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NONDESTRUCTIVE EXAMINATIONS OF REACTOR PRESSURE VESSEL CLOSURE STUDS AT THE COOPER NUCLEAR STATION

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IMPORTANT NOTICE REGARDING CONTENTS OF THIS REPORT

Please Read Carefully

ACKNOWLEDGMENTS

GENE acknowledges the contributions of many individuals involved with the Cooper RPV stud inspection development program. The field support that was provided by personnel from GENE, NPPD and CECO, including labor through upper management, was superb and instrumental in the success of this program.

Especially appreciated are the contributions of the following personnel;

Gerry Hicks (NPPD) - Gerry's direct interest and participation along with his diligence and perseverance helped make this program efficient and successful.

Tom Black (GENE - SSM at Cooper) - Tom's help in dealing with the day to day administrative matters kept many of the "small" obstacles from interfering with the job at hand.

John Nash (GENE - SSM at Dresden) - John was outstanding in the manner in which he made all the arrangements needed at Dresden. He also provided escort and worked with the examination team through all of the entire job.

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1.0 EXECUTIVE SUMMARY

During the Fall 1991 outage at the Cooper Nuclear Station, ultrasonic (UT) indications were reported in 51 of 52 reactor pressure vessel closure studs. The initial indication in one stud was reportedly detected with a 0° longitudinal wave (straight beam) directed from the end of the stud (end shot). Although this indication was later attributed to a problem with the automatic pulse repetition rate (which could result in false calls, but would not prevent indications from being detected), it resulted in a more extensive examination of all the studs.

The more extensive examinations were conducted with a manually operated 60° shear wave bore probe, which was inserted into the stud's extensiometer hole. Indications were reported in all but one of the other studs. These studs all had corrosion and pitting in the thread areas, just below the nut area, at the vessel flange, and a few at the top of the nut area. The UT indications were located in these corroded areas. Efforts to evaluate these indications were unsuccessful in proving that they were not associated with circumferential cracking (similar to cracking, associated with corrosion, that had been previously reported at another plant).

One of the studs, which was believed to have the largest of the indications, was evaluated using extensive nondestructive examinations (NDE) and metallography at GENE's Vallecitos Nuclear Center (VNC). No evidence of cracking was found. Cooper replaced all of their studs and a decision was made to disposition the indications in the original studs after the plant was back in service.

A plan was developed and implemented to resolve the indications. Five studs were selected for extensive NDE examinations. The five studs were selected based on the following; two of these studs had large UT indications, one had a faint radiographic (RT) indication (in the area of UT indications), one had a faint penetrant (PT) indication and one had no indications reported. The five studs were examined using automated UT with both a 60 and a 70° bore probe and with an "enhanced end shot".

The studs were then cleaned using a glass bead blast to remove the corrosion products. The UT was repeated plus RT and magnetic particle examinations were performed. Notches were also placed in the root of corroded threads on one stud and the UT was repeated proving that crack-like indications could be detected and evaluated in corroded areas.

It was shown that the 70° bore probe was least affected by the corrosion and that crack like indications (notches) could be detected, and a meaningful examination could be performed using that probe. The enhanced end shot was also effective in detecting the notches in the corroded threads. However, it is clear that if recordable indications are detected with an end shot technique, a bore probe will have to be used for evaluating, sizing and characterizing the indications.

Based on these results (assuming that these studs are representative of the other studs), and the NDE and metallography performed at VNC, it can be concluded that the UT indications were not due to cracking but were associated with corroded threads. Therefore, the remaining studs at Cooper are judged to be free from cracking and the UT techniques, procedure and equipment used are considered as qualified for field use on studs similar to Coopers. However, a training and qualification program will have to be established for field personnel prior to these examiners performing such examinations in the field.

An additional qualification was performed on a stud containing a real crack and a notch at the Dresden Nuclear Power Station. All of the UT equipment used at Cooper was also used during these examinations. In addition, a special developmental bore probe was used in the examinations of this stud. This probe was not used at Cooper because it was still undergoing fabrication in a vendors shop and was not received until several weeks after the Cooper examination. This probe contained two 45° and one 0° transducers, arranged for performing time of flight diffraction (TOFD) measurements to determine crack depths. The probe worked very well and provides another good tocl for the evaluation of UT indications in studs.

The crack and the notch were readily detected and characterized, adding to the previous qualification on notches at the Cooper site. With the 70° probe the EDM notches in the Cooper stud appear to have UT signal characteristics very similar to the indications from the Dresden stud crack, which further validates the qualification at Cooper. The only real difference between the signals from the notches and that from the crack is that the Dresden stud crack is very large resulting in very large signal responses.

2.0 INTRODUCTION

During the Fall 1991 outage, ultrasonic (UT) examinations were performed on reactor pressure vessel (RPV) closure studs at the Cooper Nuclear Power Station. The UT and magnetic particle (MT) exams were conducted originally in accordance with Section XI of the ASME Boiler and Pressure Vessel Code.

One recordable UT indication was detected with a straight beam (0° longitudinal wave) aimed down the length of the stud from the top. This type of technique is referred to as an "end shot". The indication appeared to be located in an area of corroded threads in stud number 26. Because of this, and other indications detected later, supplemental UT and MT examinations were performed on the remaining studs. Radiographic (RT) and penetrant (PT) were also tried on some of the studs for evaluation purposes.

A spare Cooper stud was modified for use as a calibration standard for future UT examinations. This calibration standard meets the requirements of Appendix VI "Ultrasonic Examination of Bolts and Studs" of the 1989 Edition of Section XI of the ASME Boiler and Pressure Vessel Code.

The supplemental UT exams were performed using a 60° shear wave, bore probe from inside the extensiometer hole in the studs. This probe contained an up-looking and a down-looking 60° transducer, plus a surface wave transducer to detect cracking inside the extensiometer hole. The 60° angle had been selected since the resulting sound beams are close to perpendicular to the side walls of the threads on the studs, thus maximizing the reflections from the threads.

There has been considerable work done (Reference 6.)that indicate that circumferential cracks initiating in the threads will block the sound beam from reaching the threads behind the crack, thus eliminating the reflections from those threads. This being so, the loss of signals from the threads might be used in both the detection and sizing of cracks. There were UT indications reported in 51 of the 52 studs with this probe.

An "enhanced end shot" UT was also performed and small indications were reported in several of the studs. It was noted by the examiners that corrosion appeared in bands located at areas corresponding to the bottom of the nut, in the bolted-up configuration, and at the top of the threads on the flange end of the studs. There was also some corrosion at the top of the nut (bolt up configuration) on several studs. The corroded areas corresponded with the UT indications noted.

The indications detected with the 60° bore probe, were partially based on the loss of thread signal response, due to the blocking effect that a planar flaw would have if it was initiating at the root of a thread. All recorded indications exhibited some loss of thread signals.

A recent experience at another nuclear power plant (see Reference 3.) showed that severe cracking had initiated at corrosion pits in 2 studs. Preliminary evaluations at the Cooper site were not able to eliminate cracking as a possible cause of the UT indications. During the evaluation of the UT indications, one of the studs was reported to have a faint PT indication and one had a faint RT indication. The corroded surface could not be PT'd adequately due to the inability to clean the surface. The corrosion products on the surface, being somewhat porous, absorbed the penetrant thus potentially masking any real penetrant indications The RT could also have been affected by the corrosion build-up on the surface, since deep scratches or other adnormalities in the corrosion layer could appear to be is the base material of the stud on a radiograph. Of the four methods used, all seemed to be somewhat affected by the corrosion products.

Replacement studs were obtained and installed due to the indeterminate condition of the existing studs. Extensive examinations, which included the 60° bore probe, the enhanced "end shot", PT and RT were conducted on stud no. 26 at GENE's Vallecitos Nuclear Center (VNC). The stud was then sectioned in the areas of the UT indications on one end of the stud and a metallographic examination was performed. No cracking was observed on the metallurgical samples.

On the other end of the stud, the threads in the area of the UT indications were removed by machining and the UT was repeated. The UT indications were no longer detectable, indicating that they were related to the corroded threads.

The initial end shot indication in stud No. 26 is a false indication and has been attributed to a problem with the pulse repetition rate of a UT instrument (See Appendix G to this report). This type of problem can produce false or phantom indications over long metal paths but would not cause real indications to be missed.

References 1. and 2. document the work performed at VNC. Supplement 1 to reference 3 was issued to inform other GE/BWR plant owners of the problems that had been experienced at Cooper. At that time, Cooper Nuclear Station and GE personnel determined that the activities for resolution of the indications would be performed after start-up. This report covers the joint GENE/NPPD activities toward resolution of the indications.

Appendix C (tab 9) to this report documents the UT examination of a known cracked stud at the Dresden Nuclear Power Station. All of the transducers used at Cooper were used during the Dresden examination plus an additional developmental bore probe. This probe was not available during the Cooper examination because it was just designed shortly before the Cooper exam and was still undergoing fabrication in a vendors shop. That probe contained two 45° and one 0° transducer arranged to provide time of flight diffraction measurements for determining the depth of cracks and represents an advance in the technology for UT stud examinations. It provides an additional tool for evaluating UT indications in studs.

3.0 ACTIONS TO RESOLVE INDICATIONS

During a joint GENE/NPPD lessons learned meeting, held at the Cooper Site on March 2, 1992, a plan of action was formulated to resolve the indications in the remaining studs at Cooper. This agreement is documented in Agreement No. 86A-MS2, Task Authorization, Amendment No. 3 (see tab 7, Appendix A).

GENE had decided to develop new UT techniques utilizing special bore probes, which should help in the resolution. An option that was chosen was to use an opposite approach to that previously mentioned. That is, to select beam angles which would tend to minimize the reflections from the threads, while maintaining good sensitivity to vertical flaws. A $70+^{\circ}$ bore probe was purchased. This probe has specially shaped transducer elements designed to help overcome the focusing effect that results from the curved, inside surface of the extensiometer hole.

A 45° time-of-flight, bore probe was also designed and purchased. Unfortunately, it was still being fabricated during the Cooper examination, but its use at another site is discussed later in this report.

The agreed method of resolution was to select five studs for evaluation. Stud No. 39 was selected for the faint PT indication that was reported during the outage. Stud No. 40 was selected because of the faint RT indication also reported during the outage. Stud No. 44 was selected because it was reported to have no recordable UT indications. Studs Nos. 14 and 17 were selected because they appeared to have the largest number of UT indications. The studs were selected based on testing results from the outage. The suspect areas of these five studs were subjected to the following:

A) Automated UT with a 60-degree bore probe (same as outage exam) both before and after glass-bead-blast cleaning.

B) Automated UT with a 70-degree bore probe both before and after glass bead blast cleaning.

The automated exams with these bore probes provide for complete data acquisition, with complete digitized A-scan data recorded for each inspection. The GENE SMART 2000 System was selected because of the great amount of data that needed to be collected and the relative ease with which the examination can be reconstructed during data analysis using color coded B and C-scans. Automated exams are much preferred during difficult inspections and investigations for these reasons.

C) Alternating current, magnetic particle (AC-MT) examinations with the Yoke technique after glass-bead-blast cleaning.

D) Electric discharge machined (EDM) notches were placed in a corroded area of Stud 14 after cleaning and were scanned with the 60 and 70-degree bore probes.

E) Visual examination (10X glass) of the corroded areas both before and after glass-bead-blast cleaning.

F) Selected areas on studs 17, 39, and 40 were radiographed.

G) The enhanced "end shot" technique used during the outage examinations was used on Stud 14. This was to verify notch detection capability for the straight beam on corroded threads.

4.0 DISCUSSION

4.1 SET UP FOR EXAMINATIONS

Cooper personnel provided an area on the lower floor of the turbine building where most of the examinations were performed. The contaminated studs were set up in a room bounded by a plastic tent with step off pads to a clean area where all of the data acquisition equipment was located. The UT data was obtained with the SMART 2000 System, described in Appendix G. Automation of the system was achieved by modifying GENE's piping weld scanner to transport the bore probes in the extensiometer hole of the studs in a raster scan pattern. The scanner operated from a track that was clamped around the upper part of the stud. The SMART 2000 equipment setup is shown in Figure 1. The scanner setup in the tented room is shown in Figure 2 and the SMART 2000 location in Figure 3. Figures 4, 5 and 6 show the UT beam geometries for the different bore probes. The areas of interest for the studs is shown in Figure 7.

4.1 EXAMINATIONS BEFORE BEAD BLASTING

Automated UT examinations were performed with a 60-degree bore probe in areas that had recordable indications during the outage. Calibration sensitivities were used that duplicated the manual exams performed during the outage (to the extent possible). These exams served as a baseline for the investigation that followed. Automated exam data included A-scan, B-scan and C-scan recordings for each channel. Scans were performed with transducers aimed in both the up and down directions for each area examined.

This exam showed the same basic results as the outage's manual exams for all studs, except for stud No. 44, which was reported to be free from indications during the outage exams. The automated examinations showed this stud to have indications similar to the indications in all other studs and was not significantly different from the other studs. There were areas in all 5 studs that exhibited an apparent loss of thread response in the locations seen during the outage. Typical UT data outputs are shown in Figures 8A & 8B.

There was also a geometric indication recorded that originated at the clamp holding the studs in place. The geometric origin was confirmed using two methods. Water was poured over the suspected area and signal amplitude increased as the water worked its way between the stud and the clamp. The clamp was removed and the signal was not present. This proved that this reflection was from the clamp and that the indication was geometric in origin. This is relevant, since the fact that it can happen should be known by field examiners. This knowledge could help to prevent false calls when studs which have been removed from the RPV are being examined.

Automated UT examinations were performed with a 70-degree bore probe in the same areas that were examined with the 60-degree probe. The only exception to that is that the area of interest on the flange end of the stud. This area could only be examined with the 70-degree transducer that was aimed downward, towards the flange end of the stud. The reason for this was that the probe bottomed out in the stud before the transducer that was aimed upwards, towards the top of the stud, could pulse sound into the area of interest. Calibrations were used that duplicated the 60-degree sensitivity, as closely as possible. These exams were intended to show whether the 70-degree probe was less affected by the thread corrosion than the 60-degree probe was. They also served as a baseline for the investigation that followed. Automated exam data included A-scans, B-scans and C-scans. Scans were performed in both axial directions, where possible. There is a geometric restriction on the vessel flange end of the studs that prevents scanning with the up-looking transducer on the 70-degree probe.

The 70° exam showed that this probe was less affected by corrosion than the 60-degree probe. There was less amplitude change from the threads. Calibration notches were easily detected with an excellent signal-to-noise ratio and moved in time (walked) well beyond the envelope of reflections from the threads. There were no indications in the studs that exhibited characteristics similar to the calibration notches. The geometric indication, from the clamp, noted during the 60 degree exam was also seen with the 70 degree probe. These indications from the clamp are shown in Figures 9A & 9B.

4.2 EXAMINATIONS AFTER GLASS-BEAD BLASTING

The corroded threads on studs 17, 39 and 40, after glass-bead blasting, are shown in Figures 10 through 17. Note that the corrosion and pitting is more severe at the nut end of the stud than it is at the vessel flange end. There is also considerable pitting on the shank of the studs, adjacent to the threaded regions. By visual inspection the pitting in all areas varies from about 0.010 inches to 0.035 inches. Studs 39 and 40 are so called "cattle chute studs" which are removed every outage. That is probably why they appear to be less corroded.

The 60-degree examinations were repeated on all five studs after bead blasting. Calibrations were the same as the precleaning exams. The same areas were scanned. The removal of corrosion products changed the UT response significantly. There was less evidence of thread signal loss and the overall amplitude of the thread response was about 4-6 dB greater than the precleaning amplitude. These effects are shown in Figure 18.

The 70-degree examinations were repeated on all five studs after bead blasting. Calibrations were the same as the precleaning exams. The same areas were scanned. As with the 60-degree exam, the removal of corrosion products changed the UT response significantly. The results were the same as those described for the 60-degree exam. These effects are shown in Figure 19.

MT was performed on all five studs using an AC Yoke technique. A wet fluorescent method was used. This is similar to the examinations that were attempted during the ISI examination. The pitted areas were detected easily. There was no indication of cracking, even in heavily pitted areas.

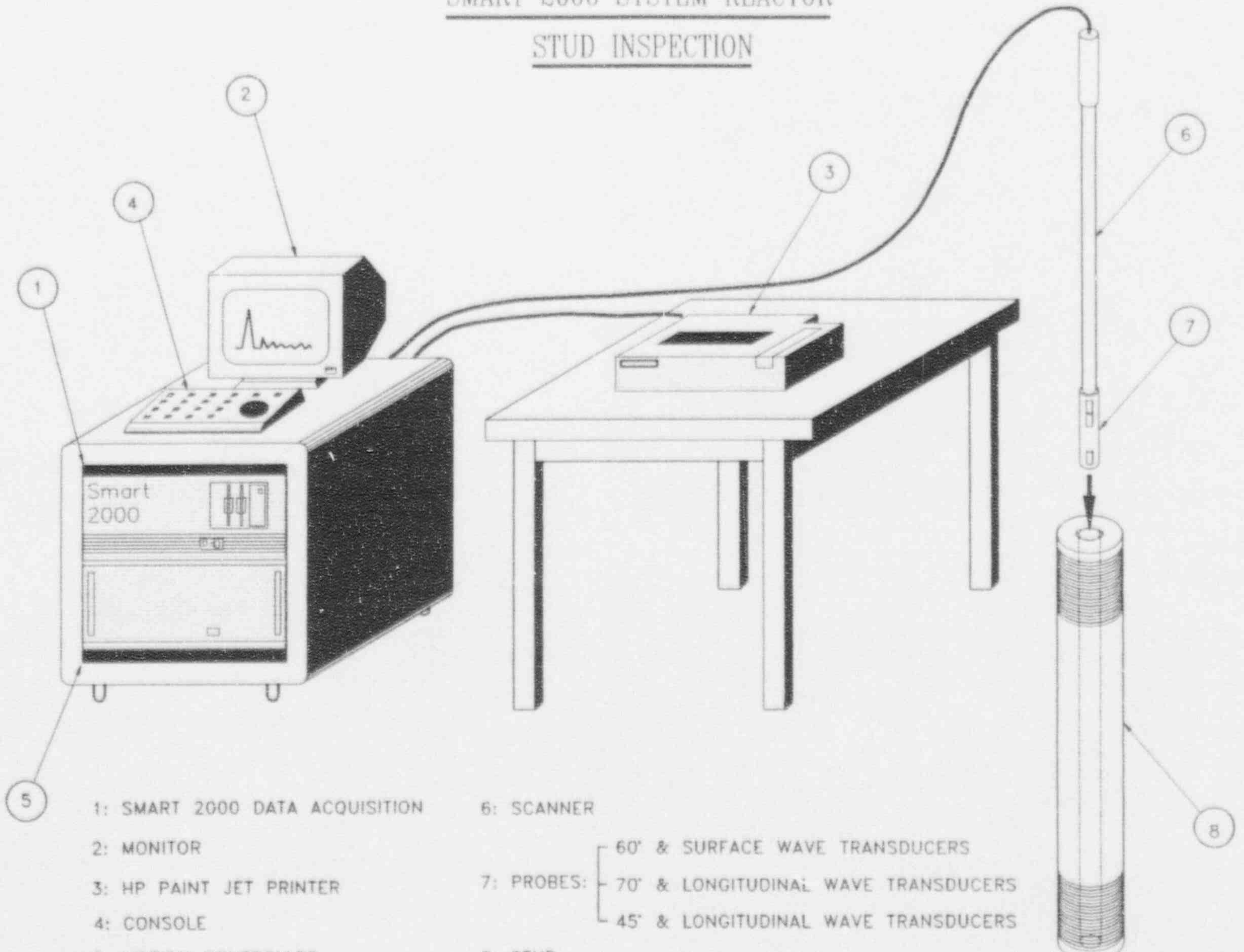
RT was performed, in the areas containing UT indications on studs 17, 39, and 40. RT showed the thread corrosion, but there was no evidence of cracking.

Visual (VT) exams were performed on all five studs, using a 10X magnifying glass and ambient lighting. A moderate amount of pitting was observed. On the nut end of the studs, pitting was noted in the threads near the bottom of the nut extending onto the body of the studs below the threads. At the vessel flange end of the studs, pitting was noted in the first few threads engaged in the bushing. Pits ranged in size from approximately 1/64" to 1/8" in diameter. The pits were aligned in many areas. Edge-to-edge distances were as small as 1/64".

UT reflections from circumferential EDM notches provide the same basic UT response as circumferential cracks. Therefore, EDM notches were placed in corroded threads on Stud No. 14 to demonstrate that small crack like indications could be detected despite the corrosion. The EDM setup is shown in Figure 20. Figures 21 and 22 are close ups of the EDM electrode being positioned to machine a notch in the corroded threads. Three notch sizes were targeted for use in the investigation. One additional notch was machined due to a miscut on one of the target notches. The miscut notch is shown in Figure 23, while one of the other notches is shown in Figure 24. EDM notch location and sizes are shown in Figure 25.

SMART 2000 SYSTEM REACTOR

STUD INSPECTION



1: SMART 2000 DATA ACQUISITION
2: MONITOR
3: HP PAINT JET PRINTER
4: CONSOLE
5: MOTION CONTROLLER
6: SCANNER
7: PROBES:
- 60° & SURFACE WAVE TRANSDUCERS
- 70° & LONGITUDINAL WAVE TRANSDUCERS
- 45° & LONGITUDINAL WAVE TRANSDUCERS

8: STUD

FIGURE 1

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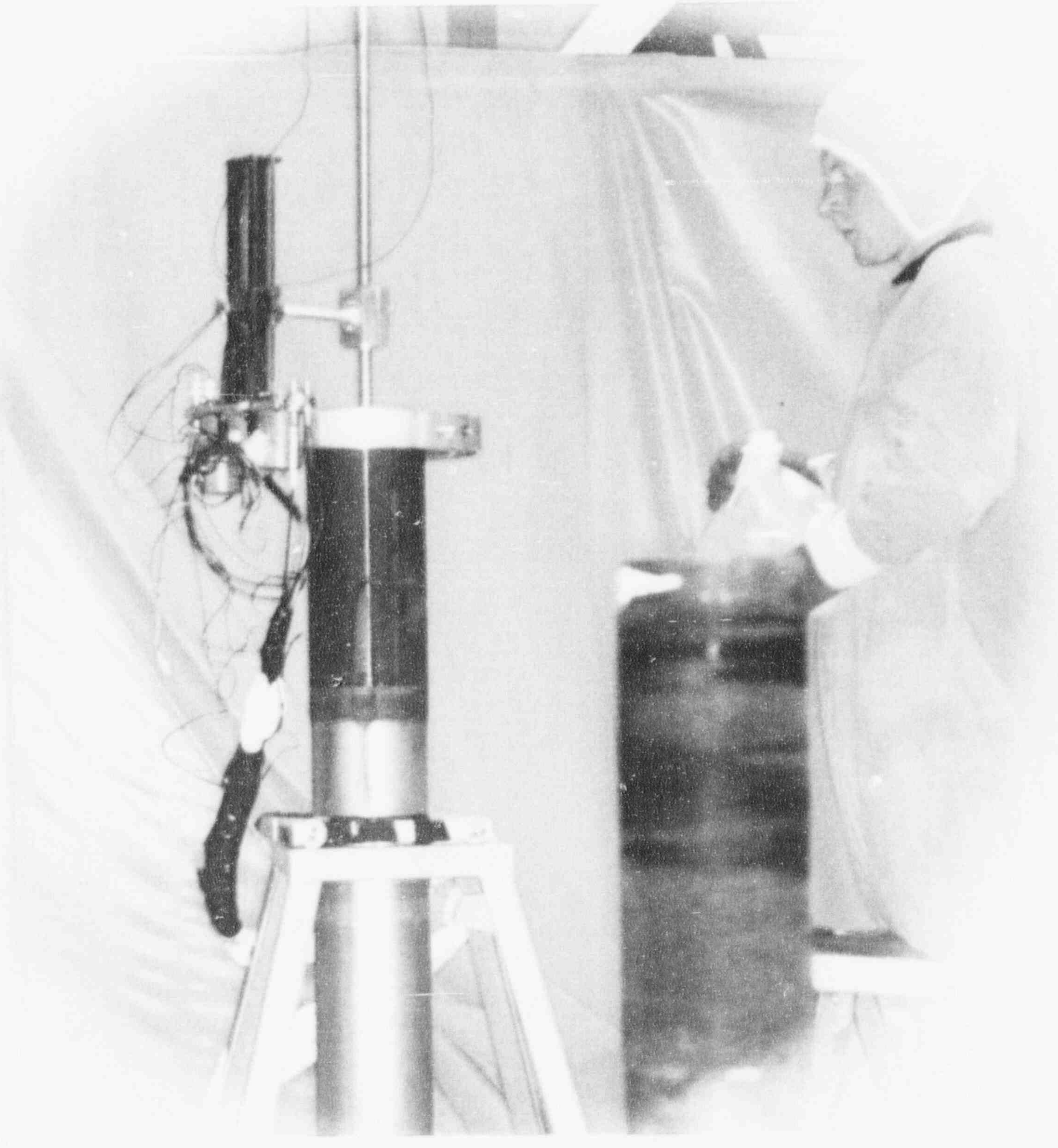


Figure 2. Scanner Set Up For Performing Automated UT Examinations Of Cooper RPV Studs In An Enclosed Contaminated Area (Plastic Tent).

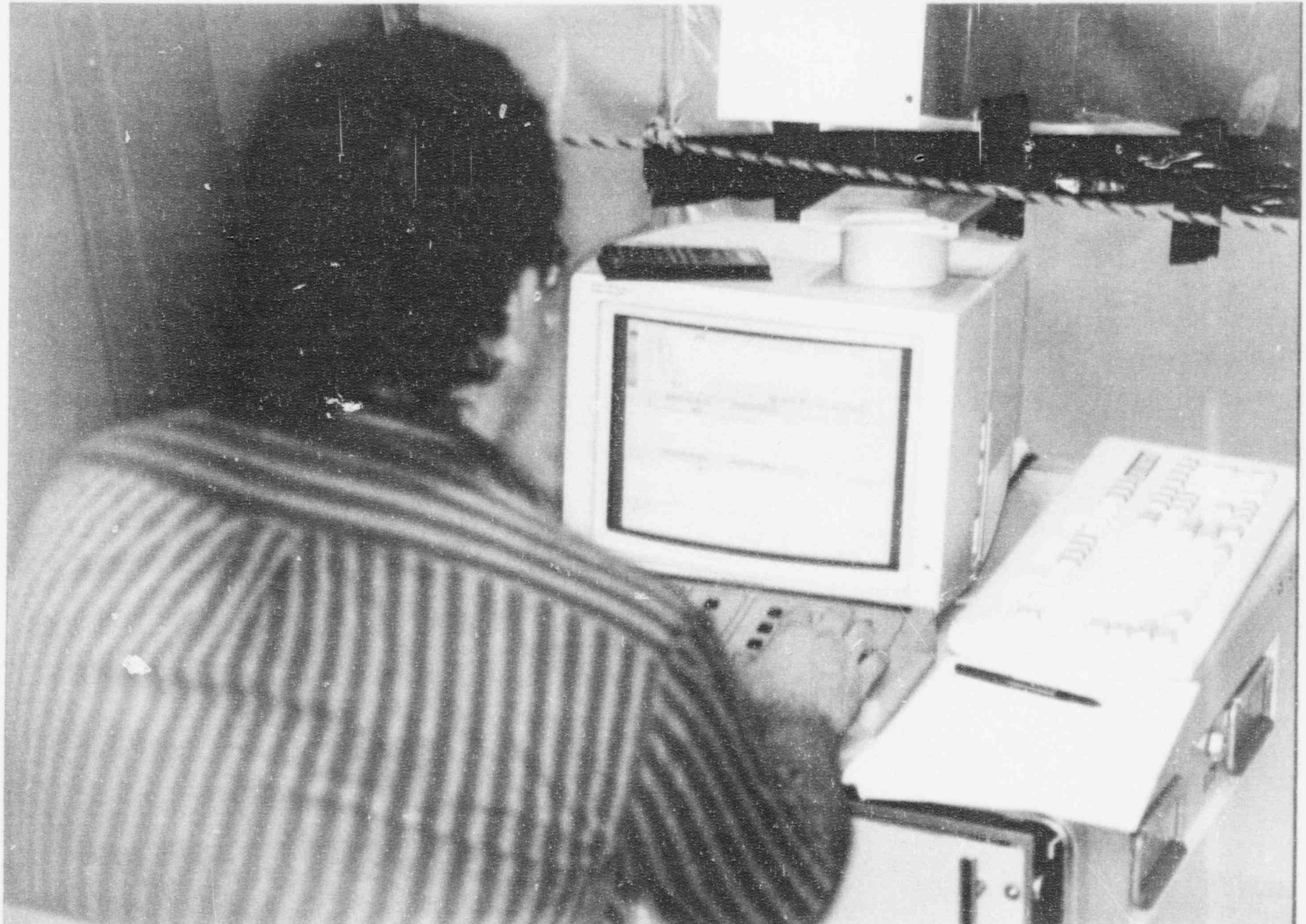
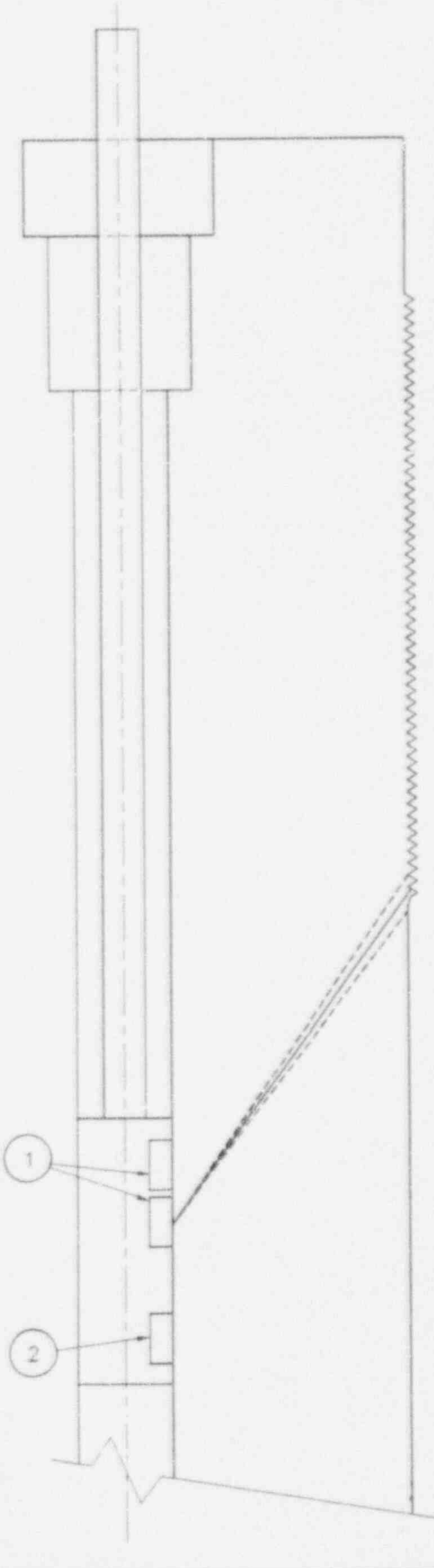
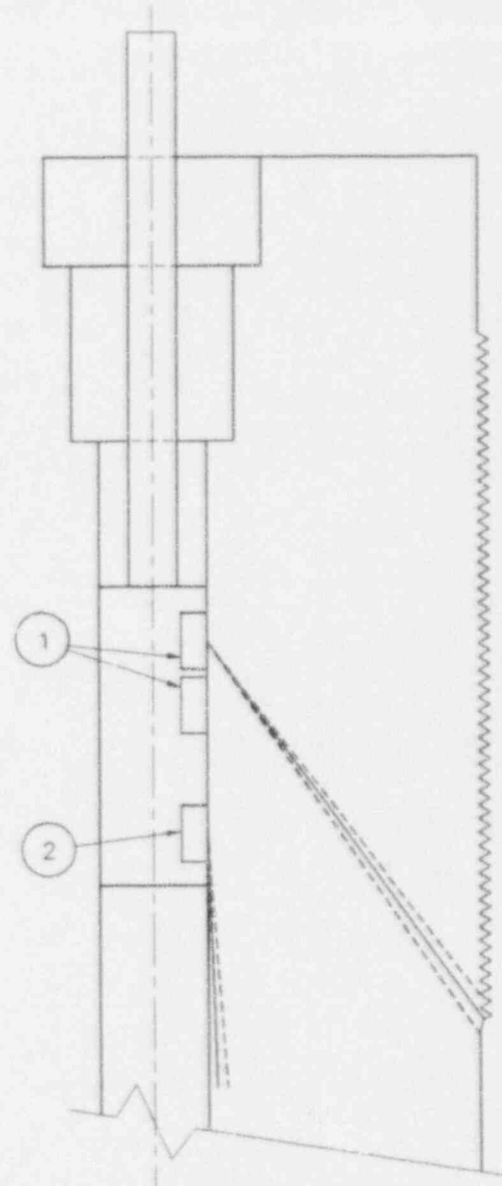


Figure 3. SMART 2000 UT Data Acquisition And Analysis Station For Examination Of Cooper RPV Studs. Setup Is Just Outside The Contaminated Area (Plastic Tent).

UT BEAM GEOMETRY





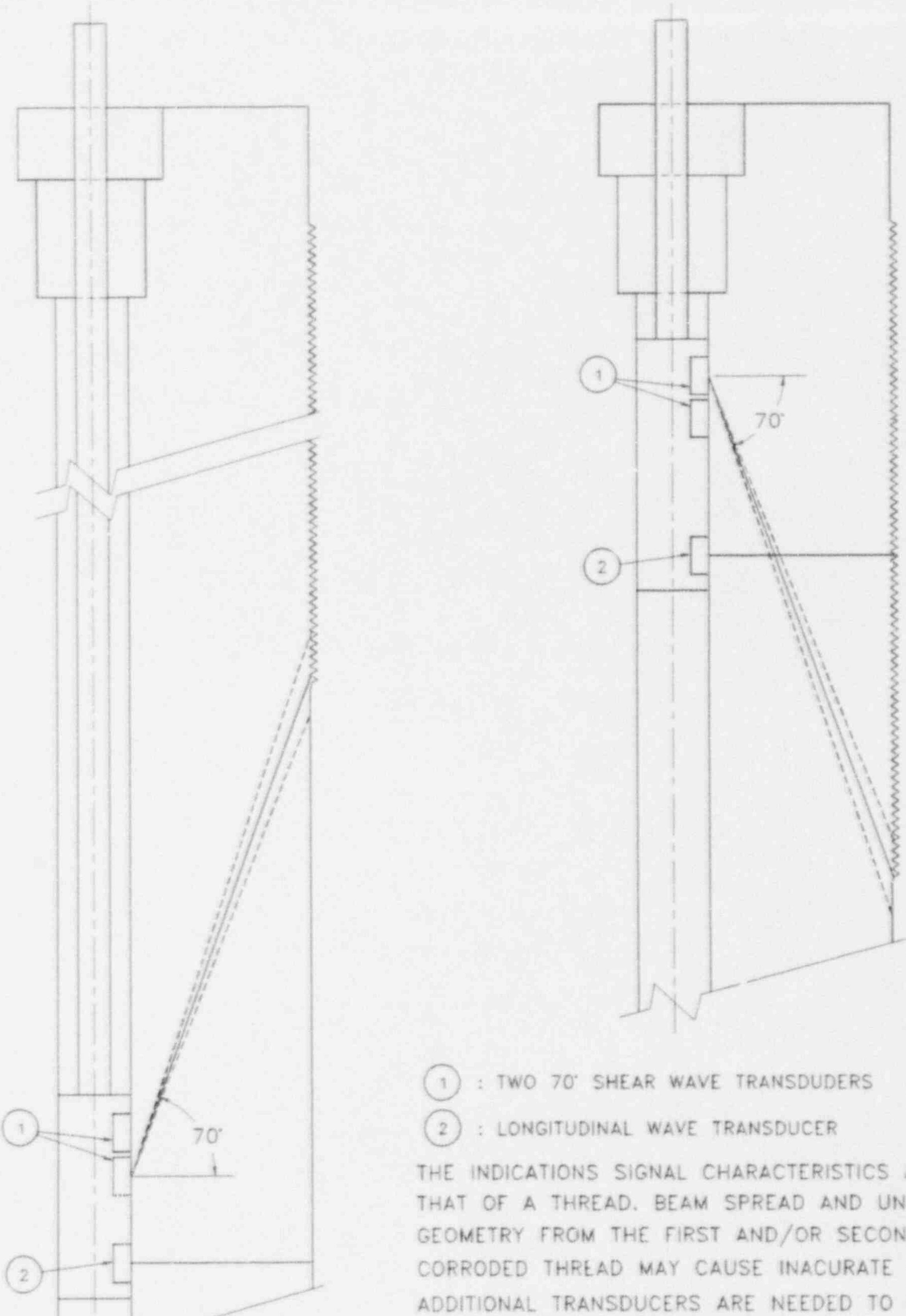
1: TWO 60' SHEAR WAVE TRANSDUCERS

2: 88' SHEAR WAVE TRANSDUCER

THE INDICATIONS SIGNAL CHARACTERISTICS ARE THAT OF A THREAD. BEAM SPREAD AND UNUNIFORM GEOMETRY FROM THE FIRST AND/OR SECOND CORRODED THREAD MAY CAUSE INACURATE SIZING. ADDITIONAL TRANSDUCERS ARE NEEDED TO CONFIRM THAT THE INDICATIONS ARE RELEVANT AND/OR GEOMETRIC.

FIGURE 4

UT BEAM GEOMETRY



(1) : TWO 70° SHEAR WAVE TRANSDUDERS

(2) : LONGITUDINAL WAVE TRANSDUCER

THE INDICATIONS SIGNAL CHARACTERISTICS ARE THAT OF A THREAD. BEAM SPREAD AND UNUNIFORM GEOMETRY FROM THE FIRST AND/OR SECOND CORRODED THREAD MAY CAUSE INACURATE SIZING. ADDITIONAL TRANSDUCERS ARE NEEDED TO CONFIRM THAT THE INDICATIONS ARE RELEVANT AND/OR GEOMETRIC.

FIGURE 5

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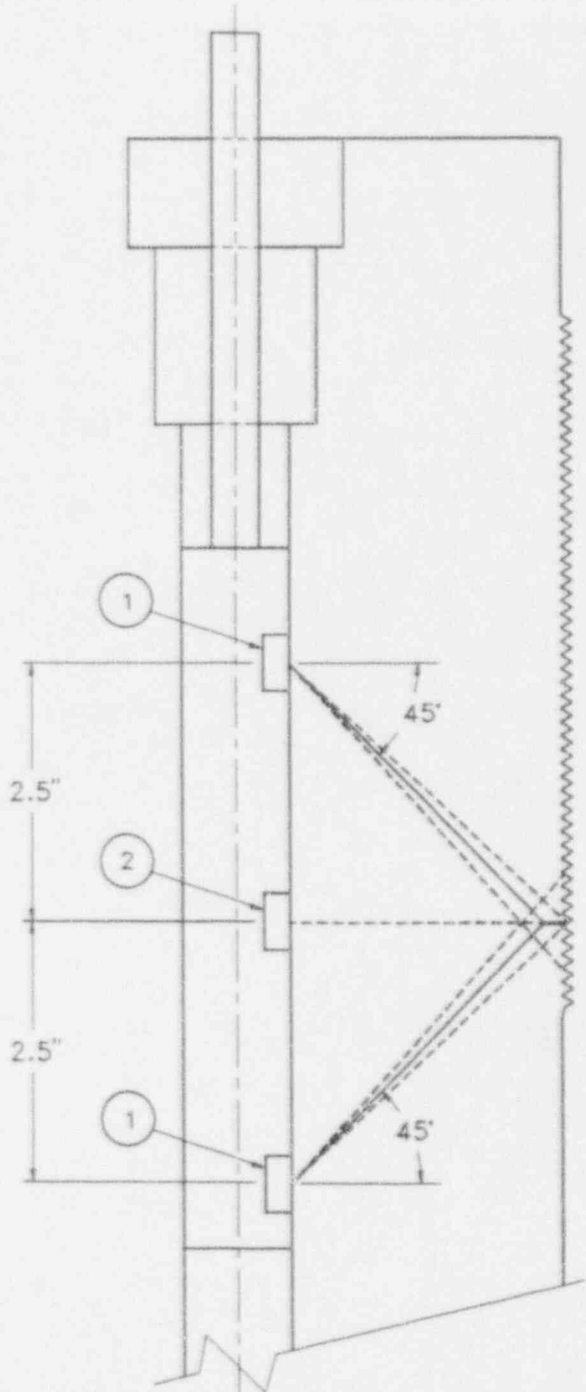
UT BEAM GEOMETRY



(1) : TWO 45' SHEAR WAVE TRANSDUCERS (2) : LONGITUDINAL WAVE TRANSDUCER

THE INDICATION SIGNAL CHARACTERISTICS ARE THAT OF A THREAD. BEAM SPREAD AND UNUNIFORM GEOMETRY FROM THE FIRST AND/OR SECOND CORRODED THREAD MAY CAUSE INACURATE SIZING. ADDITIONAL TRANSDUCERS ARE NEEDED TO CONFIRM THAT THE INDICATIONS ARE RELEVANT AND/OR GEOMETRIC.

FIGURE 6

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COVERAGE PLOT

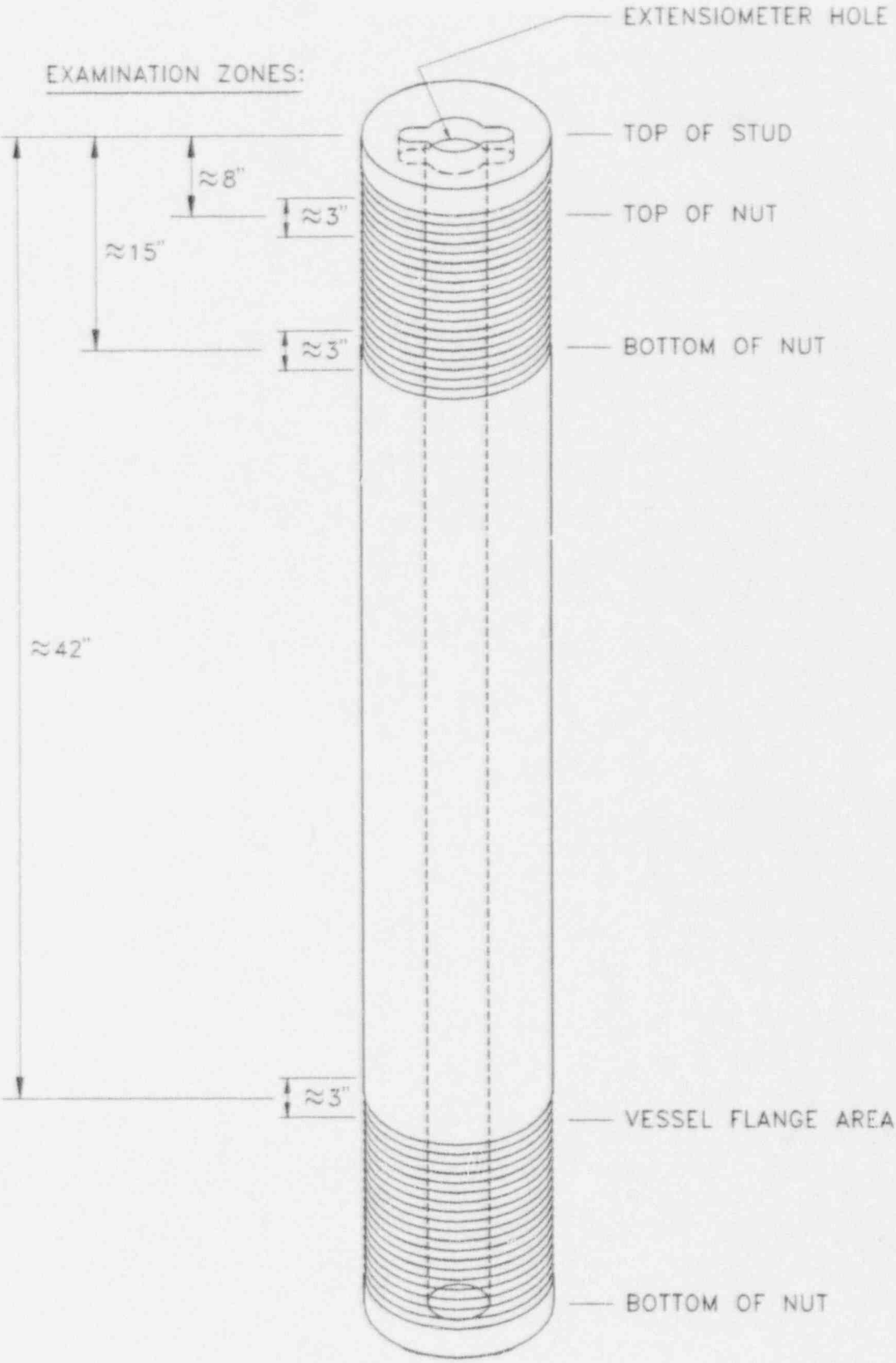

FIGURE 7

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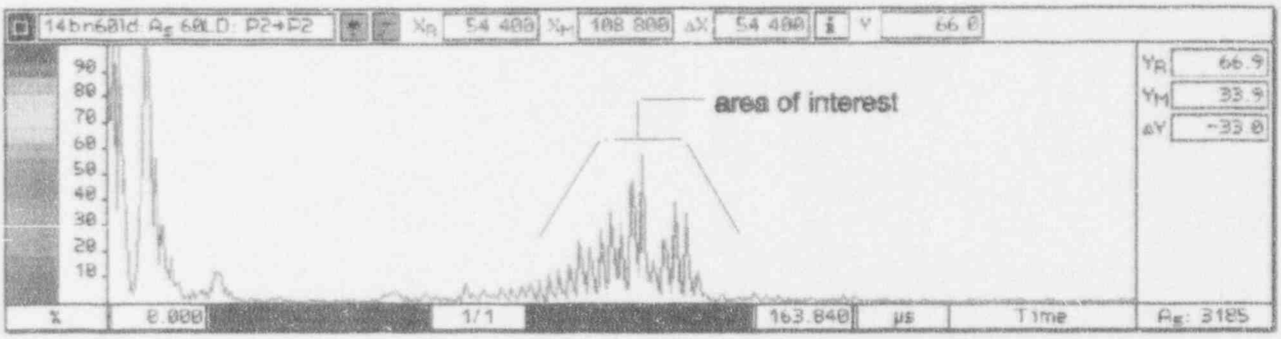
Signal comparison of the 60° looking up

and looking down scans in the area of interest

of the top threads.

60° down scan



Note the negitive signal response in the area

of interest for both scans.

60° up scans

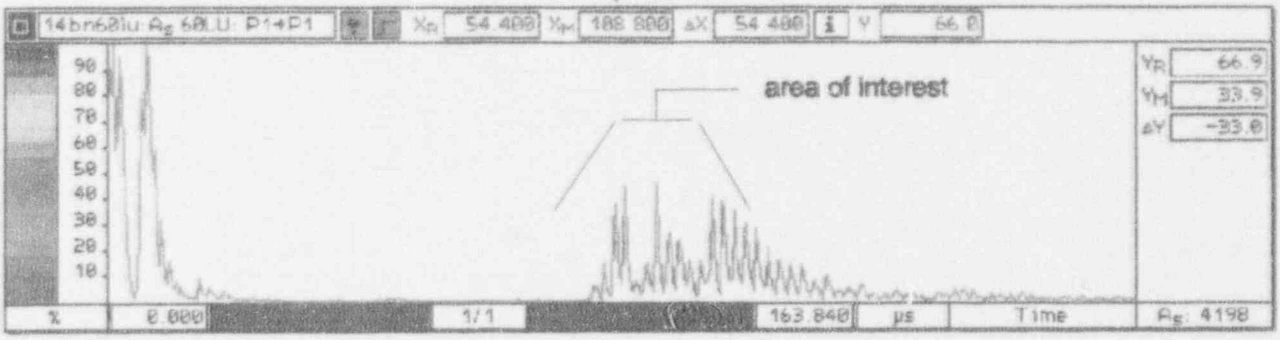


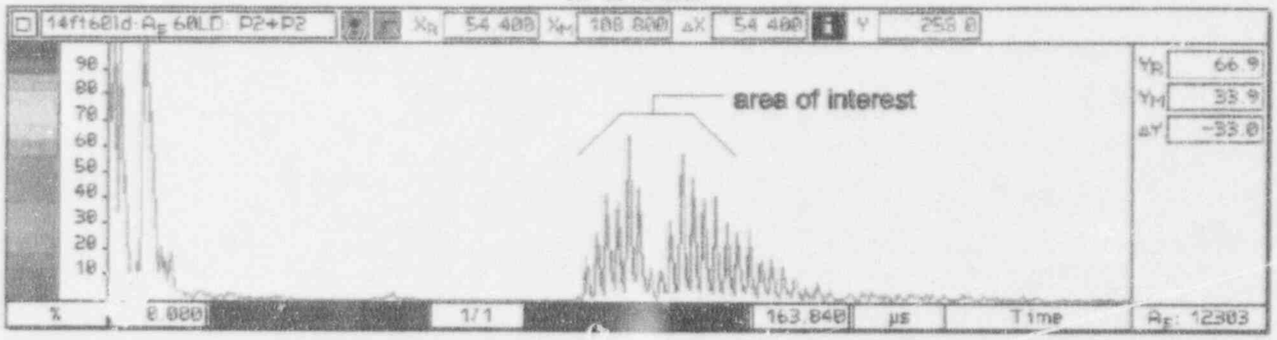
FIGURE 8 A

Signal comparison of the 60° up

down scans in the area of interest

of the flange threads.

60° d... n scan



Note the negitive signal response in the

area of interest for both scans.

