# PHILADELPHIA ELECTRIC COMPANY

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Metallurgical Laboratory Note No. 85-990

## Metallurgical Analysis of the 3A and 3C Wear Rings Removed from the Residual Heat Removal Pump Impellers, Peach Bottom Unit #3

By

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# Metallurgy Laboratory Note No. 85-990

**Subject:** Metallurgical Analysis of the 3A and 3C Wear Rings Removed from the Residual Heat Removal (RHR) Pump Impellers, Peach Bottom Unit #3.

**Purpose:** To examine the impeller wear rings and determine the probable cause of cracking.

**Background:** Station Maintenance had requested Metallurgical assistance when cracked wear rings were observed during RHR Pump/Motor maintenance. The metallurgical examination and maintenance inspection results prompted an inquiry by the NRC with regard to possible implications of a generic problem. The manufacturer was Bingham-Willamette.

This laboratory note contains the Summation of Results, Conclusions and the illustrations that were presented to the NRC in Bethesda, Maryland on December 19, 1985. Also, additional illustrations, a discussion and suggestion are included.

**Conclusions:**

1. The wear rings failed by intergranular stress-assisted corrosion cracking which propagated from numerous surface indications.

2. The susceptibility of these wear rings to IGSCC was increased due to the following:

   a. Initiation sites - folds, laps and possible quench cracks.
   b. Residual OD hoop stresses from the shrink fit.
   c. Full hardness heat treatment in a susceptible material - 410SS

**Summation of Results**

1. Visually, the final fracture appears to propagate O.D. to I.D. from an older crack as judged from the gradual decline in corrosion scale. (Figures 1 & 2)

2. The wear ring material had an average Rockwell hardness of C43 (BHN 404). Bingham-Willamette specifies a range of BHN 315 to 365 (C34-C39). (Figures 2 & 3)

3. Visually, the O.D. was observed to contain a multitude of parallel cracks which were perpendicular to the hoop stress and to the abrasion, and were parallel to the fractures. (Figures 4 & 5)

4. Debris within the O.D. surface discontinuities and corrosion deposits on the fracture surface were examined by x-ray microprobe. The presence of harmful contaminates were not detected. (Figures 6 & 7)

5. The material was verified to be ASTM A182 grade F6A (410) as specified by Bingham-Willamette. (Figure 8)

6. The mode of fracture, observed by electron microscopy and metallography, was intergranular cracking. (Figures 9 & 10)

7. The O.D. of the wear rings contained undesirable indications which appeared to be folds or laps typical of a machining operation and possible quench cracks from fabrication heat treatment. (Figures 11, 12, 13, & 14)

8. The microstructure was characteristic of a 410 Martensitic stainless steel in the quenched and tempered condition. There was no evidence of elongated or worked grains on the I.D. or O.D. surface. (Figure 15)

Discussion:

The wear rings were examined visually, by metallography, by electron microscopy, for semi-quantitive chemical verification, for microhardness and Rockwell hardness. The attached figures document our findings and are referenced in the Summation of Results.

The results of this examination suggest that the austenitizing and tempering heat treating temperatures were not chosen for the optimum combination of hardness, toughness and corrosion resistance properties.

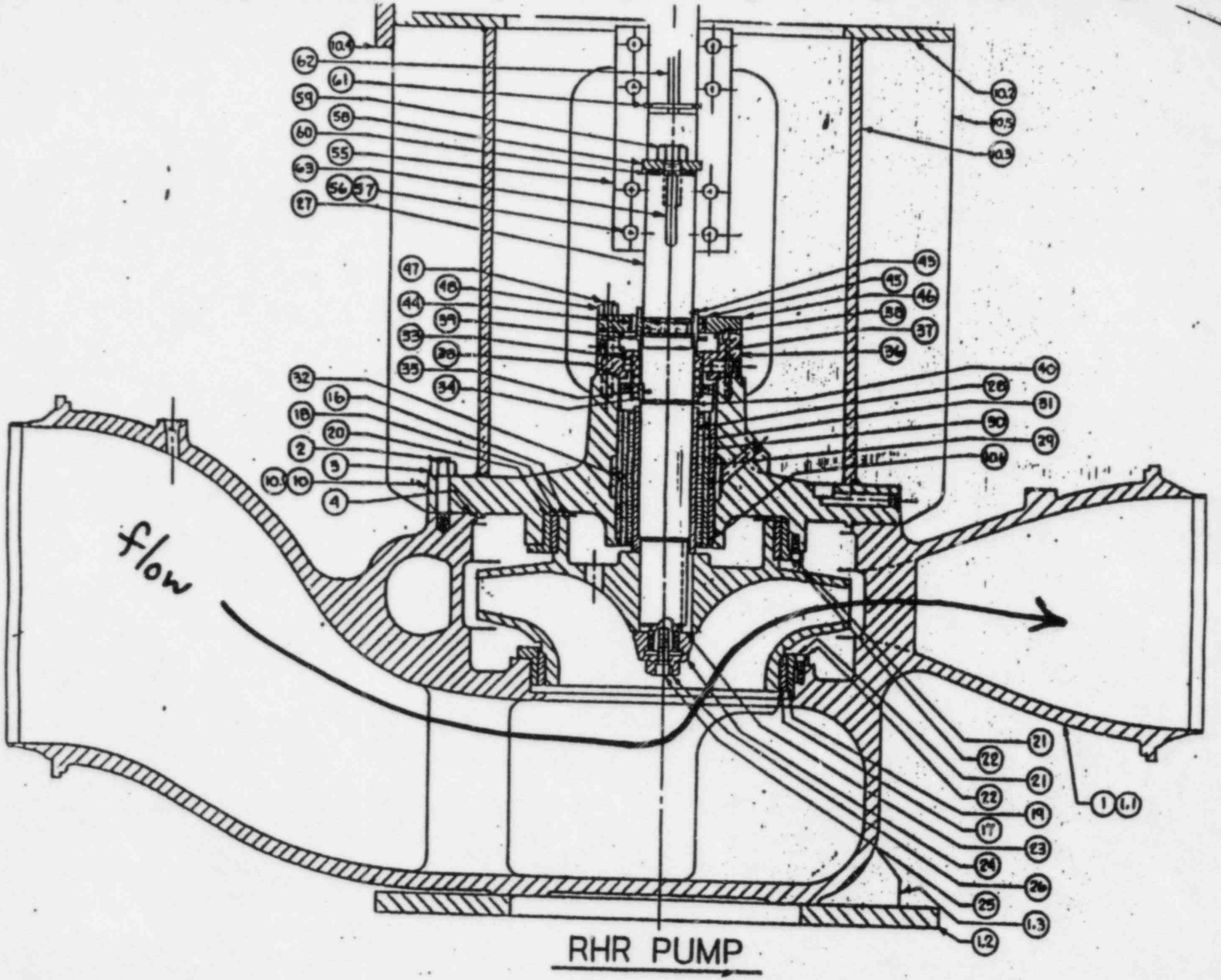
Similar failures were reported by Bechtel, Materials and Quality Services Department, at the Palo Verde Nuclear Generating Station. Their auxiliary feedwater pump, manufactured by Bingham-Willamette, had wear rings fabricated from type 440A Martensitic stainless steel. The reported specified heat treatment required full austenitization with a tempering temperature that achieved near full hardenability.

Additionally, several parallel cracks adjacent to the main fracture were observed on the wear ring O.D. surface. The pattern of these cracks was reported as being similar to that of grinding cracks.

Suggestion: The results of this examination suggest that Bingham-Willamette, the manufacture, review their 410SS wear ring processing sequence from forging through to final grind in order to optimize the desired hardness and corrosion properties for this shrink fit application. Alternate materials not susceptible to stress corrosion cracking or embrittlement should be considered by the manufacture.

