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POSTIRRADIATION EXAMINATION OF CENTRIFUGALLY BONDED EBR-II DRIVER FUEL

By

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PRELIMINARY REPORT

This report contains information of a preliminary nature prepared in the course of work under Atomic Energy Commission Contract AT(45-1)-1830. This information is subject to correction or modification upon the collection and evaluation of additional data.

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POSTIRRADIATION EXAMINATION OF CENTRIFUGALLY BONDED EBR-II DRIVER FUEL

R. D. Leggett, C. R. Hann, G. A. Last and W. J. Gruber

INTRODUCTION

This report was prepared by Battelle-Northwest under Contract No. AT(45-1)-1830 for the USAEC Division of Reactor Development and Technology.

Results presented herein were summarized in BNWL-1164, FFTF Monthly Informal Technical Progress Report, July 1969.

SUMMARY

BNW was requested by AEC/DRDT to assist ANL with the postirradiation examination of EBR-II driver fuel (U + 5Fs) pins that became shortened during irradiation. To date, three irradiated pins and one nonirradiated pin were examined. A portion of the data is summarized in the following tabulations.

Measurements on EBR-II Driver Fuel Pins

	Length, in.	Average Density g/cm^3	Average %ΔV/V
Control PNL No. C - Batch 112 - No. 01924	13 5/8	17.987	---
PNL No. 1 (ANL-21) - Batch 100 - No. 2244	13.479	17.667	1.81
PNL No. 2 (ANL-25) - Batch 112 - No. 1909	12.668	17.685	1.71
PNL No. 3 (ANL-40) - Batch 119 - No. 2147	12.509	17.704	1.60

DISCUSSION

The diameter changes, mass per unit length and swelling of the pins are plotted for individual 1 in. long sections in Figures 1a, b, and c as a function of position in the pin. The diameter changes were calculated assuming a nominal

