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United States Nuclear Regulatory Commission
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Braidwood Station, Unit 1
Facility Operating License No. NPF-72
NRC Docket No. 50-456

Subject: Relaxation Request for First Revised Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors

References: (1) Letter from K. J. Polson (Exelon Generation Company, LLC) to NRC, "Braidwood Station, Unit 1, 60-Day Response to First Revised NRC Order EA-03-009, 'Issuance of First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors,'" dated June 29, 2006

(2) Letter from J. A. Bauer (Exelon Generation Company, LLC) to NRC, "Relaxation Request for First Revised Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors," dated March 31, 2006

(3) Letter from T.J. McGinty (NRR) to C.M. Crane (Exelon), "Byron Station, Unit No. 1, and Braidwood Station, Unit No. 2 – Relaxation of the First Revised Order EA-03-009 (TAC NOS. MD 1159 and MD 1160)" dated September 11, 2006

On February 11, 2003, the NRC issued Order EA-03-009 for interim inspection requirements for reactor pressure vessel (RPV) heads at pressurized water reactor (PWR) facilities. On February 20, 2004, the NRC issued the First Revised Order EA-03-009 (the Order), which superseded Order EA-03-009. Revision 1 of the Order modified the requirements regarding nondestructive examination of the penetration nozzles.

During the Braidwood Station Unit 1 Spring 2006 refueling outage, Exelon Generation Company (EGC) completed nondestructive examinations (NDE) of the RPV head penetrations in accordance with the Order. As described in the Reference 1 submittal for Braidwood Station Unit 1, these examinations were performed in advance, by one refueling outage, of the due date of February 11, 2008, for those RPV heads categorized as "low susceptibility" in accordance with Section IV.A and IV.B of the Order. In addition, Braidwood Station Unit 1 has completed the 100% bare metal visual examinations (BMV) required by the Order.

EGC has determined that because of the physical configuration of certain Braidwood Station Unit 1 RPV nozzles, along with a surface anomaly on the inner diameter (ID) in one penetration, the required coverage specified in Section IV.C.(5)(b)(i) of the Order could not be met for these nozzles and therefore in accordance with Section IV.F.(2) of the Order, relaxation is requested because compliance with the Order would result in a hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Specifically, for ten Braidwood Station Unit 1 RPV penetration nozzles, EGC is requesting relaxation from the Order by proposing to redefine the Section IV.C.(5)(b)(i) inspection area as "the volume of the penetration tube extending from 2 inches above the J-groove weld down to the lowest elevation that can be practically inspected." For one additional penetration, a surface anomaly prevented the complete collection of data, and EGC is proposing an alternative inspection method until the next scheduled volumetric examination required by the Order. The details of the Braidwood Station Unit 1 Relaxation Request are contained in Attachment 1.

The technical justification for the Braidwood Station Unit 1 relaxation request regarding physical configuration of the Braidwood nozzles was previously provided in Reference 2 Attachment 4, "WCAP-16349-P, Revision 0, 'Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support Continued Operation: Byron and Braidwood Units 1 and 2.'"

As stated in Reference 2, Westinghouse determined that information contained in Reference 2 Attachment 4 is proprietary, as previously supported by an affidavit signed by Westinghouse, the owner of the information. The affidavit set forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b)(4) of 10CFR 2.390. Accordingly, it is respectfully requested that the information that is proprietary to Westinghouse be withheld from public disclosure in accordance with 10CFR 2.390 of the Commission's regulations.

Correspondence with respect to the copyright or proprietary aspects of the items listed above, or the supporting Westinghouse affidavit, should reference CAW-05-2070 and should be addressed to B. F. Maurer, Acting Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

The attached relaxation request is specific to Braidwood Station Unit 1. The previous submittal for Braidwood Unit 2 and Byron Unit 1 was placed on the dockets for all four Braidwood Station and Byron Station units since the supporting Westinghouse WCAP-16349 report is applicable to all four units.

EGC is formally committing to the following actions as a condition of the "Proposed Alternative and Basis for Use" statements proposed in Attachment 1 of the Submittal. If the NRC finds that the crack-growth formula in industry report MRP-55 is unacceptable, then EGC will revise its analysis that justifies relaxation of the Order within 30 days after the NRC notifies EGC by written correspondence of an NRC-approved crack-growth formula. If the EGC revised analysis for Braidwood Station Unit 1 shows that the crack-growth acceptance criteria are exceeded prior to the end of the current operating cycle, the relaxation request will be rescinded and EGC will, within 72 hours, submit to the NRC written justification for continued operation.

If the revised analysis shows that the crack-growth acceptance criteria are exceeded during the subsequent operating cycle, EGC will, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack-growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, EGC will, within 30 days, submit a letter to the NRC confirming that its analysis has been revised. Any future crack-growth analyses performed for this and future cycles for RPV head penetrations will be based on an acceptable crack-growth rate formula. These commitments are detailed in Attachment 4.

In addition, because total coverage required by the Order could not be achieved for penetration number 74 due to a surface anomaly on the ID surface, EGC is committing to perform a bare metal visual examination, consistent with the Order Section IV.C.(5) (a), of penetration number 74 including a 1-inch annulus 360° around the penetration, every refueling outage until the next scheduled volumetric examination of the Braidwood Station Unit 1 RPV head penetrations. At that time the ID surface of penetration number 74 will be reconditioned to allow for complete volumetric coverage. The current schedule is to perform the next Order volumetric examination during the Braidwood Station Unit 1 Spring 2012 refueling outage (i.e., A1R16).

EGC requests that the review of these relaxation requests be completed by October 1, 2007. If you have any questions regarding this letter, please contact Mr. Dale Ambler, Regulatory Assurance Manager, at (815) 417-2800.

Respectfully,

Thomas Coutu
Site Vice President
Braidwood Station

Attachments:

1. Relaxation Request From NRC Order EA-03-009 Section IV, Paragraph C(5)(b)(i) – Braidwood Station, Unit 1
2. Wesdyne Evaluation of NDE Results for Braidwood Unit 1 CRDM Penetration Number 74
3. Braidwood Unit 1 Penetration Number 74 Remote Visual Images
4. Braidwood Station Unit 1 – List of Commitments Regarding First Revised Order EA-03-009 Relaxation Request

Attachment 1

Relaxation Request From NRC Order EA-03-009
Section IV, Paragraph C(5)(b)(i)

Braidwood Station Unit 1

Component

Braidwood Station Unit 1 has seventy-nine (79) reactor pressure vessel (RPV) head penetration nozzles comprised of fifty-three (55) penetration tubes with thermal sleeves, twenty-three (23) locations without thermal sleeves, and one (1) vent penetration nozzle.

In accordance with Section IV.A of the First Revised NRC Order EA-03-009 (the Order), the Braidwood Unit 1 susceptibility category is classified as "low" based on a calculated value of less than eight effective degradation years (EDY) and no previous inspection findings prior to and including the Spring 2006 refueling outage (A1R12). The results of this examination were previously submitted by letter dated June 29, 2006 (ADAMS Accession No. ML0618100270).

NRC Order EA-03-009 Applicable Examination Requirements

The requirements for the nonvisual NDE examinations (ultrasonic and eddy current) performed on the Braidwood Station Unit 1 reactor pressure vessel (RPV) head during the A1R12 refueling outage are specified in the Order, Section IV, paragraphs C.(3) and C.(5)(b).

Paragraph IV.C.(3) of the Order states in part:

> *"...The requirements of paragraph IV.C.(5)(b) must be completed at least once prior to February 11, 2008, and thereafter, at least every 4 refueling outages or every 7 years, whichever occurs first."*

Paragraph IV.C.(5)(b) of the Order states:

> *"For each penetration, perform a nonvisual NDE in accordance with either (i), (ii) or (iii):*
>
> *(i) Ultrasonic testing of the RPV head penetration nozzle volume (i.e., nozzle base material) from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches [see Figure IV-1]); OR from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0-inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including*

all residual and normal operation stresses) of 20 ksi tension and greater (see Figure IV-2). In addition, an assessment shall be made to determine if leakage has occurred into the annulus between the RPV head penetration nozzle and the RPV head low-alloy steel.

(ii) Eddy current testing or dye penetrant testing of the entire wetted surface of the J-groove weld and the wetted surface of the RPV head penetration nozzle base material from at least 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches [see Figure IV-3]; OR from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0-inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operation stresses) of 20 ksi tension and greater (see Figure IV-4).

(iii) A combination of (i) and (ii) to cover equivalent volumes, surfaces and leak paths of the RPV head penetration nozzle base material and J-groove weld as described in (i) and (ii). Substitution of a portion of a volumetric exam on a nozzle with a surface examination may be performed with the following requirements:

1. On nozzle material below the J-groove weld, both the outside diameter and inside diameter surfaces of the nozzle must be examined.

2. On nozzle material above the J-groove weld, surface examination of the inside diameter surface of the nozzle is permitted provided a surface examination of the J-groove weld is also performed."

Requirement from Which Relaxation is Requested

In accordance with Section IV.F.(2) of the Order, relaxation from the above requirements is requested since compliance with the Order would result in a hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Relaxation is requested from Section IV.C.(5)(b)(i) of the Order to perform ultrasonic testing (UT) of the RPV head penetrations inside the tube from 2 inches above the J-groove weld to:

- 2 inches below the lowest point of the toe of the J-groove weld (or the bottom of the nozzle if less than 2 inches) OR

- 1.0 inch below the lowest point of the toe of the J-groove weld and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level of 20 ksi tension and greater.

Based on the physical configuration of the nozzles and the limitations of the test equipment at Braidwood Station Unit 1, it is not possible to achieve the inspection coverage specified in Section IV.C.(5)(b)(i) of the Order for ten RPV penetration nozzles on Braidwood Station Unit 1.

Relaxation is requested to redefine the inspection area for the affected penetrations as *"the volume of the penetration tube extending from 2" above the J-groove weld down to the lowest elevation that can be practically inspected."*

Also, for one penetration (number 74), relaxation is requested from the inspection area requirements of Order Figure IV-2, "Inspection Area Using Ultrasonic Inspection Technique With Stress Analysis." The examination coverage of Braidwood Station Unit 1 RPV nozzle penetration number 74 was restricted due to a small surface anomaly on the inside diameter (ID) of the tube. The anomaly caused probe lift off which prohibited complete eddy current and ultrasonic data acquisition. The estimated percent of required coverage for penetration number 74 is greater than 94%.

Reason for Request

The Braidwood Unit 1 RPV head penetration non-visual examinations were performed during the Spring 2006 (A1R12) refueling outage. The examinations were performed using Westinghouse/WesDyne equipment and procedures demonstrated through the EPRI Materials Reliability Project. Due to physical limitations and interferences associated with some of the penetrations, the examinations required by Section IV.C.(5)(b)(i) of the Order cannot be performed.

The nozzle inspections of the volume from the J-groove weld root up to 2 inches above the weld and the leakage assessments required under Section IV, Paragraph C.(5)(b)(i) of the Order were satisfied for all penetrations. The lower nozzle inspection volume (1.0-inch below the lowest point at the toe of the J-groove weld including all RPV head penetration nozzle surfaces of 20 ksi tension and greater) required under Section IV, Paragraph C.(5)(b)(i) of the Order were satisfied for all but ten penetrations. For the lower portion of the penetration defined in Figure IV-2 of the Order, required coverage one inch below the lowest point of the J-groove weld toe could not be achieved for ten penetrations (i.e., numbers 42, 49, 54, 63, 65, 66, 71, 72, 77, and 78).

For one penetration (number 74), a limited amount (less than 6%) of volumetric examination coverage was restricted due to a surface anomaly on the ID of the tube. The anomaly caused probe lift off which prohibited complete eddy current and ultrasonic data acquisition.

The surface anomaly was examined by a remote visual examination. Upon visual examination, the base metal appeared to be scratched and gouged (reference electronic photographs contained in Attachment 3). Based on the remote visual examination, the physical size of the disruption was estimated at 0.25-inch in circumferential extent and 0.6-inch in axial height and located at the downhill location of the J-Groove weld.

