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MEMORANDUM TO: Edmund J. Sullivan, Jr., Chief
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SUBJECT: SUMMARY OF PUBLIC MEETING HELD ON OCTOBER 11, 2000, WITH PDI REPRESENTATIVES

On October 11, 2000, the staff participated in a public meeting with representatives from the Electric Power Research Institute (EPRI) - Performance Demonstration Initiative (PDI) program at the NRC in Rockville, Maryland. The purpose of the meeting was to discuss the implementation of Appendix VIII, "Performance Demonstration for Ultrasonic Examination Systems," Section XI of the American Society of Mechanical Engineers, Boiler and Pressure Vessel Code (Code) as being administered by the PDI program and to discuss selected paragraphs in 10 CFR 50.55a(b)(2)(xv) and (xvi). The participants for the staff were Don Naujock, (NRC), Terence Chan (NRC), and Michael Modes (NRC/Region I); the participants for PDI were Philip Ashwin, Carl Latiolais, Mike Gothard, Larry Becker, Frank Ammirato, and Frank Leonard (PDI/Tennessee Valley Authority).

A PDI representative began the meeting with an overview of the agenda that was followed by topical presentations. The presentations outlined PDI's approach for implementing selected supplements to Appendix VIII with associated modifications required by 10 CFR 50.55a(g)(6)(ii)(C) and 50.55a(b)(2)(xv) and (xvi). The meeting agenda is Attachment 1. Handouts provided by PDI for selected items in the agenda are provided in Attachments 2 through 6.

SINGLE SIDE EXAMINATION FOR FERRITIC REACTOR PRESSURE VESSEL WELDS

Attachment 2, "Single Side Examination for Ferritic RPV Welds," described PDI's technical basis for flaw selection and test specimen design with supporting experimental results. The experimental results showed that all of the flaws were detectable in both the optimum and non-optimum scanning directions. Based on the presented data, the NRC staff did not take exception to the flaws or test specimen design. The NRC staff also accepted the approach presented by PDI for meeting the requirements of 10 CFR 50.55a(b)(2)(xv)(G)(2). In their approach, the qualification is an add-on to Appendix VIII, Supplement 4. The technical basis for the approach is provided in Attachment 2. This approach recommends PDI members

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develop a specific technical basis by vendors, perform open demonstrations, and issue a supplemental qualification certificate. The NRC staff accepted this approach with the stipulation that the demonstration must use the same sensitivity used to qualify the Appendix VIII, Supplement 4 procedure and that the procedure does not require confirmation of an ultrasonic signal from two insonification directions in order to consider the signal a flaw.

The NRC staff provided clarification on the percent coverage aspects to the application of 10 CFR 50.55a(b)(2)(xv)(G)(1), (2), (3), and (4). If essentially 100%, but not less than 90%, of the inner 15% through-wall weld volume is examined according to 10 CFR 50.55a(b)(2)(xv)(G)(1), the coverage requirement for the weld is satisfied. If less than 90% is examined with a qualified Supplement 4 procedure, the unexamined portion of the inner 15% must be examined to the extent possible using a qualified single-side, Supplement 4 procedure, and the outer 85% must be examined using a qualified Supplement 6 procedure. To receive full credit for the portion of the inner 15% of the weld volume not examined in 4 directions, the weld volume must be examined in at least one parallel and one perpendicular direction to the weld.

EXAMINATION OF PIPING FROM THE INSIDE SURFACE

Attachment 3, "PWR Piping Welds Examined from the RPV Inside Surface per Appendix VIII and 10 CFR 50.55a," presented PDI's scope and approach for qualifying procedures and personnel for piping examinations performed from the RPV. The NRC staff did not take exception to PDI's approach. PDI agreed to develop their approach into a separate supplement to Appendix VIII, and submit the supplement as a proposed Code case for ASME committee action. The NRC staff representative on the ASME Code committee will review the technical details of PDI's proposed Code case from documents distributed to ASME committee members.

EXAMINATION OF WELD OVERLAY

Attachment 4, "Supplement 11, PDI Overlay Development Program," presented PDI's scope and approach for qualifying procedures and personnel for examining weld overlays. The NRC staff stated that the scope and approach must contain the elements from the tri-party agreement[1] and the requirements in Appendix VIII, Supplement 11, paragraphs 1.1(a), (b), (c), and (f). The NRC staff did not take exception to the other aspects of the scope and approach. PDI agreed to develop a revision to paragraphs 1.1 (d) and (e) to include the test specimens from the tri-party agreement and to submit the revision as a Code case to the appropriate ASME committee for action. The NRC staff representative on the ASME Code committee will review the technical details of PDI's proposed Code case from documents distributed to ASME committee members.

[1] In a letter dated July 3, 1984, NRC, Boiling Water Reactor Owners' Group, and Electric Power Research Institute entered into an agreement regarding the qualification of procedures and personnel for the examination of intergranular stress-corrosion cracking and weld overlays.

EXAMINATION OF DISSIMILAR METAL WELDS

Attachment 5, "Dissimilar Metal Weld Program Development," presented PDI's scope and approach for qualifying procedures and personnel for examining dissimilar metal welds. The NRC staff did not take exception to PDI's approach and the method being used to determine the test specimen population. The NRC staff requested that PDI provide the NRC staff with a detailed submittal in a format similar to that of a Code case. Included in the details would be discussions of scope, technical issues, specimen selection, and minimum number of flaws and flaw distributions comprising a test set.

OTHER ITEMS

Attachment 6 (no title) presents specific items of interest to PDI. The meeting discussions of these items are summarized below.

FLAWS IN SUPPLEMENT 5 AND 7 TEST SPECIMENS

PDI asked about the significance of transverse flaws in Supplement 7 performance demonstrations. The NRC staff informed PDI that no technical basis for removing the transverse flaws from the testing criteria has been provided that would allow the staff to conclude that such a removal was justified. PDI also asked for coverage clarification of 10 CFR 50.55a(b)(2)(xv)(K)(1), vessel-to-nozzle examinations when the examinations are performed exclusively from the nozzle bore. The NRC staff expressed that 10 CFR 50.55a(b)(2)(xv)(K)(1) is for qualification purposes and not for coverage.

EXAMINATIONS OF CORROSION RESISTANCE CLADDING

PDI stated that examination of corrosion resistance cladding (CRC) affects only a small number of licensees and is not covered by Appendix VIII of ASME Section XI. PDI stated that licensees were continuing to use their current inspection programs for CRC examinations. The NRC staff will determine the degree to which nondestructive evaluations are relied upon in structural integrity evaluations of CRC welds before agreeing with PDI's stated position.

FUTURE NRC /PDI INTERACTIONS

The PDI representative initiated a discussion on the need for NRC to periodically assess the development of performance demonstrations currently being added to the PDI program. These demonstrations are examinations of: piping from the inside surface, weld overlays, and dissimilar metal welds. PDI believes that these items will be sufficiently developed for staff review in early 2001. The NRC staff expressed a willingness to conduct an assessment of these items at a mutually agreeable time.

QUESTIONS PERTAINING TO THE RULE

PDI expressed its belief that paragraph 3.2(c) in Supplement 4 to Appendix VIII should have been deleted by the recent 10 CFR 50.55a rulemaking. The NRC staff agreed to look into the issue.

PDI asked for clarification of the parts of the 1995 Edition with 1996 Addenda of the ASME Code that was covered by the rule. The discussion centered around the wording in 10 CFR 50.55a(g)(6)(ii)(C). The NRC staff expressed that the scope of coverage is addressed in 10 CFR 50.55a(g)(4)(iv), wherein it states "Portions of editions or addenda may be used provided that all related requirements of the respective editions or addenda are met." This sentence in the rule is to provide the licensee with an opportunity to use parts in a later endorsed edition and addenda of the Code. When the rule requires that the licensees use a specific reference from a later edition and addenda of the Code, the NRC staff believes that the licensees must implement the specific reference and in so doing must also use all related requirements in the specified edition and addenda, unless limitations are specifically addressed in 10 CFR 50.55a(b)(2). The mandatory implementation of Appendix VIII establishes UT examinations at the same level of performance for all licensees.

Attachments: As stated:

Meeting Agenda

Wednesday, October 11,2000

1. Single side examinations of the reactor pressure vessel.
2. Implementation schedule for examination of piping from the inside surface.
3. Proposed approach for overlay samples.
4. Proposed approach for dissimilar metal welds.
5. Scope and schedule for NRC/PDI interactions.
6. Other items of interest:

    A) Supplement 5 and 7 - the need for transverse flaws.

    B) Corrosion resistance cladding.

    C) Revision to PDI Program Document.

IMPLEMENTATION OF ASME SECTION XI, APPENDIX VIII, PERFORMANCE DEMONSTRATION REQUIREMENTS AS MODIFIED BY 10 CFR 50.55a

Single Side Examination for Ferritic RPV Welds

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October 9, 2000

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Executive Summary

The ASME Code, Section XI, Div 1, 1995 Edition, 1996 Addenda, Appendix VIII was incorporated into the Code of Federal Regulations, September 22, 1999. Several additional requirements were also incorporated at that time. In particular several requirements addressed concerns relative to examination coverage for the reactor pressure vessel (RPV). These requirements include:

1. Demonstrations on flaws oriented up to 45 degrees relative to the local surface normal within the inner 15% of the vessel thickness.
2. No coverage credit is allowed for the inner 15% of the vessel where access is restricted to a single side of the weld even if the procedure and personnel are qualified for this limitation.
3. Coverage credit is allowed in the outer 85% provided personnel and procedures are qualified for that limitation.

It is agreed that the additional redundancy of multidirectional scanning is beneficial in assuring detection of unacceptable flaw conditions. However, there are many occasions where access is restricted to a single direction due to the design of the component. Single side Qualifications for Appendix VIII Supplements 4 and 6 were completed prior to incorporation of these new 10 CFR 50.55a requirements. EPRI and PDI have proposed a supplemental qualification approach to address the concern regarding the misoriented flaws.

A block containing flaws with orientations up to 45 degrees from the local surface normal was constructed. The flaws are located within two inches of the clad surface, which represents at least 15% of the thickest vessels currently operating units. The flaw types and locations were modeled after those found in the PVRUF vessel, Ref. (1). A series of measurements using conventional inspection approaches indicated that crack-like flaws of unacceptable size should be detected even if they are oriented in an unfavorable direction.

The proposed supplemental qualification approach includes:

1. A generalized technical basis describing the approach and justification (this document)
2. A Specific Technical Basis by each inspection vendor
3. Procedure Evaluation and Demonstration
4. Procedure Qualification.

The NDE Center will monitor the procedure demonstrations to assure that procedures are effective and the evaluation criteria addresses single side accesses conditions and unfavorable flaw orientations. The supplemental demonstration described in this document along with PDI Supplement 4 and 6 demonstrations address the concerns expressed by NRC relative to miss-oriented flaws and single side examinations.

Background

The EPRI NDE Center has administered qualifications for reactor vessel shell weld examinations in accordance with the PDI's implementation of Appendix VIII Supplements 4 and 6 since 1994. The PDI program procedures and instructions used by EPRI allow for procedures and/or personnel to be qualified for App VIII, Supplements 4 and 6, where access is restricted to one side of the examination volume. This restricted access condition is described as "single side." Accordingly, when procedures or personnel have met the qualification requirements, they are referred to as a "single side qualification." Single side qualifications endorsed by the PDI require the procedure or personnel to demonstrate capabilities to the same (equivalent) acceptance criteria as used for qualifications where full access to the examination volume is achievable.

Single side qualifications were administered to provide a qualified procedure for the common situation where access is available from only a single side of the weld. Equivalent performance was demonstrated from a single direction in these demonstrations. This appeared to be a reasonable interpretation of Section XI, 95 Edition, 96 Addenda, Appendix I, I-2220.

