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June 24, 1994
VPLTR 94-0027

Mr. William T. Russell, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attn: Document Control Desk

Subject: Dresden Nuclear Power Station Unit 3
Quad Cities Nuclear Power Station Unit 1
Clarification of Ultrasonic Examination Methods Used at Dresden Unit 3 and Quad Cities Unit 1 to Address Core Shroud Cracking at the H5 Weld
NRC Docket No. 50-249 and 50-254

Reference: Meeting between Commonwealth Edison (J. Williams, P.Piet, et. al.) and the NRC Staff (R. Capra, T. Sullivan, et. al.), dated June 21, 1994.

Dear Mr. Russell:

In the referenced meeting, ComEd met with the NRC staff to discuss issues concerning the core shroud cracking at Dresden and Quad Cities Stations. During the meeting, ComEd discussed specific issues regarding the ultrasonic (UT) examination methods used to establish the depth of uncracked material in the core shrouds. The purpose of this letter is to supplement material presented during the referenced meeting and to present ComEd's exclusion zone approach (attached).

ComEd's approach is based upon the receipt of consistent geometry signals when examining the H5 fillet weld with UT. If a flaw were to penetrate the sound path of the transducer during the examination of the inner diameter (ID) of the fillet weld region, recognizable responses would be detected. The exclusion zone approach is similar to that utilized by the EPRI NDE center to detect Intergranular Stress Corrosion Cracking (IGSCC). ComEd's approach is discussed in more detail in the attachment to this letter.

The NRC staff expressed concerns regarding the potential transparency of a flaw using ComEd's approach near a crack tip. It was noted that this phenomenon may have occurred during the qualification of other plants' core shroud UT techniques. ComEd's methodology detected shallow crack indications along with the ID fillet weld using 45° shear wave UT. These flaws were determined by boat sample evaluation to be IGSCC, demonstrating the detectability of IGSCC with 45° shear wave UT. Because the ID fillet weld was observed in each of the more than 2000 stepped

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transducer scans performed on the H5 weld, it is unlikely that a crack-like defect intersecting the central beam path would remain transparent along the entire inspected length.

The exclusion zone approach requires that no significant cracking be present at the inside surface of the H5 weld. ComEd did not identify any indications of cracking during the UT examinations of the H5 welds at Dresden Unit 3 or Quad Cities Unit 1.

Therefore, ComEd concludes that the exclusion zone approach is a valid and conservative technique for determining a bounding crack depth for the H5 weld, because: the ID fillet weld was consistently identified during the UT examinations; the metallography results show the cracks to be relatively open and exhibit grain encirclement, and the technique is very sensitive to grain boundaries; the bounding flaw represents the largest flaw that could possibly exist; and flaws shadowing the root is an established flaw detection method.

To the best of my knowledge and belief, the statements contained in this response are true and correct. In some respects, these statements are not based on my personal knowledge, but obtained information furnished by other ComEd employees, contractor employees, and consultants. Such information has been reviewed in accordance with company practice, and I believe it to be reliable.

Please direct any questions you may have concerning this response to this office.

Sincerely,

M. D. Lyster

Michael D. Lyster
Site Vice-President
Dresden Station

Attachment: Ultrasonic Examination Methods - Dresden Unit 3 and Quad Cities Unit 1

cc: J.B. Martin, Regional Administrator - RIII
C. Miller, Senior Resident Inspector - Quad Cities
M.N. Leach, Senior Resident Inspector - Dresden
C.P. Patel, Project Manager - NRR
~~J.F. Stang, Project Manager~~ - NRR
R. Hermann, NRR
Office of Nuclear Facility Safety - IDNS

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June 24, 1994

Mr. Joe D. Williams, Project Manager
Dresden Shroud Project
Dresden Nuclear Power Station
ComEd

Subject: Ultrasonic Examination Methods Report, Dresden 3 and Quad Cities 1.

Dear Mr. Williams,

Attached please find the Subject Report, as authored by Mr. Tony R. Jaschke, GE Nuclear Energy UT Level III.

The report describes an alternate approach to establishing with certainty the depth of uncracked material in the Core Shroud H5 Weld of the subject reactors.

John E. Nash
GE Site Services Manager
Dresden Station

ULTRASONIC EXAMINATION METHODS

As used at Dresden 3 and Quad Cities 1

Introduction

An inconsistency between the depth of flaws determined by UT sizing techniques versus the actual measured depths determined by examination of boat sample cross-sections was discovered at the H5 weld location during the recent ultrasonic examination of the Dresden 3 and Quad Cities 1 shrouds. An alternate approach was developed to establish with certainty the depth of uncracked material in the shroud. This alternate approach is identified as the exclusion zone approach and is the subject of this report.

45° shear wave exclusion zone

The examination recorded fillet weld geometry with both the 45° shear (as well as 60° RL) transducer, because of the shroud geometry at the H5 weld (see Figure 1). The geometry signals were from the fillet weld on the ID surface. This weld geometry gave an excellent benchmark indication on the system C-scan using both 45° shear and 60° RL search units. It is the 45° shear that is used as the primary exclusion zone transducer.