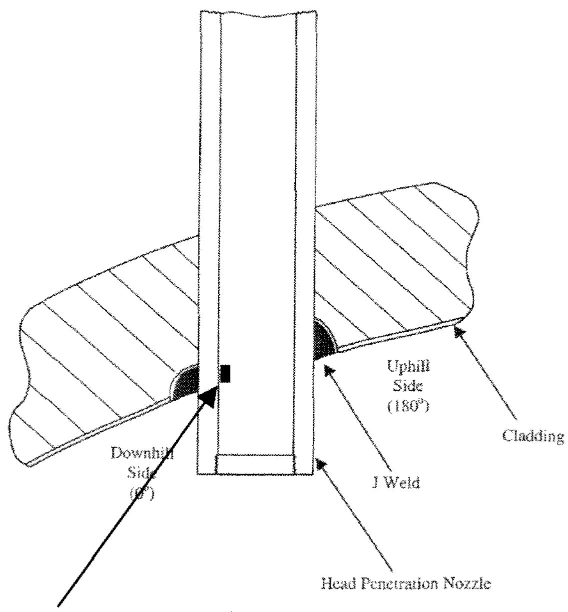

Figure 1A
Relative location of ID surface anomaly on penetration 74.

It is believed the anomaly is the result of contact between an incore thermocouple probe (bullet nose) retaining clip that slipped out of place and came in contact with the nozzle thereby gouging the inside surface during RPV head lift during the first refueling outage for Braidwood Unit 1. As depicted in Figure 1A above, the lowest axial height location is near the 0° downhill start of the J-Groove weld.

Component Geometry

For Braidwood Station Unit 1, the bottom of each RPV head penetration nozzle includes a threaded region approximately 1.00 inch long on the outside diameter along with a chamfered area at the ID which extends approximately 0.76 inches from the bottom of the penetration tube (see Figure 1B). The chamfered surface is machined at a 20-degree angle. In addition to the presence of the threaded and chamfered regions on all penetration tubes, 5 penetration tubes also have a threaded guide cone attached to the bottom of the penetration tube via the threaded connection along with a welded set screw and two tack welds.

The distance from the top of the thread relief to the bottom of the fillet of the J-groove weld, identified as "A" in Figure 1B, varies based on location of the penetration in the RPV head. These distances are generally longer for penetrations at "inboard" locations and become progressively shorter for penetrations located further away from the center of the RPV head. At the ten subject penetration nozzles (i.e., numbers 42, 49, 54, 63, 65, 66, 71, 72, 77, and 78) the configuration is such that the distance from the lowest point at the toe of the J-groove weld to the bottom of the scanned region is less than the 1-inch lower boundary limit specified in section IV.C.(5)(b)(i) of the Order.

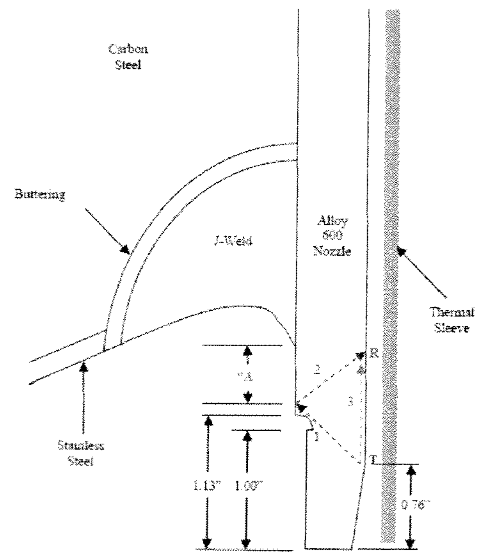

Figure 1B
Illustration of Axially Oriented TOFD Examination Coverage on Braidwood Station Unit 1 Penetration Geometry (Including General Dimensions) at 0 Degrees

Examination Details

The inspection system used for Braidwood Station Unit 1 consisted of two probes to perform UT inspection of the penetration nozzles. The first probe type (Trinity Probe) was used to inspect nozzles that contained thermal sleeves (55 total). The second probe type (Open Housing Probe) was used to inspect nozzles without thermal sleeves (23 total). Both probes use axially oriented time-of-flight tip diffraction (TOFD) as the primary crack detection method. The vent line examination (1 total) is not included in the discussion as this examination area has a different geometry that was not limited.

The TOFD technique is a “pitch/catch” ultrasonic method, which uses two transducers (one a transmitter, and one a receiver) oriented along the vertical axis of the probe. The focus point of the TOFD beam is at the midpoint between the upper and lower transducers. Longitudinal waves are transmitted into the tube at an angle by the transmitter (T) and reflect off the backside of the tube to a receiver (R), as shown in path “1-2” in Figure 1B. A lateral wave also travels on the tube ID surface between the transmitter and receiver as shown in path “3”. The transmitting and receiving elements are mounted on a “shoe” with a probe center spacing of 0.925 inches. ID TOFD coverage is provided by the lateral wave to the elevation of the chamfer of the tube on the ID surface. With an axially oriented TOFD transducer pair in the Trinity probe, outside diameter (OD) coverage becomes completely effective at an elevation just above the top of the thread relief. The presence of the thread relief results in a slight masking of the ultrasound to the OD surface to an elevation conservatively estimated at 0.20 inches above the thread relief. In this area however, OD initiated degradation would be detected once the depth of the degradation exceeded the depth of the masked area. With a circumferentially oriented TOFD transducer pair, included in the Open Housing Scanner, OD coverage is extended to the elevation of the top of the chamfer, approximately 0.76 inches above the bottom of the tube. In the threaded region, cracks extending deeper than the threads will be detected.

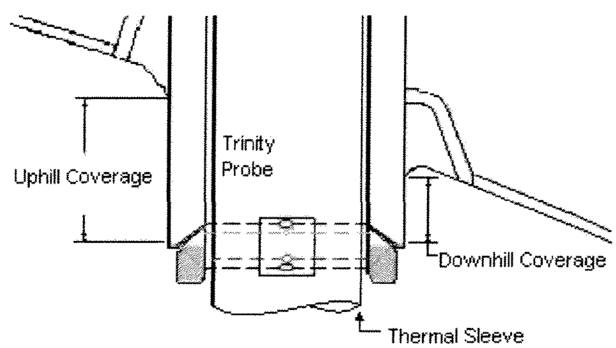

Figure 2
Trinity Probe Inspection Circumferential UT Coverage

The Open Housing Probe has a transducer pair with a 55-degree angle of refraction. The Trinity Probe (Figure 2) has a transducer pair with a 44-degree angle of refraction. Since the Trinity Probe transducers are a smaller size and spacing is less than that of the Open Housing Probe, the focus point of the Trinity Probe transducers are at a lower elevation (closer to the bottom of the tube) than the Open Housing Probe focus point when the probes reach the top of the ID chamfer. However, due to the difference in the refracted angles, the thread relief on the OD of the tube interferes with the TOFD beam for the Trinity Probe. Due to this interference, there is a small area above the thread relief where the Trinity Probe cannot inspect. Figure 3 shows the lower transducer at the top of the ID chamfer and the OD thread relief interference with the TOFD beam. Figure 4 shows the probe at the minimum (higher) elevation where the TOFD beam is not interrupted by the thread relief.

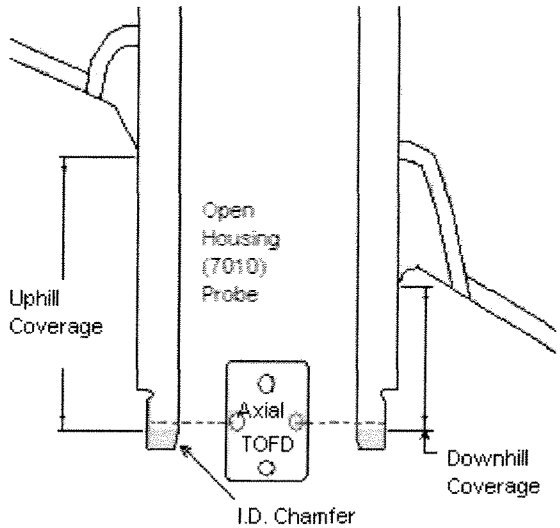

Figure 3
Open Housing Probe Circumferential UT Coverage

The shaded areas from both Figures 3 and 4 make up the total portion of the tube that cannot be inspected. The dimensions listed in Table 1 are based on the maximum coverage limitation of 1.13 inches shown in Figures 1 and 4.

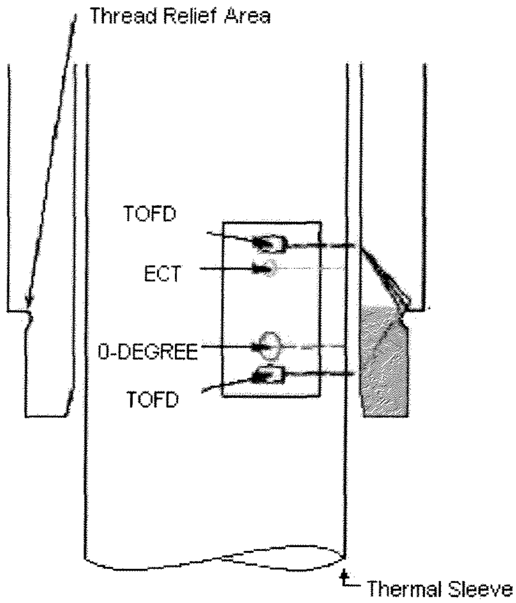

Figure 4
Trinity Probe – Lower TOFD Transducer to Top of Chamfer

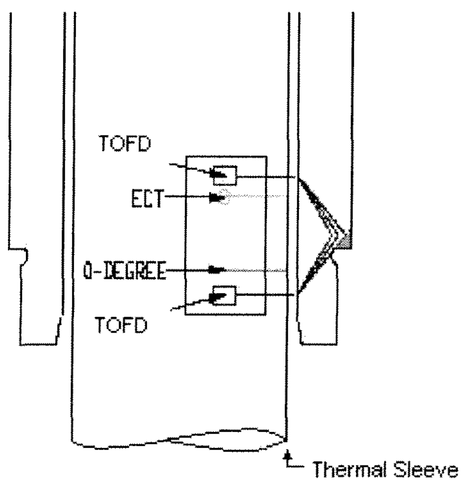

Figure 5
Trinity Probe – TOFD Beam Uninterrupted by Thread Relief

In addition to the axially oriented TOFD transducers (Figure 5), the Open Housing Probe has circumferentially oriented TOFD transducers that the Trinity Probe does not have. This circumferentially oriented TOFD signal allows the Open Housing Probe to inspect the tube down to the top of the ID chamfer. Also, with the Open

Housing Probe's circumferentially oriented transducers, the TOFD beam is not interrupted by the OD thread relief. The dimensions listed in Table 1 reflect the circumferential TOFD transducer coverage limitation of 0.76 inches due to the chamfered region. This is why the Open Housing Probe coverage is consistently greater than the Trinity Probe coverage. Figure 6 shows both the axial and circumferential Open Housing Probe TOFD coverage limitations. The shaded areas indicate the portions of the tube that cannot be inspected.

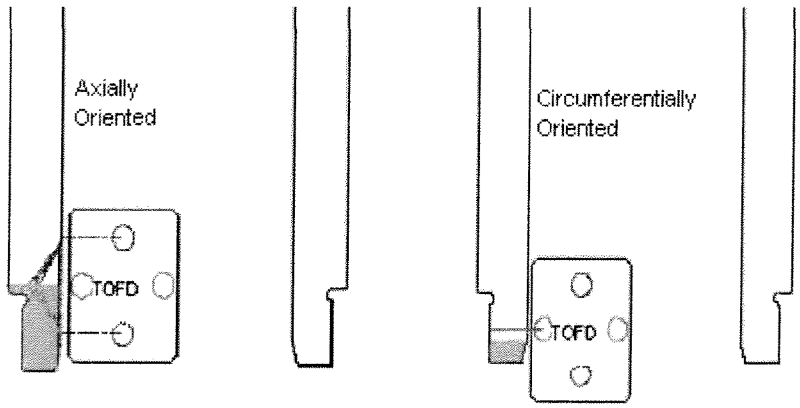

Figure 6
Open Housing Probe Coverage Limitations

The Order allows provisions for dye penetrant inspection. However, dye penetrant inspection would require extensive work under and around the RPV head. Based on radiological surveys taken during A1R12 for the vent line examination, the general area radiation level under the Unit 1 head during A1R12 was approximately 4.0 R/hr (2.5 R/hr at the knee, 4.0 R/hr at the head, 7.0 R/hr at the nozzle). Section IV.C.(5)(b)(iii)1 of the Order requires penetrant inspection on both the inside and outside diameter surfaces in order to be considered an acceptable substitution for ultrasonic examination. The threaded region on the outside diameter of the penetration tubes along with the presence of the welded guide funnels on penetration tube ends makes a dye penetrant examination on the lower section of the tube impractical. Therefore, performing dye penetrant inspections on the bottom nozzle area would result in significant radiation exposure to personnel without a compensating increase in the level of quality or safety.

