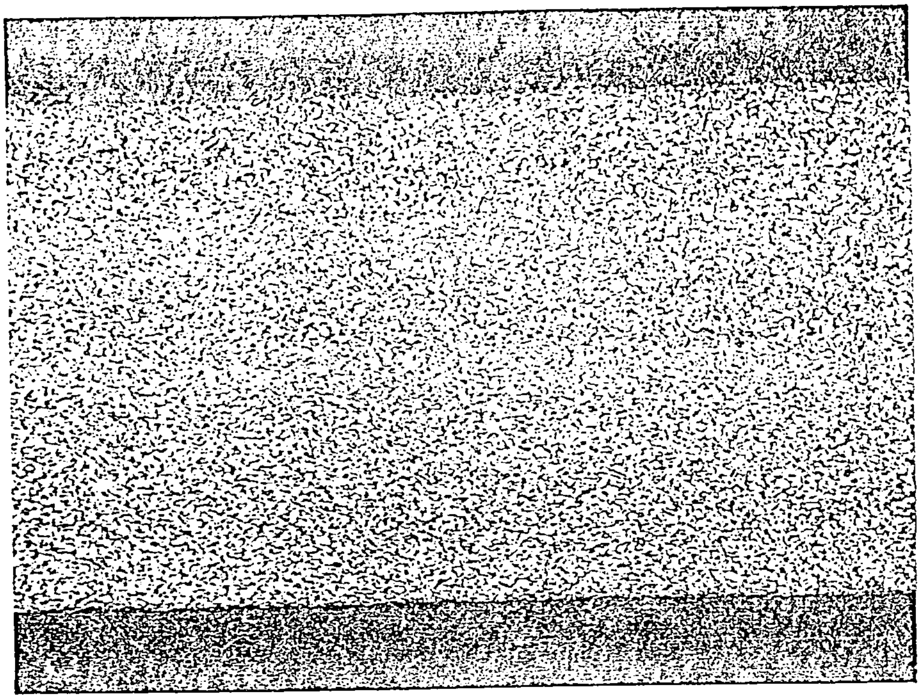

Figure 30: Cross sectional micrograph of the new contact finger material in the straight area showing a grain structure indicative of Quarter Hard temper. Mag:50X

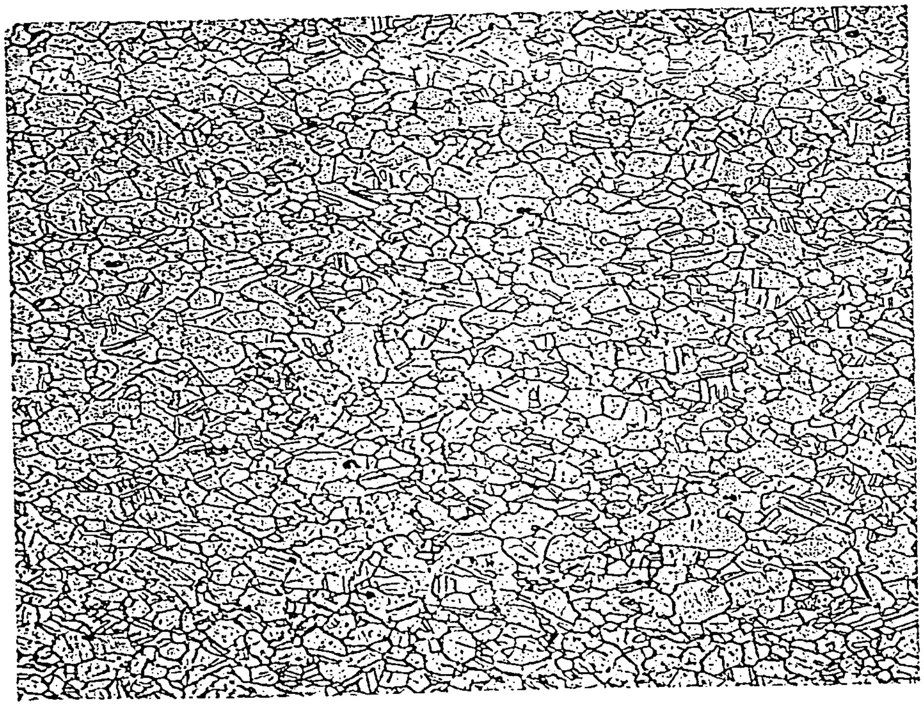

Figure 31: Magnified view of the new material in the straight area showing the acceptable grain structure. Mag:200X

