Tennessee Valley Authority, Post Office Box 2000, Soddy-Daisy, Tennessee 37384

December 12, 2000

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Gentlemen:

| | | |
|---|---|---|
| In the Matter of | ) | Docket Nos. 50-327 |
| Tennessee Valley Authority | ) | 50-328 |

SEQUOYAH NUCLEAR PLANT (SQN) - RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION (RAI) REGARDING CODE RELIEF REQUEST INSERVICE INSPECTION (ISI)-15

Reference: NRC letter to TVA dated September 28, 2000, "Sequoyah Nuclear Plant, Units 1 and 2 - Request for Additional Information on Code Relief Request ISI-15 (TAC Nos. MA9898 and MA9900)"

This letter provides the additional information NRC requested as part of its review of our request for relief from examination of the nozzle inside radius sections for the residual heat removal heat exchangers (referenced letter).

Enclosure 1 provides TVA responses to the NRC staff questions as contained in the referenced letter. Enclosure 2 provides, as NRC requested, a copy of the full report from Rochester Gas & Electric (RG&E) for the Ginna inner radius nozzle performance demonstration. Enclosure 3 provides the SQN nozzle dimensional drawings. Finally, Enclosure 4 provides ultrasonic attenuation measurements that were performed on the SQN nozzle and the RG&E mockup.

A047

We are grateful of the NRC's diligence in reviewing our request within the schedule we requested. Should you require additional information or clarification, please contact us as soon as possible.

No commitments are made in this response. Please direct questions concerning this issue to me at (423) 843-7170 or J. D. Smith at (423) 843-6672.

Sincerely,

Pedro Salas
Licensing and Industry Affairs Manager

Enclosures
cc (Enclosures):

Mr. R. W. Hernan, Project Manager
Nuclear Regulatory Commission
One White Flint, North
11555 Rockville Pike
Rockville, Maryland 20852-2739

NRC Resident Inspector
Sequoyah Nuclear Plant
2600 Igou Ferry Road
Soddy-Daisy, Tennessee 37379-3624

Regional Administrator
U.S. Nuclear Regulatory Commission
Region II
61 Forsythe St., SW, Suite 23T85
Atlanta, Georgia 30303-3415

**ENCLOSURE 1**

**RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING CODE RELIEF REQUEST ISI-15**

The following is a restatement of the requested information from the NRC letter to TVA dated September 28, 2000, followed by the TVA response.

NRC Request (Item 1)

The Tennessee Valley Authority (TVA) submittal dated June 29, 2000, references a report on the Rochester Gas & Electric (RG&E) Ginna Nuclear Plant that discusses an inner nozzle radius performance demonstration. The performance demonstration was performed on a mock-up of Ginna's nozzle configuration, which is stated to be similar to Sequoyah's (SQN's) nozzle configuration. SQN should provide the staff with a copy of this report with all of its attachments (mock-up construction, material specification, and ultrasonic testing experiments). Provide the dimensions for SQN's nozzle.

TVA Response

A copy of the report with all of its attachments (mock-up construction, material specification, and ultrasonic testing experiments) are included in this submittal(see Enclosure 2). The dimensions for the nozzle are identified on the enclosed drawings (see Enclosure 3).

NRC Request (Item 2)

According to the TVA submittal, the performance demonstration on the Ginna mock-up was unable to detect the notches on the inner radius. Discuss the effects of nozzle configuration, micro-structure, and metal acoustic on the flaw detectability. Discuss ways to minimize the reasons for poor flaw detectability in the mock-up. Discuss any research performed on the mock-up to verify the reasons for poor flaw detection.

TVA Response

With regard to the SQN RHR nozzle, the base material, nozzle-to-shell weld material, and the nozzle geometry complicate inspection of the inner radius region. The stainless steel baseand weld materials cause increased attenuation that affects the overall signal-to-noise ratio. The negative effects of the attenuative material can in many cases be overcome by optimizing the beam angle to be more normal to the flaw. However, the nozzle geometry restricts optimization; it does not allow introduction of an ultrasonic beam that is oriented such that detection is possible. In some nozzle geometry, the misorientation angle (skew at the flaw) can be reduced significantly by scanning on the blend radius, but the radius of the RHR nozzle is small and in most cases, irregular.

During procedure development, experiments are performed on mock-ups with conservative reflectors. Ultrasonic parameters such as transducer frequency, size, etc., are optimized and reflectors are interrogated to determine the degree of misorientation that can be tolerated without affecting detectability. A final procedure guideline is then developed which constrains inspection parameters to the required misorientation angle.

With regard to the RG&E nozzle mock-up, reflectors could not be detected at even the geometrically optimum (minimum) misorientation angle. Procedures have been developed for carbon steel nozzles of similar geometry in the past, and good detection was observed. Therefore, while nozzle configuration is still a factor with the SQN RHR nozzle, the lack of detectability is largely attributable to the stainless steel material.

Flaw detectability is improved by minimizing the misorientation angle, minimizing the sound beam metal path, and optimizing other conventional ultrasonic variables such as transducer frequency, wedge contact, etc. All of these variables were optimized during the investigation on the RG&E mock-up.

Minimization of the misorientation angle and the sound beam metal path was performed using three-dimensional computer modeling. Remaining ultrasonic variables such as transducer frequency, wedge contact, etc., were optimized by experimentation on the RG&E nozzle mock-up.

<u>NRC Request (Item 3)</u>

The TVA submittal states that SQN nozzle is similar to the mock-up. Discuss any acoustic comparisons between the SQN nozzles and Ginna nozzle mock-up.

<u>TVA Response</u>

TVA staff performed attenuation measurements comparing the RG&E mock-up material and the SQN nozzle material (Enclosure 4). The measurements showed the materials to be acoustically similar. These findings support the original determination that the RG&E mock-up is appropriate for evaluating the effectiveness of the SQN inspection procedures.

Due to the significant nozzle geometry similarities, procedures optimized for the SQN geometry delivered the same misorientation angles as the RG&E procedures. Since the SQN nozzle is somewhat larger, the metal paths are even longer. With equivalent misorientation angles and longer metal paths, inspection performance would be even further degraded on the SQN nozzle; therefore, the use of the RG&E mock-up is considered conservative.

NRC Request (Item 4)

Which paragraph(s) in Section V, Article 4 or 5 in the American Society of Mechanical Engineers Code stipulate the scan directions and beam angles for inner nozzle radius examinations? If none, describe the guidance used by SQN for selecting scan directions and beam angles. Explain the coverage calculation in terms of beam angles and scan directions, i.e. angle one, clockwise; angle one, counter clockwise; . . . .

TVA *Response*

Neither Article 4 or Article 5 of ASME Code Section V is appropriate for this application.

With respect to Section XI of the 1989 Edition of ASME Code, Paragraph IWA-2232 states:

> *"Ultrasonic examination shall be conducted in accordance with Appendix I."*

With respect to Appendix I, Paragraph I-2200 states:

> *"Ultrasonic examination of vessel welds less than or equal to 2 in.thickness and all piping welds shall be conducted in accordance with Appendix III, as supplemented by this Appendix. Supplements identified in Table I-2000-1 shall be applied."*

Within Appendix III, no specific requirements for examination of inner corner radius areas are provided; however, Appendix III does provide allowances for development and application of appropriate examination techniques. These are contained in Supplement 4, "Austenitic and Dissimilar Metal Welds," in Paragraph (c) which states:

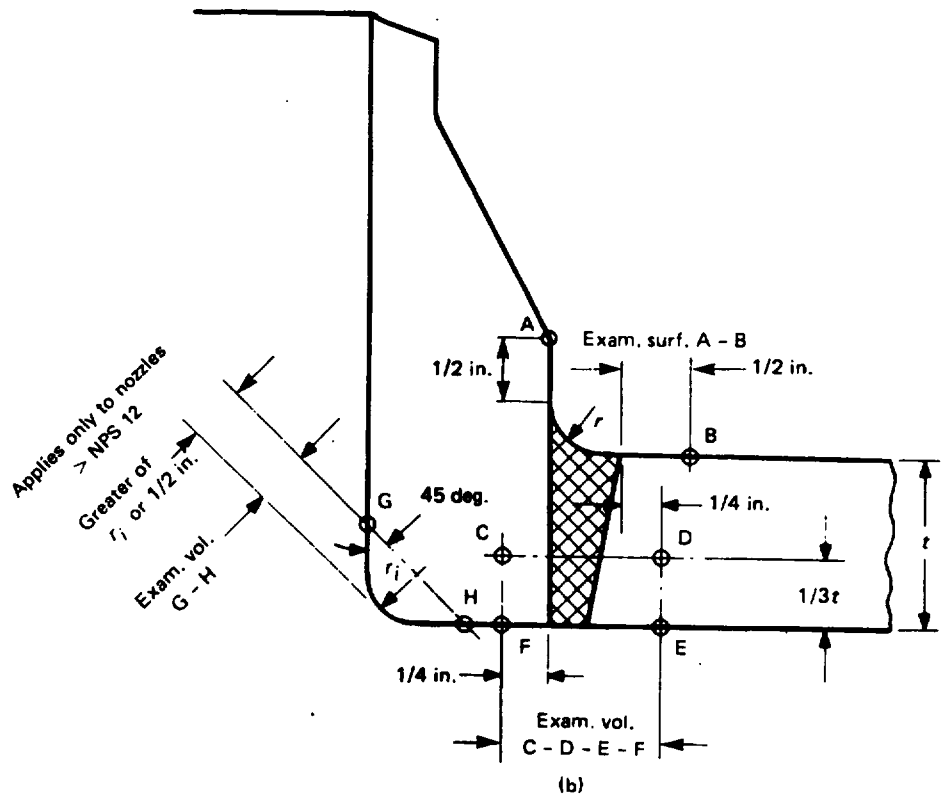
*"Qualification - In recognition of the difficulty in ultrasonic examination of the welds and materials in (a), it is recommended that examiners and procedures be qualified using welded samples, and simulated or actual flaws, or both, located in positions where geometry may make them more difficult to detect (e.g., the break in counterbore or adjacent to the weld root). The purpose of the examination procedure qualification is to determine that the proposed examination technique is capable of detecting the specified flaws of interest and that its capabilities and limitations will be identified. Requirements for the qualification of examiners and procedures are in course of preparation."*

As noted above, ASME Section XI does not provide specific requirements. In an effort to qualify an acceptable alternative, TVA investigated alternative NDE methods (i.e., RT, PT, etc.). The feasibility of an alternative NDE method is discussed in TVA's June 29, 2000, submittal and is based on the conclusions provided in the EPRI report of Enclosure 1.

The conclusions of the EPRI report indicate that RG&E studies can be applied conservatively to the TVA RHR Heat Exchanger inner radius application. Based on the experimental findings from the RG&E study, EPRI demonstrated that a feasible examination procedure cannot be developed for the TVA RHR Heat Exchanger nozzle inner radius. Optimized inspection angles using either shear or longitudinal wave mode cannot be developed which would detect ultrasonic responses from a 30-percent through-wall notch. Based on these conclusions, TVA is proposing alternative NDE for SQN's RHR Heat Exchanger nozzle inner radius section (refer to TVA's June 29, 2000 submittal).