R. John Diletto

Prepared by: R. John Diletto


flow
RHR PUMP

PARTS LIST WITH MATERIAL DESIGNATIONS 270683/690

| PART No. | PART DESCRIPTION | QTY | MATERIAL DESIGNATION |
|---|---|---|---|
| 1 | VOLUTE: Consisting of part 1, 2 & 3 | | |
| 1.1 | Volute Case | 1 | ASTM A216, GR. WCB |
| 1.2 | Base Plate (welded to Vol.) | 1 | ASTM A36 |
| 1.3 | Ribs (Welded to Volute) | 4 | ASTM A36 |
| 2 | Studs (Volute) | 24 | ASTM A193, GR. B7 |
| 3 | Nuts (Volute Studs) | 24 | ASTM A194, GR. 2H |
| 4 | Gasket (Volute) | 1 | AISI 304 Asbestos Filled |
| 5 | Plug (Volute Drain & Vent) | 2 | ASTM A181 GR. II |
| 6 | Plug (Volute Vent) | 1 | ASTM A181 GR. II |
| 10 | STUFFING BOX W/ DRIVER STAND: Consisting of Parts 10.1 thru 10.6 | | |
| 10.1 | Stuffing Box | 1 | ASTM A216 GR. WCB |
| 10.2 | Motor Base (Weld to 10.3 & 10.5) | 1 | ASTM A36 |
| 10.3 | Riser Pipe (Welded to 10.1, 10.2 & 10.5) | 1 | ASTM A36 |
| 10.4 | Lug | 4 | ASTM A36 |
| 10.5 | Ribs (Welded to 10.1, 10.2 & 10.3) | 4 | ASTM A36 |
| 10.6 | Pin (Lock - Bearing - Retainer) | 1 | AISI 304 |
| 11 | Capscrews (Motor Adjusting) | 4 | SAE GR. 5 |
| 16 — | Impeller | 1 | ASTM A296, GR. CA-15 |
| 17 — | Wearing Ring (Impeller Eye) lower end of pump | 1 | ASTM A182 GR. F6, 315-365 BH Or A351 CA15 315-365 BHN |
| 18 | Wearing Ring (Impeller Hub) upper end of pump | 1 | ASTM A182 GR. F6, 315-365 BH Or A351 CA-15 315-365 BHN |
| 19 — | Wearing Ring (Volute) | 1 | Ni-Resist #2. |
| 20 | Wearing Ring (Stuffing Box) | 1 | Ni-Resist #2 |
| 21 | Hex. Soc. Hd. Capscrew (Used with parts 19 & 20) | 16 | AISI 304 |
| 22 | "Spirol" Locking Pin (Welded to 19, 20 & 21) | 16 | AISI 302 |
| 23 | Key - Impeller | 1 | AISI 416 |
| 24 | Lockmut - Impeller | 1 | AISI 304 |
| 25 | Hex - Soc. Hd. Capscrew | 1 | AISI 304 |
| 26 | "Spirol" Locking Pin (Welded to 24 & 25) | 1 | AISI 302 |
| 27 | Shaft | 1 | ASTM A276, Type 416 260-302 BHN |
| 28 | Sleeve - Shaft | 1 | AISI 403, 0.25% Ni. Max. Colmonoy #6 Overlay |
| | CARTRIDGE-JOURNAL BEARING: Consisting of parts 29 thru 32 | | |
| 29 | Retainer - Bearing Shell | 1 | CA-15 315-365 BHN |

FIGURE ①

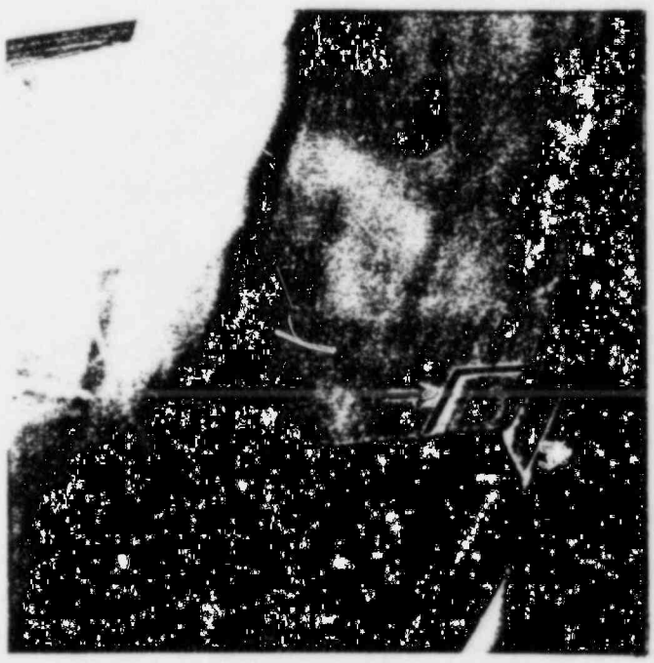
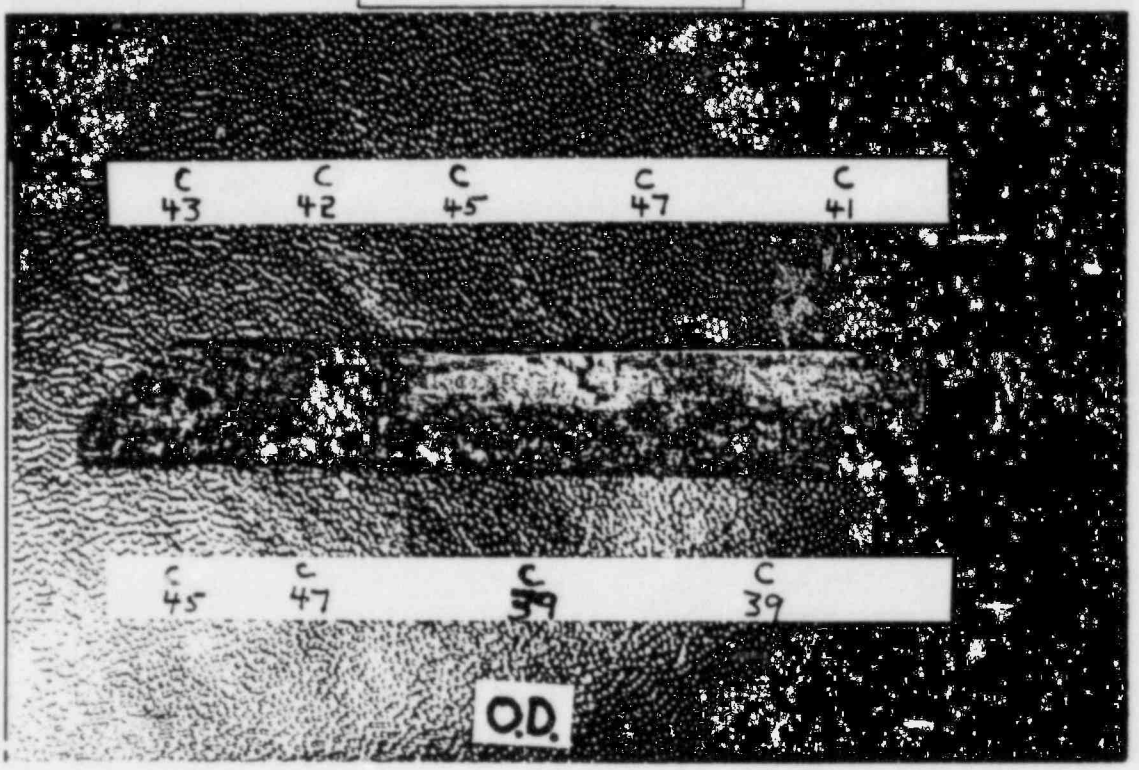
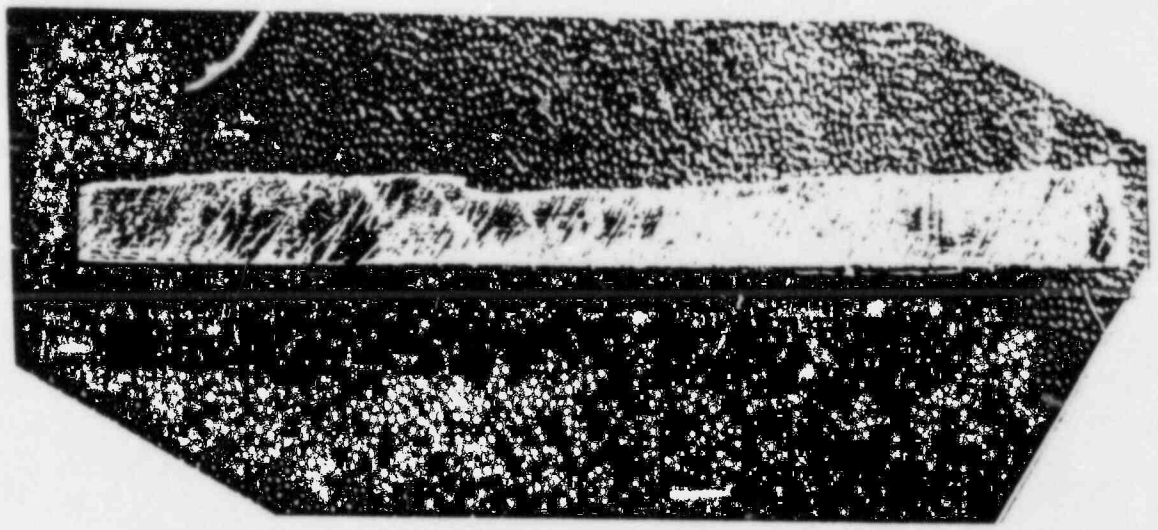