Figure 2 shows the 45° sound pattern including beam spread and how it can insonify the entire ID fillet weld region. The technical basis for establishing an exclusion zone is the fact that during normal examination of the weld, geometric signals were consistently recorded from the fillet weld. If a flaw were to penetrate the sound path of the 45° transducer while the transducer was insonifying the ID fillet weld region, 2 responses would be recorded on the acquisition system:

1. The response amplitude from the ID fillet weld region would be noticeably reduced by the flaw.
2. An indication response of the shorter metal path to the flaw, than to the ID fillet weld, would be observed.

During acquisition and analysis of these data, the examiner and analyst would recognize these indication responses and record them as part of the final data package.

This detection method is directly analogous to techniques taught at the EPRI NDE center for IGSCC detection. For example, when an operator finds a signal that obscures the response from the weld root geometry, he can be confident that the signal is a crack. Conversely, if no signal obscures the response from the weld root geometry, it is concluded that no crack is present between the 45° shear wave transducer and the weld root. This premise is fundamental to IGSCC crack detection using a 45° shear wave. Figure 3 below displays this concept for the H5 weld configuration. In this case a flaw intersects the 45° sound beam at its mid point, obscuring ~ 50% of the sound energy, which would both reduce the amplitude response from the ID fillet weld, and produce a response from the flaw at a shorter metal path.