The following provides a summary of TVA's evaluation process associated with the examination requirements and techniques for SQN's nozzle configuration.

ASME Section XI, 1989 Edition, Table IWC-2500-1, Examination Category C-B, Item Number C2.22, requires a Volumetric Examination. The examination requirements from Table IWC-2500-1 specify Figure No. IWC-2500-4(a) or (b). The figure that most closely resembles the SQN RHR Heat Exchanger is Figure IWC-2500-4 (b). The examination volume indicated for the inner radius examination is area G-H. The actual SQN RHR Heat Exchanger nozzle configuration does not indicate a radius; therefore, the examination volume is a ½-inch region as indicated in Figure 1.




GENERAL NOTE: Nozzle sizes over NPS 4; vessel thickness over 1/2 in.

Figure 1

Figure IWC-2500-4 (b) indicates the required flaw orientation to be radial/axial, therefore, two circumferential scans, one clockwise and one counterclockwise, are required to examine the examination volume as indicated in Figure 1. The transducer angle and skew must be optimized to impinge the flaw at the correct orientation.

In order to ascertain the required beam angle, scan direction, skew (search unit orientation angle) and required search unit placement (nozzle side or shell side), TVA consulted the EPRI NDE Center to provide beam modeling due to the unique configuration of this component. The RHR Heat Exchanger has limited scan area on the shell side due to welded support pads. The nozzle to shell weld is not amenable for search unit coupling due to the short radius of contour. The nozzle boss has varying scan area due to the radius of curvature of the vessel shell. TVA evaluates inner radius examinations by the use of computer aided modeling or other engineering controls in order to assess the specific configuration for optimum interrogation. Calibration standards, search unit angle, skew angle, scan surface and other factors are considered in order to develop a procedure which will examine the required ASME Code volume. The EPRI studies concluded no technique could be developed which would effectively examine the SQN RHR heat exchanger inner radius region.

The technique modeled by EPRI optimized for the examination of the RHR Heat Exchanger Inner Radius consisted of the following:

| Probe Angle | Probe Skew | Scan Surface | Mode of Propagation |
|---|---|---|---|
| *46* | *90* | *Outer Nozzle Boss* | *Shear Wave* |
| *62* | *140* | *Outer Nozzle Boss* | *Shear Wave* |
| *70* | *22-38* | *Outer Vessel* | *Shear Wave* |

The maximum percent examination coverage modeled by the EPRI studies indicates a potential of 82 percent of the SQN RHR heat exchanger inner radius. However, this only means that the sound beam is going out in the correct orientation with respect to the inner radius. The experiments show that because of the sound beam attenuation, reflections from even a 30 percent through-wall notch do not return to the transducer and provide an adequate response. This is discussed in the EPRI report with regard to the RG&E mockup. Longer metal paths in the Sequoyah RHR Heat Exchanger would cause additional attenuation of the ultrasonic beam and further degrade the signal-to-noise ratio.

NRC Request (Item 5)

The Electric Power Research Institute report attached to the submittal states that 82 percent coverage is achievable for the inner nozzle radius using 46° beam angle skewed 90° , 62° beam angle skewed 140°, and 70° beam angle skewed 22-38°. Explain why this coverage is considered unacceptable. Discuss the difficulty associated with ultrasonic examination (not discussed above) of this specific nozzle (inner radius).

TVA *Response*

The coverage determination provided in the EPRI report only refers to the "best effort" inspection parameters for the RHR nozzle geometry. It does not refer to coverage with an effective procedure.

The purpose of the coverage maps in the EPRI report was to illustrate the optimum beam angles, transducer skew, and probe position which would deliver the lowest misorientation at the nozzle inner radius surface. As discussed in the EPRI report, signals returned from the reflectors could not be resolved from the general material noise, even after the reflector was increased from 10 percent to 30 percent of the wall thickness.

With regard to the difficulty associated with ultrasonic examination, refer to the discussion previously provided in response to item 2.

Enclosure 1

Electric Power Research Institute (EPRI) Report

Dated April 10, 2000

(Includes Attachments 1 Through 4)

EPRI

April 10, 2000

Mr. Joel W. Whitaker
Tennessee Valley Authority (TVA)
M/S STC-1I-SQN
PO BOX 2000
Soddy Daisy, TN 37384-2000

SUBJECT: Inner Radius Region Sequoyah Units 1 and 2 Residual Heat Removal (RHR) Heat Exchanger

Dear Joel:

This report is in response to your request to use the NDE Center SRA program to investigate the feasibility of performing ultrasonic inspection on the inner radius region of the Sequoyah residual heat removal (RHR) inlet and outlet nozzles.

As we discussed, your application is very similar to that of the RG&E Ginna Plant, and as a result we were able to apply findings from a study performed for RG&E in 1996. I've gotten approval from Paul Lewis at RG&E to use and include their study findings and report. Paul only asked that he be included in discussions if you decide to pursue further inspection procedure development.

To summarize, the RG&E study showed that manual ultrasonic inspection of the regenerative heat exchanger (RHE) nozzles is not practical because the sound beam is attenuated by material grain structure and weld boundaries resulting in an inadequate signal-to-noise ratio for manual detection. In addition, as we discussed previously, other considerations with respect to this examination are the high dose rates to personnel and the fact that efforts are now underway at the ASME code to eliminate these examinations.

We have compared TVA component drawings and RG&E's drawings. From an inspection standpoint, it appears that the work performed on the RG&E mock-up is directly applicable to your heat exchanger nozzles. However, I would appreciate it if you would review the information enclosed on component materials so that we can discuss it further and make sure that you concur. Keep in mind that we have the option to perform similar experiments on your mock-up if there are any concerns.

Attachment 1 is the report issued to RG&E on their 1996 project. To summarize, we found that even with optimized inspection angles, frequencies etc., we could not develop a feasible inspection procedure with either shear or longitudinal wave modes.

**CHARLOTTE OFFICE**
1300 W.T. Harris Boulevard | Charlotte | NC | 28262 | USA
P.O. Box 217097 | Charlotte | NC | 28221
Tel 704 547 6100 | Fax 704 547 6168

**CORPORATE HEADQUARTERS**
3412 Hillview Avenue | P.O. Box 10412 | Palo Alto | CA | 94303-0813 | USA
Tel 650 855 2000 | www.epri.com

To achieve the desired sound beam orientation in the nozzle inner radius region, metal paths can get quite long. Long metal paths combined with the poor signal-to-noise ratios inherent to anisotropic materials, make manual detection very challenging. In your configuration the metal paths are longer than the Ginna mock-up, therefore we would expect the signal-to-noise ratio to be even further degraded.

Attachment 2 shows a drawing of the mock-up constructed for RG&E. Also included is information on the mock-up material specification. Notch locations are indicated on the mock-up drawings. Attachment 3 is the report produced by Kent Gebetsberger summarizing the experiments on the RG&E mock-up. When it was found that the notches could not be detected, RG&E elected to make one of the notches even deeper, from 10% to 30% thru-wall. The deeper notch was still not detectable.

Attachment 4 addresses Doug MacDonald's work on optimization of inspection procedures for the Sequoyah nozzle geometry using 3D computer modeling. You should note that Doug's work compares very well with similar efforts performed by AEA for RG&E in 1992, further substantiating the procedure design philosophy. When reviewing this information, you will note differences in the inspection angle between the TVA and RG&E procedures. Although there are differences in the incident inspection angles, the resulting angle relative to the flaw was designed to be the same. As a result, the RG&E experiments are applicable to the TVA application.

Attachment 4 also provides the resulting coverage determination. As you will see the coverage is around 80%. However, this only means that the sound beam is going out in the correct orientation with respect to the nozzle inner radius. The experiments show that because of the sound beam attenuation, reflections from even a 30% thru-wall notch do not return to the transducer and provide an adequate detection response.

To summarize, given that the materials are the same from an ultrasonic standpoint the only difference between the TVA nozzle geometry and the RG&E mock-up is that the RG&E mock-up is considerably smaller. Since the mock-up is smaller and the metal paths shorter, the notches should be easier to detect. Since they cannot be detected, detection would not be expected in the TVA application. Longer metal path in the TVA application would cause more attenuation of the ultrasonic beam and further degrade the signal-to noise ratio. As a result, use of the RG&E experiment for TVA's application is conservative.

As mentioned earlier, there are efforts underway to eliminate examinations of this kind. Industry studies have documented the lack of a flaw initiation mechanism. ASME Code Case N-619 has progressed successfully through the code process, and is now under formal review by the NRC. NRC representatives participating in the ASME code process gave their approval, however the NRC approval is still pending. We cannot speculate on

NRC acceptance of the code case, but the fact that it has gone this far should factor into your decision on whether or not to perform this examination.

To summarize, the limited coverage combined with the lack of notch detectability would seem to be adequate justification to seek relief from performing this examination. Especially when considering the typically high dose rates and the ASME Code efforts to eliminate this examination.

Please feel free to contact me if you need further information. I should be in all week.

Sincerely,

E. Kim Kietzman

E. Kim Kietzman

Cc: F. Ammirato
L. Becker
M. Turnbow
J. Goulart
D. MacDonald
B. Rassler

# Attachment 1

# EPRI NDE CENTER

Electric Power Research Institute
Nondestructive Evaluation Center ____________________ *Leadership in Technology Transfer*

April 23, 1996

Paul Lewis
Rochester Gas & Electric
89 East Avenue
Rochester, NY 14649

SUBJECT: Evaluation of Ultrasonic Examination Technology for Inspection of Regenerative Heat Exchanger Nozzle Inner Radii at the Rochester Gas & Electric, Ginna Nuclear Plant

Dear Paul,

The information enclosed summarizes efforts to-date on the RG&E, SRA project to assess ultrasonic inner radius examination of Ginna RHR nozzles. I have also included a draft of the report on activities to support the development of procedures and equipment for examination of steam generator nozzles at the Ginna Plant.

As we have discussed in the past few weeks, our work has shown that examination of the RHR nozzle inner radius region is very challenging with manual pulse-echo examination techniques. As you will see in the attached reports, we were in some cases able to obtain signals from the notches but the signals could not be differentiated from noise and geometric reflectors without the aid of finger damping on the ID surface. As a result, the techniques assessed could not be refined into a feasible detection procedure.

Modeling was performed on both the 6.0" and the 8.0" nozzle. These results compared well with the results generated by AEA in their 1992 modeling report. The results of the modeling are included in the attached report. Based on the modeling results, suitable transducers were selected and attempted first on the 8.0" nozzle as received, since the inspection geometry of the 8.0" nozzle was more favorable (3D modeling identified lower misorientation angles).

Inspection from the boss region of the nozzle was emphasized. Inspection from the shell surface was attempted but was greatly affected by attenuation and scattering from the nozzle-to-shell weld material. Transducer wedges were contoured to fit the nozzle boss and deliver the optimum examination angle identified by 3D modeling. A variety of frequencies were attempted. Since this and other transducers were not successful in delivering adequate detection results, it was decided to increase the depth of one of the notches from the required 10% to 30%. Adequate detection results were still not achieved.