FIGURE ②



# FIGURE ③

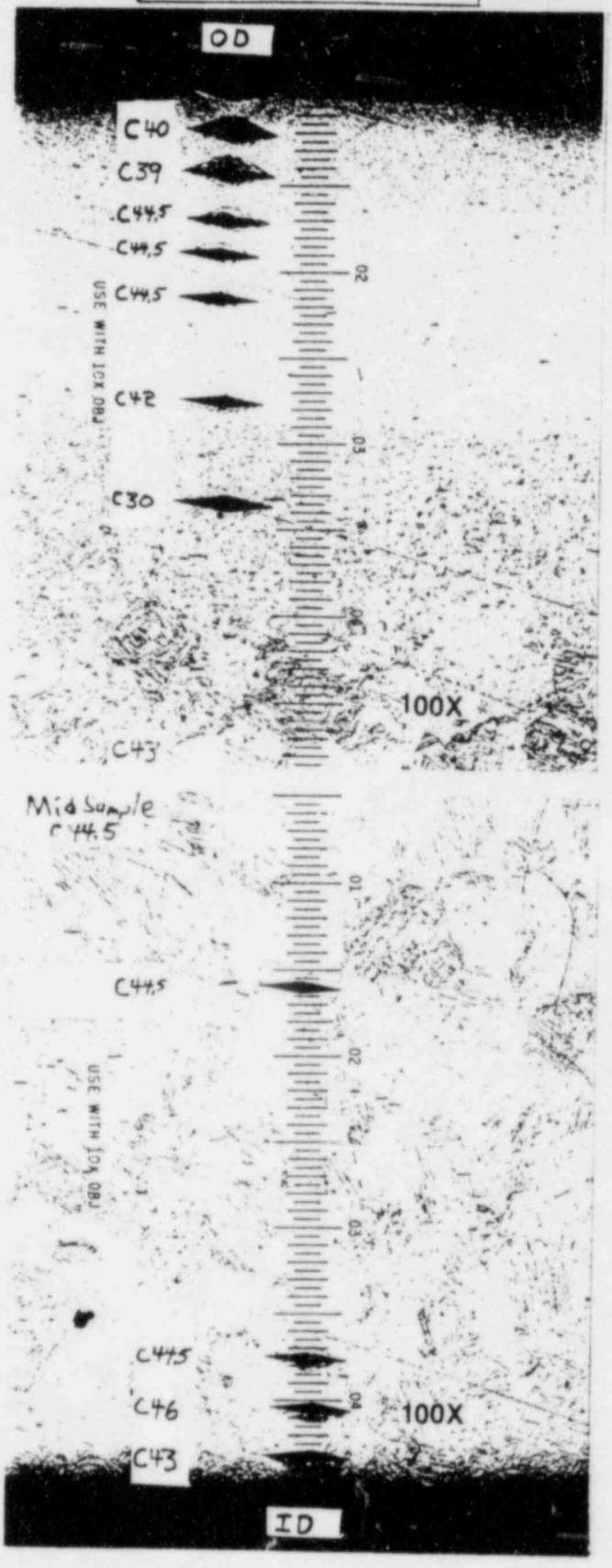
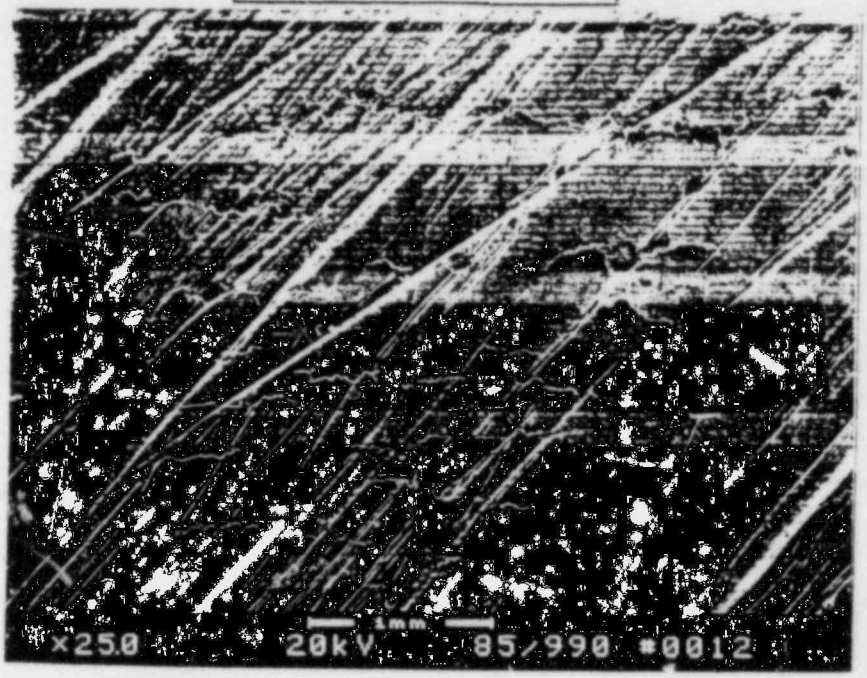

OD
C40
C39
C44.5
C44.5
C44.5
C42
C30
C43
USE WITH 10X OBJ
100X
Mid Sample
C44.5
C44.5
C44.5
C46
C43
USE WITH 10X OBJ
100X
ID

FIGURE ④



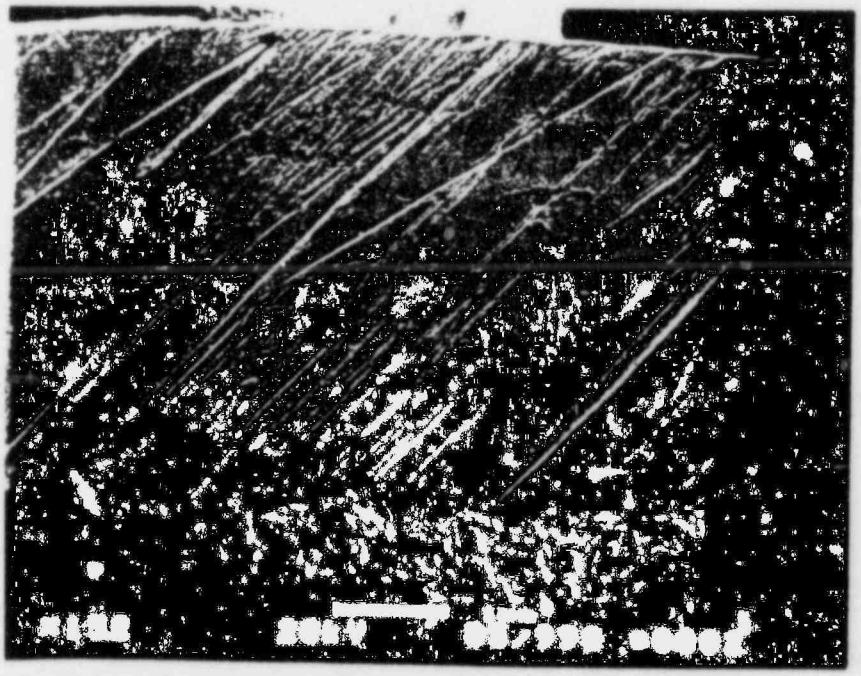
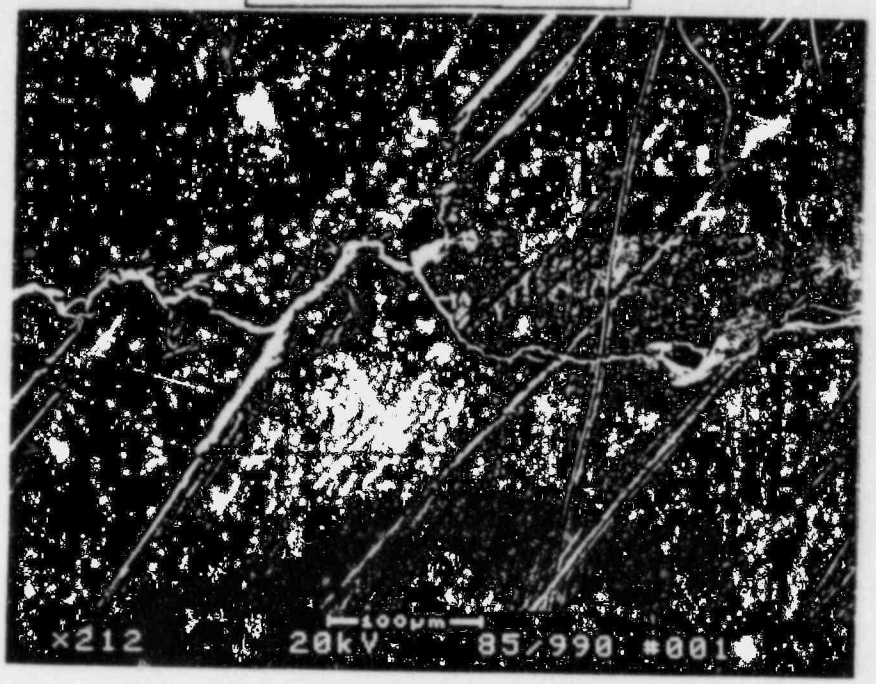