ABB

ABB Combustion Engineering Nuclear Operations

CERTIFICATE OF CONFORMANCE

Customer:
NAME: ABB Power T&D-Sanford,FL
ORDER NO.: P311407-00
LATEST REV.: NONE

Certificate Number: 1 — Page 1 of 1
Certificate is: CONDITIONAL ☐ UNCONDITIONAL ☒
Order is: INCOMPLETE ☐ COMPLETE ☒
Record Checklist Attached: YES ☒ NO ☐
ABB CE Order No. 406265 – 01 **Supplement No.** 0

Cust. Item#	ABB CE Item#	Quantity Order	Quantity Ship	Part Number	Description
1	1.0	3	3	701902C00	Material Analysis of Secondary Contacts--3/6 samples.
2	2.0	3	3	816978A00	Material Analysis of Secondary Contacts--3/6 samples.
3	3.0	6	6	816978A00	Material Analysis of Secondary Contacts--6/6 samples.
c					

As checked off; the following apply to the item(s) and /or services being certified:

☑ Nuclear Spare Parts Quality Assurance Program description (QAM-300), revision 09.

☐ System Staging Group Quality Assurance Program (QAM-400), revision 01.

As checked off; the following method(s) for acceptance apply:

☐ Source Verification ☐ Dropship/Receiving Inspection ☐ Post Assy Test/ Inspection ☑ Documentation Review

Whereby this order has been processed in accordance with the ABB Combustion Engineering Nuclear Quality Assurance Manual (QAM-100), 4th Edition, revision 2, dated 2/1/95 and any of the above checked. ABB hereby certifies that the item(s) and/or services described above meet the referenced purchase order requirements, including applicable codes, specifications, standards and equipment qualification requirements. Any exceptions to these requirements have been documented and evaluated by properly executed deviation notices as noted within this documentation. Additionally; this item(s) and or service is supplied from ABB/CE's facility at Windsor, Ct. or from a supplier that has been previously approved by ABB/CE Windsor, Connecticut.

Comments: (1)THIS CERTIFICATION PROVIDES RESULTS OF MATERIAL ANALYSES ON SAMPLE SECONDARY CONTACTS PROVIDED BY ABB POWER T&D, DISTRIBUTION SYSTEMS DIVISION, SANFORD, FL. (2) THIS WORK WAS PERFORMED TO VERIFY COMPLIANCE WITH MATERIAL/PROCESS SPECIFICATIONS AS DEFINED ON ABB DRAWINGS 701902, REV. 6 AND 816978, REV. 7. THESE SPECIFICATIONS INCLUDED:---BASE MATERIAL: C.F. BRASS #2, ALLOY 230,---SILVER PLATING: ABB SPEC. 51664A, REV. 5. (3) COPIES OF ORIGINAL TEST REPORTS AND PHOTOGRAPHS WILL BE FORWARDED BY MAIL.

Distribution:
Quality Assurance File
Purchasing File
Engineering
Other
Customer: ABB POWER T&D

[signature]
QA Representative
M. W. STEWART
Date: 8/28/95

N/A
Cognizant Engineer
Date: N/A

COFC-E 3/95

ATTACHMENT #2

ABB

ABB Combustion Engineering Nuclear Operations

RECORDS CHECKLIST (RCL)

CUSTOMER: ABB POWER T&D

ORDER NO. P311407-00

ABB CE ORDER NO. 406265-01

C OF C NUMBER ONE

RCL PAGE 1 OF 1

SEE CODES AT RIGHT FOR IDENTIFYING RECORDS INDICATED BELOW

EXCLUDING THIS RCL AND C OF C; THE TOTAL PAGE COUNT INCLUDED IS SEVEN (7)