60° up scan

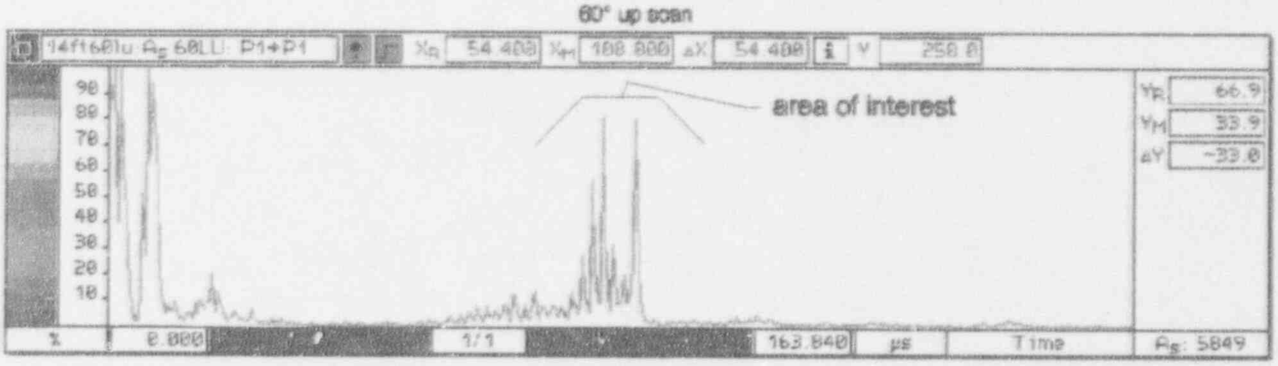
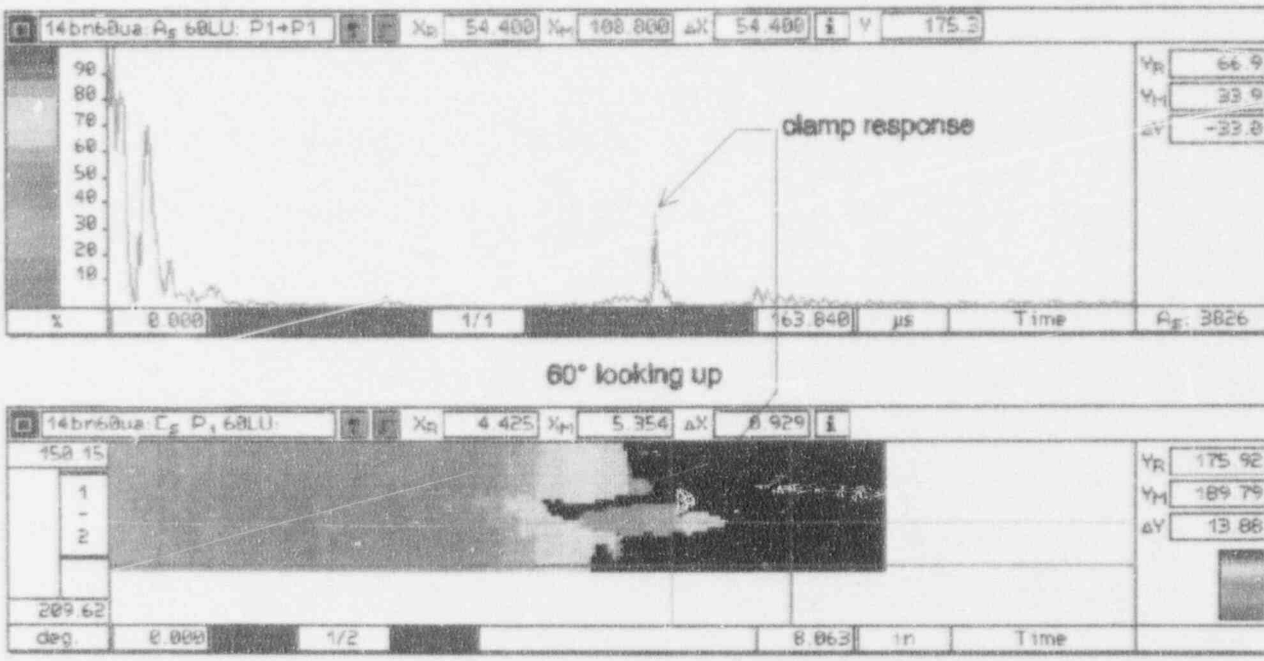


FIGURE 8 B

60° geometric response caused by the temporary support clamp.



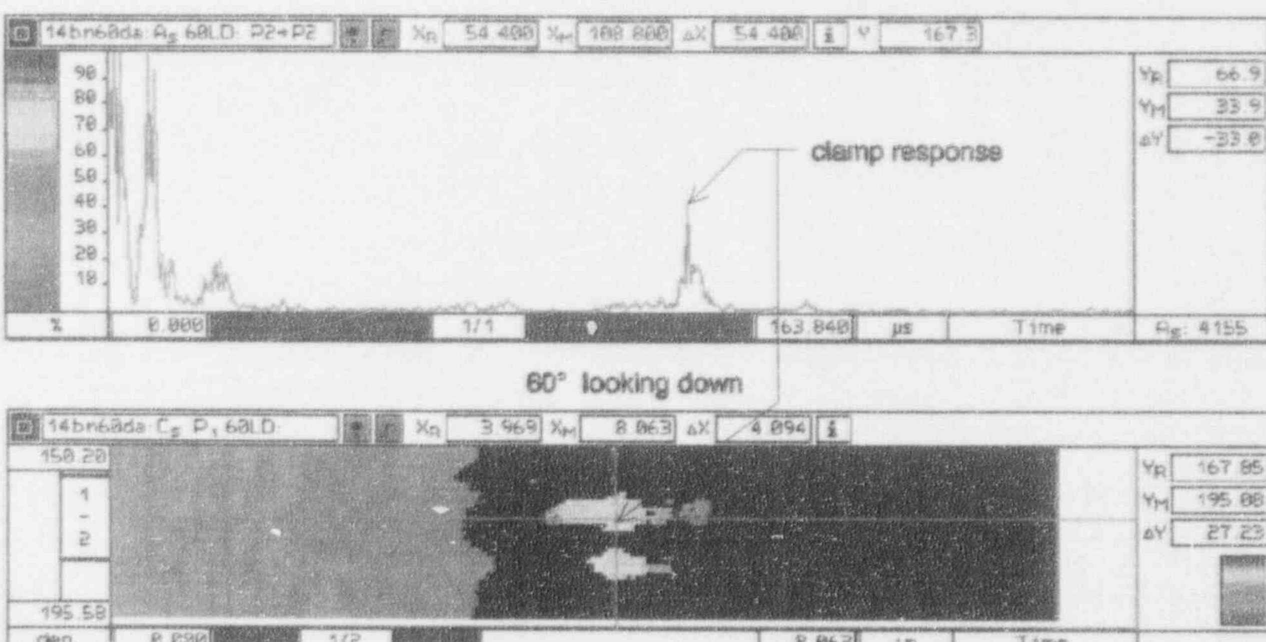
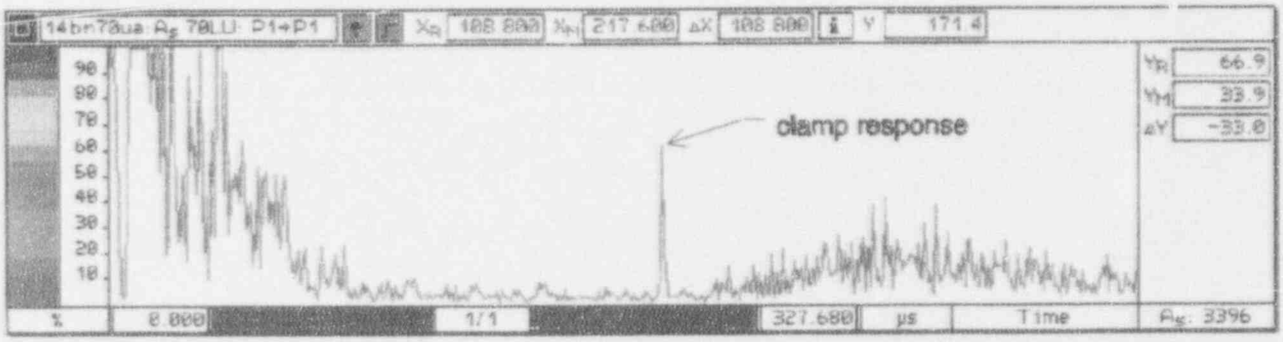


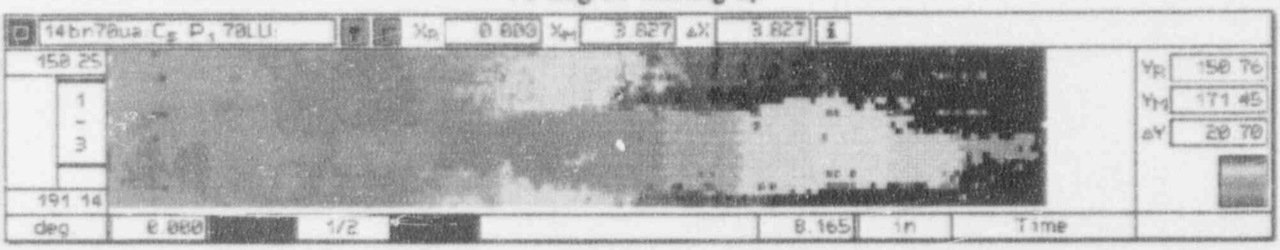
FIGURE 9 A

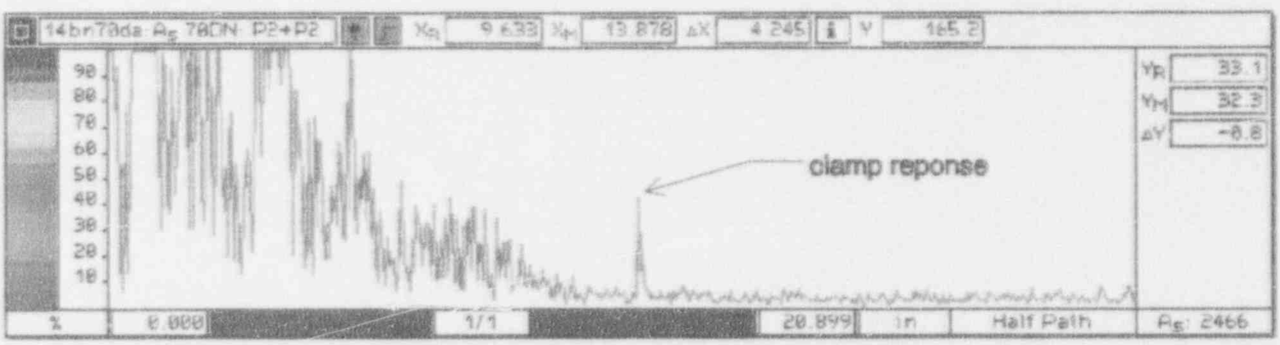
70 degree geometric response caused

by a temporary support clamp.



70 degree looking up





70 degree looking down

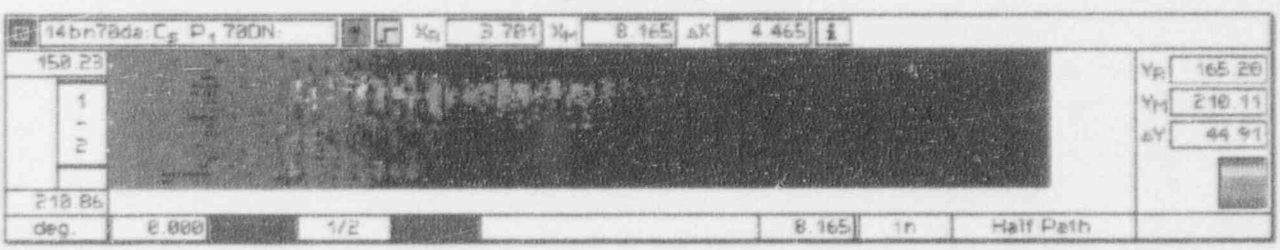


FIGURE 9 B

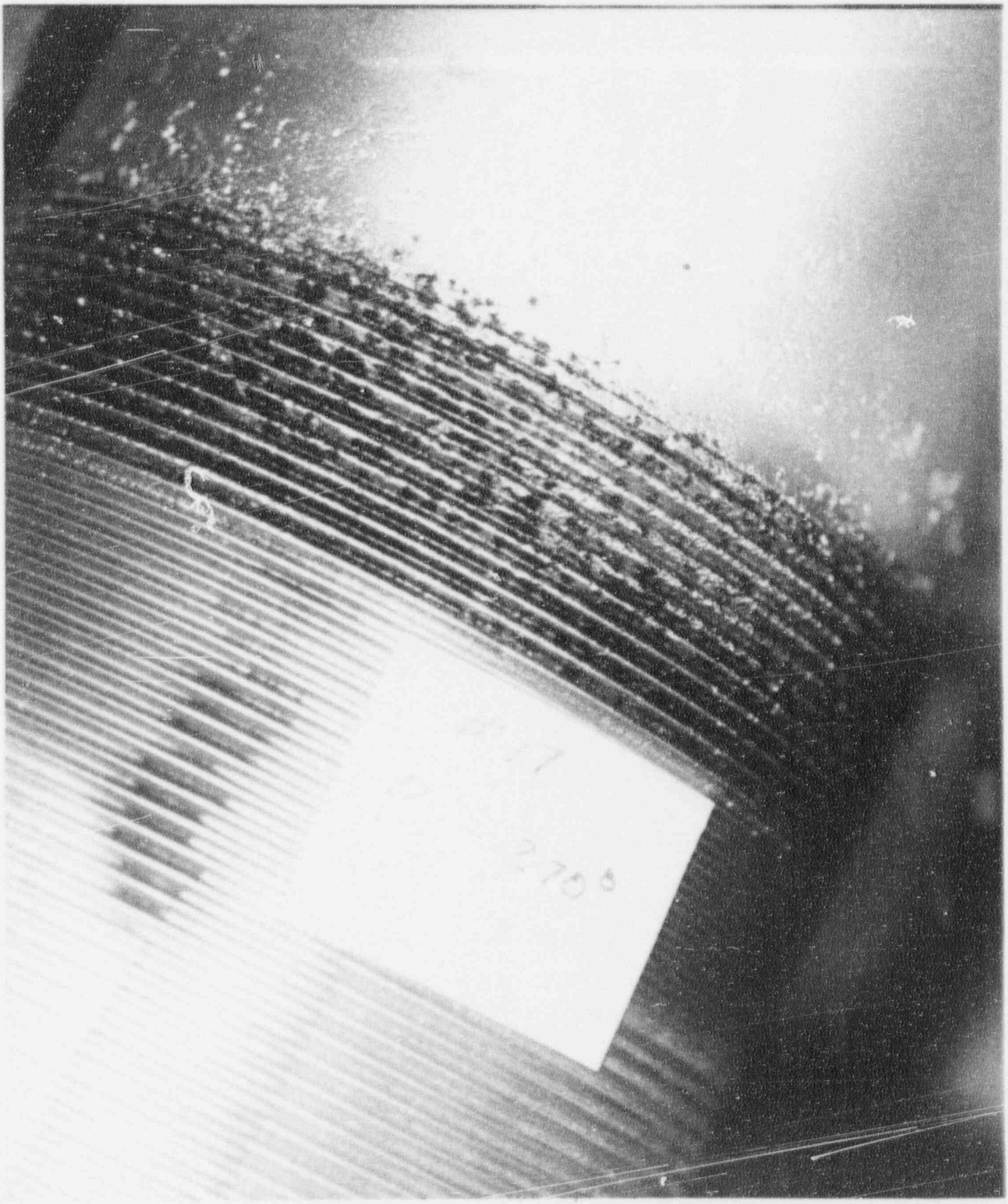


Figure 10. Cooper Stud # 17

Corrosion And Pitting In The Threads And On The Shank, Just Below The Nut Area, After Cleaning By Glass Bead Blasting.

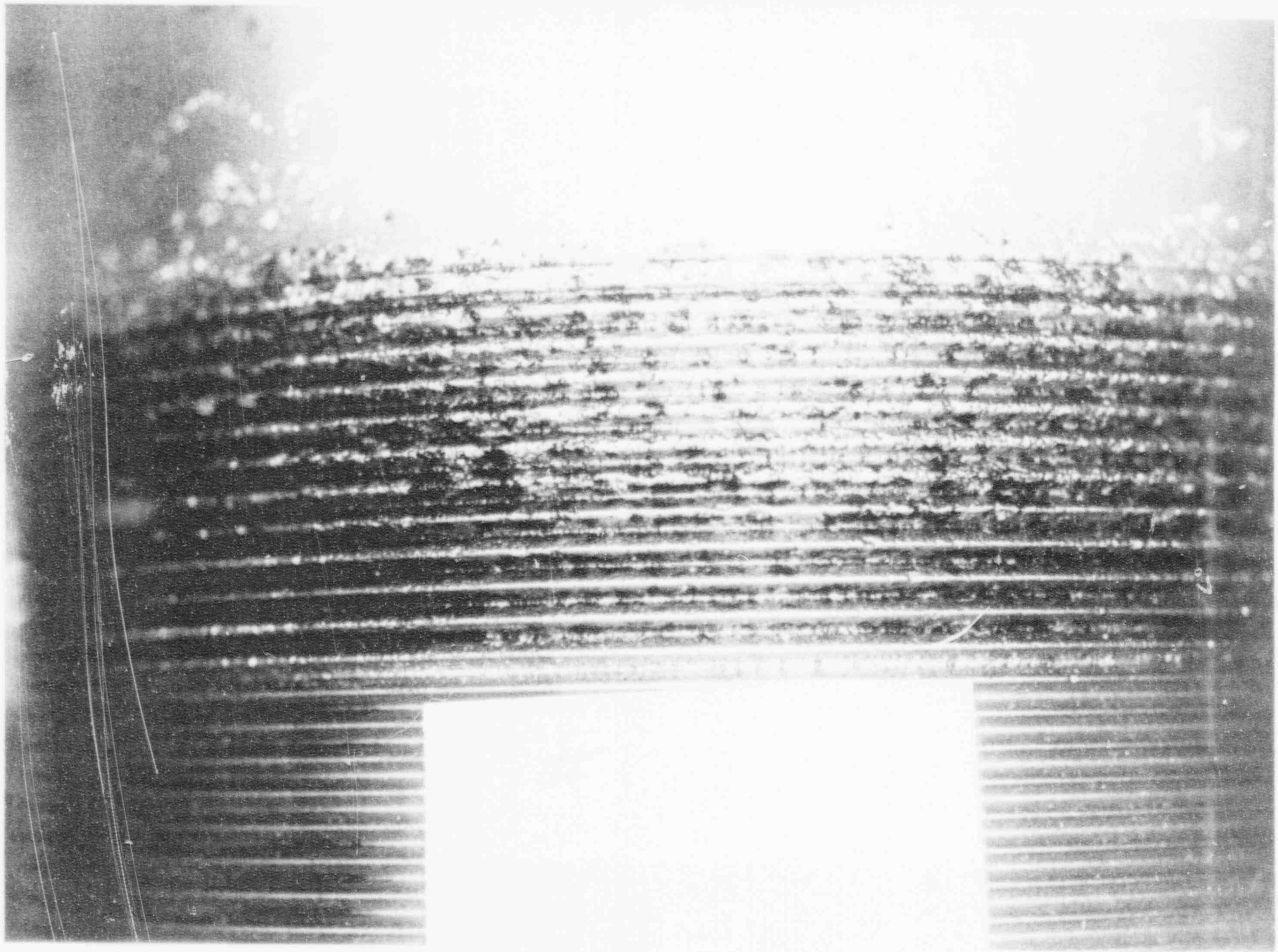


Figure 1_ Cooper Stud # 17

Corrosion And Pitting In The Threads And On The Shank, Just Below The Nut Area, After Cleaning By Glass Bead Blasting.

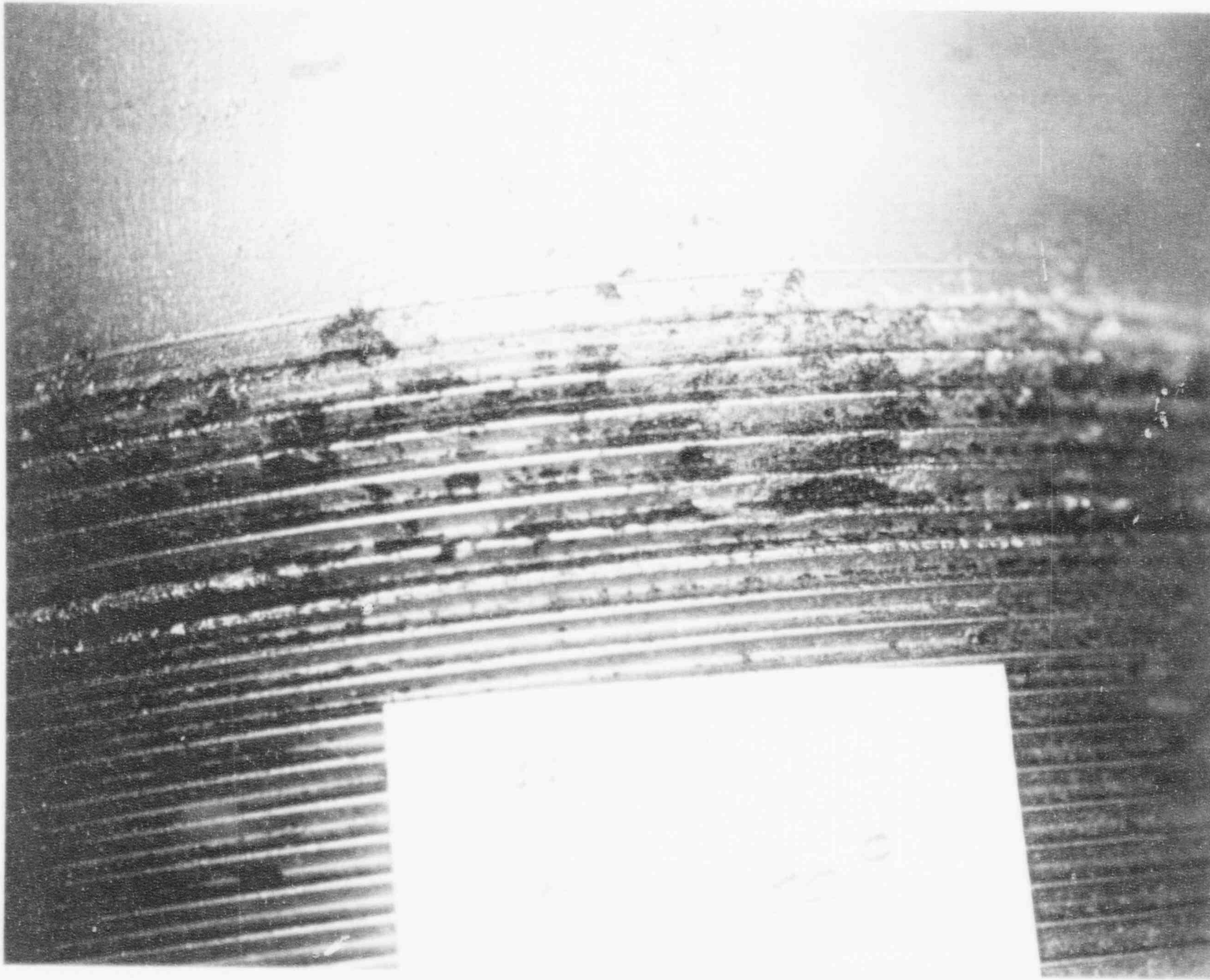


Figure 12 Cooper Stud # 17

Corrosion And Pitting In The Threads And On The Shank, At The Vessel Flange End, After Cleaning By Glass Bead Blasting.

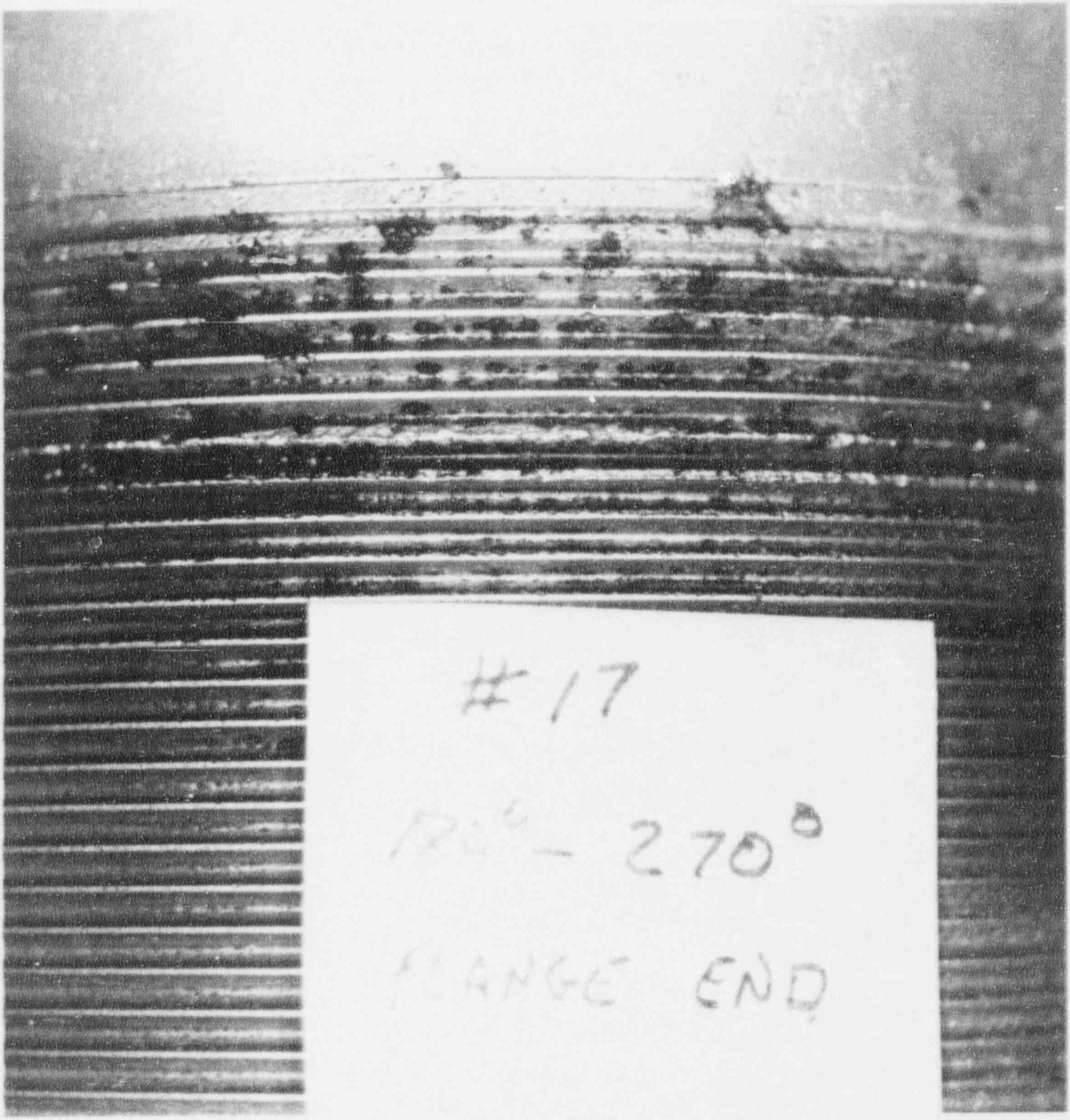


Figure 13. Cooper Stud # 17

Corrosion And Pitting In The Threads And On The Shank, At The Vessel Flange End, After Cleaning By Glass Bead Blasting.

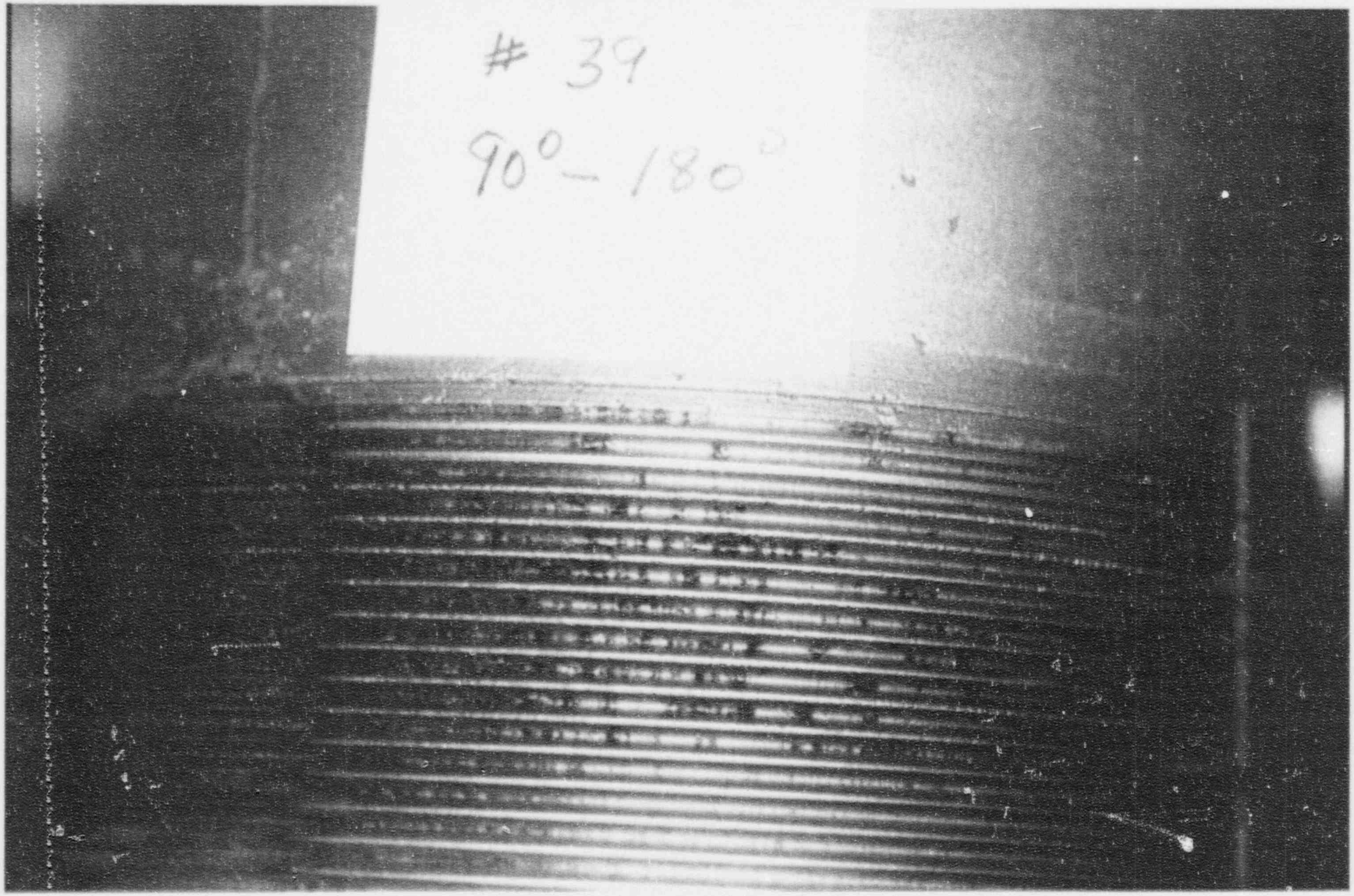


Figure 14. Cooper Stud # 39

Corrosion And Pitting In The Threads And On The Shank, Just Below The Nut Area, After Cleaning By Glass Bead Blasting.

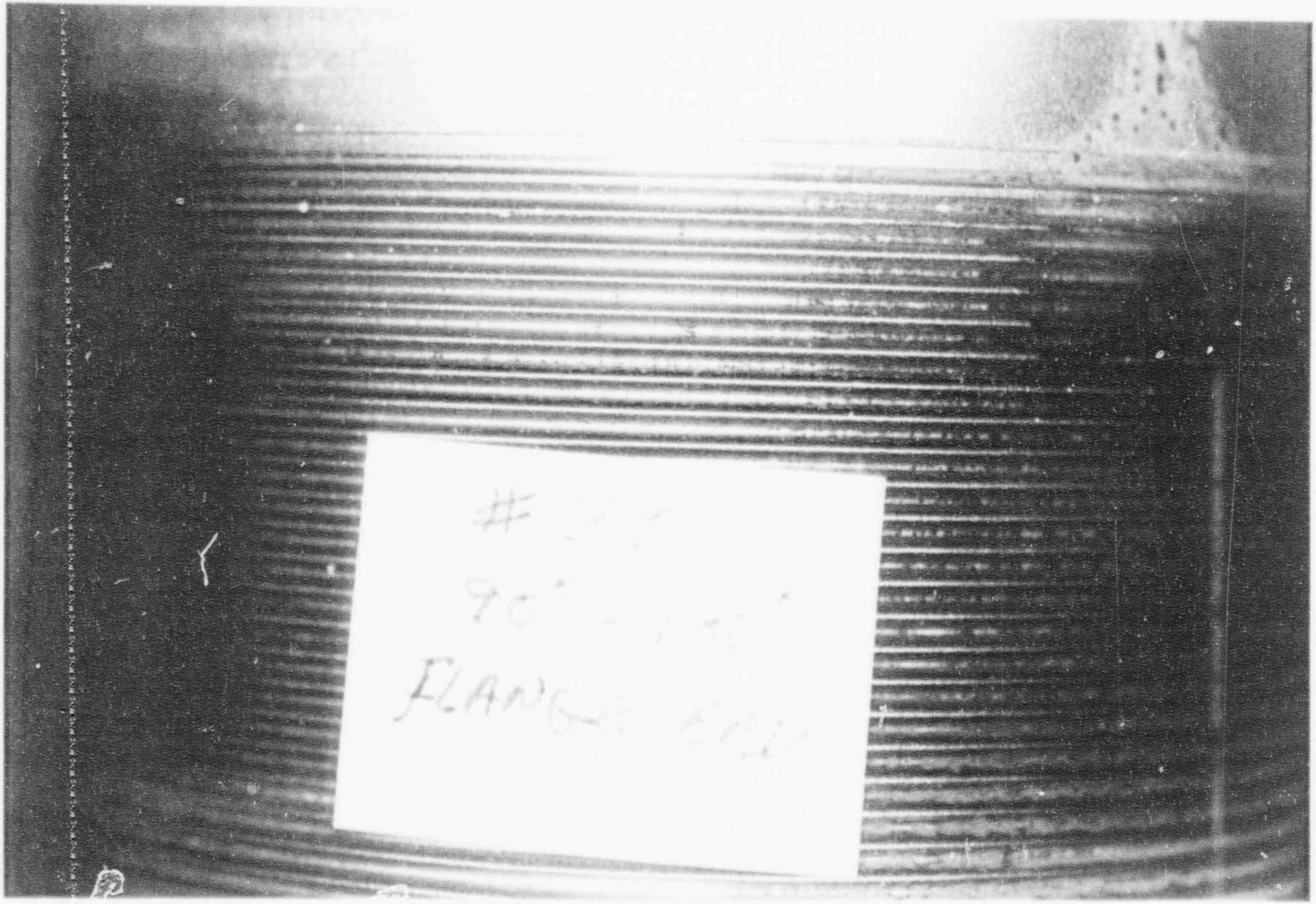


Figure 15. Cooper Stud # 39

Corrosion And Pitting In The Threads And On The Shank, At The Vessel Flange End, After Cleaning By Glass Bead Blasting.

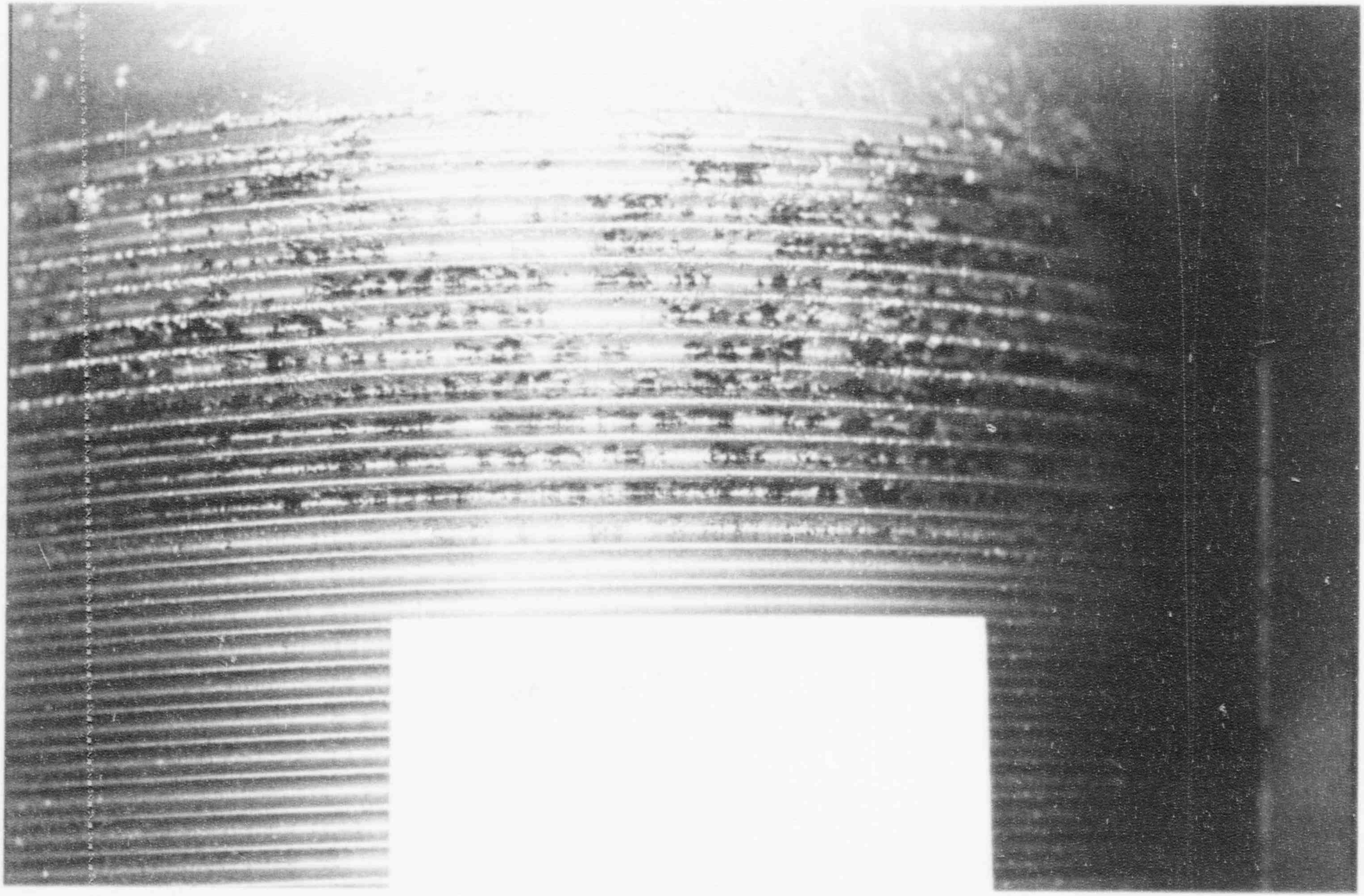


Figure 16. Cooper Stud # 40

Corrosion And Pitting In The Threads And On The Shank, Just Below The Nut Area, After Cleaning By Glass Bead Blasting.

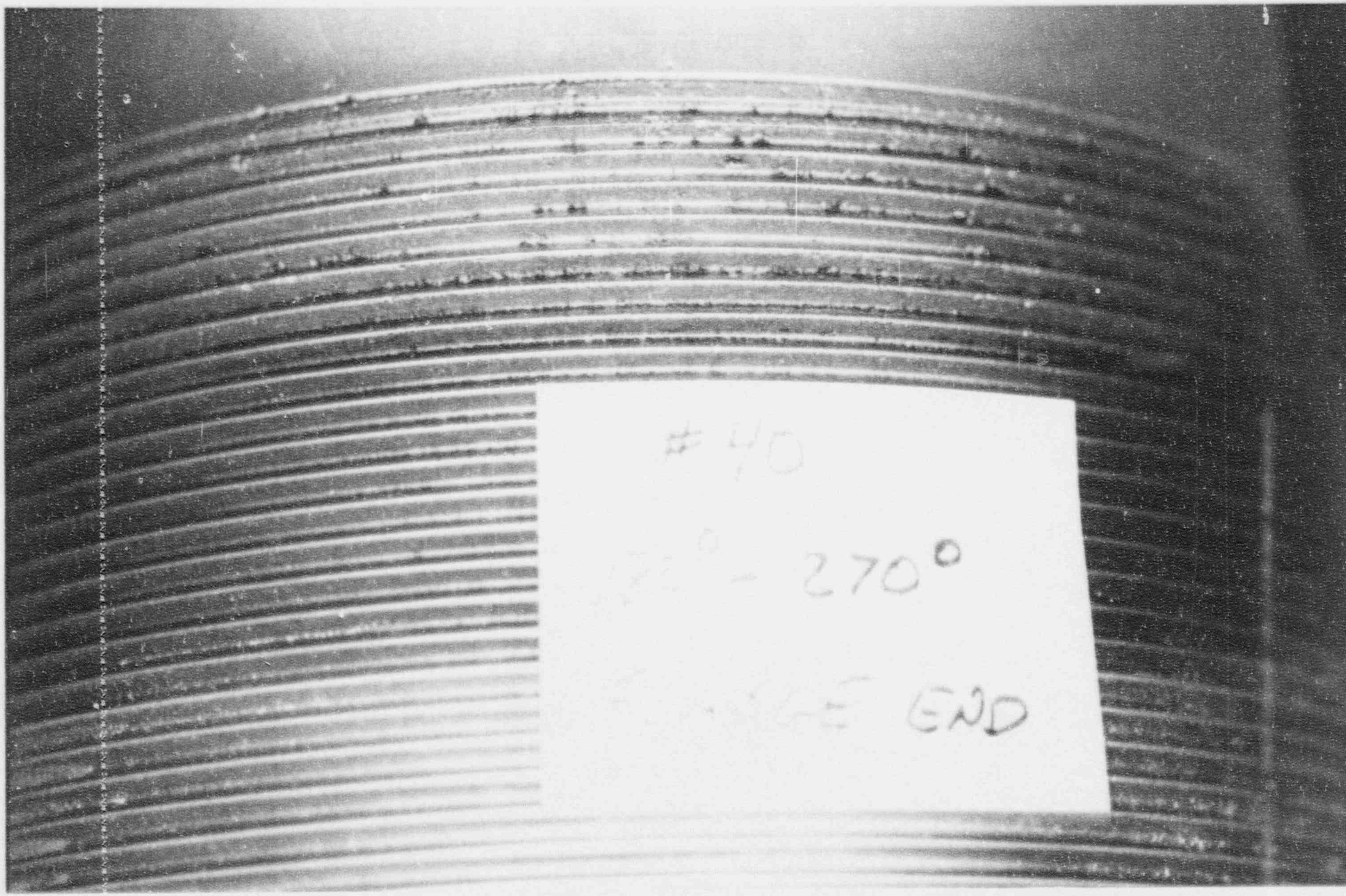


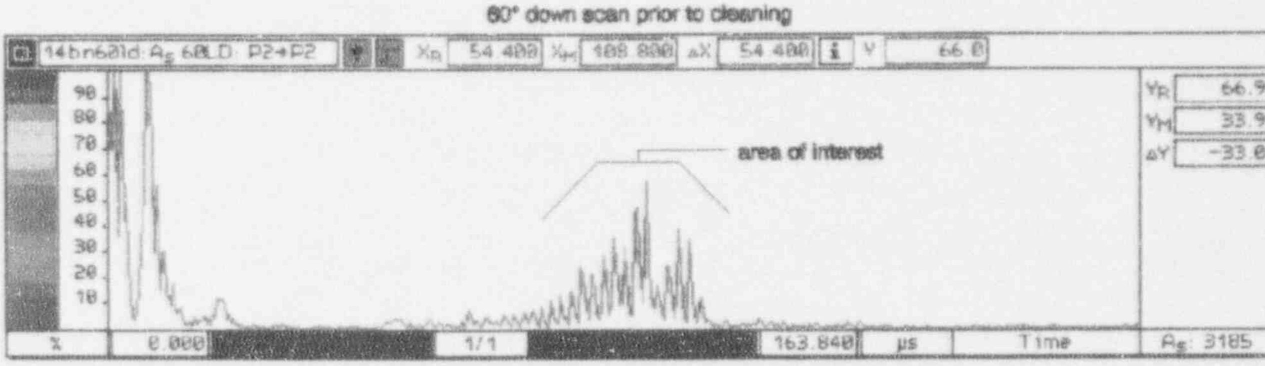
Figure 17. Cooper Stud # 40

Corrosion And Pitting In The Threads And On The Shank, At The Vessel Flange End, After Cleaning By Glass Bead Blasting.

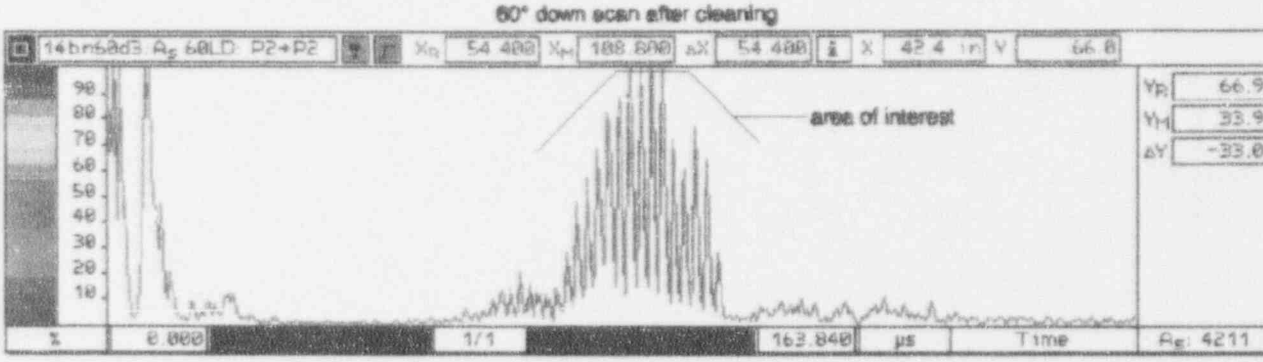
Figure 18.

Comparison of signal charictoristics and amplitude between pre and post cleaning for the 60° probe

60° down scan prior to cleaning

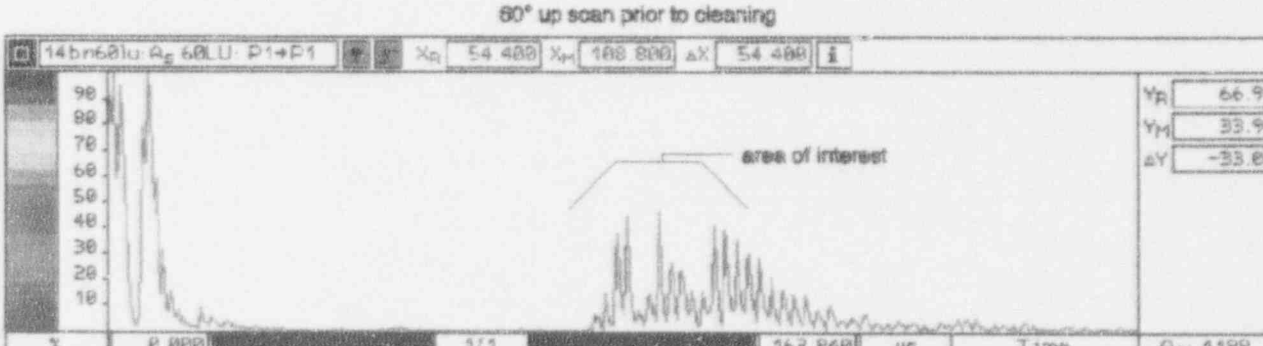


60° down scan after cleaning



Gain settings for both the 60° down scans were 49 dB. Settings for the up scans were changed from 47 dB before cleaning to 43 dB after cleaning to anable full veiwing of the signal in the area of interest.

60° up scan prior to cleaning



60° up scan after cleaning

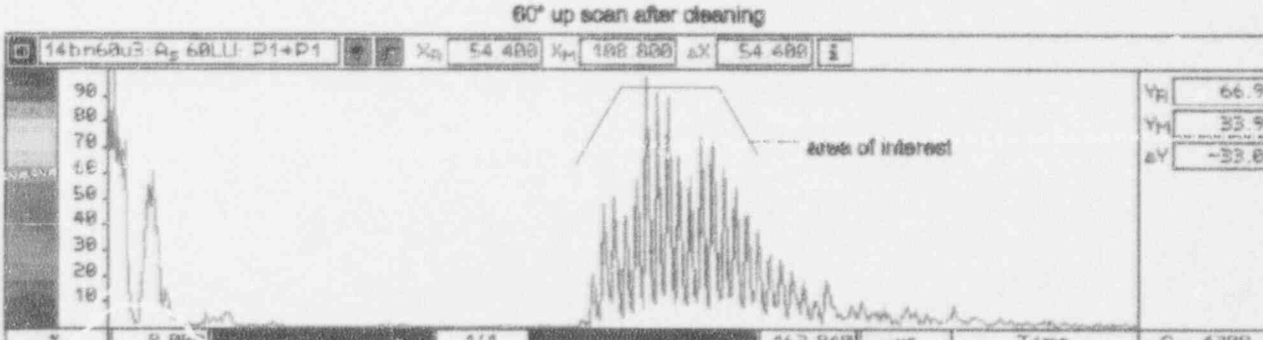
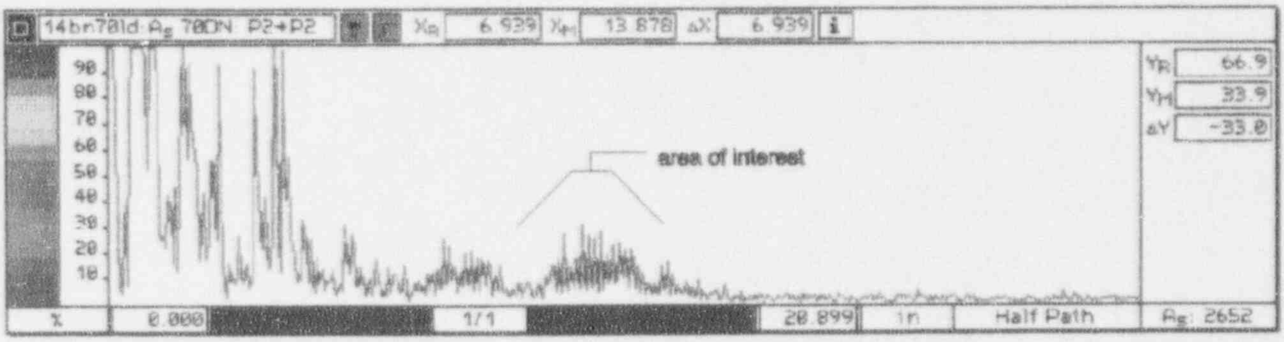


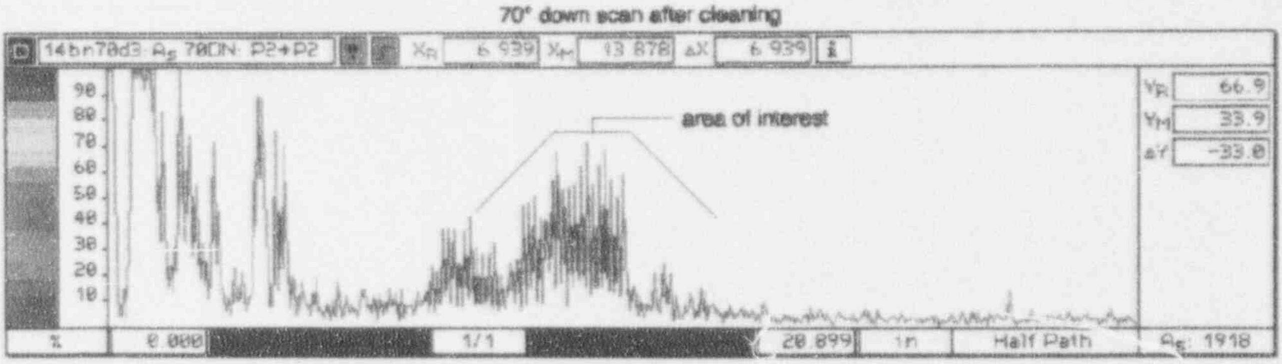
Figure 19.

