GE Nuclear Energy

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SUPPLEMENTAL REPORT OF ULTRASONIC INDICATIONS IN THE TOP HEAD WELD VC-TH-1-2 AT JA FITZPATRICK POWER STATION

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IMPORTANT NOTICE REGARDING

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SUMMARY

During the 1990 inservice inspection at the James A. Fitzpatrick Nuclear Power Station, an ultrasonic indication was detected in the top head dollar plate weld VC-TH-1-2 examination volume using standard ASME Section XI manual techniques. In an attempt to characterize this indication, Refracted Longitudinal (RL) sizing techniques were used. What were interpreted to be tip diffracted signals from this flaw, were in fact signals from mid-plate segregates located in the base material. This resulted in over estimating the size of the flaw. A considerable amount of additional effort was then required to disposition this indication. It has been shown that the indication was, in fact, a weld fabrication flaw.

This report provides a discussion of the RL examinations performed at Fitzpatrick and of laboratory RL data obtained from a plate containing known segregates. The data from these examinations, demonstrating the presence of mid-plate segregates in the RPV top head at Fitzpatrick, and the effect of the segregates on the RL sizing efforts are presented in this report.

1.0 INTRODUCTION

During the 1990 inservice inspection at the James A. Fitzpatrick Nuclear Power Station, an ultrasonic indication was detected in the top head dollar plate weld VC-TH-1-2 examination volume using standard ASME Section XI manual techniques. Considerable effort was used in characterizing this indication. This included a review of fabrication records and radiographs, taking of new radiographs, automated UT, visual, magnetic particle, liquid penetrant and manual refracted longitudinal (RL) sizing techniques.

The indication was shown, by a combination of these techniques to be due to a fabrication flaw. However, the data from the RL sizing technique was misleading because what was interpreted to be tip diffraction signals from the flaw was actually mid-plate segregates in the base material.

Mid-plate segregations are concentrations of alloying elements in specific regions, that form differences in metallurgical structure due to variations in chemical composition. They are formed during solidification of the original ingot. These concentrations of alloying elements form bonded interfaces with different acoustic impedances that, from an ultrasonic point of view, are similar to the interface in a dissimilar metal weld. When an ultrasonic beam interrogates this interface, portions of the beam are reflected due to the acoustic impedance mismatch at the interface. Similar ultrasonic responses are also caused by small inclusions, such as Manganese Sulphides (MnS). These inclusions are found parallel to the plate surfaces and are often called stringers. Segregates and stringer inclusions differ from laminations in that laminations are larger areas consisting of unbonded material and are normally contained in one plane near the center of the plate thickness. Segregates on the other hand are usually scattered through out the middle one third of the plate thickness.

This report is not meant to provide the evaluation of the indication in the Fitzpatrick top head which is contained in reference 1. Instead the purpose of this report is to supply supplemental data on the findings related to plate segregates.

2.0 FITZPATRICK FIELD DATA

After detection of a high amplitude indication using 45° and 60° shear wave transducers, the indication was further characterized with 60° and 70° RL's from the inside surface of the top head and a 45° RL from the outside surface. The sizing signals were not clear, distinct, tip diffracted signals and at times the screen contained additional signals. The indication, when finally plotted with a 45° RL, showed a flaw configuration that was not consistent with any postulated in-service flaw. The base material was scanned with a 0° manual examination at 5 MHz at 30 dB above reference and revealed mid-plate indications typical of segregates.

The base material on each side of top head weld VC-TH-1-2 was scanned with the General Electric's Reactor Inspection System (GERIS), an automated ultrasonic system. This base material was scanned for a distance of approximately 1-T from the edge of the weld with a 1" diameter, 2.25 MHz transducer. The calibration sensitivity was determined according to ASME Section V, Article 4, T-441.6 which utilized the side drilled holes in Fitzpatrick's 5" thick ASME Code calibration block PT-No-1. This is the procedure used for the detection of planar reflectors. The recording sensitivity of the data was 4 dB above reference gain.