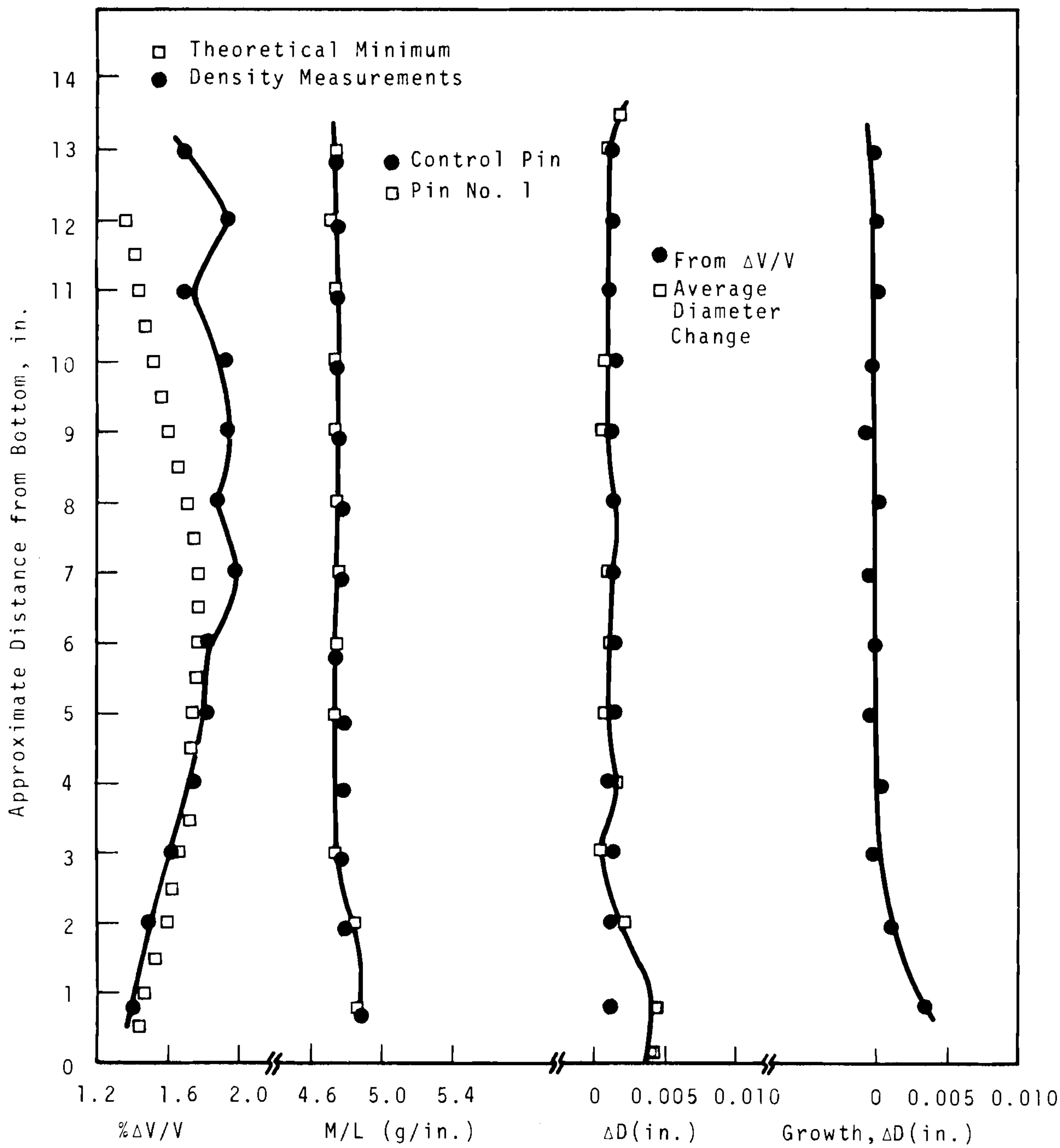


FIGURE 1a. *Postirradiation Data on EBR-II Driver Fuel Subassembly C-2178, Pin No. E-21--PNL Pin No. 1, Batch No. 100*