FIGURE ⑤



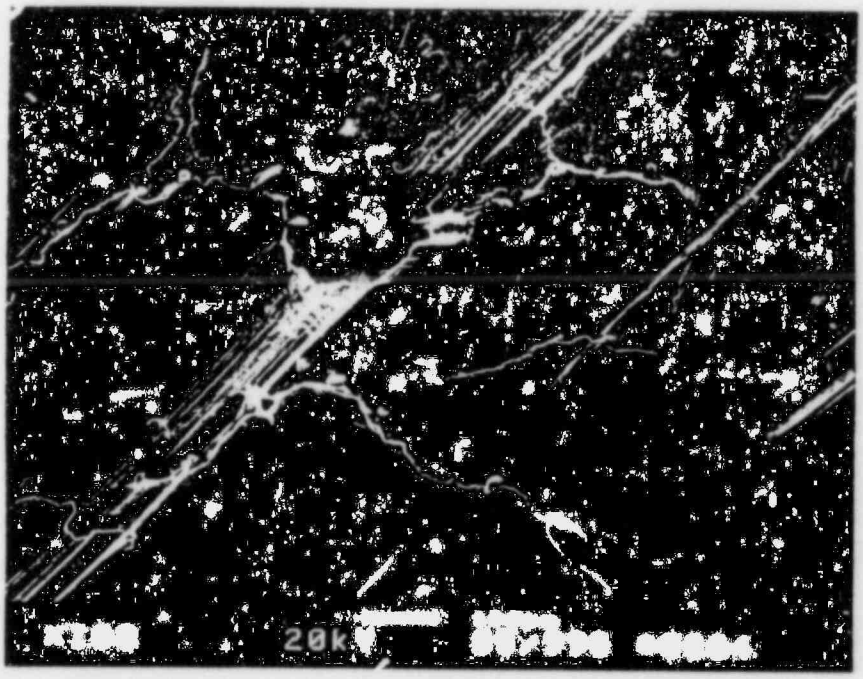
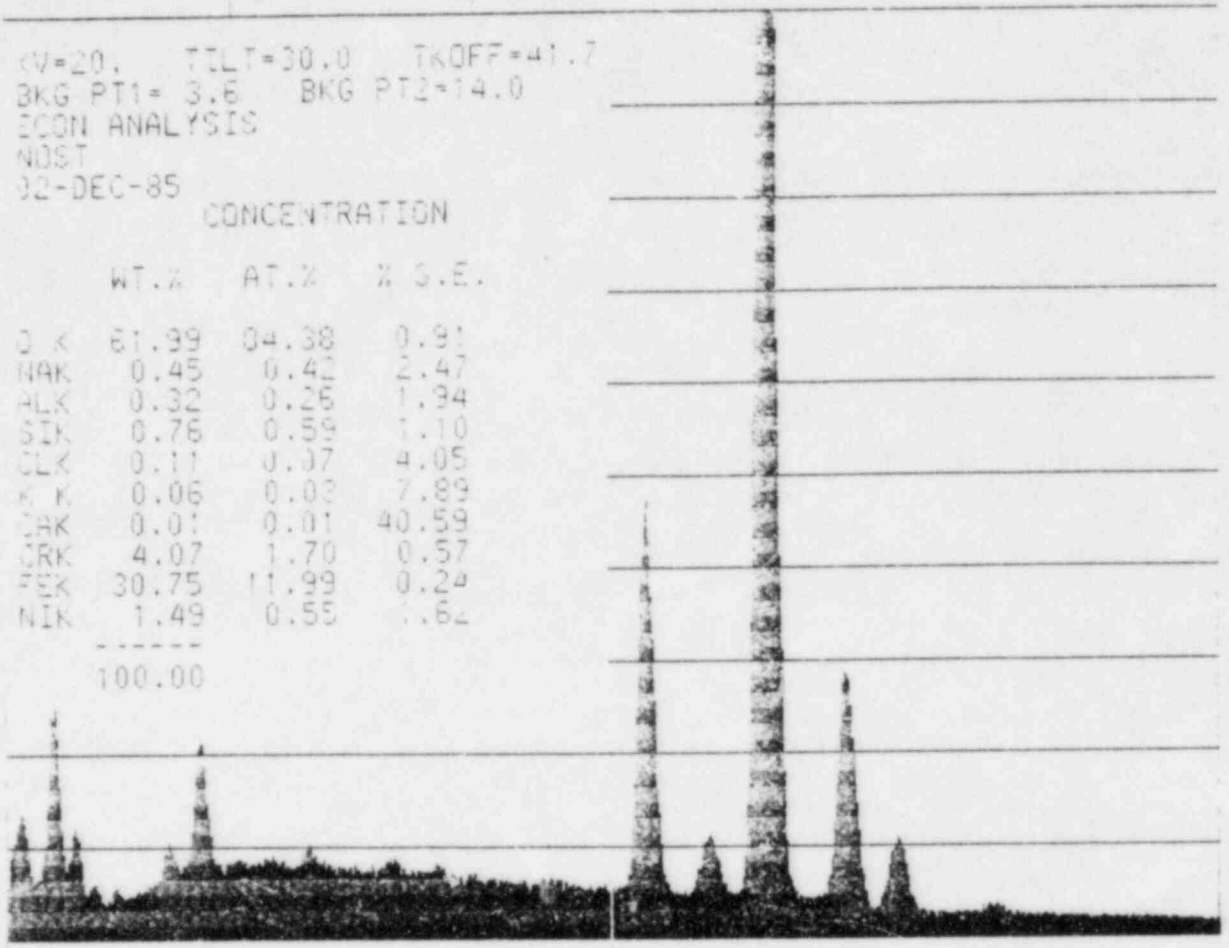