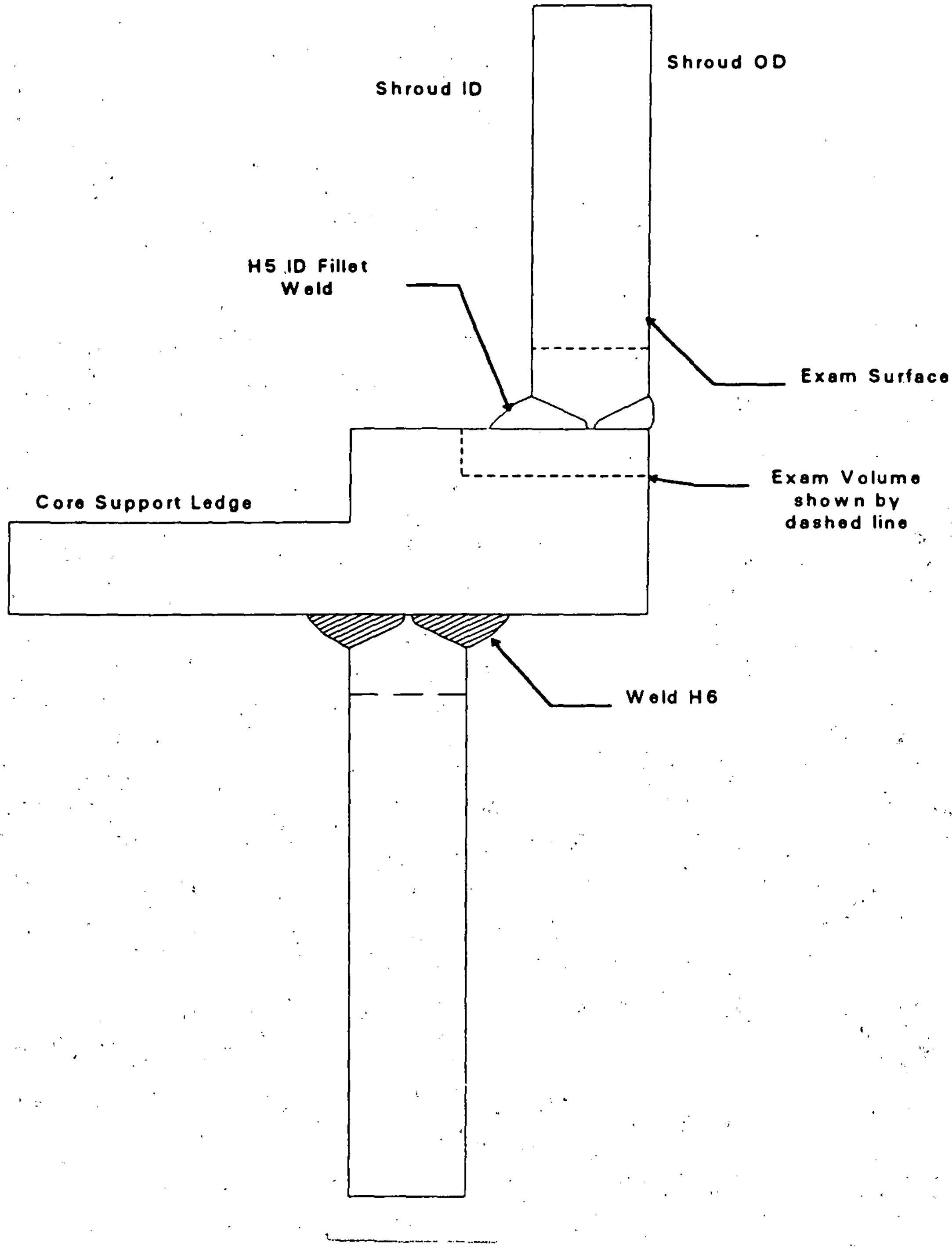

Figure 1 - H5 Weld Geometry

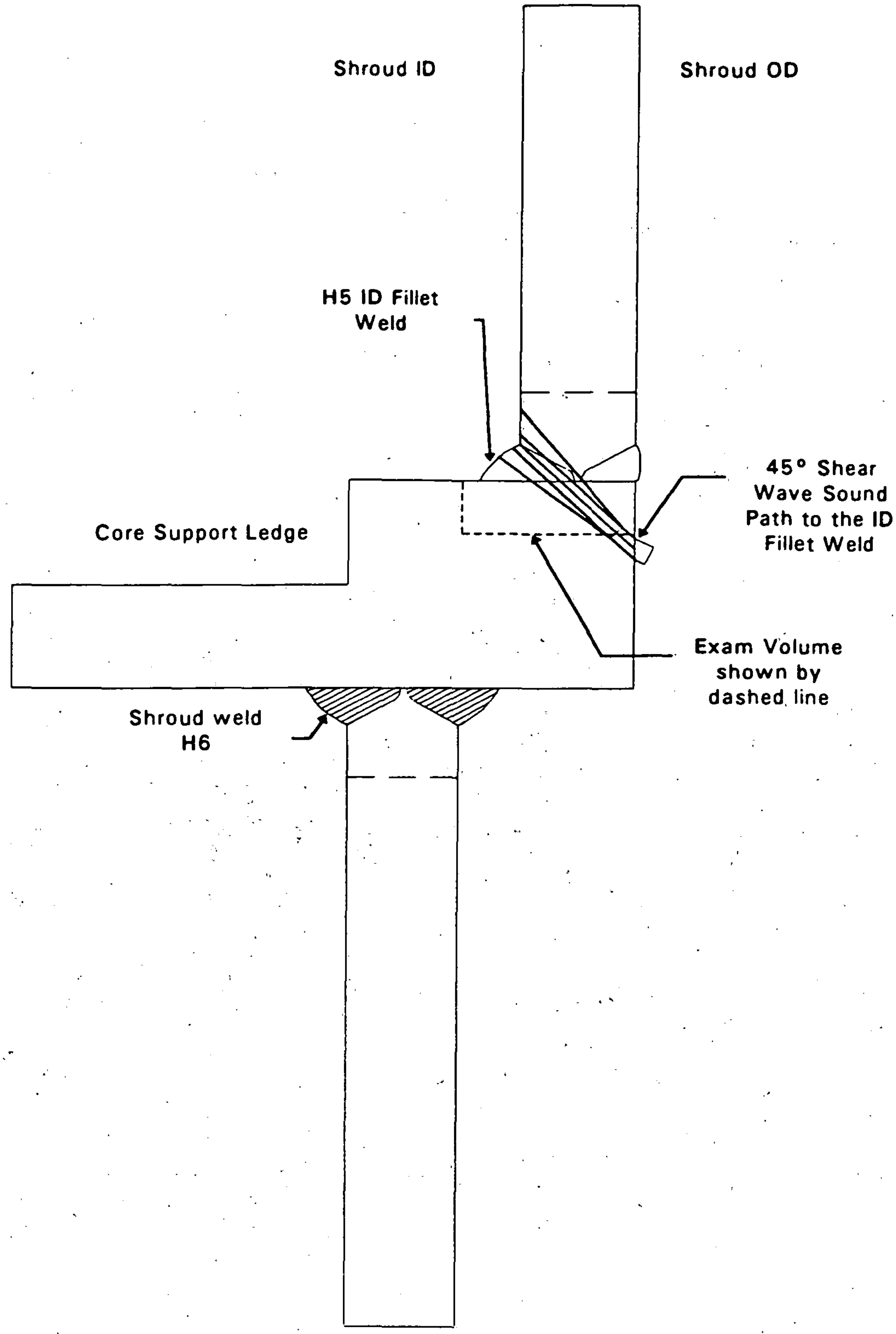

Figure 2 - 45° Shear Wave No Flaw

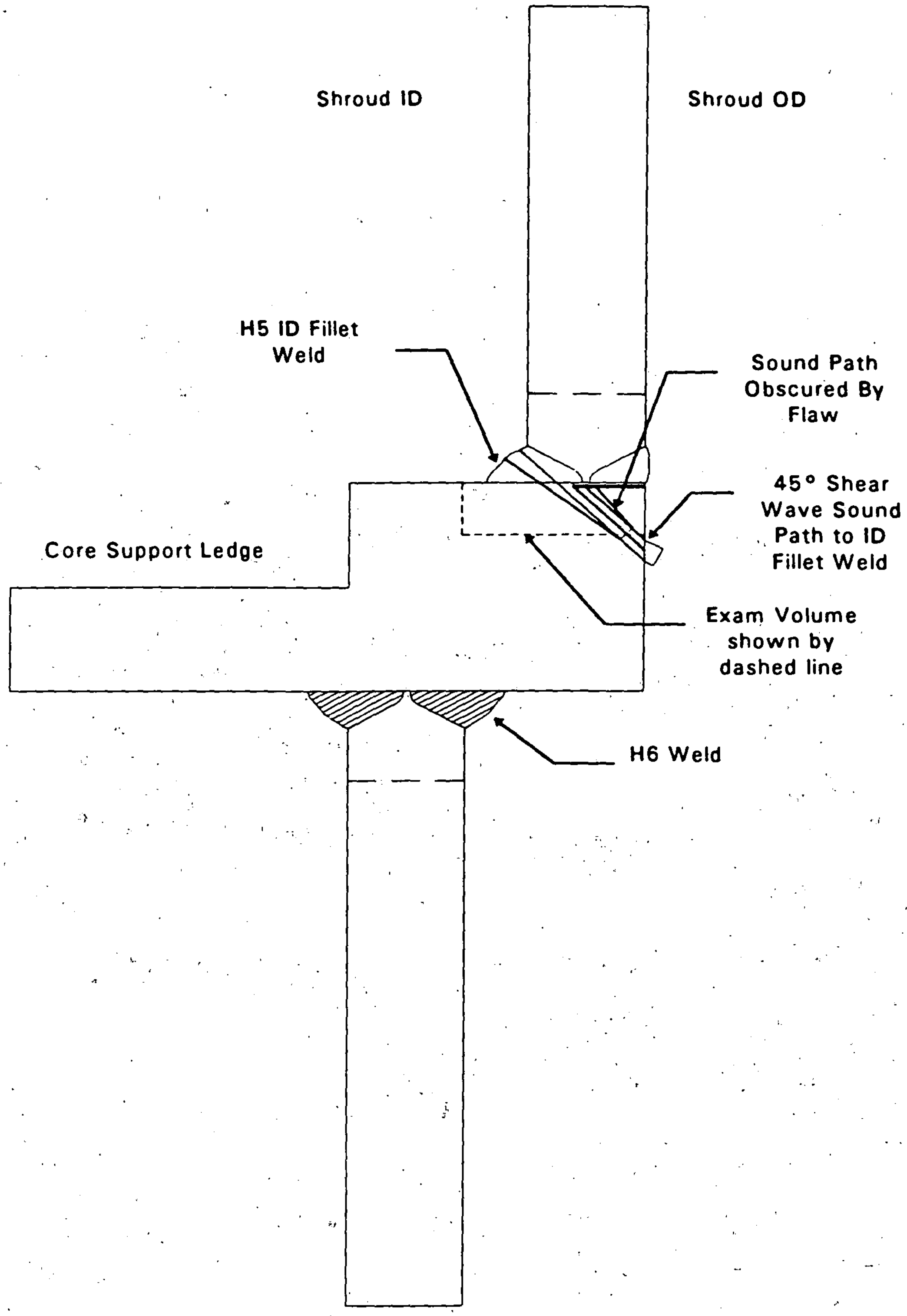