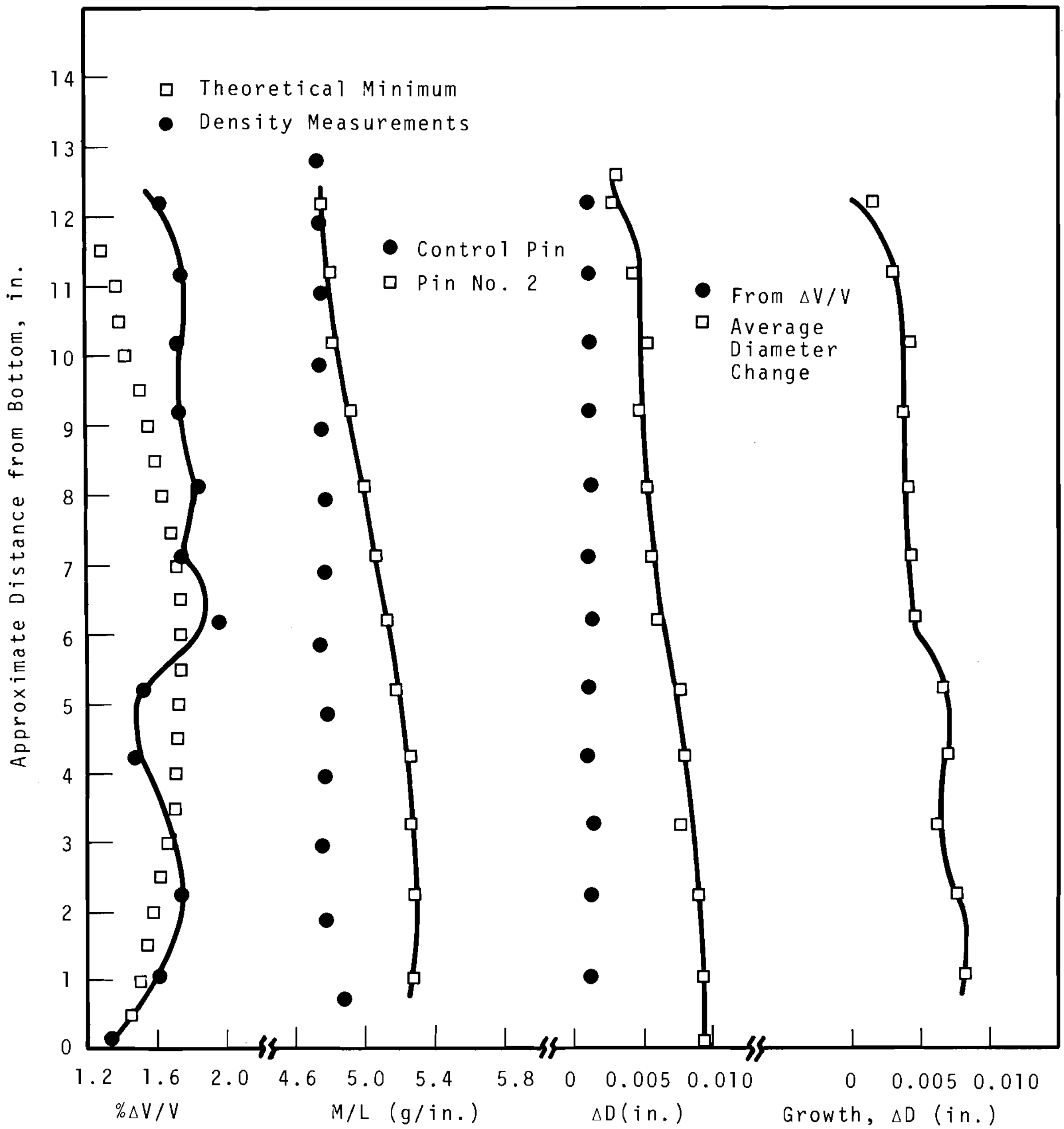


FIGURE 1b. *Postirradiation Data on EBR-II Driver Fuel Subassembly C-2178, Pin No. E-25--PNL Pin No. 2, Batch No. 112*

