PDR

June 9, 1997

Mr. Sam Volk
Yankee Atomic Electric Co.
580 Main Street
Bolton, MA 01740-1398

50-444

Dear Mr. Volk:

The purpose of this letter is to forward to you part of a draft NUREG/CR report that documents work which was performed by PNNL staff at Seabrook Station Unit 2. In January 1996, Pacific Northwest National Laboratory (PNNL) staff, in conjunction with NRC Inspectors, participated in a field exercise aimed at evaluating a low frequency, long wavelength inspection technique for examining thick section, coarse grained stainless components. This field exercise allowed PNNL to acquire true field measurements of velocity and attenuation as a function of position on primary cast stainless steel piping under true field conditions and provided a basis for establishing a complete assessment of the utility and effectiveness of the low frequency/SAFT inspection technique. This exercise also greatly enhanced PNNL's database for cast stainless steel material thicker than 75mm.

The enclosed document only covers a portion of the work that PNNL performed and does not cover the work that the NRC staff performed. The rest of the information in the draft report is currently undergoing review at the NRC.

It is my understanding that Yankee Atomic and Northeast Utilities have an interest in how the SAFT-UT technology coupled with a new special low frequency transducer works on coarse grained stainless steel piping specimens containing known flaws and an interest in spending time at the EPRI NDE center reviewing this technology as it is undergoing further evaluation.

A copy of this letter and the enclosure will be placed in the NRC's public document room. If additional information is required, please contact Deborah A. Jackson of my staff at (301) 415-5887.

Sincerely yours,

/s/

Michael E. Mayfield, Chief
Electrical, Materials and Mechanical
Engineering Branch
Office of Nuclear Regulatory Research

DF01

Enclosure: As stated

cc: A. DeAgazio, PM for Seabrook
S. Doctor, PNNL
A. Diaz, PNNL

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Field Exercise: Seabrook Station Unit 2

During mid-January 1996, PNNL staff participated in a field exercise aimed at evaluating a low frequency, long wavelength inspection technique for examining thick section, coarse grained stainless steel components. The exercise was conducted in coordination with NRC Region I inspectors, Yankee Atomic personnel and Seabrook Station engineers. NRC Region I inspectors were conducting their own assessment of current industry standard inspections on CCSS components.

The opportunity to perform data acquisition using laboratory equipment in a field environment with NRC inspection personnel and utility personnel proved very educational. Limitations and constraints experienced by ISI personnel during a typical inspection became apparent, and this field test provided PNNL staff with a more realistic view of the many differences between laboratory experiments and actual field testing. The information acquired was very valuable and provided a foundation for a more complete discussion and assessment of the low frequency/SAFT technique from the standpoint of effectiveness, potential utility of the technique in the field, access and coupling limitations, environmental constraints, and a variety of other parameters arising under field conditions that do not typically exist in the laboratory.

The actual piping installed within the Unit 2 reactor consisted of four pressure vessel loops with a hot and cold leg elbow associated with each loop. The actual elbows (most oriented vertically with 40° bends) were the only components available for inspection, and these were statically cast elbows, not centrifugally cast, and no CCSS pipe-to-pipe or pipe-to-elbow sections existed. The surface geometries (on both the OD and ID) precluded PNNL staff from examining them with the large low frequency transducer as the unit was too big to couple to the elbow surface without being de-coupled by a surface ridge, lip, weld crown, or other surface anomaly. These elbows provided very little surface area near the weld that was conducive for implementing any scanning at any angle (except perhaps 0°) using the low frequency transducer. The radiographs that existed for loops 1, 2, and 4 were not useful as there were no indications or flaws (besides a gouged out area near one weld) that existed in these loops. Our consultations with NRC Region 1 inspectors were invaluable, and our expectations of obtaining reliable information using industry standard transducers and inspection protocol for detection and sizing remained unchanged as the work was conducted. The degree of material variability was quite high from component to component as indicated by velocity data acquired as a function of position and incident angle in these materials.

A calibration block (curved pipe-section) was provided by Seabrook Station engineers for testing and calibrating the automated data acquisition system. The calibration block consisted of a mixed columnar-equiaxed macrostructure with a 1.27 cm. (1.0 in.) long axially machined notch, 0.635 cm. (0.25 in.) in width and 10% deep, and a second notch of circumferential orientation also 1.27 cm. (1.0 in.) long, 0.635 cm. (0.25 in.) wide, and 10% deep. These notches were spaced far apart from each other and at least 5.08 cm. (2.0 in.) from the nearest edge of the block. The calibration block was 7.62 cm. (3.0 in.) thick, 27.94 cm. (11.0 in.) wide, and 27.94 cm. (11.0 in.) in length. Velocity measurements were acquired as a function of spatial position on the calibration block at 0° incidence, and the average of seven individual longitudinal wave measurements was 0.5890 cm/µs (0.2319 in/µs). The wavelength at 350 kHz was 1.68 cm.

