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AMES LABORATORY Energy & Mineral Resources Research Institute

Iowa State University | Ames, Iowa 50011

June 12, 1985

JUN 17 1985

Dr. E. G. Igne, Staff Engineer
Advisory Committee on Reactor Safeguards
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Al:

Enclosed please find a report on my recent trip to Charlotte. If you have any questions, please don't hesitate to call.

Sincerely,

Bruce

R. Bruce Thompson

RBT/dfb
Enclosure

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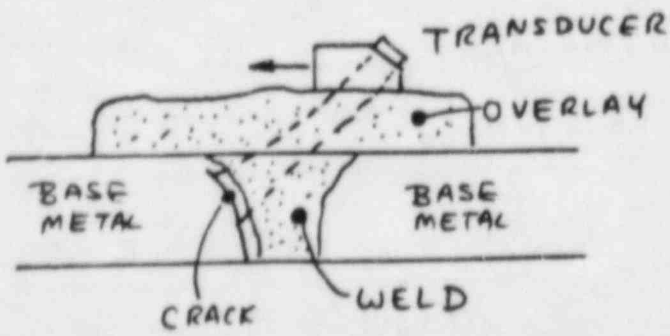
TRIP REPORT
EPRI Workshop for the NRC on Ultrasonic Pipe Inspection Issues
EPRI NDE Center
June 5-6, 1985

The agenda for the workshop is attached as Appendix A. Reviews of progress being made in the inspection of four problem areas were presented: weld overlays, corrosion resistant clad (CRC), bimetallic welds, and centrifugally cast stainless steel pipe. Included was the opportunity for hands-on experience by the attendees. Summaries of the status follows.

Weld Overlay: This discussion was presented by G. Selby of the NDE Center. The goal was to demonstrate the detection and sizing of a) cracks in the outer 75% of the base metal and b) cracks in the overlay. The primary technique selected was a shallow angle refracted longitudinal wave. This was preferred over shear waves because of the smaller influence of the elastic anisotropy of the overlay on the ultrasonic propagation. A complete protocol had not yet been developed. 60° L probes were shown to be effective for base metal cracks. The procedure is sketched below. The 60° angle has been selected to allow the beam to strike the crack surface at near normal incidence, so that an easily



recognized return signal is obtained. As the probe is moved to the left (as indicated by the arrow), the beam moves toward the tip of the crack. The reflection then starts to drop in amplitude as the beam passes off of the crack. A correlation has been developed between thickness of the remaining ligament and the time of arrival of the signal produced when the probe has been translated sufficiently to drop the signal strength by 3dB.

This technique gave reasonable results on cracks (simulated IGSCC's as grown by ISI) 50-100% through the base metal in a subsequently overlayed pipe. Detection was good and oversizing was typical with errors on the order of .050" to .080". Shallower cracks, less than 20% of base metal thickness, were difficult to detect. It was emphasized that these were not of interest in an overlayed pipe. EDM notches in the base metal, which were subsequently grown through the clad, were readily detected using a different, dual beam probe. As the cracks approached the through-wall condition, depth resolution became poorer. However, it was claimed that this was not a problem since such flaws were already well beyond the depth at which they would be rejectable. Results were also reported for automated inspections. In general, similar defects could be detected, although deficiencies were noted in cases in which a manual operator would have fine tuned the transducer orientation to maximize a signal.

It was emphasized by the NDE Center personnel that some degree of preparation of the as welded overlay surface was essential to the attainment of good results. It was shown in the demonstrations that a) excellent results could be obtained on a ground surface and b) the

results on a rough overlay surface were totally unacceptable. An intermediate level of surface preparation was shown to produce results which were probably acceptable, but no firm criteria for the required finish have been yet received.

A careful study of the effects of crack orientation, and hence of the existence of the strong specular signal which is monitored in the technique, has not been performed.

One of the factors associated with the difficulty in detecting the shallow cracks were the compressive stresses induced on the inner pipe surface by the overlaying technique. Micrographs of deeper cracks suggested that there was also an apparent opening of the tip of deeper cracks, which might suggest that these were being placed in tension. It would appear that the significance of this with respect to failure should be evaluated further if it has not already been considered.

A major motivation for this work is the utilities desire to consider the weld overlay repair (WOR) as a long term rather than short term remedy. Consequently, all of the above and much more is documented in the EPRI (DRAFT) INTERIM Report of April, 1985 entitled, "Examination of Weld Overlayed Pipe Joints", by Becker et al.

Corrosion Resistant Clad Piping: F. Ammirato and S. Walker discussed the inspection of corrosion resistant clad piping. As in the overlay case, refracted longitudinal waves were used to minimize the effect of elastic anisotropy. Samples were included from Hope Creek (12 and 27 inch diameter piping) and Perry (16, 22, and 24 inch diameter piping) mockups. The cracks were induced by an EPRI technique whose details were not discussed. In general they were open and

undulating, and hence produced relatively easy to detect reflections (with respect to IGSCC's). Crack positions included were just below the clad interface, just above the clad interface, at the center of the base metal, and just below the overlay interface. It had been found that shear wave examination was unreliable. Using refracted longitudinal waves, the ID corner crack signal was poor but that diffraction/reflection from the crack tip produced an adequate signal for detection with promise for sizing.

The laboratory observations generally confirmed these conclusions. However, some non-ideal situations were observed. For example, a 1/8 inch crack produced a larger signal than a 1/4 inch crack, with the latter being difficult to differentiate from noise even under these ideal laboratory conditions. A 45° probe produced larger signals from flaws, but was also more likely to give false calls than a 60° probe. Thus a multiple probe procedure might be indicated although ALARA concerns would have to be considered. It is not known what field induced crack might look like. Should they have tighter tips, the results might not be as good. Despite these caveats, it was an encouraging first demonstration.