> **I-2220 REACTOR VESSELS**
> **(a) Ultrasonic examination procedures, equipment, and personnel used to detect and size flaws in reactor vessels greater than 2 in. in thickness shall be qualified by performance demonstration in accordance with appendix VIII for the following specific examinations and no other I-2000 requirements apply.**
>
> **(1) Shell and Head Welds Excluding Flange Welds**
> **(2) Nozzle-to-vessel Welds**
> **(3) Nozzle Inside Radius Section**
> (4) **Clad/Base Metal Interface Region**

On September 22, 1999 the NRC issued its final ruling requiring implementation of the ASME Code, 1995 Edition with 1996 Addenda, Div. 1, Section XI, Appendix VIII, with additional requirements and modifications as listed in 10 CFR 50.55a. Within the ruling there are specific requirements concerning the qualification and use of procedures for Supplement 4 and 6 relating to single side access

Excerpts from the Code of Federal Regulations, shown in bold, that describe the new and supplemental requirements, that now must be addressed:

"10 CFR 50.55a(b)(2)(xv)
(G) When applying Supplement 4 to Appendix VIII, Supplement 6 to Appendix VIII or combined Supplement 4 and Supplement 6 qualification, the following additional provisions must be used, and examination coverage must include:

(1) **The clad to base metal interface, including a minimum of 15 percent T (measured from the clad to base metal interface), shall be examined from four orthogonal directions using procedures and personnel qualified in accordance with Supplement 4 to Appendix VIII."**

(2) **If the clad-to-base-metal-interface procedure demonstrates detectability of flaws with a tilt angle relative to the weld centerline of at least 45 degrees, the remainder of the examination volume is considered fully examined if coverage is obtained in one parallel and one perpendicular direction. This must be accomplished using a procedure and personnel qualified for single-side examination in accordance with Supplement 6. Subsequent examinations of this volume may be performed using examination techniques qualified for a tilt angle of at least 10 degrees."**

"10CFR 50.55a(b)(2)(xvi) ***Appendix VIII single side ferritic vessel and piping and stainless steel piping examination.***
(A) Examinations performed from one side of a ferritic vessel weld must be conducted with equipment, procedures, and personnel that have demonstrated proficiency with single side examinations. To demonstrate equivalency to two sided examinations, the demonstration must be performed to the requirements of Appendix VIII as modified by this paragraph and §§50.55a(b)(2)(xv) (B) through (G), on specimens containing flaws with non-optimum sound energy reflecting characteristics or flaws similar to those in the vessel being examined."

The above requirements were not considered during Supplement 4 & 6 qualification demonstrations performed from 1994 through 1999. Supplemental demonstrations will be required to incorporate these new requirements. Qualifications administered by PDI meet the equivalency requirements of 10CFR 50.55a(b)(2)(xvi)(A), in that both single side and dual side qualification

demonstrations were performed to the same acceptance standards. They do not meet the requirement relating to **"specimens containing flaws with non-optimum sound energy reflecting characteristics or flaws similar to those in the vessel being examined."** The objective of this document is to describe a satisfactory method of demonstrating the required "equivalent" performance.

Supplemental Qualification Program

In response to the Final Rule the PDI Program will administer a program of qualifications that will address the supplemental requirements contained in the Final Rule. The Program will include the following components:

1. PDI Technical Basis (General)
   Provides basis for postulated flaw and general expectations of performance
2. Vendor Technical Basis (Specific)
   Reports vendor specific flaw evaluation criteria and results on the PDI test block
3. Procedure Evaluation
   PDI will observe and evaluate results of open demonstrations in light of reporting criteria and any required changes to the previously qualified procedure
4. Procedure Qualification/Certification
   PDQS Certificates will be reissued with amended Scope
   The PDQS will state that it is or is not in compliance with the Final Rule.

PDI Technical Basis

The PDI Technical Basis provides the general framework for the supplemental qualification program. It describes the flaws and the test block to be used, experimental results that provide general conclusions of capability as well as conclusions and recommendations.

The PDI supplemental qualification was initiated based on agreements with the ASME Section XI Appendix VIII rewrite Committee during the February 1999 meeting. The position of that committee relative to supplemental demonstrations for single side accesses and the 45-degree tilted flaw is recorded in the minutes dated February 23,1999. The minutes are exerpted as follows:

"Regarding the 45 degree tilted flaw referred to in A.2 (b) of Code Case N-622, the committee agreed to the following

1. *Two (2) cracks will be used*
2. *The cracks may be weld solidification type*

3. *Both cracks will be oriented parallel to the clad direction*
4. *One crack will be 4 mm through wall, the second will be 17 mm through wall*
5. *The flaw aspect ratio will be between 2 and 10*
6. *Both will be sub-surface as defined in Section XI*
7. *They will be located within the inner 15 % of the vessel wall*
8. *The demonstrations on these flaws will be conducted under non-blind conditions within the demonstrated parameters of a previously qualified Supplement 4 procedure.*

The flaw sizes and locations were approximate and are related to the size and locations of flaws reported in the Pressure Vessel Research User Facility, (PVRUF) vessel, Ref. (1)(2).

Postulated Flaw

The crack type to be used in the supplemental qualification is based on the most likely flaw morphology, should one occur. Recent evaluations of RPV Vessel material and welds, for the purpose of establishing realistic flaw distributions, Ref. (2)(3), revealed complex cluster type flaws, thought to result from repairs. These clusters of small indications appeared to have an overall orientation approaching 45 degrees relative to the local surface normal. The flaws revealed by these investigations are acceptable according to the ASME Code, IWA-3000 and IWB-3500 Acceptance Standards.

The most likely origin for an unacceptably large flaw at an extreme orientation is a repair area. Repairs are routinely performed to remove welding defects. Repairs are also performed to remove defects in the plate material prior to welding. Flaws in a repair area could include cracking, slag or lack of fusion (LOF). Cracking could result from contamination due to inadequate cleaning, or improper preheat. Under repair conditions slag and LOF flaw are normally restricted to a single weld bead. A cross section a weld solidification flaw is shown in Figure 1A. The morphology of the flaw shown in Figure 1A is very similar to one that was found during the metallographic analysis of the PVRUF vessel, Ref. (4). The PVRUF crack, shown in Figure 1B, initiates at a contaminated lack of fusion. Weld solidification cracks for NDE mockups are made by controlled introduction of a small quantity of material that has a lower melting point than the parent weld material. The lower strength at normal solidification temperatures results in a crack.

Multiple aligned slag or LOF would have an ultrasonic response characteristic similar to multiple point reflectors as opposed to a smooth mirror like flaw. Cracks resulting from contamination are small short and rough, as they result from cracking during solidification of the weld. Cracking occurring as the result of improper preheat are also rough, occur in clusters and are normally oriented parallel to the weld fusion line. A smooth mirror like flaw, of unacceptable size,

oriented at large angle relative to the surface normal is not a reasonable assumption. Therefore, a solidification crack, as shown in Figure 1, is the most appropriate simulation of the defect in question.

Rough cracks provide lower ultrasonic responses than mirror like flaws at normal incidence. However, the rough crack can be seen over a much larger range of angles as a result of the scattering from multiple small facets Ref. (5)(6).

Test Specimen

A test specimen containing five solidification cracks oriented at 45 degrees to the surface normal has been fabricated. The specimen was fabricated at Southwest Research Institute (SwRI). SwRI used the same procedures that they used for the fabrication of the PDI RPV shell test specimens. The test specimen is approximately 1105mm (43.5") long x 200mm (8") wide x 102mm (4") inches thick and contains five (5) weld solidification cracks. The cracks are all embedded and each contains a ligament from the crack tip to the clad to base metal interface. The scanning surface (i.e. the clad surface) is covered with 6-7mm (0.25") SMAW stainless steel cladding. The clad has been deposited along the same axis as the flaw length to represent the worst case condition from an inspection point of view. The surface condition of the cladding is hand ground to similar standards and finish as used on PDI test specimens.

Solidification cracks were chosen for the PDI RPV demonstration samples as they most closely simulate flaws that might occur during fabrication. They have the additional advantage of fewer satellite reflectors, which act as signposts to aid in the detection. PDI has qualified each of its' vendors for the production of flawed samples. The objective of this qualification is to assure the vendor and vendor personnel are capable of producing flaws of known size and flaw characteristics. A second objective is to assure the capability to produce flaws free from satellite reflectors. A cross section of a weld solidification flaw from the vendor qualification trial is shown in Figure 1A.

The supplemental demonstration flaws, identified as A, B, C, D and E, are described in Table 1. The flaws are fabricated at a 45-degree tilt relative to the scanning surface. The depth of the flaw is the projected depth (through wall dimension) parallel to the inspection/scan surface.

Table 1
SUPPLEMENTAL DEMONSTRATION FLAWS

Flaw	Dimensions		Evaluation According to Section XI IWB 3510			
	Length x Depth Inch (mm)	Ligament Inch (mm)	Position and % of T based on 12.0 inch shell T	based on 4 inch shell T	based on 8 inch shell T	based on 12 inch shell T
A	2.0 x 0.673 (50.8 x17.09)	1.969 (50.01)	Sub-surface 16.4%	Unacceptable	Unacceptable	Acceptable
B	2.0 x 0.668 (50.8 x16.96)	1.969 (50.01)	Sub-surface 16.4%	Unacceptable	Unacceptable	Acceptable
C	1.22 x 0.155 (31.0 x 3.94)	1.969 (50.01)	Sub-surface 16.4%	Acceptable	Acceptable	Acceptable
D	0.99 x 0.096 (25.1 x 2.44)	0.193 (4.90)	Sub-surface 1.6%	Acceptable	Acceptable	Acceptable
E	1.18 x 0.198 (30.0 x 5.03)	0.121 (3.07)	Sub-surface 1%	Unacceptable	Acceptable	Acceptable

The test specimen flaws meet or exceed the requirements agreed upon by the ASME Section XI Appendix VIII Rewrite Committee. Additional flaws at a wider range of positions are included to assure a more comprehensive test of the procedure's capability over a larger range of thickness.

It is important to consider how the specified test specimen flaws might be handled by the ASME code if they were present in an RPV and reported during ISI. For example, based on the ASME Code Section XI, IWB-3500 Flaw Acceptance Tables, flaw A would be acceptable in a 12 inch thick RPV shell course and no further action would be required. However the same flaw in the examination volume of an 11-inch thickness RPV shell course would require further analysis. The acceptability for each flaw is indicated for 4, 8 and 12 inch plate thickness.

PDI Experimental Results

Using the test specimen described above, the EPRI NDE Center has carried out experiments to provide empirical data relative to non-optimum flaw orientations and reflection surfaces. The objective of these experiments was to determine if the flaws in the test specimen would be detected by single side procedures qualified to the PDI's implementation of Appendix VIII. In essence, could the flaws be detected from both the optimum and non-optimum transducer positions using typical ultrasonic techniques that might be used by qualified procedures. In this case, the optimum condition would be a sound beam entering the material and striking at or near perpendicular to the flaw face. The non-optimum condition would be with the sound beam entering the material along the same axis as the flaw face i.e. near parallel to the flaw.

Experiments conducted by EPRI were carried out using transducers that would be considered appropriate for the depth of the flaws. For flaws connected to or close to the clad to base metal interface (Flaws D and E) a 70 degree dual element longitudinal transducer focussed at a metal path of 55 mm was used. For flaws beyond this range (Flaws A, B and C) a 45 dual element longitudinal wave focussed at a metal path of 130mm transducer was used. Sensitivity of the transducers was based on ASME calibration block side drilled holes, (i.e. a 0.125 inch diameter side drilled hole for the 70 degree transducer and a 0.313 inch diameter side drilled hole for the 45 degree transducer). These calibration points are referred to as the DAC. Each flaw was scanned from the optimum side and the non-optimum side and reported based on the maximum amplitude response from the reference hole as a percentage of DAC. The results are illustrated in Figure 2.

Flaws would be considered detected if the amplitude response was equal to or greater than 20% DAC. Therefore, it is reasonable to conclude that each of the flaws regardless of their orientation relative to the sound beam would be detected using a traditional 20% DAC reporting criterion. Indications less than 20% DAC may also be reported provided that they meet certain characteristics specified in the procedure. Typically NDE procedures qualified through the PDI program have required more than amplitude criteria to report a flaw. For example, the signal to noise characteristics of the flaw in the material along with the imaging capabilities of the data analysis system are used to specify criteria such that a target motion in the data display is indicative of a flaw. The data images from the flaws meet such criteria. The Vendor Specific Technical Basis will demonstrate the capabilities of each vendor's procedure.

The ultrasonic data collected by the EPRI experiments indicates that both the optimum and non-optimum orientations are detectable using standard ultrasonic techniques. The maximum relative amplitude is very similar for both the optimum and non-optimum orientations. Factors contributing to this condition include:

1. The random scan surface conditions and the SMAW cladding along the axis of the flaw influence the amount of sound transmitted to and received from the flaw.
2. The flaw is rough relative to the ultrasonic wavelength, i.e. non-optimum reflectivity, for normal incidence.
3. The maximum signal amplitude locations correspond with the location of the flaw tips as opposed to the face of the flaw.