Table 1 contains information specific to the ten penetrations for which relaxation is being requested. The values for Control Rod Drive Housing (CRDM) penetration hoop stress distributions at a point where the operating stress levels are less than 20 ksi tension (i.e., 20 Ksi Line) were extrapolated from the associated graphs contained in Figures 11 through 18, which are also contained in Appendix A of WCAP-16394-P, Revision 0, *"Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support Continued Operation: Byron and Braidwood Units 1 and 2,"* dated February 2005 (previously submitted as Attachment 4 to the submittal from J. A. Bauer (Exelon Generation Company, LLC) to NRC, "Relaxation Request for First Revised Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors," dated March 31, 2006).

Table 1
Penetrations with Limited Examination Volume

Penetration Number	Angle (Degrees)	A1R12 Inspection Coverage (Inches Below Weld)	20 Ksi line (Inches below J-Groove Weld)				Inspection Method
			Uphill Side		Downhill Side		
			ID	OD	ID	OD	
42	34.1	0.92	1.85	.61	.93	.43	Trinity
49	34.1	0.76	1.85	.61	.93	.43	Trinity
54	37.4	0.92	1.85	.61	.93	.43	Trinity
63	42.8	0.92	2.9	.61	.64	.49	Trinity
65	42.8	0.92	2.9	.61	.64	.49	Trinity
66	43.8	0.92	3.02	.62	.60	.47	Trinity
71	43.8	0.88	3.02	.62	.60	.47	Trinity
72	43.8	0.92	3.02	.62	.60	.47	Trinity
77	47.0	0.92	3.29	.54	.48	.44	Open Housing
78	47.0	0.84	3.29	.54	.48	.44	Open Housing

Proposed Alternative and Basis for Use

Exelon Generation Company, LLC (EGC) proposes to define the lower boundary of the inspection volume for the affected RPV head penetration nozzles as: *"the volume of the penetration tube extending from 2" above the J-groove weld down to the lowest elevation that can be practically inspected".*

EGC performed UT examinations to the maximum extent possible and for Braidwood Station Unit 1 meets all requirements of the Order with the exception of the ten penetration tubes previously noted.

EGC was unable to completely comply with the requirements for UT inspection for ten RPV penetration nozzles below the J-groove weld, due to the physical configuration of the nozzles and the limitations of the test equipment. The bottom ends of these nozzles are externally threaded and internally tapered. Loss of UT probe coupling due to the internal taper and/or disruption of the UT signal due to the external thread prevented UT data acquisition in a zone extending to approximately one-inch above the bottom of each nozzle.

Testing of portions of the nozzle significantly below the J-groove weld is not significant to the phenomena of concern. The phenomena that are of concern are leakage through the J-groove weld and circumferential cracking in the nozzle above the J-groove weld. This is appropriately reflected in the requirements of the Order (as stated in Section II above) that the testing extend to two inches above the J-groove weld. However, the Order also requires that testing be extended to:

- 2 inches below the lowest point of the toe of the J-groove weld (or the bottom of the nozzle if less than 2 inches) OR

- 1.0 inch below the lowest point at the toe of the J-groove weld and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level of 20 ksi tension or greater.

The nozzle is essentially an open-ended tube, and the nozzle wall below the J-groove weld is not part of the reactor coolant system pressure boundary.

EGC believes the proposed inspection coverage is adequate because the cited inspection limitation for the RPV head penetration nozzles does not preclude full UT examination coverage of the portions of these nozzles that are of primary interest.

This can be assumed because:

- UT of the most highly stressed portion of the nozzle (the weld heat affected zone) is unaffected by this limitation.

- UT of the interference fit zone above the weld (for leakage assessment) is unaffected by this limitation, and cracks initiating in the unexamined bottom portion (non-pressure boundary) of the nozzle would be of minimal safety significance with respect to pressure boundary leakage or nozzle ejection, since this portion of the nozzle is below the pressure boundary and any cracks would have to grow through a significant examined portion of the tube to reach the pressure boundary.

This proposed alternative is consistent with the analysis submitted in the industry topical report MRP-95, "Materials Reliability Program: Generic Evaluation of Examination Coverage Requirements for Reactor Pressure Vessel Head Penetration Nozzles," and the site-specific analysis in WCAP-16394-P. The zones of inspection selected are such that the stresses in the remaining uninspected zones are at levels for which Primary Water Stress Corrosion Cracking (PWSCC) is considered highly unlikely.

The major inherent conservatisms in WCAP-16394-P are summarized below:

Conservatism in Assumed Crack Geometry

It is understood that high stresses, on the order of the material yield strength, are necessary to initiate PWSCC. There is no known case of stress corrosion cracking of Alloy 600 below the yield stress. The yield strengths for wrought Alloy 600 head penetration nozzles are in the range of 37 ksi to 65 ksi. Weld metal yield strengths are generally higher. The yield strength of the head penetration nozzles for Braidwood Station Unit 1 varies from 37 ksi to 51.7 ksi. The stress level of 20 ksi is a conservative value below which PWSCC initiation is extremely unlikely.

Therefore, the assumption of any PWSCC crack initiation in the region of the penetration nozzle with a stress level of 20 ksi or less is conservative. The assumption of a through-wall flaw in these unlikely PWSCC crack initiation regions of the head penetration is an important additional conservatism, since the penetration tubes were inspected with maximum achievable coverage on the tube ID.

Flaw Propagation Calculations and Examination Coverage

A structural integrity evaluation was performed for the Byron and Braidwood Stations Unit 1 and Unit 2 reactor vessel head penetrations under WCAP-16394-P. The basis of this analysis is a detailed three-dimensional elastic-plastic finite element stress analysis of several penetration locations, which considers all the pertinent loadings on the penetration, and a fracture analysis using the crack growth rates recommended by the EPRI "Materials Reliability Program (MRP) Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick Wall Alloy 600 Material (MRP-55) Revision 1." A series of crack growth calculations were performed presuming a flaw where the lower extremity of this initial through wall flaw is conservatively postulated to be located on the penetration nozzle where either the inside or outside surface hoop stress drops below 0 ksi. The results of these calculations provided the estimated remaining operating cycles that would elapse before a postulated flaw in the unexamined area of the penetration nozzle would propagate into the pressure boundary formed by the J-groove weld.

The postulated flaw at the lower extent of coverage was located on the flaw growth curve associated with the penetration angle. For those penetrations that do not have a flaw growth curve specific to the tube penetration angle, a conservative curve (nearest the lower penetration angle) was used. The time it would take for the postulated flaws to intersect the weld metal for the minimum coverage achieved was then determined.

Braidwood Station Unit 1 past operating cycles have been approximately 18 months (1.5 calendar years or 1.24 Effective Full Power Years (EFPY) per cycle based on historical data). Braidwood Station Unit 1 will remain on 18-month cycles according to the current long-term schedule. Conservatively using 1.5 EFPY for the remaining four operating cycles until the next required examination, there are 6.0 EFPY between the A1R12 examinations until the next scheduled examination required by the Order. Per the current Order requirements (perform examination within every four refueling outages or seven years, whichever occurs first), the next inspection for the Braidwood Station Unit 1 RPV penetrations must be completed by the A1R16 outage, which is currently scheduled in April of 2012.

Based on A1R12 examination results (see Table 1), the worst-case minimum distance below the J-groove weld to the top of the zone that could not be inspected was determined to be 0.76 inches on the downhill side of the penetration nozzle number 49. To account for the inspection tolerance of the inspection equipment (0.04 inches), an axial through-wall flaw was conservatively postulated to be located at 0.70 inches below the J-groove weld in the crack propagation calculation for the downhill side of the penetration nozzle. Using the applicable crack growth rate for the penetration (Figure 7), it would take greater than 6.8 EFPY for the postulated flaw to propagate from that location to the bottom of the J-groove weld, which would occur after the next scheduled inspection.

For the subject penetrations that EGC is seeking relaxation, Figures 7 through 10 (WCAP-16394-P, Figures 6-12, 6-13, 6-14, and 6-15) provide results of the calculation. The calculation demonstrates that the minimum time for a flaw to propagate from that location to the bottom of the J-groove weld would be greater than four operating cycles. The results of the flaw propagation calculation indicate that, even if a flaw were to occur in the region of the penetration nozzle not being inspected, there would be adequate opportunity for detection prior to the crack reaching the reactor coolant system pressure boundary. The results demonstrate that the extent of the proposed inspection coverage would provide reasonable assurance of the structural integrity of the Braidwood Unit 1 RPV head penetration nozzles and the J-groove welds.

Penetration Number 74

In addition to the limited examination coverage of the ten penetrations above, total coverage required by the Order could not be achieved for penetration number 74 due to a surface anomaly on the ID surface which caused probe liftoff. EGC is proposing to perform a bare metal visual examination, consistent with the Order

Section IV.C.(5)(a), of penetration number 74, including a 1-inch annulus 360° around the penetration every refueling outage until the next scheduled volumetric examination of the Braidwood Station Unit 1 RPV head penetrations. At that time, the ID surface of penetration number 74 will be reconditioned to allow for complete volumetric coverage. The current schedule is to perform the next Order volumetric examination during the Braidwood Station Unit 1 Spring 2012 refueling outage (i.e., A1R16).

Accelerating the schedule for reconditioning penetration number 74 and performing a 100% volumetric examination would result in an unnecessary hardship without a compensating increase in quality or safety. Braidwood Station Unit 1 is classified as a low susceptibility RPV head, currently at 2.2 EDY. Previous volumetric examinations of RPV head penetrations at sister units, Braidwood Station Unit 2 and Byron Station Unit 1, with similar nozzle configurations have not detected any indications of service induced degradation. The current estimate to recondition and reexamine penetration number 74 is approximately $800,000.

A supplemental visual examination using a borescope video recording was performed on the areas of concern. The area of the surface anomaly that caused the limited examination coverage was estimated at 0.25-inch in circumferential extent and 0.6-inch in axial height.

Based on the UT and Eddy Current data collected, there was enough coverage to assure that there were no crack-like indications, under the anomaly, connected to the ID surface of penetration 74 (Attachment 3). Primary water stress corrosion cracking (PWSCC) possibly originating at the ID of the RPV penetration tube and progressing to the OD of the tube is not a concern, since full ID coverage directly under the anomaly was obtained. Available leak path results showed no suspect areas in the J-groove weld above the location of the anomaly.

Conclusion

In all cases, the measured coverage is adequate to allow Braidwood Station Unit 1 to continue to operate prior to the hypothetical flaws reaching the J-groove weld. Per the current Order requirements, the next examination required for the Braidwood Station Unit 1 RPV penetrations would be completed prior to flaw propagation into J-groove welds.

Also, the low susceptibility of the Braidwood Station Unit 1 RPV head combined with bare visual examination examinations of penetration number 74 at a refueling outage frequency assures that the small unexamined volume (less than 6%) of the penetration presents no challenge to the integrity of the nozzle housing nor to the reactor coolant pressure boundary.

