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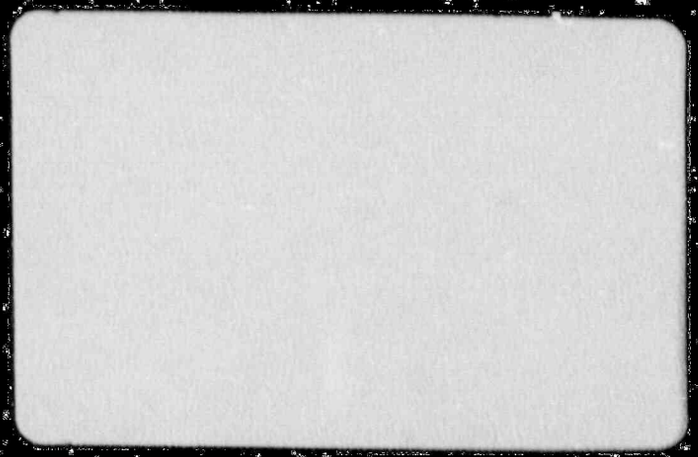

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REPORT ON

WELD OVERLAY PROCEDURE DEVELOPMENT

FOR

WATERBACKED NOZZLE-TO-SAFE END WELDS

Prepared for:

GPU Nuclear Corporation

Prepared by:

NUTECH Engineers, Inc.

Prepared by:

Bhaven Chakravarti

B. Chakravarti, PhD.
Project Engineer

Reviewed by:

J. A. Brown, P.E.
Staff Engineer

Approved by:

Carl H. Froehlich

C. H. Froehlich, P.E.
Engineering Manager

Issued by:

John R. Sheffield

J. R. Sheffield, P.E.
Project Manager

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B. Chakravarti/Staff Consultant — BC
NAME/TITLE — INITIALS

C. J. Johns/Consultant I — CJJ
NAME/TITLE — INITIALS

J. A. Brown/Staff Engineer — JB
NAME/TITLE — INITIALS

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1.0 INTRODUCTION

Recent experience has shown that reactor pressure vessel nozzle-to-safe end welds are not immune to intergranular stress corrosion cracking (IGSCC) in Boiling Water Reactor (BWR) recirculation systems. Cracks have been observed in Inconel 182 butt welds and nozzle butter welds in nozzle-to-safe end (N-to-SE) weldments. In an increasing number of instances, these cracks have proceeded into the low alloy steel (LAS) SA 508 Class 2 nozzle material, classified as P3 under Section IX of the ASME Code. Weld overlay represents an economically viable technique available to arrest the crack growth in such situations and re-establish the structural integrity of the weldment. Such overlays require special weld metal deposition techniques because the nozzle is a LAS hardenable material. The American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (BPVC) Code requirements for welding on such material are to preheat to 300°F min. and postweld heat treat (PWHT) at 1250°F min. to temper the hardened heat-affected zone (HAZ) created by welding.

However, the ASME Code Section XI recognizes that under certain circumstances the full PWHT is impractical and allows the use of the Half-Bead Welding Technique deposited with the Shielded Metal Arc Welding (SMAW) process. In this technique, the heat from the second weld layer tempers the HAZ of the first layer weld beads. To assure such tempering, half of the first layer bead thickness is removed by grinding or machining before the second and subsequent layers are deposited. Finally, a low temperature (450°F-550°F) postweld heating is used to drive potential hydrogen away from the weld.

Recently, the ASME Code has approved Code Case N-432 which allows the use of a machine Gas Tungsten Arc Welding (GTAW) temper bead technique. Here, the same tempering effect is developed by using controlled GTAW welding parameters and without removing one-half of the first layer bead thickness. In this case also, the full PWHT requirements of the P-3 material is substituted with the low temperature postweld heating. The Code Case N-432 is for repair of a cavity created by excavation of a defect found in a carbon or low alloy steel pressure boundary material. Presently there is no guidance available in the Code on the requirements for qualifying structural weld overlays. The general practice has been to qualify these weld procedures by performing a groove weld. Thus, structural weld overlays over nozzle to safe end welds have been qualified by taking guidance from this Code Case N-432 with regard to the welding requirements, preheat and postweld heat treatment, and approved by testing the base material, weld and heat affected zones of a groove welded test piece. Thus, most nozzle-to-safe end weld overlay repair procedures to date require 300°F min. preheat, the maintenance of this 300°F temperature during welding and until the start of postweld heating, and a postweld heating at 450-550°F for 2 hours minimum to bake out the hydrogen from the weld (Ref. 2-3). The postweld heating is performed after three to four layers of temper bead weld metal have been deposited. Thereafter, the weld is completed without any preheat or postweld heating. Such a weld overlay WPS is referred to as base on the Code Case N-432 or dry preheat WPS.

The repair methods described above present several economic disadvantages. Preheating the reactor nozzle for depositing the overlay weld and performing the hydrogen bake out of the overlay requires the water level in the reactor to be lowered below the nozzle area until the temper bead

layers are complete. To accomplish this, requires either removal of the reactor fuel or at least draining of the reactor vessel's outer annulus depending on the location of the affected nozzle. These steps can significantly extend an outage and the cost for performing overlay repairs. It would be very desirable to be able to perform nozzle-to-safe end weld overlay repairs without having to drain the reactor or it's outer annulus, that is, perform the welding under a waterbacked condition. However, with the water-backing it is extremely difficult to develop and maintain sufficient preheat or perform the postweld heating of the weld using standard resistance heating pads. Also, as shown in Figure 1 for the Reactor Recirculation System discharge nozzles at the Oyster Creek Nuclear Generating Station, very limited space can exist within a nozzle-to-safe end bioshield opening making it impossible to place heating pads and machine GTAW welding equipment simultaneously around the weldment.

This report describes the welding procedure development for nozzle-to-safe end weld overlays <u>without</u> the benefit of preheating or postheating. It is assumed the reactor will not be drained, thus the nozzles will be full of water. Tempering of the base metal heat-affected zone must be performed through control of the welding parameters used in the first few temper bead layers. The objectives of this development effort were to perform such welding without any base metal cracking while meeting the ASME Code minimum required base metal properties in the heat-affected zone.

2.0 EXPERIMENTAL PROCEDURE

Materials

In the experimental program to develop the welding procedure specifications, several materials were procured. In the initial stages of the program, a common grade thick-wall carbon steel pipe was used. The objective was to use this pipe in the initial assessment of the effectiveness of waterbacked welding on a carbon steel pipe. The exact grade of this material is of no consequence in this case.

In addition, two SA508 Class 2 nozzles were procured from Babcock and Wilcox (B&W). These nozzles came from the same heat and had identical quench and temper heat treatment, and fabrication simulated post weld heat treatment. One of these nozzles had a stainless steel safe end welded to it. The nozzle without the safe end was used as a "practice" nozzle to determine optimum welding parameters. The nozzle with the safe end was used for the mock-up assembly in the final qualification of the welding procedures.