1300 Harris Boulevard • Charlotte, North Carolina 28262 • Telephone (704) 547-6100
(P.O. Box 217097, Charlotte, North Carolina 28221) • FAX (704) 547-6168

It should also be noted that the transcducer position for detecting this notch was nearly optimum. ~~Boss area is much reduced in the~~ 0 and 180 degree positions, limiting the size of transducers that can be employed and limiting transducer positioning and further degrading performance of the techniques. Since adequate detection was not possible on ~~the notch in the~~ more optimum position, other notches were not modified. More detail on the technique evaluation is provided in the attached report by Kent Gebetsberger.

Please contact me if you need further information or wish to pursue this project further.

Sincerely,

E. Kim Kietzman

E. Kim Kietzman
Project Manager
Reactor Pressure Vessel NDE
EPRI NDE Center

EKK:inb
RG&E_LET.DOC

cc: Mike Saporito, RG&E
F. Ammirato
L. Becker
D. MacDonald
B. Rassler
K. Gebetsburger
W. Money

# Evaluation of Ultrasonic Examination Technology for Inspection of Regenerative Heat Exchanger Nozzles at the Rochester Gas & Electric, Ginna Nuclear Plant

Douglas E. MacDonald
E. Kim Kietzman

April 17, 1996

## Introduction

This report summarizes EPRI NDE Center modeling activities to support Rochester Gas & Electric (RG&E) in a project to develop and evaluate manual ultrasonic scan plans. The project was directed specifically at determining inspection capability on the regenerative heat exchanger nozzles at the Rochester Gas & Electric, Ginna Nuclear Plant.

## 3-D Modeling of Ginna Regenerative Heat Exchanger Nozzle

The NDE Center used 3-D geometric models to develop recommendations for ultrasonic search units relative to the basic angle of incidence and skew required to provide optimum reflection.

The NDE Center's 3-D spreadsheet model was used to calculate the probe angle and probe skew needed for a perfect (45 degree) corner trap response everywhere on the examination volume of the 8 inch regenerative heat exchanger nozzle. Figure 1 shows a plot of the average probe angle vs. probe skew needed to accomplish a 45 degree corner trap examination. Also shown in Figure 1 are the procedures suggested for the examination of the 8 inch regenerative heat exchanger nozzle by AEA Technology. The following Table 1 summarizes the procedures proposed by the NDE Center to examine the 8 inch regenerative heat exchanger nozzle.

Table 1. Procedures for the 8 inch Regenerative Heat Exchanger Nozzle

| Probe Angle (degrees) | Probe Skew (degrees) | Metal Path (inches) | Probe Position |
|---|---|---|---|
| 18 | ±90 | 1.3 | Boss |
| 70 | ±20 | 2.5 | Shell |
| 45 | ±145 | 2.0 | Boss |

REGENHX8.XLS Chart 7

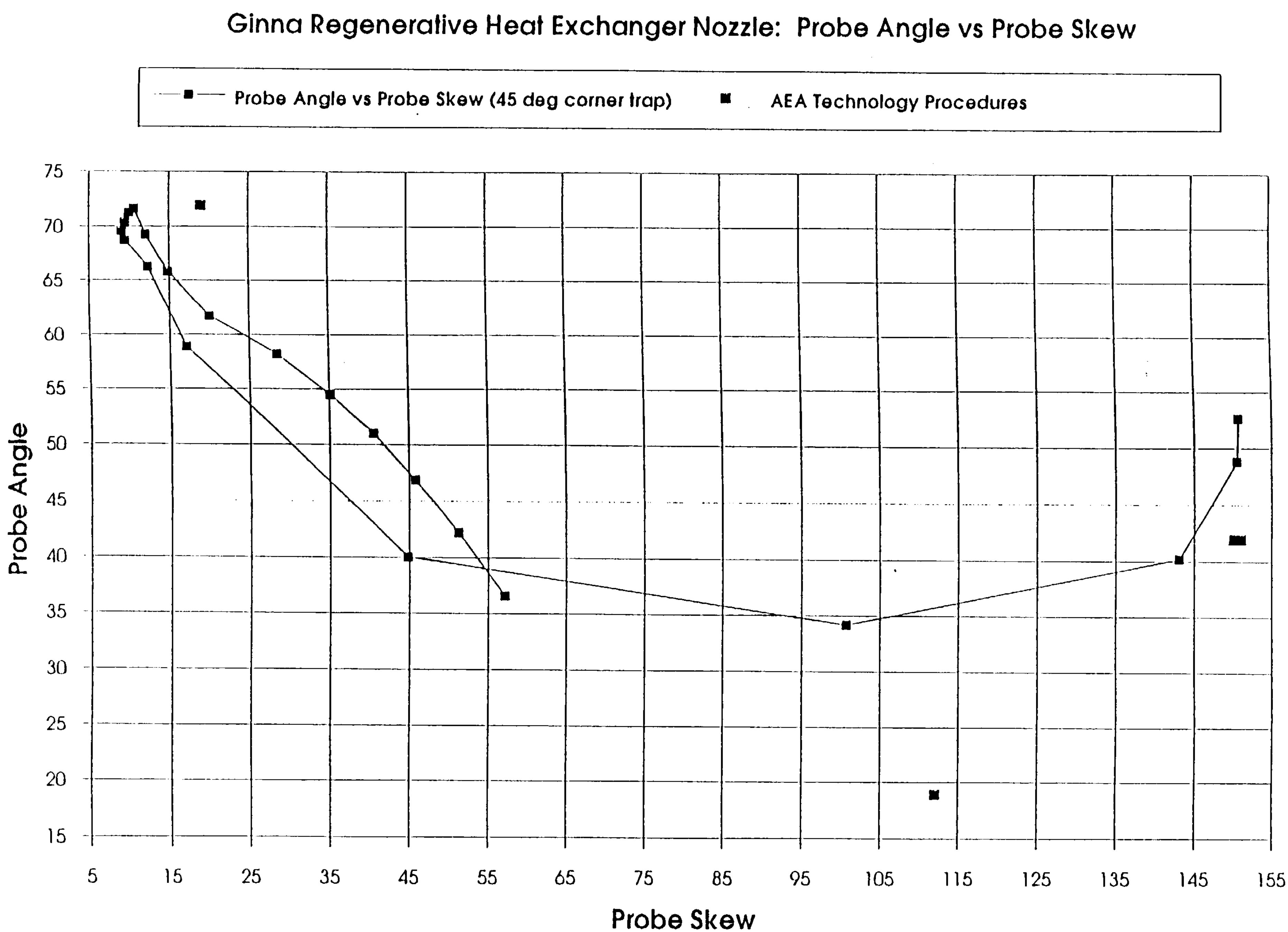
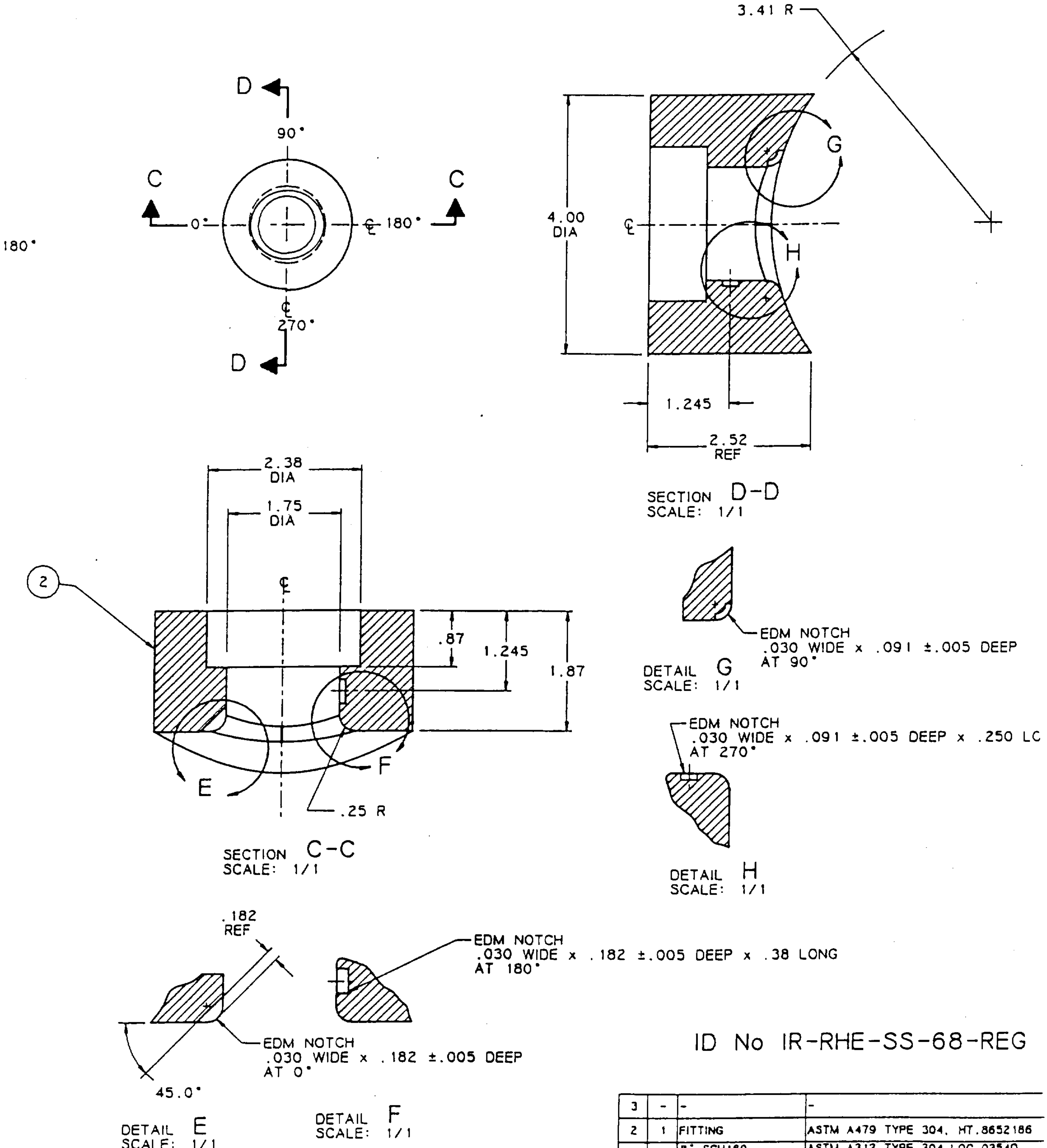



Figure 1

# Attachment 2




ID No IR-RHE-SS-68-REG

| DASH NO. | NO. REQD | PART NAME | MATERIAL |
|---|---|---|---|
| 3 | - | - | - |
| 2 | 1 | FITTING | ASTM A479 TYPE 304, HT.8652186 |
| 1 | 1 | 8" SCH160 PIPE | ASTM A312 TYPE 304 LOG 03540 HT. TH7173 |