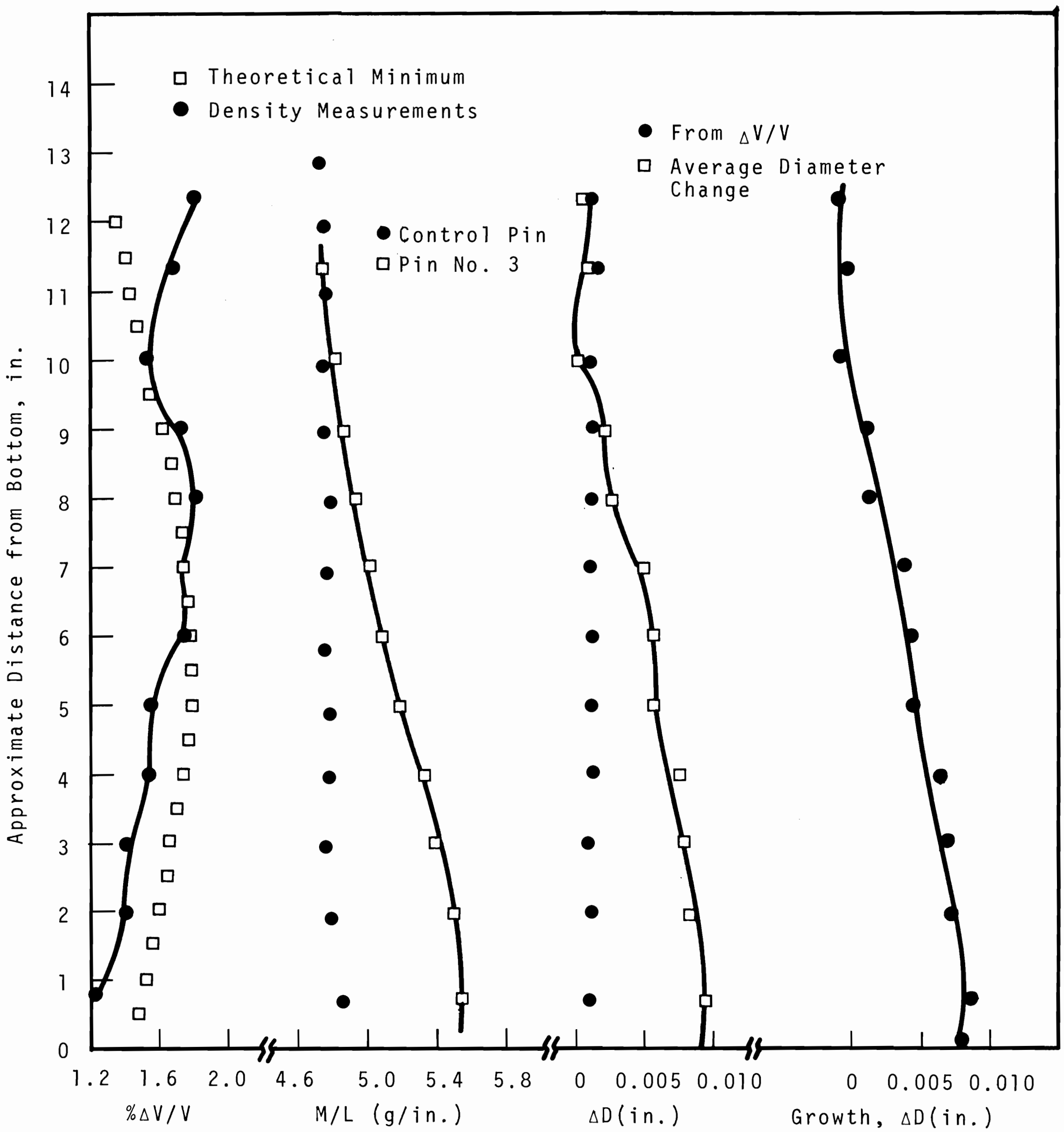


FIGURE 1c. *Postirradiation Data on EBR-II Driver Fuel Subassembly C-2178, Pin No. E-40--PNL Pin No. 3, Batch No. 119*

0.144-in. original diameter. Swelling values were calculated using the average density of the control pin as the original density. Diameter changes caused by swelling only were calculated and these values were subtracted from the diameter changes estimated from micrometer measurements. This yields a diameter change resulting only from irradiation growth which is plotted as the fourth curve in Figures 1a, b, and c. The shape of this curve is similar to the mass per unit length curve or the actual diameter change curve and clearly shows that the bulk of the diameter change results from irradiation growth. This accounts for the decrease in length.

The theoretically minimum swelling expected along the length of the pins was estimated from burnup profile data supplied by ANL. This is plotted alongside the measured swelling data in Figures 1a, b, and c for each pin. The observed swelling corresponds closely to that estimated from B.U. in the lower portion of the pins but may be somewhat higher in the upper portion. It is uncertain at the moment whether this is because of the higher operating temperatures in the upper portions or is the result of lower original densities in the pins in the upper portions. Figure 2 is a plot of the density variation in the single control pin that we have examined. In the control pin the top corresponds to the top of the casting but no record was kept on the other pins that can positively relate the top of irradiated pins to the top of the casting. Thus, there is some uncertainty in interpreting the swelling data. Nevertheless it is significant that the values are small and cannot account for the observed diameter increases or the shift in mass that occurred during irradiation with those pins that became shortened. These diameter increases with the attendant shortening can only be explained by irradiation growth due to texturing of the alpha uranium.

