Sandia National Laboratories

Albuquerque, New Mexico 87185

October 29, 1987

Mr. M. R. Hum
U. S. Nuclear Regulatory Commission
Materials Engineering Branch
Washington, DC 20555

Subject: Indian Point Unit 2 Vessel Indication Inspection 1987

Dear Mr. Hum:

A preliminary look at the ultrasonic data collected on the reactor pressure vessel was accomplished from October 22 through October 24, 1987 at the Indian Point Unit 2 site. Several different examinations were performed which started with a manual repeat examination using the ASME Code Section XI ultrasonic testing techniques as done in 1984 using the 10 year transducer array plate. The ten year array plate contained 5 transducers which provided 0 degree, 45 degree, and 60 degree angle beams in both the clockwise and counter clockwise directions. The same Code techniques were then repeated using the automatic Ultrasonic Data Recording and Processing System (UDRPS). Two additional examinations were performed using a delta array plate with flat transducers and another using a delta focused array plate with large 5.5 inch diameter focused transducers. The delta array plates provided 45 and 0 degree longitudinal and shear beams which can operate in the pulse echo, delta, or pitch-catch modes. The focused array plate also contained one 60 degree angle beam. The UDRPS system was used in all these examinations to record, display, and analyze the data.

The flaw was initially sized by the manual ASME Code Section XI methods to be 1.89 inches deep and 1.96 inches long. This compares very well with the size obtained by the same method in 1984 which was 2.03 inches deep and 1.96 inches long. The pulse echo amplitude responses from the two 45 degree transducers and the two 60 degree transducers were all within 3db of those obtained in 1984. The locations of the peak amplitudes were also within 0.1 inch for three of the four angle beam transducers. The peak amplitude location of the fourth transducer TR27 was within 0.6 inch. This is well within experimental error and it demonstrates without a doubt that the flaw indication is unchanged from 1984. The slight decrease in depth sizing from 2.03 inches to 1.89 inches as recorded by the 60 degree transducer TR27 is easily accounted for since the recorded amplitude in 1987 was 2 db lower than that recorded in 1984 which could be due to a very slight transducer alignment change between the two examinations.

The sizing by ASME Code Section XI methods and the UDRPS system was not made during this preliminary evaluation at Indian Point due to time constraints. Most of the time was spent in evaluating pulse echo and delta data taken with the flat and focused delta array transducers in order to establish the geometry and depth of the flaw by these techniques with the UDRPS system. Th length of the flaw was, however, measured by 6 db down points fo the 45 degree shear large diameter transducer where a 2.0 inch value was obtained.

Comparing characteristics of the 1987 delta data and the 1984 delta data also indicates that the flaw is unchanged between the two examinations. However, a very comprehensive set of pulse echo and delta data was acquired in the 1987 examinations so tha a great deal of time was taken up in reviewing this data with th UDRPS system.

All UDRPS displays clearly showed that the flaw was within the weld area between two plates of the vessel. The edge of one plate was clearly defined since a large number of small amplitud pulse echo signals were recorded due to small discontinuities within the volume of that plate. The number of small recorded signals was significantly reduced in the weld area and within the volume of the other plate. The flaw echo was located in the welc just beside the edge of the spotty plate.

The A-scan characteristics of the pulse echo and delta signals were very similar. They both showed one large amplitude pulse from the flaw with one or two equidistant trailing pulses which were successively reduced in amplitude. The amplitudes of the trailing pulses increased in unison with the large pulse as the transducer approached the flaw. The trailing pulses reached a maximum with the maximum of the large pulse, and they decreased in unison with the large pulse as the transducer passed over the flaw. The second feature of the A-scan traces was that the time separation of the trailing pulses was a maximum at the extremities of the flaw length and it was a minimum when the large pulse was at maximum amplitude near the middle of the flaw.