Figure 3 - 45° Shear Wave with Flaw

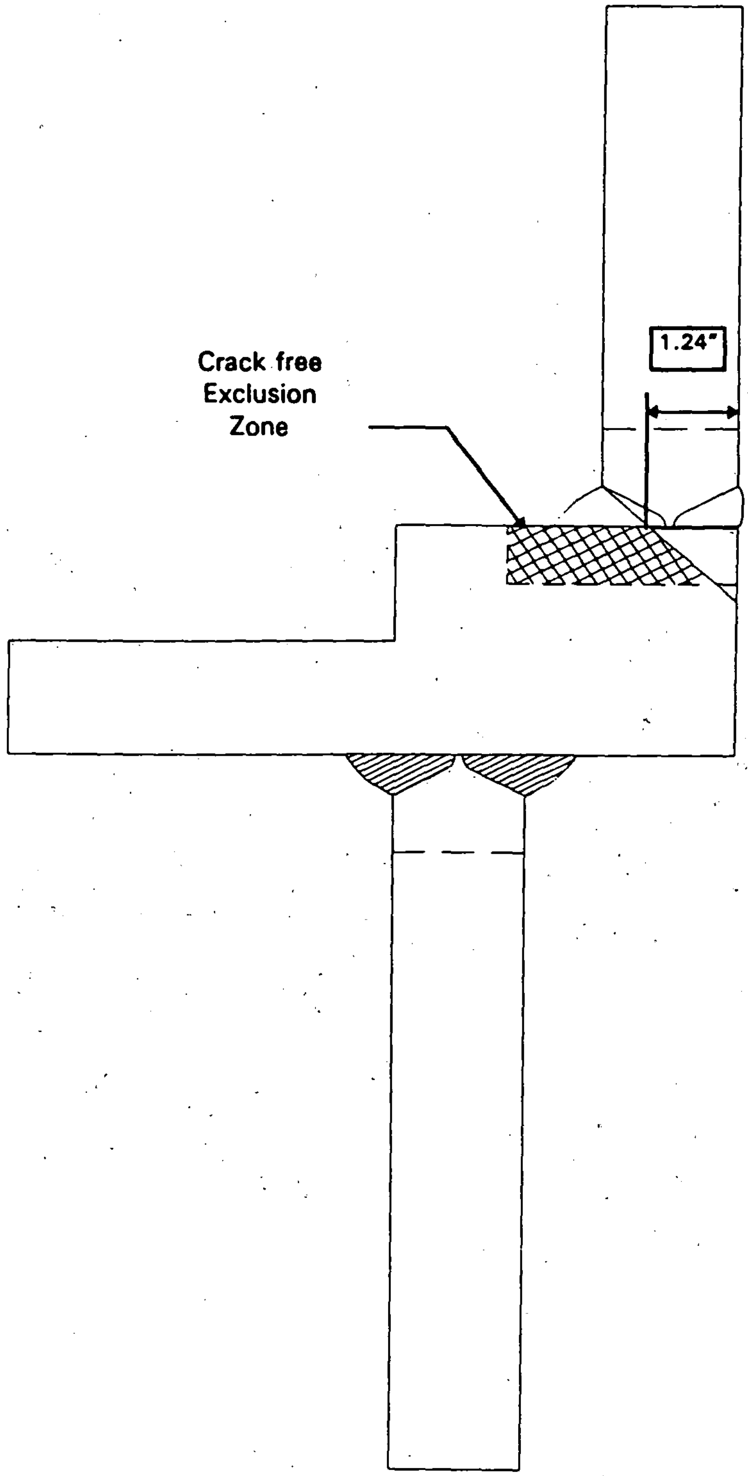

Figure 4 - Definition of "Crack Free" Exclusion Zone Based on 45° Shear Wave Examination