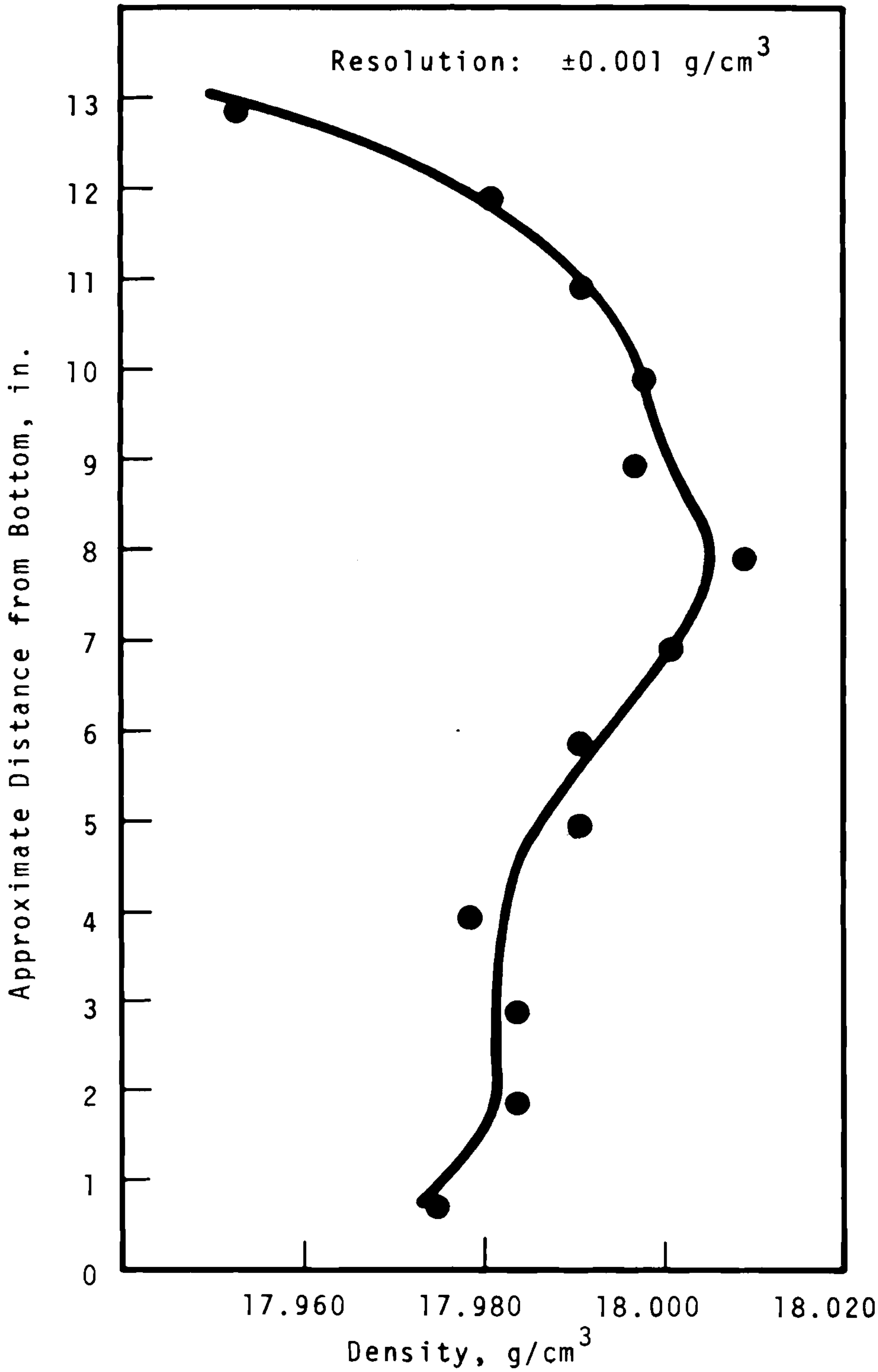
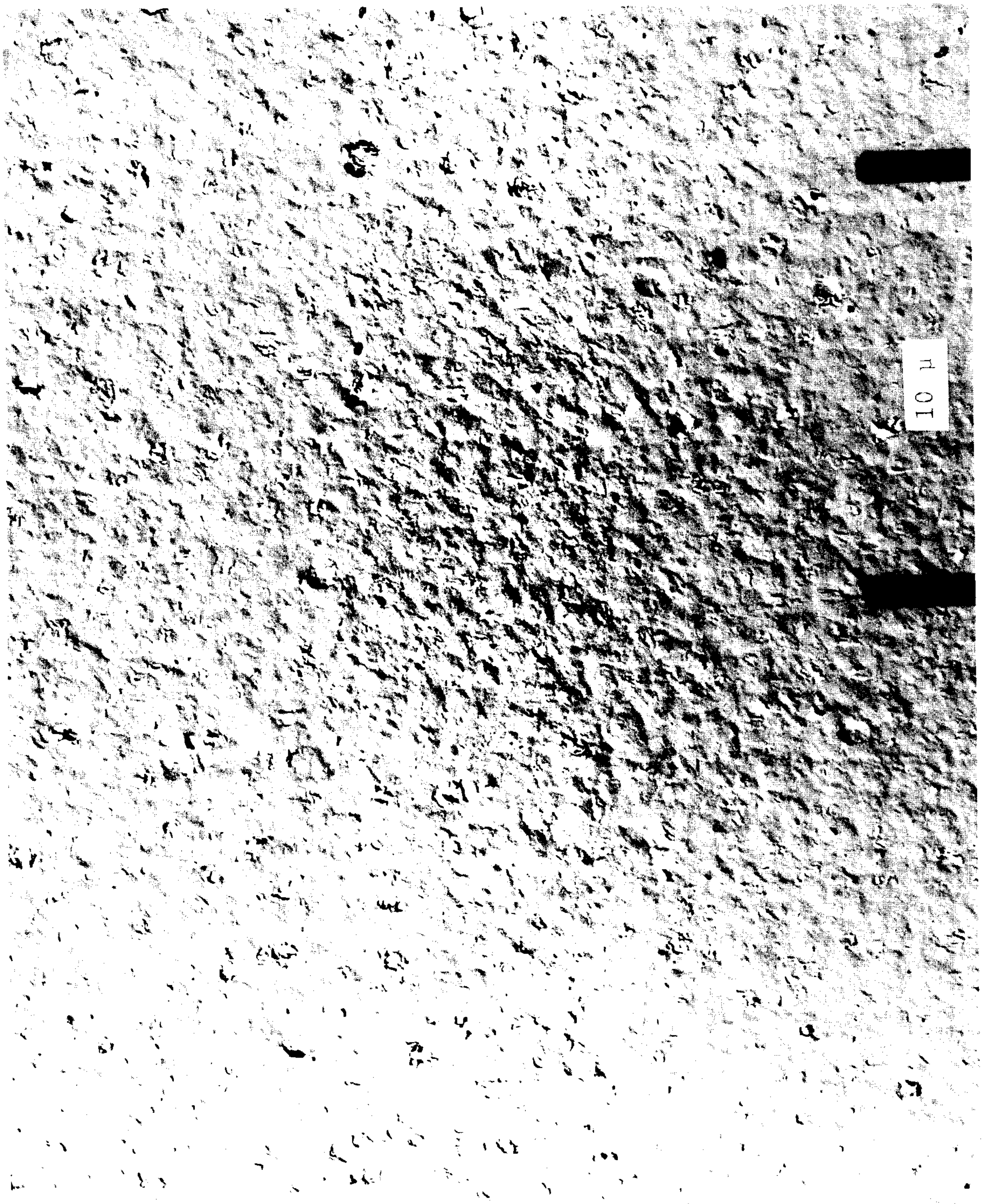