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE CHEMICALLY APPLIED OR PLATED FINISHES

TOLERANCES UNLESS NOTED

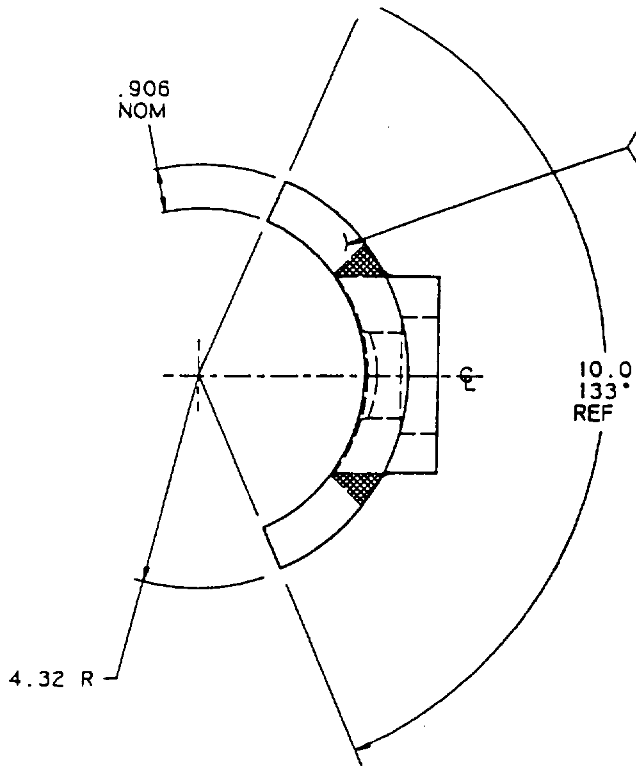
| BASIC DIMENSION | DECIMALS 1 PLACES | 2 PLACES | 3 PLACES |
|---|---|---|---|
| UNDER 6 | ±.06 | ±.02 | ±.005 |
| 6-24 INCL | ±.12 | ±.03 | ±.010 |
| OVER 24 | ±.25 | ±.06 | ±.015 |
| ANGLES | ±0°30' | | |

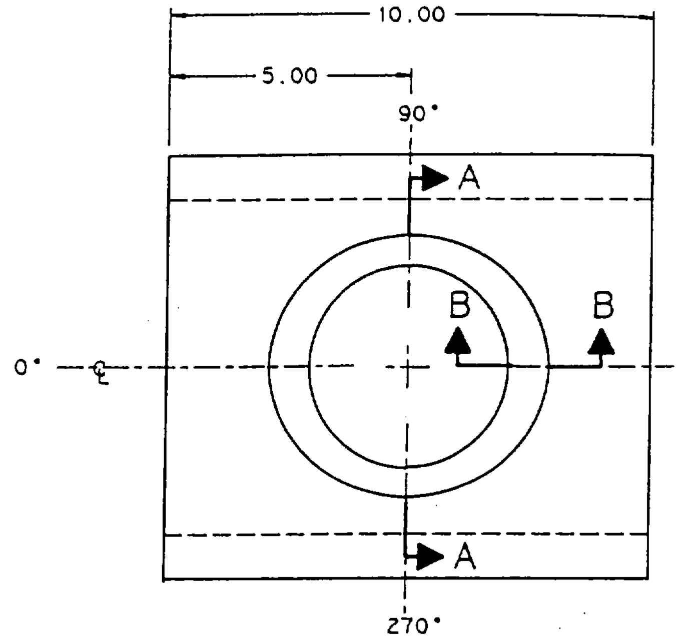
COML TOL APPLY TO STOCK SIZES

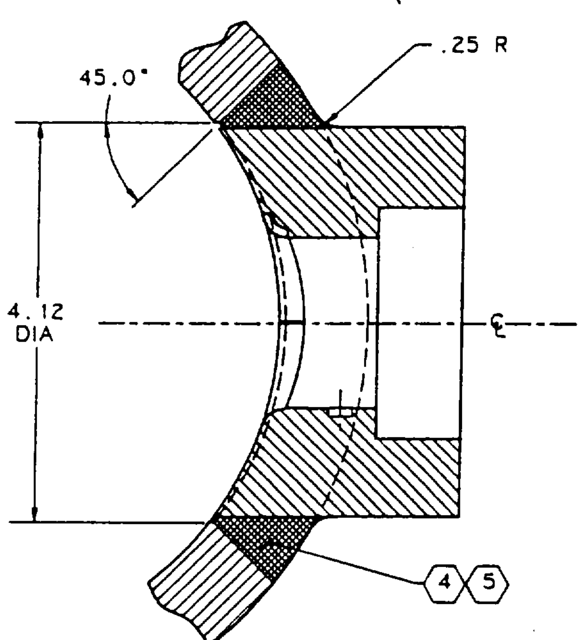
| | |
|---|---|
| DESIGNED BY J. CRANE | - |
| DRAWN BY JC RAMOS | 3-24-92 |
| APPROVAL SIGNATURES & DATE | |
| CHECKED BY RALPH HERNANDEZ | 4-4-92 |
| DESIGN VERIFICATION - | 4-2-92 |

SOUTHWEST RESEARCH INSTITUTE
NONDESTRUCTIVE EVALUATION SCIENCE & TECHNOLOGY DIVISION
SAN ANTONIO, TEXAS

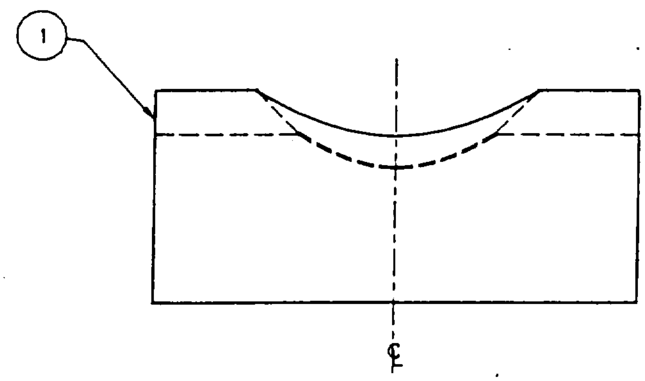
# 8" REGEN. HEAT EXCHANGER MOCKUP

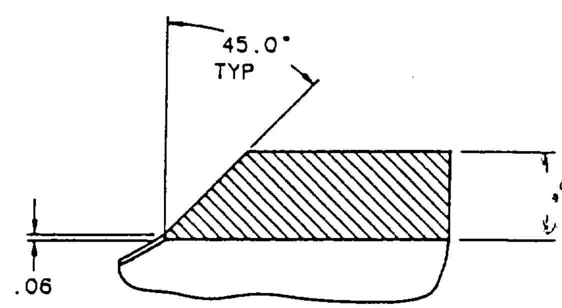



SECTION A-A
SCALE: 1/1




SECTION B-B
SCALE: 1/1

WELD PREP

NOTES:

1. REMOVE BURRS AND BREAK SHARP EDGES

2. MATERIAL FOR BLOCK TO BE ULTRASONICALLY EXAMINED IN ACCORDANCE WITH SwRI NPOP UT-1, LATEST REVISION

3. STEEL STAMP ID No AND HEAT No ON SURFACE INDICATED USING CHARACTERS 3/16 MIN HEIGHT.

4. THE ROOT PASS SHALL BE SFA5.9 CLASS ER-308L. THE FILLER WIRE DIAMETER SHALL BE 1/16 INCH. THE FILLER METAL FOR THE SECOND AND ALL SUBSEQUENT LAYERS SHALL BE SFA 5.4, CLASS E-308L-16. THE ELECTRODE DIAMETER SHALL BE 1/8 OR 5/32 INCH.

5. THE WELD PROFILE WILL BE CONTOURED BY GRINDING TO SIMULATE THE OUTSIDE RADIUS OF EXISTING COMPONENT.

SOUTHWEST RESEARCH INSTITUTE

# P-NUMBER CLASSIFICATION FOR CALIBRATION BLOCKS

Mockup IR-RHE-SS-68-REG is hereby classified as P-Number 8 Group 1 in accordance with Section IX, 1986 Edition of the ASME Boiler and Pressure Vessel Code. The P-Number classification for this mockup is substantiated with the attached mill test reports for SA312 TP304, Heat No. TH7173 and SA479 TP304, Heat No. 8652186 in accordance with the Materials Specification Section II of the ASME Boiler and Pressure Vessel Code.

## Design Criteria

The design for the above mockup simulates the 8-inch regenerative heat exchanger weldment at R. E. Ginna Nuclear Power Station. This is a verification that the mockup was fabricated from the material specified and the enclosed drawings reflect the as-built dimensions.

## Attachments

- Mill Test Reports
- Preliminary UT Data Sheets
- Dimensional Data Sheets
- Welding Electrode Certifications
- Drawing (SwRI) D-3084-629B

| Signature | Sr. Research Engineer<br>Title | December 14, 1992<br>Date |
|---|---|---|

Attachment 3

**Evaluation of NDE Techniques to Inspect Regenerative Heat Exchanger Nozzles for RG&E, Ginna Nuclear Station**

Kent C. Gebetsberger
April 19, 1996

## Project Description

To determine what specific ultrasonic NDE techniques could be used to detect four (4) EDM notches located in a Regenerative Heat Exchanger Nozzle Mock-Up. If any ultrasonic NDE techniques were proven to be useful, these techniques were to be provided to RG&E as a guideline for procedure development for their planned inspection of this component at the Ginna Nuclear Station.

## Project Techniques

Utilizing the information from the 3-D Modeling for the "ideal" transducer positioning, an 18 degree shear wave and longitudinal wave transducer were first tried. These transducers were 0.25" in diameter with a nominal frequency of 2.25 MHz. The 18 degree beam angle was used to provide a 45 degree angle at the ID of the nozzle boss. Even with the ideal positioning utilized from the 3-D modeling, the detection of the notches was inconclusive. There was a signal response produced from what was determined to be notch and bore geometry combined. This response could not differentiate the notch out of the geometry signal.

The two 18 degree wedges were then contoured to provide better coupling to the part by sanding down the wedge to fit the part at the ideal 3-D modeling skew angle. This provided no better results of a definitive notch response.

Another approach taken was to inspect from the shell side utilizing various Refracted Longitudinal wave transducers to better penetrate the weld material. This technique was to place high angle RL's on the shell with the beam directed at the bore then skew off so as to provide a tangent line of sound at the notch area. The notches to be looked at were the two placed in the radius area of the inside surface. The transducers used were 70 degree RL, and an ODCR (85 degree RL) with a nominal frequency of 2.0 MHz.

The same results were achieved as with the 18 degree transducers. A signal response was detected that appeared to be notch and geometry (Bore) response combined in one signal on the CRT. The entire area around the notch could be finger dampened including inside the notch with no distinction between geometry and notch.