Comparison of signal charictoristics and amplitude between pre and post cleaning for the 70° probe.

70° down scan prior to cleaning

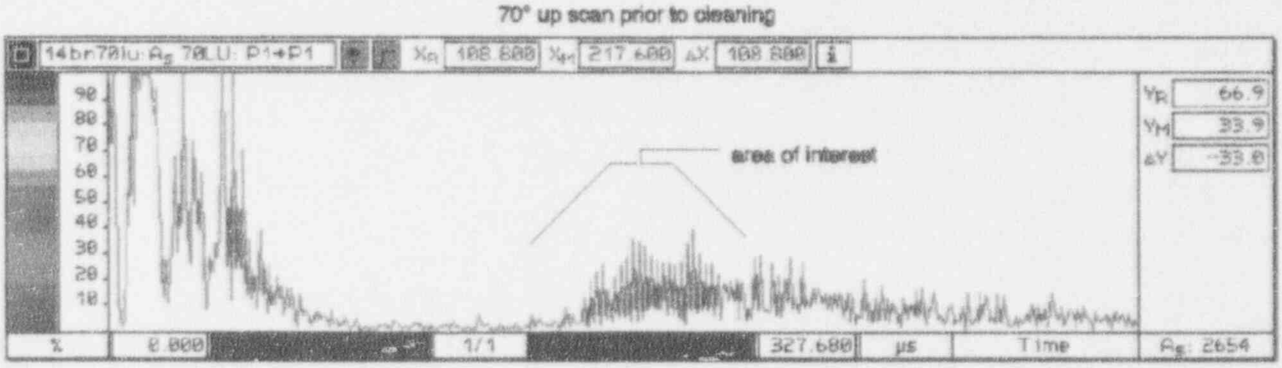


70° down scan after cleaning

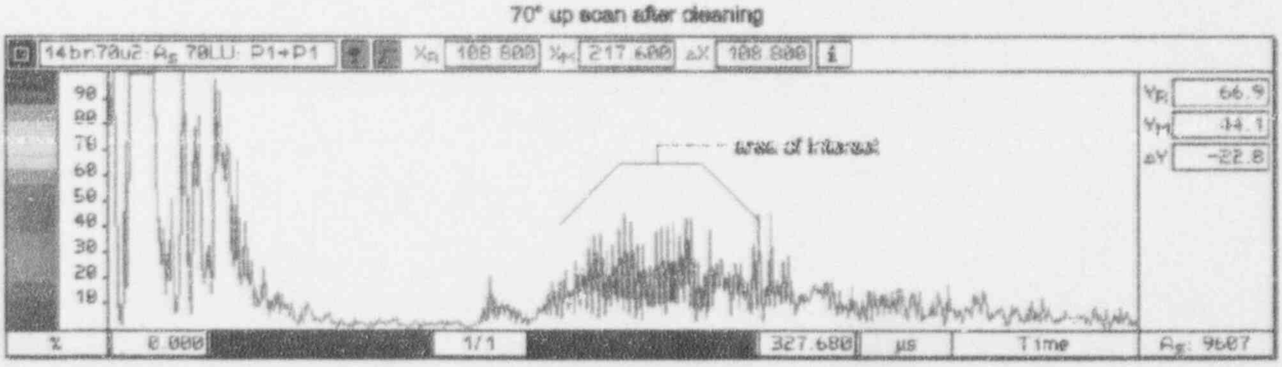


Gain settings for both the 70 degree down scans was 69.5dB, and for both the 70 degree up scans 66 dB.

70° up scan prior to cleaning



70° up scan after cleaning



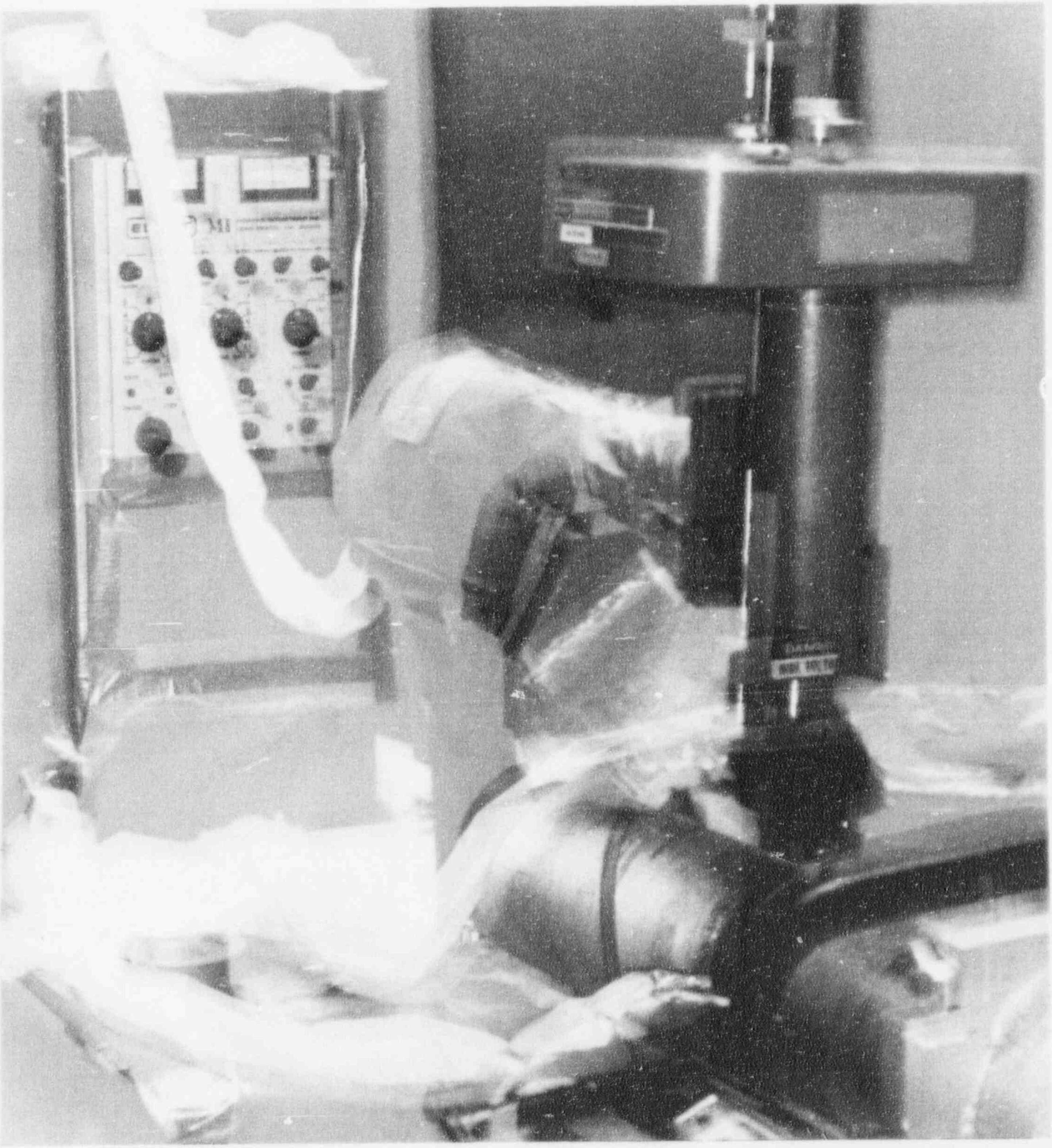


Figure 20. EDM Equipment

Set Up In Contaminated Area To Machine Notches In The Corroded Threads Of Cooper Stud # 14.

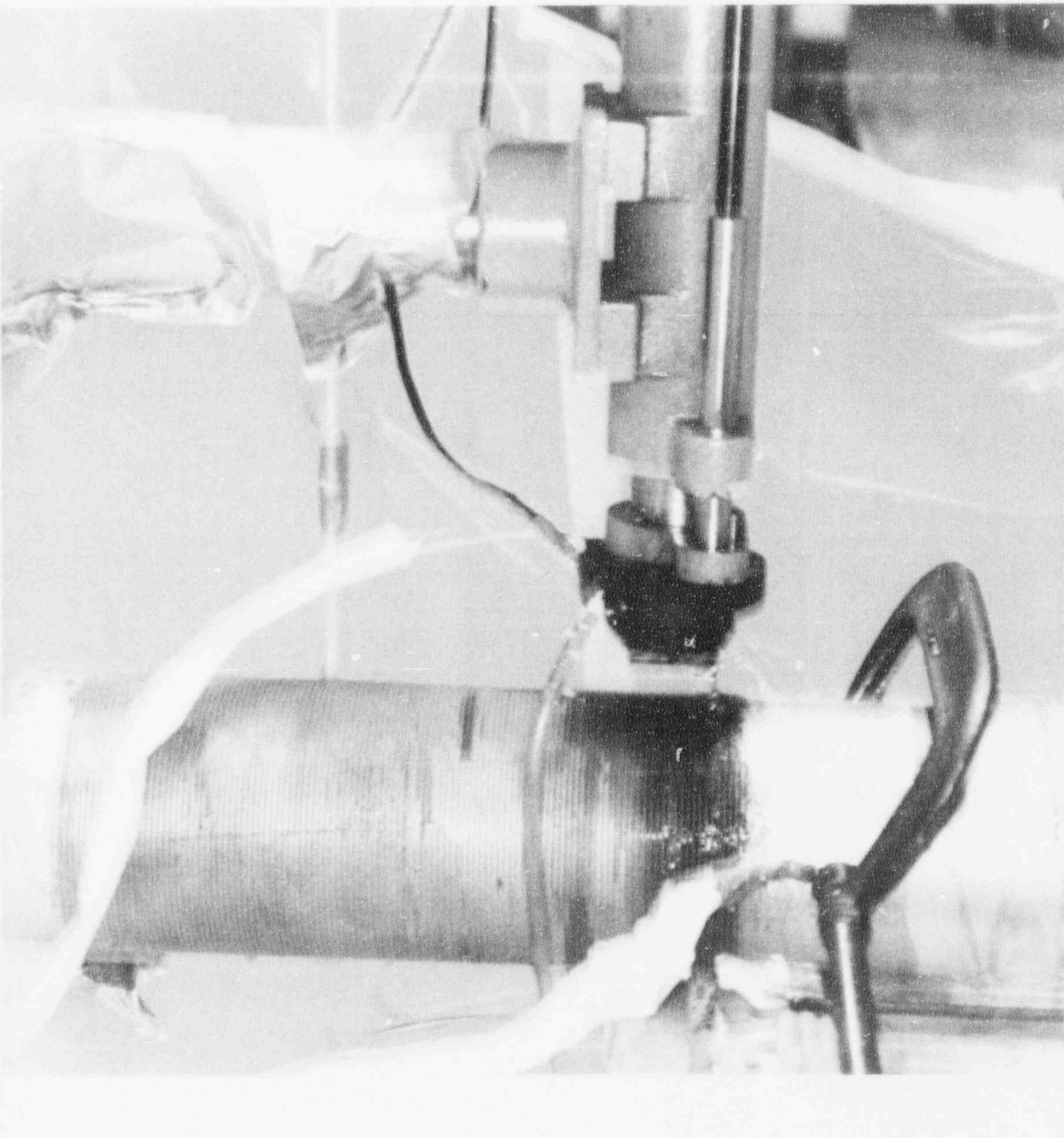


Figure 21   EDM Equipment

Positioning Of EDM Electrode For Placing Notches In The Corroded Threads Of Cooper Stud # 14.

Figure 22 EDM Electrode

Electrode Shown As It Is Being Applied To The Root Of A Thread To Machine A Notch In Cooper Stud # 14.

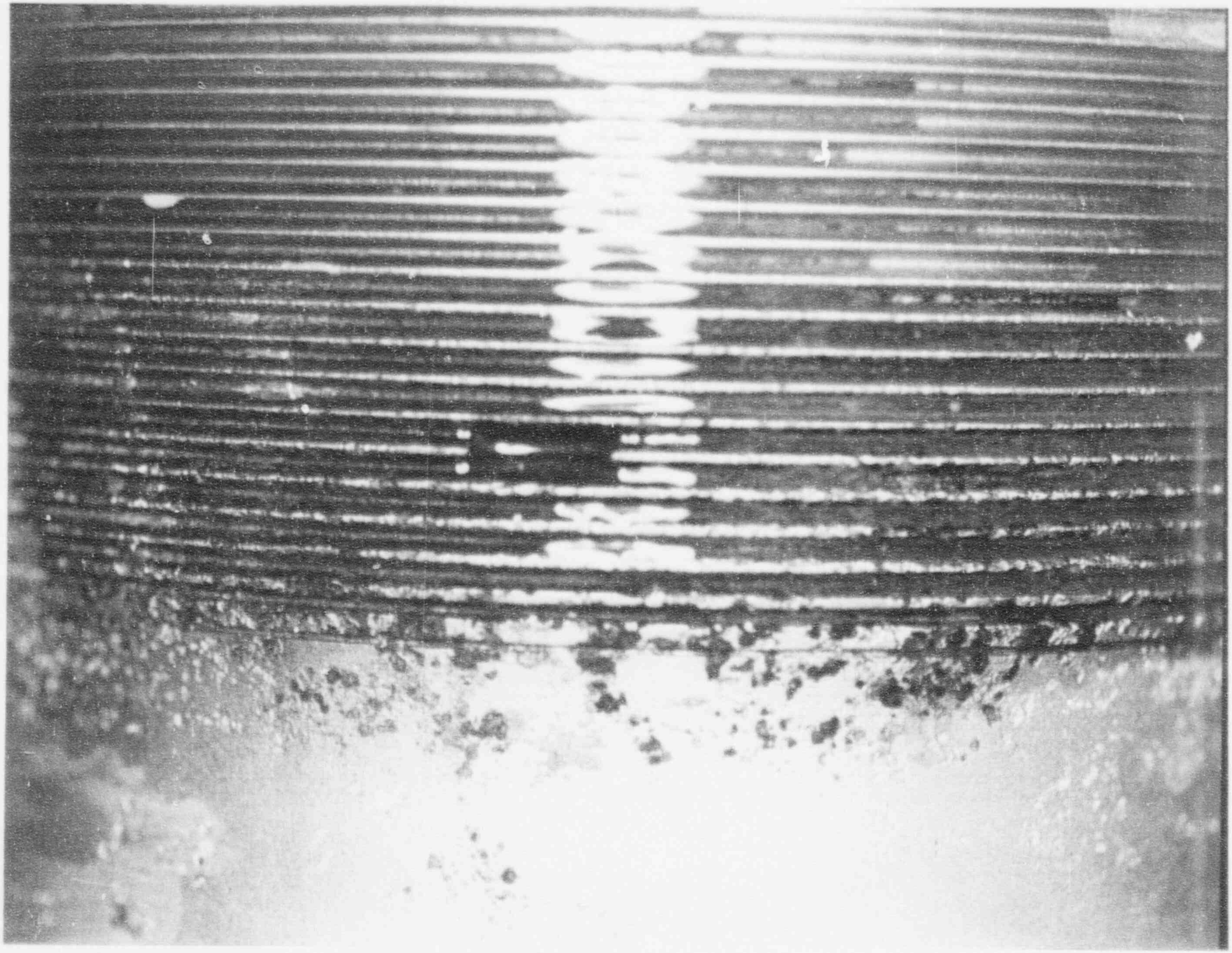


Figure 23 Miscut Notch In Cooper Stud # 14.

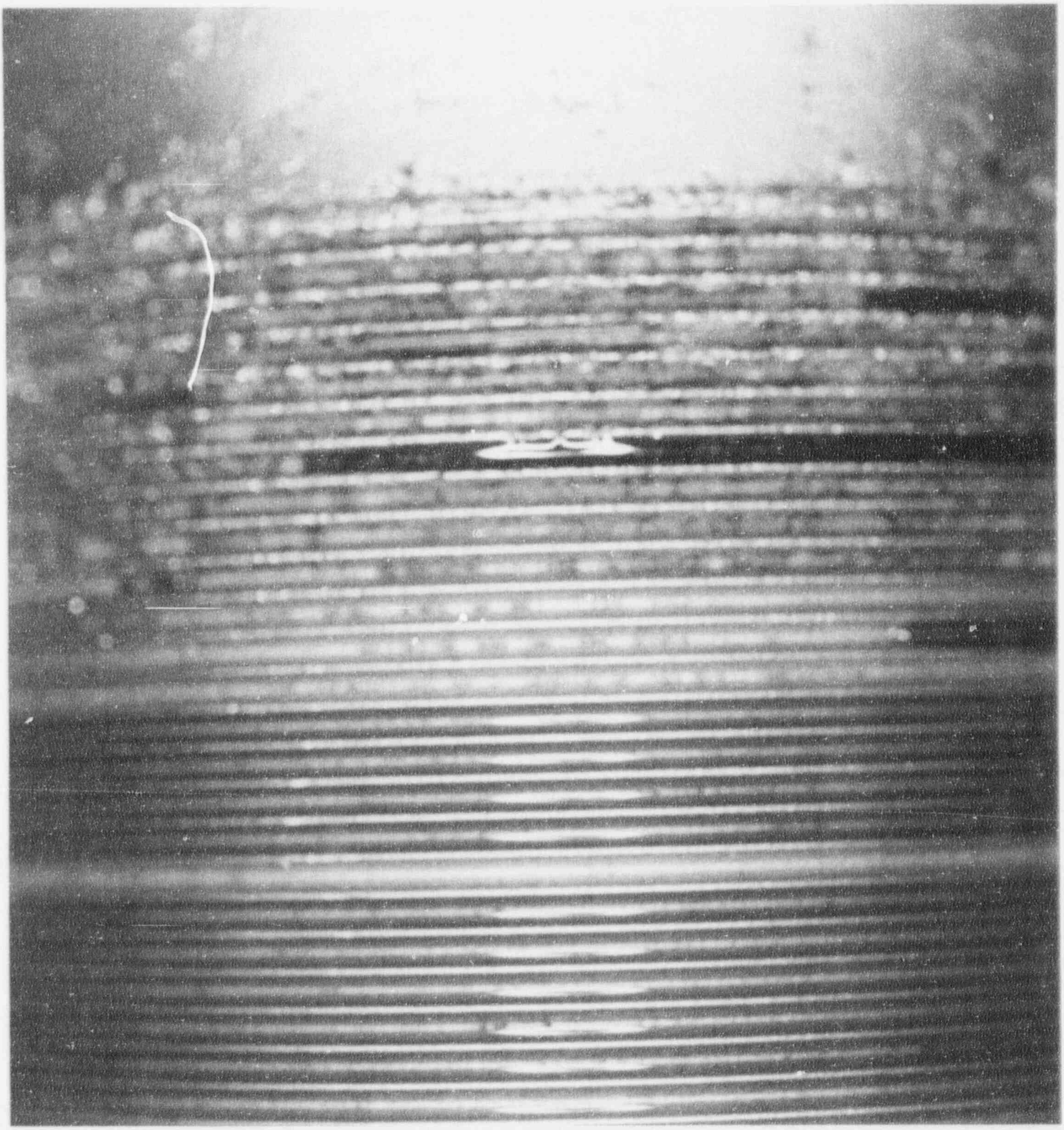
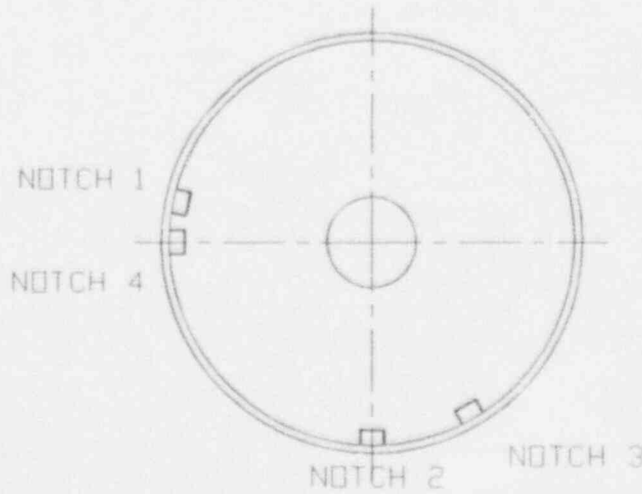


Figure 24. Typical EDM Notch As Machined In The Root Of A Thread In Cooper Stud # 14.

NOTCH	DEPTH	LENGTH	WIDTH
1	.125	.470	.025
2	.060	1.000	.025
3	.500	.500	.025
4	N.A.	N.A.	N.A

NOTCH #4 WAS A MISCUT



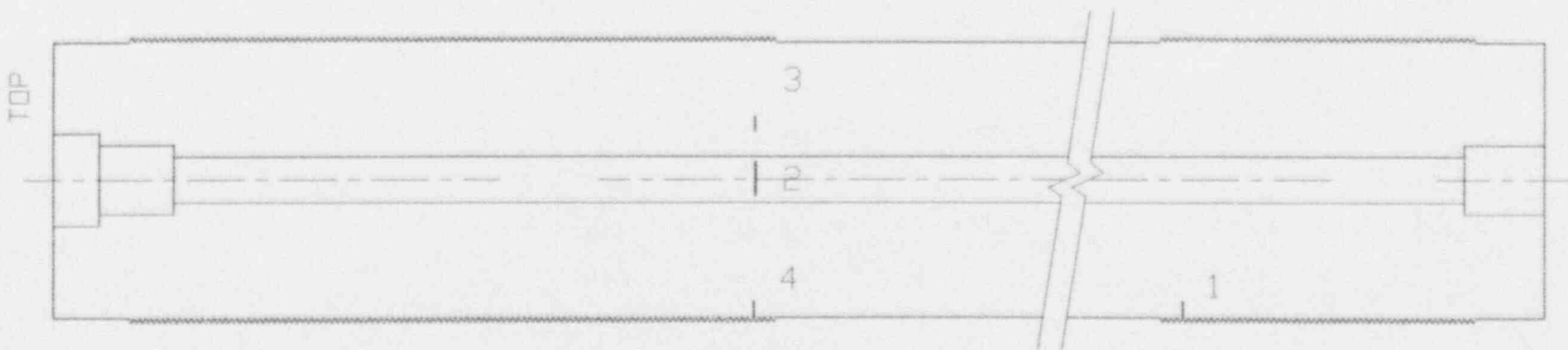


Figure 25. Notch Locations In Cooper Stud # 14.

COOPER RPV STUD
14

illustr studcoll 111391

5.0 RESULTS

Evaluation of the test data shows that corrosion products had a higher than anticipated effect on the outage UT examination results. The loss-of-thread signal response noted during the manual exams appears to have been caused by a combination of a damping mechanism (caused by the corrosion products) and scatter due to geometric effects from the pitting on the sides of the threads. Exams performed after glass-bead blasting seemed to be affected only by the scatter mechanism.

The PT and RT indications noted during the outage could not be found after blast cleaning. Wet Florescent MT was used to examine the area where the PT indication was noted. There were no MT indications. This means that the indication was removed by the cleaning process. It appears that the corrosion products caused the PT indication, possibly by separations within the build-up. The area on Stud 40 that showed RT indications during the outage, showed no indications after cleaning. The indication was removed by the cleaning process. The cause is probably similar to the PT indication.

The data recorded with the 60^{o} and 70^{o} bore probes on the calibration notch in the Cooper stud calibration standard are shown in Figure 26. Figure 27 shows the data recorded using the 70 ^{o} bore probe as it is traversed over this same notch and the reflection is seen to travel (walk) in time. Figure 28 shows typical thread reflections from stud # 14 in unnotched and uncracked regions. Figure 29 through 32 provides the UT data on the detection of the notches that were machined into the corroded threads of stud # 14 (see Figure 25 for notch data). Clearly, there is no problem with the detection of these notches in the region of these corroded threads. This data provided a qualification for both probes, it also shows that the interpretation of the data using the 70^{o} probe is much easier than that obtained with the 60^{o} probe.

The enhanced "End Shot" UT was able to detect the EDM notches placed in all of the corroded areas on Stud 14. This is important since this technique was used for the baseline examination of the replacement studs.

The 70-degree bore probe was shown to be the most effective tool for both detecting and evaluating indications.

It is believed that the MT and PT examinations of these studs would be ineffective without cleaning off the corrosion products. The corrosion products tend to be very porous and absorb the fluorescent magnetic particle and penetrant solutions, which could mask any real indications Therefore, it is felt that a cleaning method needs to be developed for future MT or PT exams on studs. Bead blasting, since it removes the Parkerized coating, may not be a viable option for inservice inspections. It should be noted that ASME Section XI requires surface exams (MT or PT) on studs that are removed from the vessel flange.

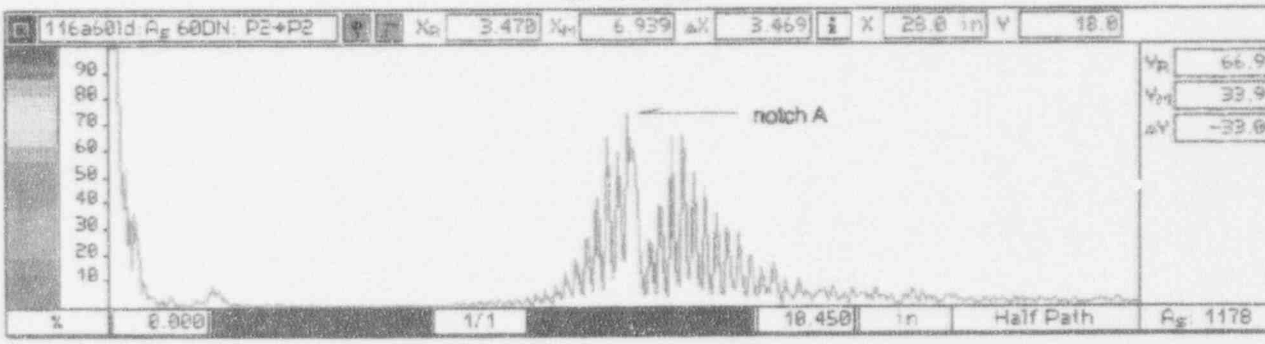
Based on the examinations performed on the five (5) representative studs at Cooper, and the work performed on stud no. 26 at VNC, some conclusions regarding the condition of the remaining Cooper studs can be made. The PT and RT indications, detected during the outage in studs 39 and 40 were related to the corrosion products in the threads and are of no concern. With the assumption that these 5 studs are truly representative, and that studs 14 and 17 represent the worst case with regards to UT indications, then the conclusion can be reached that the UT indications detected during the outage in the remaining studs are strictly related to the corroded threads and not to cracks.

The 45° TOFD probe used at Dresden has been shown to be another valuable tool for both detection and sizing. The probe is usable for evaluating indications in the areas where corrosion is known to occur on studs. However, it would require at least two more transducers, if it were to be the only probe used to perform a complete Section XI UT examination, in accordance with Appendix VI of Section XI.

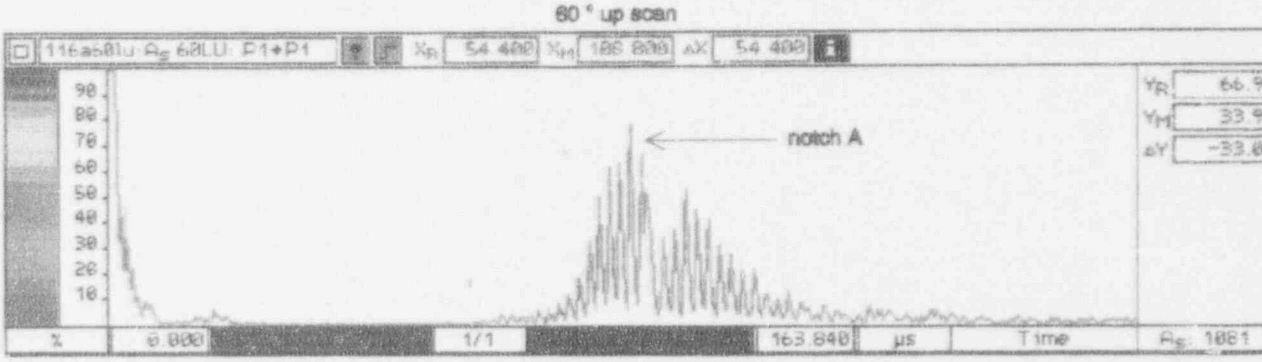
The data from the cracked stud at Dresden, presented in Appendix C (tab 9) to this report add to the qualifications of the UT techniques, procedures, and equipment obtained at Cooper. A comparison of the data from the Dresden crack shows that the UT signals from the notches in the Cooper stud are very similar and have the same basic characteristics. Therefore, the work performed at Cooper resulted in a valid qualification in accordance with Appendix VI of Section XI of the Code. Of course, that is providing that the examiners are properly trained and qualified with the UT techniques, procedures and equipment. This being the case, justification has been provided for use of the techniques, described in this report, on RPV stud inspections in the field, subject to the approval of customers and the ANI.

Calibration A-scans for the 60° and 70° probes.

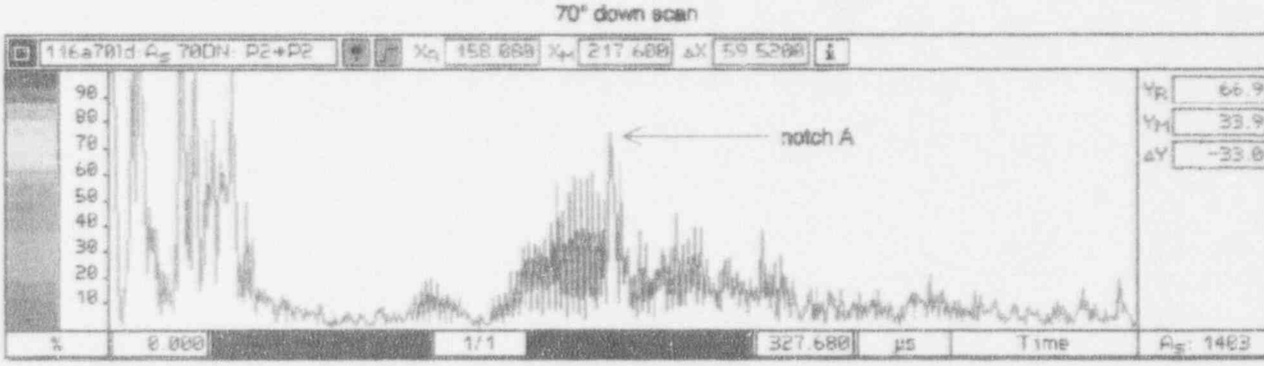
60° down scan



60° up scan



70° down scan



70° up scan

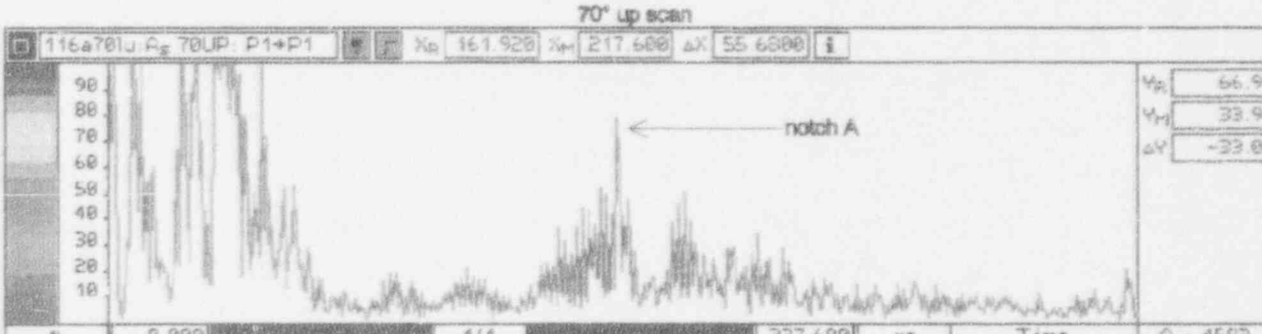


Figure 26. A-Scans Of The UT Calibrations For The 60° And 70° Bore Probes On Notch A Of The Cooper Stud UT Calibration Standard.

Progression of 70° signal from notch A

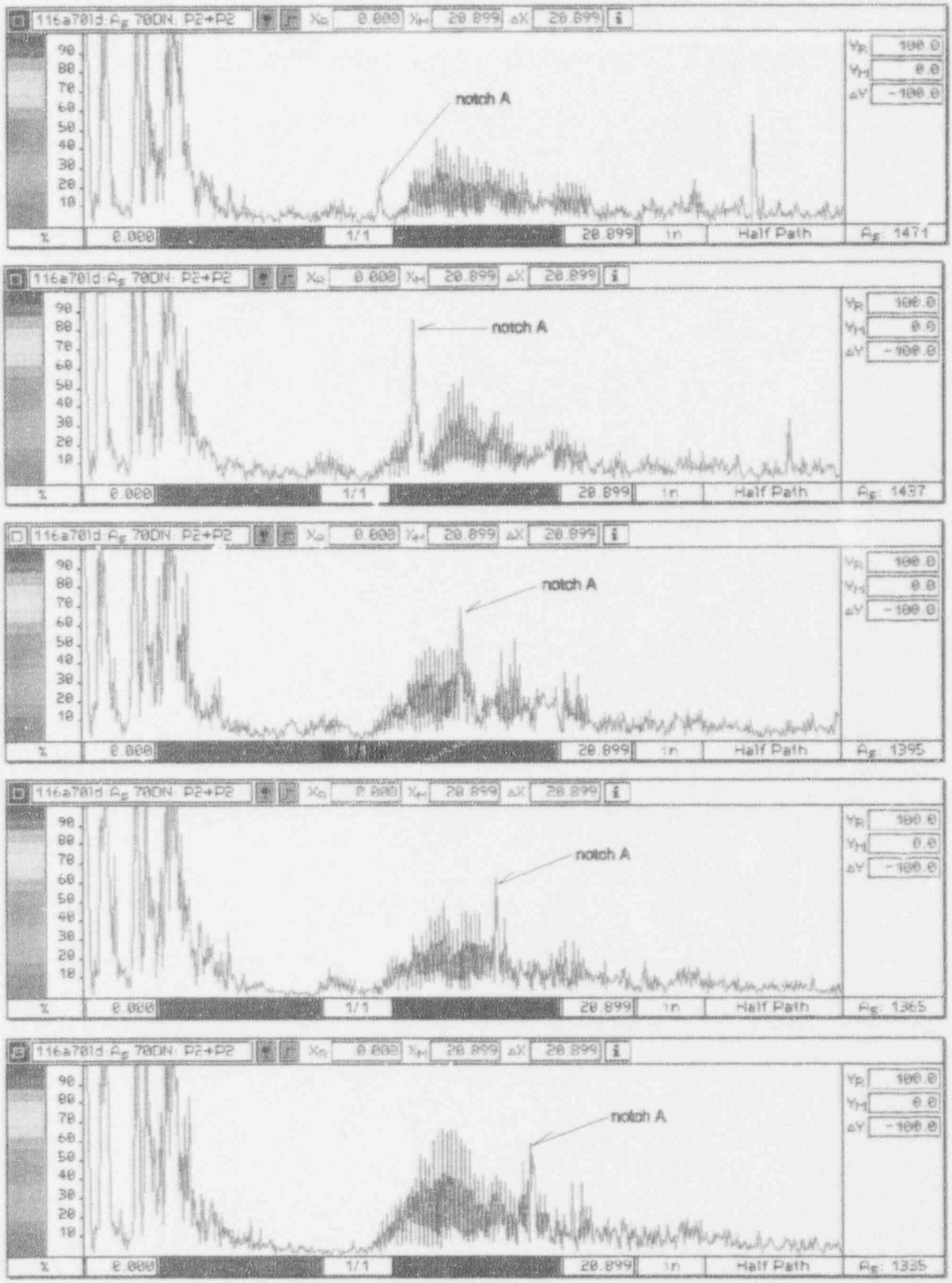


Figure 27. Series Of A-Scans With The 70° Bore Probe

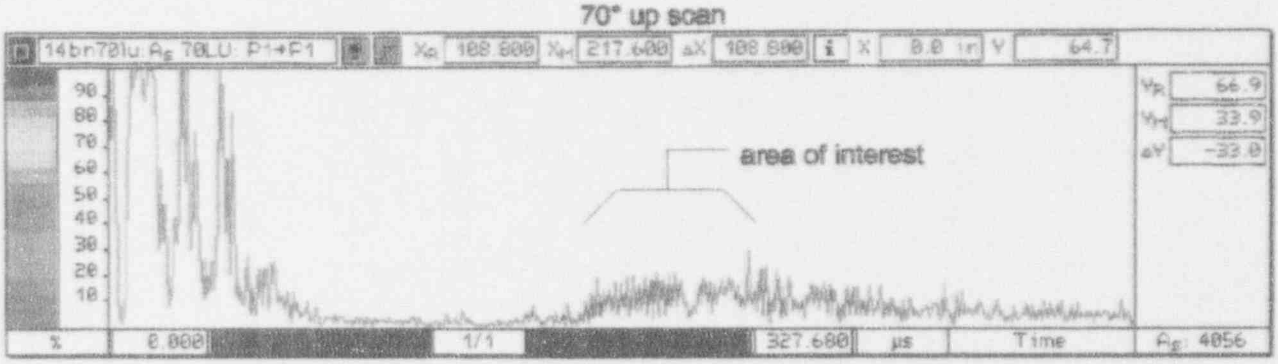
Reflection From Notch A In The Cooper Stud Calibration Standard Are Shown To Travel In Time (Walk)

Signal comparison of the 70° up and

down scans in the area of interest in

the top threads.

70° up scan



Note there is no possitive signal response

in the area of interest in both scans.

70° down scan

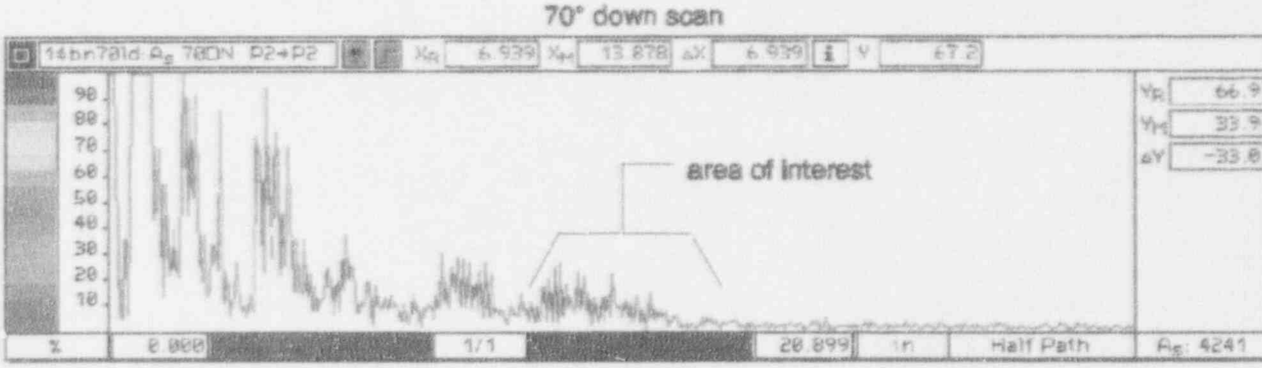
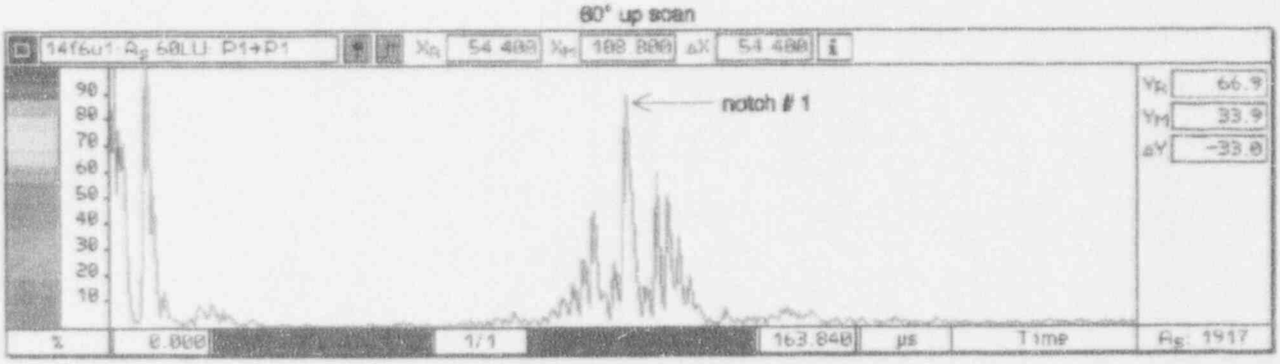


Figure 28. Typical A-Scans From Corroded Threads In Cooper Stud #14 With The 70° Bore Probe. This Is In An Area Where There Are No Notches, Therefore, There Is No Direct Reflection Detected (as in the case of a notch or crack).

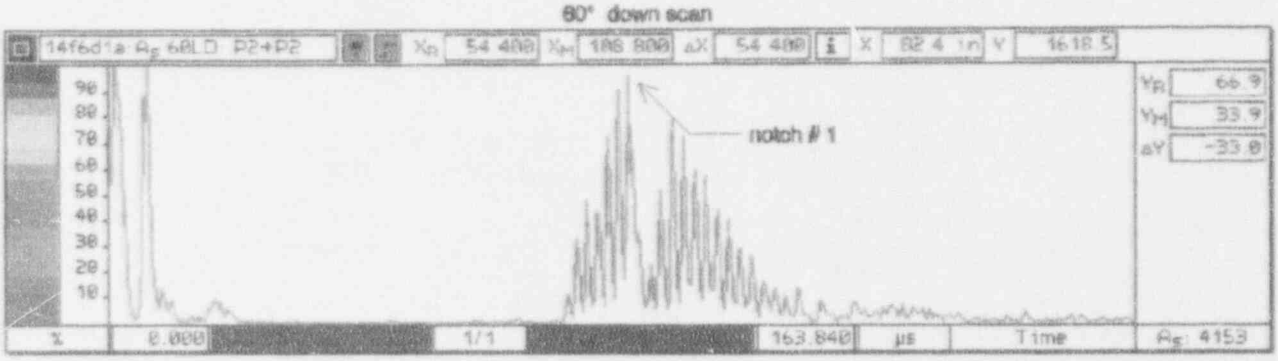
Figure 29.

Signal responses from EDM notch # 1 with the 60° and 70° probes

60° up scan

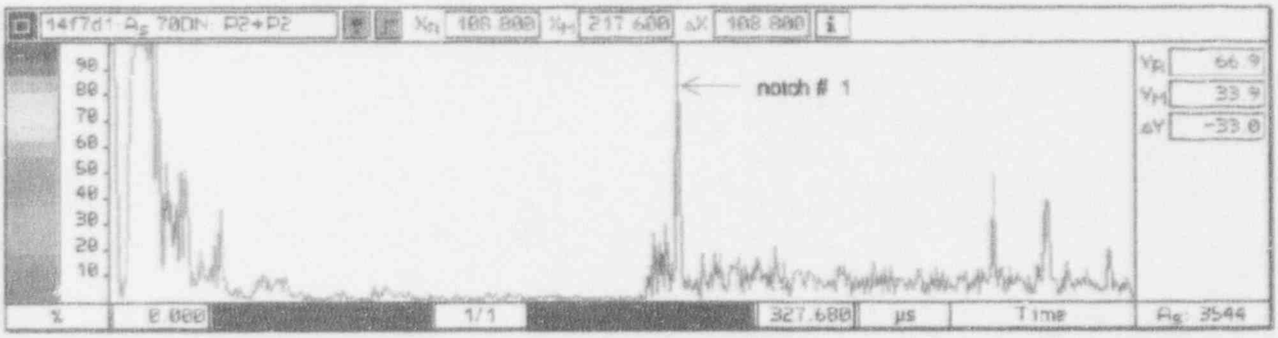


60° down scan

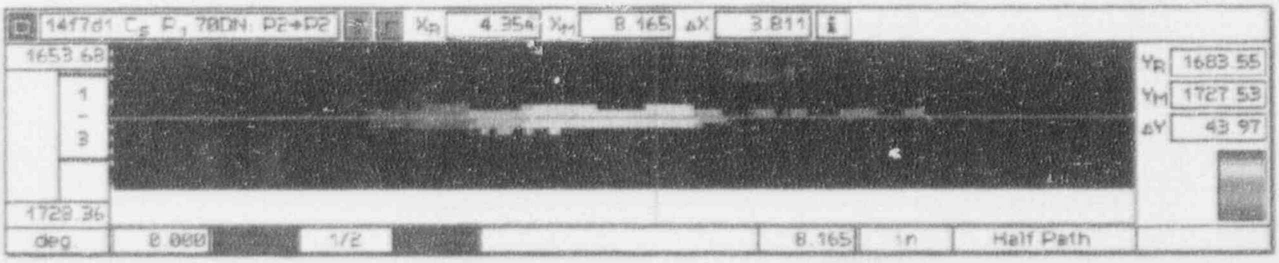


No 70° up scans were performed due to stud length limitation.

70° down scan



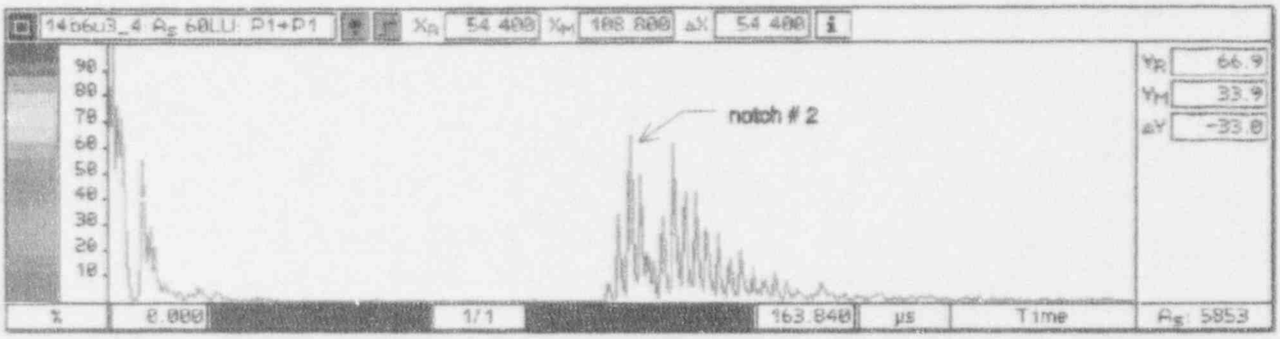
70° down scan



Signal responses from EDM notch # 2 with

60° probe.

60° up scan



Note negitive signal response (loss of thread roll) behind the response from the notch.

60° down scan

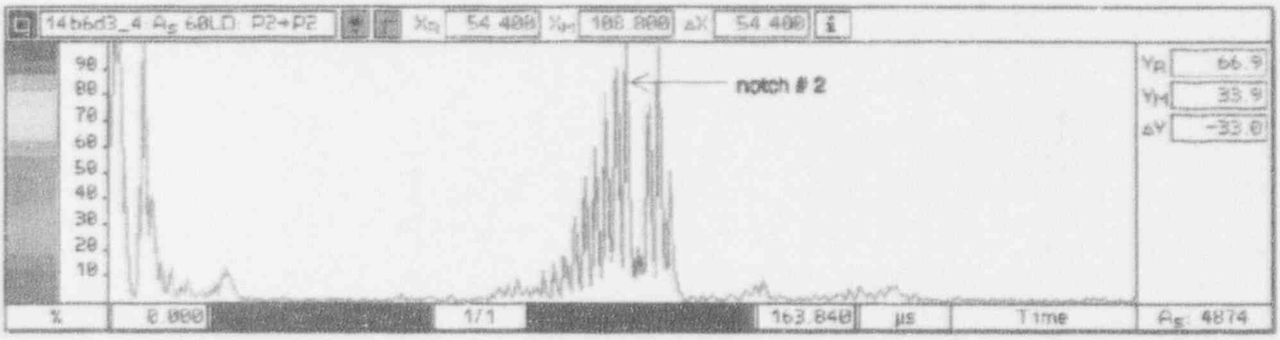
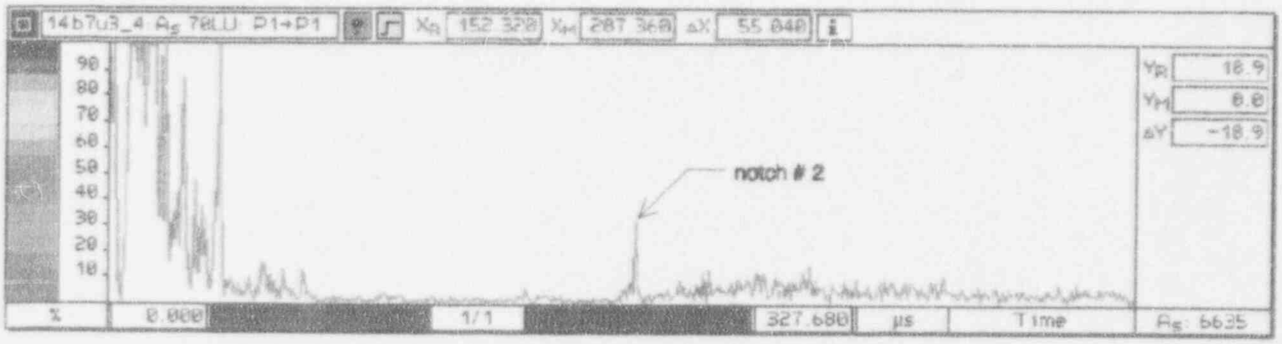


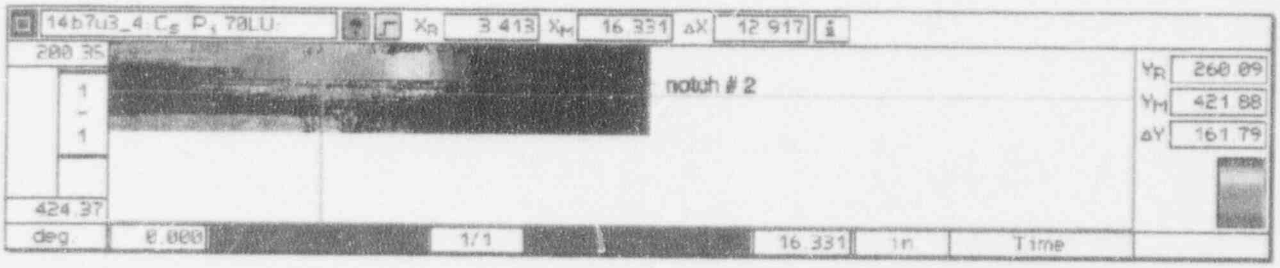
Figure 30.