ABB CE ITEM NO.														
1.0--3.0	E													

RECORD CODES

A. NO ADDITIONAL DOC. REQ.
B. (NOT USED)
C. SUPPLIER'S C OF C
D. CERTIFICATE OF COMPLIANCE (MAT'LS)
E. TEST RESULTS
F. MILL TEST CERT. AND ANALYSIS (CMTR)
G. WELD MATERIAL CERT. AND ANALYSIS (CMTR)
H. SEISMIC TEST REPORT
I. WATER ANALYSIS
J. CHEMICAL ANALYSIS
K. DYE PENETRANT REPORT
L. MAGNETIC PARTICLE REPORT
M. RADIOGRAPHIC READER SHEET
N. RADIOGRAPHIC FILM
O. ULTRASONIC REPORT
P. HYDROSTATIC TEST REPORT
R. DIMENSIONAL REPORT
S. AS-BUILT DRAWINGS
T. CLEANING CERTIFICATION
U. PACKAGING PROCEDURE
V. SHIPPING AND STORAGE PROCEDURE
W. HEAT TREATMENT CERTIFICATION
X. SENSITIVITY COEFFICIENTS
Y. RECEIPT INSPECTION DEFICIENCY REPORT
Z. LOW CHLORIDE CERTIFICATION
AA. NIICKEL PLATE CERTIFICATION
AB. SHELF LIFE STATEMENT
BB. COMPONENT FAILURE REPORT
CD. ASME CODE DATA REPORT
IM. INTEGRATED MANUFACTURING AND QUALITY PLAN

ADDITIONAL CODES, AS REQUIRED

DD.
EE.
FF.
GG.
HH.

COMMENTS: DIRATS LABORATORIES TEST REPORTS NUMBER 226979, 226980, & 226981.

APPLICABLE TECHNICAL CHANGE REQUESTS (TCR'S): NONE

APPLICABLE DEVIATION FROM CONTRACT REQUIREMENTS FORM (DCR'S): NONE

QA REP. M. W. STEWART [signature]

DATE: 8/29/95

RCL494

DIRATS LABORATORIES

TEST REPORT

Tom B. Preston
ABB Combustion Engineering
Nuclear Spare Parts
P.O. Box 500 M/S 9426-DH24
Windsor, CT 06095-0500

Report Number	226979
Report Date	29-AUG-95
Page	1 of 2
Client Number	004400
Client Order	406265-01
Release	ITEM 1.0

RECEIVED	6 Contacts
IDENT AS	P/N 701902C00
MATERIAL	.050 CF Brass #2, Alloy 230 Silver Plated
CONDITION	*
TEST TO	ITE 51664A Rev. 5 and Client Instructions
TEST PER	*
PURPOSE	*
SPEC INST	Return specimens and 3 unused parts

PROPERTIES AS SUPPLIED

SEMI-QUANTITATIVE SPECTRO CHECK OF PLATING

Disp

S/N 1 — In Spec
The spectrographically detectable elements are present in approximately the required amounts for Silver.

S/N 2 — In Spec
The spectrographically detectable elements are present in approximately the required amounts for Silver.

S/N 3 — In Spec
The spectrographically detectable elements are present in approximately the required amounts for Silver.

QUANTITATIVE ANALYSIS BY XRF

Sample	1	2	3
	Base Metal	Base Metal	Base Metal
%			
Cu	84.91	84.91	85.16
Fe	<0.01	0.01	<0.01
Pb	0.01	<0.01	<0.01
Zn	REM	REM	REM
Cu + sum of named elements	99.99	99.95	99.99
Disp:	For Info	For Info	For Info

The symbol < signifies not detected at the detectability limit indicated.

DIRATS LABORATORIES

TEST REPORT

ABB Combustion Engineering
Nuclear Spare Parts
Windsor, CT 06095-0500

Report Number 226979
Report Date 29-AUG-95
Page 2 of 2

HARDNESS TEST OF BASE METAL

Sample	Hardness	Disp
1	HR30T 67	For Info
2	HR30T 67	For Info
3	HR30T 66	For Info

Note: No authorized hardness conversion table for this material.