FIGURE ⑥

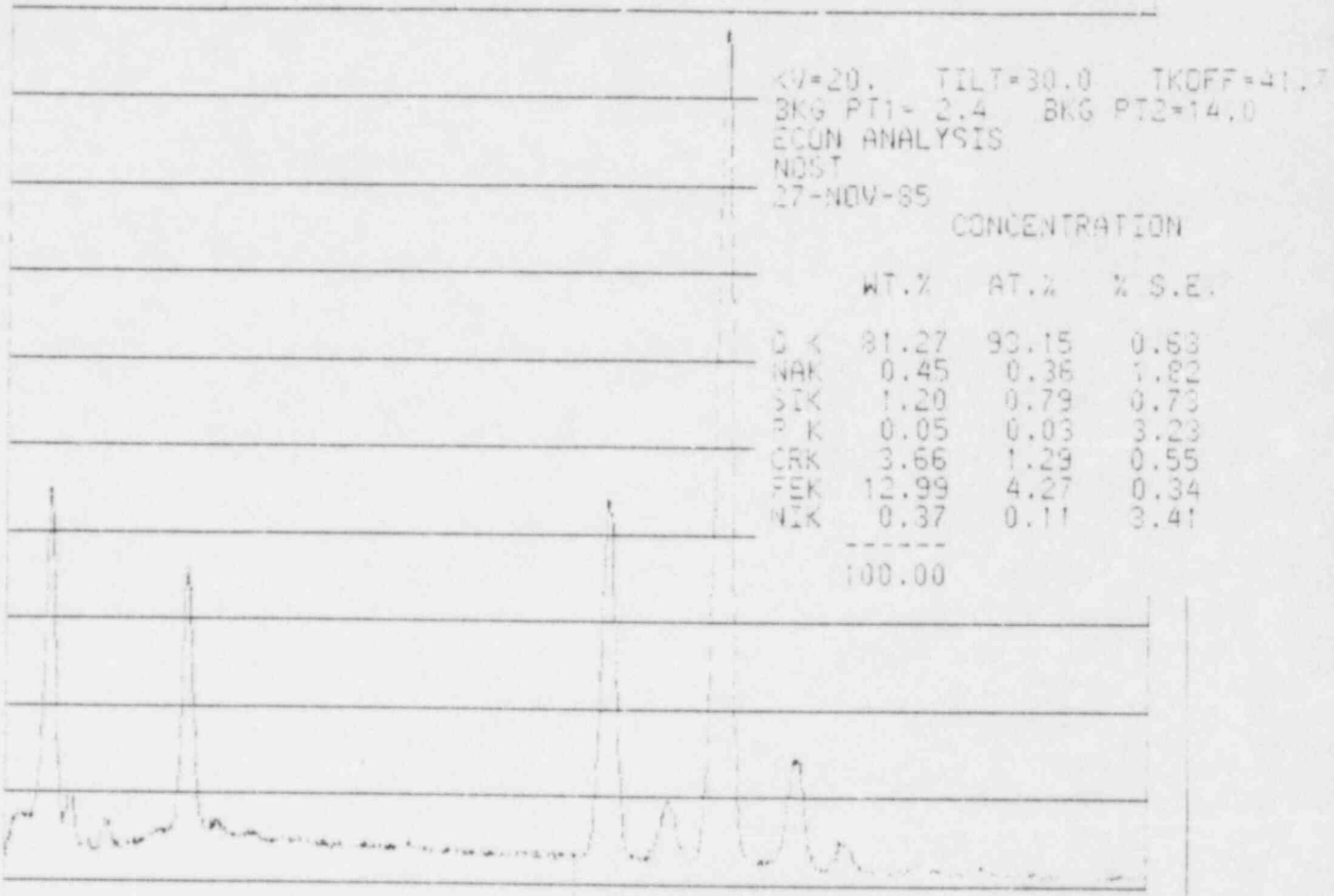
02-DEC-85
RATE:
00-20KEV:
A:
FS= 7220 MEM: A FS= 100
02 04 06 08




ON AS C KC C F N
A LI L A R E I
CURSOR (KEV)=05.120 EDAX

XRAY AT 4000X
SEE 2000X PHOTO OF CRACK

FIGURE ⑦




DEPOSITS ON # 16
3000X

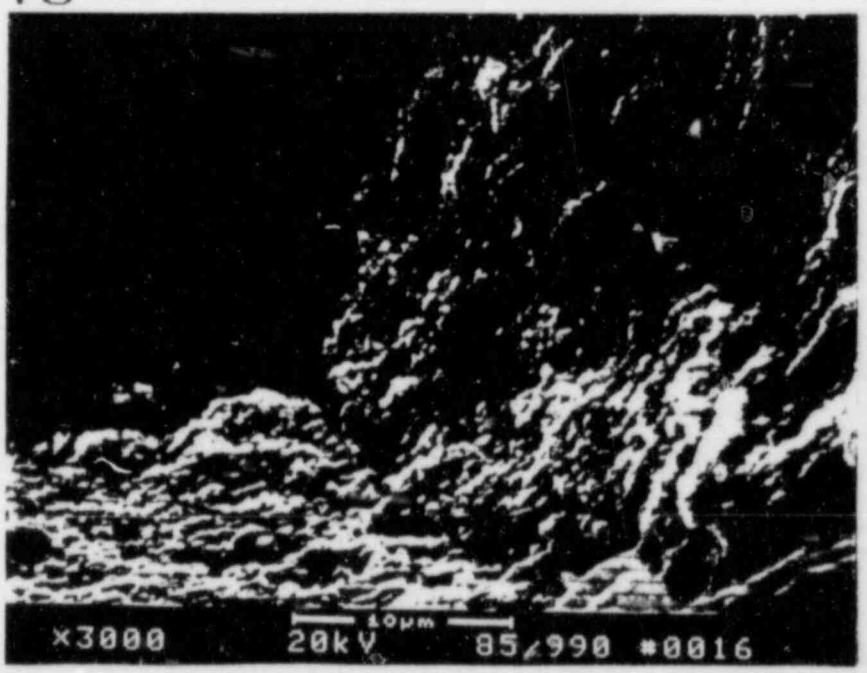
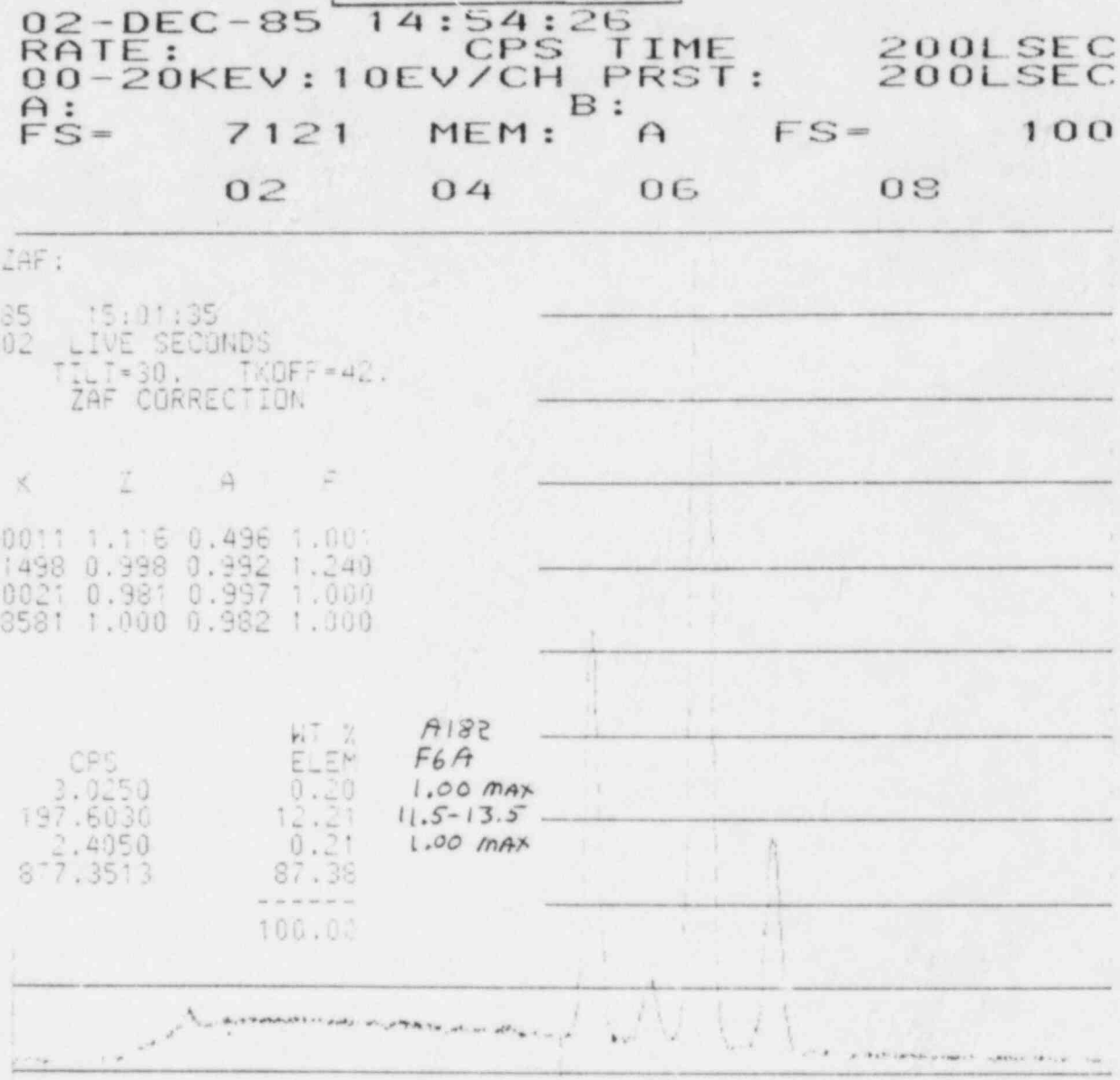
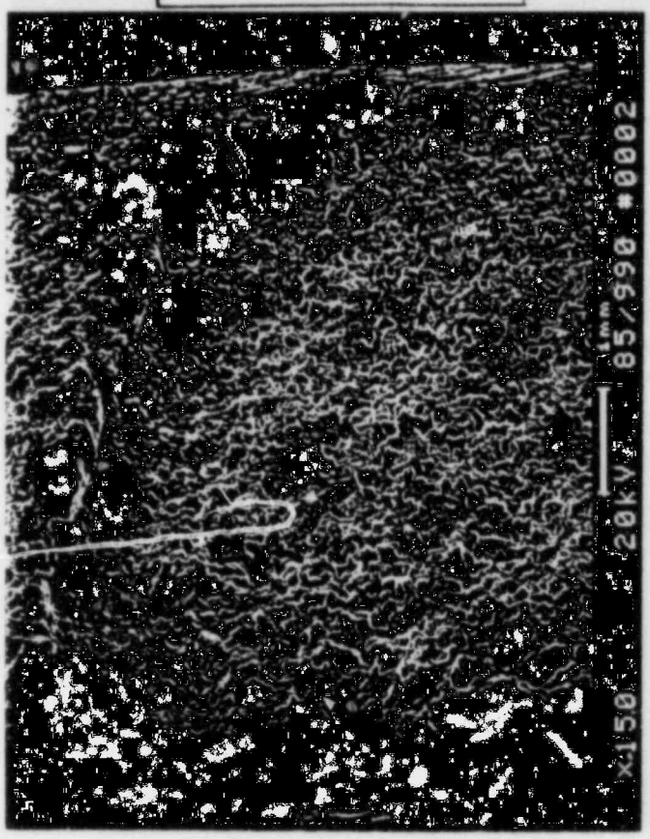