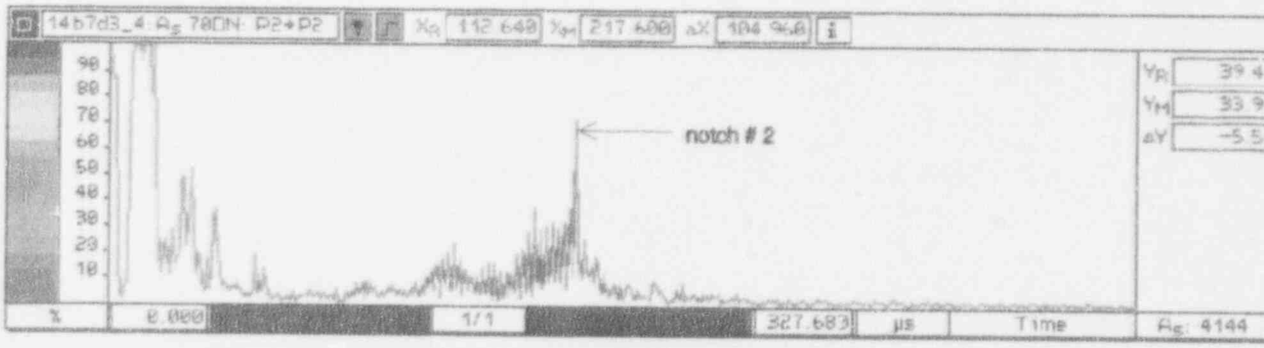
Signal responses from EDM notch # 2 with

the 70° probe.



70° up scan





70° down scan

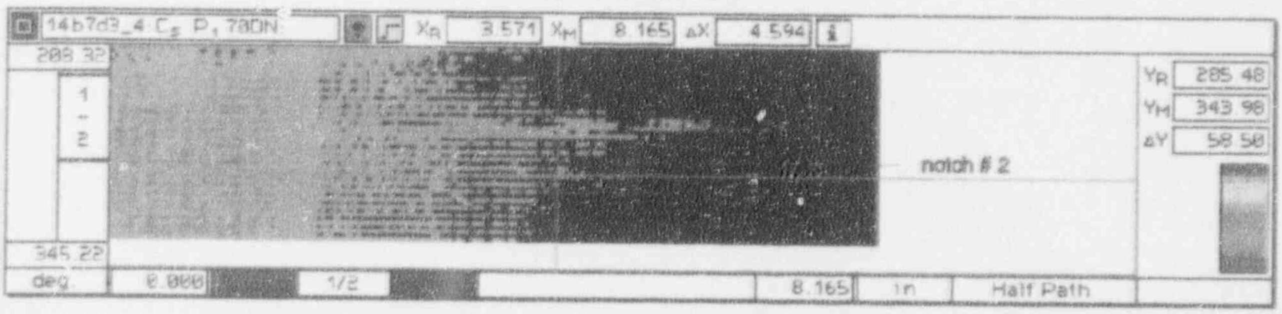
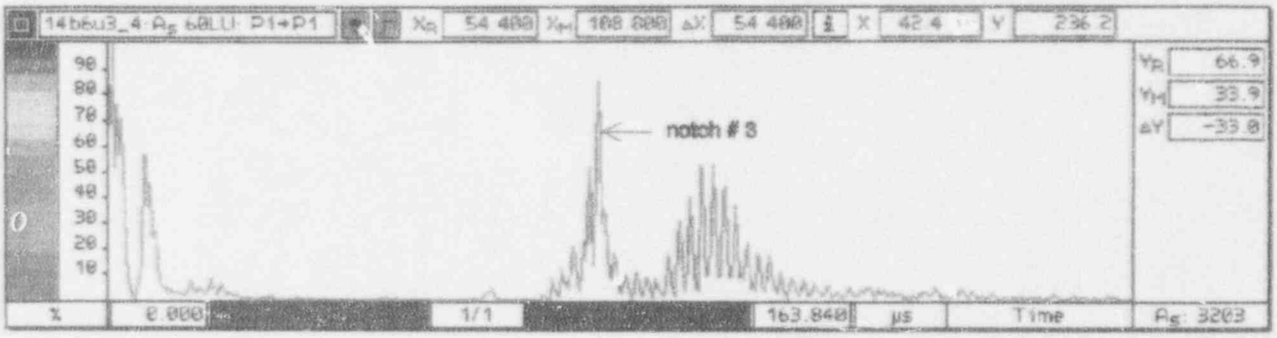


Figure 31

Signal responses from notch # 3 with the

60° probe.

60° up scan



Note the negitive signal response (loss of thread roll) behind the response from the notch.

60° down scan

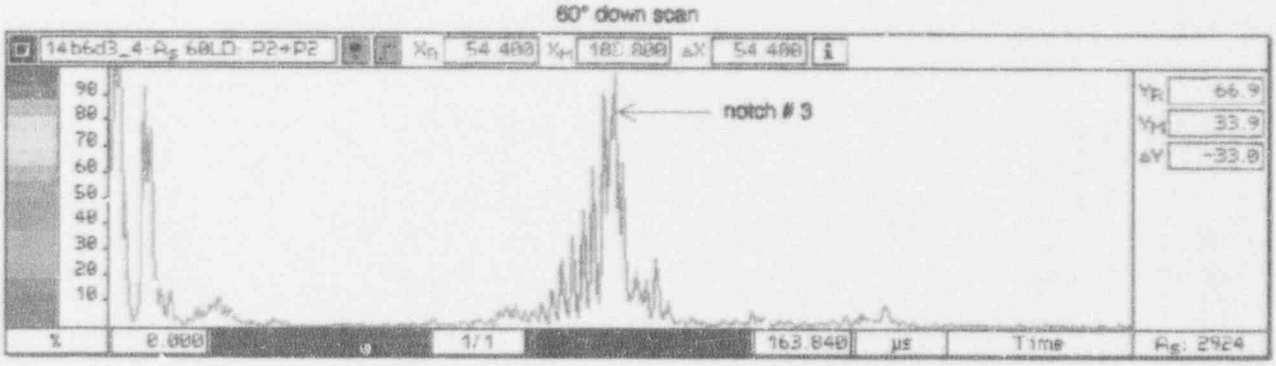
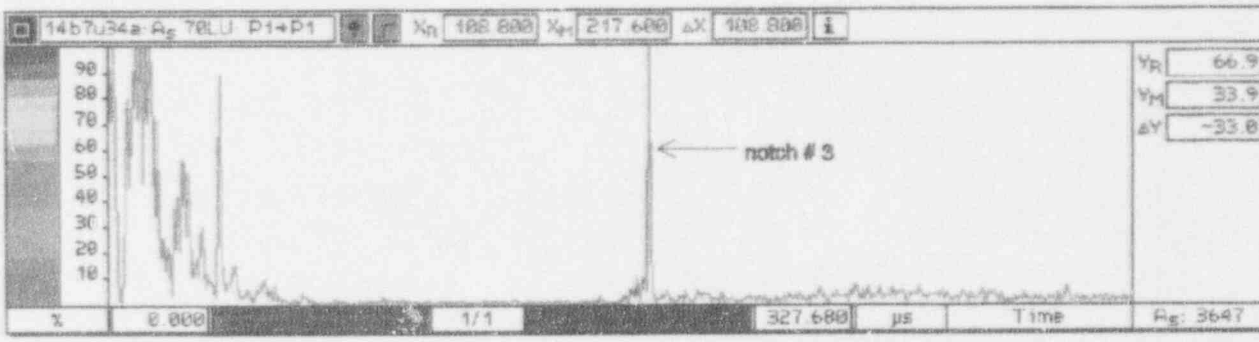


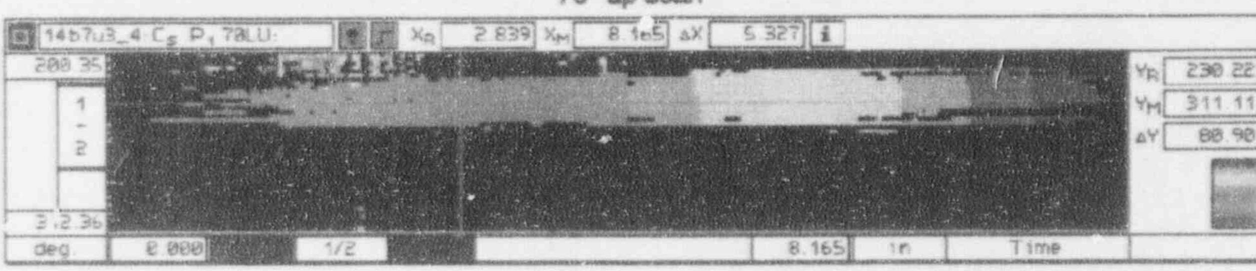
Figure 32.

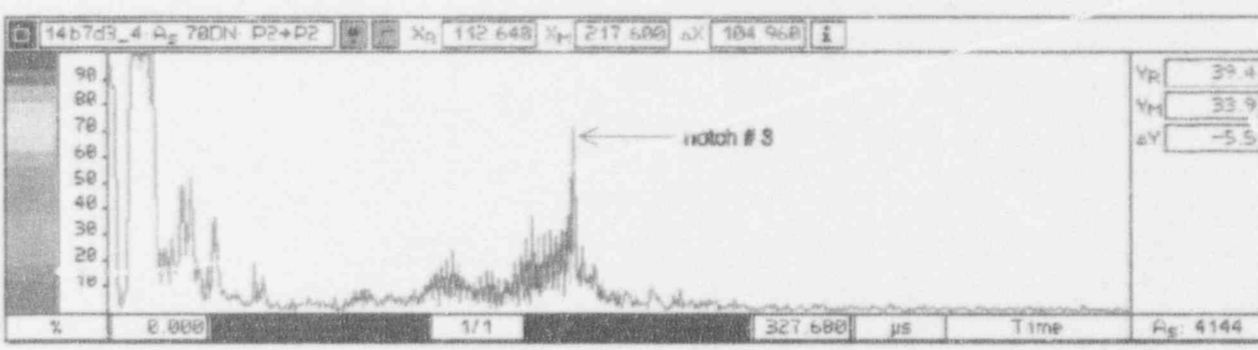
Signal responses from EDM notch # 3 with

the 70° probe.



70° up scan





70° down scan

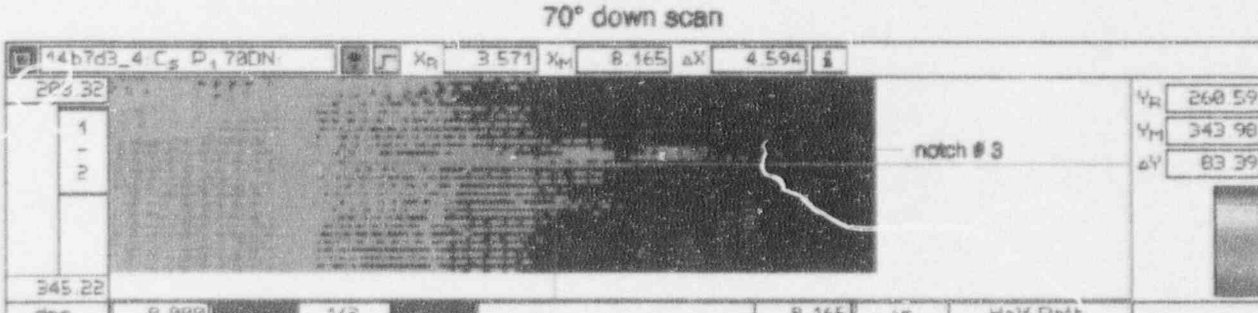


Figure 33

6.0 CONCLUSIONS

Conclusions based on the results of these examinations are as follows:

As previously reported, it is believed that the first UT indication (Stud No. 26) detected at Cooper was due to a problem with the automatic pulse repetition rate of the UT instrument being used (see Appendix G). This type of problem only occurs when examining components with long metal paths. The problem can only result in false calls and not cause a real indication to be missed. There should be no concern regarding indications that might have been missed when this instrument was used on other components (such as piping welds).

Indications of thread loss, which was thought to be one indication of possible cracking with the 60-degree bore probe, have been shown to be related to the damping and scattering effects of the corrosion products. The indications with the enhanced end shot were probably related to the corroded threads (as the sides corrode away) becoming somewhat better reflectors from the end shot orientation.

Corrosion induced scattering does not affect notch detection capability to a great extent with a 70-degree probe.

The 70-degree probe is less affected by corrosion and a build-up of corrosion products than the 60-degree probe and can be used to perform reliable examinations of RPV studs which have a design similar to Coopers. In addition, it has been shown that the 70 degree probe is superior to both the 60-degree probe and the enhanced "end shot" for both detection and evaluation of indications.

The examination baseline on replacement studs was performed with the enhanced "end shot". The enhanced end shot has been shown to be a method capable of detecting Appendix VI size EDM notches in corroded threads. It can be used for the inservice inspection of studs. However, if indications are detected, the 70-degree bore probe should be used for evaluation.

It is believed that the MT and PT examinations of these studs would be ineffective without cleaning off the corrosion products. The corrosion products tend to be very porous and absorb the fluorescent magnetic particle and penetrant solutions, which could mask any real indications Therefore, it is felt that a cleaning method needs to be developed for future MT or PT exams on studs. Bead blasting, since it removes the Parkerized coating, may not be a viable option for inservice inspections. It should be noted that ASME Section XI requires surface exams (MT or PT) on studs that are removed from the vessel flange.

Based on the examinations performed on the five (5) representative studs at Cooper, and the work performed on stud no. 26 at VNC, some conclusions regarding the condition of the remaining Cooper studs can be made. The PT and RT indications, detected during the outage in studs 39 and 40 were related to the corrosion products in the threads and are of no concern. With the assumption that these 5 studs are truly representative, and that studs 14 and 17 represent the worst case with regards to UT indications, then the conclusion can be reached that the UT indications detected during the outage in the remaining studs are strictly related to the corroded threads and not to cracks.

The 45^{o} TOFD probe used at Dresden has been shown to be another valuable tool for both detection and sizing. The probe is usable for evaluating indications in the areas where corrosion is known to occur on studs. However, it would require at least two more transducers, if it were to be the only probe used to perform a complete Section XI UT examination, in accordance with Appendix VI of Section XI.

The data from the cracked stud at Dresden, presented in Appendix C (tab 9) to this report add to the qualifications of the UT techniques, procedures, and equipment obtained at Cooper. A comparison of the data from the Dresden crack shows that the UT signals from the notches in the Cooper stud are very similar and have the same basic characteristics. Therefore, the work performed at Cooper resulted in a valid qualification in accordance with Appendix VI of Section XI of the Code. Of course, that is providing that the examiners are properly trained and qualified with the UT techniques, procedures and equipment. This being the case, justification has been provided for use of the techniques, described in this report, on RPV stud inspections in the field, subject to the approval of customers and the ANI.

APPENDIX A

AGREEMENT NO. 86A-MS2, TASK AUTHORIZATION, TASK NO. 161, AMENDMENT NO. 3

LOG NO. 020

Customer Order Transmittal

(Send to San Jose Order Service (M/C 397) or Field Finance and responsible organizations)

I) Nebraska Public Power District - Cooper
Customer/Plant

II) Task 161, Am. 3 — Purchase Order Number; Verbal ____ Written x; -0- $ Value; OSD32 ISIS Number

III) UT Inspection Program - RPV Studs
Work Scope Description

IV) *Deliverables & Customer Schedule Requirements*

V) *Customer Expectations* (not stated in Purchase Order) — *Customer/Title* (O/E/I)

VI) *Customer Agreed Checkpoints During Work*

VII) *Reference Documents* (proposals, contracts, etc. – attach if feasible)

Task Authorization - attached

a) Bradley J. Erbes, NSM
Prepared by (name and title: NSM, SSM, TPE, etc.)

b) 6/3/92
Transmittal Date

c) Bradley J. Erbes
NSM Concurrence

d) ______
Pre-meeting or Kickoff Conference Call Plan (schedule, date & time, people participating, etc.)

e) Send to: Finance – L. Marlow - Oak Brook
cc: T. Black - CNS
J. Clark - M/C 777 - SJ
H. Herzog - Oak Brook
R. Hooper - Oak Brook

f) J. Clark
Job Leader (Pr. Mgr., TPE, Engineer, etc.)

This Task is considered Routine Consulting Services in accordance with the Settlement Agreement between NPPD and GE, dated as of September 7, 1989.

AGREEMENT NO. 86A-MS2
TASK AUTHORIZATION

Task No. 161, Amendment No. 3 — Task Authorization Number

March 6, 1992 — Effective Date

179-OSD32-HP1-91 — GE Identification Number

This Task Authorization is issued pursuant to the Agreement effective September 1, 1986, between NEBRASKA PUBLIC POWER DISTRICT (DISTRICT) and GE.

I. PROJECT

Inservice inspection (ISI) and Erosion-Corrosion (E-C) Services for Cooper Nuclear Station (CNS). This Amendment No. 3 provides the basis of understanding regarding work on the RPV Stud Inspection Program. This Program was discussed during the lessons learned meeting at CNS on March 2, 1992.

II. SCOPE OF WORK

The primary objective of this Task Amendment is for GE to provide the necessary NDE documentation to support disposition of the UT indications found on 51 of the original CNS RPV studs. The following work will be performed by GE:

1. Develop improved UT technique for examination of CNS RPV studs.
2. Prepare a new UT procedure as a result of UT development activities.
3. Review previous (1991 outage) UT data for original RPV studs and select five (5) studs for further evaluation.
4. Conduct UT examination of the selected five (5) studs using new procedures.
5. Conduct additional surface NDE examination, including penetrant (PT) or magnetic particle (MT) as required to confirm presence or absence of surface breaking flaws.
6. Machine notches in at least one (1) stud using electrical discharge machining (EDM) to simulate a surface breaking flaw and compare UT indication from this EDM notch to UT indications observed in CNS RPV studs.
7. Provide a preliminary report of work performed to support disposition of 51 RPV studs and provide a final report after completion of all development activities. This final report shall include the results of all additional procedure and equipment development work to support initial disposition of UT indications.

The performance of the above activities will entail several work segments and will generally follow the activities listed in Attachment A which is incorporated herein.

In support of the Program objectives, the responsibilities of GE and the DISTRICT are listed below:

GE Responsibilities:

Provide any necessary procedures for applicable UT and EDM activities.
Provide a list of GE personnel and expected arrival dates on site.
Provide EDM equipment.
Provide Smart 2000 UT equipment.
Provide the needed transducers.
Return of the CNS UT calibration standard.
Provide the necessary NDE documentation to support disposition of the UT indications found on 51 of the CNS original RPV studs.

DISTRICT Responsibilities:

Ship the CNS UT calibration standard to GE's San Jose or Vallecitos facility.
Provide GOT for GE personnel at CNS.
Provide sufficient work space and access (including handling of the studs) to the RPV studs, (Contaminated, in RCA) approx. 10" x 20".

Provide the following miscellaneous items:

- Power: 110 VAC; 15 amps.
- Water.
- Floor Drain.
- HP Coverage.
- Power for EDM Machine.
- Clean area for GE's Smart 2000 equipment.
- Office Space with phone, access for local and long distance calls.
- Provide radiographic testing (RT) of 4 or 5 studs.
- Provide walnut shell blasting of studs.
- Capability to machine threads off of selected studs.
- Provide MT and PT materials, including yoke and perhaps fluorescent materials.

III. SAFETY CLASSIFICATION

The review of previous UT data, the performance of the additional examinations, and the machining of notches utilizing the EDM will be performed at CNS and are classified Essential (Nuclear Safety-Related) Working Under the DISTRICT QA Program. All such on-site work at CNS shall be performed in accordance with Section 4 of Article XXIII of the Agreement for Services and Equipment, No. 86A-MS2.

The remaining work which is to be performed at GE facilities is classified Non-Essential (Nuclear Non-Safety Related). All such off-site work shall be performed under the GE Quality Assurance Program and in accordance with Section 5 of Article XXIII of the Agreement for Services and Equipment No. 86A-MS2.

IV. SUPPLIER LIMITATIONS

Same as stated in Amendment No. 2 to this Task Authorization.

V. PROJECT MANAGEMENT

The following individuals shall be the primary contacts for the DISTRICT and GE with respect to the performance of this Task:

DISTRICT	Mr. G. E. Hicks Mechanical Engineer Cooper Nuclear Station	(402) 825-5720
GE	Mr. J. P. Clark Program Manager	(408) 925-6772

VI. PROJECT TEAM

This Amendment will require additional home office engineering consulting and analysis services to support the project team.

VII. SCHEDULE

Attachment A provides an estimated schedule for performance of the work hereunder.

VIII. ESTIMATED COST

GE will perform the work described herein at no cost to the DISTRICT.

Any additional material or services not identified in this Amendment and purchased by GE at the request of the DISTRICT will be billed at cost. In addition, an amount of 20 percent of such costs shall be added to cover administrative costs.

GE shall not incur additional costs under this Task Amendment without obtaining the prior written approval of the DISTRICT.

The total authorized amount of this Task Authorization is: $1,231,082.

Summary	Original Task	$ 975,000
	Amendment No. 1	114,082
	Amendment No. 2	142,000
	This Amendment	-0-
	Total	$1,231,082

IX. SPECIAL TERMS

This Task Amendment No. 3 is considered Routine Consulting Services under the Settlement Agreement between the parties dated as of September 7, 1989, and is subject to the terms and conditions therein.

X. TERMS AND CONDITIONS

This Task Authorization, the performance of the services described herein and the rights and obligations of the parties with respect thereto are governed by the Agreement for Services and Equipment between the parties effective September 1, 1986, and such terms and conditions as are set forth in this Task Authorization pursuant to such Agreement. The terms and conditions set forth in such Agreement are hereby incorporated herein by reference and except as expressly provided in this Task Authorization shall be applicable hereto.

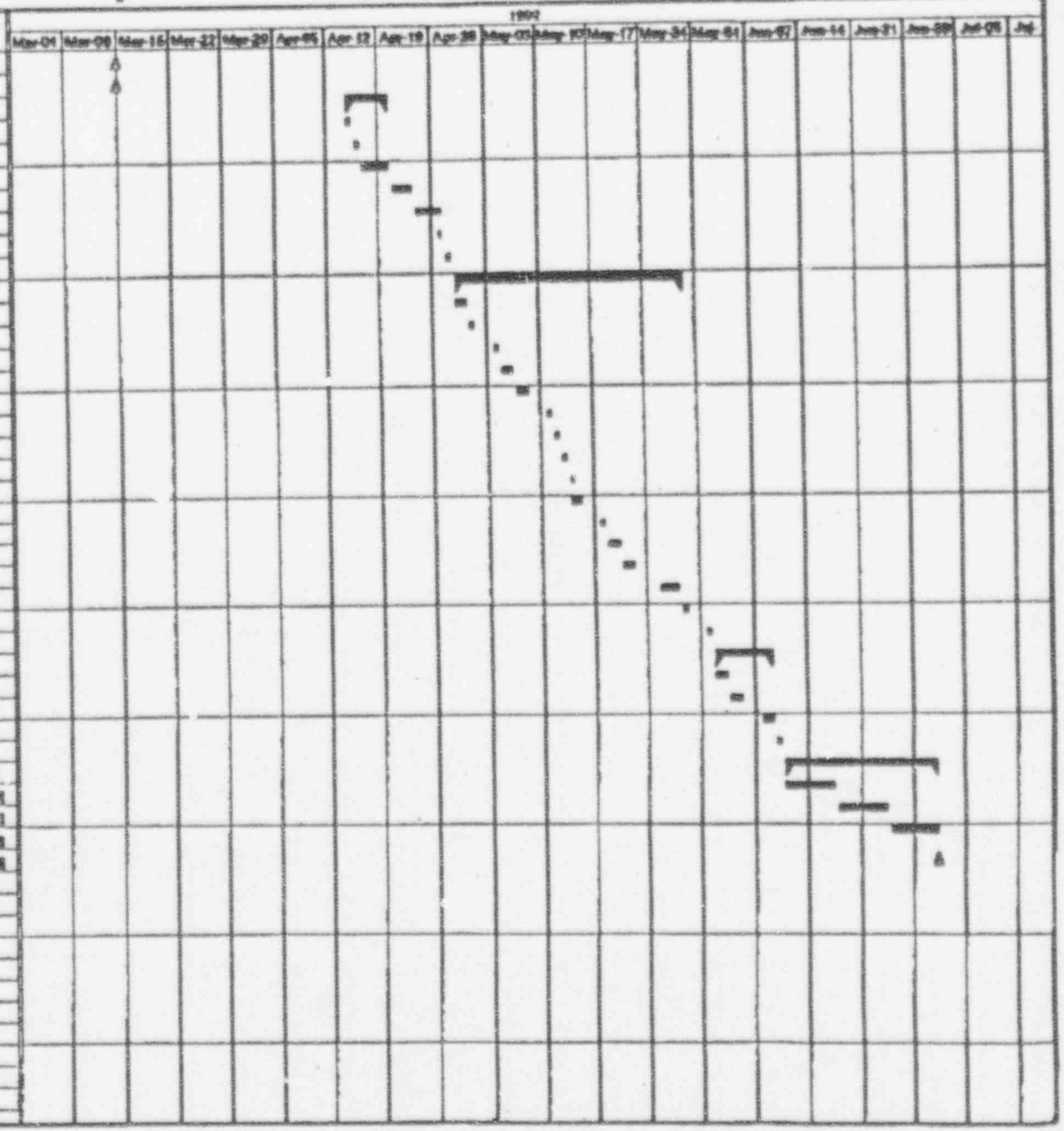
Accepted and Agreed to:

NEBRASKA PUBLIC POWER DISTRICT	GENERAL ELECTRIC COMPANY
By: [signature] 5/29/92 Date	By: [signature] 5/22/92 Date
Title: Division Manager, Nuclear Operations	Title: Nuclear Services Manager

ATTACHMENT A

RPV Stud UT Inspection Development Prog.

Task Name	Duration	Start	Progress Manager - Resources
Cooper Standard & Probe to San Jose	0.00 d	Mar-15-92	JPC
Order 70s Probe	0.00 d	Mar-15-92	TLB
Scan Cal Standard	4.00 d	Apr-16-92	JPC
Scan w/0 Degree	1.00 d	Apr-15-92	BA, TR
60 Degree Shear	1.00 d	Apr-16-92	BA, TR
70 Degree Shear	2.00 d	Apr-17-92	BA, TR, JP
Develop improved technique	3.00 d	Apr-21-92	BA, TR, JPC, TLB
Generate new procedure	2.00 d	Apr-24-92	BA, JPC, TLB
Layout EDM notch placement	1.00 d	Apr-27-92	BA, TLB, JPC
Mobilize to Cooper	1.00 d	Apr-28-92	BA, TR, WM, TLB
On site - Cooper	22.00 d	Apr-29-92	
Review previous data	2.00 d	Apr-29-92	BA, TR, WM, TLB
Locate Previous Indication	1.00 d	May-01-92	BA, TR, WM, TLB
Scan w/ 0 degree Pre-cleaning	1.00 d	May-04-92	BA, TR, WM, TLB
Scan w/60s Pre-cleaning	2.00 d	May-06-92	BA, TR, WM, TLB
Scan w/70s Pre-cleaning	2.00 d	May-07-92	BA, TR, WM, TLB
RT all 4 studs	1.00 d	May-11-92	RT Vendor + GE
Clean all studs Grit Blast	1.00 d	May-12-92	BA, TR, WM, TLB
Perform MT Exam	1.00 d	May-13-92	
Send EDM Machine to Site	1.00 d	May-14-92	BS
Machine EDM notches in Studs	2.00 d	May-14-92	BS+GE
Scan w/ 0 degree Post-cleaning	1.00 d	May-18-92	
Scan w/60 s Post-cleaning	2.00 d	May-19-92	
Scan w/70 s Postcleaning	2.00 d	May-21-92	
Data Analysis	3.00 d	May-26-92	BA, TR, TLB, JPC
Machine Threads if need	1.00 d	May-29-92	
Mob Site to Dresden	1.00 d	Jun-01-92	BA, TR, TLB, JPC
On Site - Dresden	8.00 d	Jun-02-92	
0 degree	2.00 d	Jun-02-92	
60 shear	2.00 d	Jun-04-92	
70 shear	2.00 d	Jun-08-92	
Mobilize to San Jose	1.00 d	Jun-10-92	
San Jose - Program Summary	15.00 d	Jun-11-92	BA, TLB, JPC, DH
Final Report Generation	5.00 d	Jun-11-92	BA, TLB, JPC, DH
Revise Procedure as needed	5.00 d	Jun-18-92	BA, TLB, JPC, DH
Prepare Training Program	5.00 d	Jun-25-92	BA, TLB, JPC, DH
Auto scanner development decision	0.00 d	Jul-01-92	BA, TLB, JPC, DH



Printed: Apr-06-92
Page 1

APPENDIX B - PROCEDURES

EIS IDENT:

GE Nuclear Energy

TP 527-1509 SH NO. 1
REV 1

REVISION STATUS SHEET

DOC TITLE AUTOMATED ULTRASONIC PROCEDURE FOR THE EVALUATION OF MANUALLY DETECTED ULTRASONIC INDICATIONS IN RPV CLOSURE STUDS

LEGEND OR DESCRIPTION OF GROUPS

TYPE: TEST PROCEDURE

FMF: N.A.

MPL NO: N.A.

THIS DOCUMENT IS OR CONTAINS A SAFETY RELATED ITEM YES ☒ NO EQUIP CLASS CODE ___

REVISION	
1.	Revised to incorporate NPPD & ANII comments. J.C.S. Tung 4/29/92 J.P. Clark 4/29/92

PRINTS TO

MADE BY J.C.S. TUNG J.C.S. Tung 4/23/92	APPROVALS J.P. CLARK J.P. Clark 4/23/92	GENERAL ELECTRIC COMPANY 175 CURTNER AVENUE SAN JOSE CALIFORNIA 95125
CHKD BY R.W. ANDERSON [signature] LVII	ISSUED	CONT ON SHEET 2

NEO 808 (REV 3/90)

1.0 SCOPE

1.1 This procedure defines an automated ultrasonic (UT) method to be used for evaluation of ultrasonic indications previously detected in Reactor Pressure Vessel closure studs by manual UT procedures.

1.2 The examination shall be a remote, automated, angle beam, pulse echo technique utilizing a shaft with attached ultrasonic probes.

1.3 The extent of the examinations is to cover a minimum of 1 inch of stud length on each side of the area or areas where the manual indications were reported.

2.0 REFERENCES

The following documents form a part of this procedure to the extent specified herein.

2.1 American Society of Mechanical Engineers (ASME), Boiler and Pressure Vessel Code, Sections V and XI, 1980 Edition including Addenda through Winter 1981

2.2 GE Nuclear Energy procedure for qualification and certification of Nondestructive Examination personnel Specification 386HA480 and/or Field Quality Procedure FQP-03.

2.3 GE Nuclear Energy Procedure GE-UT-307, Revision 0, "Procedure For Ultrasonic Examination of RPV Closure Studs including Field Revision Requests (FRR) numbered NPPD-91-16 and NPPD-91-35

2.4 Stud drawings and/or a detailed identification and marking plan meeting the requirements of ASME Code Section XI.

3.0 PERSONNEL

3.1 Personnel performing the ultrasonic examinations and evaluations to this procedure shall be certified to a minimum of Level II.

3.2 In addition personnel performing the examination shall have completed sufficient training in the use of the automated inspection system as applied to the stud calibration standard/mock-up. The training shall be conducted by the GENE NDE personnel responsible for the development of the ultrasonic inspection system, the calibration standard/mock-up, and the procedure for performing this inspection. The training shall be conducted using the automated equipment and this procedure.

4.0 EQUIPMENT

The equipment needed to perform the stud ultrasonic inspection is as follows:

4.1 The Smart 2000 digitized ultrasonic data acquisition system shall be used. The automated equipment primarily consists of an ultrasonic pulser/receiver, analog to digital converter, console, optical disk drive for archiving data, high resolution color monitor and color printer.

4.2 A multi-element probe or probes are used to perform this examination. The probe or probes are to contain a minimum of two contact, shear wave, angle beam transducers with the sound beams directed in opposite directions along the length of the stud. The refracted angles shall not be less than 40 or greater than 80 degrees. The active element for each transducer shall not exceed 1/2" diameter. Nominal frequency of the transducers shall be in the range of 1 to 5 MHz.

4.3 In addition a contact, straight beam transducer (0 degree longitudinal) may be included to measure the studs effective wall thickness and to evaluate corroded areas.

4.4 Other probes of different frequency and angle can be used for evaluations at the discretion of the examiner.

4.5 Deionized water is to be used as the couplant and is to be supplied by the owner. Other couplants can be used at the discretion of the examiner providing they meet the specification from procedure GE-UT-307, paragraph 4.5.2 as revised by FRR NPPD-91-16, with the approval of the Owner

4.6 The scanning equipment shall be designed to be remotely motor driven with the appropriate motor controller to assura that proper scanning can be achieved with the above ultrasonic probe. The motor controller shall be capable of providing an index which results in 50% coverage overlap. The scanner and the motor controller shall provide position information to the data acquisition system with regard to the probe location.

4.7 A calibration mock-up fabricated from a real stud is required for calibrating the UT examination system. See the figure attached to procedure GE-UT-307 , as revised by FRR No. NPPD-91-35 as an example. If the mock-up shown in this figure is used then the appropriate notch for angle beam calibration is notch A.

5.0 CALIBRATION

5.1 Calibration shall be performed and recorded prior to commencement of any examinations. Calibration shall include the complete ultrasonic examination test system.

5.2 Assemble the inspection track on the calibration mock up and attach the scanner to it.

5.3 Using the automated scanner, position the angle beam transducers to the appropriate circumferential notch, and optimize the reference signal to approximate 80% full screen height.

5.4 If a straight beam transducer is used it shall be calibrated such that the average back reflection over the threaded areas on the outside diameter of the stud is 80% of full screen height.

5.5 Scan the required volume and record all data on optical disk.

5.6 Calibration shall be verified at the start and finish of a series of examinations or at other time the examiner deems necessary.

6.0 EXAMINATION

6.1 The examination shall be performed from the inside surface of the center hole using the specially designed probe or probes as required to provide 100% coverage of the area of concern from two different directions and with two different refracted angles.

6.2 The rate of transducer travel shall not exceed 3" per second and shall be the same as used for system calibration in section 5.0.

6.3 The required examination volume shall be examined with a minimum scanning overlap of 50% of each search unit's active element size.

6.4 Probe And Scanner Positioning - Identify a zero location on the top of the stud for future referencing. Position the probe with the elements indexed to this zero reference. Lower the probe to the pre-determined position with respect to the indications to be evaluated. Set scan limits a minimum of 1 inch on either side of the area where the sound beam will interrogate the previously recorded indication. Set this position as vertical zero and angle zero. Record this zero location identification for future reference.

6.5 All studs shall be scanned once initially at reference level, determined from equipment calibration, as a minimum. Additional scanning with gain setting higher than reference level (+6dB) is recommended if base line noise permits. Scanning below reference level due to excessive base line noise must be approved by the cognizant Level III.

6.6 Scan the required volume and record all data on optical disk.

6.6.1 UT examination of all studs shall be accomplished both before and after corrosion product removal.

7.0 EVALUATION

7.1 Review and evaluate each circumferentially oriented indication determined to be valid. Nicks, scratches, corroded threads or changes in metallurgical properties in themselves may not constitute a defect. Circumferential cracks and/or other circumferentially oriented indications are considered to be relevant.

7.2 Carefully evaluate all signals emanating at the OD surface in order to determine each indication's length, depth, maximum signal amplitude and/or location/ orientation with respect to vertical position and the stud's zero.

7.3 Compare the results obtained from the two different directions and at the different refracted angles with the manual results which are under evaluation. The straight beam results may also be used to help determine if certain indications are related to geometry.

7.4 The level II or III performing the evaluation will base his results on this comparison and on the results of other NDE methods, such as magnetic particle, liquid penetrant, or radiography, if such data is available.

8.0 REPORT

8.1 Report all non-geometric relevant indications to the plant owner. The owner is responsible for the final evaluation and disposition of all reported indications.

8.2 A preliminary report will be provided to the customer prior to departure of key examination personnel from the site.

8.3 A complete final report shall be completed and submitted to the customer for review within sixty days after returning to San Jose.

Field Revision Request

Project: Cooper Nuclear Station

Project No. TA161 FRR No. NPPD-91-16 Date 9-16-91

Document to Be Changed:

Title: Procedure for Ultrasonic Examinations of RPV Closure Studs

Number: GE-UT-307, Rev. 0

Reason Change is Requested:

To meet customer requirements.

Proposed Change:

Change the last sentence in paragraph 4.5.2 to read: Total residual sulfur and halogen content shall not exceed the following:

- * Fluorine - 300 PPM
- * Chlorine - 500 PPM
- Sulfur - 700 PPM
- * Halogen

Change sentence in paragraph 5.5.1 to read: Move the <u>probe</u> away from the notch until the amplitude of the signal is 50% (-6dB) from the maximum.

Add new Ultrasonic Calibration Data Sheet, Exhibit I.

Add new Ultrasonic Examination Data Sheet, Exhibit II.

Approved By Project Manager [signature] Date 9-16-91 Approved By QC Supervisor [signature] Date 9-19-91

Comments:

N/A R. [signature] 9-16-91

Change Approved. Work May Proceed By: ______ Client (If Required) Date ______

Change Not Approved for Above Reasons By: ______ Client (If Required) Date ______

Work May Proceed Provided the Above Comments are Incorporated By: ______ Client (If Required) Date ______

This Change May/May Not Be Used for Pro... Before the Base Document if Revised:

Project Manager ______ Date ______

QC Supervisor ______ Date ______

ANI (If Required) ______ Date ______

11-88

Field Revision Request

Project: Cooper Nuclear Station

Project No. TA161 FRR No: NPPD-91-35 Date 11-15-91

Document to Be Changed:

Title: Procedure for Ultrasonic Examination of RPV Closure Studs Number: GE-UT-307

Reason Change is Requested: To Meet NPPD Requirements

Proposed Change:

#1 Delete Paragraphs 5.3.1, 5.3.2, 5.3.3, and 5.3.4. Replace with new 5.3.1, 5.3.2, 5.3.3, 5.3.4, to read as follows:

5.3.1 Sweep Range Calibration. Using a suitable Calibration Block, adjust the instrument sweep to display a minimum of 50" of Metal Path.

5.3.2 System Calibration and construction of DAC's shall be performed using a 2 (two) Zone technique on a full length Stud Calibration Block. Zone 1 (one) shall cover the metal path range from 0" - 24 7/16" minimum, as measured from the nut end of the block. Zone 2 (two) shall cover the metal path range from 24 7/16" - 48 7/8" minimum.

5.3.3 The Zone 1 (one) DAC shall be obtained using a 5.0 MHZ Nominal Frequency Transducer from the nut end of the block. Obtain signals from slots A and D in the Calibration Block. Set the higher amplitude

Approved By Project Manager [signature] Date 11-15-91 Approved By QC Supervisor [signature] Date 11-15-91

Comments:

[signature] 11-15-91

Change Approved, Work May Proceed By: ______ Client (If Required) Date ______

Change Not Approved for Above Reasons By: ______ Client (If Required) Date ______

Work May Proceed Provided the Above Comments are Incorporated By: ______ Client (If Required) Date ______

This Change May/May Not Be Used for Production Before the Base Document If Revised:

Project Manager ______ Date ______

QC Supervisor ______ Date ______

ANI (If Required) ______ Date ______

Field Revision Request

Project Cooper Nuclear Station

Project No. TA161 FRR No. NPPD-91-35 Date 11-15-91

5.3.3 (cont'd)

response to 80% FSH. Mark the signal's position and amplitude on the CRT. Without changing gain, obtain a response from the remaining slot. Mark the position and amplitude on the CRT. Connect these points and extrapolate them to cover the examination range. This is primary reference level for Zone 1. Mark a second curve 20% of primary reference level on the CRT. Record instrument settings and DAC's on the Calibration Data Sheet.

5.3.4 The Zone 2 DAC shall be obtained using a 10.0 MHZ nominal frequency transducer from the flange end of the block. Obtain signals from slots A and D in the calibration block. Set the higher amplitude response to 80% FSH. Mark the signal's position and amplitude on the CRT. Without changing gain, obtain a response from the remaining slot. Mark the position and amplitude on the CRT. Connect these points and extrapolate them to cover the examination range. This is primary reference level for Zone 2. Mark a second curve 20% of primary reference level on the CRT. Record instrument settings and DAC's on the Calibration Data Sheet.

#2 Delete 5.3.4.1, 5.3.4.2, 5.3.4.3, 5.3.4.4, 5.3.4.5, 5.3.4.6.

#3 Change 6.1.1 to read as follows:

For Zone 1, the examination should be performed with search units with a frequency within the range of 2.25 MHZ - 5.0 MHZ. For Zone 2, the examination should be performed using search units with a frequency within the range of 5.0 MHZ - 10.0 MHZ.

Change 6.1.2 to read as follows:

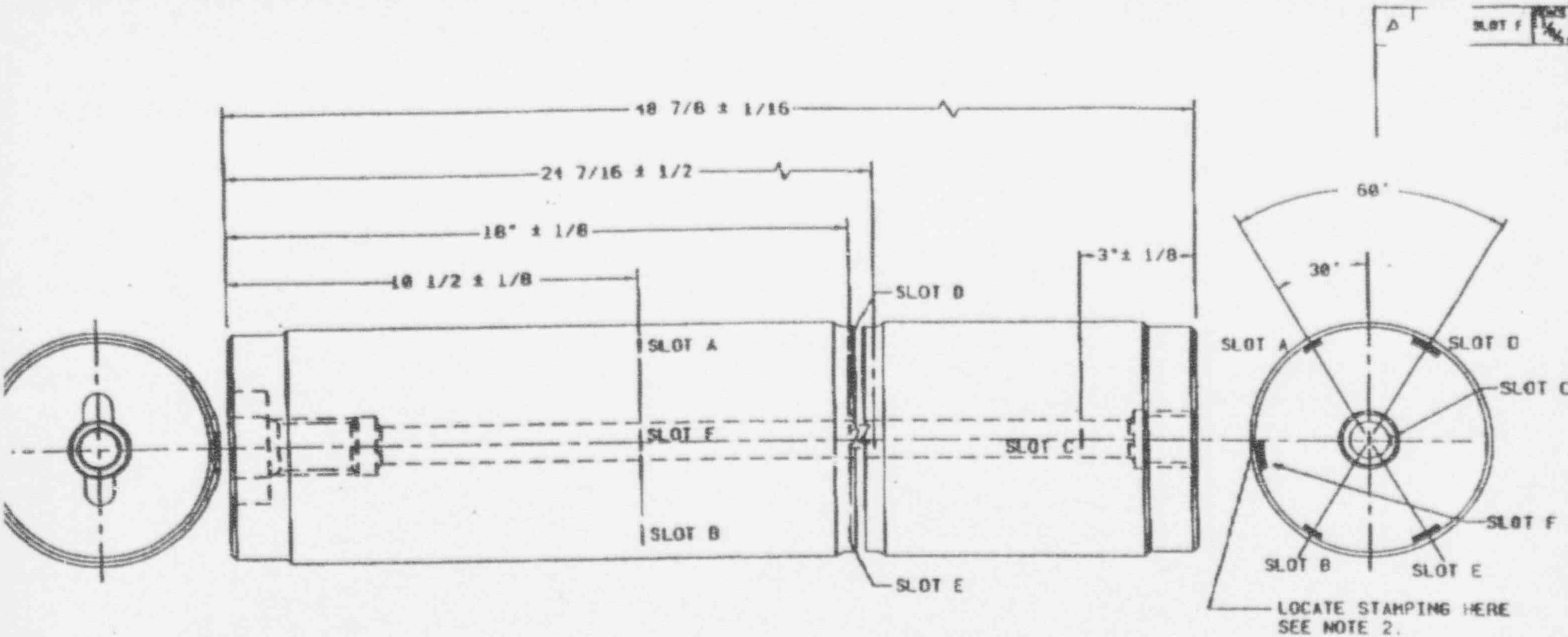
Scan at a gain setting of twice (2X) primary reference level. Record at primary reference level.

Change 6.1.4 to read as follows:

The examinations shall be performed in Zones that correspond to to those established during calibration.

Approved By Project Manager Richard Shaller Date 11-15-91 Approved By QC Supervisor ____________ Date ______

FI-88



SLOT A TO BE .340" ±.010 LONG X .020" ±.010 WIDE X .155" ±.010 DEEP. THIS EQUALS .058 in^2 MAXIMUM.
SLOT B TO BE .890" ±.010 LONG X .020" ±.010 WIDE X .065" ±.010 DEEP. THIS EQUALS .067 in^2 MAXIMUM.
SLOT C TO BE .680" ±.010 LONG X .020" ±.010 WIDE X .060" ±.010 DEEP. THIS EQUALS .040 in^2 MAXIMUM.
SLOT D TO BE .340" ±.010 LONG X .020" ±.010 WIDE X .147" ±.010 DEEP. THIS EQUALS .054 in^2 MAXIMUM.
SLOT E TO BE .890" ±.010 LONG X .020" ±.010 WIDE X .055" ±.010 DEEP. THIS EQUALS .058 in^2 MAXIMUM.
SLOT F TO BE .890" ±.010 LONG X .020" ±.010 WIDE X .055" ±.010 DEEP. THIS EQUALS .058 in^2 MAXIMUM.

NOTES:

1. SLOTS D AND E ARE PLACED IN THE UNTHREADED PORTION OF THE STUD BODY. THEY ARE USED FOR SIZING INDICATIONS IN THE UNTHREADED PART OF THE STUD.

2. STAMP THE FOLLOWING IDENT. IN 1/4" CHARACTERS:-
   LINE 1) CNSCAL. STD. NO. 116
   LINE 2) CNSNO. 20036
   LINE 3) MAT'L. SPEC. SA-540 GR.B-24
   LINE 4) HT. NO. 14677   LOT NO.65271-1

SAFETY RELATED — IEEE CLASS 1E NUCLEAR SAFETY RELATED

SIGNATURES: J. DOUAT; R.O. KILGO; R.E. CAMERON; V. MILLER

Nuclear Energy — GENERAL ELECTRIC COMPANY San Jose CA

COOPER RPV STUD CALIBRATION BLOCK

COOPER

SK-JR10-5

GE Nuclear Energy

EXHIBIT 1

STUD UT CALIBRATION DATA SHEET

Calibration Sheet No. ____________

Site ____________ ☐ P.S.I. ☐ I.S.I.