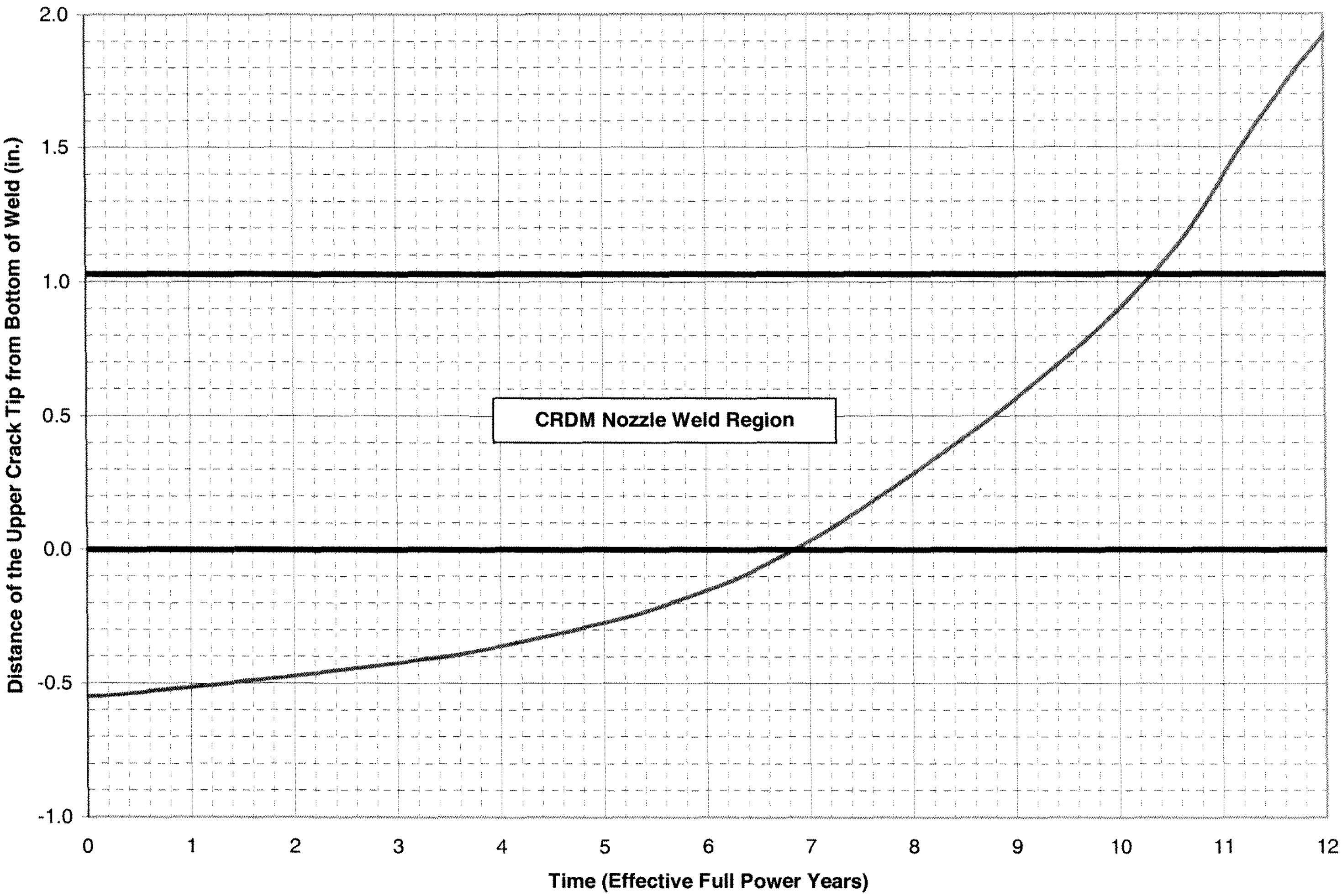

Figure 7
Through -Wall Longitudinal Flaw in the 25.4 Degree CRDM Row Downhill Side - Crack Growth Prediction
(Applies to Penetrations 42, 49, and 54)

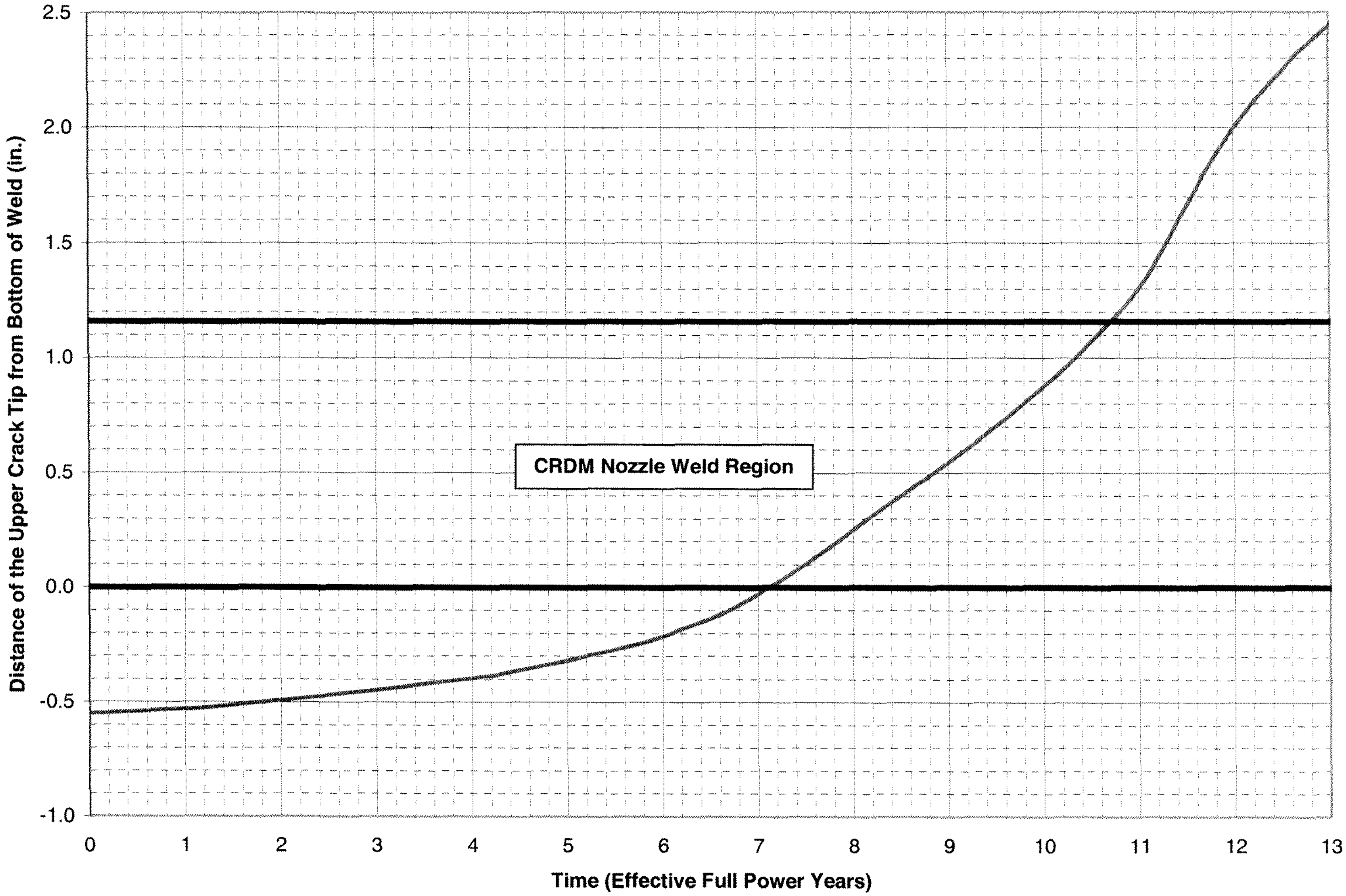

Figure 8
Through -Wall Longitudinal Flaw in the 42.8 Degree CRDM Row Downhill Side - Crack Growth Prediction
(Applies to Penetrations 63 and 65)

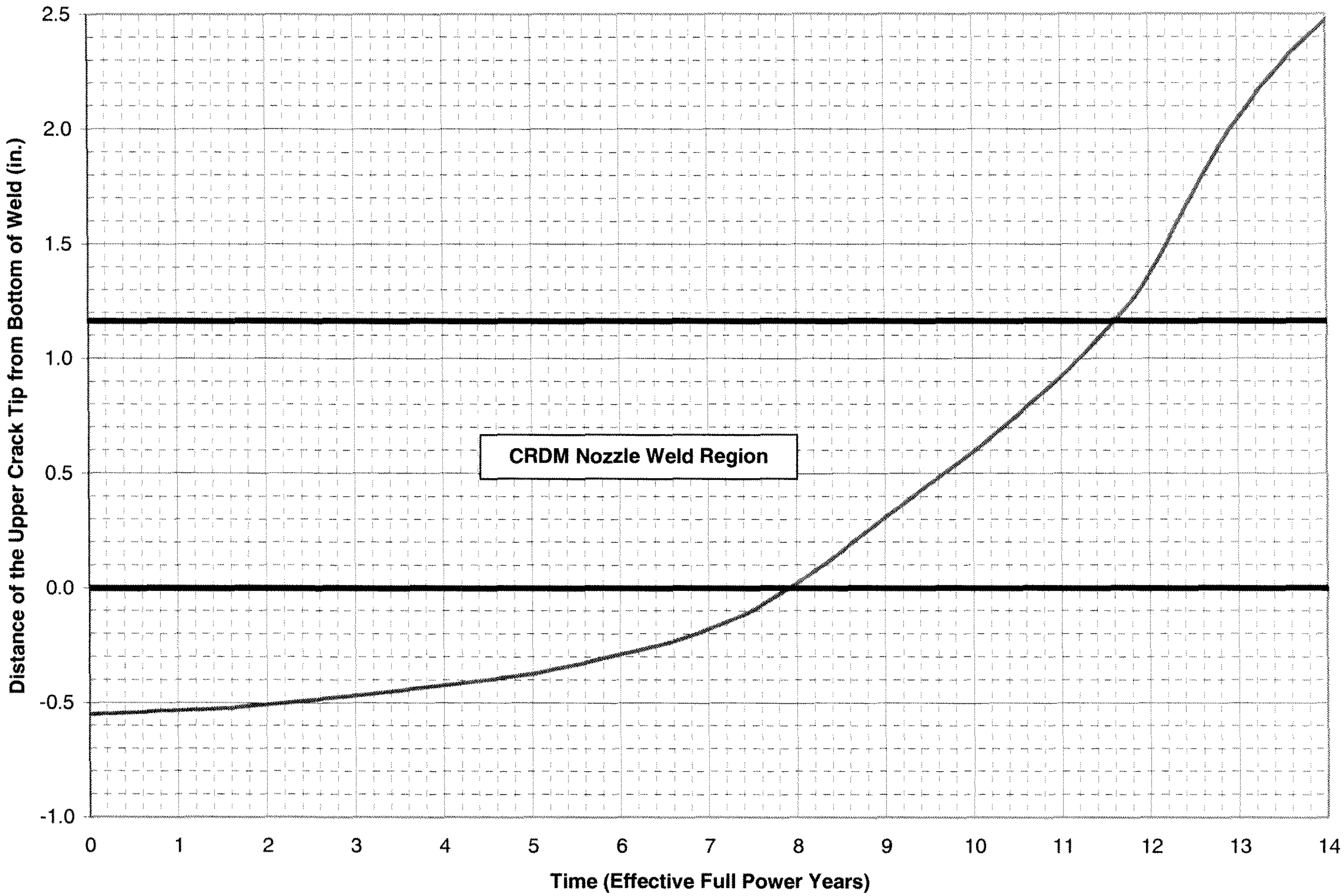

Figure 9
Through -Wall Longitudinal Flaw in the 43.8 Degree CRDM Row Downhill Side - Crack Growth Prediction
(Applies to Penetrations 66, 71, and 72)