GERIS recorded base material, mid-plate, 0° indications sporadically over the entire area of the scanned area. Figure 1 is a top view (C-scan) of the data recorded with GERIS. The GERIS data does not show the reflectors to be adjacent to the weld where the RL sizing was performed, however, as mentioned before, a supplemental high sensitivity manual 0° examination did. The area where the sizing was performed was from 130" to 155" on Figure 1. Figure 2 illustrates a cross-sectional view of all the 0° GERIS data recorded along 80" of length of top head weld VC-TH-1-2. The base material to the right side of the weld is the dollar plate, and the torus plate is on the left side. The reflectors vary in depth from 0.85 inches to 3.45 inches from the outside surface of the top head.

3.0 LABORATORY DATA

To confirm the effects of segregates on RL flaw sizing techniques, manual ultrasonic tests were conducted at the GE Nuclear Energy's NDE Development Lab in San Jose, California. Contained in this section is data from previously performed GERIS ultrasonic tests on segregates.

3.1 AUTOMATED ULTRASONIC DATA

Figure 3 illustrates the cross-sectional view of General Electric's Cracked Implant Block containing GERIS recorded ultrasonic reflectors that have been characterized as mid-plate segregates. These reflectors were similar to reflectors from an operating plant that have been characterized as mid-plate segregation through metallography. The recording sensitivity of this data was the typical ASME calibration sensitivity. The Cracked Implant Block is a 26" long section of 6.44" thick vertical shell weld from a cancelled RPV. Since this plate is from a real, as fabricated pressure vessel, and since segregates have been detected at several operating plants, it is believed that this condition is typical of many other plates in pressure vessels in the field.

The proximity of the individual reflectors and the distribution of the reflectors of the indications within the volume of material are consistent with plate segregates or small inclusions. To illustrate this fact, Figure 4 is a cross-sectional view of one scan line of data recorded at 20 dB (10 times) above calibration sensitivity. Note that areas exist that consist of densely packed reflectors of varying depths. The ultrasonic data plots of these segregates appear larger than their actual size due to transducer size and ultrasonic beam divergence. Although these segregates do reflect sound due to their metallurgical properties, they also allow some sound to pass through.