The features of the A-scan echoes can be explained by assuming that the sound energy is incident on a single flaw where portions of the energy are being scattered in many different directions. The main pulse as observed in the pulse echo mode is due to that portion of the energy being scattered directly from the flaw back toward the transducer. The main pulse as observed by the delta 0 degree transducer is due to that portion of the energy being scattered directly toward the ID wall of the vessel. The trailing pulses are due to that portion of the energy being scattered toward the OD wall of the vessel where it is reflected back toward the flaw and subsequently scattered toward the pulse echo transducer and toward the OD surface again to form the 2nd trailing pulse. A portion of the energy reflected from the OD surface of the vessel passes the flaw and arrives at the 0 degree transducer in the delta mode to form the trailing pulses observed by it. A second explanation of the trailing pulses is that a portion of the energy of the main pulse is trapped within the flaw volume which may be a slag inclusion, and multiple reflections of the pulse within the inclusion produce the trailing pulses. Since the time separation of the trailing pulses increases near the extremities of the flaw length, it appears that the scattering model may be more plausible because the distance between the flaw surface and the OD wall of the vessel can increase at the extremities of the flaw length, whereas the flaw volume is not expected to enlarge near its extremities.

Figures 1 and 2 show a cross sectional view of a model of the flaw geometry where possible ray paths of the scattered energy are displayed., A characteristic A-scan trace is also shown in Figure 2. The distances and depth of the flaw were determined from the preliminary pulse echo and delta data reviewed at the Indian Point Unit 2 site.

The flaw area was also scanned very carefully with 0 degree transducers operating in the pulse echo mode with very high gain. 2.25 and 5.0 MHz flat transducers and a 2.0 MHz large diameter focused transducer were used. No hint of pulse echo signals were recorded from the flaw for any of these tests. This indicates that the flaw geometry is very narrow at the top and no significant surface of the flaw is parallel with the ID surface of the vessel. Figure 2 shows one possible flaw geometry which may produce the echo responses recorded and yet not be detected with the 0 degree beams. The large incline to the sides of the flaw is also consistent with the maximum pulse echo response being recorded with the 60 degree incident beam and not the 45 degree beam.

It is conclusive that no tip diffracted signal from a crack was recorded in any of the examinations. If the flaw were a crack which was connected to the OD of the vessel, the A-scan trace would show a small amplitude tip diffracted signal in front of a larger base diffracted or reflected signal. These two signals would also peak in amplitude at slightly different transducer locations. These locations would correspond to the center of the ultrasonic beam first passing through the corner of the crack at the OD surface and then subsequently passing over the tip of the crack which is at some depth within the wall of the vessel. The time separation of the first arrived tip signal and the later in time large reflected or refracted base signal gives a direct measure of the crack depth. The time separation between these two signals would decrease as the transducers are scanned near the extremities of the crack length where the crack depth becomes very shallow. None of the A-scan traces recorded at Indian Point Unit 2 had these characteristics.

It is therefore concluded that the flaw in Indian Point Unit 2 reacter vessel is not a crack which is connected to the OD surface of the vessel. The flaw is most likely a thin slag inclusion which is very close to the OD vessel surface with a maximum depth of approximately .3 inches. The length of the flaw is approximately 2.0 inches.