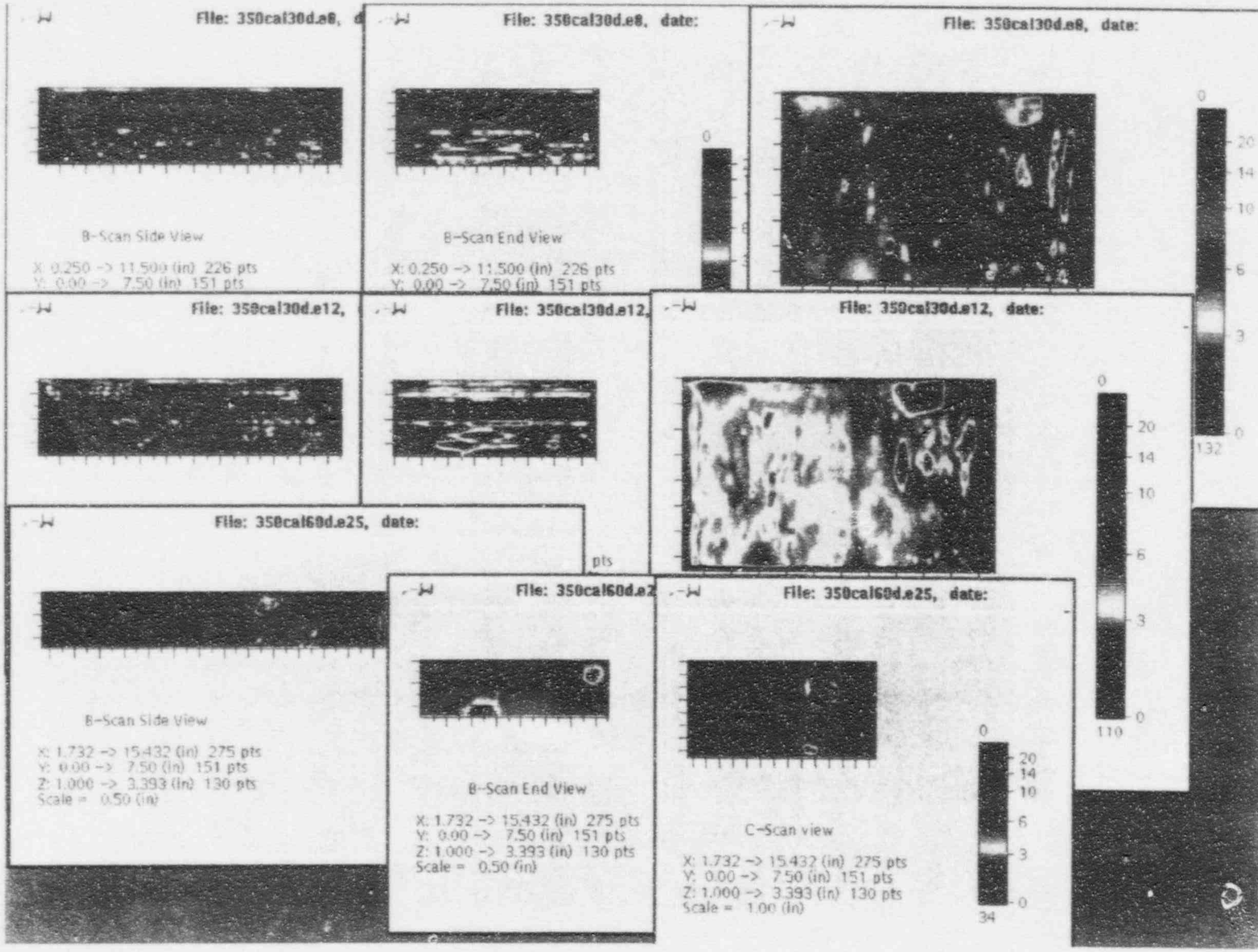
(0.663 in.). The calibration block also contained two sets of side-drilled holes, (1/4 T, ½ T, and 3/4 T for each set) with one set oriented axially and the other set oriented circumferentially. The side-drilled holes were 0.318 cm. (0.125 in.) in diameter and 5.08 cm. (2.0 in.) in length.