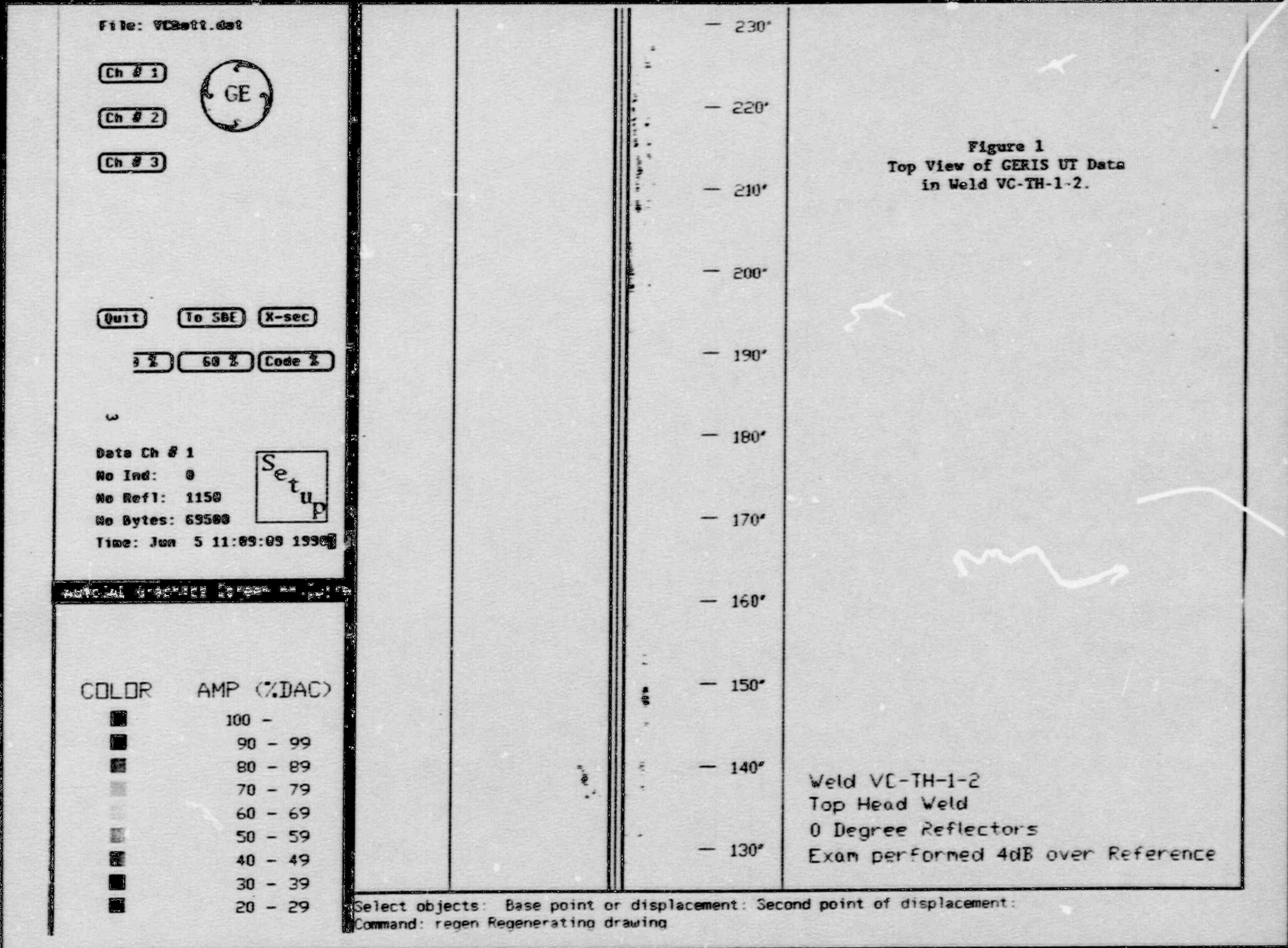

Figure 1
Top View of GERIS UT Data
in Weld VC-TH-1-2.