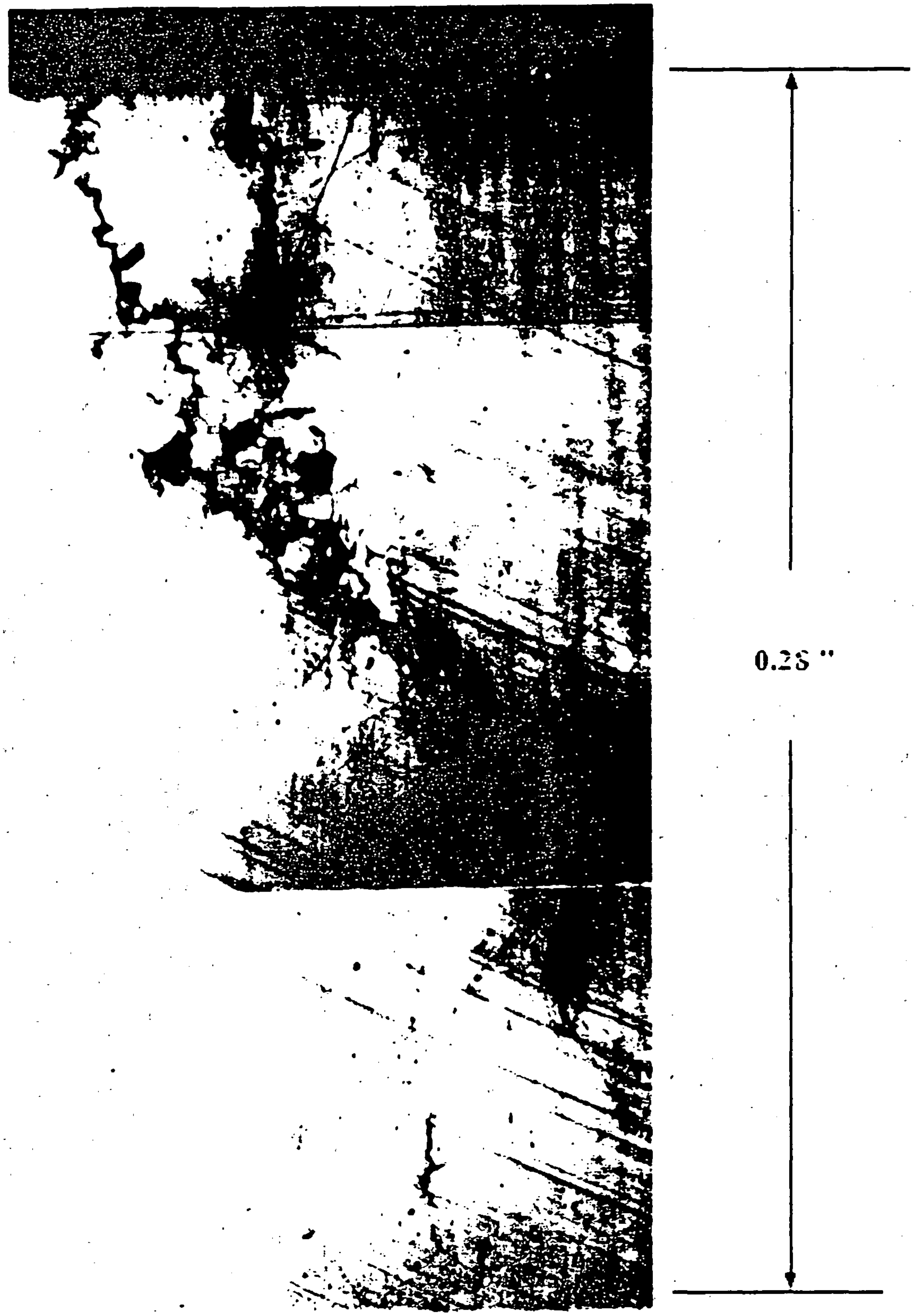

Figure 5 - Quad Cities Unit 1, 154 Degree Azimuth Showing Intergranular Cracking, Branching and Grain Encirclement