Procedure No. ________ Rev. ________ Calibration Block No. ____________

Date ________ Couplant ________ Cal. Std. Temp. ________ °F

Examiner ____________ ASNT Level ____________

Recorder ____________ ASNT Level ____________

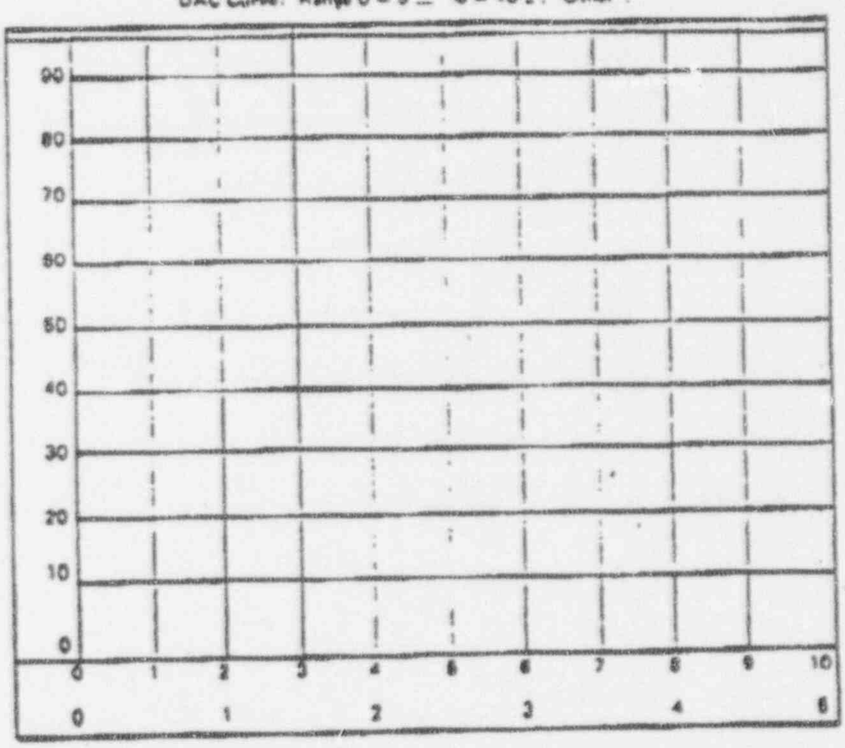
Equipment Data: Instrument Model No. ____________ Shoe No. ____________

Instrument Serial No. ____________ Cable No. ____________

Transducer Size ____________ Frequency ________ MHZ

Transducer Serial No. ____________ Beam Angle ________ °

DAC Curve: Range 0 – 5 ☐ 0 – 10 ☐ Other ☐



Reviewed by: ____________
SNT-TC-1A Level III

NPPD ISI ENGINEERING ____________ DATE ________

QA REVIEW ____________ DATE ________

ANII REVIEW ____________ DATE ________

GE Nuclear Energy

EXHIBIT 1

GENERAL ELECTRIC	CLOSURE STUD EXAMINATION DATA SHEET

SITE

☐ Preservice

☐ Inservice

EXAM. SHEET NO ______

CAL. SHEET NO ______

DATE ______

EXAMINER ______ LEVEL ______

RECORDER ______ LEVEL ______

PROCEDURE/REV ______

STUD IDENTIFICATION ______

SCANNING SENSITIVITY ______ [illegible]

EVALUATING SENSITIVITY ______ [illegible]

COUPLANT ______

STUD TEMPERATURE ______ °F

BATCH NO ______

THERMOMETER S/N ______

INDICATION RECORD:

Location		Max AMP % DAC	Metal Path [illegible]	Size of Indication 20% DAC to 20% DAC	Comments
RAD ± [illegible]	[illegible]				

Reviewed by: ______ Level: ______ Include Sketch if Applicable

[illegible] ISI ENGINEERING ______ DATE ______

QA REVIEW ______ DATE ______

ANII REVIEW ______ DATE ______

GE Nuclear Energy

PROCEDURE NO.:	TITLE	REVISION NO.:
GE-UT-307	PROCEDURE FOR ULTRASONIC EXAMINATION OF RPV CLOSURE STUDS	0

PREPARED BY:	REVIEWED BY:	APPROVED FOR USE BY:
[signature]	[signature]	[signature]
DATE: March 30, 1990 GE LEVEL: III	DATE: MARCH 30, 1990 GE LEVEL: III	DATE: MARCH 30, 1990

COMMENTS:

FORM 8.1.3-D-90

TABLE OF CONTENTS

1.0 SCOPE

1.1 The scope of this Procedure encompasses the manual, contact, pulse echo, ultrasonic examination of the ASME Section XI, Category B-G-1, reactor pressure vessel closure studs.

1.2 This Procedure contains techniques for examination using a straight beam from one or both ends of the stud, using angle beams from the extensiometer hole, and using surface waves in the extensiometer hole. These techniques may be used singly or in combination as required by the Owner's program.

1.3 This Procedure is applicable to materials up to 70 inches in length.

1.4 This Procedure is applicable to RPV closure studs when the examination is performed with the stud left in place or removed.

1.5 This Procedure contains variances from ASME Section XI requirements, qualified in accordance with Paragraph IWA-2240.

1.6 This Procedure does not delineate the acceptance and/or rejection of indications disclosed during testing. Final evaluations will be the Owner's responsibility.

2.0 REFERENCES

2.1 The following documents form a part of this Procedure to the extent specified herein.

2.1.1 Codes and Standards

2.1.1.1 American Society of Mechanical Engineers, (ASME), Boiler and Pressure Vessel Code, Sections V and XI, 1980 Edition including Addenda through Winter 1981.

2.1.2 General Electric Documents

2.1.2.1 PQP-03, or equivalent, Qualification and Certification of Nondestructive Examination Personnel.

2.1.2.2 GE-ADM-1001, Procedure for Performing Linearity Checks on Ultrasonic Instruments

2.1.3 Vessel Fabrication Documents

2.1.4.1 Detailed identification and marking plan meeting the requirements of ASME Code Section XI.

3.0 PERSONNEL

3.1 All personnel performing the ultrasonic examinations in accordance with this Procedure shall be qualified and certified to at least Level I. Level I individuals shall work under the direct supervision of a certified Level II or Level III individual. A Level I individual shall not independently evaluate or accept the results of this examination.

3.2 Personnel performing examination in accordance with this Procedure shall receive instruction in its use prior to the examination. This indoctrination shall be documented.

4.0 EQUIPMENT

4.1 The basic equipment shall be pulse echo design and shall be equipped with a calibrated gain or attenuation control, graduated in units no larger than 2 dB.

4.2 Transducers

4.2.1 Straight beam examination from the end(s) of the stud shall be performed using a ceramic type longitudinal wave search unit having a nominal frequency in the range of 2.25 through 10.0 MHz. The search unit should be from 1/2 through 3/4 inch diameter. The search unit shall be capable of detecting the qualification notches in the calibration blocks. Detection of the ASME qualification notches in both the near and far positions shall be documented on the Calibration Data Sheet.

4.2.2 Angle beam examinations from the extensiometer hole shall be performed using a specially designed stud examination probe(s). The probe(s) shall contain, as a minimum, forward and aft pointing search units with a nominal frequency of 2.25 MHz. The search unit's active element size shall not exceed 3/8" diameter. The primary inspection angle should be in the range of 40° - 60°. Probes containing more than one beaming angle may be used. More than one probe may be required to accommodate the desired beaming angles and the required scanning directions.

4.2.3 Surface wave examinations in the extensiometer hole shall be performed using a search unit designed to produce surface waves at a nominal frequency of 5.0 MHz. The search unit's active element size shall not exceed 3/8" diameter. The search units may be incorporated in a specially designed surface wave stud examination probe or placed in a probe designed for angle beam examinations.

4.2.4 With the approval of the responsible Level III, transducers of different size, shape and frequency may be used for examination, investigation of defect size, location and orientation. The use of other transducers shall be documented.

4.3 Ultrasonic examinations should be performed using coaxial cables 4 to 12 feet in length, longer cables may be used when necessary to facilitate access. The cable used shall be documented on the Calibration Data Sheet. Documentation shall include the cable type, length, and number of connectors.

4.4 Calibration blocks shall be supplied or approved by the Owner. Figures 1, 2 and 3 show the GE recommended calibration block configurations.

4.5 Couplant

4.5.1 USP grade glycerine, deionized water, or Ultragel II should be used for calibration and examinations. When required to maintain coupling, the couplant may be thinned with a suitable reducing agent.

4.5.2 All couplants other than deionized water shall be certified for total sulfur and halogen content in accordance with ASTM D-129-64 and D-808-63. The total residual halogens and sulfur shall not exceed 250 PPM. Deionized water, when used, shall be supplied by the Owner. FRR NPPD-91-16

4.5.3 Other couplants which meet the above specification may be used with Owner approval.

5.0 CALIBRATION

5.1 General Requirements for Calibration

5.1.1 The surface temperature of the calibration block(s) shall be within ± 25 degree F of the component surface temperature. The identification of the temperature measuring device shall be entered on both the Calibration and Examination Data Sheets.

5.1.2 Complete system calibration shall be made for the applicable examination(s) prior to examination. A calibration check shall be made when the examination is complete, each four hour interval, and when any change is made in personnel or system combination. System calibration and calibration checks shall be performed using the basic calibration block.

5.1.2.1 If, during the system calibration check, any point on the DAC line has changed in amplitude by 20% (2dB) or changed on the sweep line by more than 5% of the sweep division reading, since the last system calibration or calibration check, a new calibration shall be made and recorded. All data sheets since the last valid calibration or calibration check shall be marked void and the affected studs shall be re-examined.

5.1.3 In addition to the requirements of Paragraph 5.1.2, system calibration shall be checked and DAC curve verified after any change in power supply (e.g., from AC to battery or vice versa).

5.1.4 For initial ASME XI examination, the reject and damping controls of the instrument shall be set at either minimum or off position. Other settings may be used when approved by a Level III. Such approval shall be documented by the Level III by signature or initial and date on the Calibration Data Sheet. If reject or damping are used, instrument calibration shall be verified. Verification shall be documented on the Calibration Data Sheet.

5.1.5 Calibration for the examination shall include the complete Ultrasonic Test System(s). Alternate cables and search units singly and in combination that have been included in a prior system calibration may be later substituted in the system; such substitution shall not necessitate a calibration check. When any other part of the ultrasonic test system is changed, a calibration check shall be made.

5.1.6 Calibration for examination shall be performed on the calibration block(s) applicable to the stud that is being examined.

5.1.7 The UT instrument frequency setting should be set as close to the transducer frequency as possible.

5.2 Instrument Calibration

5.2.1 Instrument calibration shall be performed daily, in accordance with Reference 2.1.2.2.

5.3 Calibration for Straight Beam Examination of Full Length Closure Studs (in place or when removed).

5.3.1 Sweep Range Calibration. Using the L/8 through L calibration blocks, adjust the instrument sweep range to display the zone(s) of the stud that are being examined.

FRR: NPD-91-35

5.3.2 System calibration and construction of the DAC, shall be performed using a zoned technique. Examination zones shall be established by calibrating on the blocks that span the zone of the stud that is to be examined. It is expected that the zones will be: L/8 to L/4, L/4 to L/2, L/2 to 3L/4, and 3L/4 to L; however, zones may be combined if material attenuation permits. FRR-NPPD-35

5.3.3 The initial distance amplitude correction (DAC) curve shall be established by obtaining a peaked signal from the Flat Bottomed Hole (FBH) in the L/8 Calibration Block (see 7.1.2.1 for search unit recommendations). Using the variable gain control, adjust this signal amplitude to 80% FSH. Mark the sweep position and amplitude of this signal on the screen. Without changing the gain control, obtain a peaked signal from the FBH in the L/4 Calibration Block. Mark the sweep position and amplitude of this signal on the screen. Join the marks obtained above with a straight line point-to-point. This is the primary reference level for the zone extending from the scanning surface to L/4. Mark a second curve 20% of the primary DAC on the screen and record the data on the Calibration Data Sheet. FRR-NPPD-35

FRR-NPPD-35

5.3.4 Extension of the initial DAC to cover the other zones shall be performed (as necessary) as follows:

5.3.4.1 Determine the additional gain needed to increase the L/4 signal to 80% FSH and add this gain to the system. Mark the 80% amplitude on the screen and record the new gain setting on the Calibration Data Sheet. FRR-NPPD-35

5.3.4.2 Obtain a peaked signal from the FBH in the L/2 calibration block. Mark the sweep position and amplitude of this signal on the screen. FRR-NPPD-35

5.3.4.3 Connect the L/4 80% FSH point and the L/2 peak amplitude with a straight line point-to-point. This line is the primary reference level for the zone extending from L/4 to L/2. FRR-NPPD-35

5.3.4.4 Mark a second curve 20% of this reference level on the screen and record the data on the Calibration Data Sheet. FRR-NMO-35

5.3.4.5 Repeat steps 1-4 for the additional ranges of L/2 to 3L/4 and 3L/4 to L. When DAC's for these zones have been established, add an additional 12dB gain. This is the primary reference level for zones L/2 through L. The ASME code flaws in the near and far positions shall then be detected. The notches shall be detected at reference level with the equipment set up for the range where the flaw lies. The amplitudes from the notches shall be marked on the Calibration Data Sheet. The near position flaws are to be detected by scanning from the threaded end (nut end) of the calibration block containing the notch. The far position flaws are to be detected by scanning from the nut end of the full length (L) calibration block. FRR-NMO-35

5.3.4.6 Combination of examination zones, if possible, shall be performed. Three points shall be established, i.e., L/8 to L/2 requires DAC points from the L/8, the L/4, and the L/2 Calibration Blocks. The DAC established in this case would be valid for the examination zone extending from the scanning surface to L/2. FRR-NMO-55

5.4 Calibration for angle beam examinations performed from the extensiometer hole (in place or when removed).

5.4.1 Sweep Range Calibration. Insert the desired stud examination probe (see Figure 4) into the extensiometer hole and detect the signal from the calibrated notch in the stud threads. Adjust the instrument's sweep controls to display the distance from the OD surface of the bore hole to the notch in metal path. The sweep range is considered to be calibrated when the metal path displayed on the instrument is within ± 5% of the calibrated value. Record the instrument settings on the Calibration Data Sheet.

5.4.2 System Calibration. System calibration for this technique consists of establishing reference sensitivity only. Insert the desired stud examination probe into the extensiometer hole and detect the signal from the calibration notch. Maximize the signal and set the amplitude to 80% ± 5% FSH. This represents primary reference sensitivity. Other notches, e.g., .5 a/e, .05 a/e, etc. may be present for assistance in spring indications. If present data should be recorded from these notches for future use. Record the instrument settings on the Calibration Data Sheet.

5.4.3 More than one examination probe may be required to complete examination of a stud. When a single channel instrument is used, it is intended that all necessary calibrations be performed for each probe, e.g., fore and aft facing search units, fore or aft facing multi-angle search units, etc. Sensitivity differences between search units on the same stud examination probe shall be recorded on the Calibration Data Sheet. Appropriate adjustments, based on this data, shall be made to primary reference sensitivity during indication recording.

5.4.4 When primary reference sensitivity has been established, draw a horizontal line on the CRT screen representing the amplitude. A secondary line, representing 20% of the primary amplitude, shall also be drawn on the CRT screen. Both lines shall also be drawn on the Calibration Data Sheet.

5.5 Calibration for Surface Wave Examination in the Extensiometer Hole

5.5.1 Sweep Range Calibration. Insert the surface wave stud examination probe (see Figure 4) into the extensiometer hole and detect the ID surface notch on the stud. Move the probe toward and away from the notch and observe the signal's amplitude. Determine the point where the amplitude peaks and the distance of the search unit from the notch at peak amplitude. The distance from the notch will

usually be short. Adjust the sweep controls to display the determined distance from the notch in inches. Move the prove away from the notch until the amplitude of the signal is 50% (-6dB) from the maximum. Determine the distance. Adjust the sweep controls, if necessary, to display the minimum and maximum distances from the notch within ± 5% of the measured values. Mark the minimum and maximum points on the CRT screen and on the Calibration Data Sheet.

Rough or parkerized surfaces can preclude a surface wave having a working distance. If little or no probe movement is possible without losing the notch signal, determine the search unit distance from the notch and adjust the sweep controls to display the distance within ± 5% of the measured distance. Mark the point on the CRT screen and the Calibration Data Sheet. Note on the Calibration Data Sheet that no probe movement was possible. In this case, no DAC (see 5.5.2) is necessary.

5.5.2 System Calibration. System calibration for this technique consists of establishing primary reference sensitivity and a DAC (see 5.5.1). Move the probe to the minimum distance from the notch and detect the signal from the notch. Set this amplitude to 80% ± 5% FSH. Mark the amplitude on the CRT screen. Move the probe to the maximum distance from the notch and mark the signal amplitude on the screen. Connect the points with a straight line. This establishes the primary reference sensitivity and DAC for the working distance determined for the search unit. Construct a secondary DAC equal to 20% of primary. Record the instrument settings and CRT markings on the Calibration Data Sheet.

If no working distance can be established for the search unit, no DAC is required. In this case, set the notch response to 80% ± 5% FSH and mark the position and amplitude on the CRT screen. Mark a secondary point equal to 20% of primary. Record the instrument settings and CRT markings on the Calibration Data Sheet.

6.0 EXAMINATION

6.1 Straight Beam Examination of Full Length Closure Studs (in place or when removed)

6.1.1 For zones L/8 through L/2, examination should be performed with search units in the range of 2.25 through 5.0 MHZ. For zones L/2 through L, examination should be performed with search units in the range of 5.0 through 10.0 MHZ, to minimize beam spreading at the longer distances.

6.1.2 For zones L/8 through L/2, scan at a gain setting of twice (2X) the primary reference level. Record with the gain control set at the reference level (1X). For zones L/2 through L the scanning and recording levels shall be those established in Paragraph 5.3.4.5.

6.1.3 The studs shall be examined from one end. The complete end surface shall be scanned. The scan path of the search unit shall overlap adjacent scans by a minimum of 10% of the transducer active element. The scanning speed shall not exceed 6 inches per second.

6.1.4 The examination shall be performed in zones that correspond to the zones established during calibration. The instrument gain shall be set at 2X primary reference level and the zone from the scanning surface to L/4 examined. The instrument gain shall then be set at the gain established for the next examination zone, i.e., L/4 to L/2 and that zone shall be examined. This progressive examination shall be continued until the full length of the stud (all zones) has been examined.

6.1.5 When the calibration zones display less than full stud length, occasionally verify search unit operation by obtaining a reflection from the radial dimension of the stud.

6.2 Angle Beam Examination from the Extensiometer Hole

6.2.1 Select the desired stud examination probe and insert it into the extensiometer hole. Rotate the probe to the 0° axis of the stud.

6.2.2 Move the probe to the end of the stud opposite the end of the scan was started at, observing the CRT for indications. Scan speed shall not exceed 3" per second.

6.2.3 At the end of each scan, index the probe to the next scan location. Maintain a 50% overlap of the search unit active element. Scan the length of the stud to the limits imposed by the probe design. Repeat until the entire stud has been examined.

6.2.4 For single channel instruments, repeat 6.2.1 through 6.2.3 for each search unit in the probe. If a multiplexed instrument with automated data recording is used, it will not be necessary to scan the stud more than once.

6.3 Surface Wave Examination in the Extensiometer Hole

6.3.1 Select the desired stud examination probe and insert it into the extensiometer hole. Rotate the probe to the 0° axis of the stud.

6.3.2 Move the probe to the end of the stud opposite the end of the scan was started at, observing the CRT for indications. Scan speed shall not exceed 3" per second.

6.3.3 At the end of each scan, index the probe to the next scan location. Maintain a 50% overlap of the search unit active element. Scan the length of the stud to the limits imposed by the probe design. Repeat until the entire stud has been examined.

6.3.4 For single channel instruments, repeat 6.3.1 through 6.3.3 for each search unit in the probe. If a multiplexed instrument with automated data recording is used, it will not be necessary to scan the stud more than once.

7.0 <u>RECORDING</u>

7.1 Record all indications which exceed 20% DAC at 1X sensitivity on the Examination Data Sheet. Indications caused by stud geometry shall only be recorded once per stud.

7.2 For straight and angle beam examinations, record maximum amplitude in percent DAC, transducer movement between 20% DAC points and metal path at the maximum amplitude. Include a sketch showing the stud number and the location of any indications data recorded.

7.3 For surface wave examinations, record maximum amplitude and the surface distance shown on the CRT. Include a sketch showing the stud number and the location of any indications recorded.

8.0 EVALUATION

8.1 Data Review: All data shall be reviewed by an individual certified to Level III to determine if further examination or evaluation is required.

8.2 Evaluation of Indications: All indications shall be evaluated in accordance with the ultrasonic acceptance criteria specified in Paragraph IWB 3515 of ASME Section XI.

8.3 Recordable indications that are determined not to be geometric reflectors will be reported to the Owner after preliminary evaluation.

8.4 Final evaluation will be the Owner's responsibility.

9.0 RECORDS

9.1 Data sheets are typical; the format may change provided the minimum information shown in 9.2 and 9.3 is maintained.

9.2 Calibration Data Sheet

a) Calibration sheet identification, date and time period of calibration
b) Name(s) and ASNT Level(s) of examination personnel
c) Examination procedure number and revision
d) Basic calibration block identification
e) Ultrasonic instrument identification and serial number
f) Beam angle, couplant, and mode of wave propagation in the material
g) Search unit identification - frequency, size, manufacturer, and serial number
h) Reviewer's signature, ASNT Level and date
i) Search unit cable type, length, and number of connectors
j) Times of initial calibration and subsequent and final calibration checks
k) Calibration reflector(s) and the instrument settings, amplitudes, and sweep positions used to establish primary reference sensitivity.
l) Thermometer serial number and calibration block temperatures

9.3 Examination Data Sheet

a) Data sheet identity, examination date and time period of examination
b) Name(s) and ASNT level(s) of examination personnel
c) Examination procedure and revision
d) Applicable calibration sheet identity
e) Weld identification
f) Record of indications or of volume free from indications
g) Examination surface, volume scanned, scan identification and scan limitations if any
h) Reviewer's signature, ASNT Level and date
i) Search unit position and locations of recorded indications
j) Thermometer serial number and examination surface temperature

STUD UT CALIBRATION DATA SHEET

Calibration Sheet No ____________

Site ____________ ☐ PSI ☐ ISI

Procedure No ________ Rev. ________ Calibration Block No ____________

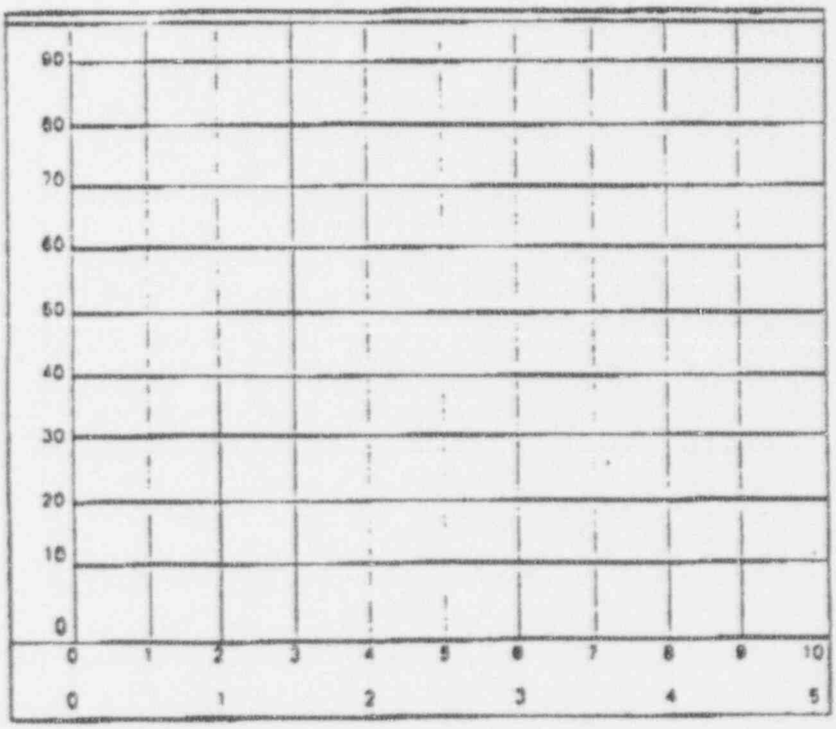
Date ________ Couplant ________ Cal. Blk Temp ____________ °F

Examiner ____________ ASNT Level ____________

Recorder ____________ ASNT Level ____________

Equipment Data
Instrument Model No ____________ Shoe No. ____________
Instrument Serial No ____________ Cable No ____________
Transducer Size ____________ Frequency ____________ MHz
Transducer Serial No ____________ Beam Angle ____________ °

DAC Curve: Range 0 – 5 ☐ 0 – 10 ☐ Other ☐



Reviewed by ____________
SNT-TC-1A Level III

EXHBIT 1

GENERAL ELECTRIC

CLOSURE STUD EXAMINATION DATA SHEET

SITE ☐ Preservice ☐ Inservice XAM SHEET NO. ________ CAL. SHEET NO. ________

DATE ________ EXAMINER ________ LEVEL ________

RECORDER ________ LEVEL ________

PROCEDURE/REV. ________ STUD IDENTIFICATION ________

SCANNING SENSITIVITY ________ dBs EVALUATING SENSITIVITY ________ dBs

COUPLANT ________ STUD TEMPERATURE ________ °F

BATCH NO. ________ THERMOMETER S/N ________

INDICATION RECORD:

Location		Max AMP % DAC	Metal Path inches	Size of Indication 20% DAC to 20% DAC	Comments
RAD. θ°	Dp. X"				

Reviewed by: ________ Level ________ Include Sketch if Applicable

EXHIBIT 2

CALIBRATION BLOCK SET
FOR STRAIGHT BEAM EXAMINATION
FROM THE END OF THE STUD

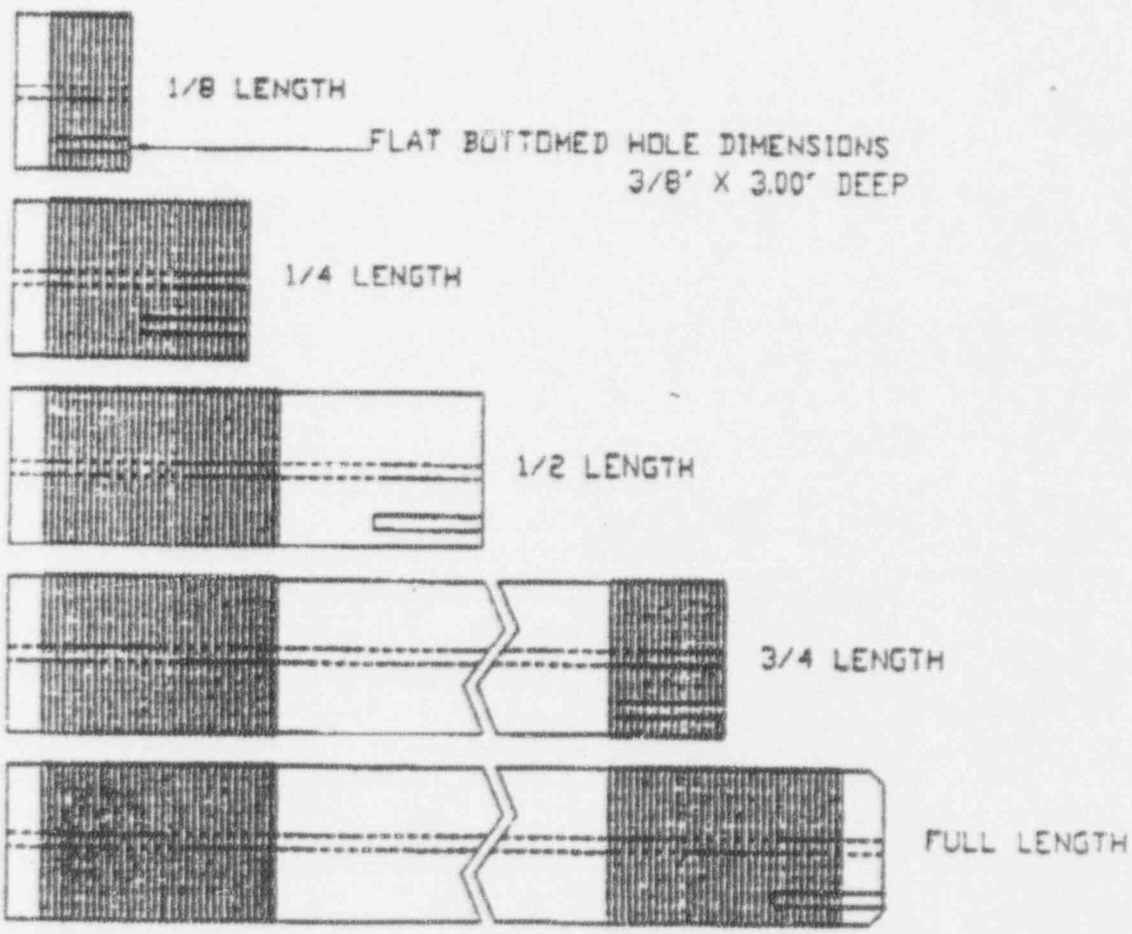


FIGURE 1

CALIBRATION BLOCK

FOR ANGLE BEAM EXAMINATION
FROM THE EXTENSIOMETER HOLE

NOTCH DEPTH
.115" ±.003 FROM THREAD ROOT

NOTCH LENGTH
.490" ±.010 CIRCUMFERENTIALLY

NOTCH REFLECTING AREA
≤.059 IN^2

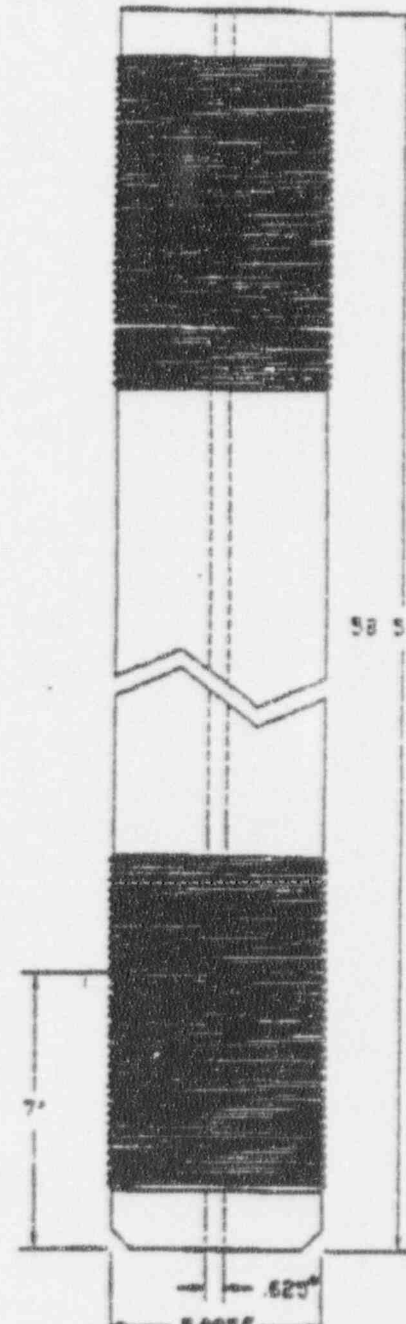


FIGURE 2

CALIBRATION BLOCK

FOR SURFACE WAVE EXAMINATION
IN THE EXTENSIOMETER HOLE

ID NOTCH DEPTH
.020" +.020 -.000

ID NOTCH LENGTH
.060" ±.010

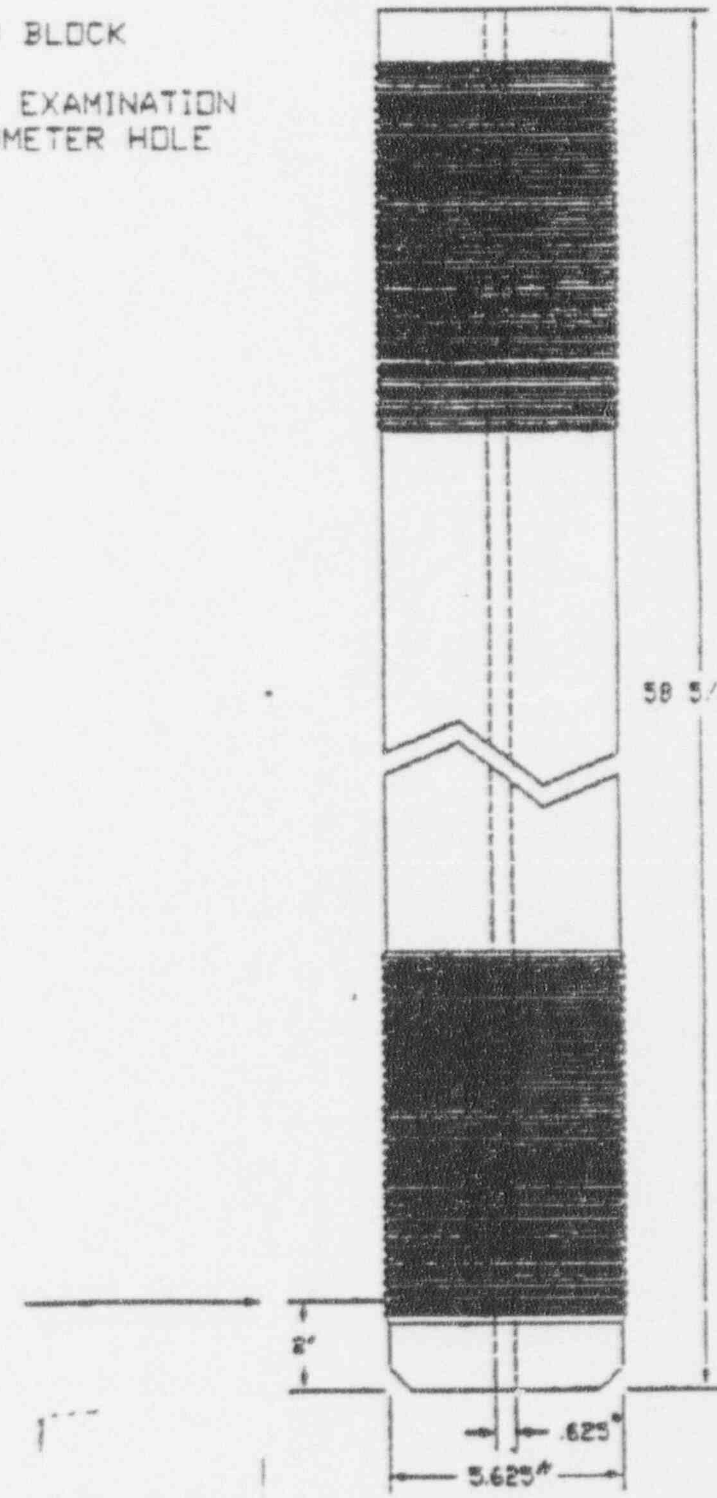


FIGURE 3

FIXTURE FOR EXAMINATIONS
PERFORMED FROM THE EXTENSIOMETER HOLE

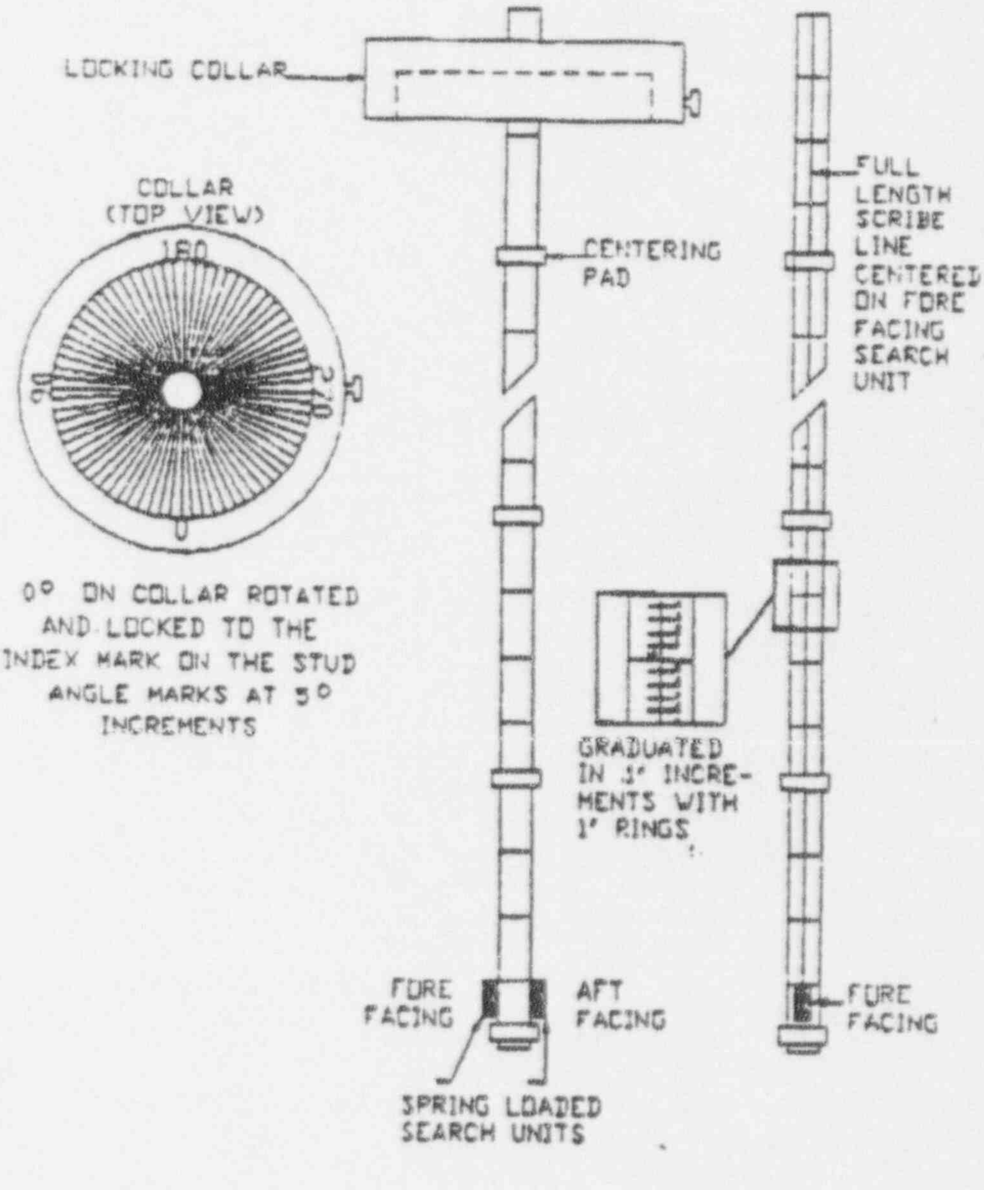


FIGURE 4

GE Nuclear Energy

PROCEDURE NO. GE-MT-101 **TITLE** REVISION NO. 0

PROCEDURE FOR WET FLUORESCENT MAGNETIC PARTICLE EXAMINATION

PREPARED BY	REVIEWED BY	APPROVED FOR USE BY
[signature]	Wesley C. Money	Ralph Edwards
DATE Jan 11, 1991 GE LEVEL III	DATE Jan 11, 1991 GE LEVEL III	DATE Jan 11, 1991

COMMENTS

TABLE OF CONTENTS

1.0 SCOPE

1.1 This procedure describes the methods, requirements, and acceptance criteria for continuous wet magnetic particle examination of ASME Section XI components, including but not limited to RPV closure studs, nuts, vessels and other ferro-magnetic components.

2.0 REFERENCES

2.1 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code Sections V and XI, 1980 Edition, including Addenda through Winter 1981.

2.2 General Electric Procedure FQP-03, "Qualification and Certification of Nondestructive Examination Personnel", which meets the requirements of the American Society of Nondestructive Testing (ASNT) Recommended Practice, SNT-TC-1A, 1975 and 1980 Editions.

2.3 General Electric Procedure GE-ADM-1005, "Procedure for Zero Reference Location and Data Recording for Nondestructive Examinations"

3.0 PERSONNEL

3.1 Personnel performing magnetic particle examination to this procedure shall be qualified and certified in accordance with paragraph 2.2

3.2 Level I personnel may perform the examination under the direction of personnel certified to at least Level II. Personnel reviewing or evaluating recorded data shall be certified to Level II or Level III

4.0 EQUIPMENT

4.1 The magnetizing apparatus used shall be capable of inducing, in the item under examination, a magnetic field of suitable intensity in the desired direction by either the circular or the longitudinal method.

4.2 Direct current obtained from DC generators, or full wave or half wave direct current obtained by rectifiers or diodes may be used to induce the magnetic field.

4.3 Any suitable means may be used to establish the magnetic field (e.g. yoke, central conductor, direct contact and prods). Care must be taken when utilizing the prod and direct contact methods to prevent arcing. The central conductor must be insulated to protect the part being examined

4.4 Magnetic Particles

4.4.1 Fluorescent magnetic particles suspended in a suitable liquid vehicle shall be used as the inspection medium. A wetting agent may be used to assure complete coverage.

4.4.2 The concentration of the fluorescent magnetic particles shall be between 0.1 and 0.7 ml in a 100 ml sample of the bath. Particle concentration shall be measured after allowing a thirty minute settling time.

4.4.3 The bath strength shall be checked at least once every eight hours or when a new solution is prepared. This shall be recorded on the Magnetic Particle Examination Sheet.

4.4.4 The bath shall be agitated in a manner which assures that the magnetic particles are uniformly suspended in the medium.

4.4.5 The application of the magnetic particles must be in such a fashion as to assure that lightly held particles are not washed away

NOTE: Aerosol spray cans of fluorescent particles can be used, if they meet the requirements of ASME Section V, SE-138.

4.5 LIGHTING

4.5.1 A darkened area shall be used to conduct the examination.

4.5.2 A high intensity black light shall be used for illumination. It shall be equipped with a filter (Kopp No. 41 or equivalent) which passes 3650 angstrom unit ultraviolet (black) light. T black light intensity at the surface under examination shall be measured at least once every eight hours, and whenever the work location is changed, using a meter which is sensitive to light in the ultraviolet spectrum and centered on 365 nanometers (nm) (3650 angstrom units). Two readings shall be taken; the first without a filter and the second with an ultraviolet (365 nm) absorbing filter placed over the sensing element of the meter. The second reading shall be subtracted from the first and the difference shall be a minimum of 800 uW/cm2. The black light bulb shall be turned on and allowed to warm up for at least five minutes prior to use.

4.6 Thermometers calibrated and certified in accordance with manufacturer's standards shall be used to measure the examination component surface temperature. Additionally, the serial number of the thermometer shall be recorded on the Examination Data Sheet (Exhibit I).

5.0 CALIBRATION

5.1 Each piece of magnetizi equipment shall be calibrated once a year or whenever the equipment has been subject to major electric repair, periodic overhaul, or damage. If equipment has not been in use for a year or more, calibration shall be done prior to first use.

5.2 Each alternating current electronic yoke shall have a lifting power of at least 10 lb. (4.5) KG at the maximum pole spacing that will be used. Yoke spacing is defined as the shortest distance between yoke legs at the contact area and shall be from 3.0" to 6.0".

5.3 Each direct current or permanent magnetic yoke shall have a lifting power of at least 40 lb. (18.1) KG at the maximum pole spacing that will be used. Yoke spacing is defined as the shortest distance between yoke legs at the contact area and shall be from 3.0" to 6.0".

5.4 Magnetizing unit ammeters shall be calibrated at least once every twelve (12) months or after each time it has been subjected to major electrical repair, periodic overhaul or damage. The unit's meter reading shall not deviate by more than ± 10% of full scale, relative to the actual current value as shown by the test meter.

6.0 EXAMINATION

6.1 Magnetic particle examination provides for the detection of surface and sub-surface discontinuities in ferromagnetic materials. Its sensitivity is greatest for surface discontinuities and diminishes rapidly with increasing sub-surface depth of discontinuities. Magnetic yokes are to be used only for surface discontinuities.

6.2 It requires that the item under examination be appropriately magnetized while finely divided fluorescent ferromagnetic particles suspended in a liquid medium are applied to the area under examination. The leakage field associated with a discontinuity attracts and holds these particles forming a visual indication of its locarion and size.

6.3 Surface to be Examined

6.3.1 Minimum examination surface requirements for nuclear power plant components and their integral attachments:

6.3.1.1 Piping, Pumps and Valves - The examination surface requirements for these components shall include the weld and .50" of base metal on both sides of the welds as a minimum.

6.3.1.2 Reactor Head-to-Flange - The examination surface requirements for this component shall include the weld and 1/2T of base metal from the toe of the weld and all of the base metal between the weld and the stud holes on the flange side of the weld as a minimum.

6.3.1.3 Bolting Larger Than 2.0" in Diameter - The examination surface requirements for these components shall include the total surface area of the threads as a minimum.

6.3.1.4 Integral Attachments - The examination surface requirements for these components shall include the weld and 1.0" of base metal on both sides of the weld as a minimum.

6.3.1.5 Heat Exchanger Nozzle Welds - The examination surface requirements for this component shall include the weld and .50" of base metal on both sides of the weld as a minimum.

6.3.1.6 Reactor Coolant Pump Flywheel - The examination surface requirements for these components shall include all exposed surfaces.

6.3.1.7 Reactor Pressure Vessel Studs - The examination surface requirements for these components shall include all exposed surfaces.

6.3.1.8 Reactor Pressure Vessel Nuts - The examination surface requirements for these components shall include all exposed surfaces.

6.3.1.9 Reactor Pressure Vessel Skirt Welds - The examination surface requirements for these components shall include the weld and 1.0" of base metal on both sides of the weld as a minimum.

6.3.1.10 Reactor Pressure Vessel Welds - The examination surface requirements for this component shall include the weld and 1/2T from the toe of the weld where "T" is the thickness of the thicker member being joined.

6.4 Process

6.4.1 Parts shall be magnetized in more than one direction. Facilities must be provided for handling and holding the part so that the magnetizing field can be applied in the proper direction in a uniform and controlled manner. Magnetizing shall be accomplished in one or both of the following ways:

6.4.1.1 By the use of a central conductor, circular magnetization.

6.4.1.2 By the use of coils, longitudinal magnetization.

6.4.2 Surface Preparation

6.4.2.1 The surface of the product being examined may be in the as finished condition (Care shall be taken to minimize abrasion of the parkerized surfaces).

6.4.2.2 Prior to magnetic particle examination, the surface to be examined and any adjacent area within at least 1.0" of the surface to be examined, shall be dry and free of any dirt, grease, lint, scale, welding flux, spatter, oil, or other extraneous matter that would interfere with the examination.

6.4.2.3 Cleaning may be accomplished by detergents, organic solvents, descaling solutions, paint removers, vapor degreasing, ultrasonic cleaning or steam cleaning methods, any other surface conditioning or cleaning (i.e. grinding, flapping etc.) shall be approved by the client.

6.5 Circular Magnetization Technique

6.5.1 Magnetization By a Central Conductor

6.5.1.1 For this technique, a central conductor is used to examine the internal surfaces of ring or cylindrically shaped parts. The central conductor technique may also be used for examining the outside surfaces of these shapes. Where large diameter cylinders are to be examined, the conductor shall be positioned close to the internal surface of the cylinder. When the conductor is not centered, the circumference of the cylinder shall be examined in increments and magnetic particle field indicator shall be used to determine the extent of the arc that may be examined for each conductor position. Bars, or cables passed through the bore of a cylinder, may be used to induce circular magnetization.

6.5.1.2 Magnetizing Current - Direct or rectified (half-wave rectified or full-wave rectified) magnetizing current shall be used. The required current shall be determined using the following guidelines:

a) For parts with outer diameters up to 5" (125 mm), 700 to 900 amp/in. of diameter shall be used;

b) For parts with outer diameters over 5" (125 mm, up to 10" (250 mm), 500 to 700 amp/in. of diameter shall be used;

c) For parts with outer diameters over 10" (250 mm) up to 15" (380 mm), 300 to 500 amp/in. of diameter shall be used.

d) For parts with outer diameters over 15" (380 mm), 100 to 330 amp/in. of outer diameters shall be used.

6.5.2 Magnetization By Direct Contact

6.5.2.1 Magnetizing Procedure. For this technique, magnetization is accomplished by passing current through the part to be examined. This produces a circular magnetic field that is approximately perpendicular to the direction of current flow in the part.

6.5.2.2 Magnetizing Current. Direct or rectified (half-wave rectified or full-wave rectified) magnetizing current shall be used. The required current shall be determined using the following guidelines:

a) For parts with outer diameters up to 5" (125 mm), 700 to 900 amp/in. of diameter shall be used.

b) For parts with outer diameters over 5" (125 mm) up to 10" (250 mm), 500 to 700 amp/in. of diameter shall be used.

c) For parts with outer diameters over 10" (250 mm) up to 15" (380 mm), 300 to 500 amp/in. of diameter shall be used.

d) For parts with outer diameters over 15" (380 mm), 100 to 330 amp/in. of diameter shall be used.

e) For parts with geometric shapes other than round, the greatest cross-sectional diagonal in a plane at right angles to the current flow shall determine the inches to be used in the above computations.

f) As an alternate, for non-cylindrical parts only, the magnetizing amperage may be established using the Magnetic Particle Field Indicator

6.5.3 Longitudinal Magnetization Technique

6.5.3.1 For this technique, magnetization is accomplished by passing current through a multi-turn fixed coil (or cables) that is wrapped around the part or section of the part to be examined. This produces a longitudinal magnetic field parallel to the axis of the coil. If a fixed, pre-wound coil is used, the part shall be placed near the side of the coil during inspection. This is of special importance when the coil opening is more than ten times the cross-sectional area of the part

6.5.3.2 Magnetic Field Strength - Direct or rectified current shall be used to magnetize parts examined by this technique. The required field strength shall be calculated based on the length (L) and the diameter (D) of the part in accordance with (a) or (b), below. Long parts shall be examined in sections not to exceed 18" (460 mm), and 18" (460 mm) shall be used for the part (L) in calculating the required field strength. For non-cylindrical parts, (D) shall be the maximum cross-sectional diagonal.

a) Parts with L/D Ratios Equal To or Greater Than 4. The magnetizing current shall be within ± 10% of the ampere-turns value determined as follows:

$$\text{Ampere-turns} = \frac{35{,}000}{(L/D) + 2}$$

For example, a part 10" (250 mm) long x 2" (50 mm) diameter has an L/D ratio of 5. Therefore,

$$\frac{35{,}000}{(5 + 2)} = 5000 \text{ Ampere-turns}$$

b) Parts with L/D Ratios Less Than 4 but Not Less Than 2. The magnetizing ampere-turns shall be within ± 10% of the ampere-turns value determined as follows:

$$\text{Ampere-turns} = \frac{45{,}000}{L/D}$$

6.5.3.3 Magnetizing Current - The current required to obtain the necessary magnetizing field strength shall be determined by dividing the ampere-turns obtained in steps (a) or (b) above by the number of turns in the coil as follows:

$$\frac{\text{Ampere-turns}}{\text{turns}} = \text{Amperes (Meter Reading)}$$

For example, if a 5-turn coil is used and the ampere-turns required are 5000, use:

$$\frac{5000}{5} = 1000 \text{ Amperes } (\pm 10\%)$$

6.5.3.4 Optionally, an electromagnetic yoke may be used to establish a longitudinal field. The yoke shall be calibrated in accordance with Paragraph 5.0. The yoke technique shall only be used to detect discontinuities that are open to the surface.

6.6 A magnetic particle field indicator shall be used to establish adequacy of the magnetic field. The magnetizing field shall be sufficient to develop a pattern on the indicator clearly. The field indicator shall be placed on the surface being examined while applying the required current and ferromagnetic particles. The production of a pattern of discernible ferromagnetic particles indicates an adequate field strength has been generated. This confirmation need only be performed on the first item (of each shape) examined during a production shift.

6.7 Temperature During Test - Magnetic particle examination shall not be performed on parts whose surface temperature is in excess of 135°F.

6.8 <u>Examination Sequence</u>

6.8.1 For yokes having both AC/DC capabilities, position selector switch to the desired mode.

6.8.2 <u>Wet Bath Technique</u>

a) Position the yoke on the surface to be examined

b) Agitate aerosol can to ensure particle suspension.

c) Apply current to yoke.

d) Apply particles thoroughly over the part to be examined and observe the formation of magnetic particle indications.

e) Switch off current and remove yoke from surface or part.

f) Under adequate lighting conditions as detailed in Paragraph 4.5.2, examine the part for indications.

g) Record observed indications on the Magnetic Particle Examination Report.