Image B.28 illustrates the 30° and 60° incident signal responses from the scans of the entire calibration block at Seabrook Station Unit 2, during the field exercise. The image consists of three rows of snapshots where the top two rows represent the 30° examination at 8° and 12° beam processing angles, respectively. The bottom row represents the signal responses from the 60° examination of the calibration block processed at a beam processing angle of 25°. The calibration block had large areas of the top surface that were bowed and rough. Even in water (immersion tank), this proved to be a problem as the signal response would tend to degrade (lower amplitude) over these areas. The noise conditions due to coherent backscatter of the material structure were high throughout the sample. The top row shows the three composite views where the tip of the axial notch is evident, the entire circumferential notch is evident, side drilled holes are evident, and the corner trap response is also evident. Although the corner trap response is not as continuous as expected, the experimental conditions and the surface discontinuities played an important role in degradation of the signal over large portions of the scans. Sizing information from this data set was quite accurate as the circumferential notch measured 10% deep and 2.54 cm. (1.0 in.) long. This corresponded exactly with the actual depth and length. The middle row represents the 12° beam processing angle of the same data set and shows a higher amplitude response from the side-drilled holes and the notch, but resolution is lost with regard to the corner trap and the axial notch tip. Sizing of the circumferential notch was also very accurate for this processing angle. The bottom row (60° exam) shows composite views that exhibit much lower noise conditions, but the dynamic range is also quite low. The side drilled holes running perpendicular to the direction of the scan (x-axis) are now no longer evident, however, the side-drilled holes that run parallel to the scan direction (x-axis) are evident. The tip of the axial notch can no longer be seen either, however, the circumferential notch and a high amplitude signal response from the corner trap are very evident. Sizing of the circumferential notch was also quite accurate with a 10% depth measurement and a 2.36 cm. (0.93 in.) length measurement.

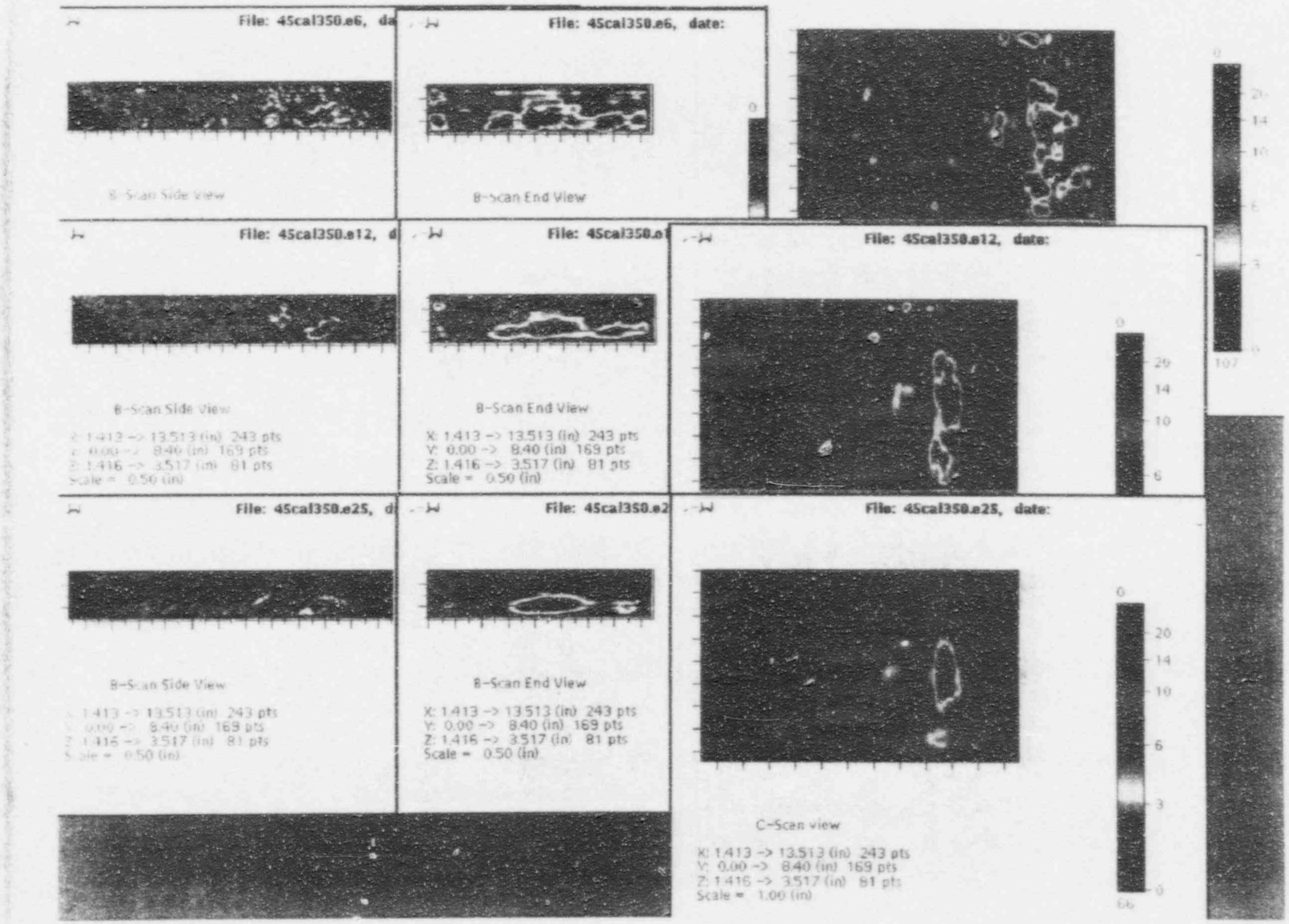
Image B.29 shows the 45° incident signal responses from the scans of the calibration taken at Seabrook Station Unit 2 during the field exercise. The image consists of three rows of snapshots where each row represents the same raw data set (taken at 45°) but processed at three different SAFT beam angles. The top row represents the 6° processing angle, the middle row represents the 12° processing angle, and the bottom row represents the 25° beam processing angle. The top row shows the capability for detection of the circumferential notch, the corner trap and the perpendicular side-drilled holes, as does the middle row. Noise conditions appear to be somewhat lower than the 30° and 60° data sets, however, coherent backscatter due to material structure is still evident here. The corner trap responses for these images are all fairly continuous and of high amplitude. The bottom row exhibits lower noise conditions and shows the tip of the axial notch as well as the perpendicular side-drilled holes, the circumferential notch, and the corner trap. The best sizing information was retrieved from the 6° and 12° processed files. The circumferential notch measured 10% in depth and 2.54 cm. (1.0 in.) matching exactly the actual dimensions of the notch.