FIGURE ⑧

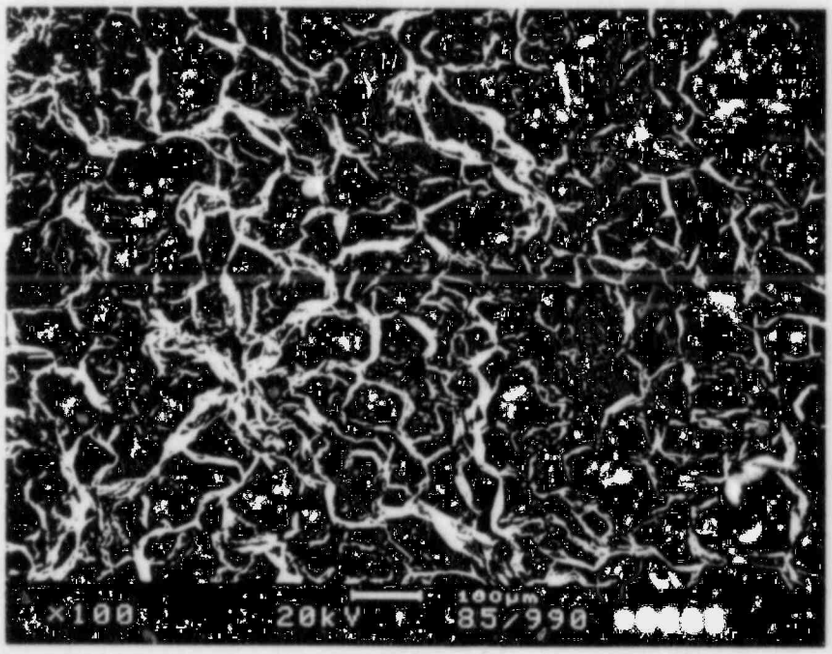



BASE MATERIAL FROM MOUNTED SAMPLE AT 200X

# FIGURE ⑨




OD to volute case.