To further quantify the responses from the Open Test Block flaws, flaws of similar size and location in the PDI RPV test blocks were scanned using the same equipment and sensitivities as described above. The response amplitudes of these flaws are shown in Figure 3. Flaw identifications A-E indicate that each flaw was selected to be similar in size and location to the same flaw in the Open

Test Block, see Table 1. The difference in response for similar flaws in each block is small. This would indicate that flaws of unacceptable size would provide sufficient response amplitude to assure that they would be detected with reliability similar to that achieved during the PDI RPV vessel qualifications.

Response amplitude is not the only factor that is considered in evaluating an indication. Qualitative evaluation factors include:

- Echo dynamic pattern, (signal persists over larger range of probe positions and metal path distances, i.e. signal "walks")
- Signal amplitude relative to local material noise, (signal to noise ratio)
- Continuity, (seen on more than one scan line)
- Length of indication
- Confirmation with multiple angles
- Confirmation with multiple directions

Each of these qualitative factors is considered in combination. Each Inspection vendor approaches the analysis slightly differently depending on the particular techniques they are using. Some vendors place specific criteria on one or more factors. Other vendors might consider them only qualitatively with the preponderance of information forming the basis for the decision making. In either case the personnel and procedure qualifications demonstrate the effectiveness of the criteria and the capability of individuals to use them. Each positive result increases the confidence in the overall decision making.

Flaw A

Responses from the Open Test Block and the PDI RPV test, although low in amplitude, provided good signal-to-noise ratio and response characteristics typical of crack-like defects for all of the flaws. The response from flaw A is shown in Figure 4A (optimum direction) and 4B (non-optimum direction) using a 45 degree longitudinal wave probe. Each figure contains four views of the ultrasonic response. The upper left A-Scan is the rectified analog signal at the maximum amplitude position. The C-Scan or plan view is shown in the upper right hand corner. The B-Scan or side view is at the lower left and the D-Scan or end view is on the lower right. It should be noted that the B and D-Scan images are projection images, i.e., multiple image planes are projected onto a single plane. Single plane images are also available and provide the fine detail needed for evaluation and sizing. The projection scans provide the best information for the detection phase. The entry surface for the B and D-Scans are at the top of the picture. The zero reference is at the vessel ID and the nominal clad thickness is 0.27 inch.

Figure 4A indications provide the best detectability as a result of the optimum flaw orientation. The flaw is also detectable in the non-optimum direction and exhibits approximately the same maximum response amplitude. It is expected that a 45 degree beam would exhibit the greatest differences as the flaw is tilted

at 45 degrees. The sensitivity used in Figure 4A is 3dB less sensitive than a 1/8" Side Drilled Hole (SDH) DAC. The sensitivity for Figure 4B is equal to 100% of the 1/8" SDH, DAC. These sensitivities were used to prevent saturation of the image. Scan sensitivity would normally be higher. With modern systems, using logarithmic recording, a much larger dynamic range is available for evaluating indications.

In examining Figure 4B, the keys that make the flaw detectable and result in further evaluation include:

- The A-Scan signal is a sharp singular spike that exhibits characteristic target motion when the cursor is moved through the scan motion range,
- The length and continuity of the image in the C-Scan view,
- Two coplanar target motion lines in the B-Scan view, and
- The apparent height of the indication in the D-Scan view.

The next step in the evaluation would be to examine data from other angles. The response from the non-optimum side using a 60 degree refracted longitudinal wave probe is shown in Figure 4C. The display sensitivity in Figure 4C is increased by 20 dB. The maximum response amplitude is 10% DAC. From Figure 4C it is clear, from the B and D –Scans, that the response is from a defect with substantial through wall extent, where upper and lower tip responses are clearly visible. The distance between the two tips is very close to the intended through wall dimension of 0.673". Sizing based on the 60 degree data provided a through wall dimension 0.75.

Flaw E

Flaw E is located 0.12 inch below the clad-to-basemetal interface and is intended to be 0.19 inch deep by 1.19 inch long. The response from Flaw E is shown in Figure 5A (optimum) and 4B (non-optimum) scan directions. The sensitivity in Figure 5A is 6 dB less sensitive than the 1/8"SDH DAC. In both instances it is possible to detect the flaw and to determine that it is not surface connected. Sizing within an acceptable accuracy is possible. A sizing scan, from the non-optimum direction, is shown in Figure 5C. The indicated size from this view is 0.296 inch or 0.1 inch larger than the intended flaw.

Shoreham Flaw

One of the flaws described in Reference (2) was imaged using techniques similar to those described above. This weld was removed from the Shoreham plant and is now being used to estimate the flaw distribution that might be expected in US fabricated reactor pressure vessels welds. Figure 6 is the image of flaw 2 from Reference (2). The gain used is 20 dB more sensitive than the ASME ¼ T, 5/16-inch diameter SDH. A 2 MHz. refracted longitudinal probe was used. Reference (2) lists this flaw as 32 mm (1.28 inch) in depth. It is our opinion that this indication should not and would not be reported using normal examination techniques based on the following:

- Maximum signal amplitude is 7% DAC
- The A-scan signal is not typical of a crack like flaws, that is, the indication does not exhibit an echo dynamic pattern of a crack
- Signals seen in the B, C and D-Scans are clearly from separate reflectors and are quite small
- The flaws would not be associated by proximity according to the rules of IWA-3000.

PDI Conclusions

Given the results of the EPRI NDE Center's evaluation described in this report, it is expected that procedures qualified for single side access will be capable of detecting flaws of an unacceptable size. Reliable detection is expected in the inner15% of the vessel thickness even if they are at extreme orientations relative to the local surface normal. Standard techniques for discrimination of response signals are effective for crack like defects and would be effective in correctly identifying unacceptable flaw conditions. Demonstration and analysis of the specific technique used by each vendor will be required. A supplemental demonstration program intended to meet the requirements of the 10 CFR 50.55a Final Rule is described below.

Vendors Technical Basis

Each organization that has qualified a procedure(s) in accordance with the PDI's implementation of ASME Section XI, Appendix VIII will be given the opportunity to present the following to PDI for review:

- A position statement as to why the qualified NDE procedure is capable of detecting flaws similar to those included in the Test Specimen manufactured by EPRI to evaluate the NRC ruling.
- The position statement should be supported by experimental data, which can be verified by the PDI as being applicable and supportive of the position statement.
- A position statement as to why the qualified NDE procedure is capable of sizing flaws similar to those included in the Test Specimen manufactured by EPRI to evaluate the NRC ruling.
- The position statement should be supported by experimental data, which can be verified by the PDI as being applicable and supportive of the position statement.

Open Demonstration

Upon review of the information the EPRI NDE Center on behalf of PDI will then evaluate the information presented and prepare a summary of observations and findings. This report will be delivered to the organization along with any recommendations for additional data to support their position. Additionally, the

organization will be given the opportunity to carry out an open demonstration using the test specimen described in this report. The purpose of the open demonstration will be to verify that the qualified procedure is capable of detecting and if specified, sizing the defects in the test specimen. Evaluation of the data will be documented by EPRI and successful demonstration will be granted based on the following:

- No changes have been made to the qualified procedure that may impact the known capability of the qualified procedure.
- All flaws in the open test specimen are detected in accordance with the equipment, instructions and criteria specified in the qualified procedure
- Where sizing of indications is included, the size of the flaws as reported by the qualified procedure during the open trials are combined with the results of the original qualification and that the sum of these results is within the acceptance criteria specified by the PDI's implementation of ASME Section XI, Appendix VIII, Supplement 6.

Supplemental Qualification Certificate

On successful completion of the open demonstration and providing all other requirements are completed in accordance with the PDI program the original PDQS document will be revised.

FUTURE QUALIFICATIONS

When new procedures are submitted for qualification it is recommended that an organization first qualify procedures in accordance with the existing PDI program requirements with the supplemental requirements added as an additional endorsement. The Supplemental qualifications may be performed in parallel, but separate from the normal blind trials that is part of the existing program. The expected sequence of events is as follows:

(1) Vendor is provided access to PDI Practice blocks and the Open Test Block, containing flaws with non optimum reflecting characteristics,
(2) Vendor submits proposed procedure for PDA review,
(3) PDA reviews procedure according to the existing PDI Program and the supplemental requirements included in the final rule,
(4) Vendor produces "working draft procedure,"
(5) Blind trials are performed and graded,
(6) Non-blind trials on the Open Test Block are performed and evaluated,
(7) PDQS Certificates are issued which describe the qualified procedure as well as the conformance to the supplemental requirements of the Final Rule.

Conclusions

The proposed Supplemental Qualification, in addition to the current single side qualification requirements for Supplements 4 and 6, will provide adequate assurance that flaws of concern will be detected.

REFERENCES:

(1) Pardini, A. F., "Validation of Fabrication Flaws in Weld Metal from PVRUF, International Conference, Second International Conference on NDE in Relation to Structural Integrity for Nuclear and Pressurized Components, May 24-26, 2000, New Orleans, Louisiana.

(2) Schuster, G. J., S. R. Doctor, and P. G. Heasler, 1998, "Characterization of Flaws in U.S. Reactor Pressure Vessels: Density and Distribution of Flaw Indications in PVRUF," NUREG /CR-647 Vol-1, PNNL-11143, U.S. Nuclear Regulatory Commission, Washington, DC.

(3) Schuster, G. J., S. R. Doctor, S. L. Crawford, A. F. Pardini, 199, "Characterization of Flaws in U.S. Reactor Pressure Vessels: Density and Distribution of Flaw Indications in the Shoreham Vessel," NUREG /CR-6471, Vol-3, PNNL-11143, U.S. Nuclear Regulatory Commission, Washington, DC.

(4) Pardini, A. F., et al, "Validation of Fabrication Flaws in Weld Metal from PVRUF, Figure 22, International Conference, Second International Conference on NDE in Relation to Structural Integrity for Nuclear and Pressurized Components, May 24-26, 2000, New Orleans, Louisiana.

(5) Becker, F. L., "Effectiveness Demonstrations for Under Clad Crack Detection", Non-Destructive Examination for Pressurized Components, Edited by Nichols, R. W., Dau, G. J., Elsevier Applied Science Publishers, London, 1984, pp 133-142.

(6) Coffey, J. M, et al, The Ultrasonic Detectability of A Postulated 'Worst Case' Flaw in a PWR Vessel", Report No. NWR/SSD/82/0045/R, Central Electricity Generating Board, NDE Applications Centre, UK, April 1982.

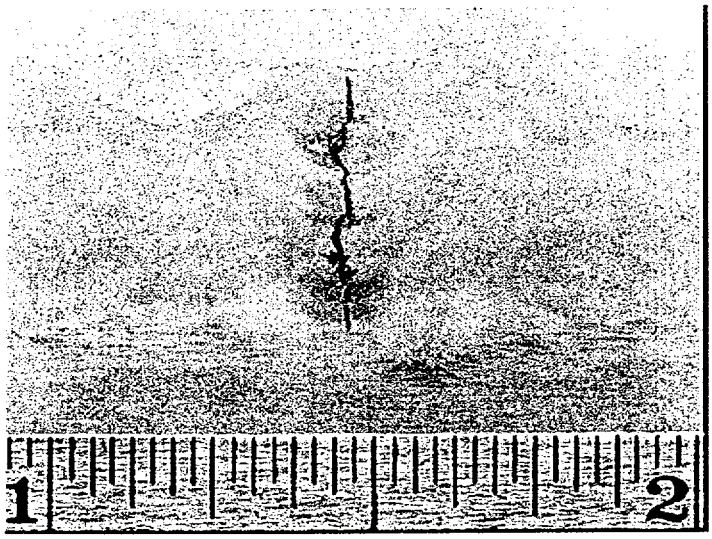


Figure 1A: Example of Fabricated Solidification Cracks of the type Used in the Supplemental Demonstration Block.