Analysis of the data while at Seabrook Station indicates that the low frequency/SAFT technique is more promising for detecting indications than the standard inspection protocol currently used by industry. A side-by-side comparison was conducted of transducers ranging from 350 kHz to 1.0 MHZ as a function of material structure, flaw size and geometrical reflectors, frequency, beam processing angle, etc. A calibration block supplied by the utility was inspected as were a number of Westinghouse Owner's Group (WOG) CCSS specimens. The low frequency/SAFT technique was the only method that provided good detection, localization and sizing data for a 10% deep, 0.318 cm. (.125 in.) thick, 2.54 cm. (1.0 in.) long circumferential notch in the calibration block. Analysis of the data showed our length measurement of the notch as 2.54 cm. (1.0 in.) and the depth measurement of the notch as 10%. This technique also identified the axial notch and proved useful for detecting 1/2-T and 3/4-T side drilled holes (0.318 cm. diameter) in both orientations, as well as a continuous corner trap response over the width of the calibration block at 45°, and semi-continuous responses at 30° and 60°. The WOG specimens presented a variety of obstacles for the low frequency-SAFT method due in large part to the size of the search unit. The search unit is 10.80 cm. (4.25 in.) in length, 12.7 cm. (5.0 in.) in width, and 8.89 cm. (3.5 in.) in height. The surface geometries on the OD surface of the WOG specimens often precluded PNNL staff from examining the welds with the full contingent of incident angles, and on two occasions only a far-side inspection using a single angle of incidence could be performed. The transducer was too large to complete even a 2.54 cm. (1.0 in.) path on some specimen surfaces without being de-coupled by a surface ridge, lip, weld crown, or other surface anomaly. Some data was acquired on the WOG specimens, and existing cracks were detected in most cases, however, depth information was poor in comparison to actual depths. More work is needed to fully assess the field utility of this technique.

It became evident during data analysis that CCSS data interpreters should be trained using some set of consistent criteria for discriminating flaw indications from material structure or geometrical indications. Variability between interpreters using the same data set was evident. Low frequency data acquisition was limited due to ID and OD surface geometry constraints. Immersion testing was implemented on-site as the problem of coupling the large transducer, under very cold conditions using ultragel, was insurmountable. A water tub was used to take data using the low frequency transducer. In order to carry out more conclusive evaluations using this technique, it is recommended that a blind test be performed using a search unit of smaller design with similar characteristics. A blind test should utilize field representative pipe sections with fabricated flaws that dimensionally approach critical flaw sizes in these components.



B.28 SAFT images from 30° and 60° incident signal responses



B.29 SAFT images from 45° incident signal responses