To fabricate the nozzle-to-safe end assembly, the nozzle weld end was buttered with Inconel 182 and stress relieved at 1110°F - 1150°F for one hour. After a butt weld end preparation was machined on the heat-treated nozzle, a SA376, TP304 stainless steel safe end was welded to it using Inconel 182 filler material. All of this work was performed by B&W at their facilities. Figure 2a shows the nozzle-to-safe end mock-up assembly. All material test reports giving ladle and check analyses, physical properties as tested and heat treatments are presented in Appendix C. The results show that the nozzle meet the material property requirements of ASME Code Section III.

Procedure Development

The development of the nozzle-to-safe end weld overlay procedure was performed in three stages.

Stage I

In this stage, the common grade thick-walled carbon steel pipe was used to compare the results of an overlaid pipe with the previously qualified dry preheated procedure and the proposed waterbacked procedure. The effort in this stage was purely exploratory to evaluate the effects of various welding parameters. A portion of this pipe was overlaid using the dry procedure while another portion was welded with waterbacking. The waterbacked welding was performed using different welding parameters on different portions of the pipe. Several test coupons were obtained on which face and side bend tests were performed. The results of the face and side bend tests were used to prepare a set of welding parameters, together with their variations, to be used as starting parameters for the second stage of the procedure development.

Stage II

Experiments were performed using the double down technique on the "practice" nozzle. This nozzle was first welded dry with preheat and then welded with waterbacking. In addition to the weld overlay, several groove welds deposited with different parameters on backing thickness of 1/2 inch were used to provide comparison between the dry and waterbacked welding procedures. Groove welds have been previously used to qualify weld overlay for nozzle-to-safe end welds (Refs. 2 and 3). These experiments were evaluated using face and side bends, microhardness

readings, charpy tests and microstructures when required. The data obtained provided an intermediate stage validation of the proposed welding parameters.

Stage III

The nozzle-to-safe end assembly was machined, as shown in Figure 3, so that two (2) groove welds and the overlay weld could be made. Acid etches were used to establish the butt weld interfaces of the nozzle and safe end. The interfaces were permanently punch marked so that the weld overlay could be properly positioned. The machined surfaces, especially the grooves, were liquid-penetrant examined and found to be indication-free (Figure 2b). The nozzle-to-safe end assembly was then mounted onto a vertical frame so that the nozzle axis was horizontal. This represents the 5G position, which is the expected orientation in BWR plants. A modified GoldTrack II head was used to perform the welding utilizing the double down technique. The GoldTrack II welding system had remote video capability which was used to perform the weld overlays. All groove and overlay welding was performed under NUTECH's direction at GAPCO's Diamond Springs facility.

It was planned to compare the differences between the dry preheated welding procedure based on the Code Case N-432 and the waterbacked welding procedure. Therefore, one side of the nozzle was welded using the dry welding procedure specification (WPS) and the other side with a waterbacked WPS. Since the heat sink effect of the waterbacked condition can be so significantly different for different backing thicknesses, two such welds with different backing thicknesses were tested. One backing thickness was 1/2 inch and the other 1-1/4 inches, as measured from the bottom of the groove to the inner surface of the nozzle which was in contact water (see Figure 3). These backing thicknesses represent the range of nozzle thicknesses typically encountered in BWR units.

First, welds using the dry preheated WPS were used to deposit an overlay (1/8 inch minimum thickness) over the nozzle-to-safe end weld. The 1/2 inch groove and the 1-1/4 inch groove were then welded. The first three (3) layers, which represent the temperbead deposits, were made to cover the groove bottom and the sidewalls. Welding was done while maintaining 300°F min. preheat. The resistance heater pads were installed on the ID surface of the nozzle. Circumferentially placed thermocouples measured the temperature and provided input for the thermostatic control (Figure 4a). Once all the welding with preheat was complete, the nozzle was covered with insulation (Figure 4b) and the temperature raised to approximately 500°F and maintained for two hours to perform the bake-out. After bake-out, the nozzle was left to cool.

The mockup nozzle welding set-up was then modified to perform the waterbacked welding. The two (2) nozzle ends were covered by welding preformed plates and a water inlet fitting was attached on one end. A pipe connected to the inlet fitting on the inside of the nozzle transported the water to the opposite side and created circulation of the enclosed volume. The water exited through a vent port attached at the top most point to avoid forming a vapor blanket (see Figure 5). Since the water temperature was around 67-68°F, below the 80°F minimum setup for the procedure, a water heating element was also installed in the nozzle assembly, close to the discharge point of the inlet water (Figure 5). The bulk water temperature was measured by a thermometer permanently attached to the opposite side (see Figure 5).

Water flow was maintained at approximately 0.5 GPM, which allowed the bulk water temperature to be around 75°F. Due to the waterbacked condition, temperature uniformity was

excellent around the circumference, except for approximately two inches of the circumference at the 12 o'clock position, where it was about 5-7°F warmer.

Using the WPS for the waterbacked condition, the overlay, and the groove welds with 1/2 inch thick backing and 1-1/4 inch thick backing were completed. This procedure requires autogeneously remelting of the first layer end beads to temper the weld toe HAZ. No problems were encountered in making these welds. The sidewall first bead is also autogeneously remelted before the second layer is deposited. Figure 6 shows the nozzle after three layers of temperbeads for both the dry preheated and waterbacked techniques for overlay and groove welds were completed. After this point, the rest of the groove on both sides of the nozzle were filled using more standard welding parameters for making Inconel welds. Typically, it used higher heat input with oscillation and higher deposit rates. A synchronous pulse mode was used to assure proper side wall tie-in.

With the welding completed, the nozzle was cut up per the sample layout plans of Figures 7 and 9. The layout plan followed the intent of the ASME Section IX rules for taking samples for tension, side bends and charpy tests. Since two WPS's were qualified using the same groove, tension test samples at precisely the 0° and 180° azimuths were not possible to take; however, tension test samples close to 0° and 180° azimuths were taken. Similarly, side bend and charpy blanks were taken at 45° and 135° azimuths from one side only, and not both sides. To assure the test results, dual sets of samples were taken. Samples for examining microstructures and microhardness were also taken. The positions of test samples machined from the blanks are shown in Figures 8 and 10.

3.0 RESULTS AND DISCUSSION

The Welding Procedure Specifications (WPSs) together with the supporting Procedure Qualification Records (PQRs) for the dry preheated and the waterbacked cases are presented in Appendices A and B, respectively. There are three (3) supporting PQRs for each WPS, one for the weld overlay and one each from the two groove welds. The groove welds qualify the procedure for welding on different thicknesses for each case. The hardness profile of the heat-affected zone (HAZ) for each groove weld and overlay, together with the HAZ microstructure are presented with each WPS.

The results documented in the PQRs from the dry preheated WPS meet the minimum requirements of the ASME Section IX and exceed those of ASME Section III (50 ft. lbs and 35 mil lateral expansion). For the welding parameters selected, the HAZ shows properties only slightly degraded from the base material properties. The hardness and microstructure correlate well, showing no hard untempered martensitic structures. The welding parameters changed little, if any, going from the overlay to the groove welds. Even the groove weld with 1/2 inch backing was done with only minor variation. Generally, due to sidewall interactions with the welding arc (a characteristic of groove welding only), arc voltage is reduced to weld at the groove bottom. This effect is small for the preheated case.