Sincerely,

John H. Gieske

JHG:jk

Copy to:
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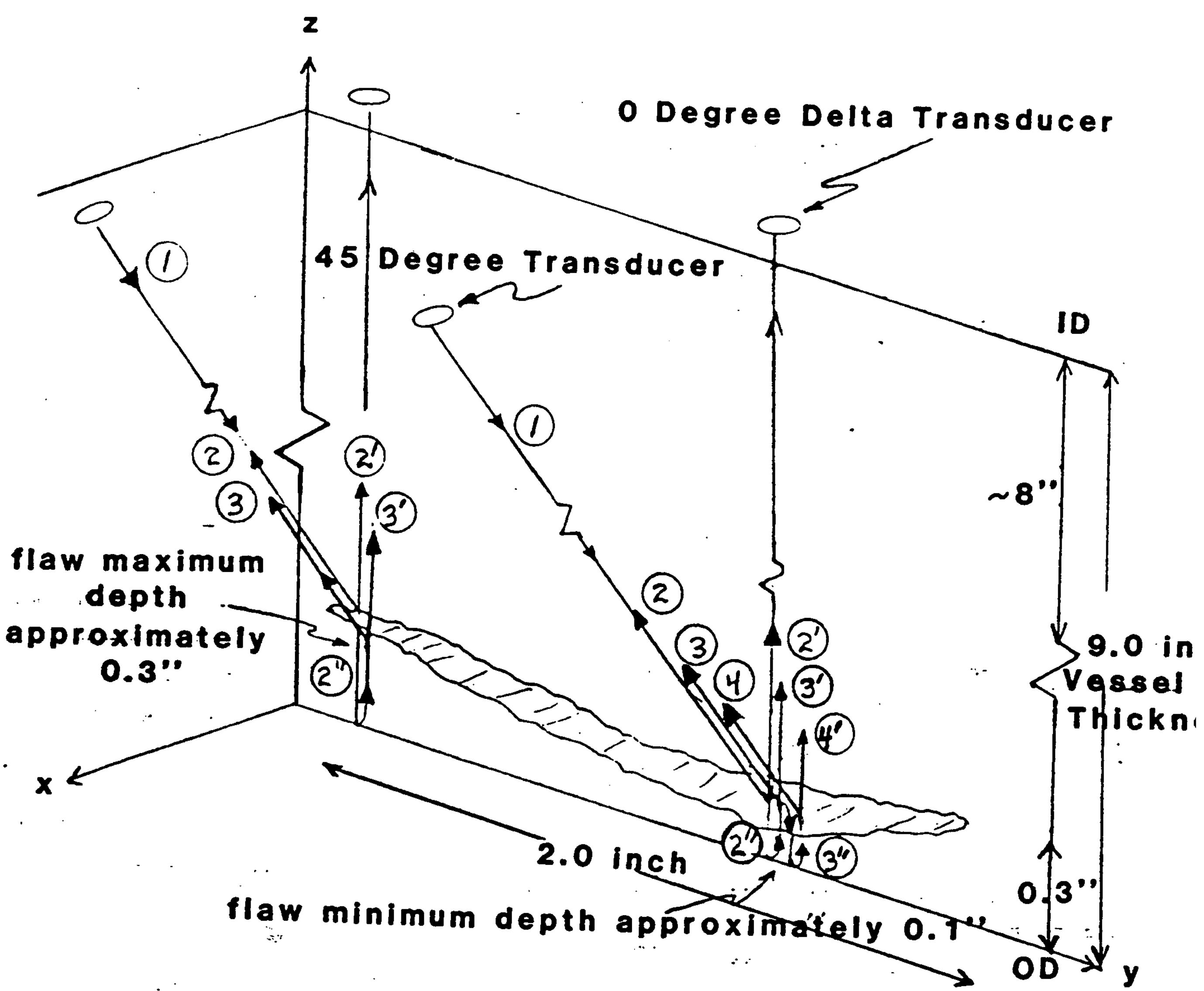

1 - 45 degree incident beam

2 - Energy scattered at 45 degrees

2′ - Energy scattered toward ID surface

2″ - Energy scattered toward OD surface

3 & 3′ First trailing pulse

3″ - Energy scattered to form the 2nd trailing pulse 4 &

FIGURE 1. Schematic of possible ray paths of scattered energy from an incident 45° angle beam at two locations of the flaw.