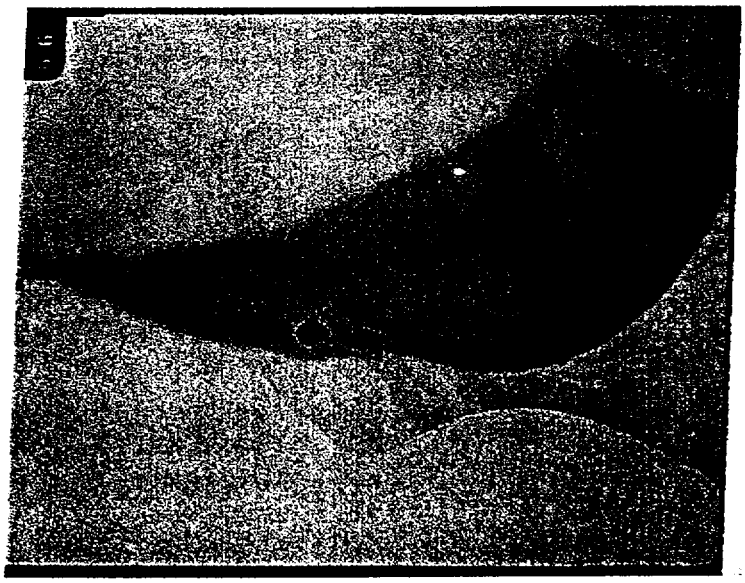


Figure: 1B: Crack found in PVRUF vessel, Ref (4)

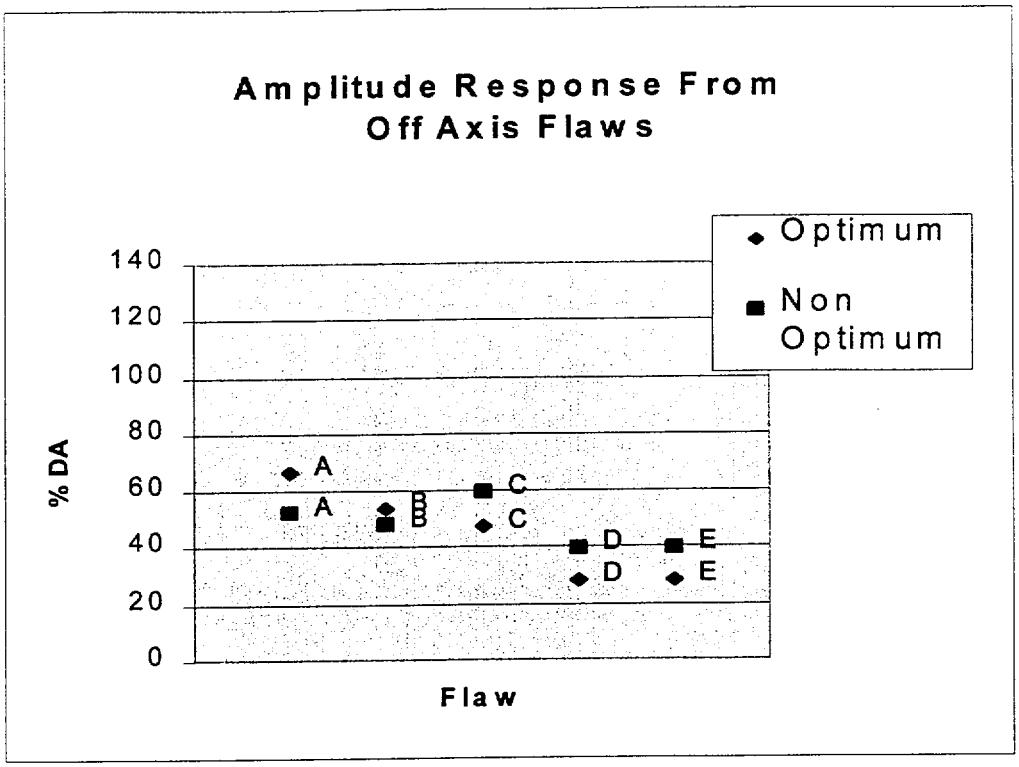


Figure 2: Amplitude Response from off Axis Flaws

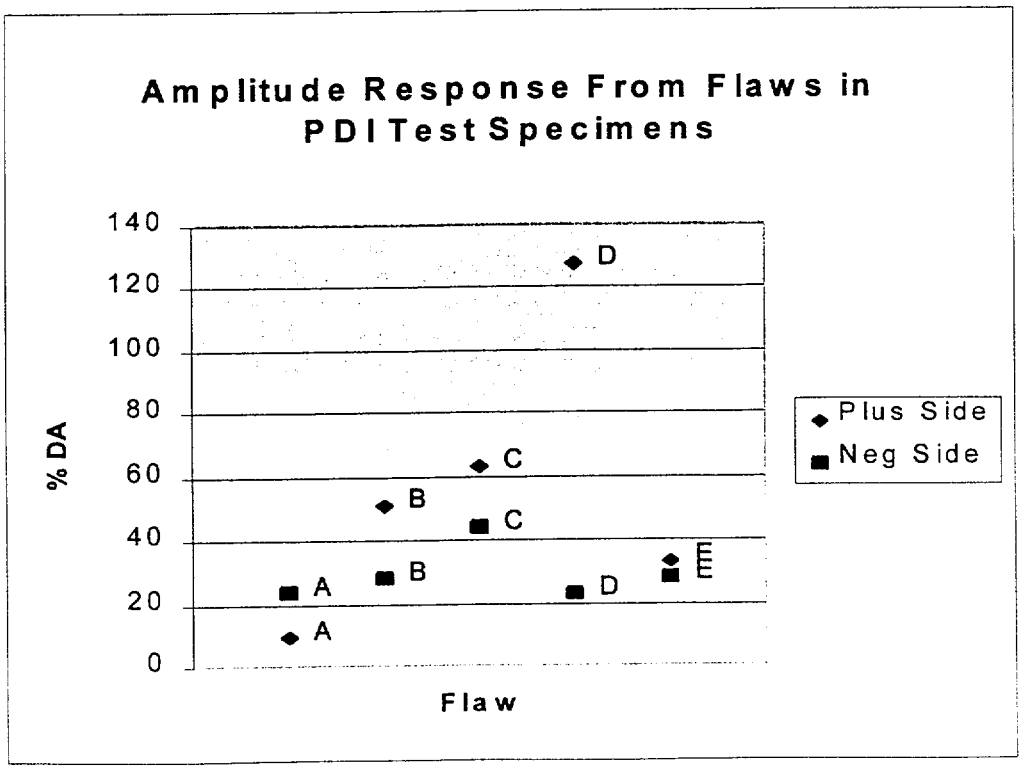


Figure 3: Amplitude Response from Flaws in PDI Test Specimens.