The results documented in the PQRs from the waterbacked WPS also meet the requirements of ASME Section IX and material property requirements of Section III. The hardness measurements and microstructures show that no hard, untempered martensitic areas remain. Although at the very top, near the weld lip area, some hard ar[illegible] were noticed. These areas developed because of the geometric effect of the groove and the manner in which the groove is

filled with higher heat input passes. They are a groove artifact and is of no consequence to overlay welding. The welding parameters are significantly different for the 1/2 inch and 1-1/4 inch thick backing, due to the substantial heat sink difference between the two cases. The thickness of the backing material becomes the overriding parameter for this procedure. The problem of groove geometry on arc voltage further complicates the welding. Thus, substantial modifications to the welding parameters are needed to successfully weld in each case.

For the waterbacked WPS case, the base metal charpy test results from various positions in the nozzle show some variance. This is possibly due to the nozzle having different forging ratios with regard to position during manufacture. However, all charpy test results met the ASME Code required, 50 ft. lbs. energy level and 35 mils lateral expansion at the RTNDT for the forging (40°F). Tensile test samples from each of the weldments met the property requirements and all side bend samples passed with no opening in the heat-affected zone. Some opening of the base metal defect structures (removed from the HAZ) were seen in the side bend samples. These results are impressive considering the fact that the microstructure near the nozzle ID surface show substantial porosity and defects.

4.0 CONCLUSIONS

1. Two (2) welding procedure specifications (WPSs) were qualified in accordance with requirements of ASME Section IX for performing double sided machine GTAW weld overlays on low alloy steel nozzle-to-safe end welds. The SA508, Class 2, nozzle material was given a full cycle of fabrication-simulated heat treatment and was joined with Inconel 182 electrodes to a SA376, Type 304 stainless steel safe end. Each WPS is supported by three (3) separate PQRs; one for the overlay, one for a 1-1/4 inch backing thickness, and one for a 1/2 inch backing thickness of the nozzle. In each case, it is clear that the welding can be successfully performed meeting all the requirements of ASME Code Sections IX and III. The procedures produce repeatable and consistent results.

2. The first WPS, similar to Code Case N-432 welding procedures developed by others, utilizes preheat before and maintained during welding and a low temperature postweld bake-out to drive the excess hydrogen from the weld. To perform the preheat and postheat, the reactor nozzle has to be dry, requiring that the reactor water be drained below this level. This requires the fuel to be removed from the core or draining of the reactor vessel's outer annulus, extending both the time for performing the overlay repair and the overall outage duration.

   The preheat WPS produces a HAZ, with properties only slightly reduced from the base metal properties, easily meeting and exceeding the ASME Code Section III material property requirements.

3. The waterbacked overlay WPS avoids reactor drain-down problems by performing the welding without the need for any preheat or postweld heat treatment. The water temperature is limited to 80°F minimum.

   The waterbacked WPS meets the material requirements of ASME Code Section III in that the HAZ meets 50 ft. lbs., 35 mils lateral expansion when tested at 40°F, the RTNDT of the nozzle. These results are particularly impressive as the base metal showed excessive variations in properties due to porosity and other defects. The microstructures showed no large untempered martensitic areas; instead, an extremely fine grained ferrite-carbide aggregate appears to form.

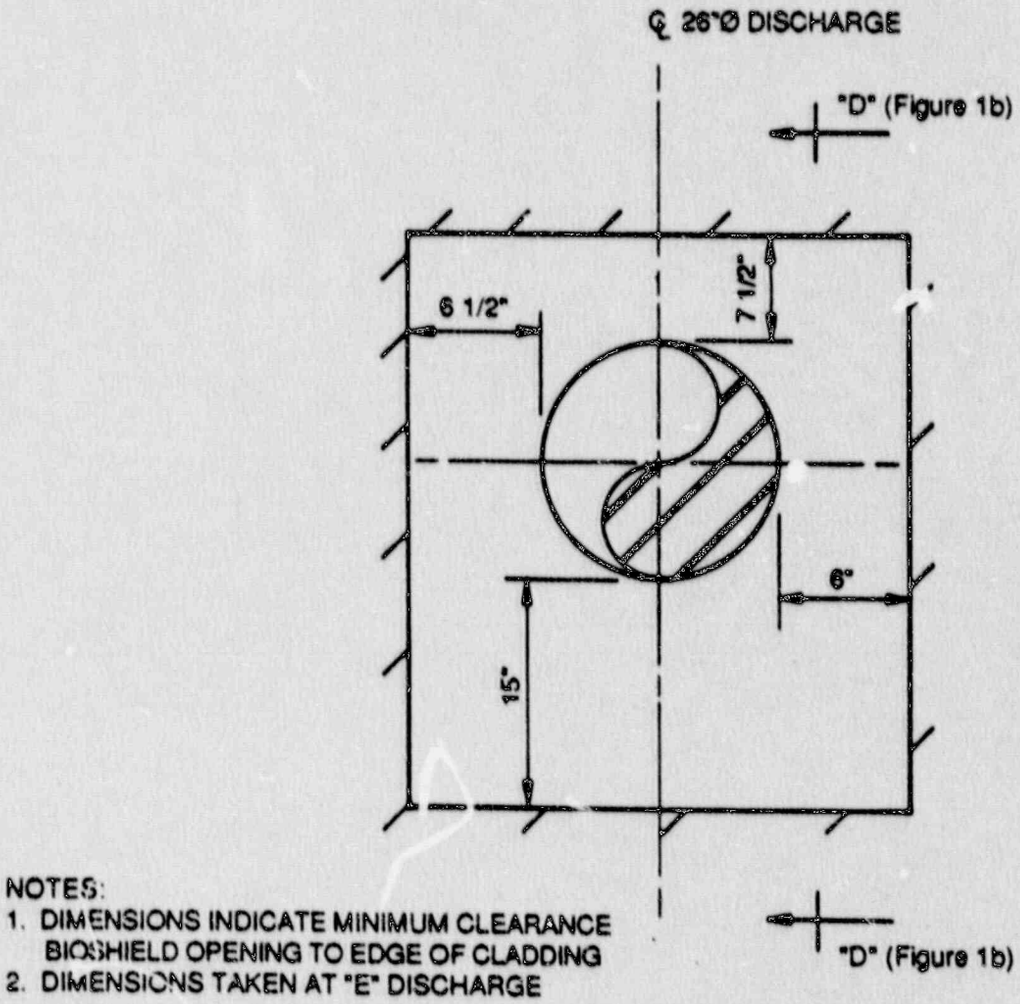
4. Presently, the ASME Code provides no guidance for qualifying structural overlays. To date, most of the nozzle-to-safe end overlay procedures have used the groove weld to qualify the WPS. While the configuration of the groove has little or no effect on the preheated WPS, the same cannot be said for the waterbacked WPS. The parameters developed for the waterbacked WPS need to be modified to successfully complete the groove weld. Thus, the three (3) separate PQRs qualified for the waterbacked WPS have significantly different welding parameters and cover the range of thicknesses of nozzles present in typical BWR units.

REFERENCES

1. Repair Welding of Heavy-Section Steel Components in LWR's, Volume 1, Summary Report, EPRI Report NP-3614, July 1984, prepared by Babcock & Wilcox Co.