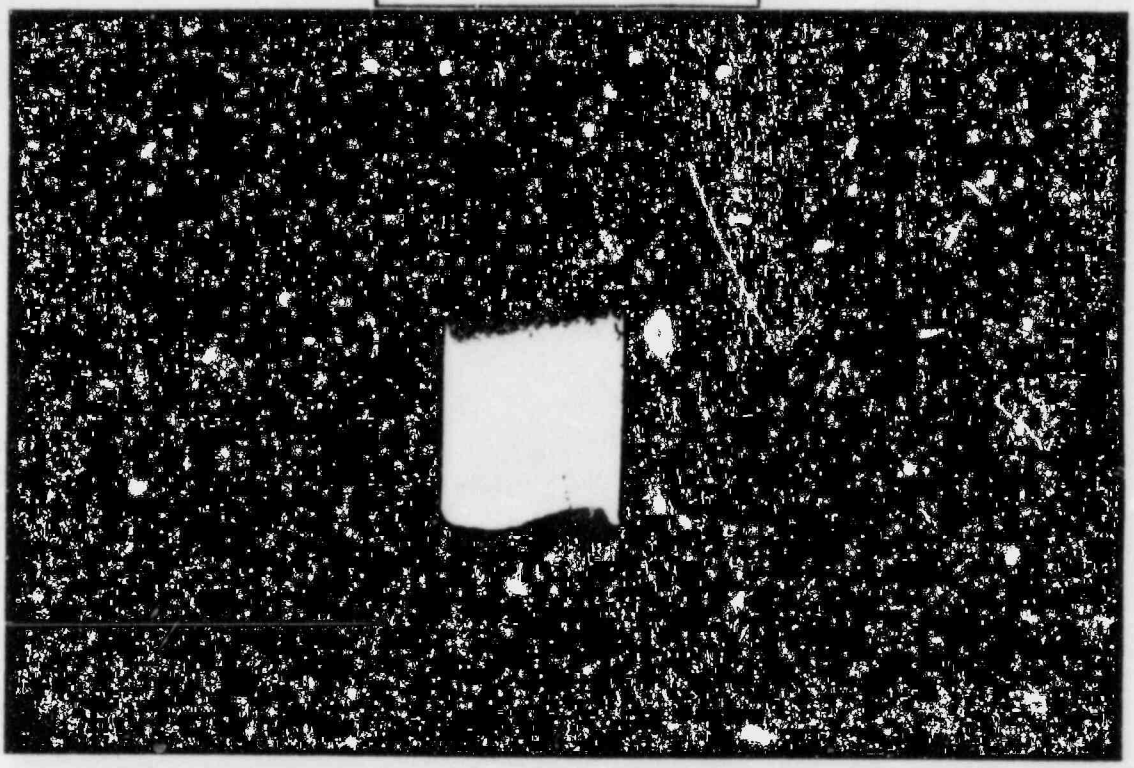


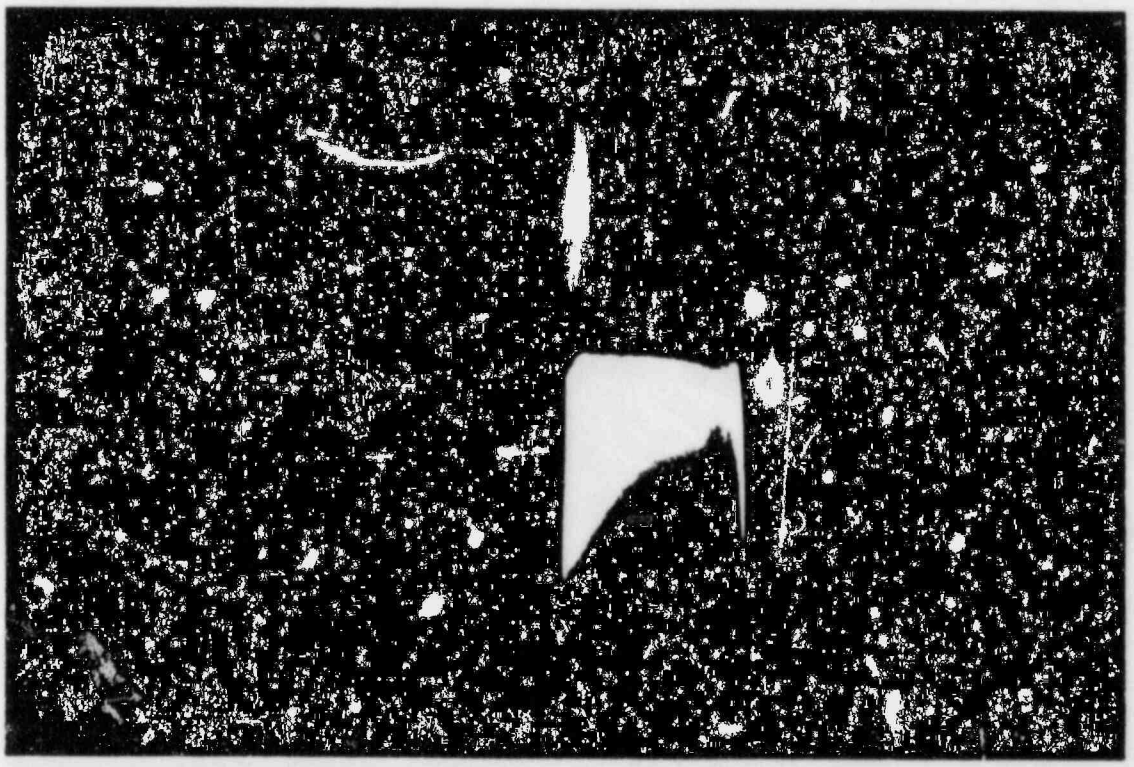
# FIGURE ⑩




CRACKING FROM MAIN FRACTURE

FIGURE (11)





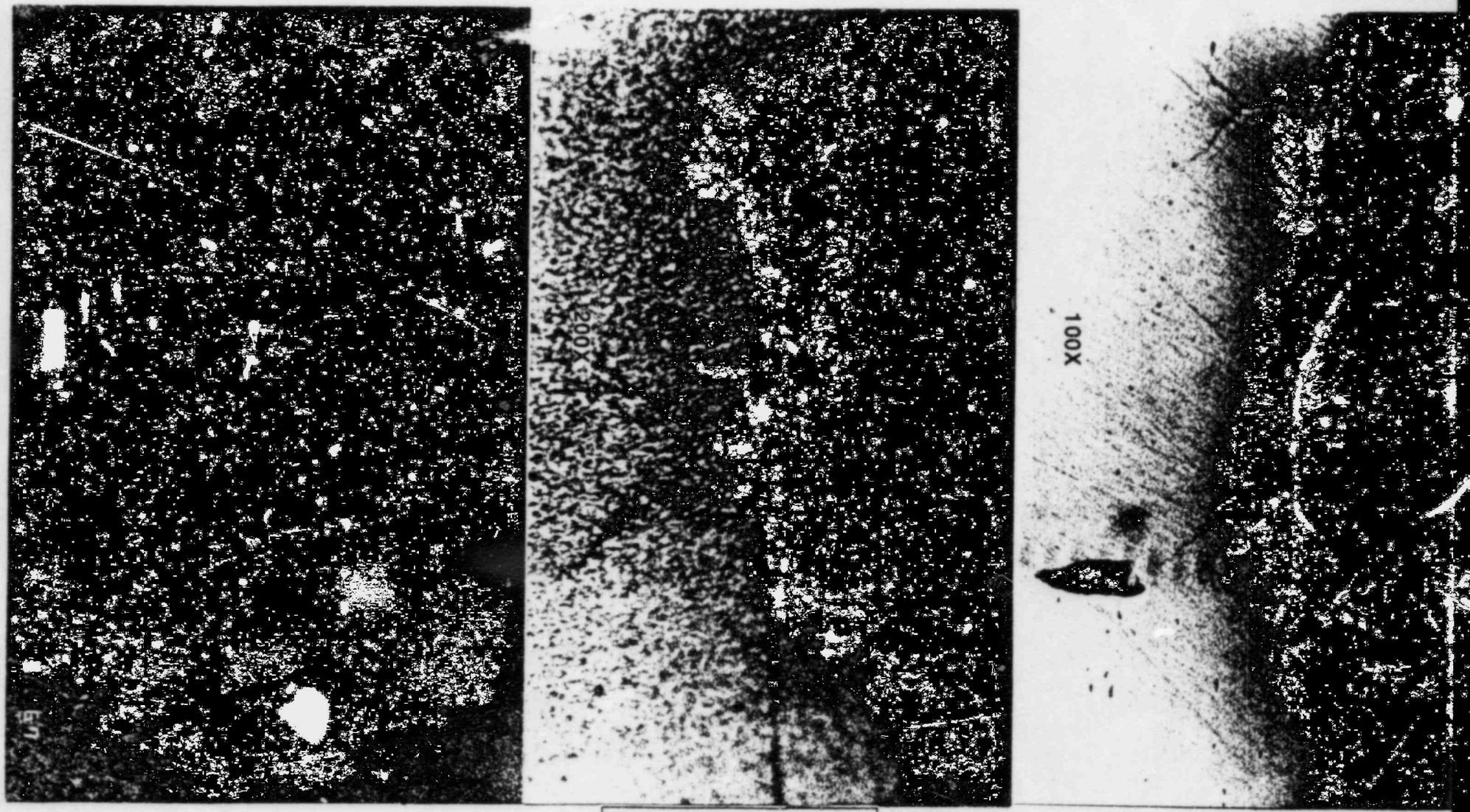
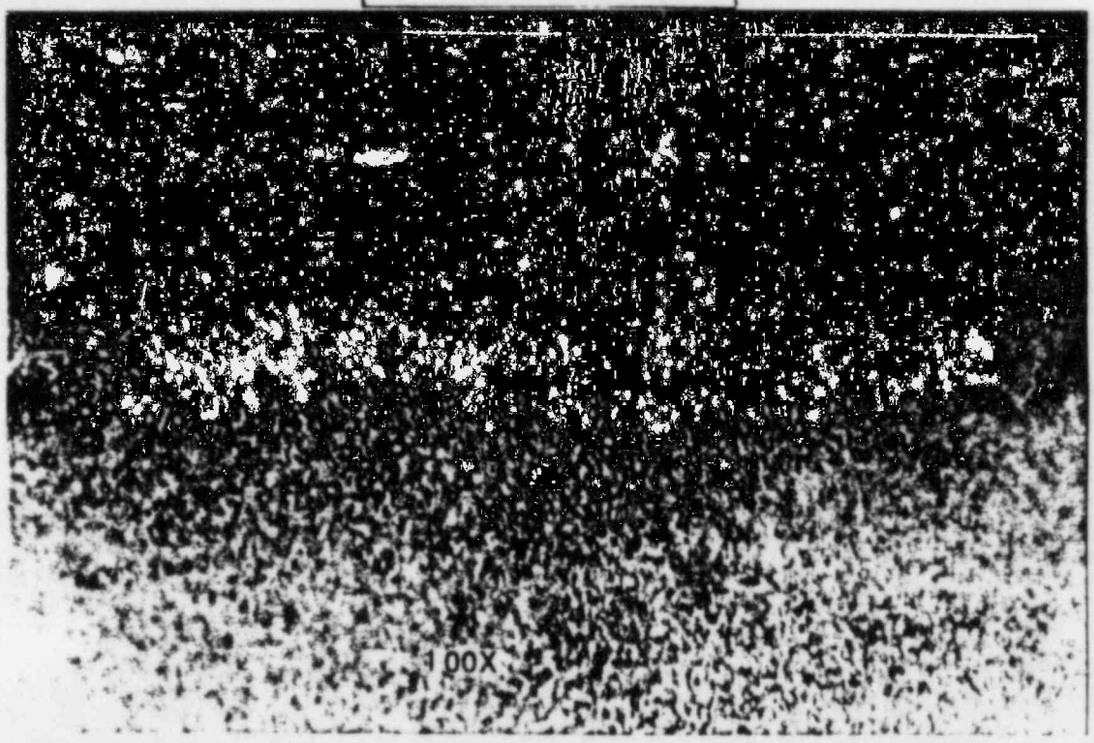