METALLOGRAPHIC EXAMINATION OF PLATING — Disp

Sample: 1 — In Spec
Thickness: Min. 0.00005", Max. 0.00010", Predom. 0.00005"

Sample: 2 — In Spec
Thickness: Min. 0.00005", Max. 0.00010", Predom. 0.00010"

Sample: 3 — In Spec
Thickness: Min. 0.00005", Max. 0.00010", Predom. 0.00005"

NADCAP

WE CERTIFY THIS IS A TRUE COPY OF OUR RECORDS
Signed for J. Dirats and Co. by Richard C. Simmons, Technical Manager
NOTE: The recording of false, fictitious or fraudulent statements or entries on this document may be punished as a felony under federal law.

DIRATS LABORATORIES

TEST REPORT

Tom B. Preston
ABB Combustion Engineering
Nuclear Spare Parts
P.O. Box 500 M/S 9426-DH24
Windsor, CT 06095-0500

Report Number	226980
Report Date	29-AUG-95
Page	1 of 2
Client Number	004400
Client Order	406265-01
Release	ITEM 2.0

RECEIVED	6 Contacts
IDENT AS	P/N 816978A00
MATERIAL	.050 CF Brass #2, Alloy 230 Silver Plated
CONDITION	*
TEST TO	ITE 51664A Rev. 5 and Client Instructions
TEST PER	*
SPEC INST	Return specimens and 3 unused parts

PROPERTIES AS SUPPLIED

SEMI-QUANTITATIVE SPECTRO CHECK OF PLATING — Disp

S/N 1 — In Spec

The spectrographically detectable elements are present in approximately the required amounts for Silver.

S/N 2 — In Spec

The spectrographically detectable elements are present in approximately the required amounts for Silver.

S/N 3 — In Spec

The spectrographically detectable elements are present in approximately the required amounts for Silver.

QUANTITATIVE ANALYSIS BY XRF

Sample	1 Base Metal	2 Base Metal	3 Base Metal
%			
Cu	85.55	85.46	85.57
Fe	<0.01	0.01	0.01
Pb	<0.01	0.01	<0.01
Zn	REM	REM	REM
Cu + sum of named elements	99.98	99.95	99.99
Disp:	For Info	For Info	For Info

The symbol < signifies not detected at the detectability limit indicated.

DIRATS LABORATORIES

TEST REPORT

ABB Combustion Engineering
Nuclear Spare Parts
Windsor, CT 06095-0500

Report Number 226980
Report Date 29-AUG-95
Page 2 of 2

HARDNESS TEST OF BASE METAL

Sample	Hardness	Disp
1	HR30T 68	For Info
2	HR30T 68	For Info
3	HR30T 68	For Info

Note: No authorized hardness conversion table for this material.

METALLOGRAPHIC EXAMINATION OF PLATING

Disp

Sample: 1 — In Spec
Thickness: Min. 0.00010", Max. 0.00010", Predom. 0.00010"

Sample: 2 — In Spec
Thickness: Min. 0.00010", Max. 0.00010", Predom. 0.00010"

Sample: 3 — In Spec
Thickness: Min. 0.00005", Max. 0.00010", Predom. 0.00010"

NADCAP

WE CERTIFY THIS IS A TRUE COPY OF OUR RECORDS
Signed for J. Dirats and Co. by Richard C. Simmons, Technical Manager
NOTE: The recording of false, fictitious or fraudulent statements or entries on this document may be punished as a felony under federal law.

DIRATS LABORATORIES

TEST REPORT

Tom B. Preston
ABB Combustion Engineering
Nuclear Spare Parts
P.O. Box 500 M/S 9426-DH24
Windsor, CT 06095-0500

Report Number	226981
Report Date	29-AUG-95
Page	1 of 3
Client Number	004400
Client Order	406265-01
Release	ITEM 3.0

RECEIVED	6 Contacts
IDENT AS	P/N 816978A00 Second Lot Identified as SCE1 thru SCE6
MATERIAL	.050 CF Brass #2, Alloy 230 Silver Plated
CONDITION	*
TEST TO	ITE 51664A Rev. 5 and Client Instructions
TEST PER	*
PURPOSE	*
SPEC INST	Return specimens