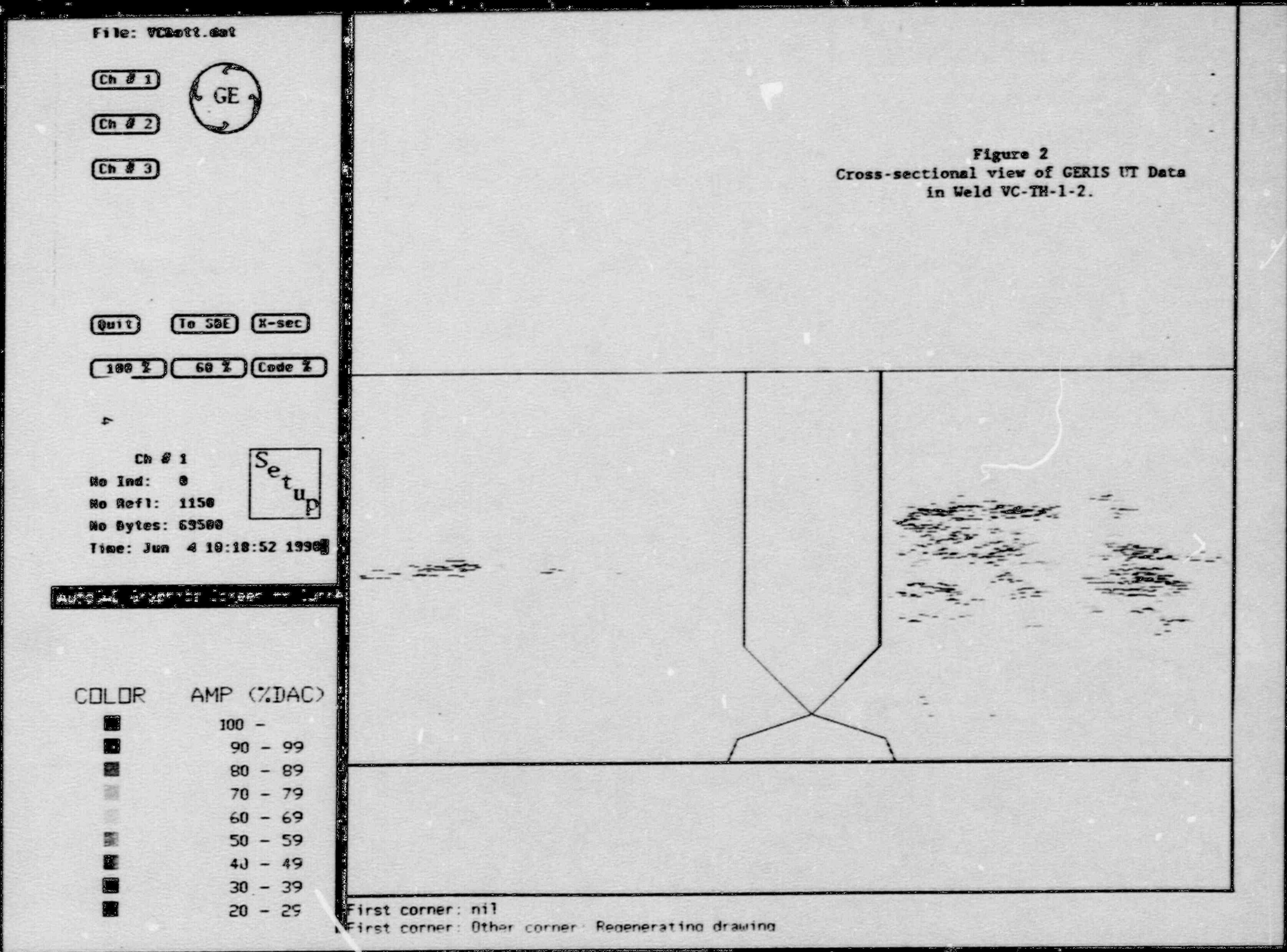

Figure 2
Cross-sectional view of GERIS UT Data in Weld VC-TH-1-2.