One final attempt was to be made using the 18 degree shear wave and longitudinal wave wedges. Prior to this attempt, one of the notches was increased in size from a 10% to a 30% notch. Using the ideal positioning from the 3-D modeling the signal response was greater in amplitude but still contained the notch and geometry response into one signal.

The techniques from the nozzle boss were also attempted again on the deeper (30%) notch. There was no noticeable improvement in detectability.

## Conclusion

Differentiation of the notch signal response from geometry signal response was inconclusive. One other factor to consider is outside surface geometry. Even if a definitive signal response could be determined with ultrasonics, the outside inspection surface area is greatly reduced at certain circumferential positions because of the saddle geometry and this would greatly limit the ability to achieve a 100% inspectability of the part.

# Attachment 4

# Sequoyah Residual Heat Removal (RHR) Heat Exchanger Inlet and Outlet Nozzles

Douglas E. MacDonald
EPRI NDE Center

## Introduction

This report describes the work performed by the EPRI NDE Center to assist TVA in assessing inner radius examination procedures for the Sequoyah residual heat removal (RHR) nozzles (N1 & N2). The necessary geometric inputs to the NDE Center spreadsheet model [1] are listed and a cross sectional plot is provided. The procedure design curve developed by the model is given together with the chosen procedures for the nozzles. Tabular and graphical information on the procedure maximum and minimum probe radial position and metal path are also provided. The combined coverage or minimum misorientation angle achieved by the chosen procedures is also given.

## RHR Heat Exchanger Inlet and Outlet Nozzles

Table 1 gives the necessary geometric inputs to the NDE Center spreadsheet model for the Sequoyah RHR heat exchanger nozzles. Figure 1 shows the geometric parameters, which define the RHR heat exchanger nozzles (cross-section at theta=90°). The ASME Section XI Class II examination volume is indicated in Figure 1.

Table 1. Sequoyah RHR Heat Exchanger Nozzles (N1 & N2) Geometry Inputs to Spreadsheet Model

| Inside Surface Dimensions | (inches) | Outside Surface Dimensions | (inches) |
|---|---|---|---|
| Rbore | 6.562 | Rnozzle | 9.0625 |
| Rvi | 17.5 | Rvo | 18.5 |

Figure 2 is a plot of the probe beam angle versus probe skew angle to obtain a 45° corner trap for the Sequoyah RHR heat exchanger nozzles. The procedures used to examine the RHR heat exchanger nozzles are listed in Table 2. The procedure design curve was compared to the procedures used to examine the RHR heat exchanger nozzles (see Figure 2). The convention adopted here for probe skew angles has 0° aligned with the nozzles axis with the beam pointed toward the nozzles; 90°, pointed circumferentially around the nozzles; and 180°, again aligned with the nozzles axis but pointed toward the vessel (see Figure 3).

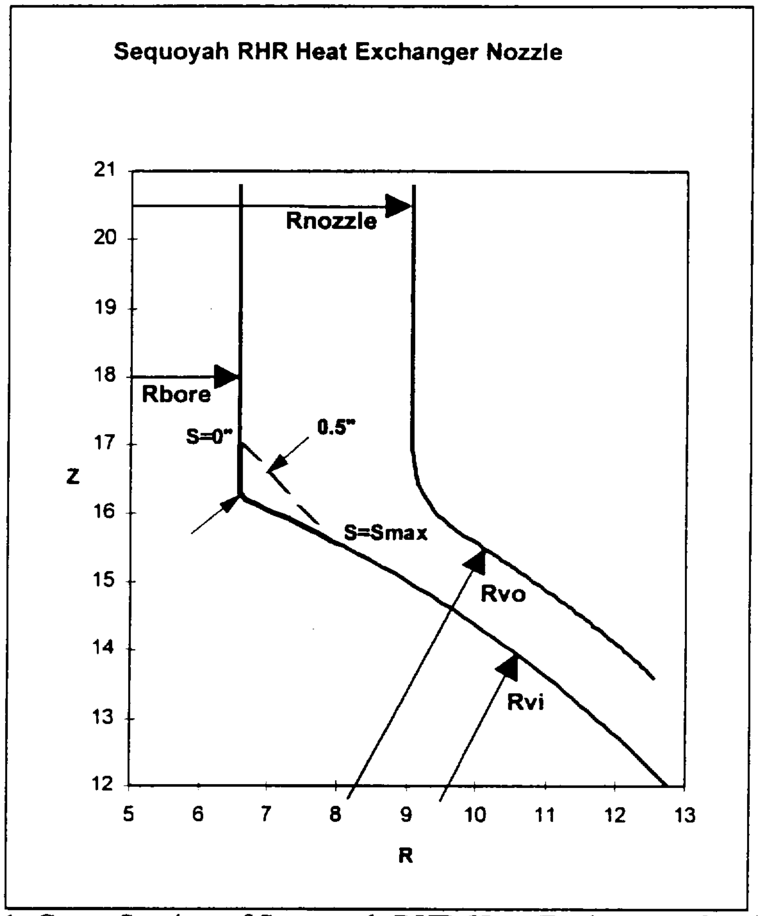



Figure 1. Cross-Section of Sequoyah RHR Heat Exchanger Nozzle (N1 & N2) Defining Class II Examination Volume.

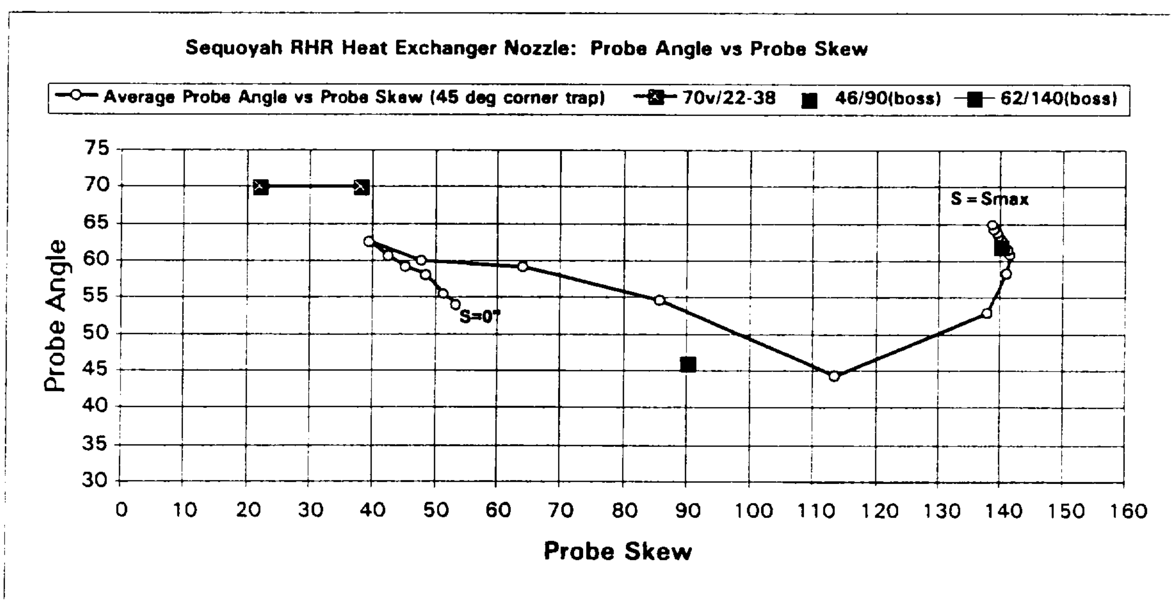
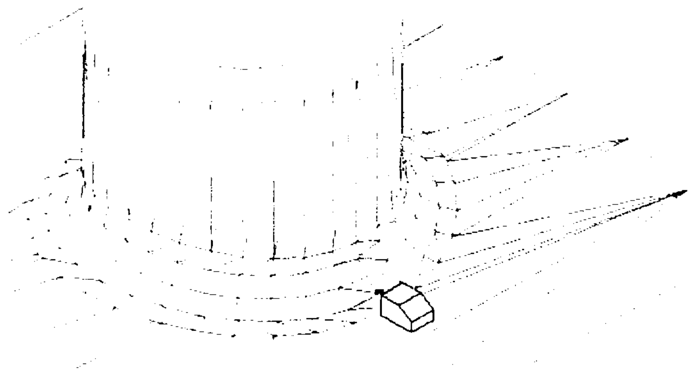
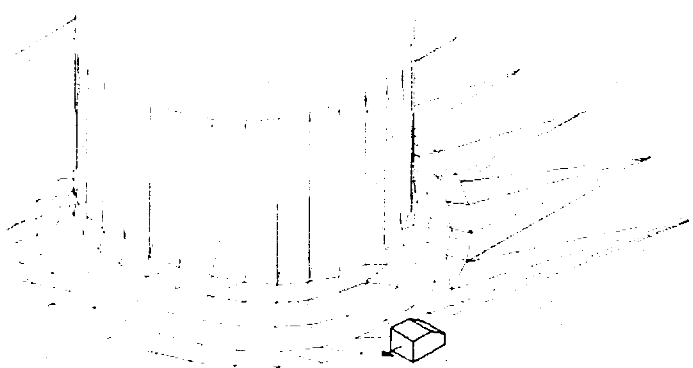


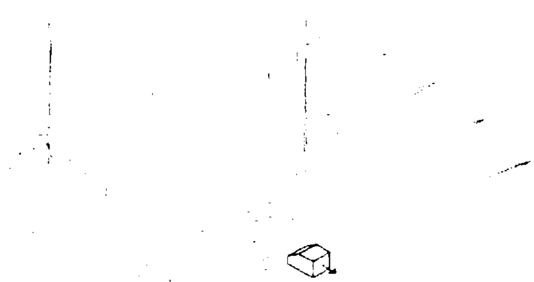

Figure 2. Sequoyah RHR Heat Exchanger Nozzle: Procedure Design Curve - Probe Angle vs. Probe Skew for 45° Corner Trap.

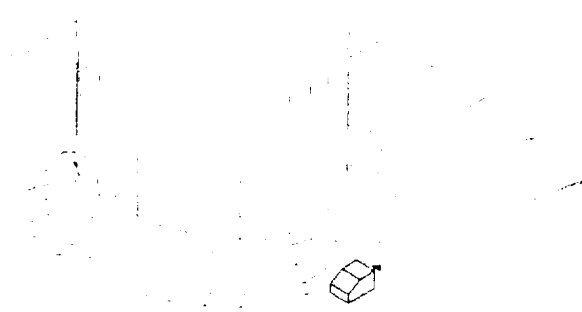


a) Probe Skew = 0°



b) Probe Skew = +90°





c) Probe Skew = 180°

d) Probe Skew = -90°

Figure 3. Definition of Probe Skew Angle.

Table 2. NDE Center Procedures for Sequoyah RHR Heat Exchanger Nozzle.

| Probe Angle | Probe Skew | Scan Surface | Mode of Propagation |
|---|---|---|---|
| 46 | 90 | Outer Nozzle Boss | Shear Wave |
| 62 | 140 | Outer Nozzle Boss | Shear Wave |
| 70 | 22-38 | Outer Vessel | Shear Wave |

The examination procedures are summarized in Table 3 as well as, the corresponding scan surfaces, the minimum and maximum probe axial, Z, or radial, R, positions, the minimum and maximum metal paths, and the maximum misorientation angle.