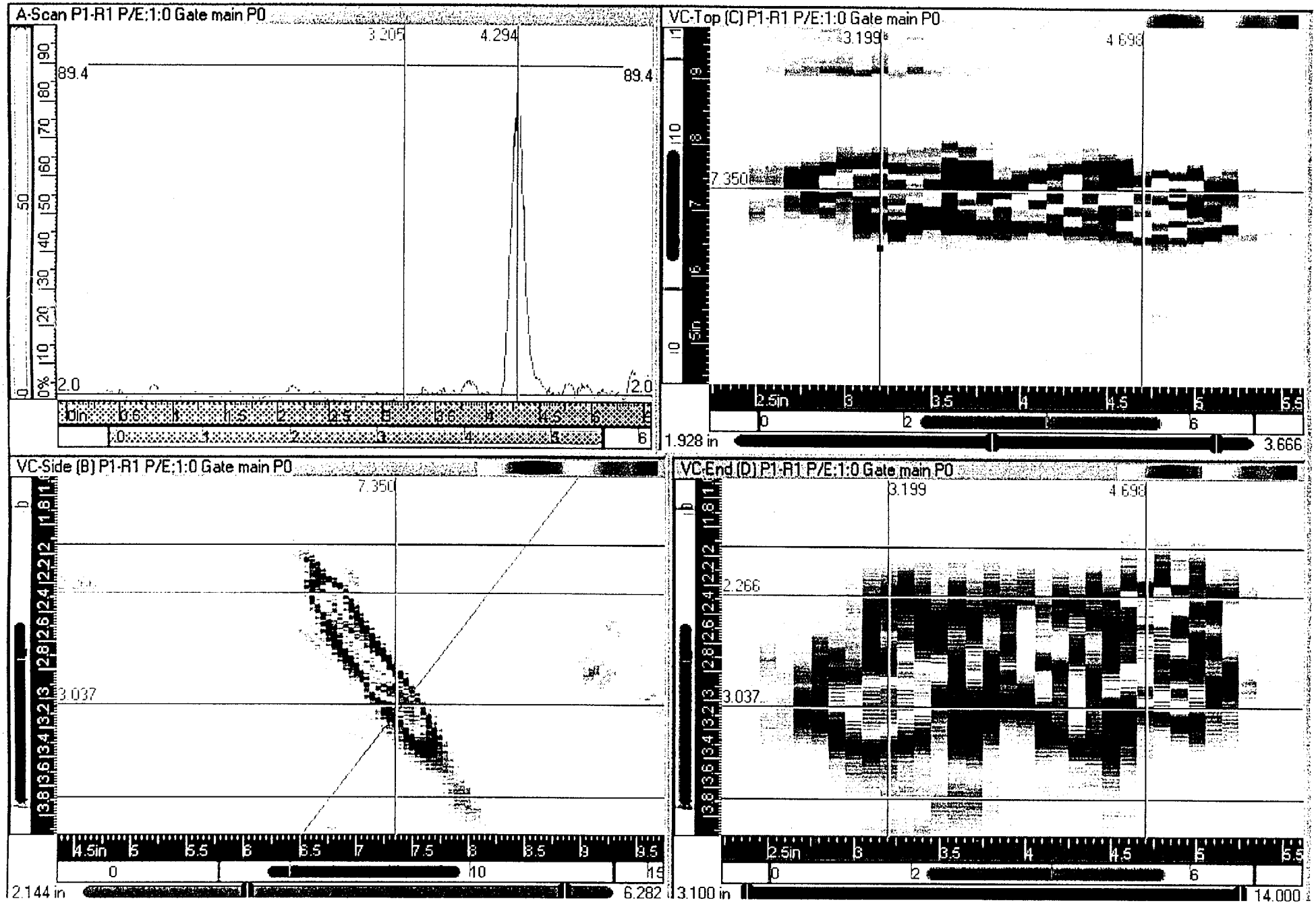


FIGURE 4A
RESPONSES FROM FLAW A FROM OPTIMAL DIRECTION

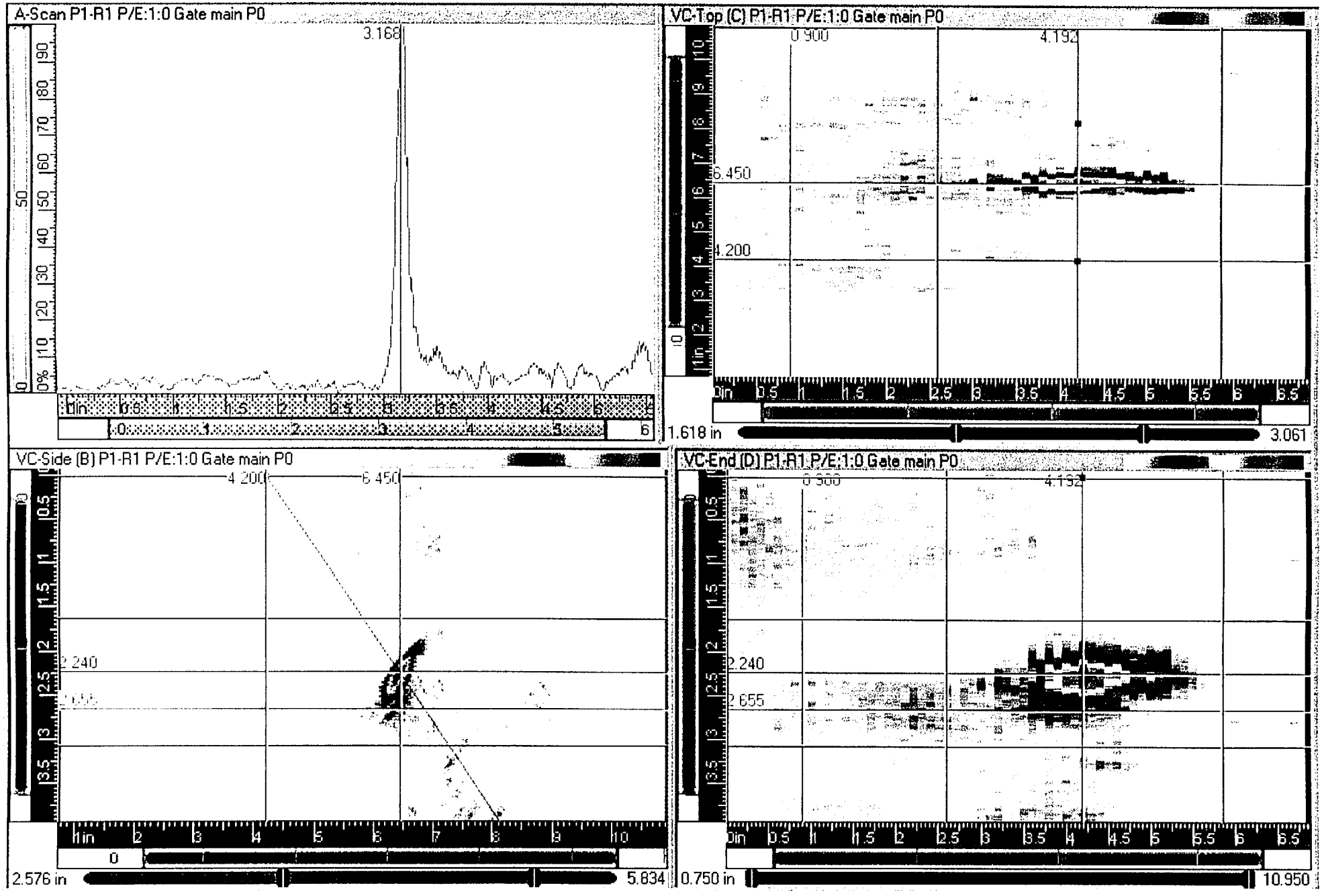


FIGURE 4B
RESPONSES FROM FLAW A FROM NON-OPTIMAL DIRECTION

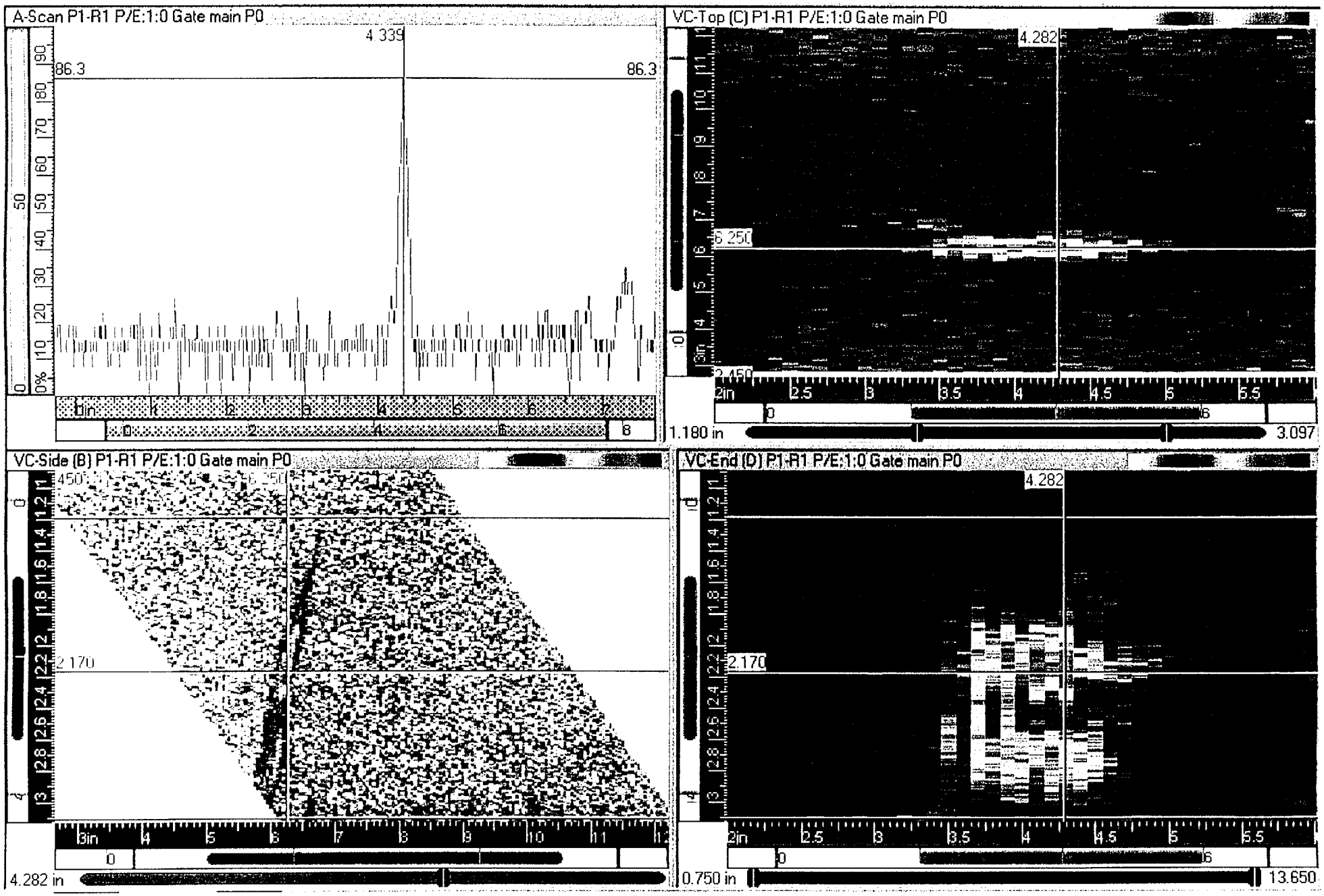


FIGURE 4C

SIZING IMAGE FROM FLAW A, FROM NON-OPTIMAL DIRECTION USING 60 DEGREE LONGITUDINAL WAVE PROBE

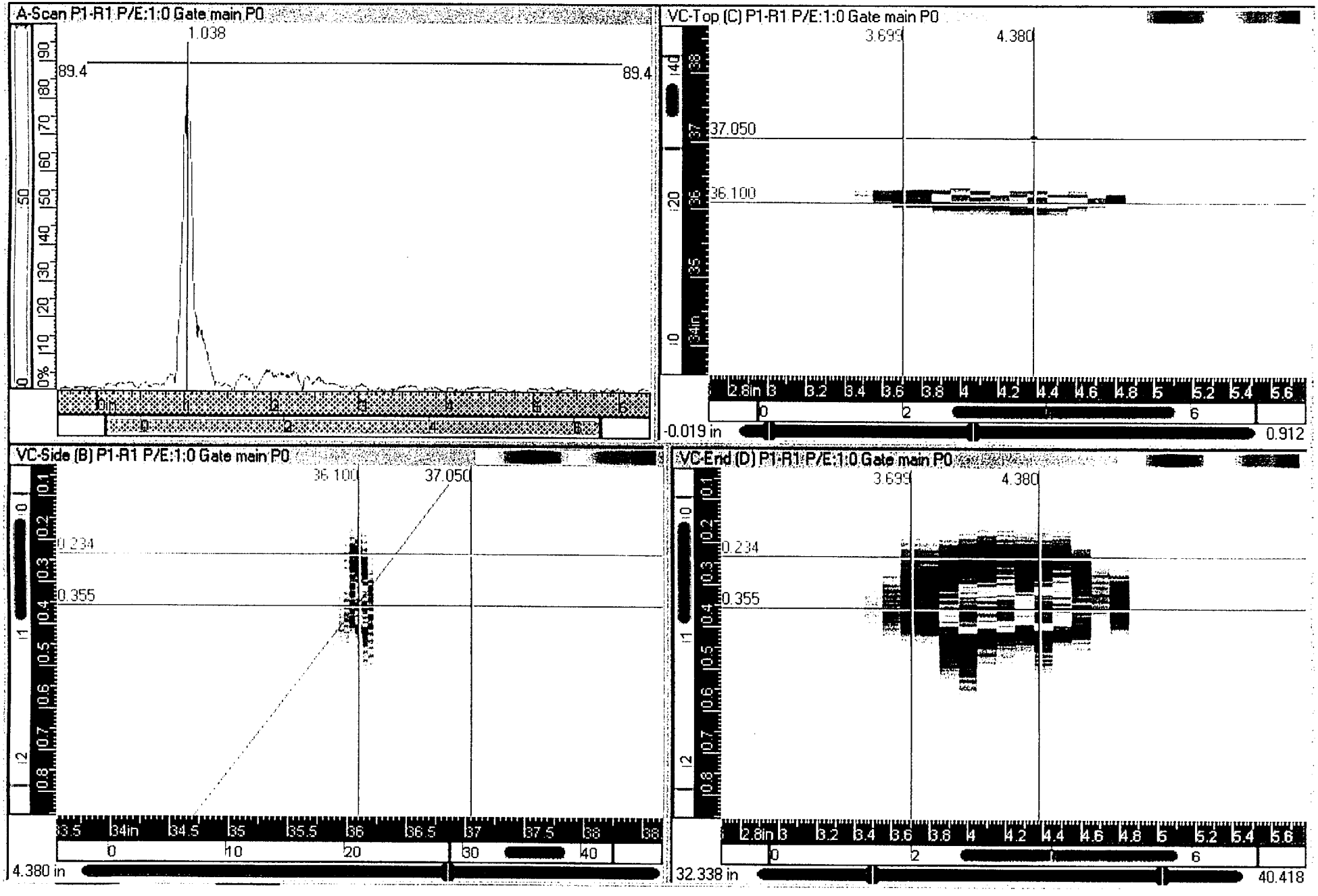


FIGURE 5A
RESPONSES FROM FLAW E, FROM OPTIMAL DIRECTION USING 70 DEGREE LONGITUDINAL WAVE PROBE

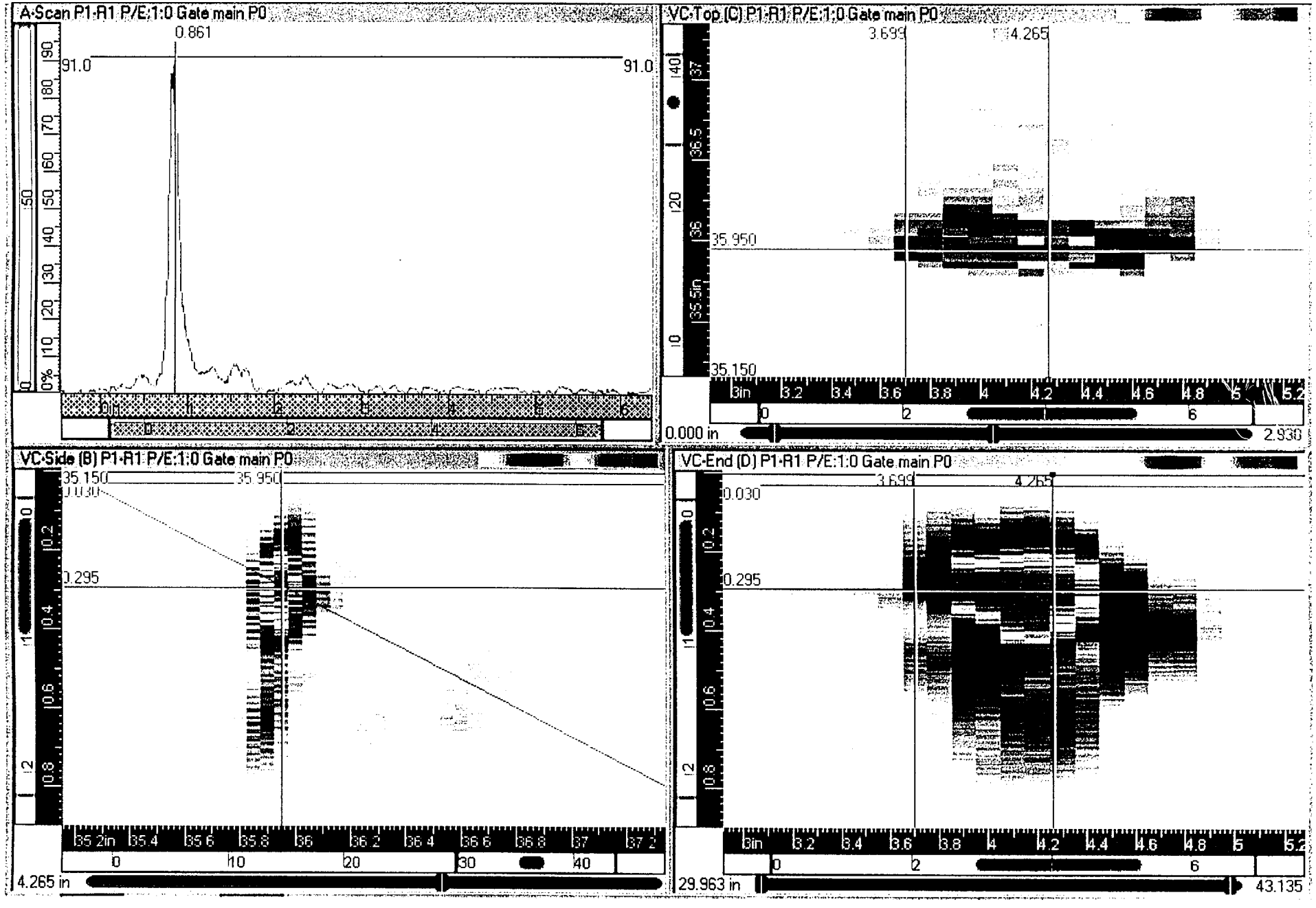


FIGURE 5B
RESPONSES FROM FLAW E, FROM NON-OPTIMAL DIRECTION USING 70 DEGREE LONGITUDINAL WAVE PROBE

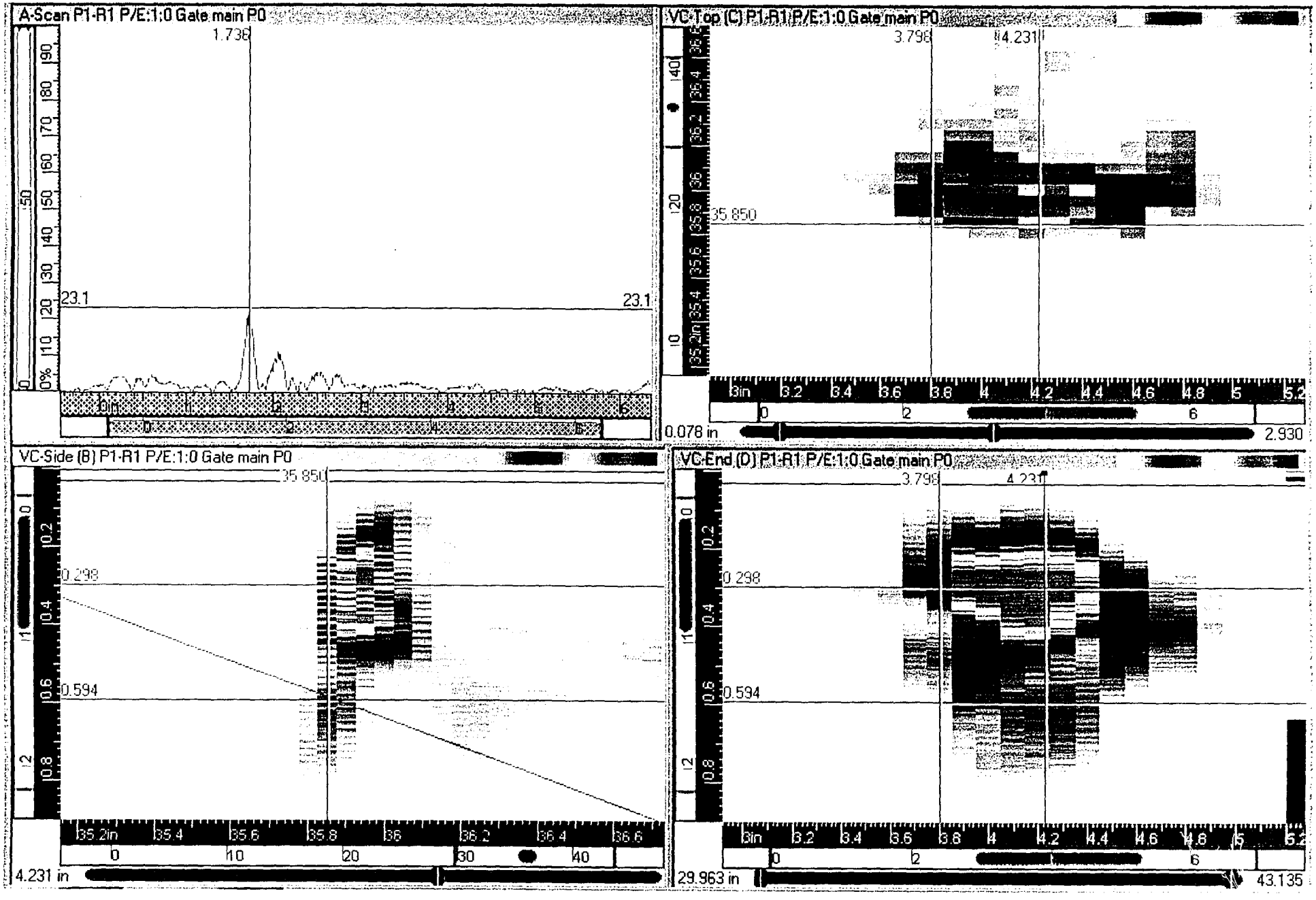


FIGURE 5C
SIZING IMAGEFROM FLAW E, FROM NON-OPTIMAL DIRECTION USING 70 DEGREE LONGITUDINAL WAVE PROBE

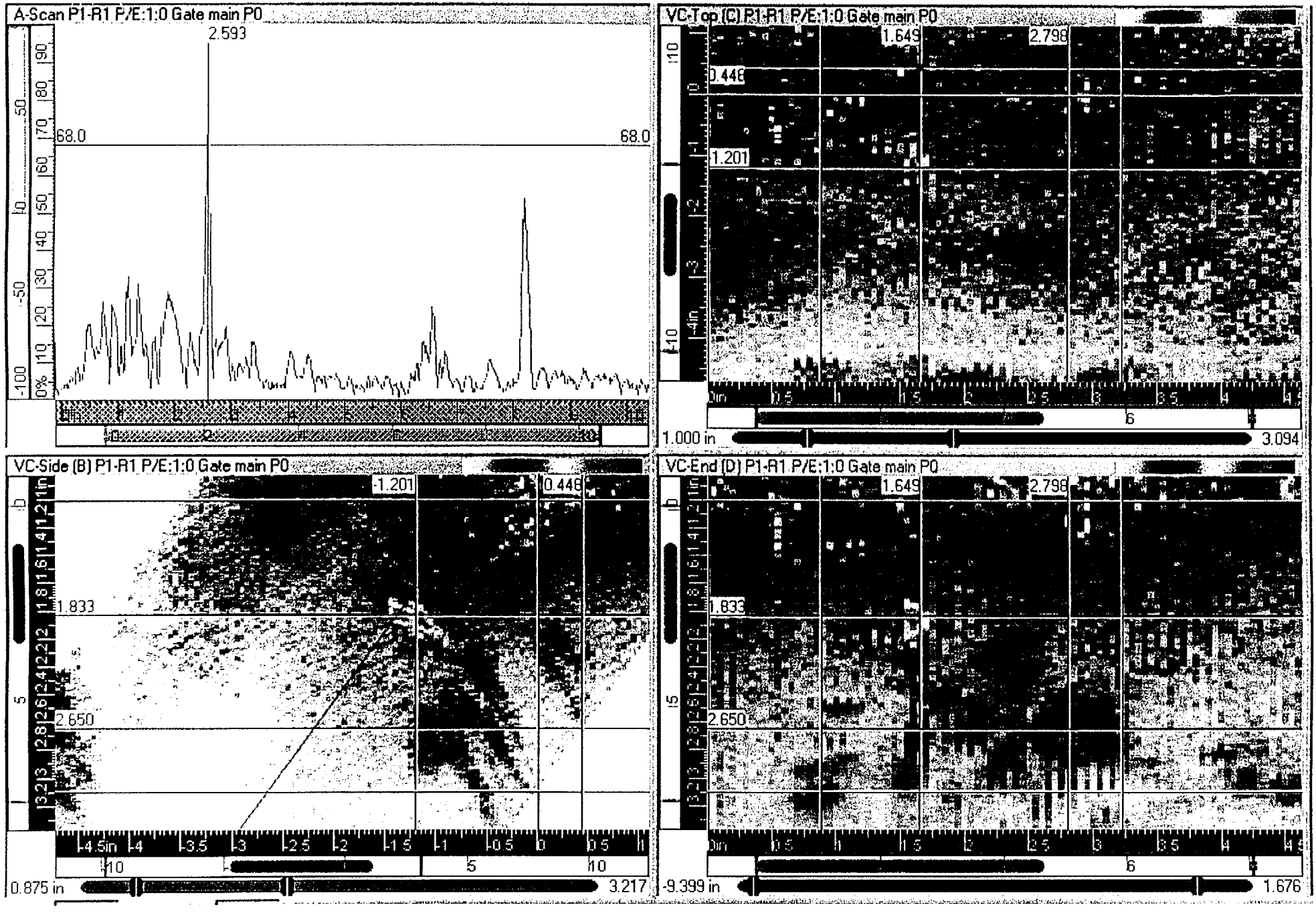


FIGURE 6
Shoreham Flaw C120E-5, 45 RL, Gain +20db, Maximum Response is 7% of ASME DAC

PDI
PERFORMANCE DEMONSTRATION INITIATIVE

Reactor Pressure Vessel Single Side Qualification

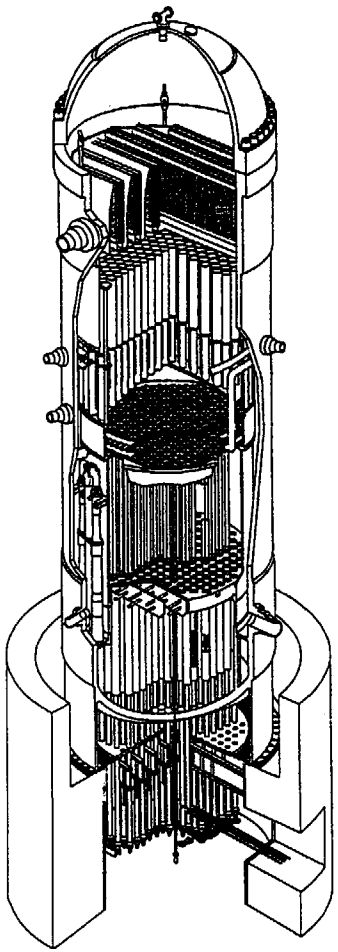
Results of EPRI Experiments and Recommendations to Comply with the NRC Ruling

P. Ashwin

L. Becker

S. Whiddon

July 2000



PDI
PERFORMANCE DEMONSTRATION INITIATIVE

Background

- **Original Objective of Single Side Qualification**
  - Obtain credit for coverage in those areas where due to access restrictions it was not possible to scan in all four directions.
- **Experience:**
  - PDI demonstrations documented that similar results could be obtained in 2 directions and "Single Side" qualifications were issued.
  - Early application of qualified procedures attempted to limit scanning to only 2 directions - Even when no access restrictions were present!
  - Flaw distribution studies being carried out by Battelle on behalf of NRC found evidence of fabrication repairs which included defects at angles up to 45 degrees from the inspection surface.
- **Result**
  - NRC assessment of the PDI Program paid close attention to

PERFORMANCE DEMONSTRATION INITIATIVE

NRC Ruling

▼ Final Rule single side access definitions.

(G) When applying Supplement 4 to Appendix VIII, Supplement 6 to Appendix VIII, or combined Supplement 4 and Supplement 6 qualification, the following additional provisions must be used, and examination coverage must include:

(1) The clad to base metal interface, including a minimum of 15 percent T (measured from the clad to base metal interface), shall be examined from four orthogonal directions using procedures and personnel qualified in accordance with Supplement 4 to Appendix VIII.

(2) If the clad-to-base-metal-interface procedure demonstrates detectability of flaws with a tilt angle relative to the weld centerline of at least 45 degrees, the remainder of the examination volume is considered fully examined if coverage is obtained in one parallel and one perpendicular direction. This must be accomplished using a procedure and personnel qualified for single-side examination in accordance with Supplement 6. Subsequent examinations of this volume may be performed using examination techniques qualified for a tilt angle of at least 10 degrees.

(3) The examination volume not addressed by §50.55a(b)(2)(xv)(G)(1) is considered fully examined if coverage is obtained in one parallel and one perpendicular direction, using a procedure and personnel qualified for single sided examination when the provisions of §50.55a(b)(2)(xv)(G)(2) are met.

(4) Where applications are limited by design to single side access, credit may be taken for the full volume provided the examination volume is covered from a single direction perpendicular to the weld and the weld volume is examined from at least one direction parallel to the weld.

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Impact of Ruling on PDI

- Within the ruling there are specific requirements concerning the qualification and use of procedures for Supplement 4 and 6 relating to single side access.
  - Inner 15 % of RPV must be examined in 4 directions
    - No single side examination allowed in the inner 15%
  - Existing "single side" RPV qualifications for the remaining 85%T are invalid without supplemental demonstration on non-optimum flaw!
- Since the additional requirements were specified following the qualification of procedures the PDI program has not considered them.
  - PDI Program is not "Ready" as previously stated!
  - NRC previously stated that the "ruling would not invalidate any existing qualifications.