Dissimilar Metal Welds in Safe-Ends: F. Ammirato also discussed recent progress in this area. Again, it was found that refracted longitudinal waves produced better performance than shear waves because of the lower attenuation and more isotropic velocity. This was primarily true in the weld metal, where even a corner reflection could not be detected with shear waves. However, it was found that the conventional shear wave technique could be used to inspect the base metal on either side of the weld.

It was reported that refracted, longitudinal search units were capable of detecting axial notches in weld metal with depths of 10% wall thickness or greater, with optimum probe parameters being component specific. Shallow angles provided the best detection for deep flaws but could miss shallow flaws. Steep angles could detect flaws down to 10% depth but sometimes showed low signal-to-noise. Depth determination, based on arrival times was possible with an rms error of 0.06 inches. Automatic scanning was successful.

Theoretical estimates of radiography performance indicated that MINAC could detect axial IGSCC's with 40% or greater depth. However, the precise alignment of the beam with the crack plane would require that exposures be made very 10° around the pipe.

All of the above comments are based on the oral presentation. Only a limited number of probes and flaws were present in the hands-on portion of the workshop. The results obtained in the laboratory were consistent with those quoted above. However, the small numbers of experiments is not sufficient to establish the generality of the conclusions. As in the CRC problem, it would appear to represent a good start with more detailed work required.

Case Stainless Steel Piping: As has been previously suggested, this appears to be a very difficult problem. M. Behravesh of EPRI discussed the present status of the EPRI activities, with emphasis restricted to centrifugally case (CCSS) materials. Included were a survey of possible flaw types, a survey of the available literature on UT of CCSS, acquisition of CCSS specimens, and UT characterization of this material.

Among the conclusions were the suggestions that weld repairs during manufacture and installation, which are common and not adequately controlled and documented, may be one of the most likely areas of fatigue initiation. However, it was claimed thác even material having long term ductility loss would be tolerant of significant flaws under design loading (30 inch pipe: 360° long 66% wall or 10 inch long 100% wall).

If this is true, it is indeed fortunate because the ultrasonic experiments confirmed the difficulty of the task. The EPRI data showed that the attenuation rose rapidly with frequency and varied considerably from point to point. This implied low test frequencies, as was confirmed by the hands-on demonstration. Using 0.5 MHz and 1 MHz, 45° refracted longitudinal wave probes, rather gross flaws could be detected with low signal-to-noise ratios and careful probe manipulation. The fieldability of the technology as it stands today is not evident.

General Comments and Discussions: In group discussions, a number of issues and concerns were raised by EPRI and NRC.

1. Sample Availability. Behravesh discussed difficulties in obtaining samples and expressed that this would preclude an extension of the extensive testing done in the IGSCC training course to other problem areas such as CCSS. It was noted, however, that EPRI has developed a cracking techniques, as used in the CRC samples, which could be used in selected situations.

2. Confidence in IGSCC Detection. NRC representative expressed concerns that the field implementation of IGSCC detection and sizing

techniques is eroding. "Horror stories" were presented describing operators who claimed to have used the dB drop technique for depth determination, something which is strongly discouraged in the NDE center training course. Similar examples of problems with length determination were cited. It was speculated that the lower visibility of this problem has caused some backsliding and the possibility of retraining was discussed.

3. Multiple Results. In a related matter, the problem of deciding how to act when significantly different results are obtained by different qualified inspectors was discussed.

4. Demonstration on CRC. Preliminary discussions were held regarding what would constitute a satisfactory demonstration of operator capability on CRC. Since the demonstrated techniques use refracted L waves in new ways, some additional training is required. However, the exact form of this, and of the subsequent competence demonstration, remains open.

5. Overlay Machining. It was agreed by all that overlay machining would be necessary before taking credit for its use as a long term remedy. The details of how to implement this requirement were not resolved.

6. Qualification of Procedures Versus People. A short discussion of this issue was held with no firm conclusion.

R.B. THOMPSON

APPENDIX A

WORKSHOP
FOR THE NRC ON ULTRASONIC PIPE INSPECTION ISSUES
EPRI NDE CENTER
CONFERENCE ROOM C
CHARLOTTE, NORTH CAROLINA
JUNE 5-6, 1985

Wednesday, June 5, 1985

8:30 a.m.	Welcome and Introduction	Gary Dau
8:45 a.m.	Presentation and Demonstration on Weld Overlay Inspection	Larry Becker Greg Selby
10:45 a.m.	Break	
11:00 a.m.	Presentation and Demonstration on Corrosion Resistant Clad (CRC) Inspection	Frank Ammirato Stan Walker
12:00 Noon	EPRI/BWROG/NRC Coordination Plan Update	Gary Dau
12:45 p.m.	Lunch	
1:45 p.m.	Laboratory Demonstration	
2:45 p.m.	Centrifugally Cast Stainless Steel Pipe Inspection	Mohamad Behravesh
3:15 p.m.	Bimetalic Weld Inspection	Frank Ammirato
4:15 p.m.	Sample Availability	Mohamad Behravesh
4:30 p.m.	Discussion	All
5:00 p.m.	Adjourn	

Thursday, June 6, 1985

8:30 a.m.	Breakup of Groups for Laboratory Hands-On	NDEC Staff
8:45 a.m.	Laboratory Hands-On	All
12:00 Noon	Lunch	
1:00 p.m.	Adjourn	
1:00 - 5:00 p.m.	Additional Opportunity for Hands-On	