Table 3. Spreadsheet Model Procedures for Sequoyah RHR Heat Exchanger Nozzle.

| Probe Angle | Probe Skew | Scan Surface | Min Z/R | Max Z/R | Min MP | Max MP | Max Misorientation Angle |
|---|---|---|---|---|---|---|---|
| 46 | 90 | Boss | 16.93 | 18.49 | 4.42 | 8.48 | 19.11 |
| 62 | 140 | Boss | 17.31 | 20.8 | 2.68 | 6.27 | 21.45 |
| 70 | 22-38 | Vessel | 9.83 | 12.50 | 3.67 | 10.72 | 23.17 |

Figure 5 shows the minimum and maximum probe axial position, Z, and the portion of the examination volume covered by the boss procedures 46/90 and 62/140.

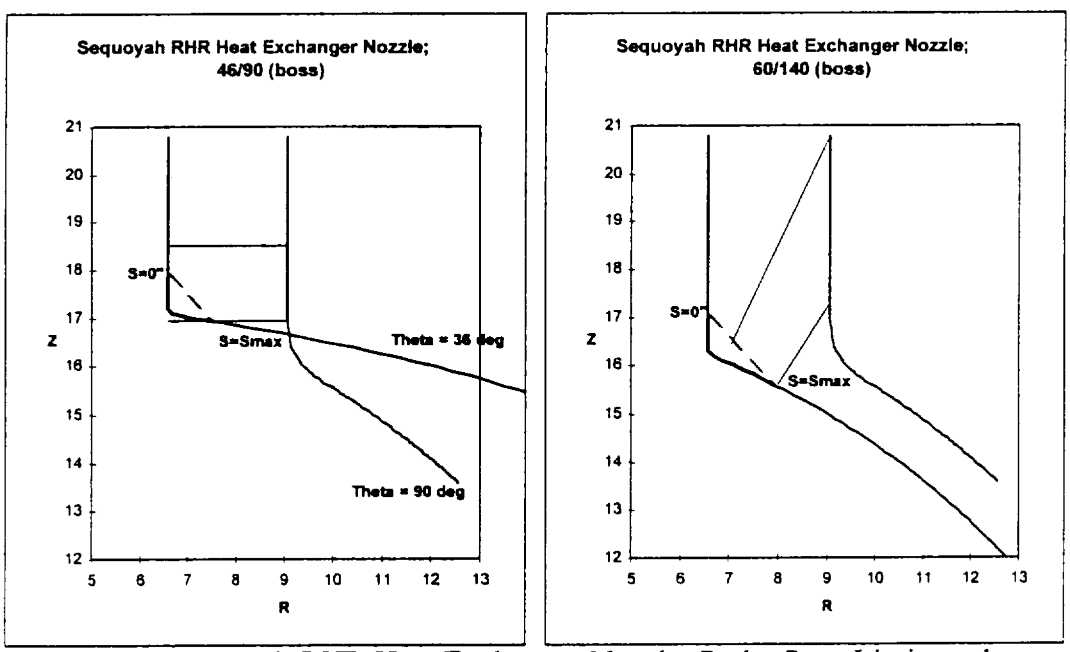



Figure 5. Sequoyah RHR Heat Exchanger Nozzle: Probe Scan Limits and Examination Coverage for Boss Procedures 46/90 and 62/140.

Figure 6 shows the minimum and maximum probe radial positions, R, and the associated portion of the examination volume covered by the vessel procedure 70/22-38.

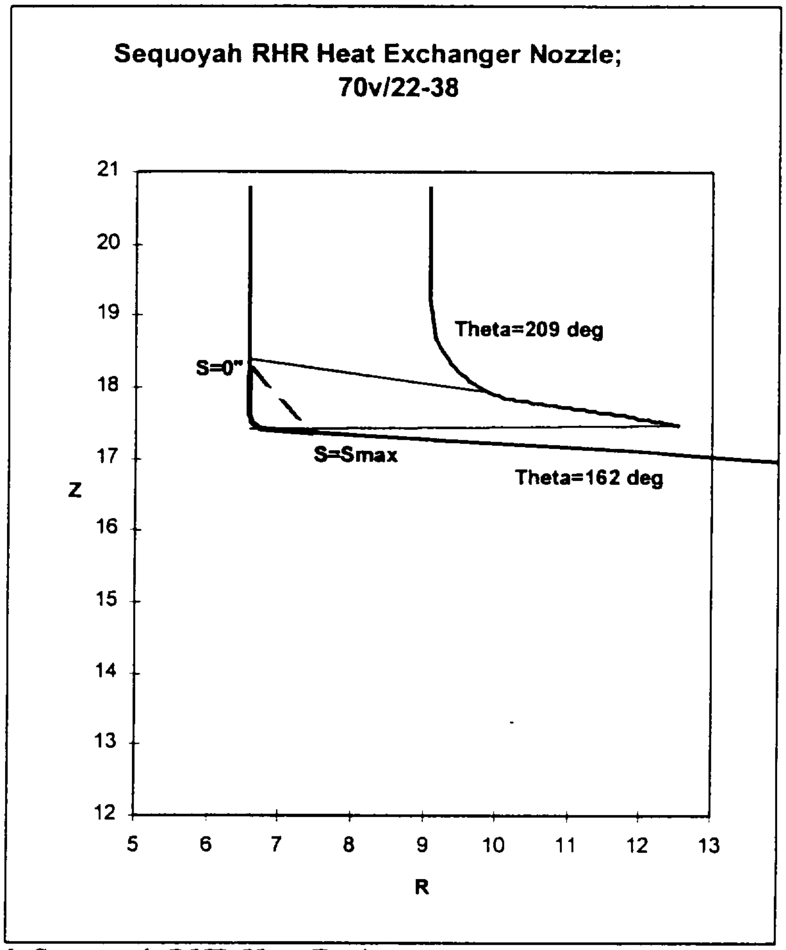



Figure 6. Sequoyah RHR Heat Exchanger Nozzle: Probe Scan Limits and Examination Coverage for Vessel Procedure 70/22-38.

The restriction on the position of the 70° probe due to the heat exchanger support pads has been taken into consideration during the coverage calculations. Figure 4 shows the combined coverage (i.e. misorientation angle) achieved by the procedures listed in Table 2, 46/90 and 62/140 from the nozzle boss and 70/22-38 from the vessel. The magnitude of the misorientation angle is plotted using a spectral color scale, see Figure 4. The white areas in the plot indicate portions of the examination volume not covered.

In viewing Figures 4 through 6, each of these probe/skew angle combinations is effective within some subset of the examination volume and ineffective in other areas. Boss procedure 46/90 is effective for flaws on the bore near theta = 36°. Boss procedure 62/140 is effective for flaws on the vessel. Vessel procedure 70/22-38 is effective for flaws on the bore near theta = 162°. Because of the limited scan area for the 70° probe, the maximum percent coverage achieved by the procedures listed in Table 2 is about 82% (see Figure 4).

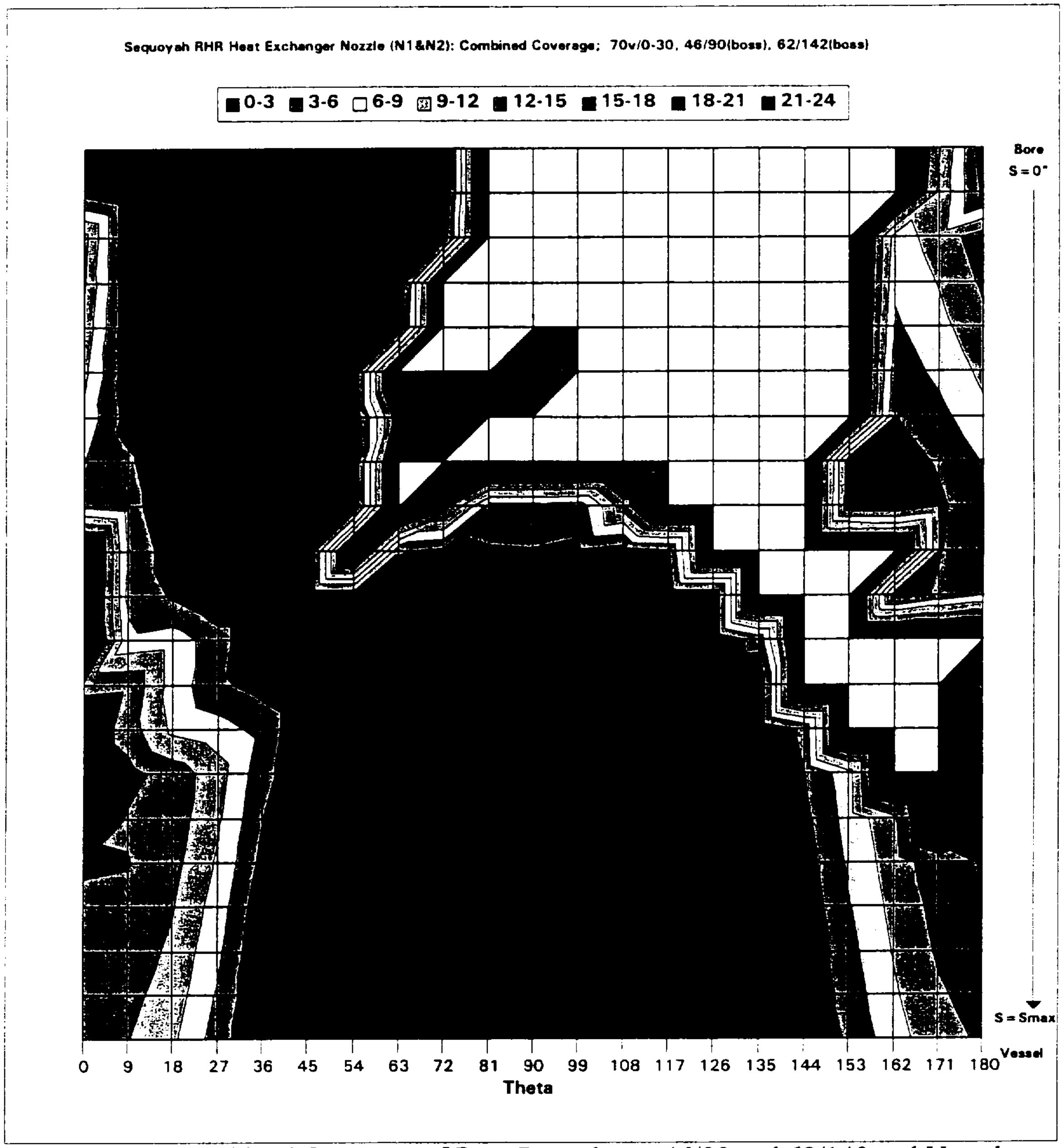



Figure 4. Combined Coverage of Boss Procedures, 46/90 and 62/140 and Vessel Procedure, 70/22-38 for Sequoyah RHR Heat Exchanger Nozzle (N1 & N2).