FIGURE 2. Density Variations Along Length of Nonirradiated Control Pin, Element 1947, Batch 112

The lack of exaggerated swelling is substantiated by the limited amount of porosity observed by electron microscopy. Figure 3 shows a shadowed, negative replica prepared from a polished and etched section from the bottom of pin No. 3. The few tiny tears present are consistent with the density measurements.

The structures present in the top and bottom of the control pin are shown in Figures 4 a and b. The grains are significantly smaller at the top and more grain boundary transformation is evident. Irradiation tends to erase this original structure and it is extremely difficult to reflect the original grain size in the irradiated samples. Figures 5a and b show the as-polished condition of the top and bottom of pin No. 3. Chromic acid was added to the final polishing wheel to produce the staining effect which we believe reflects the original grain size. On this basis it would appear that the top of pin No. 3 does correspond to the top of the casting. The etched structure at the bottom of pin No. 3 is depicted in Figure 6. Note that grain boundaries are not evident. Most of the second phase material present is believed to be impurity inclusions. Preliminary analyses with the electron microprobe indicate that many of these inclusions are high in zirconium. A possible source could be the zirconate wash used on the graphite molds that are employed by the manufacturer during the melting operation. No conclusions are possible at this time regarding the influence of these inclusions on the irradiation behavior of the fuel.

The optical metallography is completed on top and bottom sections of the four pins, and electron microscopy is in process. Scanning electron microscopy on fracture surfaces is being conducted and selected specimens from each pin are being studied with the shielded electron microprobe. X-ray diffraction patterns obtained on top and bottom sections are now