6.8.3 Studs

6.8.3.1 Circular Magnetization - Central Conductor

a) Place stud so the serial number is at the 12 o'clock position.

b) Insert central conductor through stud and connect cables to central conductor.

c) Apply the magnetizing current as determined from Paragraph 6.5.1 and confirm the adequacy of the current per Paragraph 6.6.

d) Apply the wet magnetic particles by spraying or flowing in a uniform manner over the area of interest and observe the formation of magnetic particle indications while the current remains on.

e) Switch off the magnetizing current.

f) Under adequate lighting conditions as detailed by Paragraph 4.5.2, inspect the surface for magnetic particle indications.

g) Rotate part 904 so that serial number is at the 3 o'clock or 9 o'clock position.

h) Repeat operations "c" through "g".

6.8.3.2 Longitudinal Magnetization - Coil Method

a) When the coil is made of cable wound around the test part, the turns shall be immediately adjacent to each other. Normally, these coils will consist of three to six turns.

b) Position the coil 6" to 8" from one end of the part. To ensure complete inspection, successive overlapping shots shall be used.

c) Apply the magnetizing current as determined from Paragraph 6.5.3 and confirm the adequacy of the current per Paragraph 6.6.

d) Apply the wet magnetic particles by spraying or flowing in a uniform manner over the area of interest and observe the formation of magnetic particle indications while the current remains on.

e) Switch off the magnetizing current.

f) Under adequate lighting, inspect the surface for magnetic particle indications.

6.8.4 Nuts

6.8.4.1 Circular Magnetization - Central Conductor

a) Place the nut so the serial number is at the 12 o'clock position.

b) Insert central conductor through nut and parallel to the bore centerline.

c) Apply the magnetizing current as determined from Paragraph 6.5.1 and confirm the adequacy of the current per Paragraph 6.6.

d) Apply the wet magnetic particles by spraying or flowing in a light, uniform manner over the area of interest and observe the formation of magnetic particle indications while the current remains on

e) Switch off the magnetizing current

f) Under adequate lighting, inspect the surface for magnetic particle indications.

g) Rotate part 90h so that serial number is at the 3 o'clock or 9 o'clock position

h) Repeat operations "c" through "g"

6.8.4.2 Longitudinal Magnetization - Coil Method (Figure I)

6.8.4.2.1 Outside Diameter - Coil Method

a) When the coil is made of cable wound around the test part, the turns shall be immediately adjacent to each other. Normally, these coils will consist of three to six turns.

b) Position the nut so that the serial number is at the 12 o'clock position.

c) Position the coil around the axial center of the nut.

d) Apply the magnetizing current as determined from Paragraph 6.5.3 and confirm the adequacy of the current per Paragraph 6.6.

e) Apply the wet magnetic particles by spraying or flowing in a uniform manner over the area of interest and observe the formation of magnetic particle indications while the current remains on.

f) Switch off the magnetizing current

g) Under adequate lighting, inspect the outside diameter surface and both ends for magnetic particle indications.

h) Rotate part 180h so that serial number is at the 6 o'clock position.

i) Repeat operations "c" through "h"

6.8.4.2.2 Inside Diameter Coil Magnetization

a) Position the nut so the serial number is at the 12 o'clock position.

b) Position the coil through the inside diameter of the nut. Center the coil radially and axially with respect to the I.D.

c) Apply the magnetizing current as determined from paragraph 6.5.3 and confirm the adequacy of the current per Paragraph 6.6

d) Apply the wet magnetic particles by spraying or flowing in a uniform manner over the I.D surfaces and observe the formation of magnetic particle indications while the current remains on.

e) Switch off the magnetizing current and remove the coil from the nut.

f) Under adequate lighting, inspect the inside diameter for magnetic particle indications

g) Rotate part 90° so the serial number is at the 6 o'clock position.

h) Repeat operations "c" through "g"

6.9 Postcleaning - All surfaces should be cleaned sufficiently to assure all magnetic particles are removed from the part.

6.10 When residual magnetism in the part could interfere with subsequent processing or usage, the part shall be demagnetized in accordance with ASME Section V after completion of the examination.

7.0 RECORDING

7.1 Record all relevant indications and all examination boundaries inaccessible for examination on the Magnetic Particle Examination Report form, in accordance with reference Paragraph 2.3.

7.2 Indications shall be classified as either relevant or non-relevant and shall be evaluated accordingly. The following definitions shall apply to the review and evaluation:

7.2.1 Relevant Indications - are those indications caused by discontinuities. If an indication cannot be identified as either relevant or non-relevant, it shall be assumed to be relevant until the indication is either eliminated by surface conditioning or it is re-examined by the same or other non-destructive means and demonstrated to be non-relevant. Only those indications exceeding 1/16" shall be considered relevant.

7.2.2 Non-relevant Indications - are those indications created by design or geometric configuration that have no relation as to the integrity of the part under examination.

7.3 Provide accurate indication lengths and orientation measurements with regard to weld centerline and L_o or other applicable benchmarks for all the following recordable indications:

7.3.1 Record all single linear indications 1/16" and greater in length detected on component surfaces with a nominal wall thickness of less than 2.0".

7.3.2 Record all single linear indications 3/16" and greater in length detected on component surfaces with a nominal wall thickness of 2.0" and greater.

7.3.3 Record all multiple indications 1/16" and greater in length which are separated by .50" or less in all components regardless of nominal wall thickness. Provide a sketch with all recorded multiple indications with dimensions.

7.4 All relevant indications shall be evaluated to the appropriate table, as specified by Table IWB-3410-1.

7.5 Indications extending beyond the examination boundaries, or separate indications that lie both within and beyond the examination boundaries but are characterized as single indications shall be recorded with a sketch showing the total length.

7.6 The size of indications extending into a pressure retaining membrane of the component shall be governed by the standard applicable to the pressure retaining component.

7.7 All flaw indications shall be reported to the Owner within twenty-four hours of final sizing determination, or as required by contract.

7.8 Evaluation and disposition of flaw indications are the responsibility of the Owner.

8.0 REPORTS

8.1 The format of data sheet exhibits are subjected to change as may be required. The technical content of data sheets used shall contain as a minimum the following (see Exhibit I).

a) Project and unit number identification
b) Weld seam or item identification
c) Examination procedure and revision number
d) Examiner's name and certification level
e) Examination results (including location and dimension of all reportable indications)
f) Equipment make and serial number
g) Yoke spacing used
h) Yoke calibration date
i) Particles, manufacturer's name, color and batch number
j) Examination technique, wet bath, yoke, coil, central conductor, etc.
k) Thermometer serial number
l) Component temperature

GE Nuclear Energy

WET MAGNETIC PARTICLE EXAMINATION REPORT

SITE ________ UNIT ____ REPORT NO. ________
PROJECT NO. ________ WELD / COMPONENT NO. ________

Procedure No. ________ Rev ________ FRR No ________

TECHNIQUE

MATERIAL
- CS
- SS
- OTHER ________

SURFACE CONDITION
- AS WELDED
- GROUND
- AS CAST
- CLEANED
- OTHER ________

ITEM
- PIPE
- PLATE
- FITTING
- OTHER ________
- WELD
  - ROOT
  - PARTIAL
  - FINAL

EQUIPMENT
UNIT ________
S/N ________
RATING ________ AMP
EXAM SURFACE TEMP ________
THERMOMETER NO ________

CALIBRATION*
- AC 10 LB LIFT
- DC 40 LB LIFT

CABLES
SIZE
- 4/0
- 2/0

LENGTH ________
TYPE
- COPPER
- ALUMINUM

- * YOKE
- COIL
TURNS ________
DIAMETER ________
- CENTRAL CONDUCTOR
AMPS ________

* NOTE: YOKE CALIBRATION IS DEMONSTRATION OF WEIGHT LIFTING AS INDICATED

MAGNETIZATION
- AC
- DC RECT (1/2 WAVE)
- DC

METHOD
- CONTINUOUS
- RESIDUAL

MATERIAL
- AEROSOL
- BATH

SUSPENSION
- OIL
- WATER

SUSPENSION CK
________ ML/100ML
DATE ________

BLACKLIGHT CK
________ µW/cm²
________ FT CDL
DATE ________

RESULTS

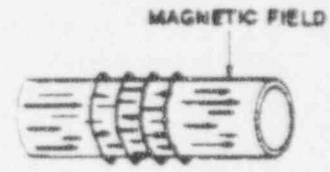
INDICATION NO.	LOCATION / DESCRIPTION	ACCEPTABLE	NOT ACCEPTABLE

COMMENTS:

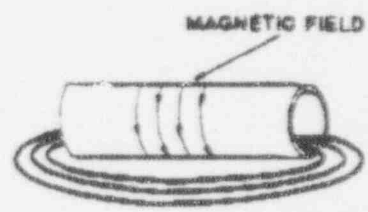
Examiner	Level	Date	Reviewed	Level	Date	Page __ of __
Examiner	Level	Date	Reviewed	Title	Date	

EXHIBIT I

OUTSIDE DIAMETER



INSIDE DIAMETER



LONGITUDINAL MAGNETIZATION
COIL METHOD

FIGURE I

GE-NE-508-008-0492
REV 1

ELECTRICAL DISCHARGE MACHINING PROCEDURE

Prepared by

Brian D. Smith

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For

Nebraska Public Power District
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P.O. Box 98
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April 4, 1992

Approved By: J. P. Clark Date 4/29/92
J.P. Clark
Principal Engineer
NDE Technology

REV. 1 To incorperate NPPD comments.
4/29/92 BDS

EDM NOTCHING PROCEDURE

1.0 SCOPE

1.1 This procedure describes the method to be used to create electrical discharged machined (EDM) notches, using a sink type EDM unit, on ferrous and nonferrous materials.

2.0 PERSONNEL

2.1 Personnel performing EDM notches with this equipment shall be familiar with the users manual.

3.0 EQUIPMENT

3.1 The EDM Machine is a precision metal removing machine tool. It Utilizes the principle of controlled electrical discharges to dissipate the material to be removed.

3.2 Specific applications for this unit are:

- Forming of difficult shapes and contours.
- Cutting hardened tool steel, carbide, and exotic alloys.
- Generating micro slots and holes.
- Burr-free production jobs.

4.0 PREPARATION

4.1 Determine the job application.

4.1.1 Verify the type of material to be notched.

4.1.2 Verify specific settings for that material.

4.2 Create conceptual EDM application.

4.2.1 Have a review meeting for the application.

4.2.2 Design electrode head and probe supports as required.

4.2.3 Procure all hardware and accessories required for the job.

4.3 Use a sample piece of material that is the same type as the job piece.

4.4 Assemble electrode hardware.

4.4.1 Verify that all parts will work for the application.

4.4.2 Check fit and form of assemblies.

4.4.3 Set up to the test piece for fit and function verification.

4.5 Set up and test D.I. Water flow system and water trapping system.

4.5.1 Check conductivity of D.I. Water. Should be less than 6.0 mS.

4.5.2 Insure that all feed lines and drainage lines do not create a possible trip hazard or interfere with the set-up.

5.0 TEST CUTS

5.1 These cuts should be done to the deepest depth required for the specimen, on the sample piece, to determine the burn ratio of electrode to material.

5.2 Record settings for the test cuts on the Burn Ratio Data Sheet.

- Finish Rate
- Cutting Rate
- Power: High, Low 2 or Low
- Servo Gap
- Pos or Neg switch
- Auto Flush - on or off
- Electrode material type
  - a) Thickness
  - b) Width
  - c) Height

5.3 Record the depth results on the Burn Ratio Data Sheet.

5.3.1 After each cut, place the cutting electrode in the cut, manually.

5.3.2 Scribe a line at the interface of the electrode and parent material.

5.3.3 Measure the distance from the scribed line to the bottom of the electrode.

5.3.4 This can be done with dial calipers or a microscope with a distance readout installed. This measurement will be within ± .003 of the actual depth.

5.3.5 A depth gauge that will fit in the cut (watch for side wall interference) or an impression of the cut may be used for sizing

5.3.6 Continue this process until the depth required is achieved within the specified tolerances.

5.3.7 At that point, record good cut settings. You can now establish the probe burn ratio.

6.0 JOB CUTS

6.1 Set up the job piece and D.I. Water system and verify all applications are acceptable to the project engineer. Verify set up is identical to process parameters determined in 5.2.

6.2 Perform cuts.

6.2.1 Record all data on the EDM Data Sheet.

6.2.2 Record time of cut, set up specification; verify that these are identical to values determined in 5.3.

- Finish Rate
- Cutting Rate
- Power: high, low 2 or low
- Servo Gap position
- Pos or Neg switch
- Auto Flush; on or off
- Electrode material type
- Thickness of material
- Length of material
- Height of material

6.3 Record the depth results on the EDM Data Sheet.

6.3.1 After each cut, place the cutting electrode in the cut, manually.

6.3.2 Scribe a line at the interface of the electrode and parent material.

6.3.3 Measure the distance from the scribed line to the bottom of the electrode. This can be done with dial calipers or a microscope with a distance readout installed. This measurement will be within $\pm$ of the actual depth. Note: Measuring equipment calibrated to NIST traceable standards is required. All measuring equipment tolerances shall be specified.

6.3.4 A depth gauge that will fit in the cut may be used to check depth. Be sure that gauge is not hanging up on the cut sides.

6.3.5 An impression of the cut may be used for sizing by using the impression under a microscope with a distance readout installed.

7.0 <u>CUT IMPRESSIONS</u>

7.1 After all cuts are finished and documented, make replicas of each cut with an impression material.

7.2 Each of these impressions should be examined on an optical comparator.

7.2.1 Record the length of the impression.

7.2.2 Cut the impression in half and use one of the cut sections to record the measurements for height and width of the cut.

7.2.3 An extra set of impressions should be made for review at any required later date.

8.0 <u>APPENDICES</u>

- EDM Data Sheet

- EDM Probe Burn Ratio Sheet

EDM DATA SHEET

OPERATOR ______________________ DATE ____________________
TECHNICIAN ____________________ CHARGE NUMBER ____________________
SPECIMEN TYPE & I.D. NUMBER ______________________________________

PROBE DATA

PROBE MATERIAL ________________________________ THICKNESS ____________

PROBE APPLICATION

PROBE FIXTURE: DIRECT MAGNETIC CHUCK OR EXTENDED FLUSHING FIXTURE
(CIRCLE ONE)

FLUSH SET-UP

APPLICATION: D.I. WATER OR CUTTING OIL (CIRCLE ONE)

SYSTEM SET-UP

FINISH RATE ____________________
CUTTING RATE ____________________
SERVO GAP POSITION ____________________
POS / NEG SWITCH - POSITIVE OR NEGATIVE (CIRCLE ONE)
POWER - HIGH LOW 2 LOW (CIRCLE ONE)
AUTO FLUSH - ON OR OFF (CIRCLE ONE)

NOTES

____
____
____
____
____
____
____

CUT DATA

DESIRED DEPTH ____________________ EDGE DISTANCE ____________________
SET DISTANCE ____________________ SET DISTANCE ____________________
RESULTS ____________________ ____________________

RECORDED CUT DATA

RECORD NOTCH DEPTH, WIDTH AND LENGTH OF EACH NOTCH.

NOTCH	DEPTH	WIDTH	LENGTH
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

METHOD OF MEASURMENT ____

RECORDED BY ______________________________ DATE ____________________

EDM PROBE BURN RATIO SHEET

OPERATOR ______________________ DATE ____________________
TECHNICIAN ____________________ CHARGE NUMBER ____________________
SPECIMEN TYPE & I.D. NUMBER ______________________________________
____

PROBE MATERIAL ____________________ THICKNESS ____________________

FLUSH SET-UP: D.I. WATER CUTTING OIL (CIRCLE ONE)

SYSTEM SET-UP:
FINISH RATE ____________________
CUTTING RATE ____________________
SERVO GAP POSITION ____________________
POS / NEG SWITCH - POSITIVE OR NEGATIVE (CIRCLE ONE)
POWER - HIGH LOW LOW2 (CIRCLE ONE)
AUTO FLUSH - ON OR OFF (CIRCLE ONE)

NOTES
____
____
____
____

CUT DATA

CUT #	DESIRED DEPTH	DEPTH SET	ACTUAL DEPTH
1	________	________	________
2	________	________	________
3	________	________	________
4	________	________	________
5	________	________	________
6	________	________	________
7	________	________	________
8	________	________	________
9	________	________	________
10	________	________	________
11	________	________	________
12	________	________	________

METHOD OF MEASUREMENT ______________________________________

RECORDED BY ______________________________ DATE ____________

APPENDIX C

ULTRASONIC EXAMINATIONS OF A CRACKED RPV STUD

AT THE DRESDEN NUCLEAR POWER STATION

1.0 INTRODUCTION

During the week of 6/21/92 ultrasonic (UT) examinations were performed on a reactor pressure vessel (RPV) closure stud (# 70) at the Dresden Nuclear Station. This stud had been found to be cracked during a previous outage. Commonwealth Edision (CECO) personnel had maintained this stud as a calibration/qualification standard. This stud also contains a notch, which was used by CECO to verify that cracks, exceeding the size determined to be acceptable to maintain the structural margin, could be detected, A second stud, which was also reported to be cracked during the same outage, had been subjected to destructive metallography and the cracking was verified.

The purpose of GENE performing examinations of this stud was to provide further qualification of UT techniques, procedures and equipment. All of these UT techniques, procedures and equipment, with the exception of one bore probe, had been qualified on notches machined into the corroded threads in stud number 14 at Cooper. That qualification, at Cooper, provided for the disposition of UT indications that had been reported in the Cooper studs during the previous outage. This further qualification on a real crack (rather than on notches) should result in justification for updating field equipment and procedures and for providing direct recommendations to other utilities with regards to the UT examinations of RPV closure studs.

2.0 SUMMARY

The UT examinations at Dresden on the cracked RPV stud # 70 were performed using the GENE SMART 2000 UT Data Acquisition and Analysis System and a special scanner to provide for a completely automated examination. Examinations were performed with the 60° and 70° shear-wave, bore probes which had been used at Cooper to disposition the UT indications in the Cooper studs during the spring of 1992. In addition examinations were conducted with a developmental 45°, shear-wave, bore probe. This probe contains 3 different transducers, so arranged to obtain time-of-flight-diffraction (TOFD) measurements to determine crack depths. Data from these examinations were collected and analyzed to determine the extent of the cracking, its through wall dimension and its position within the stud. All the probes detected the cracking in the stud and a compilation of this data was used in the final analysis.

3.0 EXAMINATION SYSTEM

The same UT system and all of the equipment that was used at Cooper was used in performing the examination on stud #70 at Dresden. This included the 60° and 70° bore probes. The 60° bore probe also contains a surface wave transducer for the examination of the surface of the extensiometer hole. In addition, a 45° time-of-flight bore probe was used and is described below. The probe contains two 45° shear-wave transducers, facing each other in a geometric arrangement such that if one of the transducers is pulsed the resulting reflection from the outside surface of the stud can be received by the other transducer. In addition a 0° straight-beam transducer is spaced half way between the angle beam transducers.

This probe can be used in a number of combinations. By assigning and calibrating each function on separate channels on the SMART 2000 Data Acquisition System all functions can be performed simultaneously. That is, all three transducers can be used in the pulse echo mode on three separate channels while they are also being operated in a transmit/receive (pitch/catch) mode on other channels. This transmit/receive mode results in time-of-flight diffraction (TOFD) capabilities for determining crack depths. The transducer arrangement on this probe is shown in figure 1.

4.0 EXAMINATION

To perform this examination the stud was placed upright in a stand with the automated scanner mounted at the upper (nut) end of the stud. Because the original top of the stud had been removed by cutting, length measurements were referenced to the ground notch in the threads on the flange end of the stud. The area of the notch and crack in the flange end were then scanned with the 45° time of flight bore probe (previously described), the 60° bore probe with the 60° pulse echo transducers and the 88° surface wave transducer and the 70° bore probe with its 70° pulse echo transducers and a 0° straight beam transducer.

5.0 RESULTS

Scans of the notch and crack area revealed that the crack in stud # 70 has propagated through the stud wall for 178° of its circumference (see Figure 2). Through wall confirmation, that the crack penetrated the inner surface of the extensiometer hole was obtained with the 70° transducers and the surface-wave transducer (which is mounted on the 60° probe).

Cross-sectional plots show that the crack is oriented at about a 23° angle in the stud (see Figure 3), The UT data also indicates that branching has occurred and that it has multiple facets along it entire length. All the probes used gave very good data and were able to define the difference between the crack and signal loss from corrosion products and pitting, which existed in this stud.

Figures 4 through 7 provides the UT A-scan responses and the C-scan representations from both the notch and the crack for the 60° and 70° transducers.

Figure 8 shows the results obtained with the 45° down looking transducer operated in the transmission mode and the 45° up looking transducer operating in the receiver mode. Note that the notch tip (upper A-scan) is readily detectable while the tip from the crack (lower A-scan) can only be seen along an edge. This is because the crack is through wall in other areas and there is no tip present to detect. The A-scan in the middle simply shows the response from threads in an uncracked region. Also note that in the C-scan complete transmission is lost over the crack indication area (black bands in the C-scan at the bottom of the figure) indicating that the size of the crack exceeds the size of the transmitted sound beam.

Figure 9 shows the response received from the tip of the notch with the 45°, down looking transducer operating as the transmitter and the 0° transducer operating as the receiver. This shows that TOFD measurements can also be made in this fashion, since the diffracted (or the forward scattering of the beam from the notch tip) beam also propagates in the vertical direction.

Figure 10 provides the response from the notch with the 0° transducer operating in the pulse-echo mode. Note in the C-scan that the complete back reflection is lost in the area of the crack. This is because the crack is oriented at an angle and completely blocks the sound beam from reaching the outer (or back) surface in this area.

Figure 12 provides verification with the 45°, the 70° and the surface wave (mounted on the 60° probe) transducers, that the crack has propagated through to the surface of the extensiometer hole.

6.0 CONCLUSIONS

Based on the results of these examinations, plus the previous qualifications performed at Cooper, it can be concluded that the UT techniques, procedures and equipment, employed at Cooper for the disposition of previously reported UT indications in the Cooper RPV studs, are fully qualified for crack detection and characterization. In addition, it has been shown that the 70° transducers are superior to the 60° transducers in evaluating indications in corroded threads.

Both the 70° and the surface-wave transducers have been shown to be effective in the detection of surface cracking in the extensiometer hole. The 45° TOFD bore probe has also been qualified and offers another very useful tool for the evaluation and characterization of cracking in RPV studs.

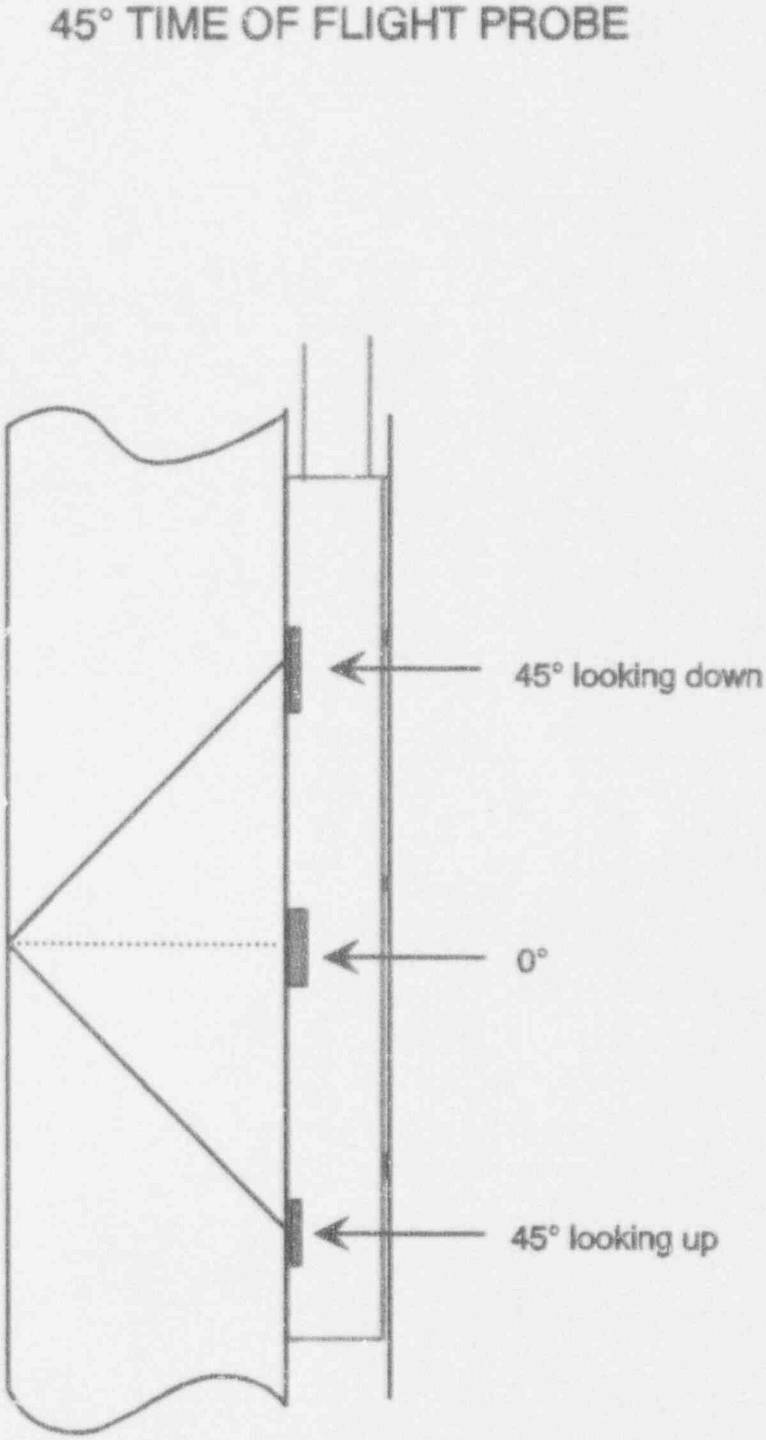


Figure 1. 45° Time-Of-Flight Bore Probe With A Center 0° Transducer

CRACK AREA PLAN VIEW

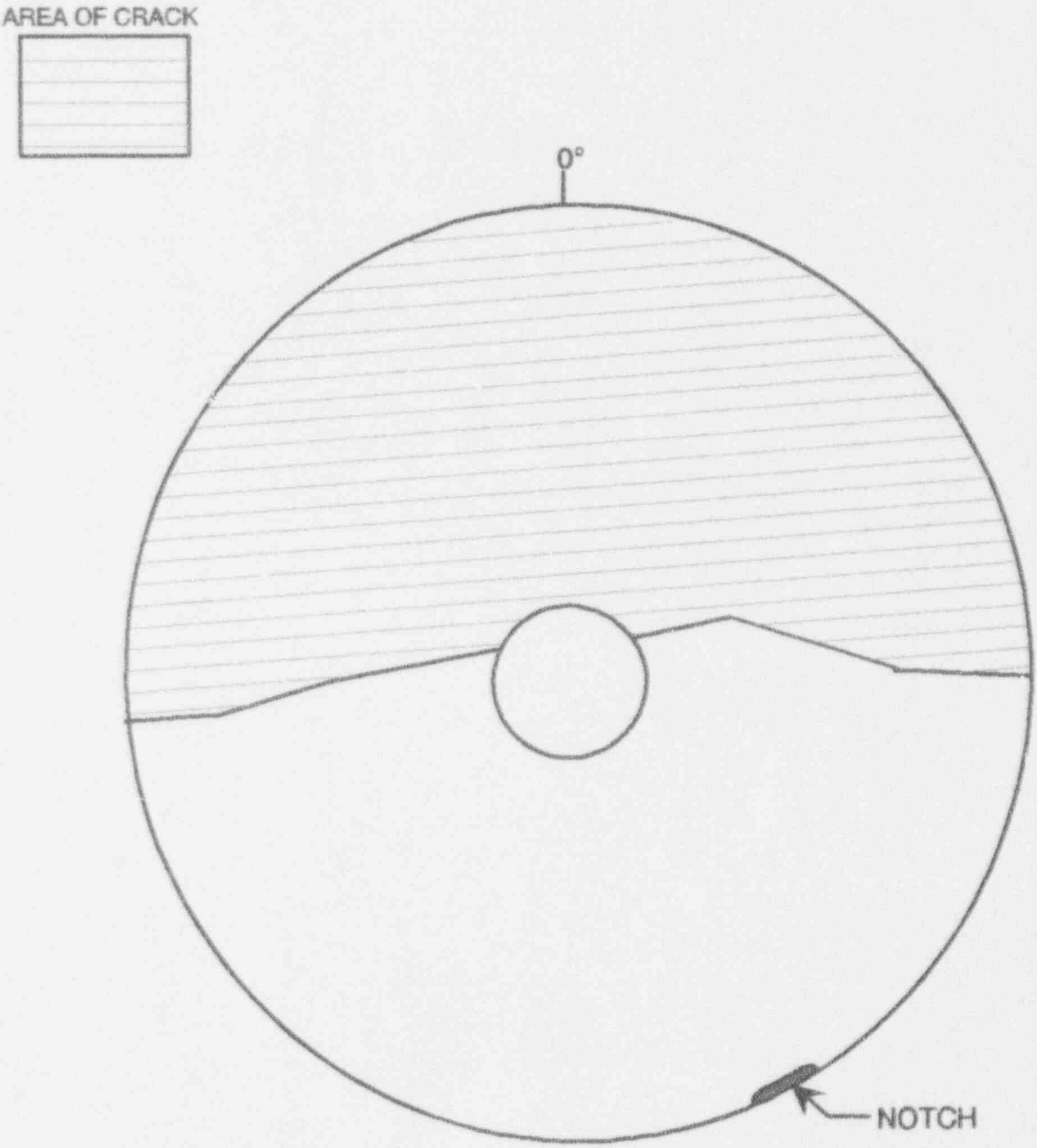


Figure 2. Circumferential Extent And Depth Of Cracking In The Dresden RPV Stud # 70

APPENDIX C

ULTRASONIC EXAMINATIONS OF A CRACKED RPV STUD

AT THE DRESDEN NUCLEAR POWER STATION

CROSS SECTION OF NOTCH AND CRACK
IN STUD # 70

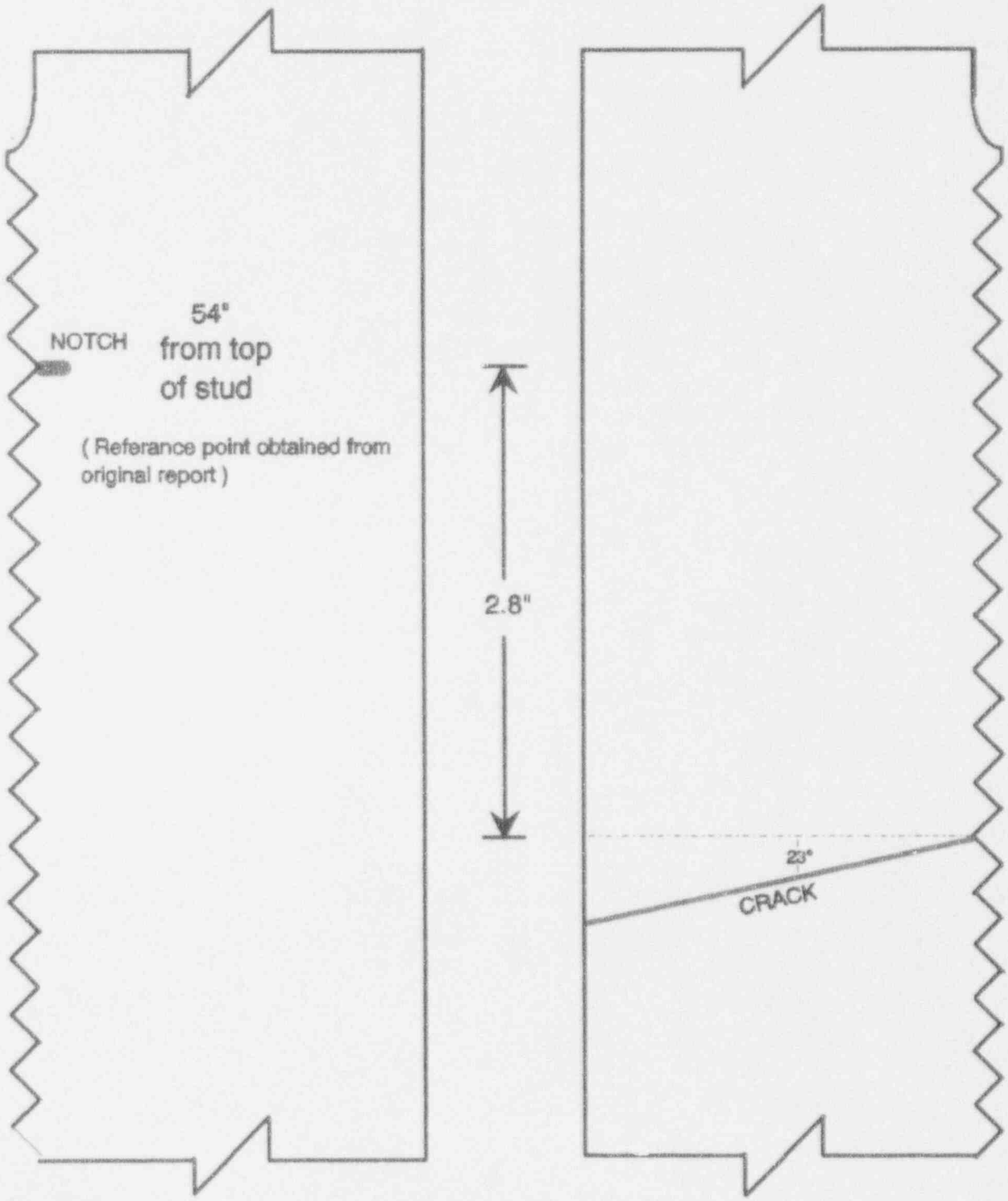


Figure 3.

60° UP SCAN

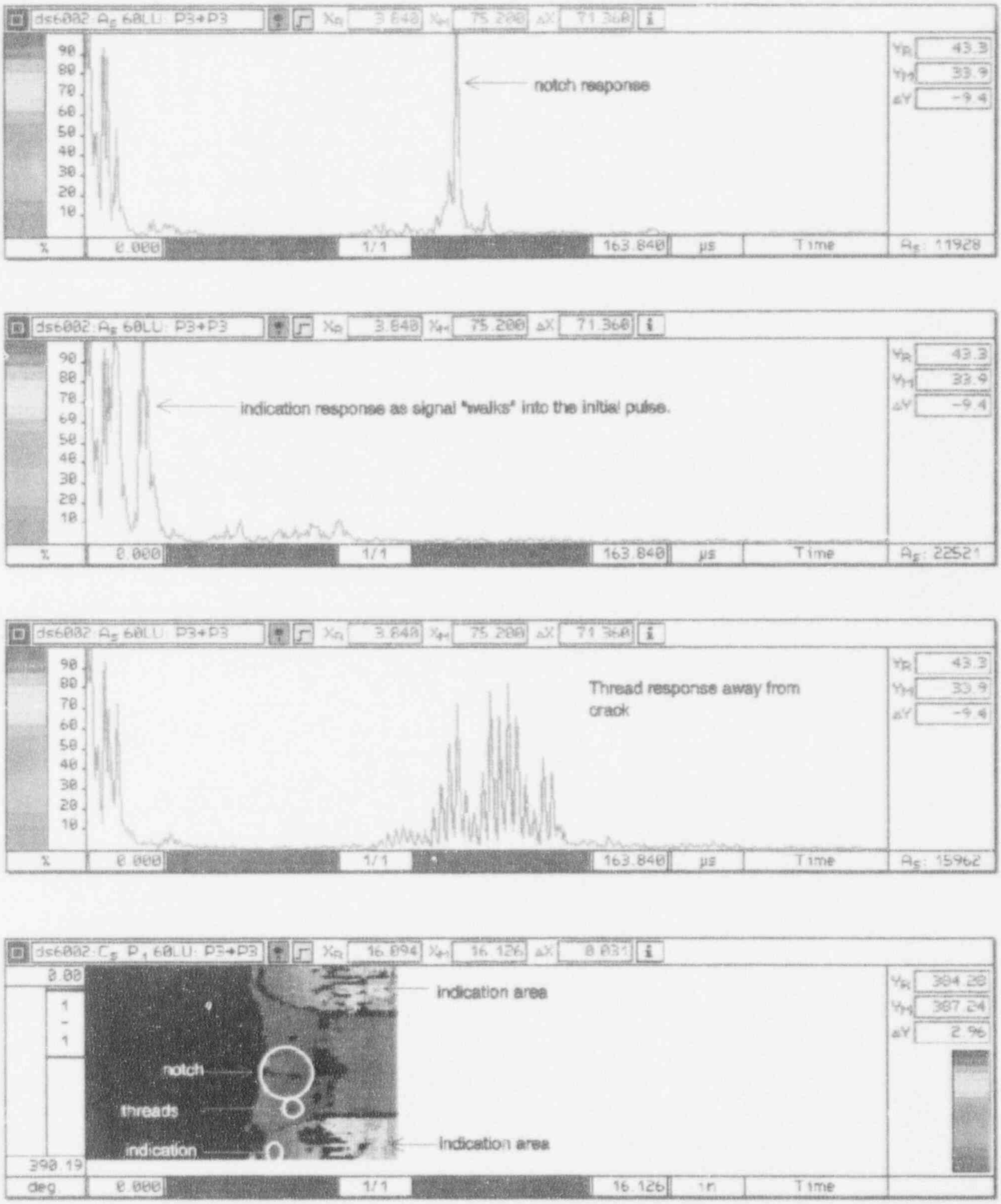


Figure 4. 60^{0} Up-Looking Transducer

C-Scan Display And Typical A-Scans From Dresden Stud # 70. The 3 A-scans Show The Reflections From The Notch, The Crack Indication Near The Inside Surface, And From Corroded Threads In An Uncracked Area.

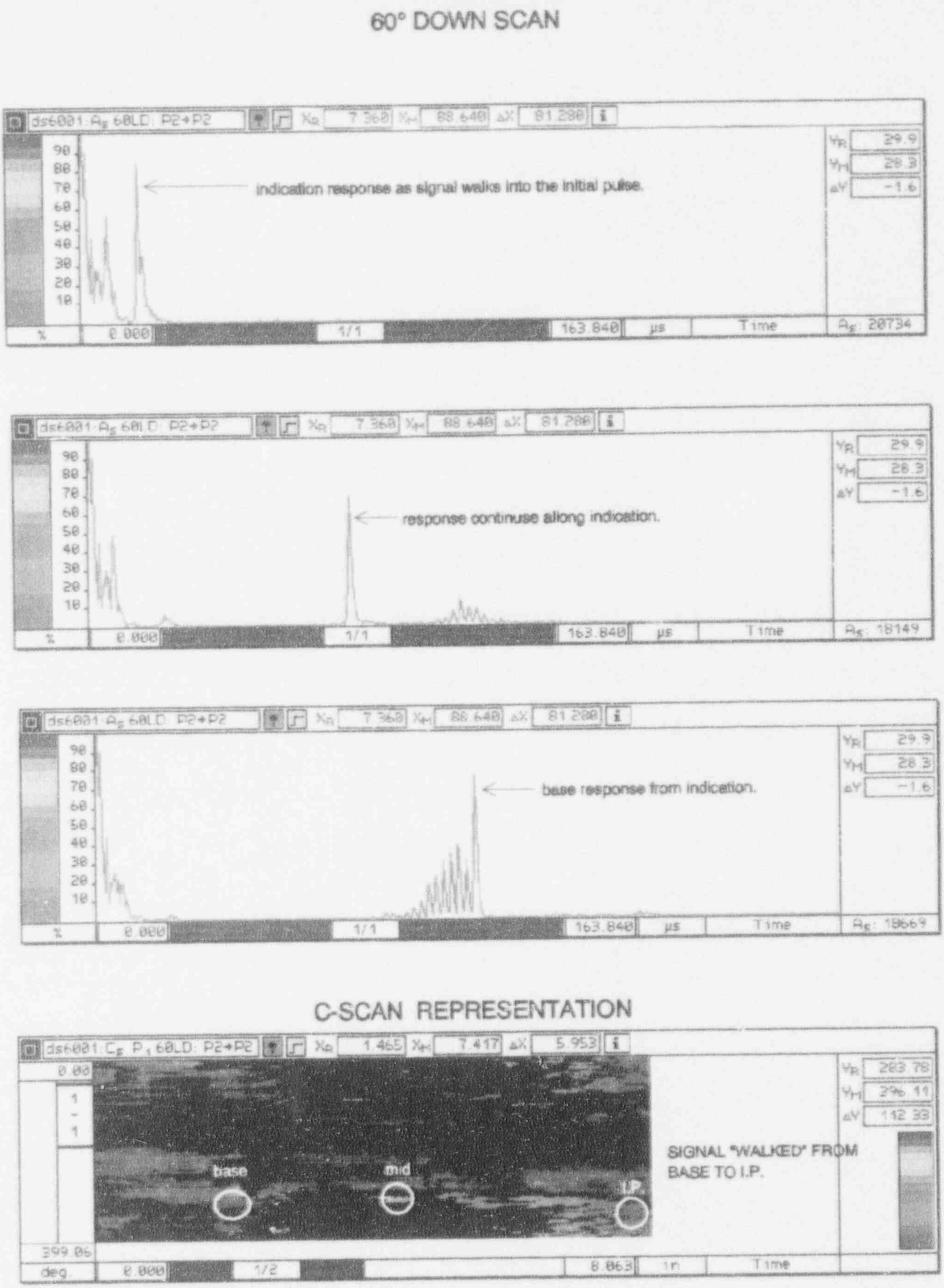


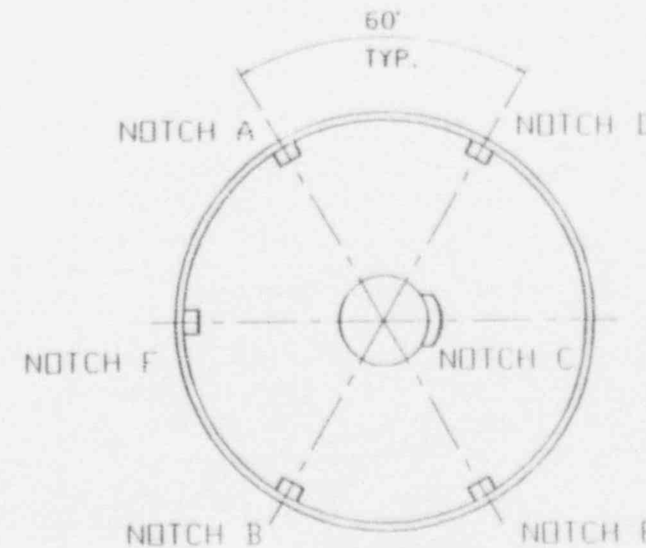
Figure 5. 60^{o} Down-Looking Transducer

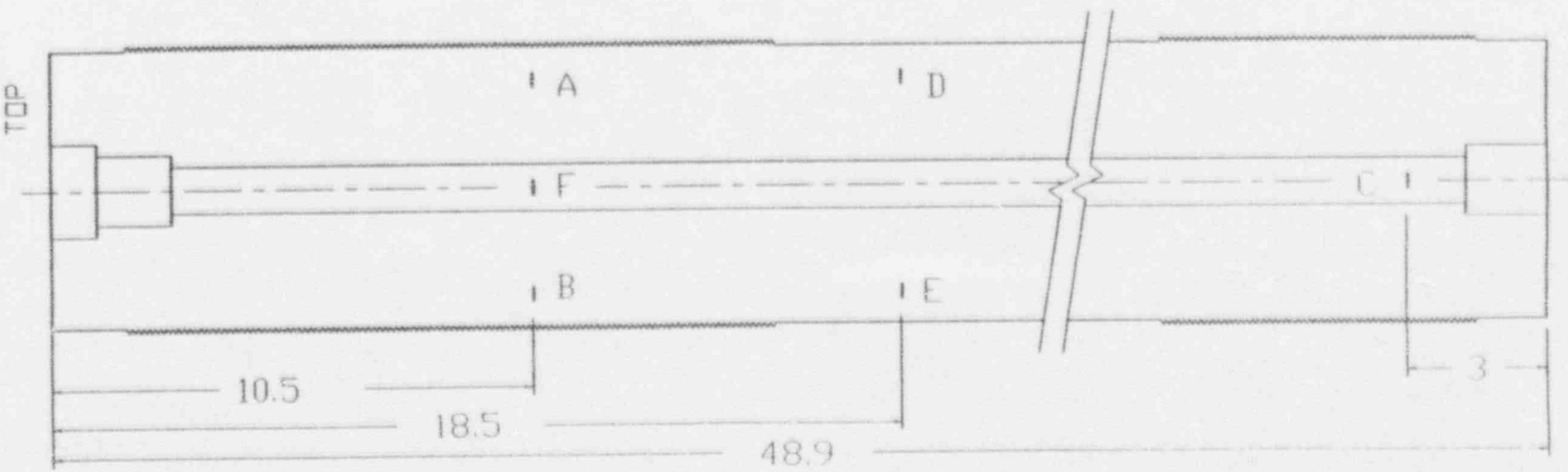
C-Scan Display And Typical A-Scans Of The Crack In The Dresden Stud # 70 As It Is Scanned From The Inside To The Outside Surface Of The Stud.

<u>Appendix D</u>

<u>Cooper Stud UT Calibration Standard</u>

NOTCH	DEPTH	LENGTH	WIDTH
A	.163	.342	.026
B	.074	.889	.026
C	.050	.678	.026
D	.152	.341	.028
E	.056	.893	.027
F	.052	.895	.027





RPV STUD CAL BLOCK

ID # G5271-1-D

COOPER RPV HEAD STUB EDM RESULTS

Notch A = Desire .155 ± .010 Deep x .020 ± .010 Wide x .340 ± .010 Length.

Actual:		Verification by:
Depth	.163	QA Allen Y.
Width	.026	QA Allen Y.
Length	.342	QA Allen Y.

Notch B = Desire .065 ± .010 Deep x .020 ± .010 Wide x .890 ± .010 Length.

Actual:		Verification by:
Depth	.074	QA Allen Y.
Width	.026	QA Allen Y.
Length	.889	QA Allen Y.

Notch C = Desire .060 ± .010 Deep x .020 ± .010 Wide x .680 ± .010 Length.

Actual:		Verification by:
Depth	.050	QA Allen Y.
Width	.026	QA Allen Y.
Length	.678	QA Allen Y.

Notch D = Desire .147 ± .010 Deep x .020 ± .010 Wide x .340 ± .010 Length.

Actual:		Verification by:
Depth	.152	QA Allen Y.
Width	.028	QA Allen Y.
Length	.341	QA Allen Y.

Notch E = Desire .055 ± .010 Deep x .020 ± .010 Wide x .890 ± .010 Length.

Actual: Verification by:

Depth	.056	QA	Allen Yu
Width	.027	QA	Allen Yu
Length	.893	QA	Allen Yu

Notch F = Desire .055 ± .010 Deep x .020 ± .010 Wide x .890 ± .010 Length.

Actual:

Depth	.052	QA	Allen Yu
Width	.027	QA	Allen Yu
Length	.895	QA	Allen Yu

QA ALLEN Yu
print name

Date: 11-8-91

QA Allen Yu
signature

Test Instrument: Optical Comparator

Calibration ID # 28570

Last Calibration: 9137

Calibration Due: 9201

All measuring equipment is calibrated and tracable to N.B.S. standards.

All notches were measured by replication. Theses replicas have been measured and have been found to be dimensionally accurate. All dimensions were recorded to the nearest thousands of an inch.

LABORATORY TEST NO. 07268

METALLURGY LABORATORY

METALLOGRAPHIC TEST REQUEST

Requestor J. P. CLARK Ext. 56772 Mail Code 777

Job Order No. 1CGHT Date Submitted 11/8/91 Date Required 11/8/91

DRF No. ______ EWA No. ______ P.O.No. ______ W.O.No. ______

Applicable Specification(s) ______

Sample Description Cooper vessel stud

Check Desired Information:

SECTIONING DIRECTION	MOUNTING MEDIA	HARDNESS TEST	PHOTOGRAPHY
__ Transverse	__ Bakelite	X Macro (Rockwell)	__ Macro
__ Longitudinal	__ Diallyl Phthalate (Cu)	__ Micro (KH) ____	__ Micro (As Pol.)
__ Tangential	__ Epoxy	__ Micro (DPH) ____	__ Micro (Etched)
__ Progressive	__ Epoxy+Al_2O_3		__ [illegible] __ [illegible]

desired etchant(s) ______

desired photographic magnifications ______

number of Polaroid copies ______ Requestor Exam. before photo ______

DATA REQUIRED

__ Grain Size	__ Sensitization	__ Nitride Case Eval.
__ Inclusion Count	__ ASTM A262 Test	__ Weld Penetration
__ Oxide Thickness	__ % Ferrite	__ Failure Mode
__ Eutectic Phase	__ Liquid Penetrant	__ Rolling Direction
__ Sigma Phase	__ EPR	__ SEM Eval.
		__ IGA

Special/Other Instructions Perform hardness survey to determine ~~the~~ surface hardness of modified 4130 material

Sketch or Sample Tabulation:

Cooper stud: Surface hardness with parkerizing removed is R_C 39.5 ave of 10 readings
Surface hardness of end is R_C 34.7 near the I.D. to R_C 37.5 near the O.D.

Reference stud: Surface hardness with parkerizing removed is R_C 31 ave of 10 readings
Surface hardness of end is R_C 28.3 near the I.D. to 31.3 near the O.D.