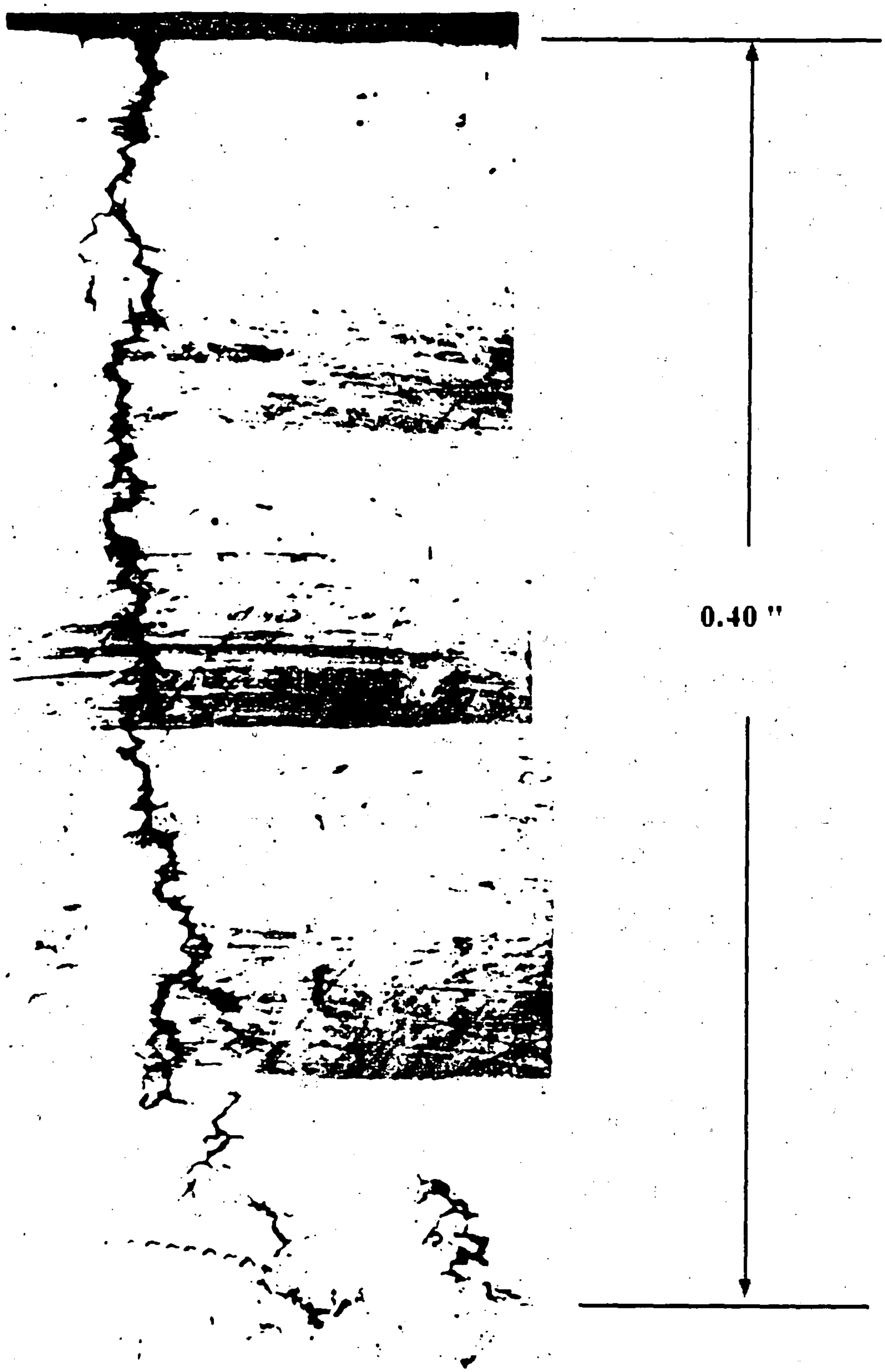

Figure 6 - Quad Cities Unit 1, 342 Degree Azimuth Showing Intergranular Cracking, Branching and Grain Encirclement