L18 000412 007

## References

1. *Ultrasonic Examination of Nozzle Inner Radius Regions.* Charlotte, North Carolina: EPRI NDE Center, December 1997. TR-107493.

# Enclosure 2

## Sequoyah RHR Heat Exchanger Nozzle

## Dimensional Drawings

1. 1,2-BEU-15588
2. Engineers and Fabricators CD-15588
3. Drawing W-100

# Enclosure 3

# TVA

# Ultrasonic Attenuation Measurements

| TENNESSEE VALLEY AUTHORITY | EXAMINATION SUMMARY AND RESOLUTION SHEET | REPORT NUMBER: BOP-1075 |
|---|---|---|

| PROJECT: SQN UNIT: 1/2 CYCLE NA | COMPONENT ID: RHR Heat Exchanger |
|---|---|
| EXAMINATION METHOD | SYSTEM: RHR / ISI DWG NO: NA |

| MT ☐ | PT ☐ | UT ☒ | VT ☐ | CONFIGURATION: | CATEGORY |
|---|---|---|---|---|---|
| PROCEDURE: | | REV | TC: | NA TO NA | C-B |

| EXAMINER: M. Kleinjan | EXAMINER: NA | EXAMINER: NA | EXAMINER: NA |
|---|---|---|---|
| LEVEL: II | LEVEL: | LEVEL: | LEVEL: |

Attenuation measurements were performed on the Unit 2 SQN RHR Heat Exchanger and the RG+E Regenerative Heat Exchanger Mockup IR-RHE-SS-68-REG. Attenuation measurements were performed with a 0 degree search unit and two 45 degree search units in a pitch/catch mode (1 vee path).

| (Component) | 0 degree Reading @ 80% | 45° Shear Reading @ 80% |
|---|---|---|
| IR-RHE-SS-68-REG | 32 dB | 26 dB |
| Unit 2 SQN Heat Exchanger A Near weld RHRW-16-A | 29 dB | 28.6 dB |
| Unit 2 SQN Heat Exchanger Near weld RHRW-17-A | 28 dB | 26.6 dB |

Summary: Acoustic properties of the RG+E Mockup (IR-RHE-SS-68-REG) And the SQN RHR Heat Exchangers were determined to be acoustically similar.

| RESOLUTION BY: [signature] | REVIEWED BY: [signature] | ANII: NA |
|---|---|---|
| LEVEL: III DATE: 10/23/00 | LEVEL: III DATE: 10-23-00 | DATE: |
| | | Page: 1 OF 6 |

| TENNESSEE VALLEY AUTHORITY | DIGITAL ULTRASONIC CALIBRATION DATA SHEET | REPORT NUMBER BOP-1075 |
|---|---|---|

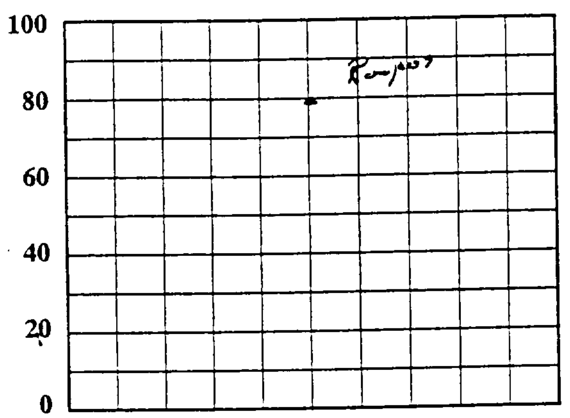
PROJECT NA UNIT/CYCLE NA
PROCEDURE: NA REV: NA TC: NA
MODEL: K13 DUE DATE: 6-20-01
INSTRUMENT: USN 50 S/N: E 24256
TRANSDUCER MANUF.: MSEB -2
S/N 1933 SIZE: .5 FREQ: 2 MHz
CABLE TYPE Dual LENGTH: 6'

CALIBRATION DATE 10-12-00
CALIBRATION BLOCK NO. 68 R6E TEMP: NA
SIMULATOR BLOCK NO.: Rompus
THERMOMETER S/N: NA DUE DATE: NA
COUPLANT: Sonotrace BATCH: 95325
EXAM TYPE: SHEAR ☐ LONG ☒ RL ☐

**ANGLE VERIFICATION**

BLOCK TYPE: Rompus S/N: 94-7995
NOMINAL ANGLE: 0 ACTUAL ANGLE: N/A

**DAC**




DISPLAY WIDTH 2

**INSTRUMENT SETTINGS**

| REFLECTOR SCAN DIRECT. | NTCH | SDH | REFERENCE SENSITIVITY | MEMORY NUMBER |
|---|---|---|---|---|
| AXIAL N/A | ☐ | ☐ | 39 dB | 1 |
| CIRC | ☐ | ☐ | N/A dB | N/A |

FREQ: Fix MHz REJECT: 0 %
ANGLE: 0 deg DAMPING: Fix ohms
DELAY: 9.839 msec PULSER: DUAL *
ZERO: 9.729 msec FILTER: Fix *
VELOCITY .2255 msec REP RATE: Fix
RANGE: 2.0 inches TOF: PEAK FLANK
RECTIFIER: POWER: DC
DUAL: ON OFF TCG: ON OFF

REF. REFLECTOR: Rompus GAIN: 59 dB
AMPLITUDE: 80 % METAL PATH: 1.0

**CALIBRATION TIMES**

INITIAL TIME 11.06 FINAL TIME: 11.10

| VERIFICATION TIMES | 1) NA | 2) | 3) | 4) | 5) | 6) | 7) | 8) | 9) |
|---|---|---|---|---|---|---|---|---|---|

*PDI QUALIFIED INSTRUMENT SETTINGS:
VERIFY INSTRUMENT SETTINGS AND CALIBRATION SEQUENCE ARE IN ACCORDANCE WITH TABLE 2 OF THE APPLICABLE PDI QUALIFICATION IMPLEMENTATION PROCEDURE!

**LINEARITY CHECK**

| VERTICAL | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SIGNAL 1 | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 | 20 |
| | SIGNAL 2 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 |

| ATTENUATOR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| GAIN | SET | -6 dB | -12dB | SET | +12 | SET | +6 | |
| AMP | 80% | 32 TO 48 | 16 TO 24 | 20% | 64 TO 96 | 40% | 64 TO 96 | |
| | | 40 | 20 | | 80 | | 80 | |

**COMMENTS**

For INFORMATION only
see PROFILE for more
INFORMATION

**WELD / ITEMS EXAMINED**

EXAMINER: Mike W Kenyon LVL.: II
EXAMINER: NA LVL.:
REVIEWER: [signature] LVL.: III DATE: 10/23/00

ANII: NA
DATE:
PAGE 2 OF 6

| TENNESSEE VALLEY AUTHORITY | DIGITAL ULTRASONIC CALIBRATION DATA SHEET | REPORT NUMBER BOP-1075 |
|---|---|---|

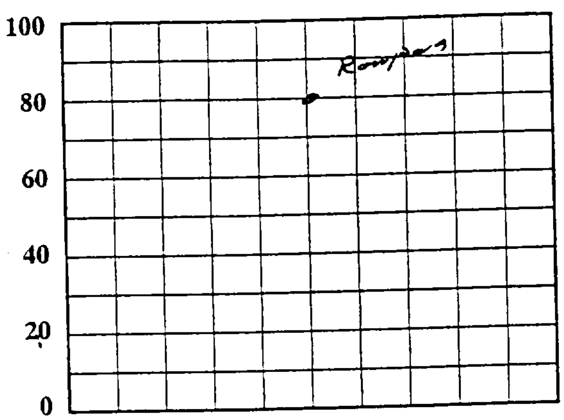
PROJECT NA UNIT/CYCLE NA
PROCEDURE: NA REV: NA TC: NA
MODEL: KB DUE DATE: 6-20-01
INSTRUMENT: USN 50 S/N: E24256
TRANSDUCER MANUF.: KBA
S/N ~~34008~~ 32347 SIZE: .375 FREQ: 2.25 MHz
CABLE TYPE RG174 LENGTH: 6'

CALIBRATION DATE 10-12-00
CALIBRATION BLOCK NO. 69-RCE TEMP: NA
SIMULATOR BLOCK NO.: Rompas
THERMOMETER S/N: NA DUE DATE: NA
COUPLANT: Sonotrace BATCH: 95325
EXAM TYPE: SHEAR ☒ LONG ☐ RL ☐

**ANGLE VERIFICATION**

BLOCK TYPE: Rompas S/N: 94-7995
NOMINAL ANGLE: 45 ACTUAL ANGLE: 45

**DAC**




DISPLAY WIDTH 2

**INSTRUMENT SETTINGS**

| REFLECTOR | | | REFERENCE SENSITIVITY | MEMORY NUMBER |
|---|---|---|---|---|
| SCAN DIRECT. | NTCH | SDH | | |
| AXIAL | N/A ☐ | ☐ | 23 dB | 2 |
| CIRC | ☐ | ☐ | N/A dB | N/A |

FREQ: Fix MHz REJECT: 0 %
ANGLE: 45 deg DAMPING: Fix ohms
DELAY: 5.023 msec PULSER: HIGH *
ZERO: 4.879 msec FILTER: Fix *
VELOCITY .1215 msec REP RATE: Fix
RANGE: 2.0" inches TOF: PEAK FLANK
RECTIFIER: POWER: DC
DUAL: ON OFF TCG: ON OFF

REF. REFLECTOR: Rompas GAIN: 18 dB
AMPLITUDE: 80 % METAL PATH: 1.00

**CALIBRATION TIMES**

INITIAL TIME 1020 FINAL TIME:

| VERIFICATION TIMES | 1) | 2) | 3) | 4) | 5) | 6) | 7) | 8) | 9) |
|---|---|---|---|---|---|---|---|---|---|

*PDI QUALIFIED INSTRUMENT SETTINGS:
VERIFY INSTRUMENT SETTINGS AND CALIBRATION SEQUENCE ARE IN ACCORDANCE WITH TABLE 2 OF THE APPLICABLE PDI QUALIFICATION IMPLEMENTATION PROCEDURE!