2. Contingency Plan for Temper Bead Weld Overlay of Safe-End To Nozzle Welds, prepared by Georgia Power Company and Structural Integrity Associates, presented to NRC, December 13, 1985.

3. Field Application of a Non-Postweld Heat Treat Weld Overlay to an Alloy Steel Reactor Pressure Vessel Nozzle, by Hoffman, J. R.; Mullins, L. E.; Willens, K. R.; and Darby, K.; presented at EPRI Seminar on Repair Welding Alternative for Nuclear Power Plant Components, Charlotte, NC; March 11, 1987.



ELEVATION - DISCHARGE

Figure 1(a): OYSTER CREEK NOZZLE FRONT VIEW

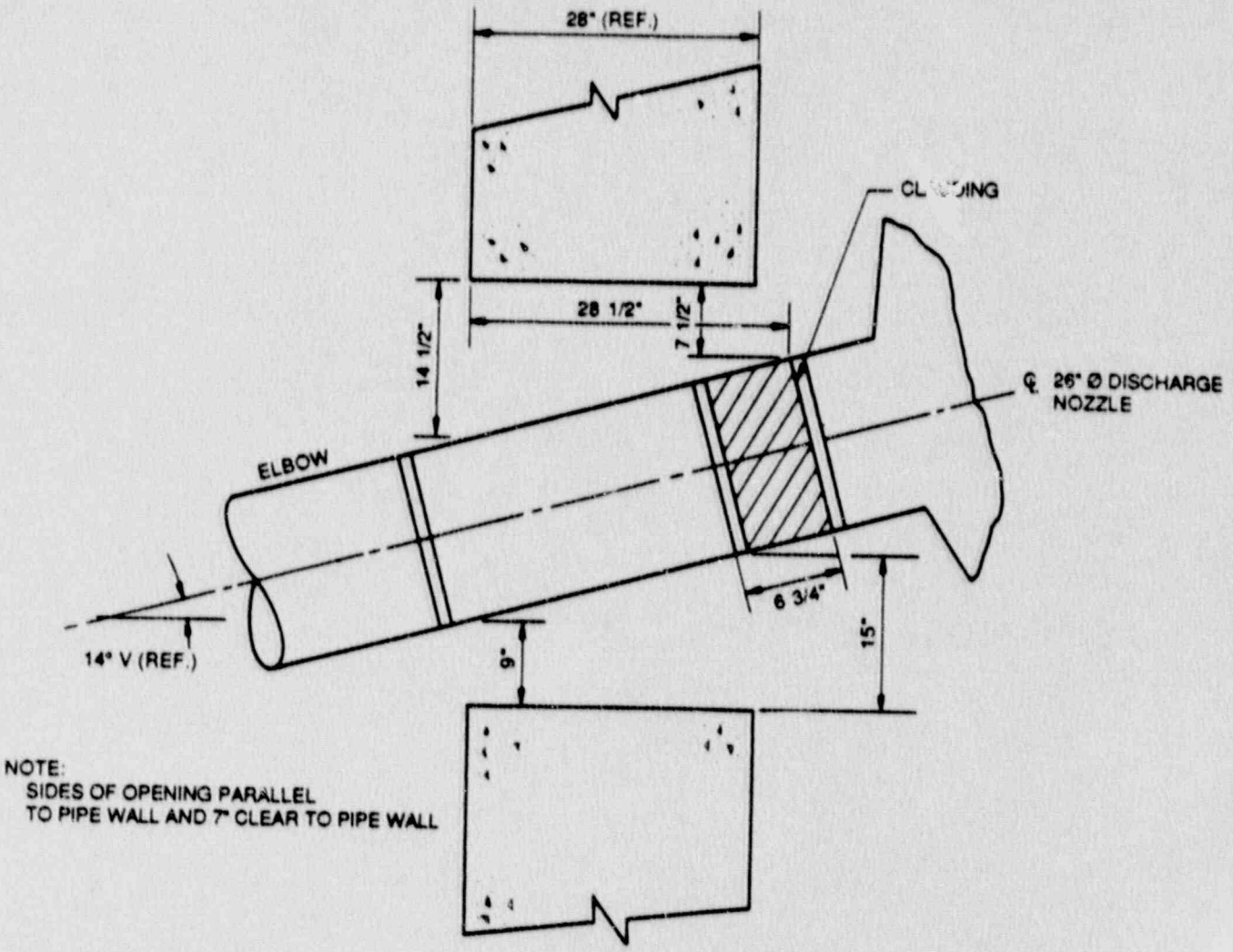


Figure 1(b): OYSTER CREEK DISCHARGE NOZZLE ORIENTATION

FIGURE 2(a): AS RECEIVED MOCKUP NOZZLE FROM B&W. STAINLESS TP304 STEEL SAFE END WELDED WITH INCONEL 182. BUTT WELD AREA SEEN GROOVED.

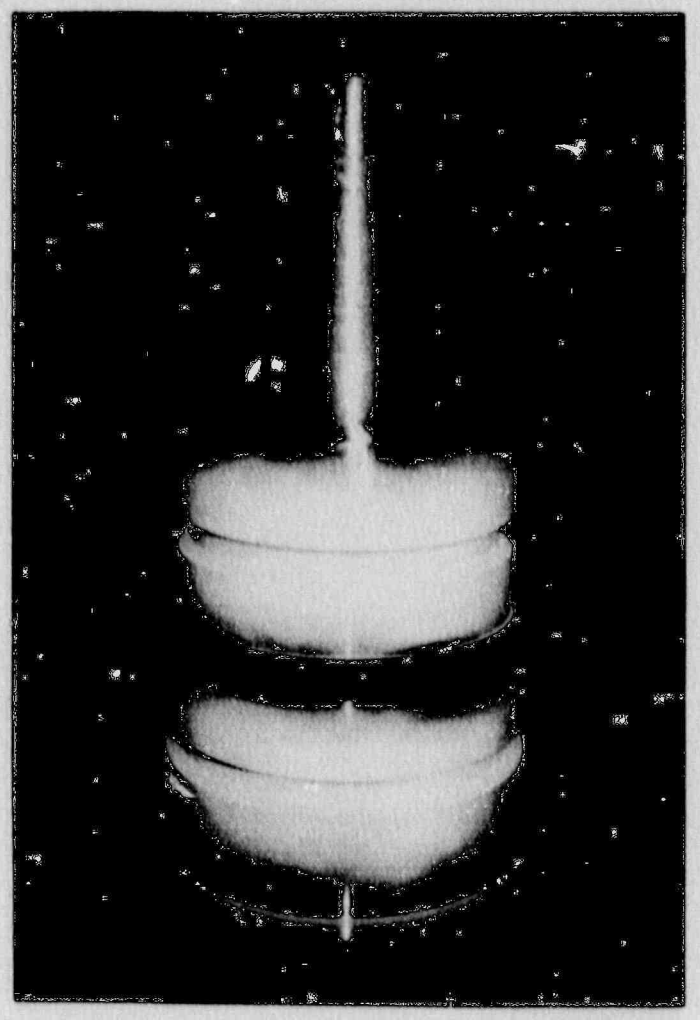


FIGURE 2(b): PHOTOGRAPH SHOWS NOZZLE-SAFE END ASSEMBLY AFTER MACHINING OF BOTH GROOVES AND DYE CHECKING.