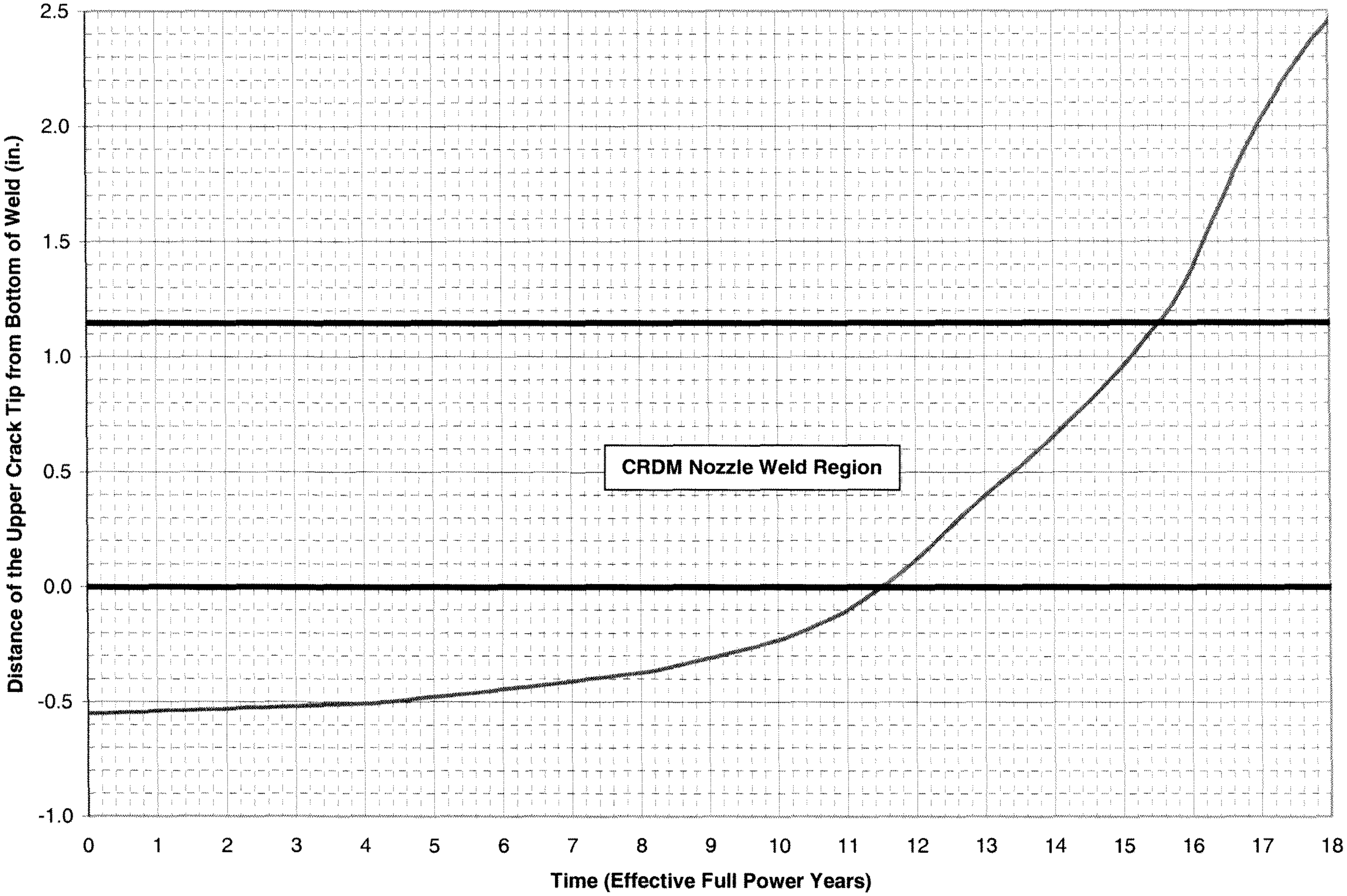

Figure 10
Through -Wall Longitudinal Flaw in the 47.0 Degree CRDM Row Downhill Side - Crack Growth Prediction
(Applies to Penetrations 77 and 78)

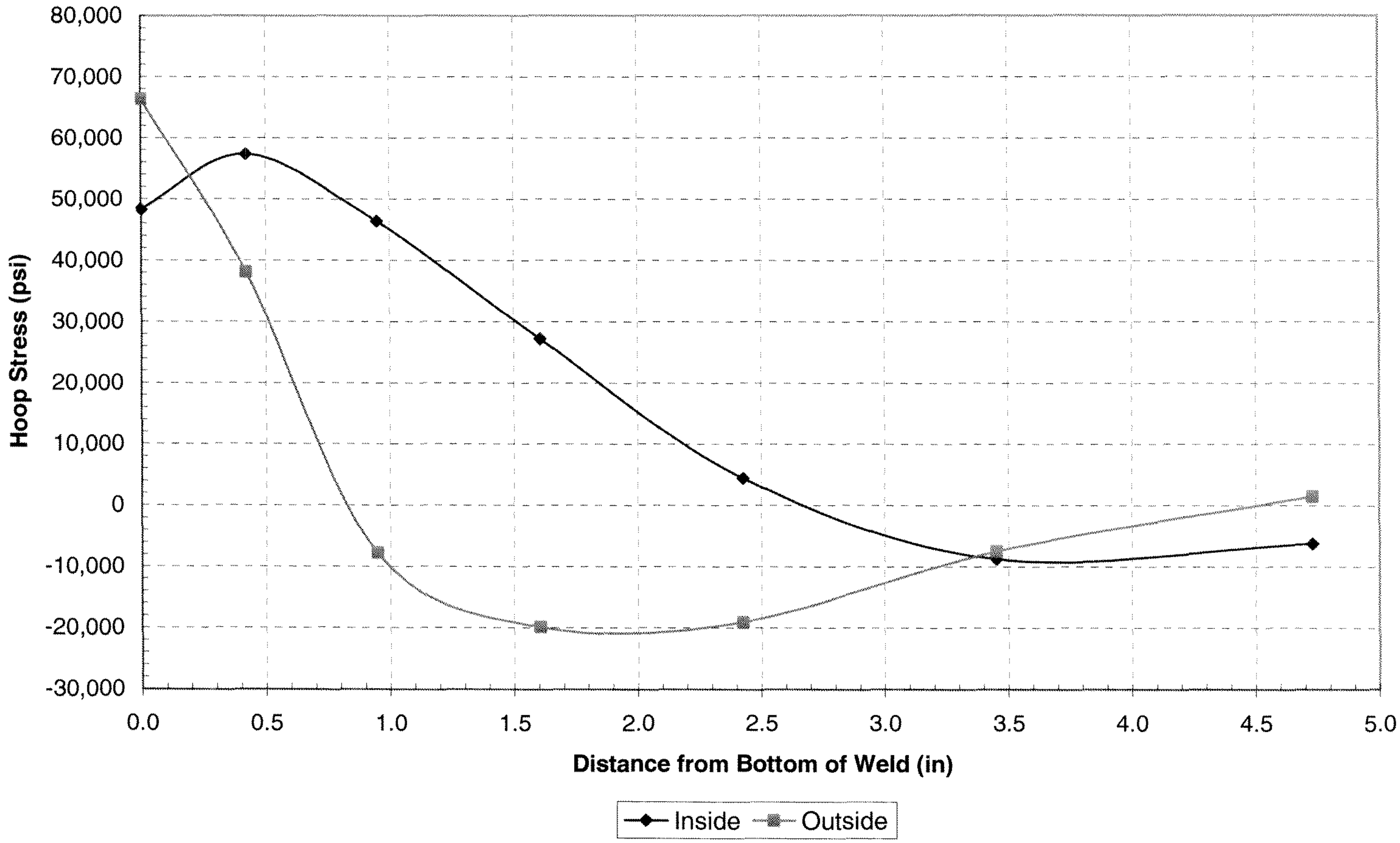

Figure 11
Hoop Stress Distribution Uphill Side
(25.4 Degree CRDM Penetration Nozzle)

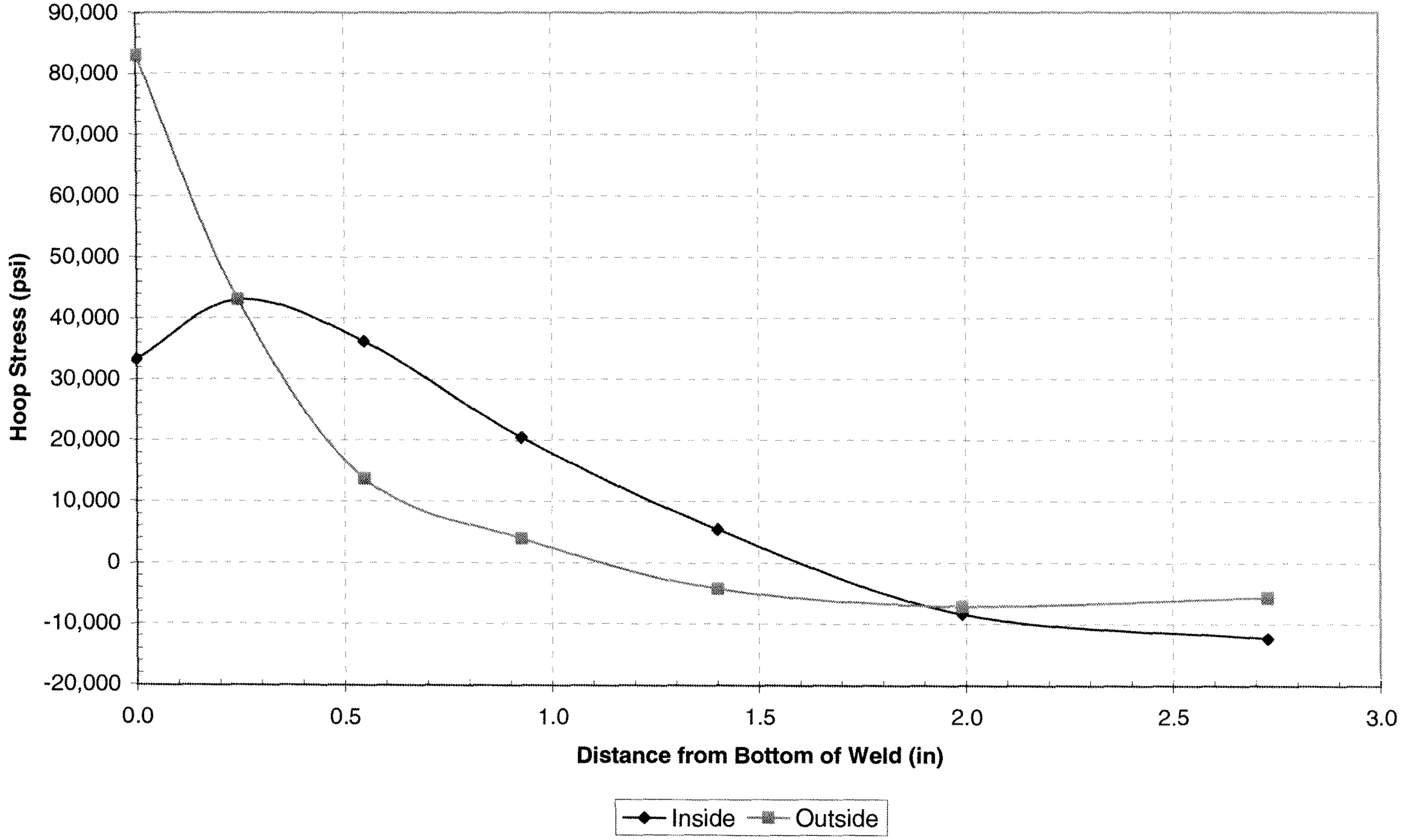

Figure 12
Hoop Stress Distribution Downhill Side
(25.4 Degree CRDM Penetration Nozzle)

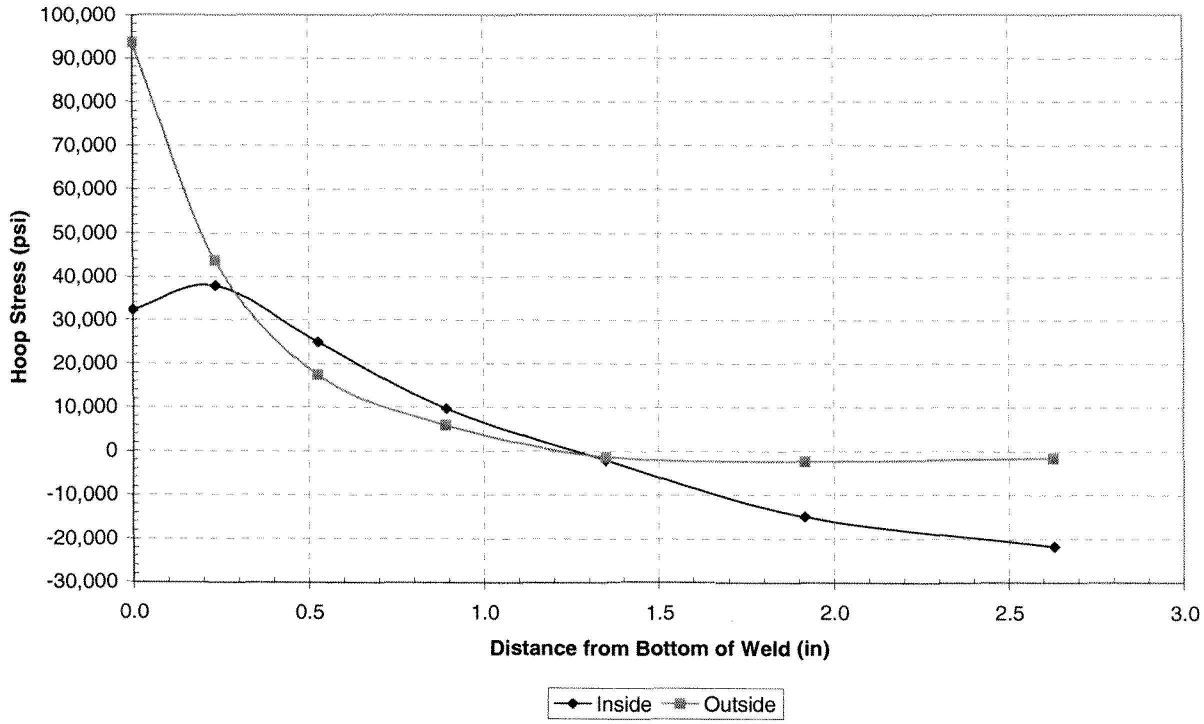

Figure 13
Hoop Stress Distribution Downhill Side
(42.8 Degree CRDM Penetration Nozzle)