Results transmitted to Wade Miller 10.00 AM

QA USE ONLY
Analysis indicates Item(s) is (are):
☐ acceptable ☐ unacceptable

LAB USE ONLY
Performed By: [signature]
Checked By: [initials]
Date: 11/8/91 Hours:
Work accepted and approved per EOP 35-

70° UP SCAN

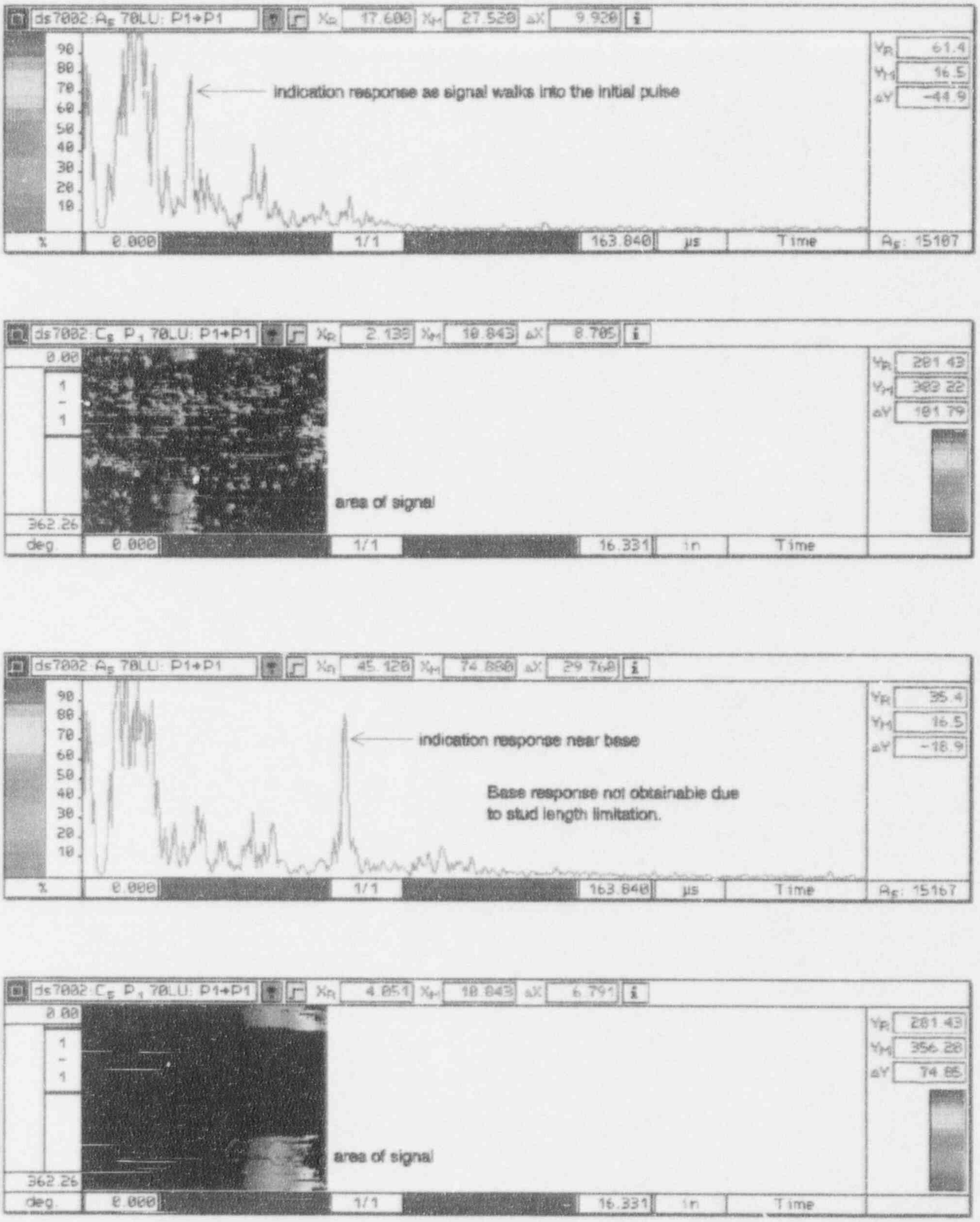


Figure 6. 70° Up-Looking Transducer

C-Scans And A-Scans Of Different Areas Of The Crack In The Dresden Stud # 70

70 ° DOWN SCAN

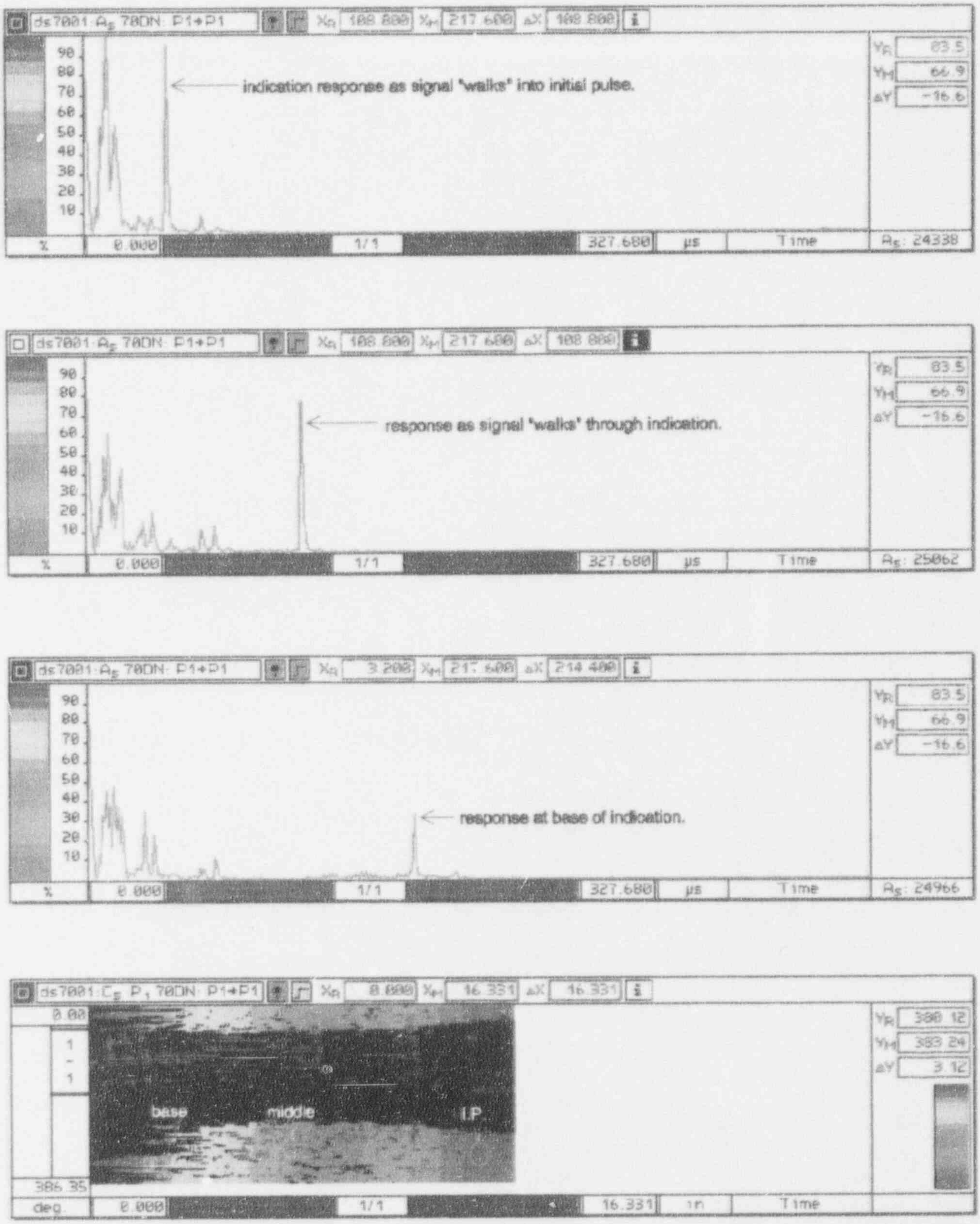
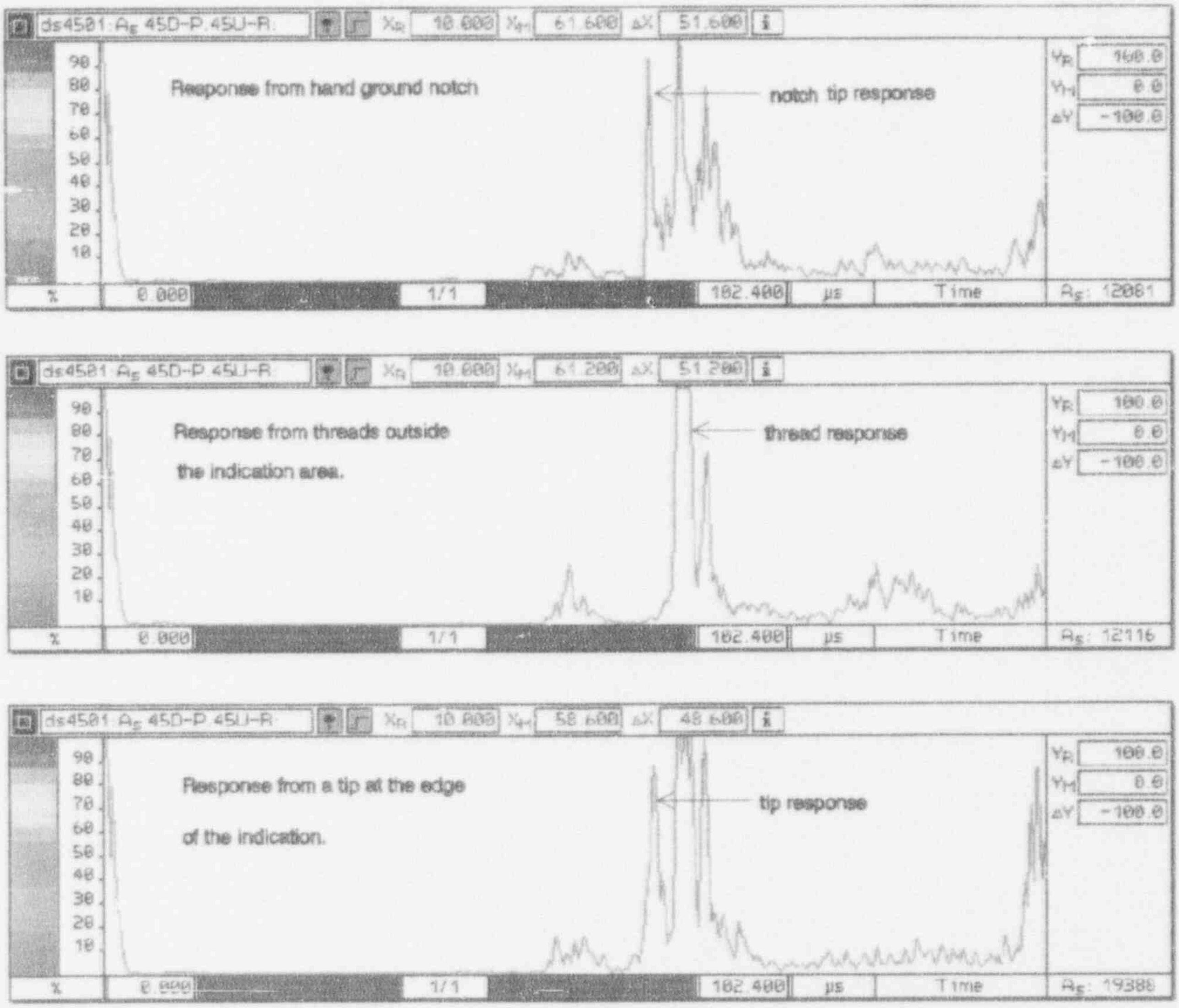


Figure 7. 70^{o} Down Looking Transducer

C-Scan Display And Typical A-Scans Of The Crack In The Dresden Stud # 70 As It Is Scanned From The Inside To The Outside Surface Of The Stud.

45° TIME OF FLIGHT PROBE



C - SCAN REPRESENTATION

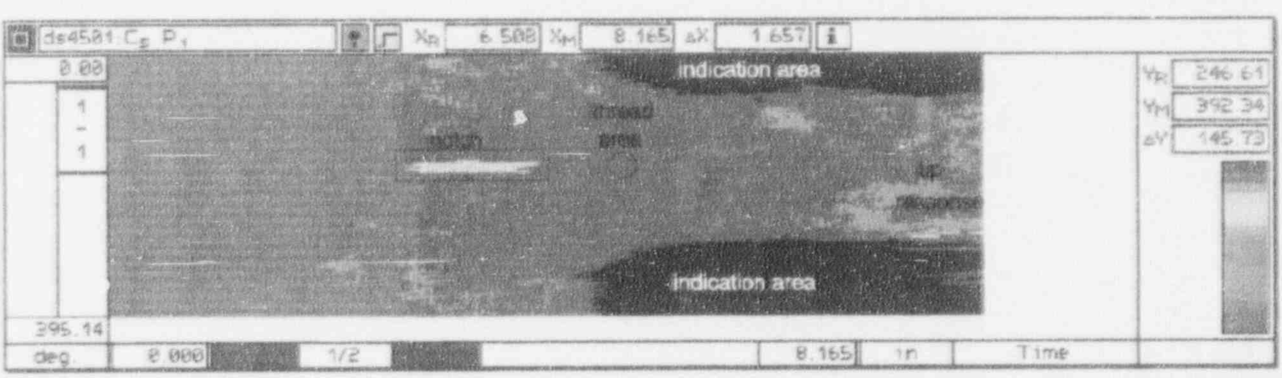


Figure 8. 45° TOFD Bore Probe With The Down-Looking Transducer Pulsing And The Up-Looking Transducer Receiving

C-Scan Display Showing Both The Notch And Area Of Cracking In The Dresden Stud # 70. The A-Scans Show The Tip Signals From The Notch And From The Edge Of The Crack.

45° DOWN PULSE, 0° RECEIVE

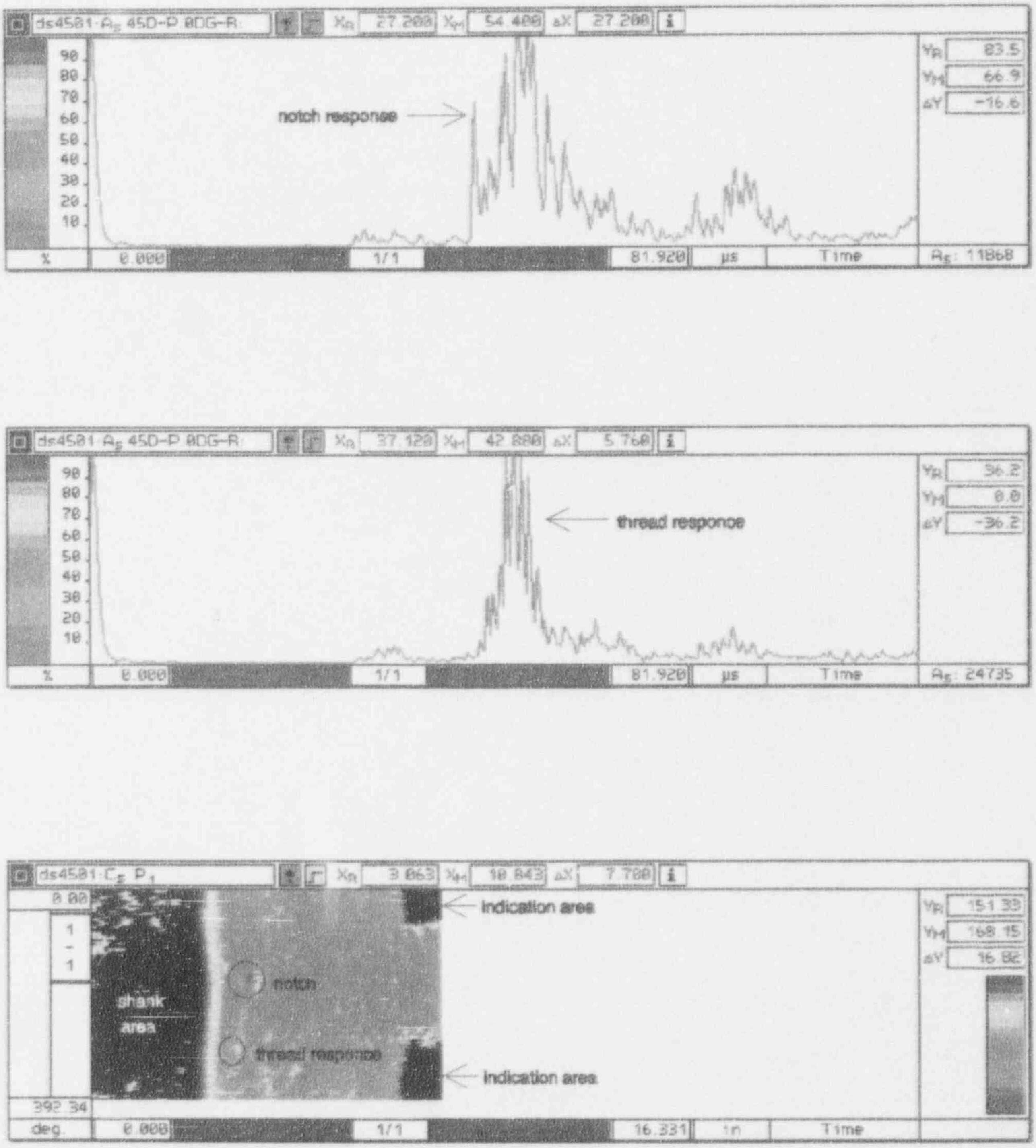


Figure 9. 45° TOFD Bore Probe With The 45° Down-Looking Transducer Pulsing And The 0° Transducer Receiving.

C-Scan Display And Resulting A-Scans Showing Typical Responses From The Notch Tip And From An Uncracked Area Of The Threads.

0° RADIAL SCAN

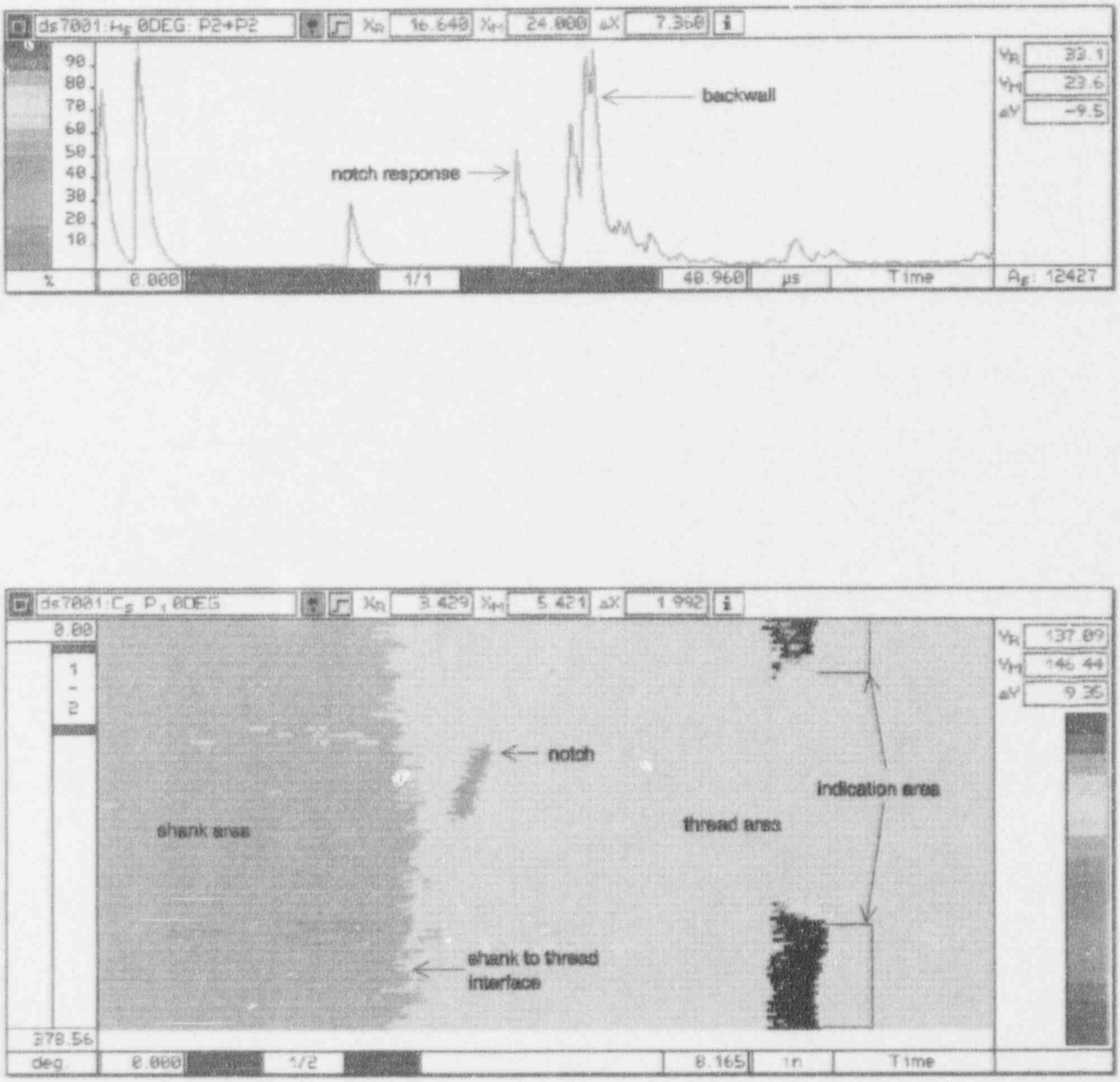
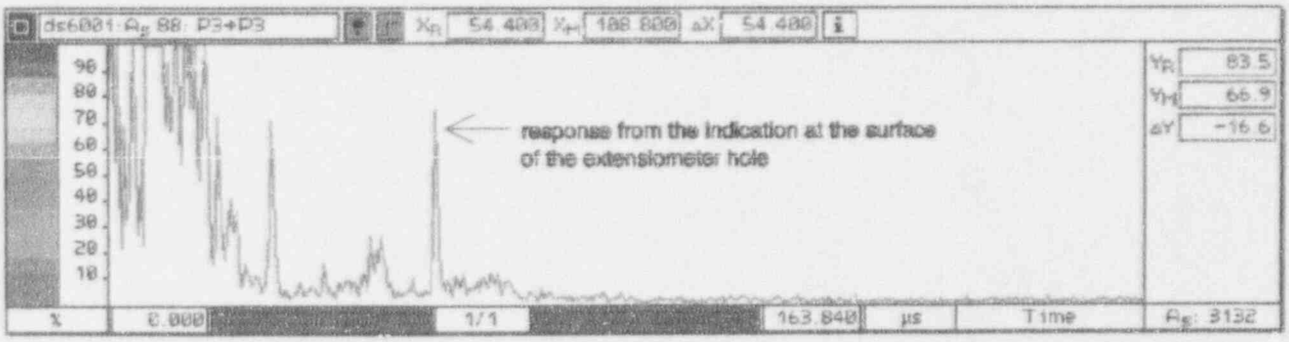


Figure 10. 45° TOFD Probe With The 0° Operating In The Pulse Echo Mode.

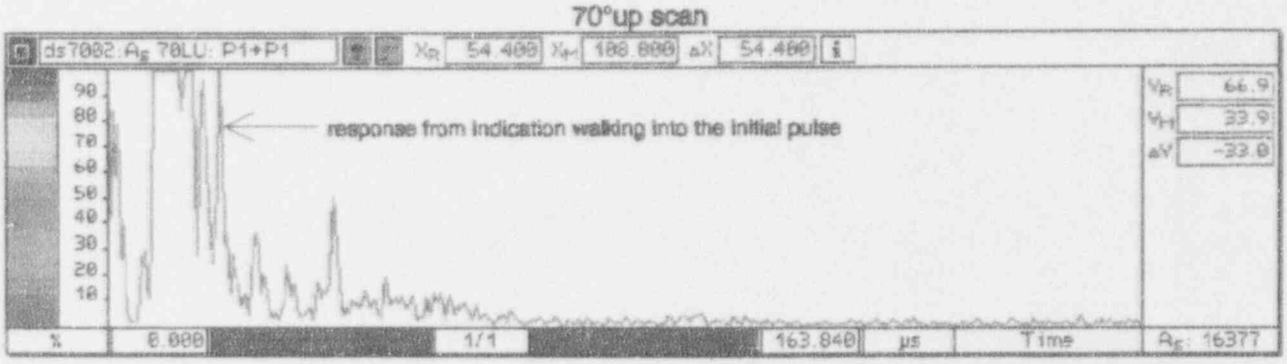
C-Scan Of The Dresden Stud # 70 And The Resulting A-Scan From The Area Of The Notch.

SIGNAL RESPONSE FROM THE INDICATION AT THE EXTENSIOMETER HOLE (THROUGH WALL) WITH THE 45° TOF PROBE AND THE 70° AND 88° TRANSDUCERS

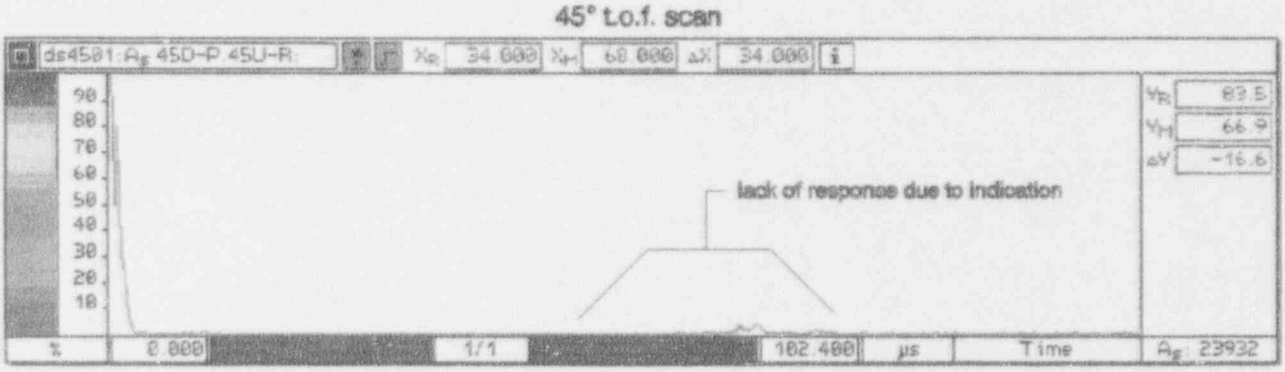
88° SCAN



70°up scan



45° t.o.f. scan



c-scan representation of 45° t.o.f. scan

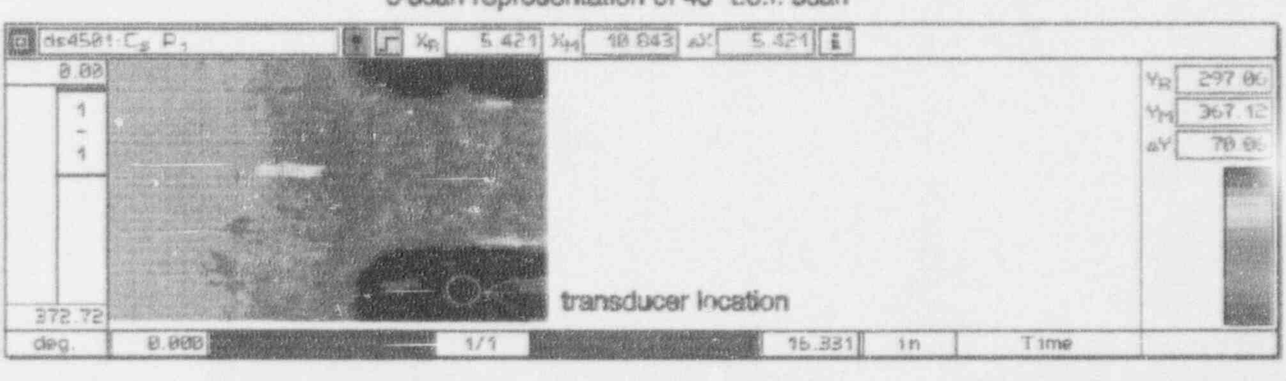


Figure 11. Verification That The Crack In The Dresden Stud # 70 Is Through Wall By Data Obtained With 45°, 70°, And 88° Transducers

Appendix E

Personnel Certifications

CERTIFICATE OF QUALIFICATION

THIS IS TO CERTIFY THAT

PAUL S. ANDERSON

IS QUALIFIED IN ACCORDANCE WITH THE GE / NPSD NDE EXAMINATION & CERTIFICATION PROCEDURE FQP-03 WHICH IS IN COMPLIANCE WITH THE REQUIREMENTS OF AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING RECOMMENDED PRACTICE.

CERTIFICATIONS EXPIRE THREE YEARS FROM CERTIFICATION DATE.

LIQUID PENETRANT TESTING (ASNT - 1980) LEVEL II
* CERTIFICATION DATE (02-15-92)

MAGNETIC PARTICLE TESTING (ASNT - 1980) LEVEL I
* CERTIFICATION DATE (02-15-92)

RADIOGRAPHIC TESTING (ASNT - 1980) LEVEL N/A
* CERTIFICATION DATE

ULTRASONIC TESTING (ASNT - 1980) LEVEL II
* CERTIFICATION DATE (02-15-92)

VISUAL TESTING (VT-1) (ASNT/ASME XI) LEVEL I
* CERTIFICATION DATE (02-15-92)

VISUAL TESTING (VT-2) (ASME XI) LEVEL N/A
* CERTIFICATION DATE

VISUAL TESTING (VT-3) (ASME XI) LEVEL N/A
* CERTIFICATION DATE

VISUAL TESTING (VT-4) (ASME XI) LEVEL N/A
* CERTIFICATION DATE

ADDITIONAL REQUIREMENTS OR LIMITATIONS:
EPRI Manual Detection 01/10/92, Spec. 01/08/92
System Detection (ONLY) 06/15/90
Manual Overlay 02/13/92, Spec. 02/10/92
System 2000 Detection/Analysis 01/31/92

Donald B. Yoder
LEVEL III EXAMINER

Gregg R. Anderson
TERRITORY MANAGER, QUALITY ASSURANCE

DATE: November xx, 1991
RS/91-

TO: Don Yoder

FROM: Rich Skalski

SUBJECT: Training For Ultrasonic Examination of RPV Studs
Cooper Nuclear Station

The following individuals have received 5 hours training in the use of 60 degree Shear and 88 degree Surface Wave Bore Probe Technique:

Paul Anderson	Jeff Kieffer
Kathy Ellis	Vic Krueger
Mark Evich	Judy Ousley
C. E. Frakes	Larry Vice
Kent Gebetsberger	
Bobbi Kieffer	

GE-UT-307, Rev. 0 Procedure for Ultrasonic Examination of RPV Closure Studs, FRR-NPPD-91-16, and FRR-NPPD-91-35 was used to conduct the training.

This training consisted of a demonstration and practice detecting the known notches on the ID and OD of Cooper Nuclear Station Calibration Block CNS-116. These techniques included echo dynamics, signal repeatability, verification utilizing a positive and negative response from a Megasonics 5 MHZ 60 degree Shear Wave Transducer to verify the O.D. surface notches. The 88 degree Surface Wave Transducer was utilized to verify the ID surface notch of Stud Calibration Block. All individuals were instructed in the proper scanning techniques and proper indexing of the probe while using the centering device.

The training also covered the enhanced stud end technique using a 5 MHZ and 10 MHZ transducer.

Instructor: M. A. Heath LEV III — NOV. 19, 1991
Mike Heath — Date

TRAINING AND QUALIFICATION RECORDS

PROCEDURE FOR ULTRASONIC EXAMINATION

RPV CLOSURE STUDS

This is to certified that the following personnel have been trained and demonstrated practical proficiency in accordance with the General Electric Test Procedure TP-527-1509 Rev. 1: "Automated Ultrasonic Procedure for the Evaluation of Manually Detected Ultrasonic Indications in RPV Closure Studs" and are qualified to perform this examinations.

As a minimum, training included Smart 2000 operation, scanner setup, motor control setup, data collection, and data analysis. This training also included practice on the Cooper Nuclear Station Calibration Standard No. 116. Training were performed at the GENE NDE Development Lab. in San Jose and in Vallecito.

NAME	PROCEDURE	HOURS	COMPLETED
Robert W. Anderson	Above	40	Apr. 24, 1992.
Paul Anderson	Above	40	Apr. 24, 1992.

Qualified by

James C.S. Tung 5/5/92

James C.S. Tung (Level III)
Sr. Engr., NDE Development

APPENDIX F

Transducer Certifications

ULTRASONIC TRANSDUCER ANALYSIS

REFLECTOR

- ☐ 1.0" Thick Flat ________ Plate.
- ☐ ________ Dia. Steel Ball.
- ☒ 1" Radius FBH.

at ________ Inch Water Path.

TRANSDUCER

SERIAL NO: B1056

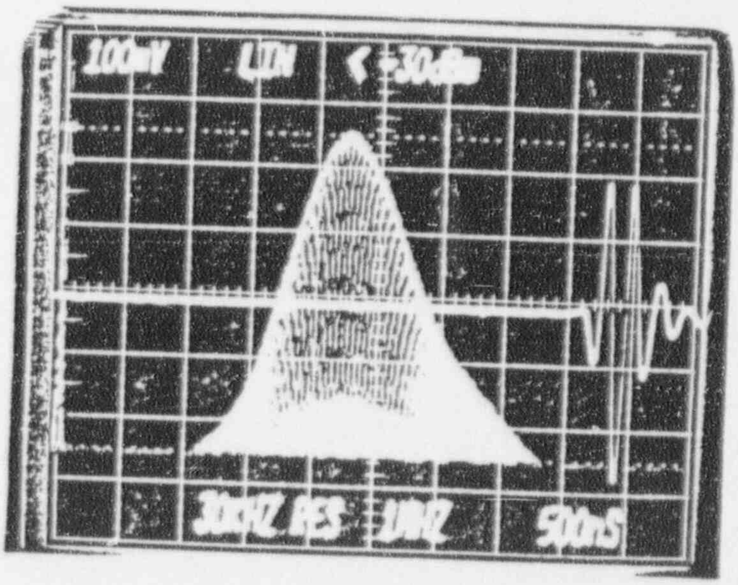
SERIES: Bore Probe

FREQUENCY: 5.0 MHz

SIZE: .250" Dia.

FOCUS: 60°S Backward Inch

1 4 5



6 3 2

WAVE FORM & FREQUENCY SPECTRUM

FREQUENCY: 4.5 MHz

BANDWIDTH: 2.4 MHz

OSCILLOSCOPE SETTINGS:

1. Vertical Sensitivity/Div.
2. Horizontal Sensitivity/Div.

SPECTRUM ANALYZER SETTINGS:

3. Scan Width/Div.
4. Scale Format
5. Input Attenuation
6. Resolution

The above data has been obtained with Megasonics Ultrasonic Transducer Analyzer, MUTA, Tektronix 7704A Main Frame with 7L12 Spectrum Analyzer, 7B92A Dual Time Base, 7A18 Dual Trace Amplifier.

DATE: 10-30-91

BY: [signature]

MEGASONICS
ULTRASONIC TRANSDUCERS

205 Benedict Hill Rd.
New Canaan, CT 06840
(203) 966-3404

ULTRASONIC TRANSDUCER ANALYSIS

REFLECTOR

☒ 1.0" Thick Flat Steel Plate.

☐ ______ Dia. Steel Ball.

☐ ______ FBH.

at ______ Inch Water Path.

TRANSDUCER

SERIAL NO: B1056

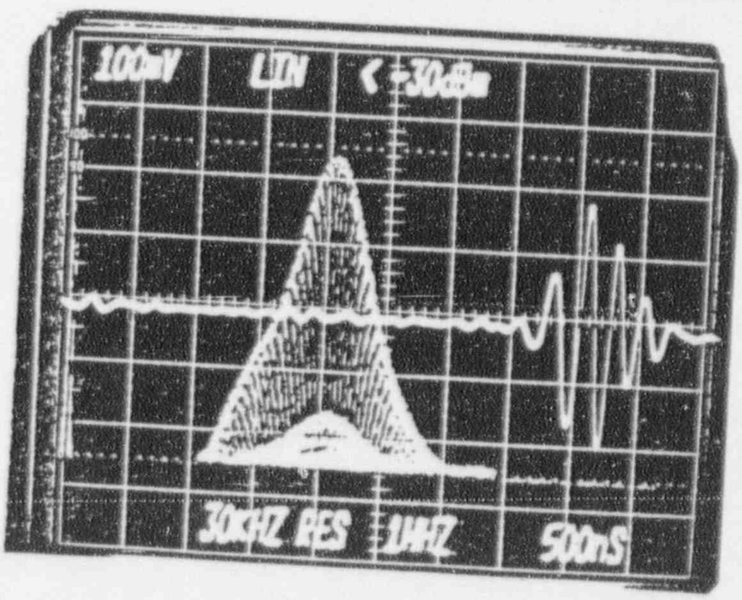
SERIES: Bore Probe

FREQUENCY: 5.0 MHz

SIZE: .250" Dia.

FOCUS: 88°S Surface ~~Inch~~

1 4 5



6 3 2

WAVE FORM & FREQUENCY SPECTRUM

FREQUENCY: 4.2 MHz

BANDWIDTH: 1.5 MHz

OSCILLOSCOPE SETTINGS:

1. Vertical Sensitivity/Div.
2. Horizontal Sensitivity/Div.

SPECTRUM ANALYZER SETTINGS:

3. Scan Width/Div.
4. Scale Format
5. Input Attenuation
6. Resolution

The above data has been obtained with Megasonics Ultrasonic Transducer Analyzer, MUTA, Tektronix 7704A Main Frame with 7L12 Spectrum Analyzer, 7B92A Dual Time Base, 7A18 Dual Trace Amplifier.

DATE: 10-30-91

BY: [signature]

MEGASONICS
ULTRASONIC TRANSDUCERS

205 Benedict Hill Rd.
New Canaan, CT 06840
(203) 966-3404

MEGASONICS
ULTRASONIC TRANSDUCERS
205 Benedict Hill Road
New Canaan, CT 06840
Tel (203) 966-3404
Fax (203) 966-5278

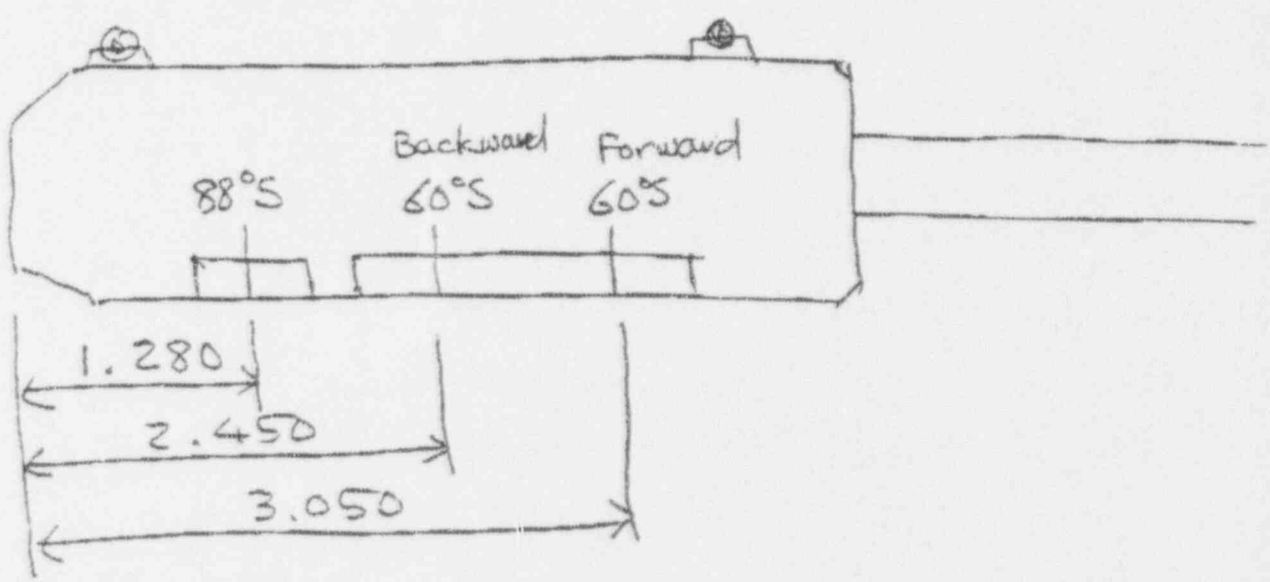
FAX TRANSMITTAL FORM

TO: G.E. ATTN: Jim Tung

FROM: Koo DATE: 11-5-91

REFERENCE: Bore Probe S/N 1056

Number of pages including this page: 1



STAVELEY SENSORS INC
A Subsidiary of Staveley NDT Technologies Inc

HARISONIC RESEARCH CENTER

Customer: G.E. Nuclear   Purchase Order No. 205-926594

Transducer Type: HB-2205-B   Frequency: 5 mHZ   Serial No. H3201

Element Diameter: .375" X .312"   Focus: Dcfocus .281" ID   Center Frequency: 5.2 mHZ

Energy Level: I   Test Material: 303 S.Steel Tube 1.375" O.D.

Damping: 340 Ω   Attenuation 10-8 dB   Gain 40 dB

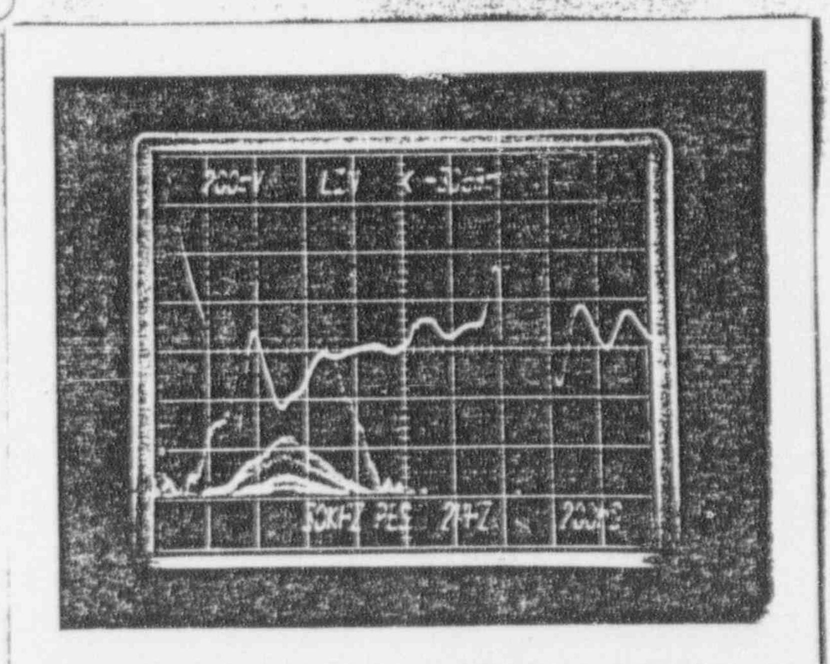
Time Base .2 u sec.   Volts/div. .2   H.P. Filter: Out

Reference Gain: ____________

Test Equipment: Panametrics 5052 UA Pulser; Hewlett Packard 8557A Spectrum Analyzer

Radial 0°

Imp. @ 5 mHZ
130 Ω
Phase -42°



Real Time Wave Form
First Return Echo from Test Material

Frequency Spectrum
2 MHz/Div.

Documented By: [signature]   Date: 3/31/92

Checked By: ____________   Date: ____________

STAVELEY SENSORS INC
A Subsidiary of Staveley NDT Technologies Inc

HARISONIC RESEARCH CENTER

Customer: G.E. Nuclear Purchase Order No. 205-926594

Transducer Type: HB-2205-B Frequency: 5 mHZ Serial No. H3201

Element Diameter: .437" Nom. Focus: Defocus .75" Rad Center Frequency: 4.75 MHZ

Energy Level: I Test Material: 303 S.Steel Tube 1.375" O.D

Damping: 340 Ω Attenuation 10-8 dB Gain 40 dB

Time Base .5 u sec. Volts/div. .2 H.P. Filter: out

Reference Gain: ____________

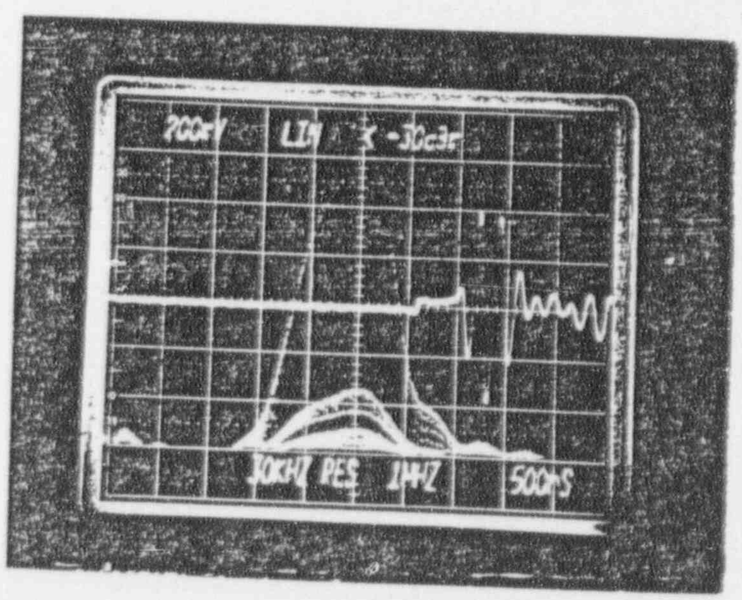
Test Equipment: Panametrics 5052 UA Pulser; Hewlett Packard 8557A Spectrum Analyzer

Forward 70°

Imp. @ 5mHZ

215 Ω

Phase +25°



Real Time Wave Form
First Return Echo from Test Material

Frequency Spectrum
1 MHz/Div.

umented By: [signature] Date: 3/31/92

Checked By: ____________ Date: ____________

STAVELEY SENSORS INC
A Subsidiary of Staveley NDT Technologies Inc

HARISONIC RESEARCH CENTER

Customer: G.E. Nuclear Purchase Order No. 205-926594

Transducer Type: HB-2205-B Frequency: 5 mHZ Serial No. H3201

Element Diameter: .437" Nom Focus: Defocus 75' Rad Center Frequency: 4.7 mHZ

Energy Level: I Test Material: 303 S.Steel Tube 1.375" O.D.

Damping: 340 Ω Attenuation 10-8 dB Gain 40 dB

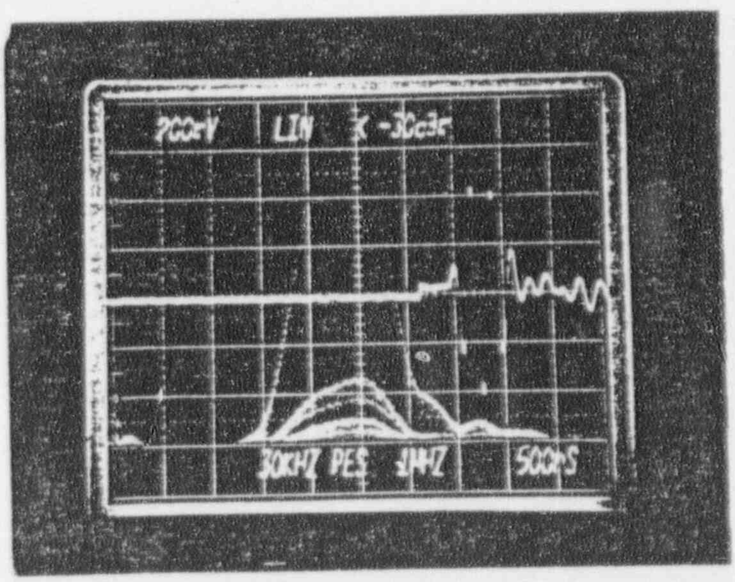
Time Base .5 u sec. Volts/div. .2 H.P. Filter: out

Reference Gain: ______

Test Equipment: Panametrics 5052 UA Pulser; Hewlett Packard 8557A Spectrum Analyzer

Reverse 70°

Imp @ 5 mHZ
210 Ω
Phase +23°



Real Time Wave Form
First Return Echo from Test Material

Frequency Spectrum
1 MHz/Div.

Documented By: [signature] Date: 3/31/92

Checked By: ______ Date: ______

STAVELEY SENSORS INC
A Subsidiary of Staveley NDT Technologies Inc

HARISONIC RESEARCH CENTER

Customer: GE Nuclear Energy Purchase Order No. 205926859

Transducer Type: HB-2217 Frequency: 5mHZ Serial No. H5202

Element Diameter: .437" Nom. Focus: Def. .75"Rad Center Frequency: 4.9 MHZ

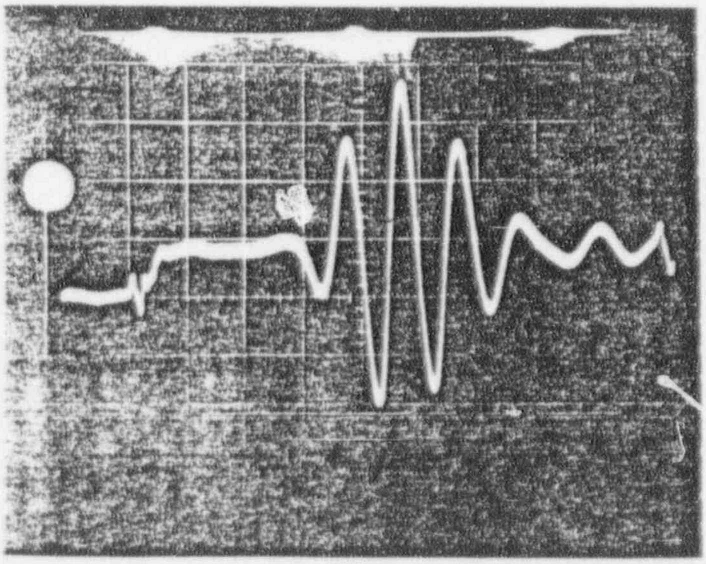
Energy Level: I Test Material: 303 SS Tube 1.375" O.D.

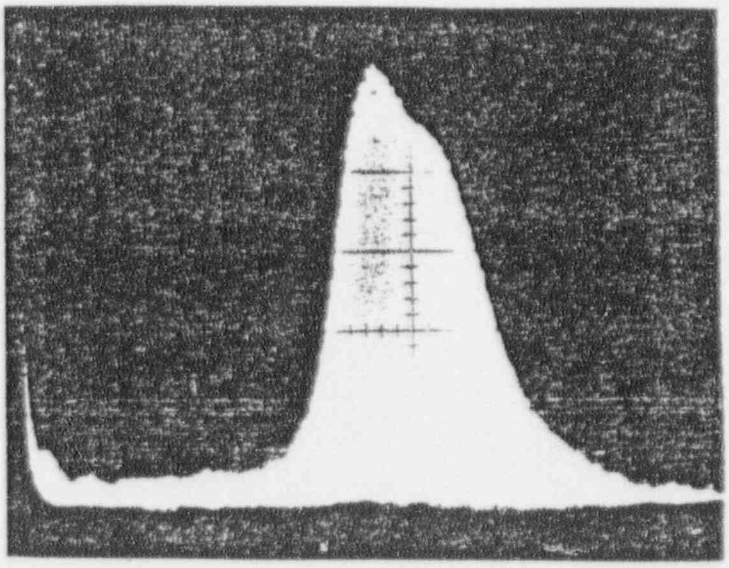
Damping: 340Ω Attenuation 30-8 dB Gain 40 dB

Time Base .2 u sec. Volts/div. .05 H.P. Filter: 1 MHZ

Reference Gain: ____________

Test Equipment: Panametrics 5052 UA Pulser; Hewlett Packard 8557A Spectrum Analyzer





Forward 45° Shear
@ 0 us Delay/Metal/Path

Real Time Wave Form
First Return Echo from Test Material

Frequency Spectrum
1 MHz/Div.