PROPERTIES AS SUPPLIED

SEMI-QUANTITATIVE SPECTRO CHECK OF PLATING	Disp
S/N SCE1 The spectrographically detectable elements are present in approximately the required amounts for Silver.	In Spec
S/N SCE2 The spectrographically detectable elements are present in approximately the required amounts for Silver.	In Spec
S/N SCE3 The spectrographically detectable elements are present in approximately the required amounts for Silver.	In Spec
S/N SCE4 The spectrographically detectable elements are present in approximately the required amounts for Silver.	In Spec
S/N SCE5 The spectrographically detectable elements are present in approximately the required amounts for Silver.	In Spec
S/N SCE6 The spectrographically detectable elements are present in approximately the required amounts for Silver.	In Spec

TEST REPORT

DIRATS LABORATORIES

ABB Combustion Engineering
Nuclear Spare Parts
Windsor, CT 06095-0500

Report Number	226981
Report Date	29-AUG-95
Page	2 of 3

QUANTITATIVE ANALYSIS BY XRF

Sample	SCE1 BASE METAL	SCE2 BASE METAL	SCE3 BASE METAL	SCE4 BASE METAL
%				
Cu	85.66	85.58	85.67	85.80
Fe	0.01	0.01	0.01	0.01
Pb	<0.01	<0.01	<0.01	<0.01
Zn	REM	REM	REM	REM
Cu and sum of named elements:	99.99	99.98	99.97	99.98
	For Info	For Info	For Info	For Info

Sample	SCE5 BASE METAL	SCE6 BASE METAL
%		
Cu	85.69	85.78
Fe	0.01	0.01
Pb	<0.01	<0.01
Zn	REM	REM
Cu and sum of named elements:	99.99	99.99
	For Info	For Info

The symbol < signifies not detected at the detectability limit indicated.

HARDNESS TEST OF BASE METAL

Sample	Hardness	Disp
SCE1	HR30T 67	For Info
SCE2	HR30T 67	For Info
SCE3	HR30T 67	For Info
SCE4	HR30T 67	For Info
SCE5	HR30T 67	For Info
SCE6	HR30T 68	For Info

Note: No authorized hardness conversion table for this material.

DIRATS LABORATORIES

TEST REPORT

ABB Combustion Engineering
Nuclear Spare Parts
Windsor, CT 06095-0500

Report Number 226981
Report Date 29-AUG-95

	Disp
METALLOGRAPHIC EXAMINATION OF PLATING	
Sample: SCE1 Thickness: Min. 0.00010", Max. 0.00020"*, Predom. 0.00010"; see photo.	Off Spec
Sample: SCE2 Thickness: Min. 0.00010", Max. 0.00020"*, Predom. 0.00020"*; see photo.	Off Spec
Sample: SCE3 Thickness: Min. 0.00005", Max. 0.00010", Predom. 0.00010"	In Spec
Sample: SCE4 Thickness: Min. 0.00005", Max. 0.00010", Predom. 0.00010"	In Spec
Sample: SCE5 Thickness: Min. 0.00005", Max. 0.00010", Predom. 0.00010"	In Spec
Sample: SCE6 Thickness: Min. 0.00005", Max. 0.00010", Predom. 0.00010"	In Spec

PHOTOGRAPHS ARE ATTACHED

WE CERTIFY THIS IS A TRUE COPY OF OUR RECORDS
Signed for J. Dirats and Co. by Richard C. Simmons, Technical Manager
NOTE: The recording of false, fictitious or fraudulent statements or entries on this document may be punished as a felony under federal law.

HK Switchgear which may incorporate Alloy 260 conductor strips
with possible forming cracks into secondary disconnect assembly