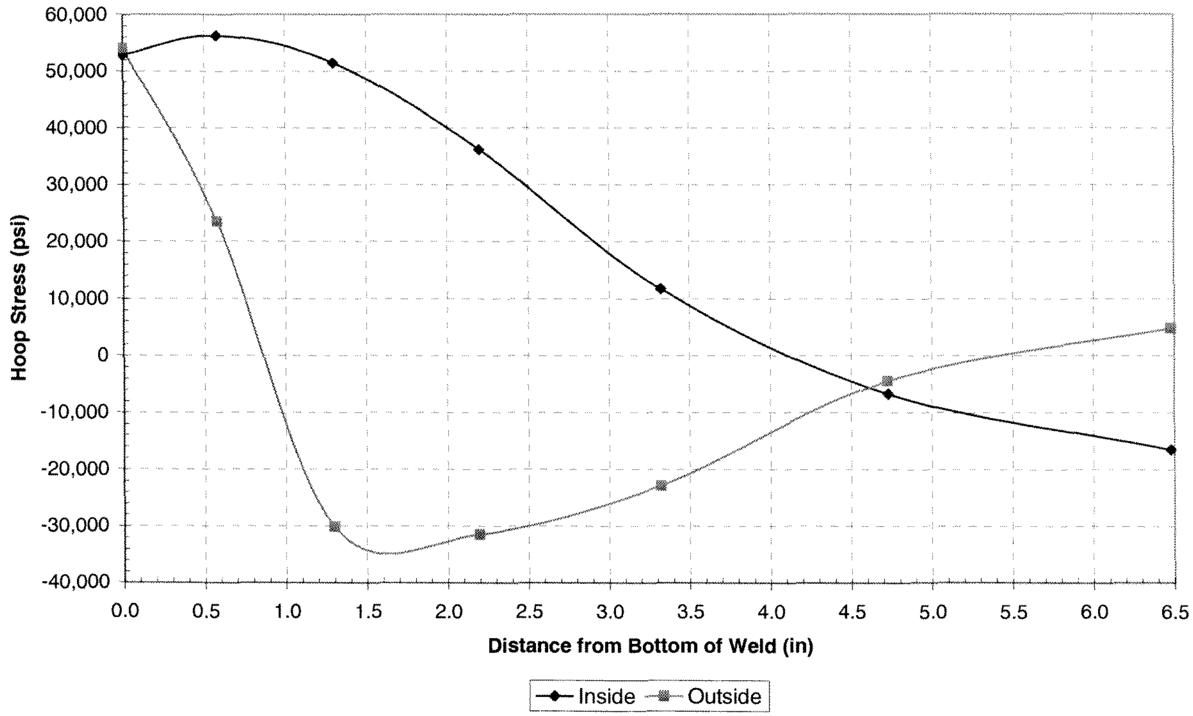

Figure 14
Hoop Stress Distribution Uphill Side
(42.8 Degree CRDM Penetration Nozzle)

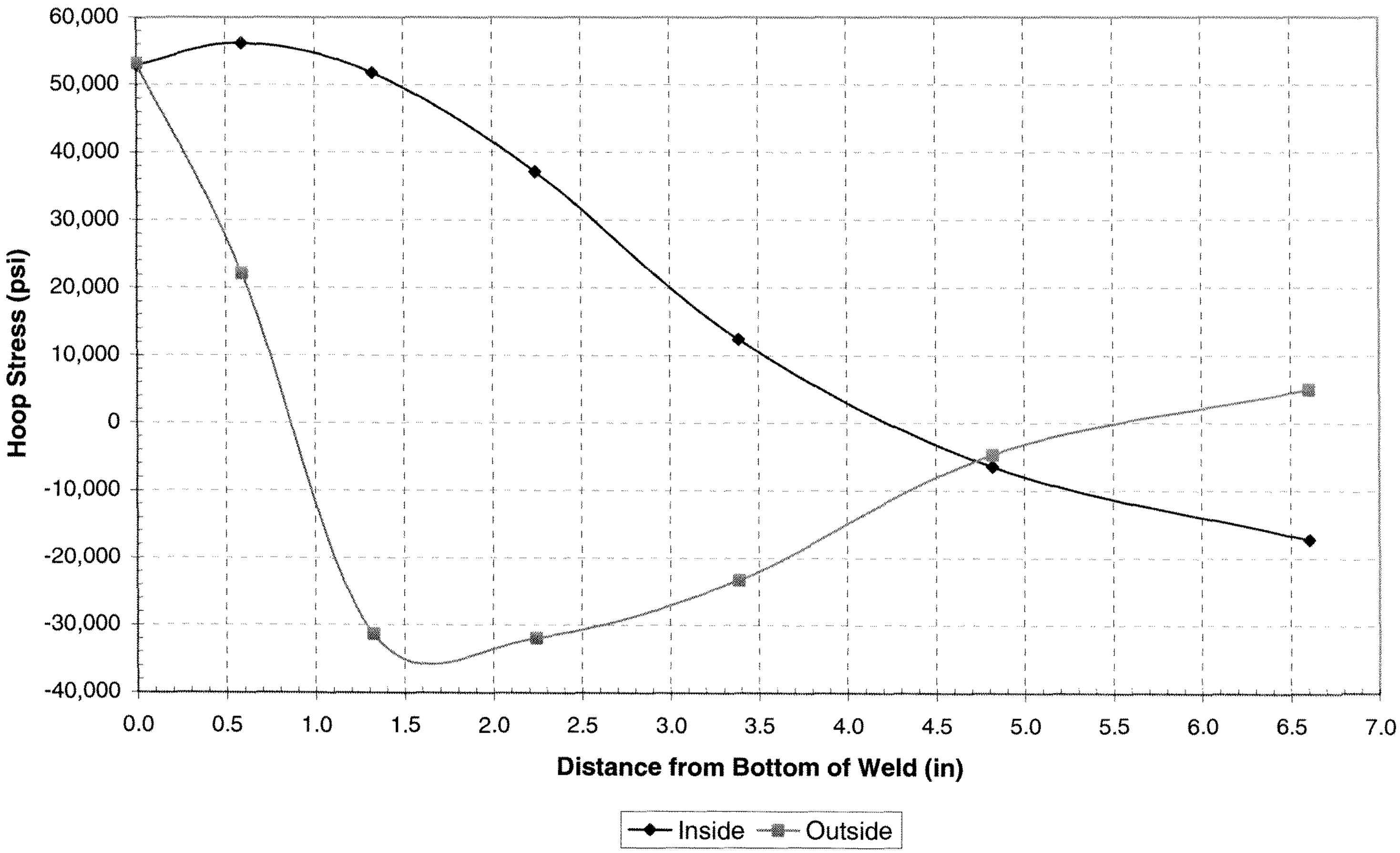

Figure 15
Hoop Stress Distribution Uphill Side
(43.8 Degree CRDM Penetration Nozzle)

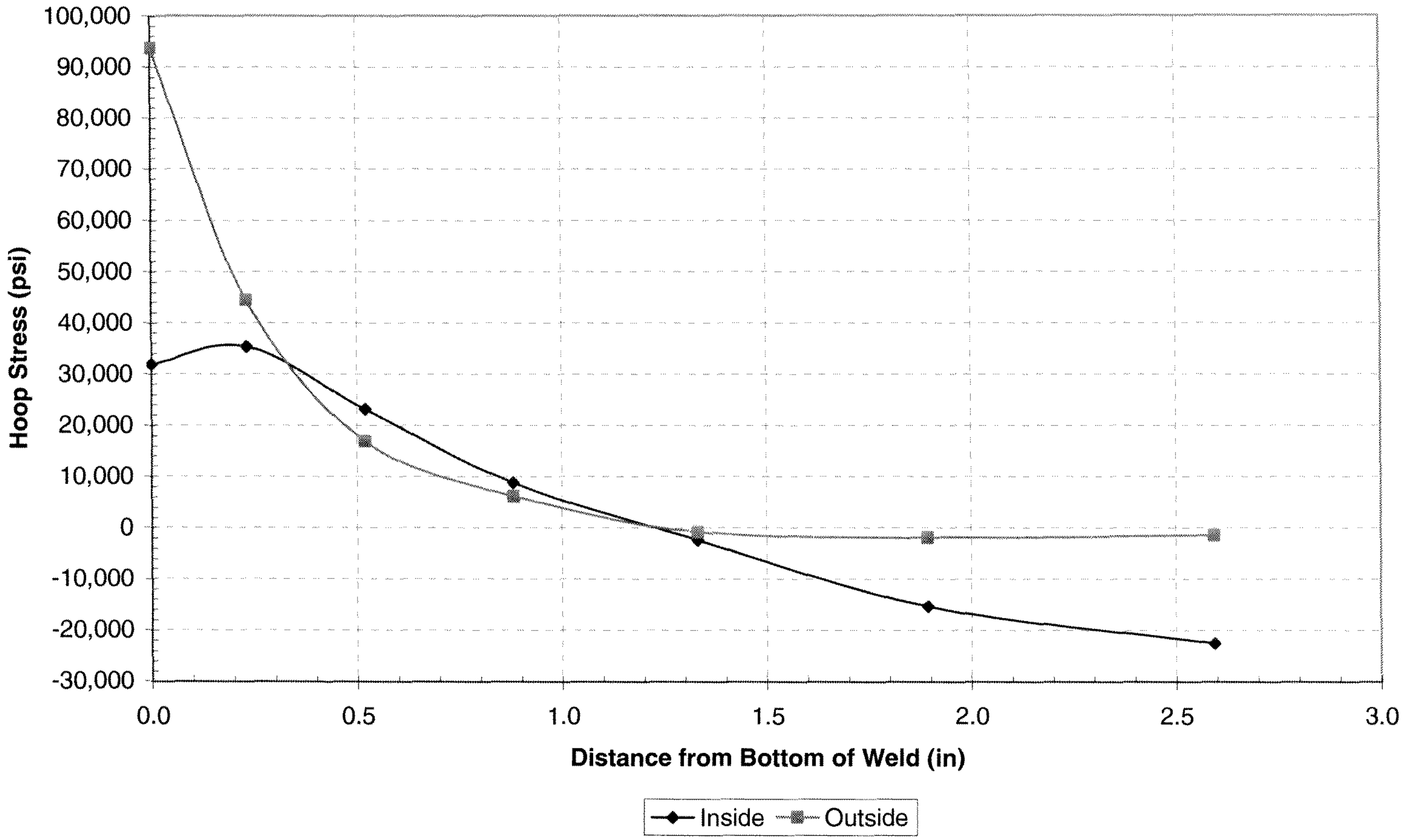

Figure 16
Hoop Stress Distribution Downhill Side
(43.8 Degree CRDM Penetration Nozzle)