Documented By: Tom Fuller Date: 5/29/92

Checked By: ____________ Date: ____________

470 WEST AVENUE/STAMFORD, CT 06902/TELEPHONE: 203-965-7233/FAX: 203-324-6219

STAVELEY SENSORS INC
A Subsidiary of Staveley NDT Technologies Inc

HARISONIC RESEARCH CENTER

Customer: G.E. Nuclear Energy Purchase Order No. 205926859

Transducer Type: HB-2217 Frequency: 5mHZ Serial No. H5202

Element Diameter: .437 Nom. Focus: Def. .75"Rad Center Frequency: 4.9mHZ

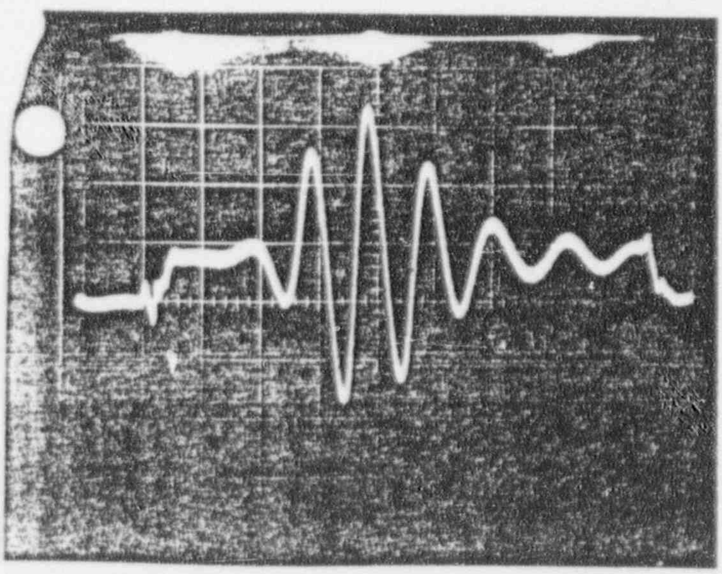
Energy Level: I Test Material: 303 SS Tube 1.375" O.D

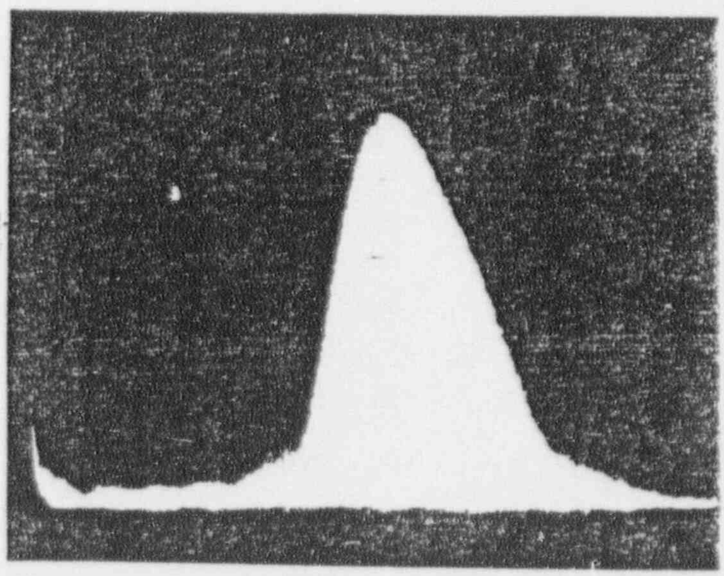
Damping: 340Ω Attenuation 30-8 dB Gain 40 dB

Time Base .2 u sec. Volts/div. .05 H.P. Filter: 1 mHZ

Reference Gain: ____________

Test Equipment: Panametrics 5052 UA Pulser; Hewlett Packard 8557A Spectrum Analyzer





Reverse 45° Shear
@
30us Delay/Metal Path

Real Time Wave Form
First Return Echo from Test Material

Frequency Spectrum
1 MHz/Div.

Documented By: [signature] Date: 5/29/92

Checked By: ____________ Date: ____________

STAVELEY SENSORS INC
A Subsidiary of Staveley NDT Technologies Inc

HARISONIC RESEARCH CENTER

Customer: GE Nuclear Energy Purchase Order No. 205926859

Transducer Type: HB-2217 Frequency: 5mHZ Serial No. H5202

Element Diameter: .312" x .375" Focus: Df. .283" ID Center Frequency: 5.1MHZ

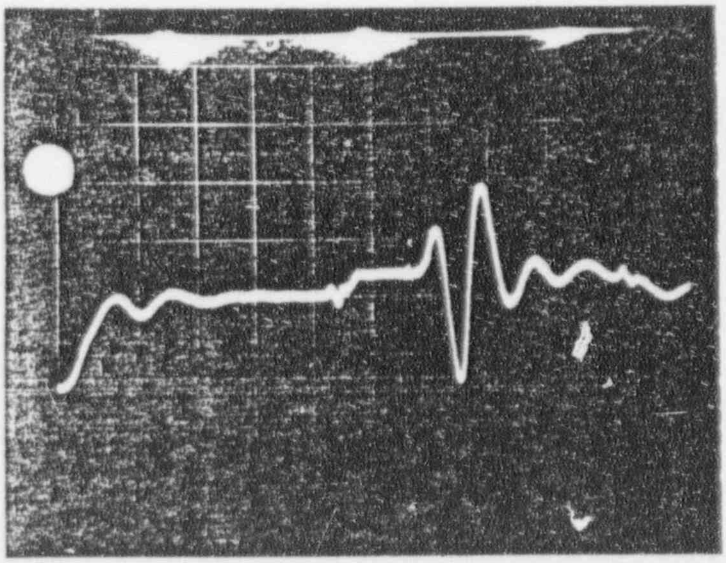
Energy Level: I Test Material: 303 SS Tube 1.375" O.D

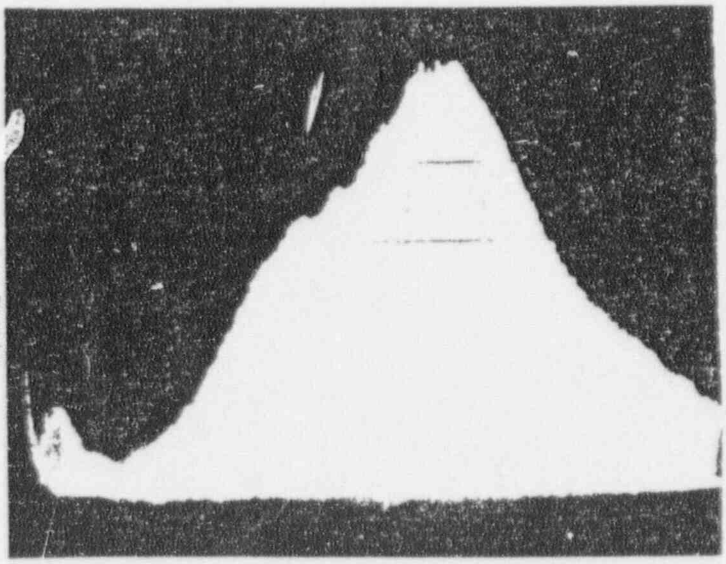
Damping: 340Ω Attenuation 30-8 dB Gain 40 dB

Time Base .2 u sec. Volts/div .1 H.P. Filter: 1 MHZ

Reference Gain: ______

Test Equipment: Panametrics 5052 UA Pulser; Hewlett Packard 8557A Spectrum Analyzer





0° Radial

Real Time Wave Form
First Return Echo from Test Material

Frequency Spectrum
1 MHz/Div.

Documented By: [signature] Date: 5/29/92

Checked By: ______ Date: ______

470 WEST AVENUE/STAMFORD CT 06902/TELEPHONE 203-965-7233/FAX 203-324-6219

APPENDIX F

Transducer Certifications

ULTRASONIC TRANSDUCER ANALYSIS

REFLECTOR

☐ 1.0" Thick Flat ________ Plate.

☐ ________ Dia. Steel Ball.

☒ 1" Radius FBH.

at ________ Inch Water Path.

TRANSDUCER

SERIAL NO: B1056

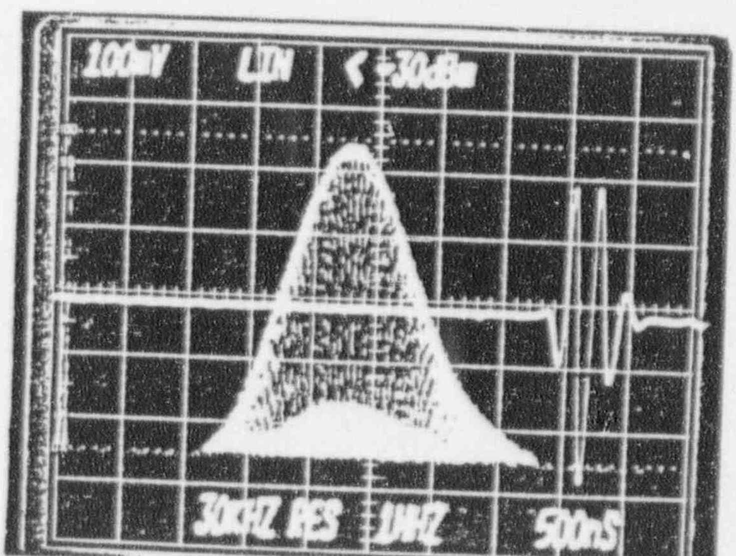
SERIES: Bore Probe

FREQUENCY: 5.0 MHz

SIZE: .250" Dia.

FOCUS: 60° S Forward Inch

1 4 5



6 3 2

WAVE FORM & FREQUENCY SPECTRUM

FREQUENCY: 4.6 MHz

BANDWIDTH: 2.4 MHz

OSCILLOSCOPE SETTINGS:

1. Vertical Sensitivity/Div.
2. Horizontal Sensitivity/Div.

SPECTRUM ANALYZER SETTINGS:

3. Scan Width/Div.
4. Scale Format
5. Input Attenuation
6. Resolution

The above data has been obtained with Megasonics Ultrasonic Transducer Analyzer, MUTA, Tektronix 7704A Main Frame with 7L12 Spectrum Analyzer, 7B92A Dual Time Base, 7A18 Dual Trace Amplifier.

DATE: 10-30-91

BY: [signature]

MEGASONICS
TRASONIC TRANSDUCERS

205 Benedict Hill Rd.
New Canaan, CT 06840
(203) 966-3404

APPENDIX G

RESOLUTION OF THE INITIAL UT INDICATION

DETECTED IN COOPER STUD # 26

Background

On 10/9/91, an ultrasonic (UT) examination of 35 of the RPV studs at the Cooper Nuclear Station was performed. The examination was performed in accordance with Section XI of the ASME B&PV Code and augmented by GENE recommendations in RICSIL Number 055, Revision 1. The UT examination technique that was used was a straight beam (0° L wave) with a 1 inch diameter 2.25 MHz. transducer, where the transducer is placed on the top of the stud. The sound beam generated by that transducer then travels the full length of the stud and is reflected at the bottom end of the stud, back to the same transducer. The purpose is to detect circumferentially oriented cracking anywhere along the length of the stud.

A large indication was detected in 1 of the 35 studs examined, stud # 26. The data from this indication is shown in Attachment 1. Several examiners witnessed the indication and it was verified by the Level III, who showed it to the Project Manager, a representative from the Cooper Station, and the Authorized Nuclear Inspector (ANI).

The cavity above the reactor was then filled with water, so that other outage work could be performed. This delayed further evaluation of the indication until the water level was again lowered. This took several weeks. When the cavity was drained, an attempt to verify the indication was not successful. Several examiners tried to verify the indication, including the examiner who initially detected it. The same transducer used initially was also tried, without success. The one item that could not be re-tried was the UT instrument, because it had been dropped and damaged during the period when the reactor cavity was flooded. That instrument was a Krautkramer/Branson Model USK-7, which is a battery operated, portable, UT instrument.

References 1 & 2 describe extensive work performed at the Vallecitos Nuclear Center (VNC) on stud # 26, which clearly shows that stud # 26 was not cracked. This then leads to the conclusion that the initial UT indication detected was a false, or a so called "phantom indication". The purpose of this appendix therefore, is to determine the probable cause of such a "phantom indication".

Possible Causes Of The Phantom Indication

One of the first thoughts, after it was found that the indication could not be verified, was that during the period that the reactor cavity was flooded, the crack had filled with water and had become transparent to sound. That would be very unlikely, and in fact it is believed that a large reflection would still be detected even with the crack full of water. It was known that this was not so, since it has been proven that there was no crack.

Another possibility is operator error. This has been ruled out, since more than one operator, including the Level III verified the indication, and also was witnessed by the Cooper representative and the ANI.

Still another variable is the transducer. However, the same transducer used to initially detect the indication was tried and the indication could not be verified with it. The transducer functioned normally during both the calibration (pre and post exam) and the re-examination including (calibrations). Therefore, it is very unlikely that the transducer was at fault.

This then makes the one item that could not be re-tried, the Krautkramer/Branson USK-7, portable UT instrument, highly suspect in causing the so called phantom indication. This particular instrument has an automatic pulse repetition rate (PRR) control. One of the things that can happen, if the PRR is to high, when examining thick or long metal components, is that the sweep on the oscilloscope of the UT instrument may repeat itself, overlaying the initial sweep. This is sometimes referred to as "screen wrap around" and can result in phantom indications anywhere along the area of interest. This phenomena can be affected by the UT frequency, the metal path through which the sound travels, (in this case 8 feet of steel, including the round trip), the sweep range, the gain, the amplitude of reflections and of course by the PRR. Therefore, if the automatic PRR of the USK-7 was operating at too high a frequency, phantom indications might be expected. This type of phenomena is conservative in that it can result in false calls, due to the phantom indications, but would not prevent the detection of real cracks.

Work Performed To Evaluate The Effects of the PRR on Stud Inspections

Work was performed in the GENE Nondestructive Examination Development Laboratory to show the effect that the PRR can have on a stud examination.

The experiments were conducted on a BWR/6 stud that was readily available. This stud is slightly longer than the Cooper studs (55 inches vs. 48 inches). However, this 7 inch difference in length only makes it easier to demonstrate the effect, since it means the sound beam has to travel 14 more inches on the round trip.

A 1 inch diameter, 2.25 MHz. transducer was used in all cases since this is the same type of transducer that was used at the site when the phantom indications were first detected. Three UT instruments were selected to perform the experiments since they all have variable PRR controls. The first two instruments included a Sperry Immerscope, Model 725 and a Krautkramer/Branson, Model USM 35. Both of these instruments have a PRR which is variable in discrete steps. The third instrument was a Branson Sonoray, Model 600, which has a continuously variable PRR from about 55 Hz. to 831 Hz., as measured with a LeCroy digital oscilloscope.

The stud was then examined with all three instruments and the PRR was varied to demonstrate the effect. That effect is shown in attachment 2 (3 pages).

At the lowest PRR for the Sperry Immerscope 725 (125 Hz.) and the Krautkramer/ Branson USM35 (250 Hz.) normal back reflections were obtained from the stud, with no phantom indications. However, in both cases, when the frequency was increased, just one step to 500 Hz., the screen wrap around started to occur, and phantom indications were observed. In both cases, as the PRR was further increased, more and higher amplitude phantom indications started to appear.

The Branson Sonoray 600 was then tried. The PRR was adjusted to the point just before low level phantom indications were observed. That PRR was 139 Hz. The PRR was then adjusted to 303.5 Hz. to simulate what may have been observed on stud # 26. That is, a high amplitude phantom indication located at about 13 inches from the top of the stud. It was then further adjusted to show that variations in the PRR could cause the phantom indications to appear to be located anywhere along the length of the stud. This only required an increase in the PRR to 337.5 Hz. Therefore, it has been shown that very slight changes in the PRR can have a large effect on the phantom indications over this long of a metal path.

The examination data sheets, in attachment 1, do not mention a loss of back reflection in the indication area of stud # 26, however the Level III later reported that it did occur.

This being the case, the questions that to be answered are: 1) if the phantom indication was caused by a variation in the automatic PRR, then why was it not observed on the other 34 studs, and 2) why was there apparently no back reflection on stud # 26? These questions are more difficult to answer.

However, the answer to the first question could be related to the amplitude of the back reflections, which can be related to how well the sound is coupled into the stud or to a number of other factors. In addition, studs do tend to act as a wave guide, and mode conversion can take place as the sound beam tries to spread and is reflected off of the sides of the stud. This could result in a shear wave, which could move the back reflection still farther out in time, such that it might not be observed on the scope. This apparent longer metal path could also aggravate the PRR problem. This of course could be influenced by the amount and location of corrosion on the sides of the stud.

Another possibility is that as the PRR varied on this stud it caused a slight shift in the sweep delay (which sometimes happens with changes in the PRR, depending on the instrument). This then could move the back reflection slightly off the scope, such that it would not be observed.

Conclusions

1. Since other variables, such as operator error and problems with the transducer have been shown to not be the cause of the phantom indication, then the instrument used has to be highly suspect.

2. It has been shown that problems with the instrument's automatic PRR could result in phantom indications such, as was detected on stud # 26.

3. There could be a number of other factors, such as mode conversion, a shift in the sweep delay due to the higher PRR, the amount of corrosion on the sides of the stud, and the coupling of sound into the stud, which contributed to the problem. It is impossible at this point to isolate those factors since the instrument was damaged and since stud # 26 has been sectioned.

4. Based on these facts, and the data presented in this appendix, it can be concluded that the cause of the phantom indication in stud # 26 is related to a problem with the instrument's PRR, plus possible other factors such as those mentioned above.

5. It can also be concluded that a problem of this type is a conservative problem, since it would only occur on bolting with long metal paths and could result in false calls but would still be effective in the detection of any real flaws. Therefore, the effectiveness of the use of this instrument on other components (such as piping welds) during the outage is not in question.

Attachment 1 Initial UT Data For Cooper Stud # 26

GE Nuclear Energy

ULTRASONIC EXAMINATION OF BOLTS OR CLOSURE STUDS OR RPV NUTS

Date 10-9-91 Unit No. & Inspection Unit 1 / OT Data Sheet No. D-020

Examiner [signature] Level II Couplant Water

Calibration Standard No. (21) CNS-CAL-STD-MM-21 Calibration Sheet No. C-001

Bolting Application Stud

Stud Length 48" Dia. 6" In Place: Yes X No

Bolt Length N/A Dia. N/A In Place: Yes N/A No N/A

Nut Dia: N/A In Place: Yes N/A No N/A

Comments: STUD # 26 APPEARS TO HAVE AN INDICATION FOR 180°, DOWN 13", 100% +6dB, AND IS LOCATED AT THE THREAD-STUD INTERFACE.

RESULTS: [signature] Lvl. III 10-9-91

Stud, ~~Nut Or Bolt No.~~	Indication Sweep Max.	Indication Amp. Max.	Stud, Nut Or Bolt No.	Indication Sweep Max.	Indication Amp. Max.
18	No Recordable	Indication			
19	No Recordable	Indication			
20	No Recordable	Indication			
21	No Recordable	Indication			
22	No Recordable	Indication			
23	No Recordable	Indication			
24	No Recordable	Indication			
25	No Recordable	Indication			
26	13"/180°	100% +6dB		N/A	
27	No Recordable	Indication			
28	No Recordable	Indication			
29	No Recordable	Indication			
30	No Recordable	Indication			
31	No Recordable	Indication			
32	No Recordable	Indication			
33	No Recordable	Indication			
34	No Recordable	Indication			
35	No Recordable	Indication			
	N/A				

Note: If no indications are found, mark "none" in indication columns.

Reviewed by: QAD N/A N/A

NDE LEVEL III REVIEW: [signature] DATE 10-09-91

NPPD ISI ENGINEER REVIEW: [signature] DATE 10/12/91

NPPD QA REVIEW: [signature] DATE 10/15/91

ANII REVIEW: [signature] DATE 10-14-91

GE Nuclear Energy

ULTRASONIC EXAMINATION OF BOLTS OR CLOSURE STUDS OR RPV NUTS

Date 10-09-91 Unit No. & Inspection Unit 1 / UT Data Sheet No. C-019

Examiner [signature] Level II Couplant WATER

Calibration Standard No. (21) CNS-CAL-STD-No. 21 Calibration Sheet No. C-001

Bolting Application STUD

Stud Length 48" Dia. 6" In Place: Yes X No

Bolt Length N/A Dia. N/A In Place: Yes N/A No N/A

Nut Dia: N/A In Place: Yes N/A No N/A

Comments: NONE

RESULTS:

Stud ~~Nut~~ ~~Or Bolt No.~~	Indication Sweep Max.	Indication Amp. Max.	Stud, Nut Or Bolt No.	Indication Sweep Max.	Indication Amp. Max.
1	No Recordable	Indication			
2	No Recordable	Indication			
3	No Recordable	Indication			
4	No Recordable	Indication			
5	No Recordable	Indication			
6	No Recordable	Indication			
7	No Recordable	Indication			
8	No Recordable	Indication		N	
9	No Recordable	Indication			A
10	No Recordable	Indication			
11	No Recordable	Indication			
12	No Recordable	Indication			
13	No Recordable	Indication			
14	No Recordable	Indication			
15	No Recordable	Indication			
16	No Recordable	Indication			
17	No Recordable	Indication			
	N				
	A				

Note: If no indications are found, mark "none" in indication columns.

Reviewed by: OAD N/A AI N/A

NDE LEVEL III REVIEW: [signature] DATE 10-09-91

NPPD ISI ENGINEER REVIEW: [signature] DATE 10/12/91

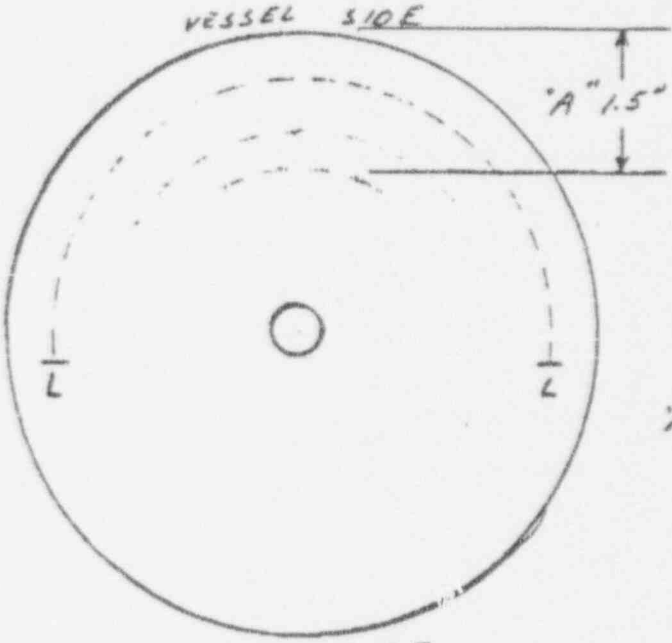
NPPD QA REVIEW: [signature] DATE 10/15/91

ANII REVIEW: [signature] DATE 10-14-91

Nuclear Energy Engineering Calculation Sheet

NUMBER: COOPER NUCLEAR STATION DATE: 10-10-91
SUBJECT: RPV STUD #26 BY: [signature] LEVEL III SHEET 1 OF 1

TABLE IWB-3515-1 WAS USED FOR THE EVALUATION OF THE RPV STUDS.



A = 1.5"
L = 6"

$\frac{A}{L}$ $\frac{1.5}{6}$ = .25

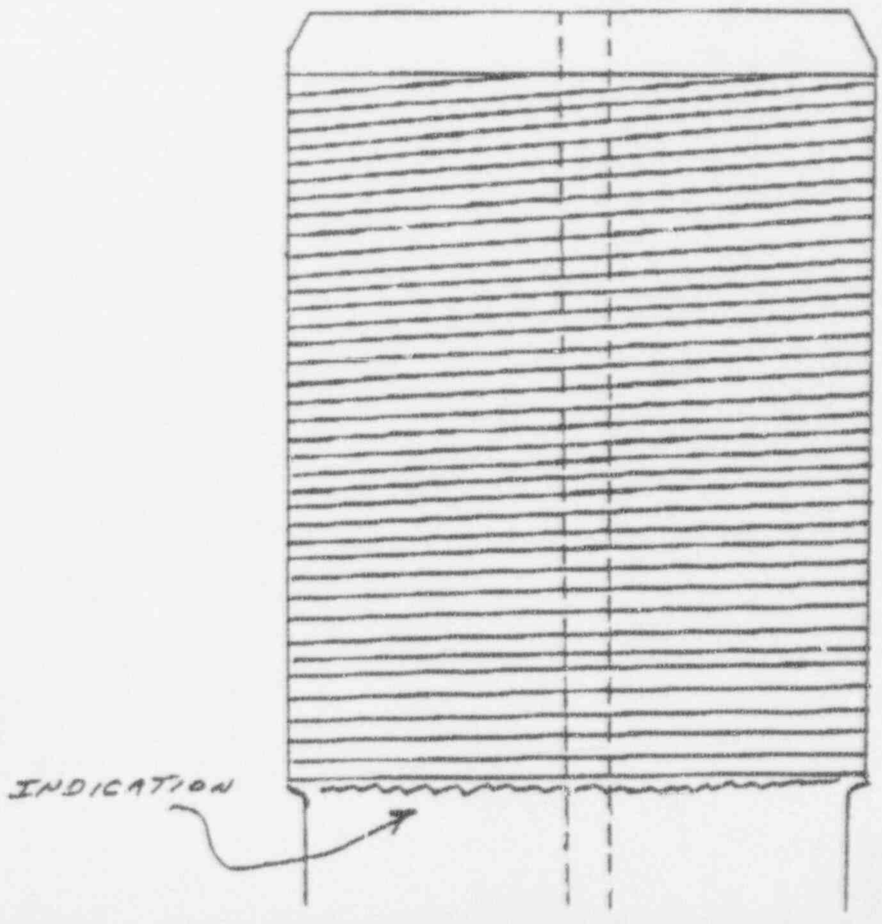
"A" MAXIMUM ALLOWABLE INDICATION = .15"

THIS INDICATION IS UNACCEPTABLE REF. TABLE IWB-3515-1

"A" ACCEPTABLE = .15"

"A" ACTUAL = 1.5"

[signature]
LEVEL III
10-10-91



NOT TO SCALE

GE Nuclear Energy

U.T. LINEARITY DATA SHEET

LDS # L-010

DATE 10-9-91

PROCEDURE NO. GE-ADM-1001 REV. 0

EXAMINER [signature] LEVEL II DATA TAKER N/A LEVEL N/A

INSTRUMENT:
SERIAL NO. 27276-4636 MODEL NO: ☐ KK/USL-32; ☐ BRANSON 300; ☐ SONIC MKI; ☒ OTHER KK/USK-7
☐ NORTEC-1310 ☐ NORTEC-1310

SEARCH UNIT:
BEAM ANGLE: ☒ 0° (LONG. WAVE); ☐ 45° (SHEAR WAVE); ☐ 60° (SHEAR WAVE); ☐ OTHER N/A

TRANSDUCER SIZE: ☐ 0.25" DIA/2.25 MHZ; ☐ 0.25" X 0.25"/2.25 MHZ; ☐ 0.25" X 0.5"/2.25 MHZ;
SERIAL NO. I01201 ☐ 0.5" X 0.5"/2.25 MHZ; ☐ 0.25" DIA/5.0 MHZ; ☐ 0.25" X 0.25"/5.0 MHZ;
☐ 0.25" X 0.5"/5.0 MHZ; ☐ 0.5" X 0.5"/5.0 MHZ; ☒ OTHER
☐ DUAL TRANSDUCERS; ☐ SINGLE TRANSDUCER; ☐ SPECIAL WEDGE 1" 2.25 MHZ

CABLE:
TYPE: ☐ RG-58; ☐ RG-58; ☐ RG-57; ☐ RG-174 (Microdot); ☒ OTHER RG-174 (BNC) LENGTH 6'

TYPE OF BLOCK USED: ☒ IIW-2; ☐ UT CAL. BLOCK NO. 800025 ☐ OTHER N/A

SCREEN HEIGHT LINEARITY CHECK:

1st REFLECTOR AMPLITUDE IN % FSH	2nd REFLECTOR AMPLITUDE IN % FSH	1st REFLECTOR AMPLITUDE IN % FSH	2nd REFLECTOR AMPLITUDE IN % FSH
100	51	50	25
90	45	40	19
80	40	30	15
70	36	20	10
60	30		

THE 2nd REFLECTOR SHALL BE 50% OF THE 1st REFLECTOR ± 5% FSH TO MEET SCREEN HEIGHT LINEARITY.

AMPLITUDE CONTROL LINEARITY:

REFLECTOR AMP. SET IN % FSH	dB CONTROL CHANGE	READING OFF SCREEN	REFLECTOR AMP LIMITS IN % FSH
80%	−6dB	39	32 to 48%
80%	−12dB	19	16 to 24%
40%	+6dB	84	64 to 96%
20%	+12dB	86	64 to 96%

MINUS (−) DENOTES DECREASE IN AMPLITUDE; PLUS (+) DENOTES INCREASE.

NDE LEVEL III REVIEW: [signature] DATE 10-09-91

NPPD ISI ENGINEER REVIEW: [signature] DATE 10/12/91

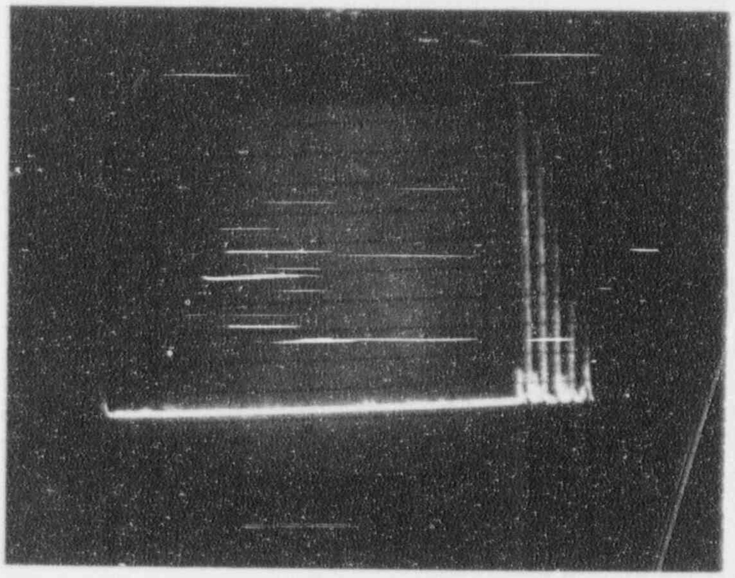
NPPD QA REVIEW: [signature] DATE 10/15/91

ANII REVIEW: [signature] DATE 10-14-91

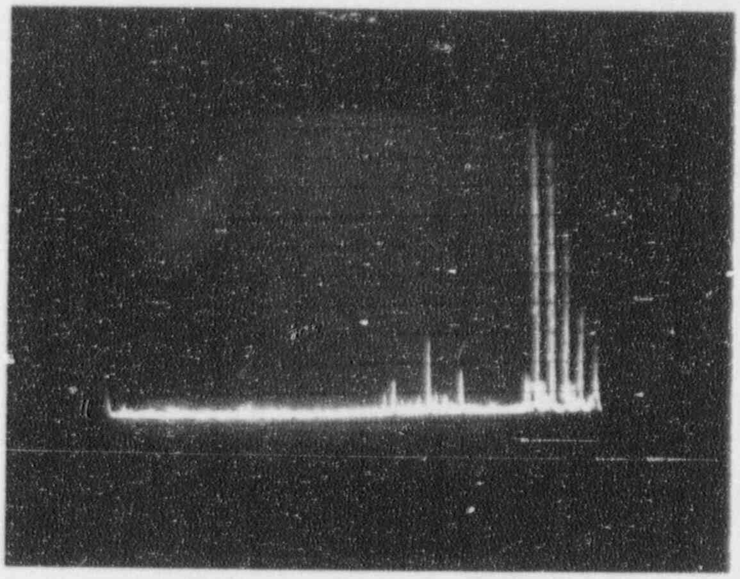
Attachment 2 - Effects of the Pulse Repetition rate on RPV Stud

UT Examinations

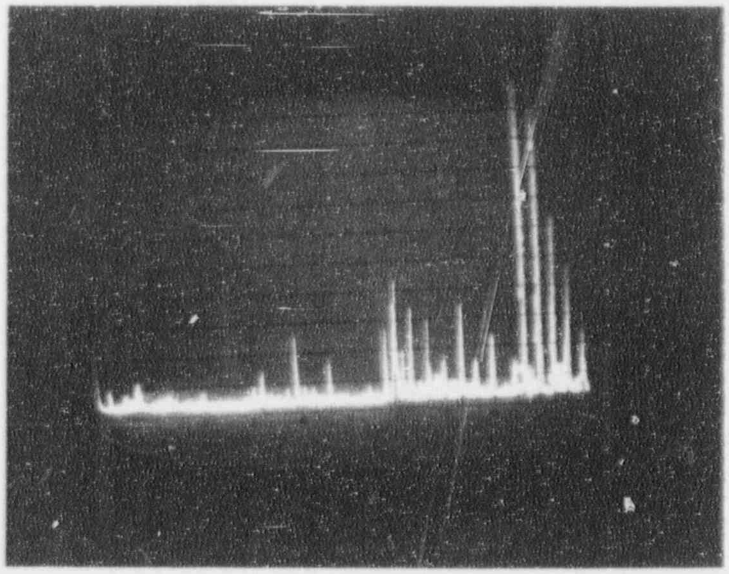
Effect of the Pulse Repetition Rate (PRR) on RPV Stud UT Examinations Using a Sperry Immerscope Model 725



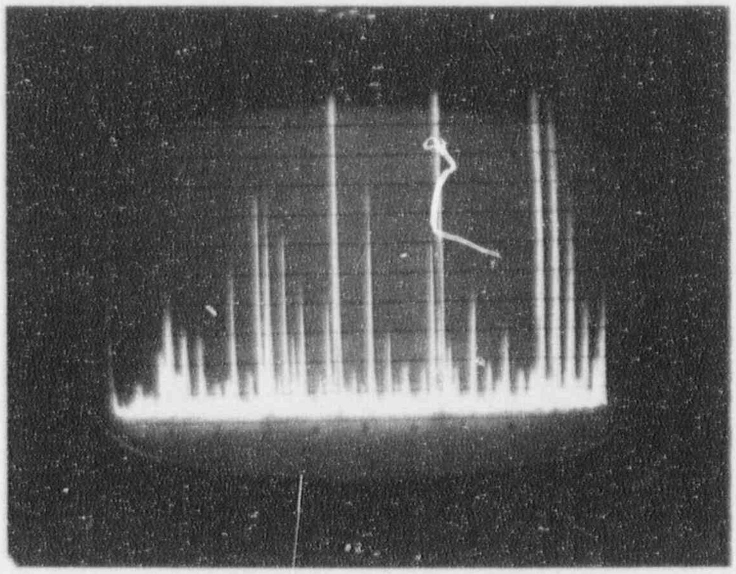
PRR = 125 Hz., Normal Back Echoes



PRR = 500 Hz., False Indications



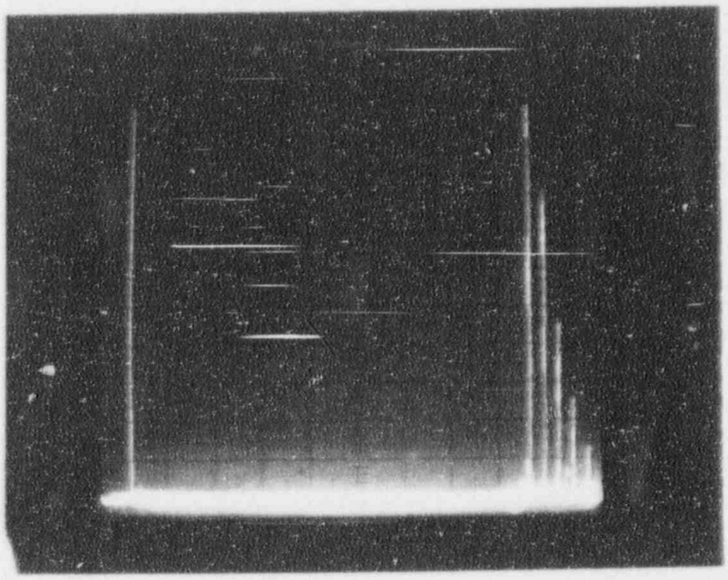
PRR = 1250 Hz., False Indications



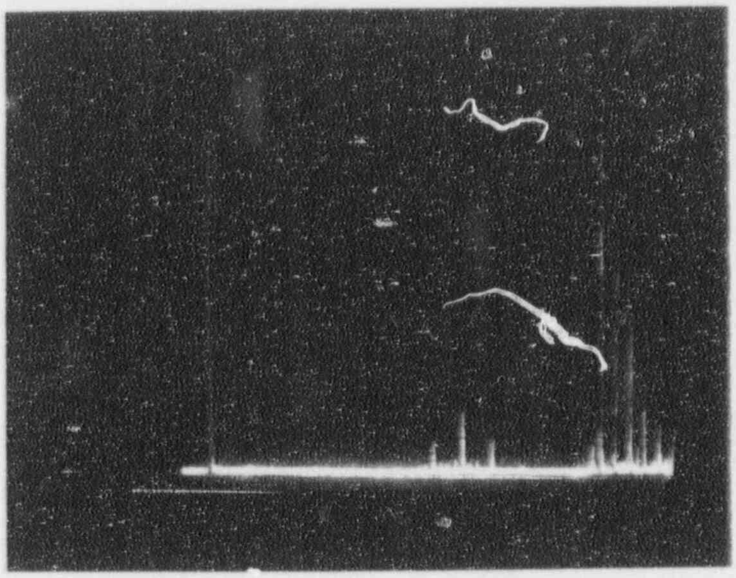
PRR = 2500 Hz., False Indications

This instrument has a PRR control that is adjustable in steps with a switch.

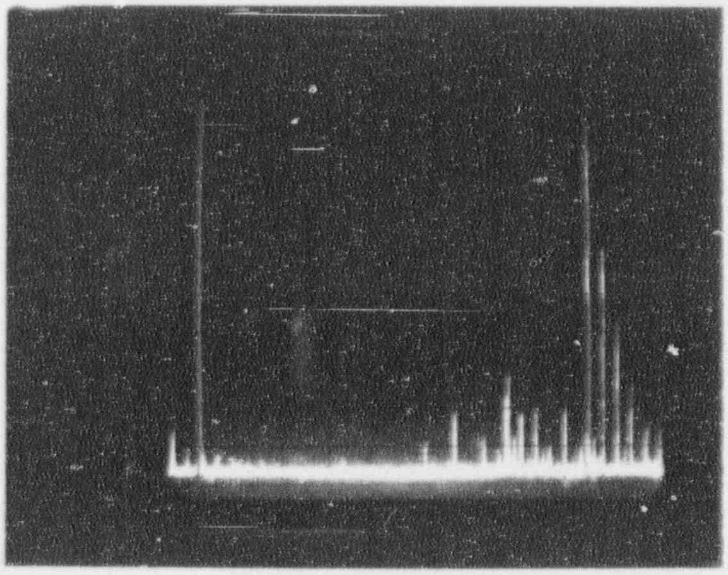
Effect of the Pulse Repetition Rate (PRR) on RPV Stud UT Examinations Using a Krautkramer/Branson Model USM35



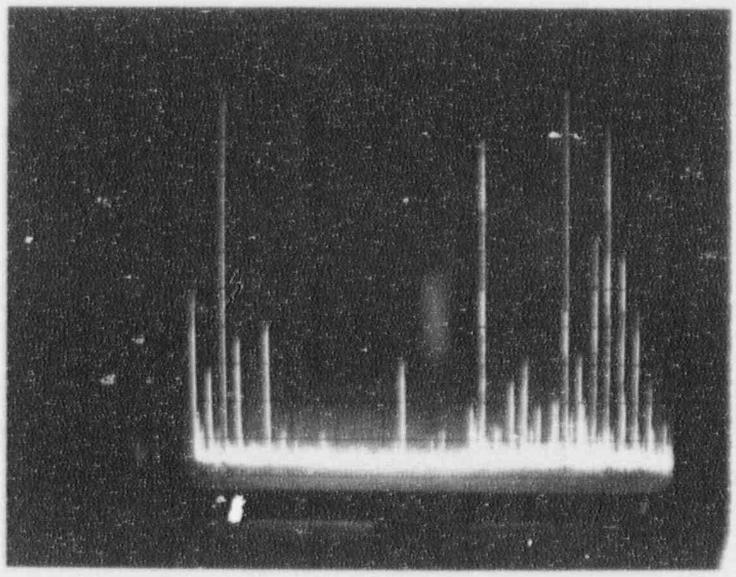
PRR = 250 Hz., Normal Back Echoes



PRR = 500 Hz., False Indications



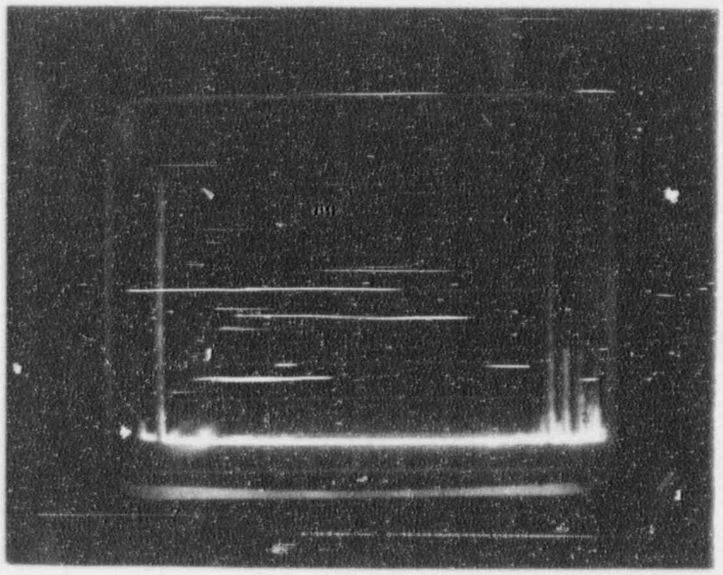
PRR = 1000 Hz., False Indications



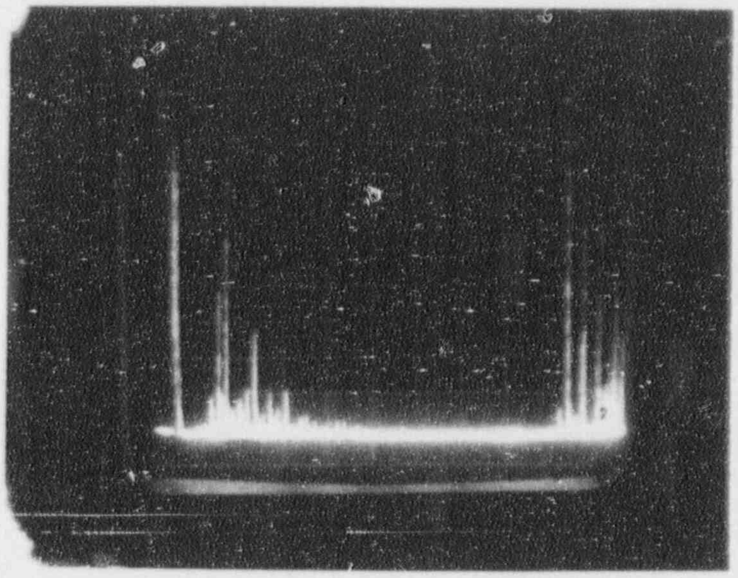
PRR = 2000 Hz., False Indications

This instrument has a PRR control that is adjustable in steps with a switch.

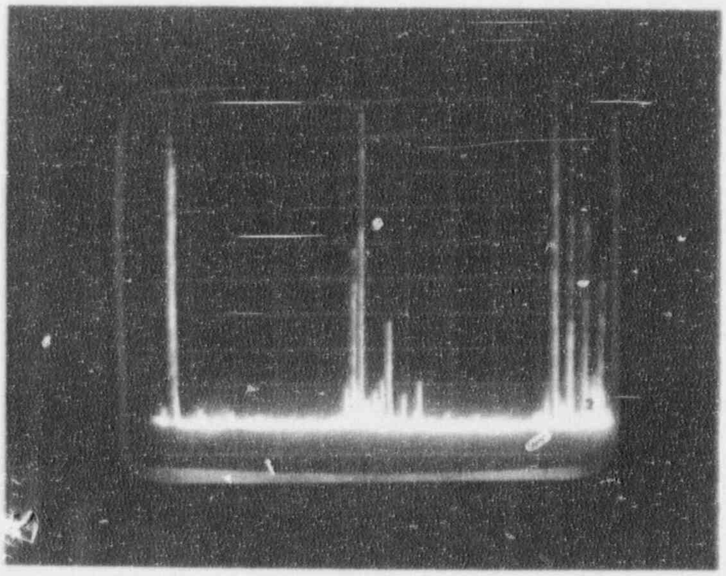
Effect of the Pulse Repetition Rate (PRR) on RPV Stud UT Examinations Using a Branson Sonoray model 600



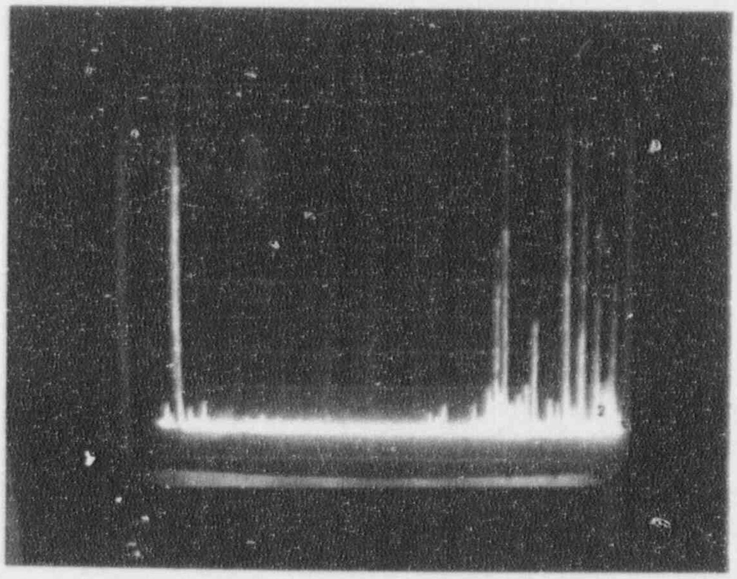
PRR = 139 Hz., Normal Back Echoes



PRR = 303.5 Hz. False Indications Near Top of the Stud



PRR = 321.5 Hz., False Indications Near Center of the Stud



PRR = 337.5 Hz. False Indications Near Bottom of the Stud

This instrument has a PRR that is continually variable from 54.5 to 831.3 Hz. The control is by a potentiometer. The frequency was determined with a LaCroy digital oscilloscope.

APPENDIX H

GENE's SMART 2000 ULTRASONIC DATA ACQUISITION AND ANALYSIS SYSTEM

GENE SMART 2000

The GENE SMART 2000 ultrasonic data acquisition and analysis system includes a motor controller, a position monitor and four (4) digital pulser/ receiver channels. The motor controller permits control of two axes: two stepping-motors and encoders or two servo-motors and encoders. The entire system is computer controlled, operating with an open UNIX based architecture, built around the high performance microprocessor, the 32-bit 68030 with VME bus. The system digitizes all raw incoming R/F waveform and/or video A-Scan presentations along with the appropriate X-Y positional information which can be from internal or external motor controller. This data is stored in a 64 megabyte RAM buffer and can be archived by an 800 megabyte optical disk for off line data analysis and for subsequent examination comparison.

The system can perform multi-task functions. The main focus is on the visual aspect, the "window principle" which has been employed so successfully in many user friendly personal computers. With several windows, different types of information such as A-Scan, B-Scan, C-Scan, UT parameters, Motor Control ... etc. can be imaged on one color monitor. The system is controlled via the console and screen. During off-line data analysis and review mode, C-scan image can be reconstructed, for any area within the digitized zone, to display either depth, time of flight, or amplitude view. Additionally, since all of the raw UT data, regardless of amplitude has been recorded, the operator can adjust the amplitude threshold between 0 to 100% of full screen height, as well as the gate length, for the reconstruction of the C-Scan display. As a further evaluation tool, the cross-sectional images (B-Scan) can be displayed to aid data analysis. Color coded hard copy prints of all of these images can be made for use in the evaluation reports.

<u>REFERENCES</u>

1. GENE REPORT, "COOPER AUTOMATED REACTOR STUD EXAMINATION" Robert W. Anderson, November 1991

2. GENE REPORT NO. 689-007-1291, "COOPER REACTOR PRESSURE VESSEL CLOSURE STUD METALLURGICAL EVALUATION" Brian F. Frew, December 1991

3. GENE RICSIL NO. 055, REVISION 1, INCLUDING SUPPLEMENT 1, "RPV HEAD STUD CRACKING" Technical Sources, J. P. Clark, J. G. Erbes, March 26, 1992

4. SECTION XI OF THE ASME BOILER AND PRESSURE VESSEL CODE, 1989 EDITION

5. GENE FIELD QUALITY PROCEDURE, FQP-03, "PROCEDURE FOR QUALIFICATION AND CERTIFICATION OF NONDESTRUCTIVE EXAMINATION PERSONNEL"

6. "COMPUTERIZED UT SYSTEM FOR STUD BOLT - IMPROVEMENT OF ULTRASONIC INSPECTION TECHNIQUE", T. Kisanuki, K. Uchida of Keihin Product Operations, Yokahama, Japan and T. Fushimi, K. Onda of Chuba Electric Power Company, Inc., Nagoya, Japan, Presented At The 9th International Conference On Nondestructive Evaluation In The Nuclear Industry, Tokyo, Japan, April 1988

GE Nuclear Energy
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