PDI
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ASME Code Activity

- **App. VIII rewrite committee (code case N-622) anticipated NRC's concerns and developed consensus approach to single side qualification - not included in code case.**
- **Regarding the 45 degree tilted flaw referred to in A.2 (b) of Code Case N-622, the following supplemental demonstration requirements** *(minutes of meeting 23 Feb 1999)*
  - *Two (2) cracks will be used*
  - *The cracks may be weld solidification type*
  - *Both cracks will be oriented parallel to the weld*
  - *One crack will be 4 mm through wall, the second will be 17 mm through wall*
  - *The flaw aspect ratio will be between 2 and 10*
  - *Both will be sub-surface as defined in Section XI*
  - *They will be located within the inner 15 % of the vessel wall*
  - *The demonstrations on these flaws will be conducted under non-blind conditions within the demonstrated parameters of a previously qualified Supplement 4*

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PERFORMANCE DEMONSTRATION INITIATIVE

Technical Basis

- Recent evaluations of RPV Vessel material and welds, revealed cluster type flaws, thought to result from repairs.
  - The clusters of small indications (acceptable to IWB-3500) appeared to have an overall orientation approaching 45 degrees relative to the local surface normal.
- Most likely flaws in repair areas may be cracking, slag or lack of fusion (LOF).
    - It is not reasonable to postulate a smooth mirror like flaw, e.g. high cycle fatigue, at a large angle relative to the surface normal
    - It is not probable that a single slag or LOF flaws would result in a flaw of unacceptable size
    - Cracking could result from contamination resulting from inadequate cleaning or improper preheat
    - Multiple aligned slag or LOF would have an ultrasonic response characteristic similar to a rough crack
- A solidification crack is therefore an appropriate

PDI
PERFORMANCE DEMONSTRATION INITIATIVE

EPRI Activities

- **Fabricated a Test Specimen**
  - Meets the basic requirements of the code committee
  - Manufactured by SwRI using similar procedures to PDI test specimens.
- **Includes 5 embedded defects at approx. 45degrees**

Flaw	Dimensions		Evaluation According to Section XI IWB 3510			
	Height x Depth Inch (mm)	Ligament Inch (mm)	Position and % of T based on 12.0 inch shell T	based on 4 inch shell T	based on 8 inch shell T	based on 12 inch shell T
A	2.0 x 0.673 (50.8 x17.09)	1.969 (50.01)	Sub-surface 16.4%	Unacceptable	Unacceptable	Acceptable
B	2.0 x 0.668 (50.8 x16.96)	1.969 (50.01)	Sub-surface 16.4%	Unacceptable	Unacceptable	Acceptable
C	1.22 x 0.155 (31.0 x 3.94)	1.969 (50.01)	Sub-surface 16.4%	Acceptable	Acceptable	Acceptable
D	0.99 x 0.096 (25.1 x 2.44)	0.193 (4.90)	Sub-surface 1.6%	Acceptable	Acceptable	Acceptable
E	1.18 x 0.198 (30.0 x 5.03)	0.121 (3.07)	Sub-surface 1%	Unacceptable	Acceptable	Acceptable

PDI
PERFORMANCE DEMONSTRATION INITIATIVE

EPRI Experiments

- **Objective to develop empirical data relative to non-optimum flaw orientations and reflections surfaces using "typical" techniques qualified through PDI program.**
  - 70 degree dual element L-wave transducer used for flaw ligaments of approx 0.2inch.
  - 45 degree dual element L-Wave transducer used for flaw ligaments of approx 2.0 inch.
  - Sensitivity based on ASME 0.125" ∅ and 0.313"∅ side drilled holes (called DAC level)
- **Each flaw scanned from optimum and non-optimum direction.**
  - Considered detected if the amplitude response was $\geq$ 20 % DAC
    - Signal to noise ratio characteristics provided "target motion"

PDI
PERFORMANCE DEMONSTRATION INITIATIVE

Results of Experiments

- The experiments indicates that the maximum relative amplitude is very similar for both the optimum and non-optimum orientations.
  - The random scan surface conditions and the SMAW cladding along the axis of the flaw influence the amount of sound transmitted to and received from the flaw.
  - The flaw is rough relative to the ultrasonic wavelength, i.e. non-optimum reflectivity.
  - The maximum signal amplitude is from the flaw tips as opposed to the face of the flaw.
- To further quantify the responses from the Open Test Block flaws, flaws of similar size and location in the PDI RPV test blocks were scanned using the same equipment and sensitivities.

PDI
PERFORMANCE DEMONSTRATION INITIATIVE

Results of Experiments

- Generally the response amplitude for these flaws is similar to the non-optimum flaws.
  - This suggests that non-optimum flaws of unacceptable size would provide sufficient response amplitude to assure that they would be detected with reliability similar to that, which has been achieved during the PDI RPV vessel qualifications.
- Response amplitude is not the not the only factor considered in evaluating an indication.
  - The echo dynamics patterns and signal to noise ratios were also found to be similar

PDI
PERFORMANCE DEMONSTRATION INITIATIVE

Conclusion & Recommendation

- Conclusion

  Given the results of the EPRI NDE Center's evaluation it is most likely that qualified procedures will be capable of detecting flaws of an unacceptable size even if they are at extreme orientations relative the local surface normal.

- Recommendation

  A supplemental demonstration program intended to meet the requirements of the 10 CFR 50.55a Final Rule is adopted by the PDI program to include

  - **Generic PDI Technical Basis (complete)**
  - **Specific Technical Basis by Vendors**
  - **Open Demonstration**
  - **Supplemental Qualification Certificate**

PDI
PERFORMANCE DEMONSTRATION INITIATIVE

Vendors Technical Basis

- Each organization that has qualified a procedure(s) in accordance with the PDI's implementation of ASME Section XI, Appendix VIII will be given the opportunity to present the following to PDI for review:
  - A position statement as to why the qualified NDE procedure is capable of detecting flaws similar to those included in the Test Specimen manufactured by EPRI to evaluate the NRC ruling.
  - The position statement should be supported by experimental data, which can be verified by the PDI as being applicable and supportive of the position statement.
  - A position statement as to why the qualified NDE procedure is capable of sizing flaws similar to those included in the Test Specimen manufactured by EPRI to evaluate the NRC ruling.
  - The position statement should be supported by experimental data,

PDI
PERFORMANCE DEMONSTRATION INITIATIVE

Open Demonstration

- The PDI will then evaluate the information presented and prepare a summary of observations and findings. This report will include recommendations for additional data to support the position.
- The organization will be given the opportunity to carry out an open demonstration using the EPRI test specimen. The open demonstration will verify that the qualified procedure is capable of detecting and if specified sizing the defects in the test specimen. Evaluation of the data will be documented and successful demonstration will be granted based on the acceptance criteria:

PDI
PERFORMANCE DEMONSTRATION INITIATIVE

Open Demonstration Acceptance Criteria

- No changes have been made to the qualified procedure that may impact the known capability of the qualified procedure.
- All flaws in the open test specimen are detected in accordance with the equipment, instructions and criteria specified in the qualified procedure
- Where sizing is included, the size of the flaws as reported by the qualified procedure during the open trials are combined with the results of the original qualification and that the sum of these results is within the acceptance criteria specified by the PDI's implementation of ASME Section XI, Appendix VIII, Supplement 6.

PDI
PERFORMANCE DEMONSTRATION INITIATIVE

Supplemental Qualification Certificate

- On successful completion of the open demonstration and providing all other requirements are completed in accordance with the PDI program the original PDQS document will be revised.

PWR PIPING WELDS

EXAMINED FROM

THE RPV INSIDE SURFACE

PER

APPENDIX VIII

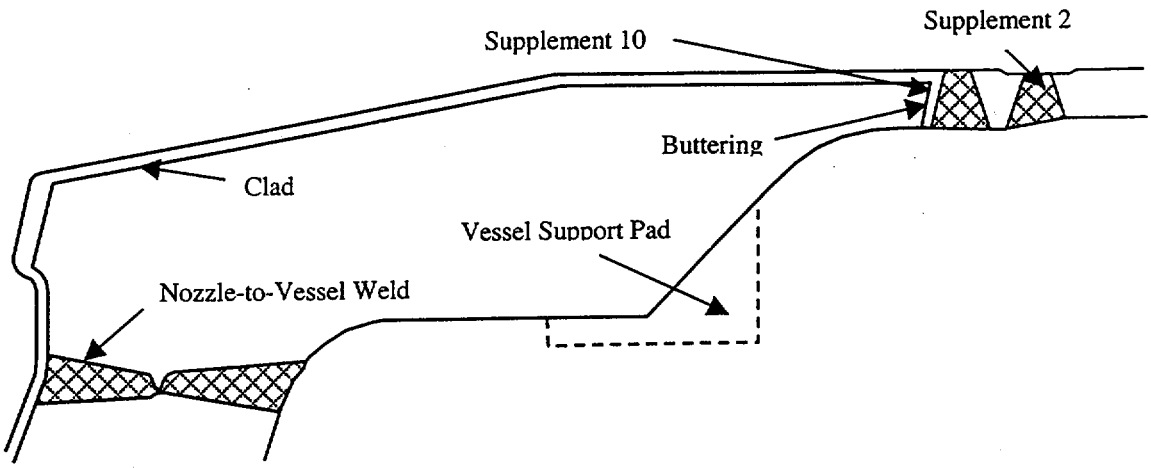
AND 10CFR 50.55a

DRAFT DRAFT DRAFT DRAFT

Prepared by
EPRI NDE Center

BACKGROUND

Typically, ultrasonic examination of the Class 1, Category B-J, pressure retaining piping weld, located adjacent to the pressurized water reactor vessel nozzle, is performed from the inside surface in conjunction with the nozzle-to-vessel weld examinations. A typical arrangement of these welds for an outlet nozzle is illustrated below.



There are several advantages to this approach including reduced radiation exposure compared to removing the nozzle covers and performing the examinations manually, depending upon the configuration there is increased coverage of the examination volume, the examinations are conducted using automated rather than manual techniques.

REQUIREMENTS

ASME Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components, 1995 Edition with 1996 Addenda, Appendix I, requires that austenitic piping welds be examined using personnel, procedures and equipment qualified to the requirements of Appendix VIII, Supplement 2, with Supplement 10 applicable for dissimilar metal welds, and Supplement 12 applicable for coordinated implementation of selected aspects of Supplements 2, 3, 10, and 11.

10CFR 50.55a(g)(6)(ii)(C) requires that Supplements 2 and 3 to Appendix VIII of Section XI, Division 1, 1995 Edition with the 1996 Addenda of the ASME Boiler and Pressure Vessel Code must be implemented by May 22, 2000. Implementation of Supplement 10 and 12 is scheduled for November 22, 2002.

PDI CONCERNS

The concept of personnel performance demonstrations for ultrasonic examination qualifications was introduced to the nuclear industry in the 1989 Edition, 1989 Addenda, of Section XI. The PDI was formed in 1991 to implement the requirements of Appendix VIII. Qualifications for piping examinations from the outside surface were initiated in 1994. These demonstrations have not included dissimilar metal welds or examinations from the pipe inside surface.

Because only outside access was considered when designing the piping specimens, the existing specimens are not suitable and, qualification specimens for an inside qualification for the category B-J welds located adjacent to the RPV nozzle are not currently available. There are several reasons for the lack of suitability:

- The existing flaws are visible from the inside surface
- The required geometric and limited scanning surface conditions are not appropriate.
- Since this qualification requires a population of large diameter heavy wall specimens, the currently available qualification specimen sets do not contain the required flaw orientations and size distributions.
- Additional implementation issues such as the requirement that the specimen inside surface be concealed from the candidate (Supplement 2, paragraph 2.0) must be addressed.

When the Performance Demonstration Initiative (PDI) proposed an alternative implementation schedule, the inside surface examinations of Category B-J welds performed from the inside surface were not considered during the public comment period. As a result, additional time will be required to design, fabricate, and acquire specimens; develop the appropriate protocol and implementation procedures; "finger print" the specimens, develop procedures, and train appropriate personnel.

VENDOR CONCERN

Performing two separate qualifications one for the Category B-J Weld and one for the Category B-F would double the vendors costs. The same equipment and procedures are used for the examinations. Each of the vendors, which perform ID examinations of PWR vessels, perform these examinations on both Westinghouse (austenitic piping) and CE/BNW (ferritic piping) units.