FIGURE ⑫

FIGURE ⑬



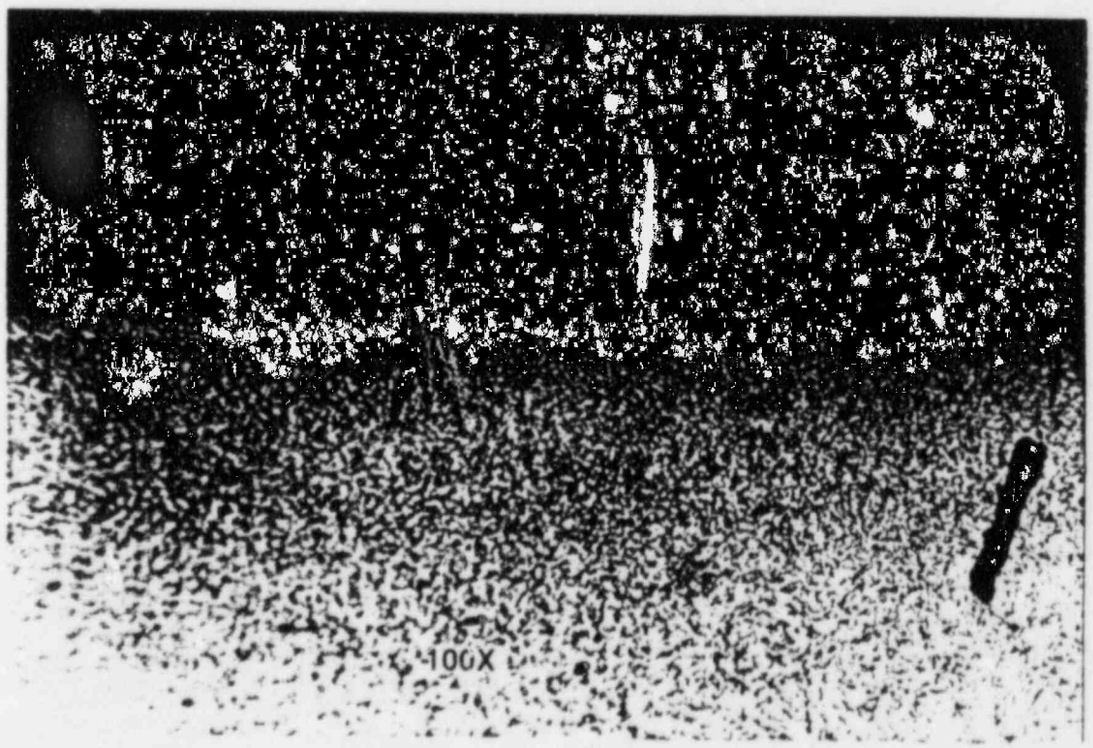
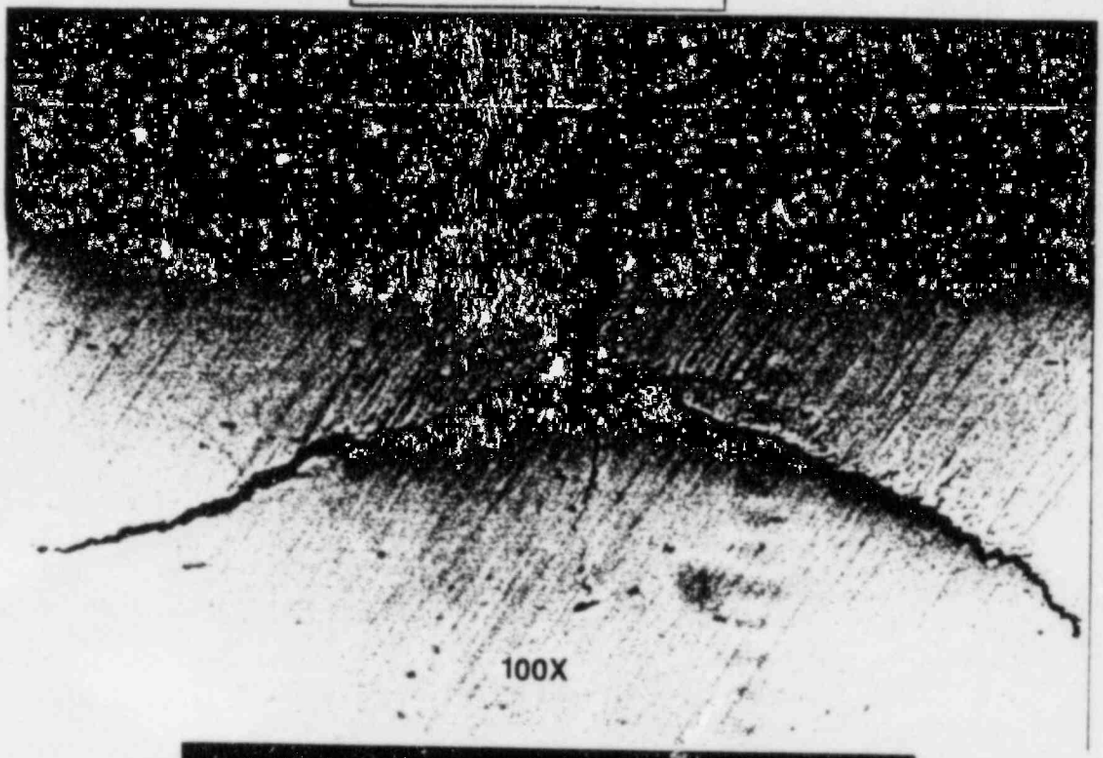



FIGURE ⑭



100X

200X

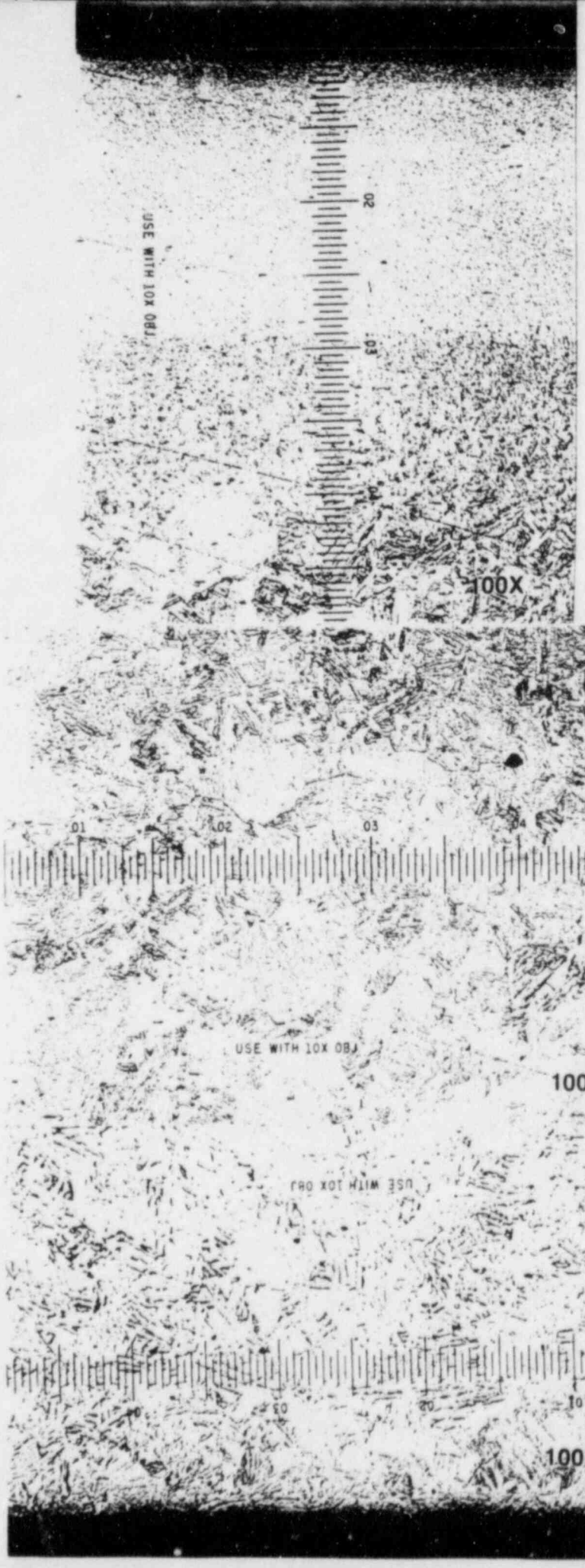



FIGURE ⑮