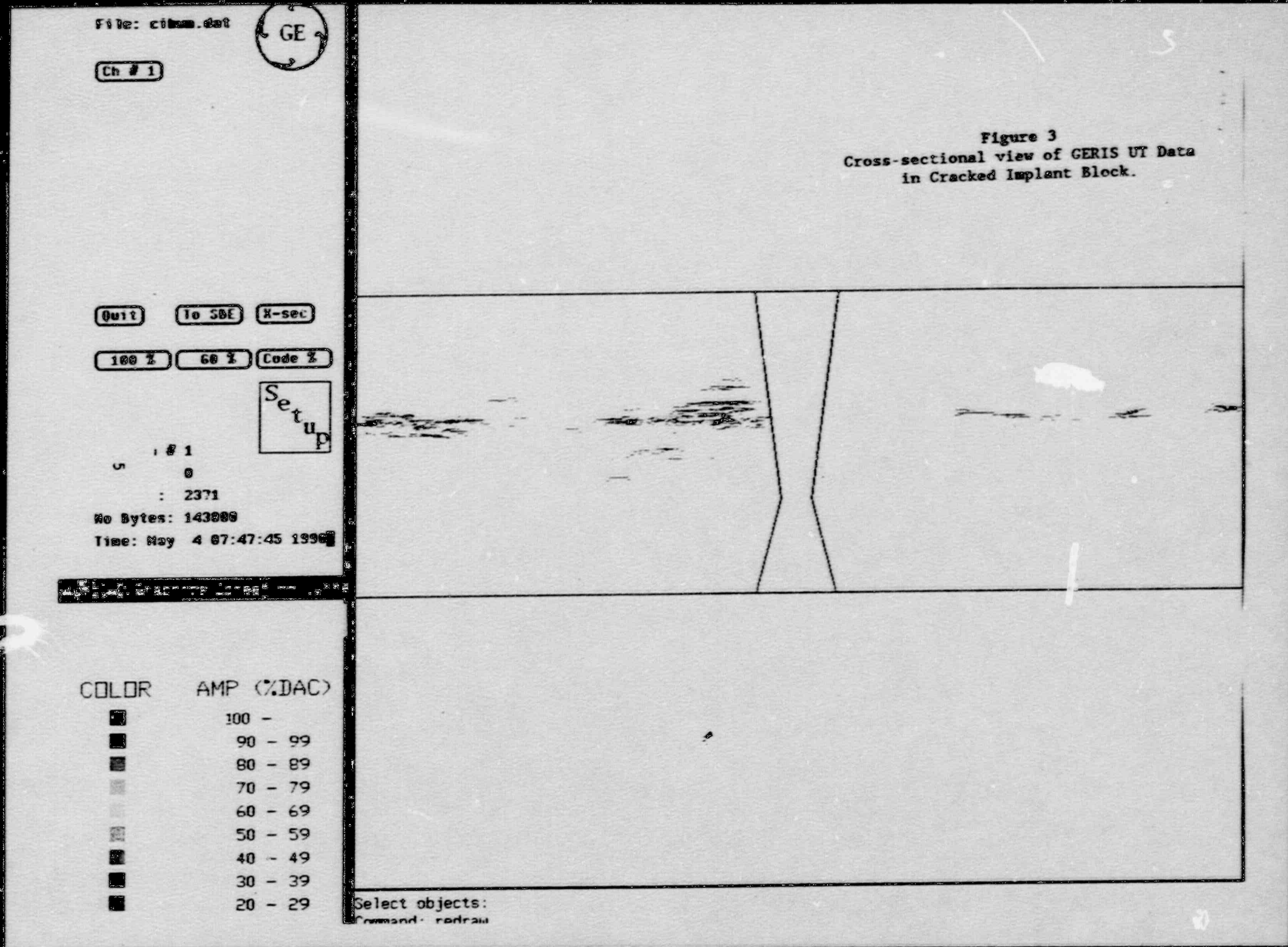

Figure 3
Cross-sectional view of GERIS UT Data
in Cracked Implant Block.