Utility	Station	S.O.	Type	Date	Product
ARKANSAS POWER & LIG	ARKANSAS NUCLEAR ONE	33-55472	ORIG	03/00/84	5HK
ARKANSAS POWER & LIG	ARKANSAS NUCLEAR ONE	33-55662	ORIG	10/00/84	5HK
BALTIMORE GAS & ELEC	CALVERT CLIFFS	33-46743	ORIG	09/07/71	15HK &3KA NSPB
CAROLINA POWER & LIG	BRUNSWICK	33-47219	ORIG	01/11/73	5HK350
CINCINATTI GAS & ELE	ZIMMER	33-49297	ORIG	12/05/74	5HK
CINCINATTI GAS & ELE	ZIMMER	33-51828	ORIG	06/00/77	5HK
CINCINATTI GAS & ELE	ZIMMER	33-51828	ORIG	06/00/77	7.5HK
CINCINATTI GAS & ELE	ZIMMER	33-54797	ORIG	09/00/81	5HK
CLEVELAND ELEC. ILLU	PERRY	33-51958	ORIG	03/03/83	5HK350
COMISION FED DE ELEC	LAGUNA VERDE	33-53462	ORIG	04/00/81	5HK
COMISION FED DE ELEC	LAGUNA VERDE	33-53462	ORIG	02/00/81	5HK 350
COMMONWEALTH EDISON	LASALLE	33-50080	ORIG	12/09/77	7.5HK - 5HK
COMMONWEALTH EDISON	LASALLE	33-52612	ORIG	04/00/78	5HK
COMMONWEALTH EDISON	LASALLE	33-52612	ORIG	04/00/78	7.5HK
COMMONWEALTH EDISON	ZION	33-45122	ORIG	02/05/73	5HK
CONSUMERS POWER	MIDLAND	33-39708	ORIG	05/00/82	5HK
CONSUMERS POWER	MIDLAND	33-50382	ORIG	01/23/82	5HK250
DETROIT EDISON	ENRICO FERMI	33-47196	ORIG	11/00/83	5HK
DUKE POWER	CATAWBA	33-40616	ORIG	03/15/82	5HK
DUKE POWER	CATAWBA	33-50465	ORIG	07/00/80	5HK
DUKE POWER	CATAWBA	33-52420	ORIG	10/00/77	7.5HK
DUKE POWER	McGUIRE	33-48564	ORIG	10/02/74	7.5HK
DUKE POWER	MCGUIRE	33-50684	orig	03/26/74	7.5HK RCP SWGR
DUKE POWER	McGUIRE	33-51059	ORIG	11/24/75	15HK
DUKE POWER	OCONEE	33-39402	ORIG	02/12/82	7.5HK
DUKE POWER	OCONEE	33-53272	ORIG	01/00/79	5HK
DUKE POWER	OCONEE	33-53566	ORIG	03/00/80	5HK
DUKE POWER	OCONEE	33-53719	ORIG	05/00/79	5HK
DUQUESNE LIGHT COMPA	BEAVER VALLEY	33-46690	ORIG	04/21/75	5HK & NSPB
DUQUESNE LIGHT COMPA	BEAVER VALLEY	33-50661	ORIG	10/00/83	5HK350
DUQUESNE LIGHT COMPA	BEAVER VALLEY	33-50661	ORIG	07/00/83	5KV HPLC 2kA