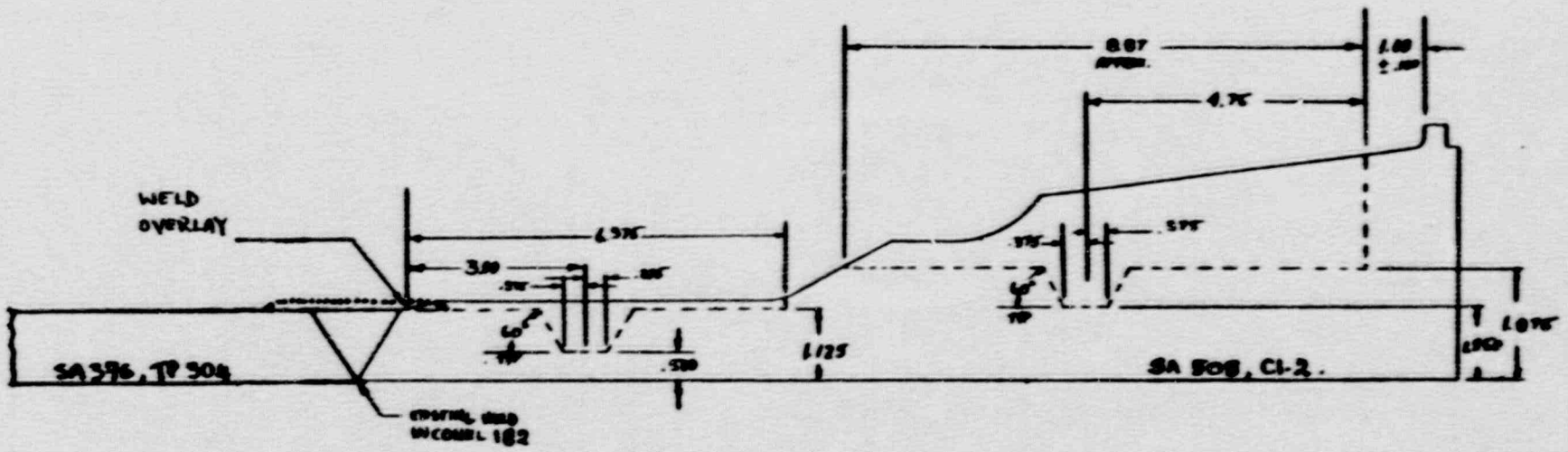


FIGURE 3: CROSS-SECTION OF NOZZLE-SAFE END, SHOWING AS-RECEIVED AND FINAL MACHINED (NOTTED LINES) DIMENSIONS.

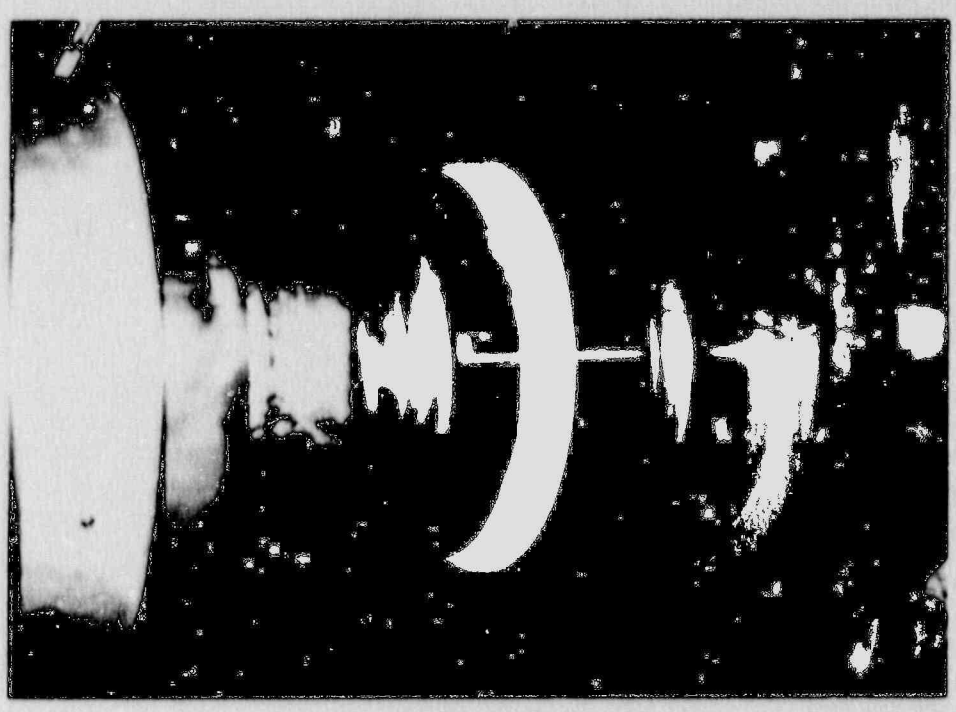


FIGURE 4(a): MOCKUP NOZZLE WITH COMPLETED TEMPER BEADS IN OVERLAY AND GROOVES FOR PREHEATED CASE. CIRCUMFERENTIALLY PLACED THERMOCOUPLES MEASURED AND CONTROLLED TEMPERATURE.

FIGURE 4(b): MOCKUP NOZZLE SHOWN WRAPPED WITH INSULATION FOR POST WELD HYDROGEN BAKE OUT. NOTICE HEATING COILS PLACED ON ID SURFACE.