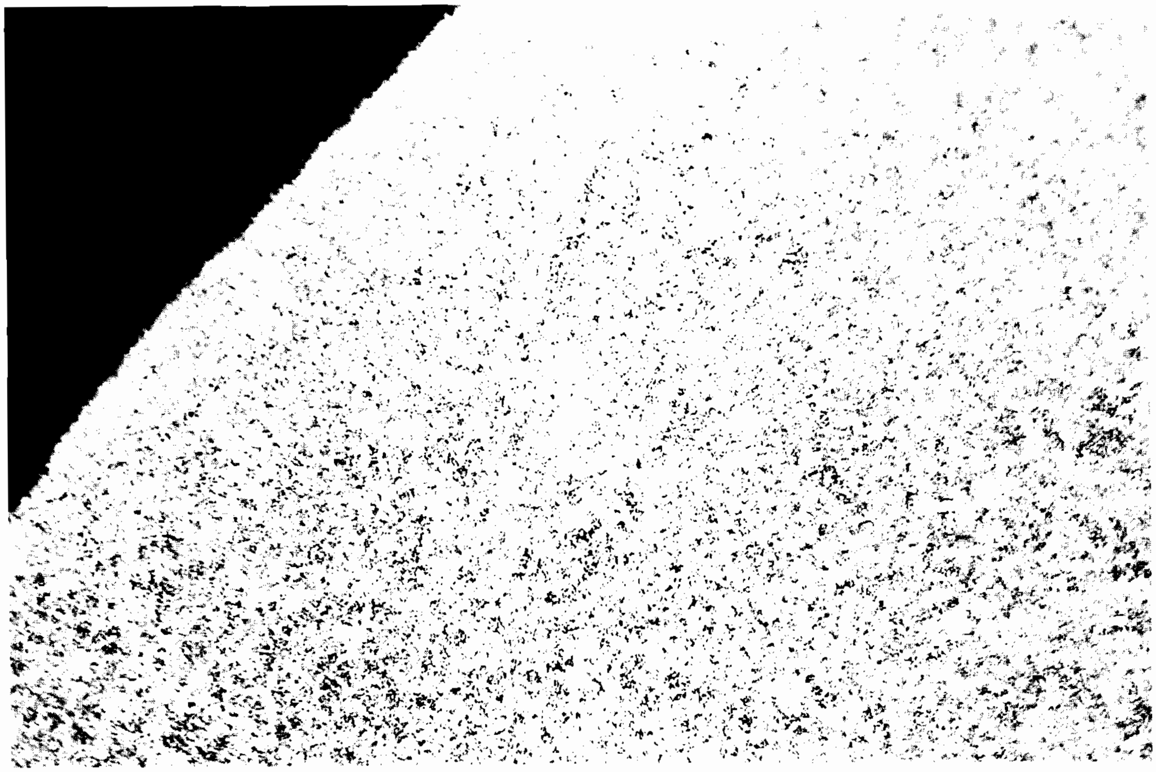
6100X

FIGURE 3. *Bottom of an EBR-II Driver Fuel Pin No.3 That Became Shortened During Irradiation to 0.6 at.% B.U. Shadowed, Negative Replica*