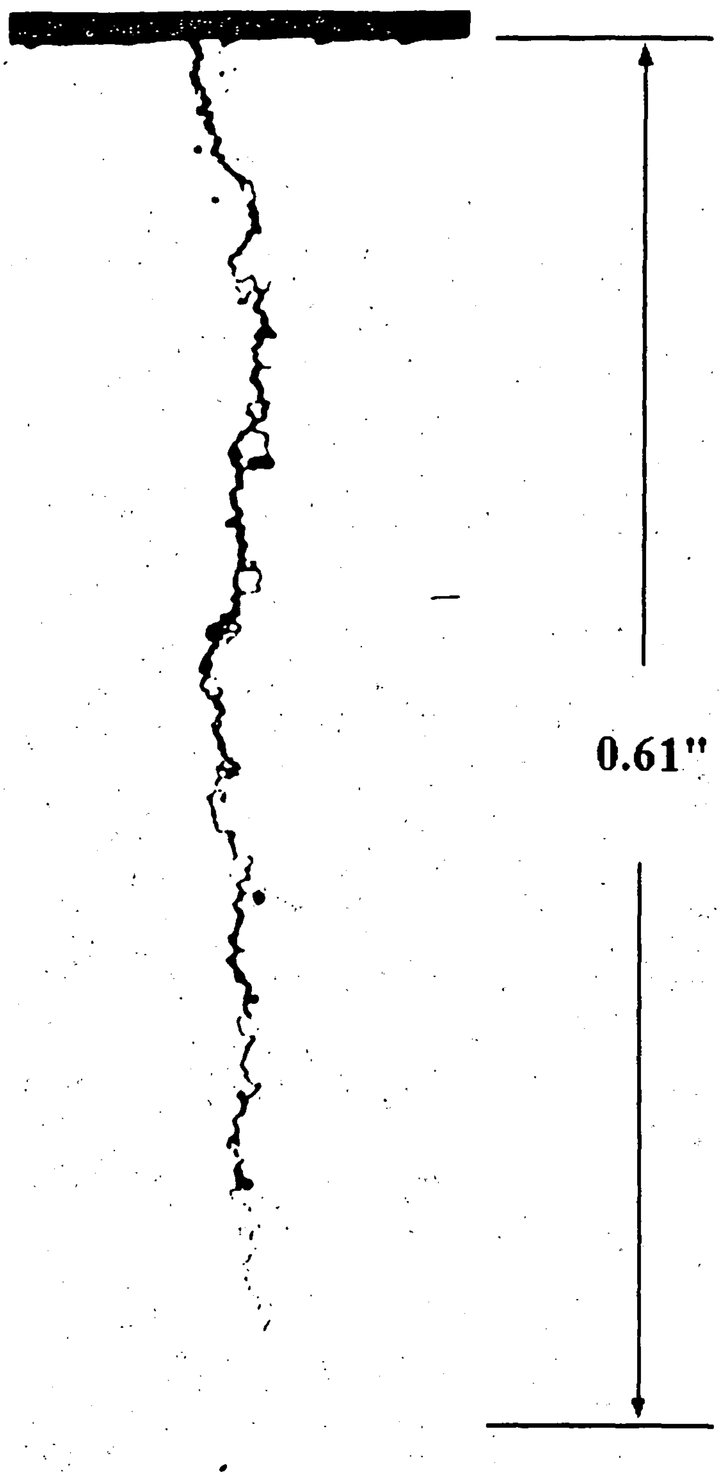

Figure 7 - Dresden Unit 3, 153 Degree Azimuth Showing Open Intergranular Cracking and Minor Branching