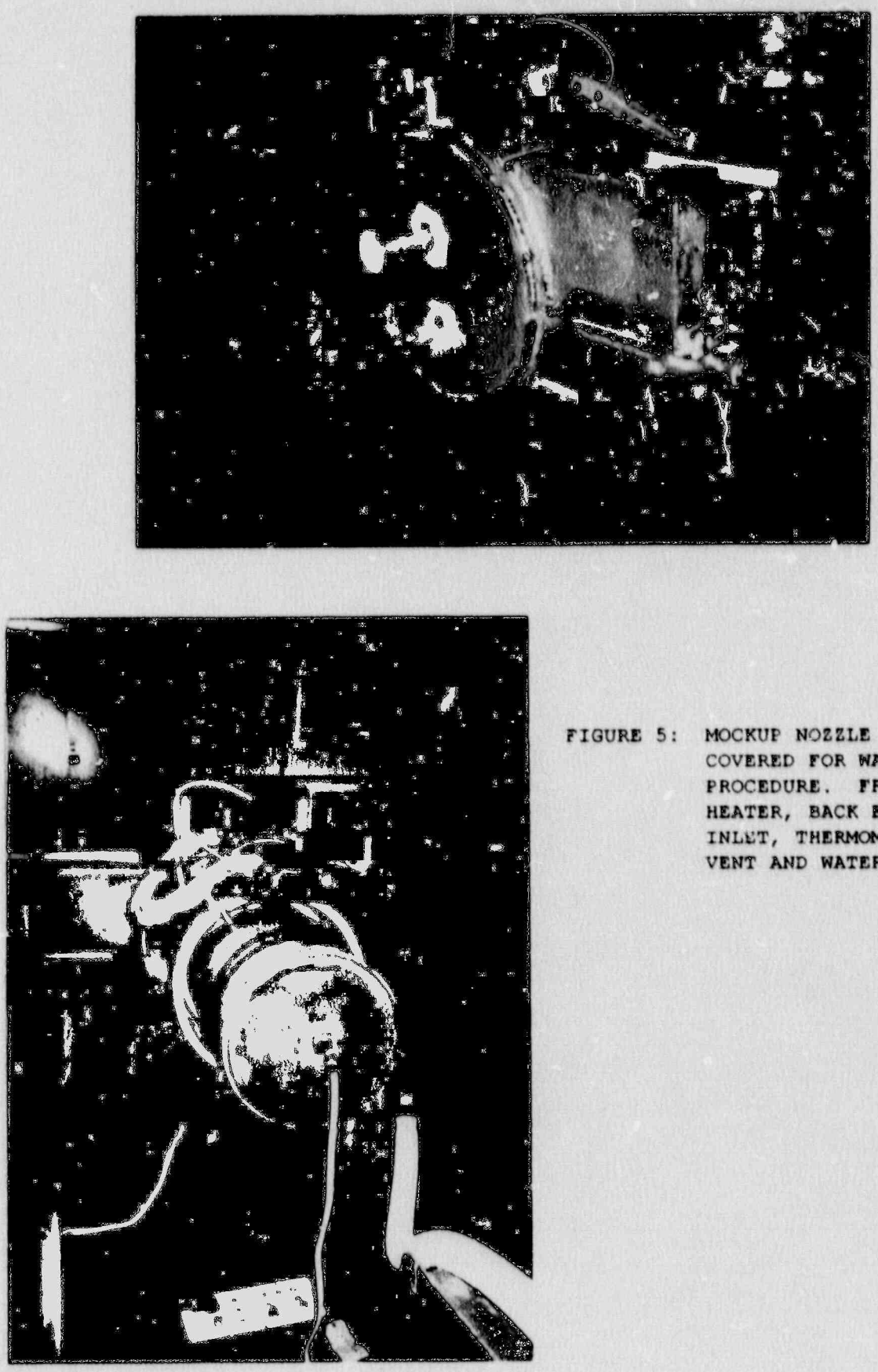


FIGURE 5: MOCKUP NOZZLE SHOWS ENDS COVERED FOR WATERBACKED PROCEDURE. FRONT END SHOWS HEATER, BACK END SHOWS WATER INLET, THERMOMETER, TOP VENT AND WATER OUTLET.

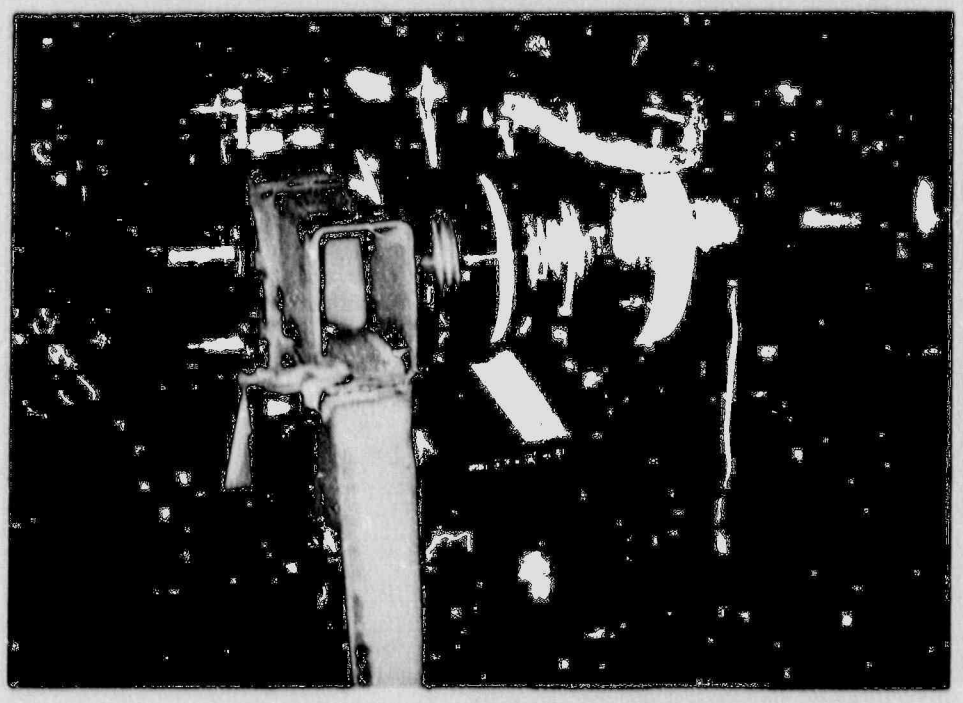


FIGURE 6: MOCKUP NOZZLE ON COMPLETION OF ALL TEMPER BEAD WELDING ON OVERLAY AND 2 GROOVE WELDS.