PROPOSED APPROACH

It was the intention of PDI to complete the piping qualifications that are performed from the inside surface, in conjunction with the nozzle to shell and dissimilar metal (DSM) welds. For PWR units, these examinations are performed

using the same RPV examination device. A Supplement 10 (DSM weld) program is under development and qualified examinations are expected to begin by the effective Rulemaking date of November 22, 2002. Since Supplements 2 and 3 do not address examination from the inside surface, it is appropriate to define the scheduled implementation date in conjunction with Supplement 10. This implementation date provides adequate time to prepare samples, protocols, procedures, and demonstrations. Until then, licensees would continue their current practice, specific to inside surface ultrasonic examinations, until November 22, 2002.

REQUSTED NRC ACTION

It is requested that NRC subject matter experts review the proposed action and the forthcoming implementation details. It is expected that this information will be incorporated into Supplement 10 or 12.

Supplement 2 &3 Qualifications from the Inside Surface

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Project Manager
Piping & Bolting
Performance Technology
EPRI NDE Center

Background

- Inside surface qualifications not considered during code development and rule making
- Examinations performed after 5/22/00 are required have to be qualified in accordance with Appendix VIII

Background

- Existing Supplements do not consider inside surface demonstrations
- No PDI protocol exists for inside surface demonstrations
- Additional samples will be required to demonstrate all aspects of procedure

Background

- No procedures or personnel qualified presently per Appendix VIII to perform examinations
- Present requirements do not consider limitations of inside surface examinations
  - Axial flaw detection and sizing
  - Counterbore conditions

Background

- Performing demonstrations now, just by category BJ welds, would double qualification cost
- Current Appendix VIII requirements are not technically sound
- PDI Originally intended to qualify these procedures during Supplement 10 (Dissimilar Metal Weld) and/or Supplement 7 (Nozzle to Shell Weld) demonstrations

Planned Actions

- Implement Supplement 2 and 3 qualifications in coordination with Supplement 10 (Dissimilar Metal Weld) by November 2002
- Utilities will continue present examination techniques until procedures and personnel are qualified

Planned Actions

- Review field configurations
- Develop appropriate testing criteria
- Design additional samples
- Incorporate required criteria into code

SUPPLEMENT 11

PDI OVERLAY DEVLOPMENT PROGRAM

Carl Latiolais
Project Manager
Piping & Bolting
Performance Technology
EPRI NDE Center

Overlay

- **Supplement 11 Weld Clad Overlay:**
  - Examinations and qualifications are presently in accordance with the former Three Party Agreement Between the BWR Owners Group, EPRI and the NRC
- **Present Program does not meet Supplement 11 requirements**
  - Only available samples are 12.0"diameter with a maximum overlay thickness of 0.50"
  - Flaw density in samples greater than what is required in code

Overlay

- Additional Samples must be fabricated
- Program must be revised to address new rules of test administration and grading

Approach

- Revise Code to allow use of existing samples and present testing criteria
- Fabricate a limited number of additional samples with smaller and larger diameters and incorporate into test

Fabrication Issues

- **Application of weld overlay is time consuming and very expensive**
  - 100 hours of welding for one 14.0" diameter 0.50" thick overlay
- **Common methods of flaw implementation not optimum for weld overlay samples**
- **Present flaws were made using graphite wool technique**
  - Expensive, time consuming and hard to control
  - Process is no longer available
  - Numerous man-hours required to quantify samples and establish truth measurements (Must be done by expert opinion)
- **Limited amount of funds and time available**

Actions

- **NDEC subcommittee has funded research into methods of fabricating additional samples in a faster cheaper way**
  - 3 techniques are presently being evaluated
    - Simulated flaws mechanically enhanced with Cold Isostatic Pressure (CIP) bonding process
    - Simulated Flaws mechanically enhanced with Hot Isostatic Pressure (HIP) bonding process
    - In-situ flaw implantation process
  - Responses of fabricated flaws are being compared with existing samples and data from field

Requested NRC Actions

- **Subject Matter Expert be Assigned to Review the Following;**
  - Sample Design
  - Flaw Implantation Process
  - Test Set Design
  - Proposed Process for Testing

Dissimilar Metal Weld

Program Development

Carl Latiolais
Project Manager
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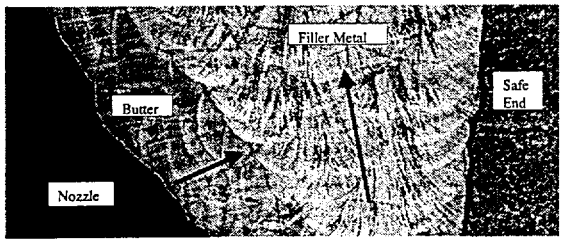
Performance Technology
EPRI NDE Center

Background

- **1999 - Formal Qualification for DM Welds Addressed in Rule- Making**
- **20 samples ordered in December of 1999**
  - Purpose
    - Evaluate Present Flaw making Capability
    - Technique Development
    - Establish Flaw Detection Threshold
    - Establish Sizing Accuracy Limits
    - Aid in PDI Test Set Design and Grading Criteria
    - Develop Criteria for Expansion of Qualification

The Challenge

- Complex Weld Configurations
- Metallurgical Interfaces
- Varying Grain Growth Patterns
- Numerous Configurations and Access limitations
- Limited Metalography Data Available

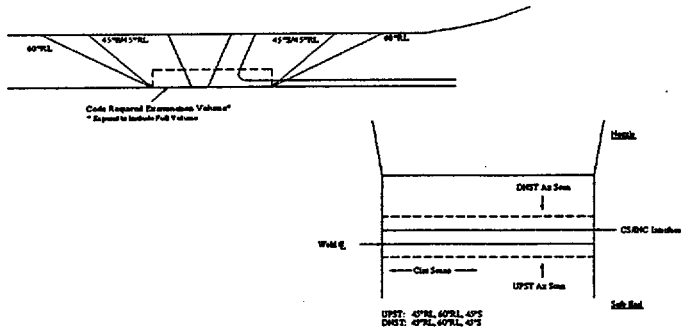


Sample Evaluation

- 18 Samples have been scanned with Automated Techniques
  - 4.0" Diameter to 36.0" Diameter
  - 0.50" to 2.9" in Thickness
  - PWR inlet, outlet and core flood samples will be scanned from both inside surface and outside surface (12.0", 36" diameter)
- Data is being input into Data Base for Easy Evaluation

Sample Evaluation

- **Approach**
  - Samples have been scanned from both sides of weld
  - Techniques are those which are commonly used for field examinations



Sample Evaluation

- **Preliminary Findings**
  - Circumferential Flaws
    - Combination of 45,60 and 70 Degree Refracted Longitudinal Search Units Provide Best Results
    - 2.0Mhz Frequency for thicknesses from 0.5" to 2.35" Provides Best Results
    - Evaluation of thicker segments being performed with 1.0 and 2.0 MHz search units
    - Flaw Orientation, Location and Growth Direction Greatly Affect Detectability

Sample Evaluation

- **Preliminary Findings (Cont.)**
  - Axial Flaws
    - Incident Angles Sufficient to Impinge on Inside Surface (31-45 degrees)
    - 45, 60 &70 Refracted Longitudinal 2.0Mhz Search Units for Thicknesses from 0.5" to 0.75 " are being evaluated and the results are promising
    - Combinations of 1.0 and 2.0 MHz are being evaluated for thicker welds >0.75" - 2.35"
    - Some Flaws Greater Than 20% <u>Not</u> Detected when access is limited to one side
    - In-situ process may not be best flaw implantation method for axial flaws

Sample Evaluation

- **Ongoing Activities**
  - Perform Limited Access Data Analysis (Automated)
  - Evaluate Depth and Length Sizing Capability(Automated)
  - Evaluate Phased Array Examinations on all samples (Automated)
  - Evaluate Manual Techniques
  - Develop Flaw making Techniques that Produce Flaws with Similar Responses to Field Flaws

PDI Sample Fabrication Activities

- **Material is being prepped for fabrication of samples**
  - 18 Safe-ends and Nozzle Sections have been Cut and Prepped
  - Preliminary Design and Layout Drawings Will Start in November/December 2000
- **Test Set Design underway**
  - Presently, diameters from 4.0" - 36" with thickness varying from 0.50" to 2.9"will be included in test set
  - Several 36" diameter samples will be designed specifically for inside surface examination and will also include Supplement 2 weld
  - Flaws will be implanted with utilizing the in-situ process and HIP bonded flaws
  - Test samples will be ordered early in 2001

PDI Sample Fabrication Activities

- **Test Set Design**
  - Test Set will not cover every configuration that exists in field, but will be a cross cut of configurations
  - Basis for sample selection will be based on the following;
    - Number of occurrences
    - Documented failures in field
    - Perceived degree of difficulty
    - Data evaluated on recently purchase samples
  - Practical Demonstration may be coupled with Training
  - Site Specific Samples may be Required to Expand the Procedure and Candidate Qualifications

Requested NRC Actions

- **Subject Matter Expert be Assigned to Review the Following;**
  - Sample Design
  - Flaw Implantation Process
  - Test Set Design
  - Proposed Process for Testing

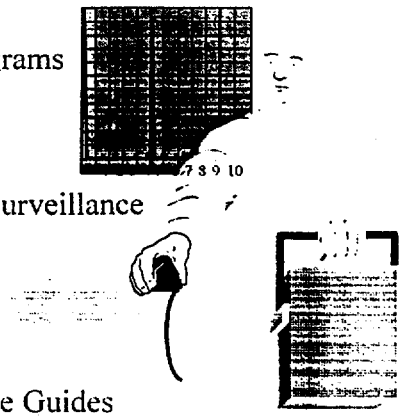
Programmatic Items

- PDI Guide - "Procedural Implementation"
- Program Description Document
- Corrosion Resistant Cladding
- Other "Related Provisions"

Mike Gothard
EPRI NDE Center
10/11/00

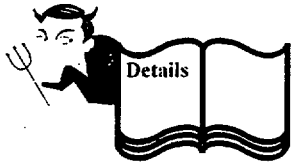
PROCEDURAL IMPLEMENTATION

- PDI Guideline Volume 2, 7/11/2000
- Pre-outage Activities
  - Review procedures and programs
  - Vendor orientation
- Outage Activities
  - Surveillance, surveillance , surveillance
- Post-Outage Activities
- Appendices
  - Generic checklists
  - PDQS and Hands-on Practice Guides



Program Description Document

- Draft Program Description transmitted to PDI volunteers on 10/29/00 for review and comment.
  - Consists primarily of a line-to-line comparison with the PDI Implementation documents and the 95/96 Appendix VIII as modified by, and with the additional requirements of, 10 CFR 50.55a.



Program Description Document (Continued)

- One current issue:

  - 10 CFR50.55a (b)(2)(xv)(C)(1) - Supplement 4, doesn't modify 3.2(c):

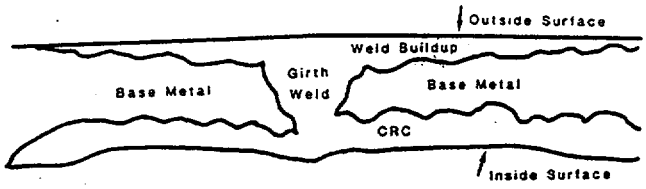
  - (1) A depth sizing requirement of 0.15 inch RMS shall be used in lieu of the requirements in Subparagraphs 3.2(a) and 3.2(b).

    (c) performance demonstration results reported by the candidate, when plotted on a two-dimensional plot (Fig. VIII-M-1) with the depth estimated by ultrasonics plotted along the ordinate and the true depth plotted along the abscissa, satisfy the following statistical parameters:
    (1) slope of the linear regression line is not less than 0.7;
    (2) the mean deviation of flaw depth is less than 0.25 in.;
    (3) correlation coefficient is not less than 0.70.

- Supplement 6 modifications are correct.

Corrosion Resistant Cladding

- Informal CRC Users Group established.
- Telecon: 10/26/00 - Consensus = CRC is not addressed in any current Appendix VIII Supplement.



Corrosion Resistant Cladding (Continued)

- Discussion items for 11/28/00 meeting:
  - Short term actions:
    - RFR not required - RFR may or may not be submitted?
    - Continue with current program and commitments.
      - Typically supplemental RL techniques and IGSCC qualified personnel.
    - Additional actions?
  - Long term actions:
    - Establish level of PDI involvement, if any - funding, programmatic, etc.
    - Develop CRC implementation plan:
      - Treat CRC as a "endorsement" to a current qualification similar to Bolting.
      - Other?

Other "Related Provisions"

- Resolution of comments:
  - The final rule would require that all related provisions be used.
- Final Rule:
  - The Supplements to Appendix VIII of Section XI, Division 1, 1995 Edition with the 1996 Addenda of the ASME Boiler and Pressure Vessel Code must be implemented in accordance with the following schedule:
- This has caused much confusion?