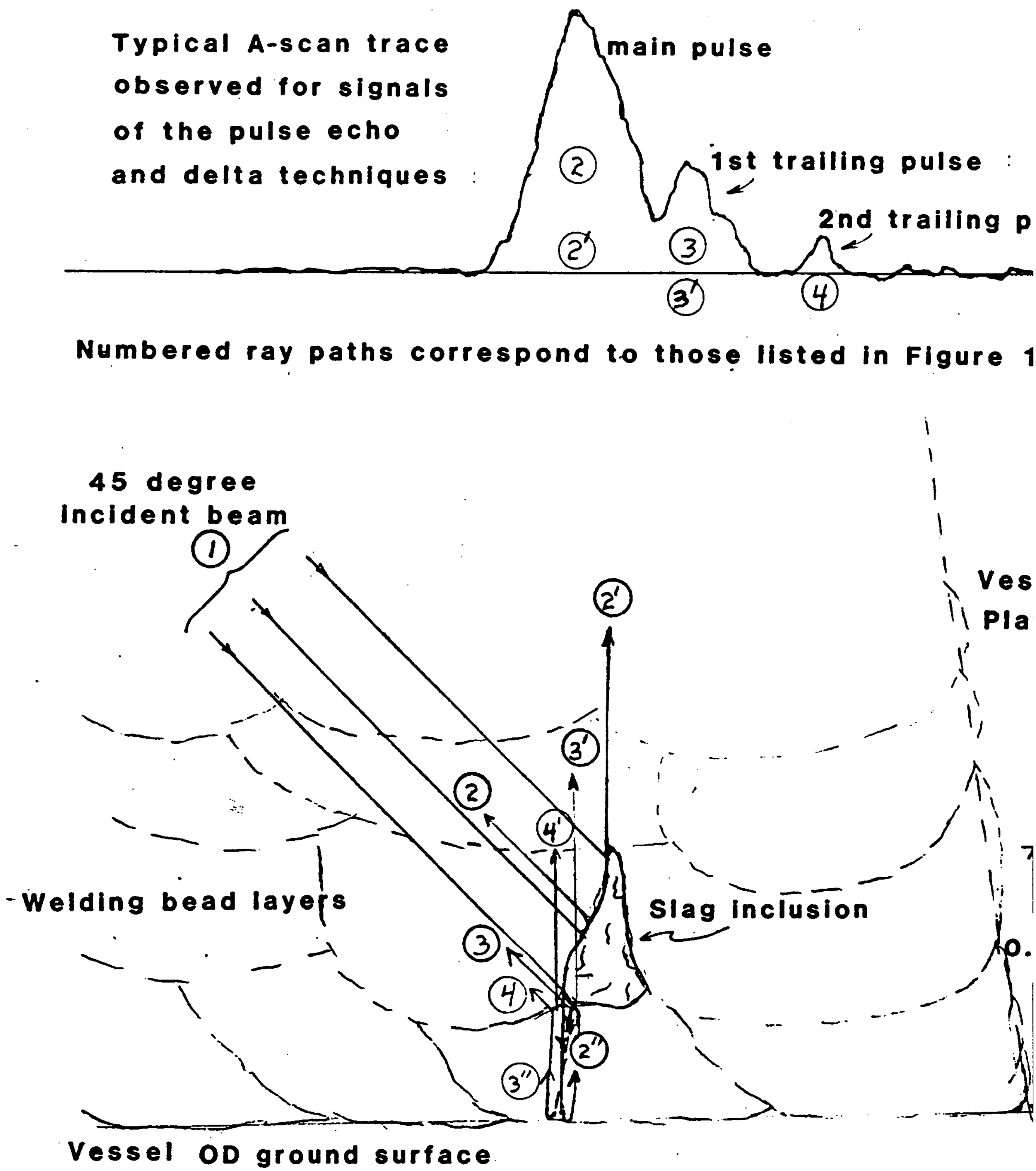

FIGURE 2. Characteristic A-scan for a Pulse Echo and Delta Transducer Configuration corresponding to the possible ray paths from a slag inclusion within the weld.