**LINEARITY CHECK**

| VERTICAL | SIGNAL 1 | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| | SIGNAL 2 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 |

| ATTENUATOR | GAIN | SET | -6 dB | -12dB | SET | +12 | SET | +6 |
|---|---|---|---|---|---|---|---|---|
| | AMP | 80% | 32 TO 48 | 16 TO 24 | 20% | 64 TO 96 | 40% | 64 TO 96 |
| | | | 40 | 20 | | 80 | | 80 |

| COMMENTS | WELD / ITEMS EXAMINED |
|---|---|
| For INFORMATION ONLY<br>See PROFILE SHEET FOR more INFORMATION. | |

EXAMINER: Mike W Kenyon LVL.: II
EXAMINER: NA LVL.:
REVIEWER: [signature] LVL.: III DATE: 10/23/00

ANII: NA
DATE: \
PAGE 3 OF 6

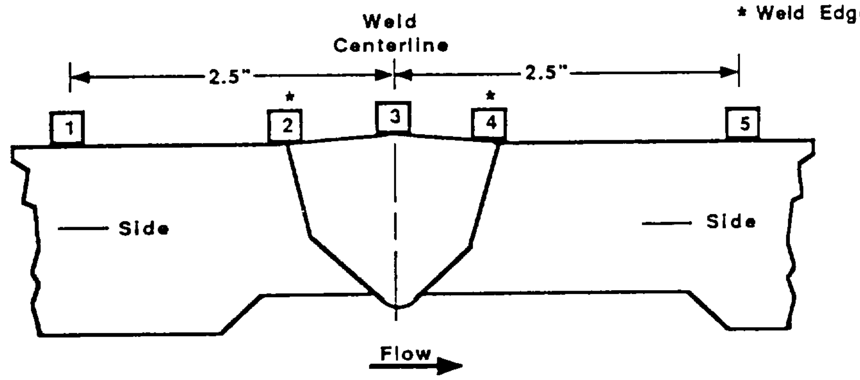
| TVA | WALL THICKNESS PROFILE SHEET | REPORT NO: BOP-1075 |
|---|---|---|

PROJECT: N/A
UNIT: N/A

WELD NO: Cal Block IO # IR-RHE-55-68-REG
SYSTEM: RHE

Record Thickness Measurements As Indicated, Including Weld Width, Edge-To-Edge At 0°

| Position | 0° | 90° | 180° | 270° |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |

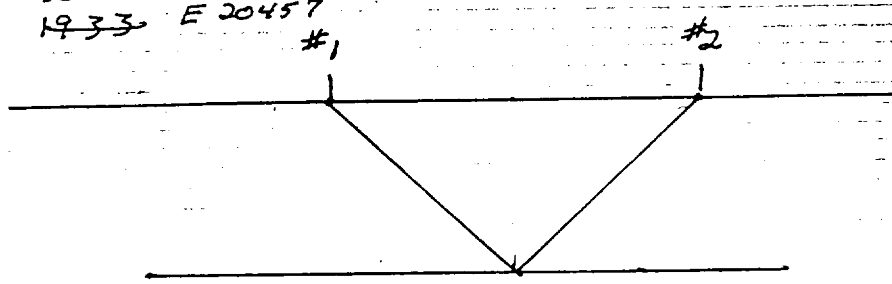



CROWN HEIGHT: N/A
CROWN WIDTH: N/A
DIAMETER: N/A
WELD LENGTH: N/A

TRANSDUCERS 45°
.375 2.25 MHZ
1. S/N 32347
2. S/N 34008

MP 1.32
SKIP 1.9
T .9
∠ 45°

TRANSDUCER 0° AEROTECH
.5 2.25 MHZ
S/N ~~1933~~ E 20457




45° dB AT 80% 26
0° dB AT 80% ~~39~~ 32
mk

EXAMINER: Mike W Kempton
LEVEL: II
DATE: 10-10-00

REVIEWED BY: [signature]
LEVEL: III
DATE: 10/23/00

ANII: N/A
DATE: -

PAGE 4 OF 6

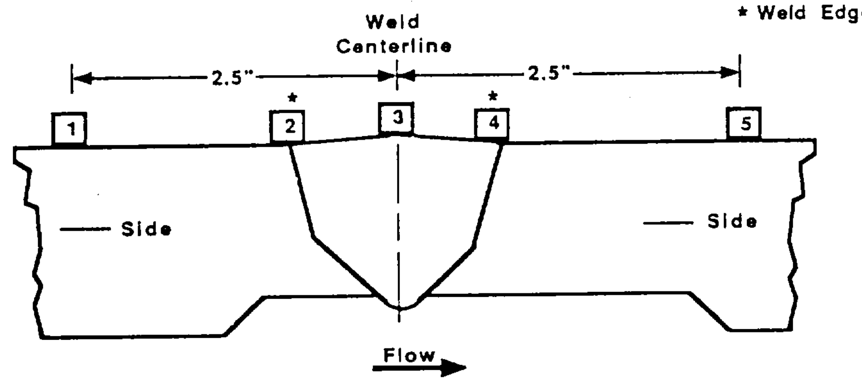
| TVA | WALL THICKNESS PROFILE SHEET | REPORT NO: BOP-1075 |
|---|---|---|

PROJECT: SQN
UNIT: 2

WELD NO: RHRW-16-A
SYSTEM: RHRS

Record Thickness Measurements As Indicated, Including Weld Width, Edge-To-Edge At 0°

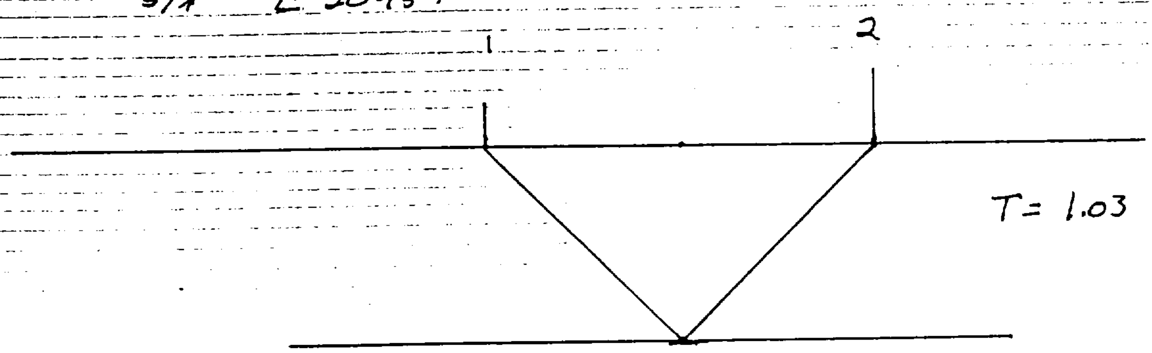
| Position | 0° | 90° | 180° | 270° |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |




CROWN HEIGHT: N/A
CROWN WIDTH: N/A
DIAMETER: N/A
WELD LENGTH: N/A

TRANSDUCER 2.25 MHZ .375
1 S/N 32347 MP 1.46
2 S/N 34008 SHELL SIDE SKIP 2"
T 1.03

0° TRANSDUCER AEROTECH
.5 2.25 MHZ 45°
S/N E 20457




T= 1.03

45° dB AT 80% 28.6
0° dB AT 80% 29.

EXAMINER: [signature]
LEVEL: II
DATE: 10-12-00

REVIEWED BY: [signature]
LEVEL: III
DATE: 10/23/00

ANII: NA
DATE:
PAGE 5 OF 6

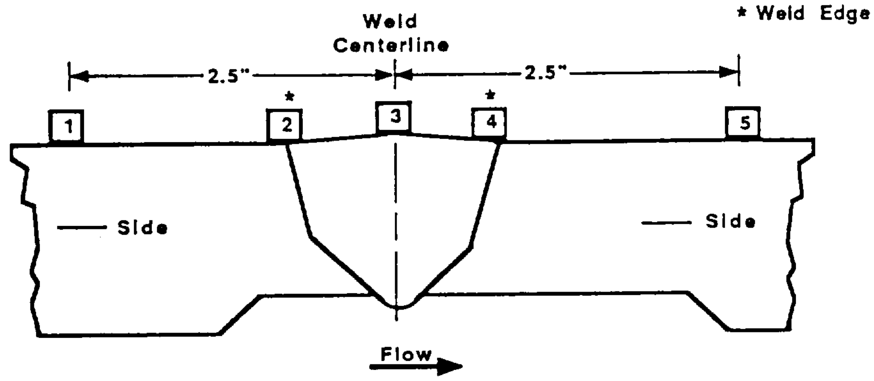
| TVA | WALL THICKNESS PROFILE SHEET | REPORT NO: BOP-1075 |
|---|---|---|

PROJECT: SQN
UNIT: 2

WELD NO: RHRW-17-A
SYSTEM: RHRS

Record Thickness Measurements As Indicated, Including Weld Width, Edge-To-Edge At 0°

| Position | 0° | 90° | 180° | 270° |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |




CROWN HEIGHT: N/A
CROWN WIDTH: N/A

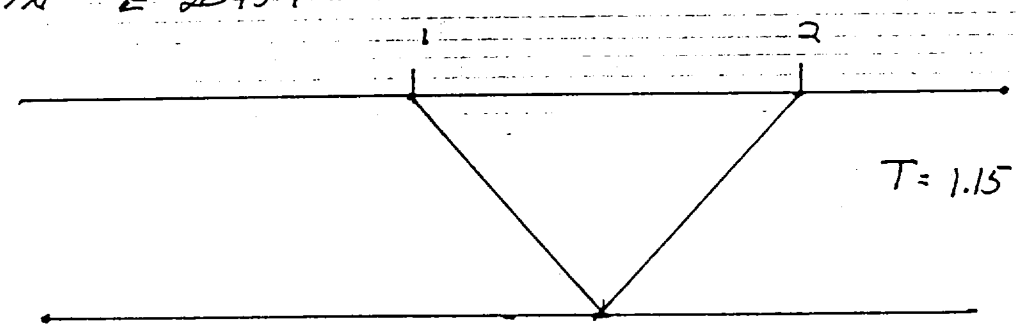
DIAMETER: N/A
WELD LENGTH: N/A

TRANSDUCER 2.25 MHz .376
1 S/N 32347
2 S/N 34068

MR 1.48
SKIP 2
T 1.15

SHELL SIDE

0° TRANSDUCER AEROTECH
.5 2.25
S/N E 20457




45° dB AT 80% 26.6
0° dB AT 80% 28

EXAMINER: [signature]
LEVEL: II
DATE: 10-12-00

REVIEWED BY: [signature]
LEVEL: III
DATE: 10/23/00

ANII: NA
DATE:
PAGE 6 OF 6

# THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

## THAT CAN BE VIEWED AT THE RECORD TITLED: BEU-15588, REV. K: SHELL AND CHANNEL DETAILS

## WITHIN THIS PACKAGE...OR, BY SEARCHING USING THE DRAWING NUMBER: BEU-15588, REV. K

**NOTE: Because of this page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.**

# THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

## THAT CAN BE VIEWED AT THE RECORD TITLED: CD-15588, REV. K: RESIDUAL HEAT EXCHANGER

## WITHIN THIS PACKAGE...OR, BY SEARCHING USING THE DRAWING NUMBER: CD-15588, REV. K

**NOTE: Because of this page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.**

# THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

## THAT CAN BE VIEWED AT THE RECORD TITLED: W-100, REV. G: STANDARD CARBON, MEDIUM & HIGH ALLOY STEEL WELD BEVEL DETAILS

## WITHIN THIS PACKAGE...OR, BY SEARCHING USING THE DRAWING NUMBER: W-100, REV. G

**NOTE: Because of this page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.**