ATTACHMENT #3

Utility	Station	S.O.	Type	Date	Product
FLORIDA POWER CORP.	CRYSTAL RIVER	33-46256	ORIG	12/21/70	5HK 250
GULF STATES UTILITIE	RIVER BEND	33-51128	ORIG	04/00/80	5HK250
HOUSTON LIGHTING & P	SOUTH TEXAS PROJECT	33-52769	ORIG	02/14/79	5HK250
HOUSTON LIGHTING & P	SOUTH TEXAS PROJECT	37-53190	ORIG	09/00/79	15HK
HYDRO-ELECTRIC POWER	PICKERING GENERATING ST	61-73386	ORIG	08/31/78	5HK, HPL-C 5KV
INDIANA & MICHIGAN E	DONALD C. COOK	33-44322	ORIG	03/15/72	K-LINE: 5HK250
INDIANA & MICHIGAN E	DONALD C. COOK	33-44322	ORIG	07/16/71	K-LINE; 5HK250
INDIANA & MICHIGAN E	DONALD C. COOK	33-48878	ORIG	01/31/73	5HK
INDIANA & MICHIGAN E	DONALD C. COOK	33-533[illegible]2	ORIG	04/00/79	5HK
MISSISSIPPI POWER &	GRAND GULF	33-50469	ORIG	09/00/76	5HK
MISSISSIPPI POWER &	GRAND GULF	33-50469	ORIG	09/26/78	5HK
MISSISSIPPI POWER &	GRAND GULF	33-50470	ORIG	06/00/76	7.5HK
NIAGARA MOHAWK	NINE MILE POINT	33-53152	ORIG	05/00/83	15HK
NORTHEAST UTILITIES	MILLSTONE	33-49988	ORIG	08/00/81	K-LINE/5HK
PECO	LIMERICK	33-47651	ORIG	03/00/77	5HK-350
PECO	LIMERICK	33-55112	ORIG	01/04/83	5HK-250
PECO	LIMERICK	33-55112	ORIG	03/02/83	5HK-350
PORTLAND GENERAL ELE	TROJAN	33-47354	ORIG	02/25/72	5HK
PUBLIC SERVICE ELEC.	HOPE CREEK	33-52260	ORIG	04/13/81	5HK350
PUBLIC SERVICE ELEC.	HOPE CREEK	33-52260	ORIG	11/01/83	5HK350
PUBLIC SERVICE INDIA	MARBLE HILL	33-52660	ORIG	08/20/80	5HK
PUBLIC SERVICE INDIA	MARBLE HILL	37-52213	ORIG	07/00/80	5HK
PUBLIC SERVICE INDIA	MARBLE HILL	37-52213	ORIG	10/00/81	7.5HK
PUBLIC SERVICE NEW H	SEABROOK	33-50750	ORIG	06/00/85	5HK
SMUD	RANCHO SECO	33-45966	ORIG	05/28/71	5HK & 5KV NSPB
SOUTHERN CALIFORNIA	SAN ONOFRE	33-03544	ORIG	06/01/83	5HK
SOUTHERN CALIFORNIA	SAN ONOFRE	33-40591	ORIG	06/23/82	5HK
SOUTHERN CALIFORNIA	SAN ONOFRE	33-50395	ORIG	04/00/76	5HK
TAIWAN POWER	KUOSHENG	33-50735	ORIG	05/23/77	5HK
TAIWAN POWER	KUOSHENG	33-53430	ORIG	02/00/81	15HK
TEXAS UTILITIES	COMANCHE PEAK	33-51261	ORIG	09/22/78	7.5HK
TVA	BELLEFONTE	33-36330	ORIG	10/28/81	7.5HK & 15HK
TVA	BELLEFONTE	33-36381	ORIG	10/28/81	7.5HK

Utility	Station	S.O.	Type	Date	Product
TVA	BELLEFONTE	33-51014	ORIG	06/00/77	7.5HK
TVA	BELLEFONTE	33-51014	ORIG	03/00/79	15HK
TVA	HARTSVILLE	37-52313	ORIG	07/00/80	7.5HK
TVA	HARTSVILLE	37-52313	ORIG	10/00/80	7.5HK
TVA	SEQUOYAH	33-35447	ORIG	01/11/79	7.5HK
TVA	SEQUOYAH	33-37216	ORIG	03/00/82	7.5HK
TVA	SEQUOYAH	33-40441	ORIG	08/00/82	7.5HK
TVA	SEQUOYAH	33-41666	ORIG	04/00/83	7.5HK
TVA	SEQUOYAH	33-47035	ORIG	02/10/72	15HK
TVA	SEQUOYAH	33-48672	ORIG	02/05/73	15HK
TVA	SEQUOYAH	33-51068	ORIG	11/14/75	7.5HK
TVA	SEQUOYAH	33-54968	ORIG	06/00/82	7.5HK
TVA	SEQUOYAH	37-54995	ORIG	05/00/82	15HK
TVA	YELLOW CREEK	33-54350	ORIG	10/00/82	7.5HK & 15HK
U.S. ATOMIC ENERGY C	FAST FLUX TEST FACILITY	33-50593	ORIG	04/09/75	15HK
U.S. DEPT OF ENERGY	GAS CENTRIFUGE ENRICH	37-55462	ORIG	12/20/83	HK,K,TR
VIRGINIA ELEC. & POW	NORTH ANNA	33-46858	ORIG	05/21/75	5HK
VIRGINIA ELEC. & POW	NORTH ANNA	33-48708	ORIG	04/26/76	5HK
WPPSS	WASHINGTON NUCLEAR PROJ	33-51659	ORIG	08/00/80	5HK
WPPSS	WASHINGTON NUCLEAR PROJ	33-54898	ORIG	04/20/82	5HK,HPLC,RCPM