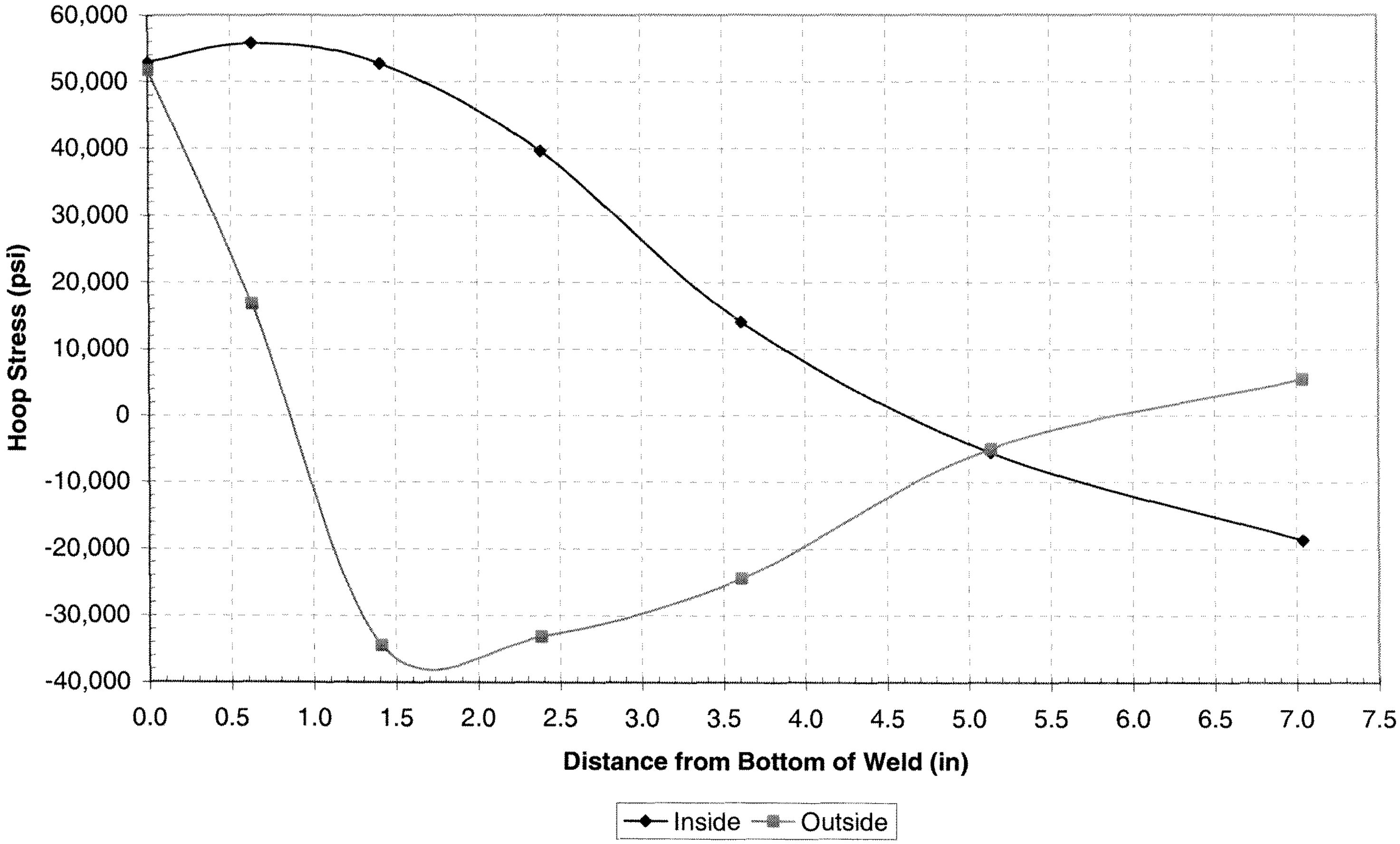

Figure 17
Hoop Stress Distribution Uphill Side
(47 Degree CRDM Penetration Nozzle)

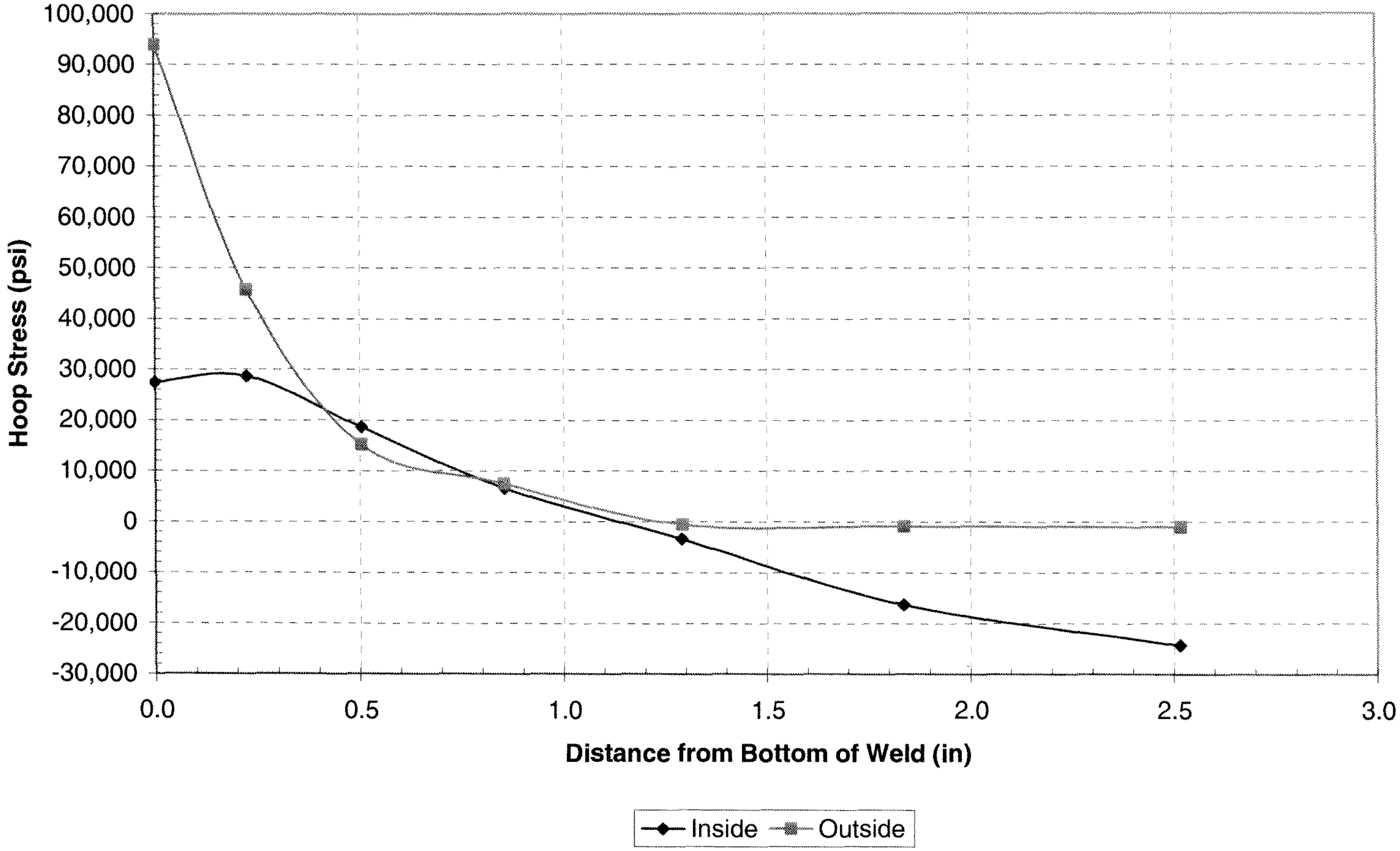

Figure 18
Hoop Stress Distribution Downhill Side
(47 Degree CRDM Penetration Nozzle)

Attachment 2

Wesdyne Evaluation of NDE Results for Braidwood Unit 1 CRDM Penetration Number 74

BRAIDWOOD 1 PENETRATION 74 EVALUATION

The inside diameter (ID) surface of Penetration 74 has a region where there is a disturbance on the ID. This disturbance resulted in the inspection probes not staying flush on the surface and causing lift-off in the eddy current (ET) data and drop outs in the ultrasonic data (UT).

In addition, there is a strong ET response near the top of the disturbance that could mask an ID associated indication.

An evaluation was performed to determine if any ID indication existed.

The evaluation consisted of two steps. The first was to evaluate the lift-off to determine if the ET data is valid in the region. The second was to determine if the strong ID signal masked an indication.

Lift-off evaluation

Section 8 of Wesdyne procedure WDI-ET-004 includes a process to evaluate lift-off to determine if a valid ET inspection was performed. Per the procedure, the operator alters the magnitude C-scan threshold to a value corresponding to two thirds of the reference notch peak-to-peak magnitude. If any magenta regions appear in the C-scan, then these regions do not have valid data due to lift-off.

For the indication associated with Penetration number 74, the 400 KHz peak-to-peak magnitude was 424.3 eddy current units (ECU's). Two thirds of this value is 282.9 ECU's, shown in Figure 1. The 100 KHz peak-to-peak magnitude was 257.6 ECU's. Two thirds of this value is 171.8 ECU's, shown in Figure 2.

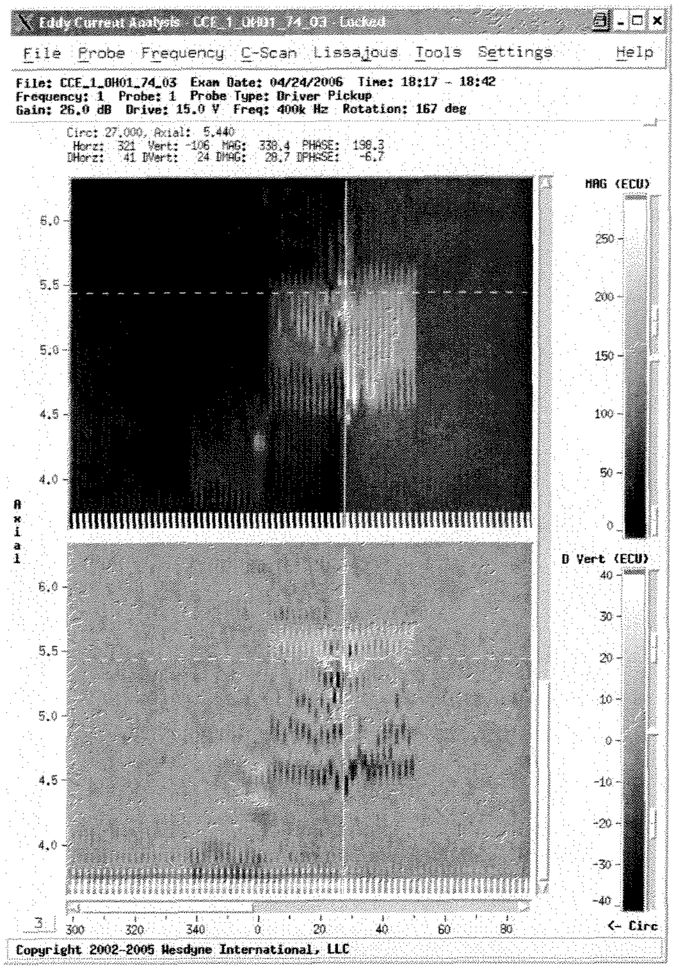

Figure 1
400 KHz Liftoff Evaluation

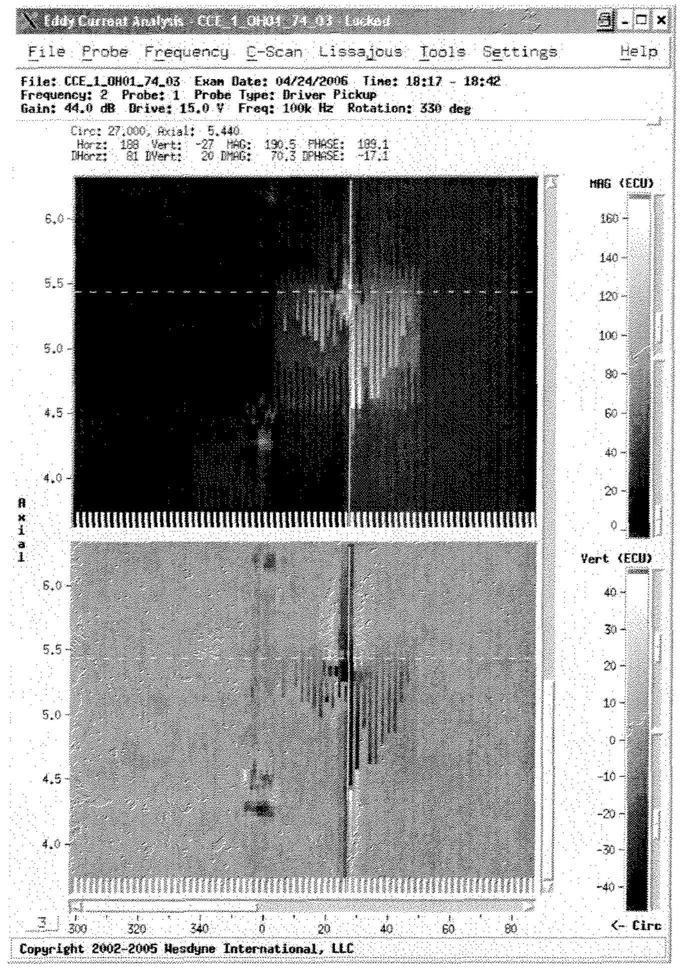

Figure 2
100 KHz Liftoff Evaluation

There are only two magenta signals in these views. The upper signal is due to the strong ET response, and is discussed in the next section.