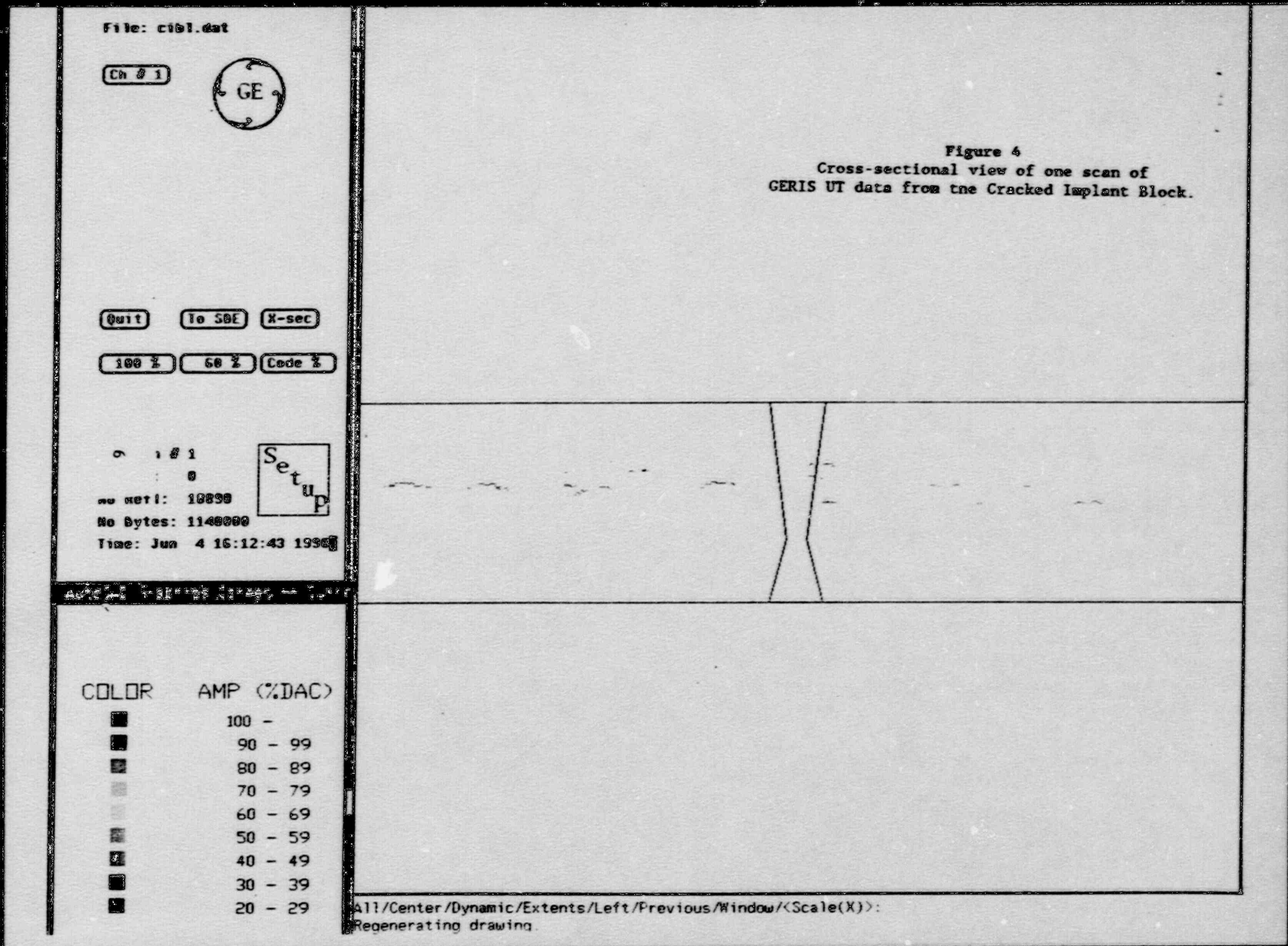

Figure 6
Cross-sectional view of one scan of
GERIS UT data from tne Cracked Implant Block.

There is no evidence that these reflectors present any significant interference to ASME Code required angle beam examinations. In fact, it has been verified that small underclad notches in this plate can be detected with a shear wave angle beam passing through these segregates.

3.2 MANUAL ULTRASONIC DATA

Manual UT data using a 5 MHz, 1" diameter, straight beam transducer, was taken at 3 locations ranging from .3 inches to 1.0", from the right side of the weld centerline. Figures 5 thru 7 are the digitized A-scans taken at these locations. Mid-plate segregates that were detected ranged in depth from 1.5" to 3". The sensitivity for this test was 20 dB over a backwall signal set at 80% FSH where no mid-plate segregates were present. The amplitude of these segregates in this test was less than one half of the amplitude of the backwall and in no case observed resulted in a complete loss of back reflection. A complete loss of back reflection is a part of the Code basis for rejection of such indications.

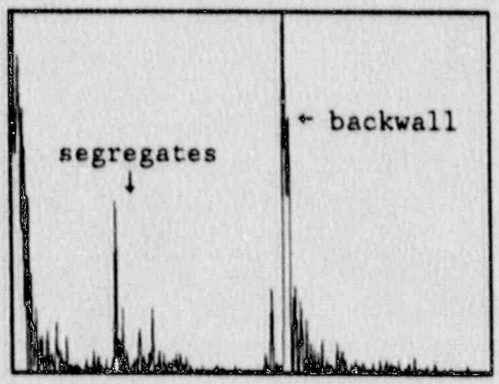

Figure 5
0° A-scan .3" from Ref.

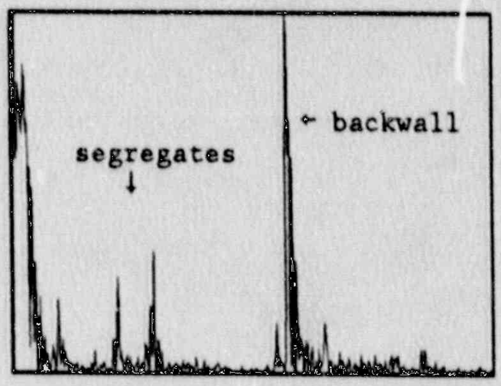

Figure 6
0° A-scan .8" from Ref.