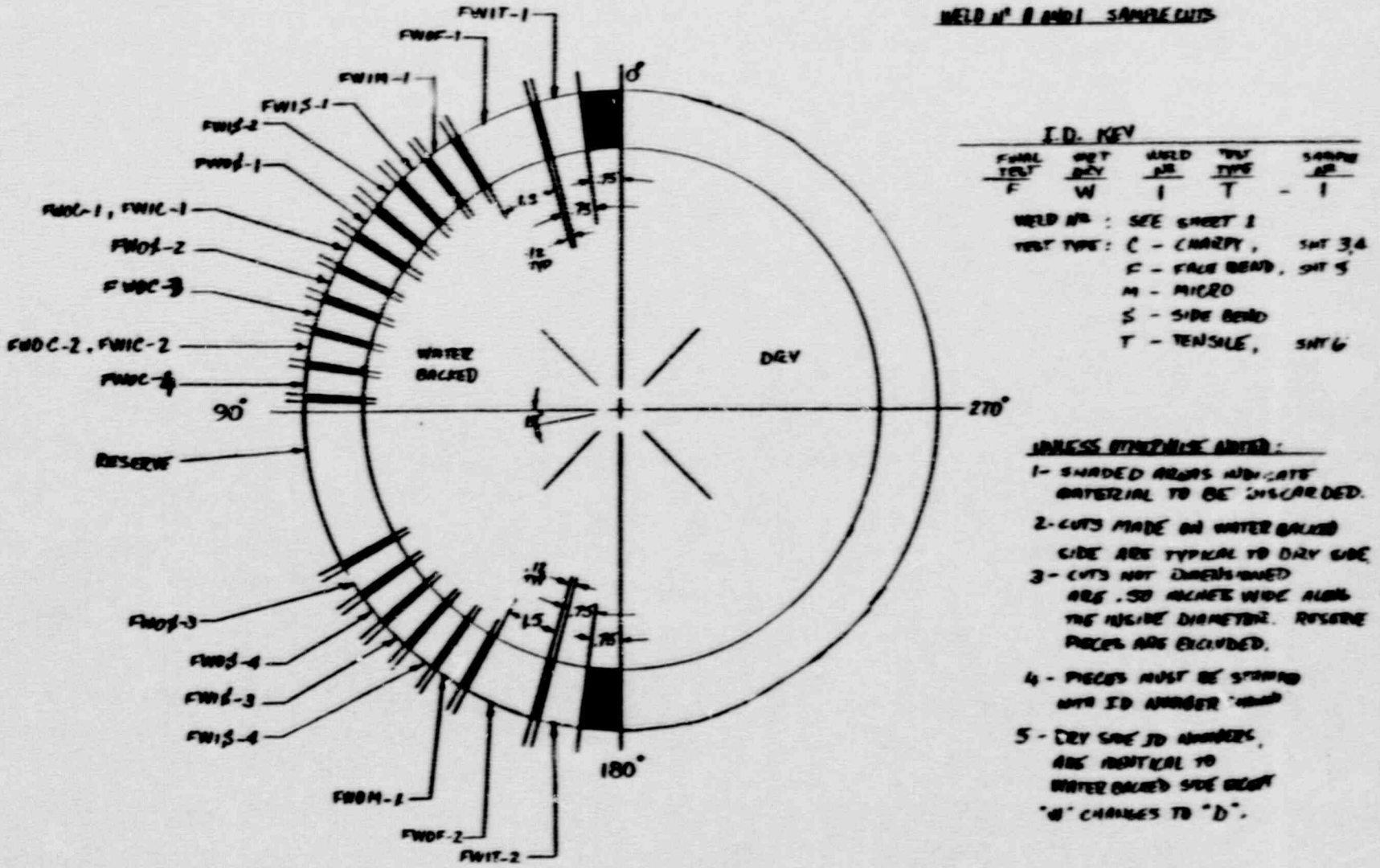


Figure 7: LAYOUT PLAN FOR REMOVING SAMPLE BLANKS FOR OVERLAY AND 1/2" THICKNESS GROOVE

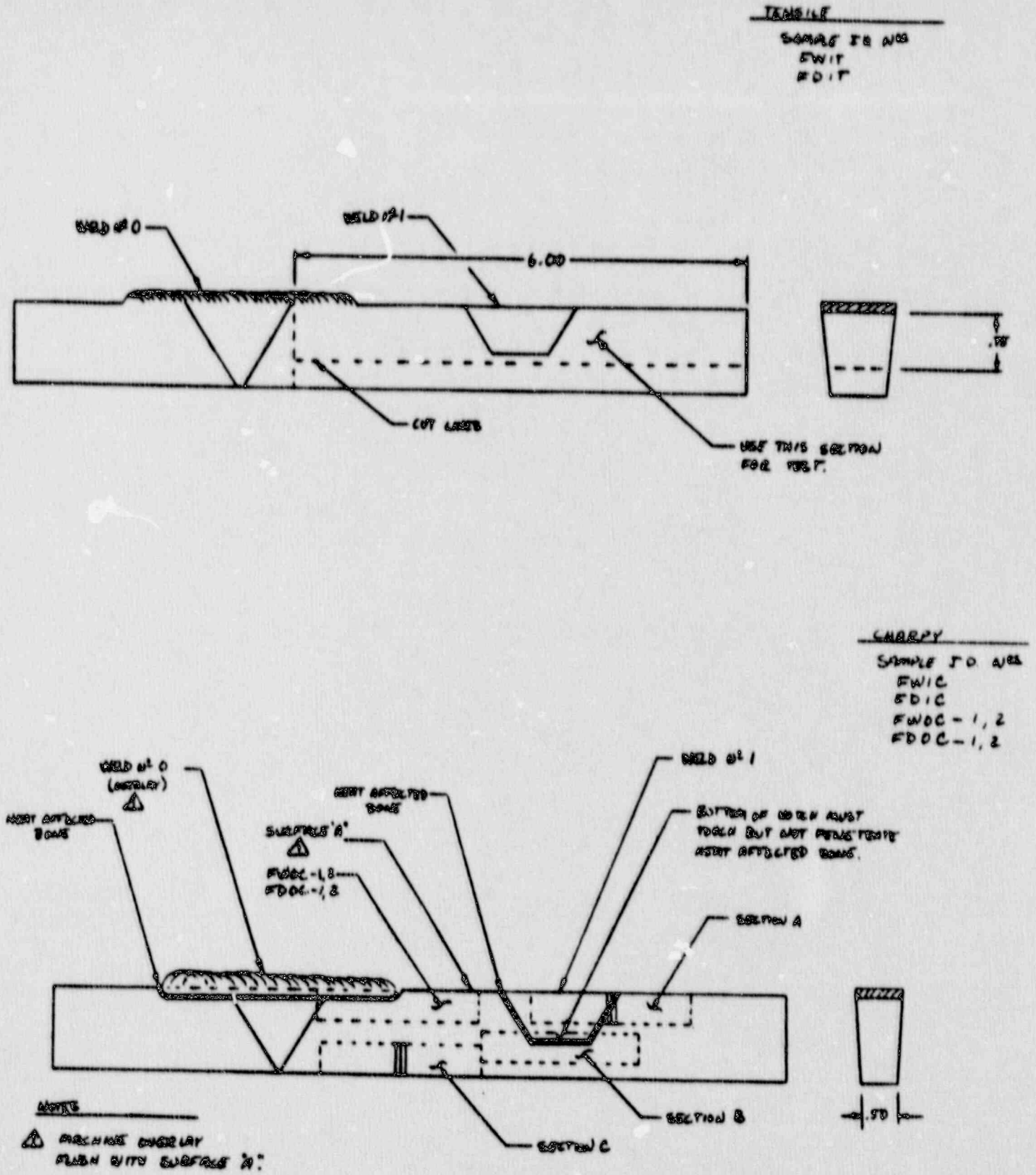


Figure 8: POSITIONS OF TENSILE AND CHARPY TEST SAMPLES FROM THE OVERLAY AND 1/2" GROOVE

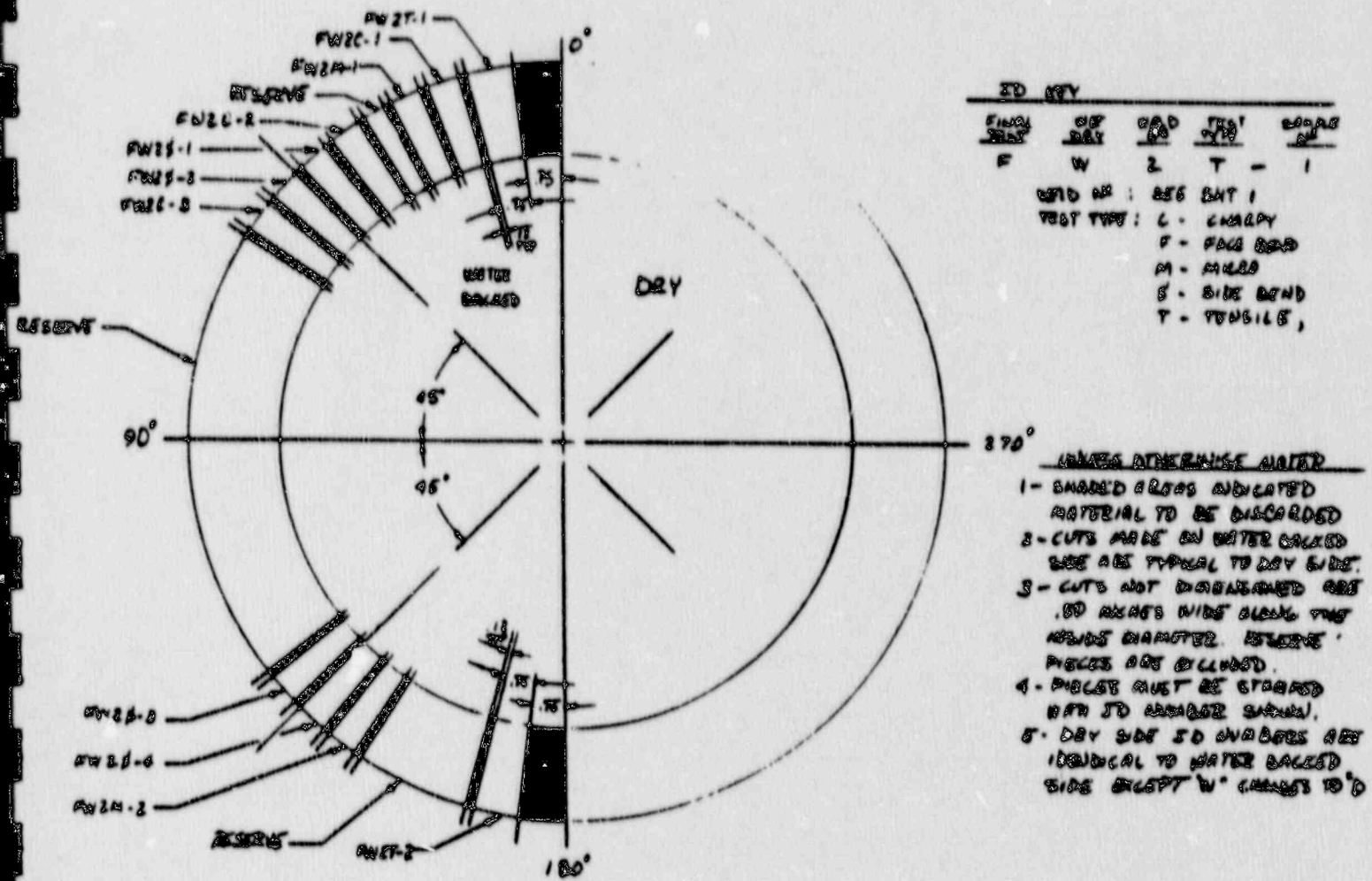
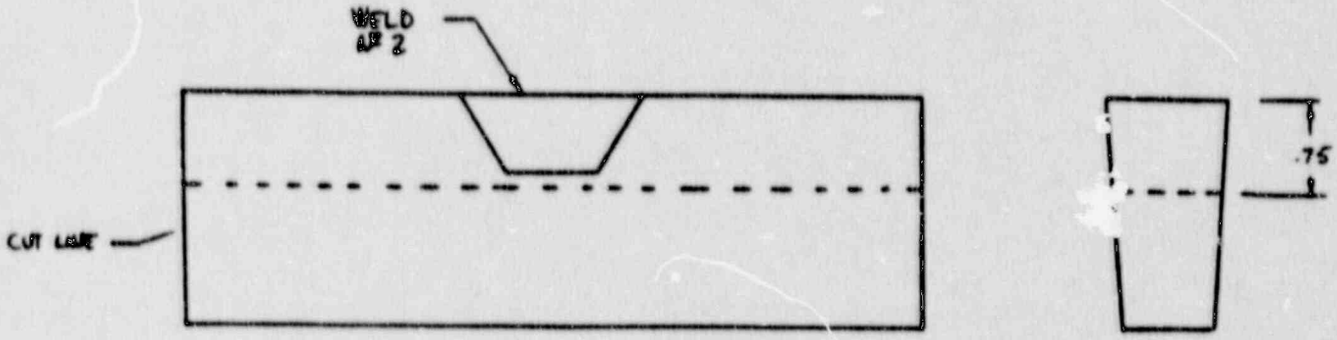


FIGURE 9: LAYOUT PLAN FOR REMOVING SAMPLE BLANKS FOR 1-1/4" THICKNESS GROOVE.