The lower signal is a localized liftoff signal due to the probe kicking as it transits the area of disturbance (see Figure 3). Since it is a single excursion that appears on only a single stroke, it does not meet the criteria of Section 5 of WDI-ET-004 and thus is not a flaw-like response.

Since no magenta appears in the general area, the ET data acquired here is valid and normal data analysis can be performed.

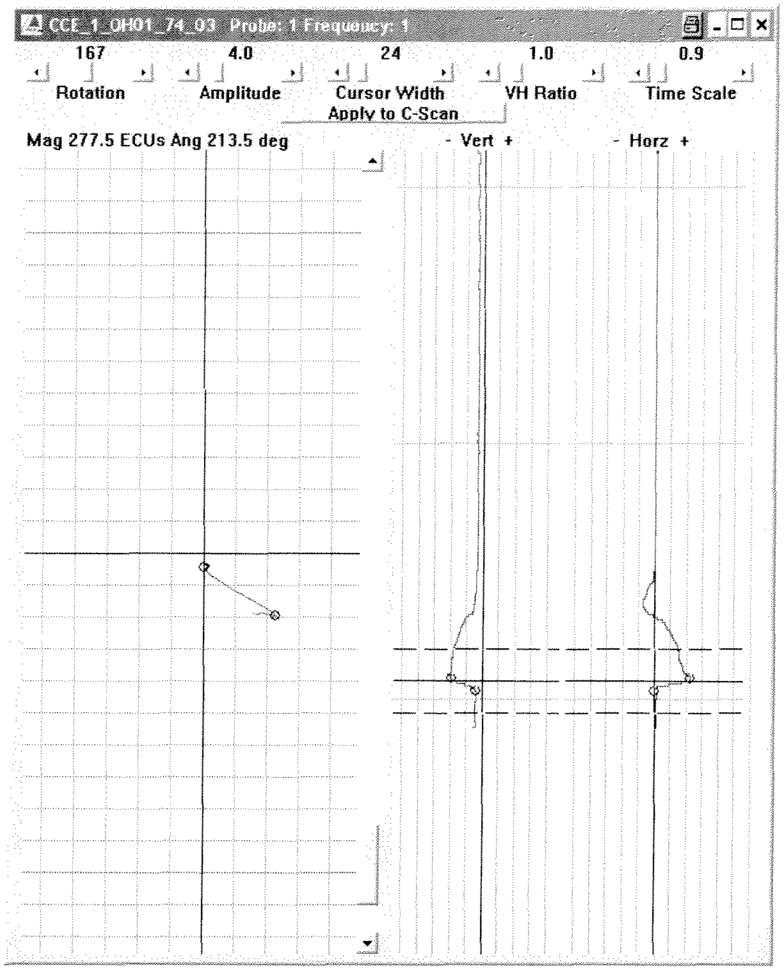

Figure 3
Lower Magenta Signal

Strong Eddy Current Signal Evaluation

The strong ET signal response can be seen near the top of the disturbed area. Reviewing the data shows that this signal responds as a volumetric indication and so is not flaw-like. However, the amplitude of the signal is large enough that it could mask a smaller ID indication.

To determine if any ID indication was hidden by the signal, the UT data was reviewed to determine if a lateral wave could be seen at that location. If an ID indication existed at that location, this would cause a break in the lateral wave.

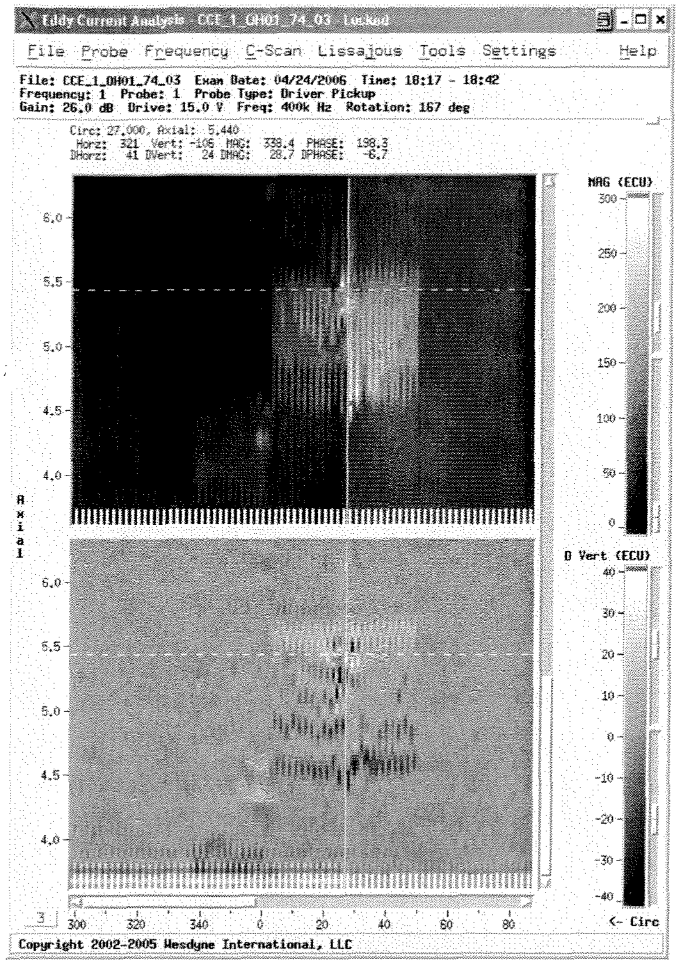

Figure 4
Strong Signal Location, ET Results

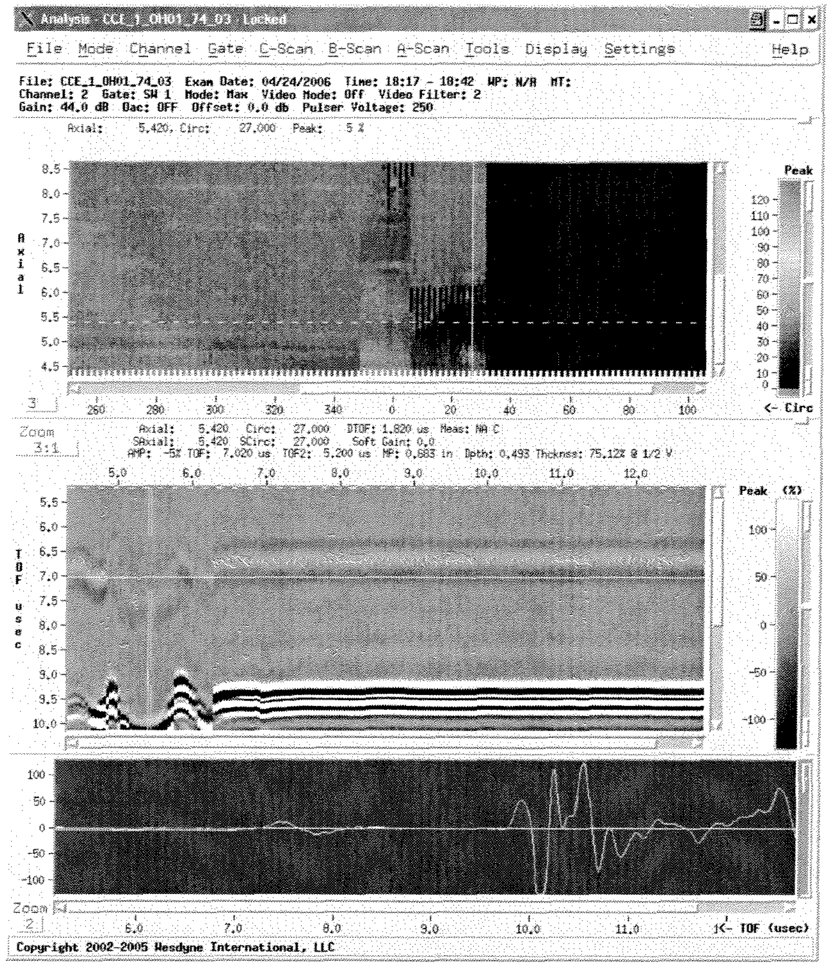

Figure 5
Strong Signal Location, UT Results

Figure 4 above shows the location of the strong response in the ET data. Figure 5 above shows the UT data for Channel 2 at the same location. The lateral wave is distorted, but there is no break. Therefore it can be concluded that there are no ID related indications at that location.

Attachment 3
Braidwood Unit 1 Penetration Number 74 Remote Visual Images


25 APR 06
22:06
Braidwood Unit 1 Penetration # 74


25 APR 06
22:06
Braidwood Unit 1 Penetration # 74


25 APR 06
22:07
Braidwood Unit 1 Penetration # 74

Attachment 4

Braidwood Station Unit 1

List of Commitments Regarding First Revised Order EA-03-009 Relaxation Request

Attachment 4

Braidwood Station Unit 1

List of Commitments Regarding First Revised Order EA-03-009 Relaxation Request

COMMITMENT	COMMITTED DATE OR "OUTAGE"	COMMITMENT TYPE	
		ONE-TIME ACTION (Yes/No)	PROGRAMMATIC (Yes/No)
If the NRC finds that the crack-growth formula in industry report MRP-55 is unacceptable, then EGC will revise its analysis for Braidwood Station Unit 1 that justifies relaxation of the Order using the new NRC-approved crack-growth formula.	Within 30 days after the NRC notifies EGC by written correspondence of an NRC-approved crack-growth formula.	Yes	No
If the EGC revised analysis for Braidwood Station Unit 1 shows that the crack-growth acceptance criteria are exceeded prior to the end of the current operating cycle, the relaxation request will be rescinded and EGC will submit to the NRC written justification for continued operation of Braidwood Station Unit 1.	Within 72 hours of determining that the crack growth acceptance criteria are exceeded prior to the end of the current Braidwood Station Unit 1 operating cycle.	Yes	No
If the EGC revised analysis for Braidwood Station Unit 1 shows that the crack-growth acceptance criteria, while acceptable for the current operating cycle, are exceeded during the subsequent operating cycle, EGC will submit the revised analysis for NRC review.	Within 30 days of determining that the crack growth acceptance criteria are exceeded during the subsequent Braidwood Station Unit 1 operating cycle.	Yes	No
If the EGC revised analysis shows that the crack-growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle for Braidwood Station Unit 1, EGC will submit a letter to the NRC confirming that its analysis has been revised.	Within 30 days of the approval of the EGC revised analysis for Braidwood Station Unit 1.	Yes	No
Any future crack-growth analyses performed for this and future cycles for Braidwood Station Unit 1 RPV head penetrations must be based on an acceptable crack-growth rate formula.	Whenever crack-growth analyses for Braidwood Station Unit 1 RPV head penetrations are revised.	No	Yes
A bare metal visual examination of the reactor pressure vessel (RPV) head surface, consistent with the Order Section IV.C.(5)(a), at the number 74 reactor head penetration location, including a 1-inch annulus 360° around the penetration, will be performed every refueling outage until the next required volumetric examination is performed. At that time, the inner surface of penetration 74 will be reconditioned and a complete volumetric examination will be performed of the penetration.	Every refueling outage until the next scheduled volumetric examination of the Braidwood Station Unit 1 RPV head penetrations. The current schedule is to perform the next volumetric examination during the Braidwood Station Unit 1 Spring 2012 refueling outage (i.e., A1R16).	No	Yes

Note: The term "current operating cycle" refers to the Braidwood Station Unit 1 operating cycle in effect when the NRC notifies EGC by written correspondence that the flaw-growth rate formula in industry report MRP-55 is no longer acceptable and an alternate NRC-approved crack-growth formula is to be used.