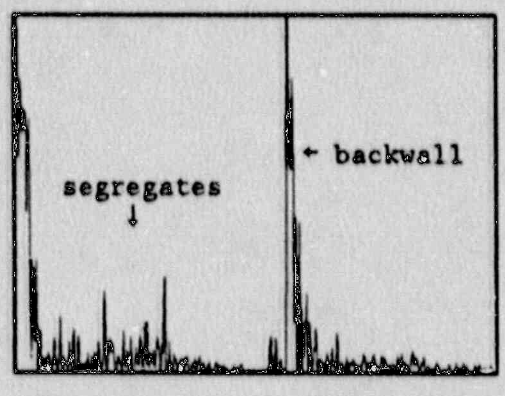

Figure 7
0° A-scan 1.0" from Ref.

The ultrasonic instrument was then calibrated with a dual element 2 MHz 45° RL transducer. The sweep was set at 5" in depth using the side-drilled holes in a 4" ASME Code calibration block. The sensitivity was set with the 2% of T notch at 80% FSH (full screen height) as shown in Figure 8.

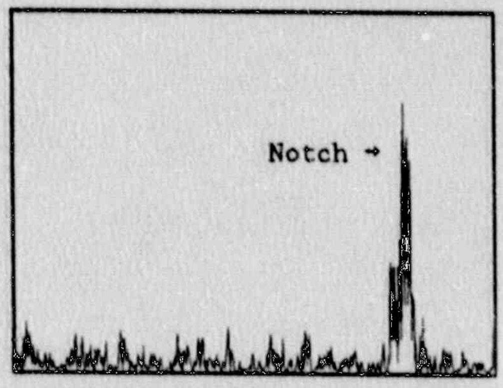

Figure 8
45° RL A-scan of
Calibration Block Notch

The area, where the 0° manual ultrasonic data (Figures 5 thru 7) was taken, was scanned with the 45° RL. At reference sensitivity a segregate was detected with the transducer at 1.6" from the weld centerline. The sweep position on the CRT screen showed 4" of depth as shown in Figure 9. With a 45° RL transducer a 23° shear wave component exists. The segregate detected was detected by the shear wave component. Since the velocity of longitudinal waves is 1.8 times greater than that of shear waves, and the refracted angle is twice that of the shear wave, the reflector appears to be 4" deep instead of the actual depth of 3". Figure 10 is a cross-sectional plot of the segregates showing longitudinal and shear wave components.

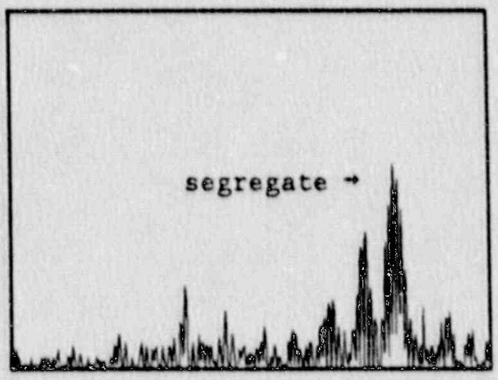

Figure 9
45° RL 1.6" from Ref.

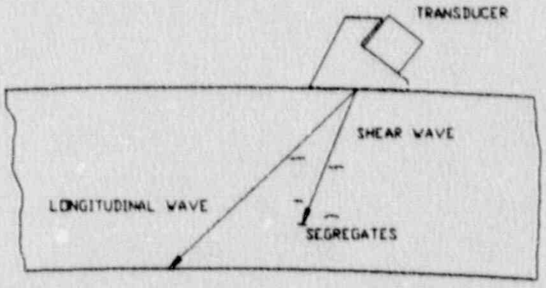

Figure 10
Plot of Figure 9 A-scan using Multiple Beam Components.

The transducer was moved forward 0.5" to a distance of 1.1" from the weld centerline. The shear wave component then detected a segregate at a different depth as shown on the sweep of the A-scan in Figure 11. The depth of this segregate was at 2.4". Therefore, the assumed depth of this reflector using the 45° RL component was 3" as illustrated in the cross-sectional plot in Figure 12.