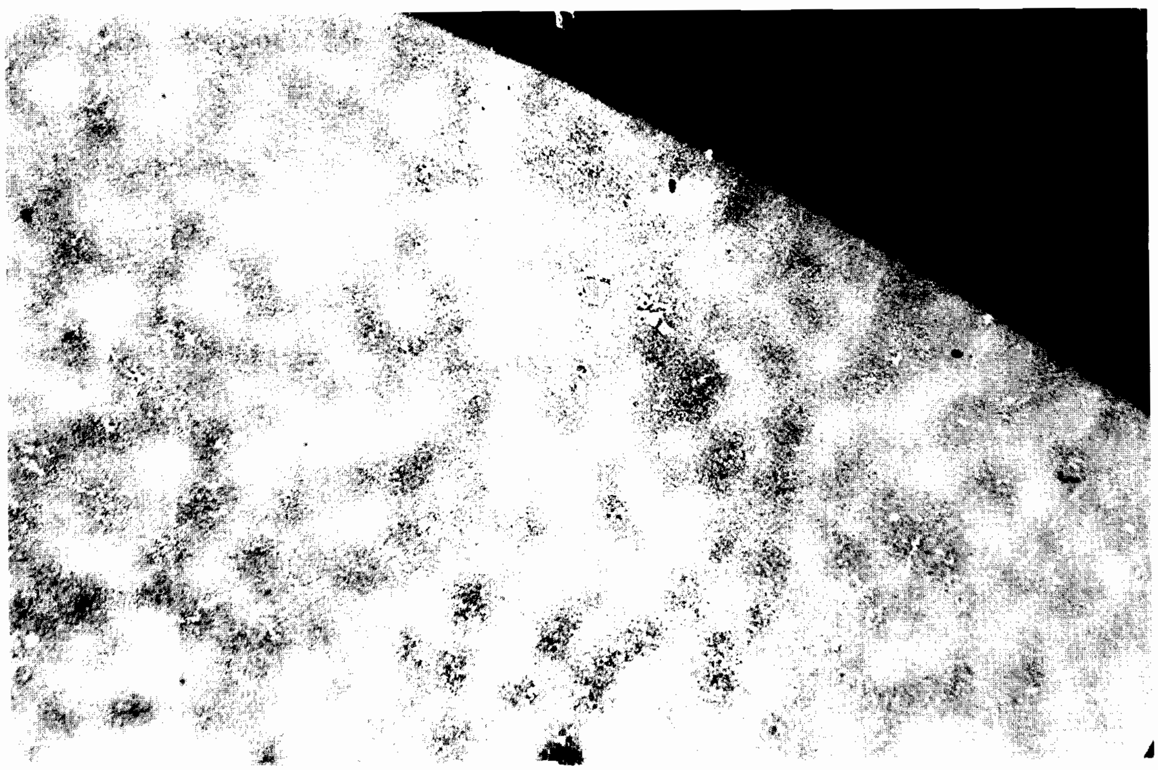
Neg E-9340 a. Top 750X

Neg E-9352 b. Bottom 750X

FIGURE 4. Top and Bottom Structure of an EBR-II Nonirradiated Driver Fuel Pin. (Etched by ion bombardment.)

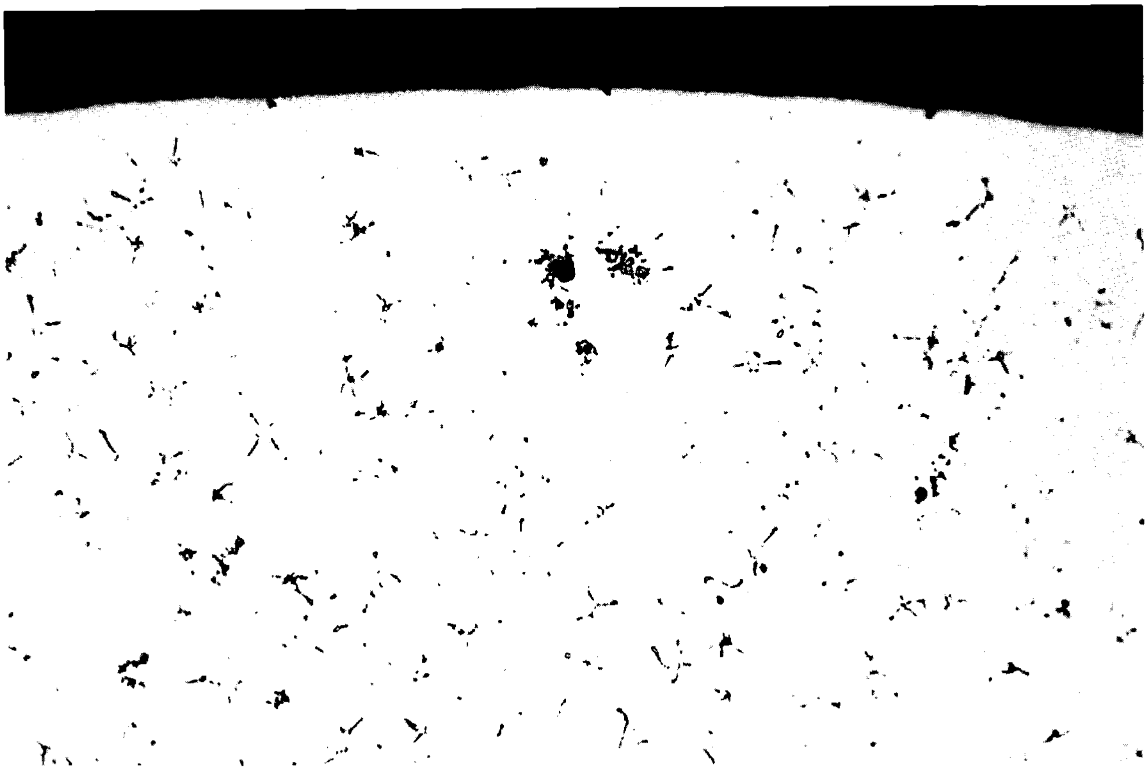


Neg E-9323 *a. Top* 250X



Neg E-9326 *b. Bottom* 250X

FIGURE 5. Top and Bottom of EBR-II Driver Fuel Pin (No. 3) That Became Shortened During Irradiation to 0.6 at.% B.U. As Polished



Neg E-9353 250X

Neg E-9354 750X

FIGURE 6. *EBR-II Driver Fuel Irradiated to 0.6 at.% B.U. (Etched by ion bombardment)*

being analyzed. An irradiated pin that is believed to have increased in diameter in the upper portion and an ANL cold line pin were recently received at PNL. These will be examined similarily to the earlier pins.

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