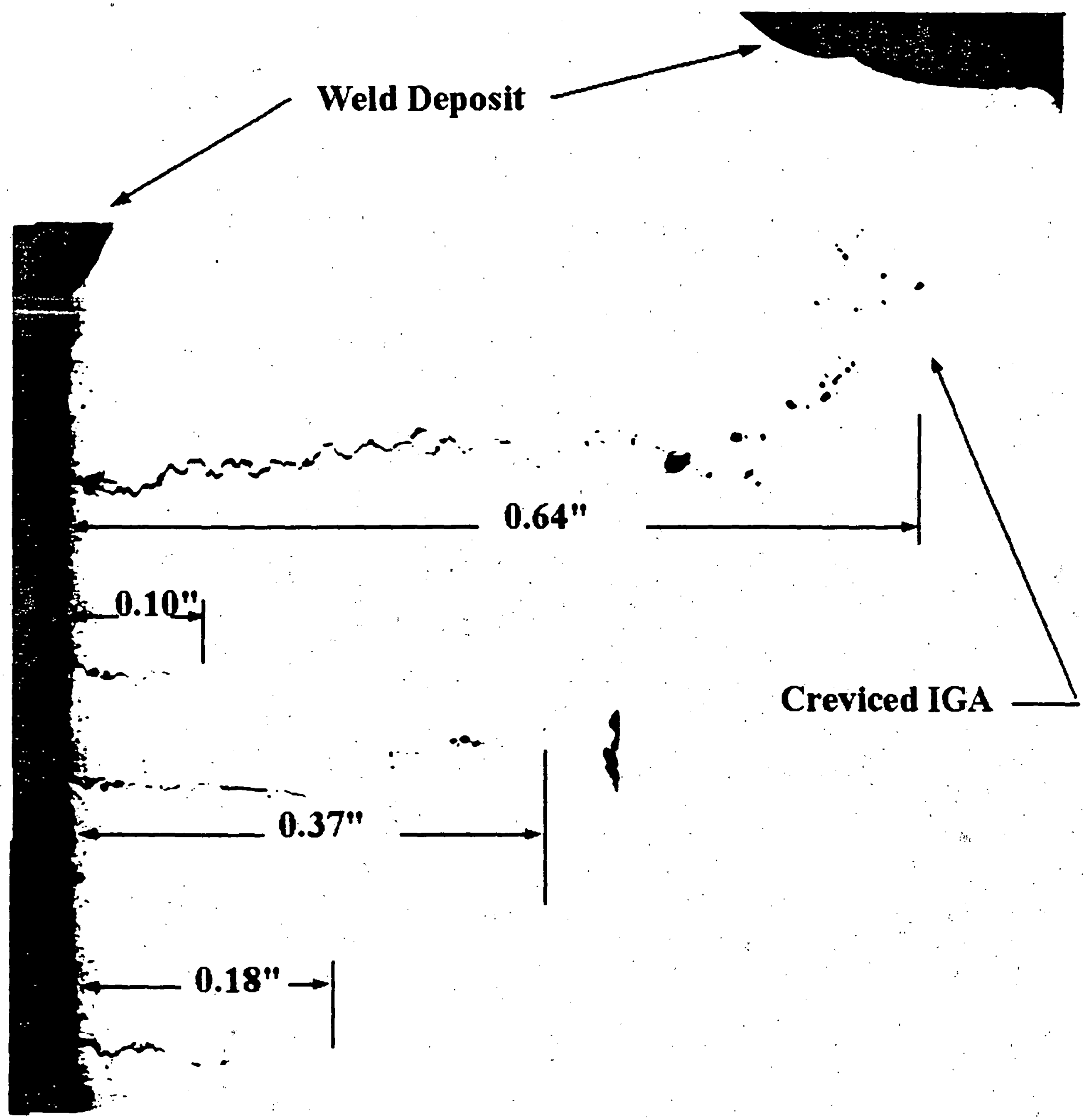

Figure 8 - Dresden Unit 3, 324 Degree Azimuth Showing Multiple Crack Initiation, Open Cracks, Branching and Grain Encirclement

Transmission of sound through flaws

A note of concern for the exclusion zone approach has been raised based on the notion that the crack would be transparent to the sound beam near the crack tip. It was noted that this phenomenon may have occurred during the qualification of Time of Flight Diffraction (TOFD) techniques for the Brunswick shroud UT. Through conversations with the team members involved with this TOFD qualification, including EPRI NDE Center personnel, it was determined that the sound transmission through cracks referred to was observed with the lateral wave produced using the TOFD technique. This lateral wave is a longitudinal wave, whereas the 45° search unit discussed for this application is a shear wave. Shear waves reflect sound energy from multifaceted flaws more strongly than longitudinal waves. Additionally, the crack morphology, as evidenced in the Dresden and Quad Cities boat samples, show these cracks to be open, with some grain encirclement from corrosion, enhancing sound reflection. Figures 5 through 8 show example cracks from each of the 4 boat samples taken at Dresden 3 and Quad Cities 1.

Empirical data supporting the 45° shear wave crack detection is available in shroud exams performed to date with the OD Tracker system. Shallow crack indications (determined to be IGSCC by evaluation of boat samples at Dresden 3 and Quad Cities 1) were detected with the 45° shear wave transducer, with the response from the ID fillet weld also present. Since the ID fillet weld was observed in each of the more than 2000 stepped transducer scans, it is unlikely that any crack-like defect intersecting the central beam path would not have been seen. Therefore, the 1.24 inch bounding limit on crack size is assured.

Detection of flaws at the inside surface of the H5 weld lower toe

Assurance of the depth of uncracked material established by the exclusion zone requires that no significant cracking be present at the inside surface of the H5 weld lower toe. The 45° shear wave scans the entire fillet weld region including the intersection with the Core Support Plate Ring. This intersection is readily apparent in the recorded data, as are reflections from minor surface irregularities such as machining marks on the ring. This establishes a high sensitivity for detection of cracking and it is the judgment of the Level III analysts that cracks would be reliably detected. No indications of cracking from the inside surface were noted during the UT examinations of the H5 welds at Dresden Unit 3 or Quad Cities Unit 1.

Conclusion

The 45° shear wave technique for determining a zone of sound metal is a valid technique. The technical justification behind this opinion is as follows:

- The 45° shear wave search unit consistently recorded the ID fillet weld during the examination.
- The 60° RL also recorded this fillet weld geometry.
- The metallography results show that these cracks are relatively open and exhibit grain encirclement. The flaw branches extensively in several instances.
- The 45° shear wave is very sensitive to grain boundaries. Crack morphology as seen in figures 5 through 8 show grain encirclement, and multifaceted flaws. The

45° shear wave would reflect sound energy from the multifaceted flaws, which would then be recorded by the system as crack tip reflections and/or as interference with the fillet weld reflection. Empirical data from boat sample evaluations indicates that the shallow flaws detected by 45° shear wave were IGSCC.

- The 1.24"flaw exclusion is based conservatively on the center of the beam. The previous figures show that approximately 50% of the sound energy, including beam spread, would be blocked from the fillet weld for a 1.24" flaw. This dimension represents the largest flaw that could possibly exist and still see the fillet intersection with the vertical cylinder.
- Sound transmission through a crack (if it occurred) would be further attenuated in this application because of the two-way transmission through the crack to the fillet weld and back to the transducer.
- Flaws shadowing the root is an established flaw detection method.