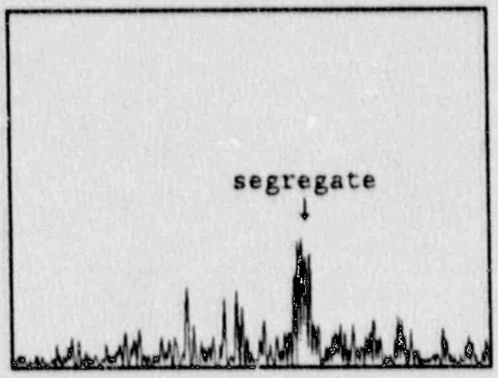

Figure 11
45° RL 1.1" from Ref.

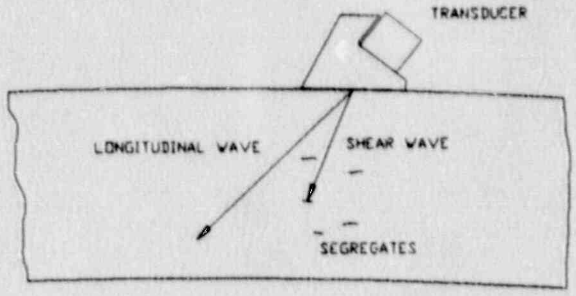

Figure 12
Plot of Figure 11 using
Multiple Beam Components

4.0 DISCUSSION

The GERIS data from the Fitzpatrick top head base material of weld VC-TH-1-2 was characteristic of the segregates in the base material of General Electric's Cracked Implant Block. A review of the vessels' fabrication ultrasonic test (reference 2) reported mid-plate spot indications with no length or width, which is typical of segregates.

The indication at Fitzpatrick was parallel to the weld and believed to be at, or near the base metal to weld metal interface, on the dollar plate side of the weld. To size such an indication, using RL techniques, the sound beam would be directed into and perpendicular to the weld from the base metal side. It becomes readily apparent that the lower angle shear wave component from the RL transducer could reflect from segregates located almost underneath the transducer in the base metal. The higher angle RL component is much less sensitive to segregates which are oriented for the most part, parallel to the surface. Because the shear wave travels at a lower velocity than the longitudinal wave, the indication would appear to be located at or near the weld metal, when plotted at the angle and the velocity of the longitudinal wave. This explains what happened at Fitzpatrick since it has been duplicated on a plate which is known to contain segregates along the side of the weld.

5.0 CONCLUSIONS

The indication in Top Head weld VC-TH-1-2, as characterized by RL sizing techniques, was of a nature unrealistic of crack propagation from any expected surface or subsurface type flaw. The larger indication, characterized by RL sizing techniques, could not be confirmed by either 45° and 60° shear wave (manual or automated GERIS) or by radiography.

Mid-plate indications with characteristics typical of segregates were detected at higher-than-normal sensitivities with both manual and GERIS systems. These mid-plate indications were located in the base material near the indication. These would affect the RL sizing data, which requires high sensitivity to detect tip diffracted signals. The RL sizing data taken on this indication, that was affected by segregates, was mis-leading.

The results of all examinations and tests have shown that the RL ultrasonic data affected by segregates, is not related to the fabrication flaw which was detected and sized (reference 1) for disposition by analysis (reference 3).

The tip diffraction method, using RL transducers, is one of the most accurate methods for determining the depth of a flaw. However, caution is recommended when RL transducers are used on rolled plates. A complete examination for segregates, along with accurate data plotting is required.

6.0 REFERENCES

1. Ultrasonic Examination Data Package for Weld VC-TH-1-2, copy contained in GE DRF B11-00497.

2. Report of Ultrasonic Testing, Combustion Engineering, Inc., Contract #21566 dtd 4-10-1971, copy contained in GE DRF B11-00497.

3. Structural Evaluation of Indications in the Reactor Top Head at the JA Fitzpatrick Power Station, Report SASR# 90-43, dtd May 1990.

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