TENSILE

SAMPLE ID NO
FW2T
FD2T



NOTES

1- USE UPPER HALF OF SAMPLE FOR TEST.

CHARPY

SAMPLE I.D NO:
FW2C
FD2C

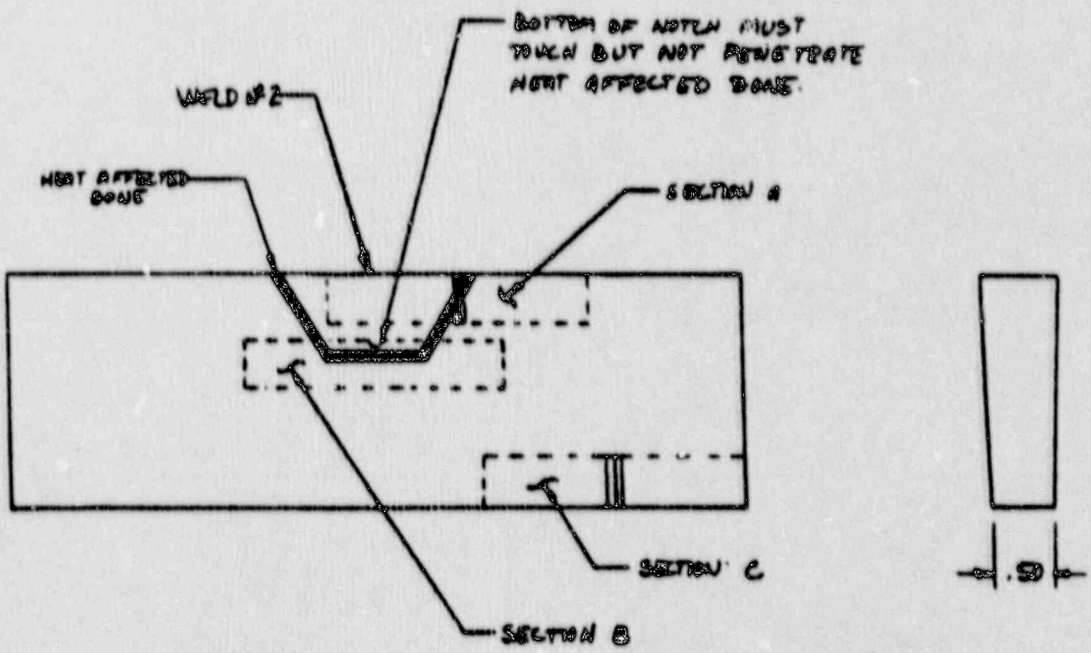


FIGURE 10: POSITIONS OF TENSILE AND CHARPY TEST SAMPLES FROM 1-1/4" THICKNESS GROOVE.

APPENDIX A

Welding Procedure Specification (WPS) and Procedure Qualification Records (PQRs) for Semi-Automated GTAW Double Down Technique, per Code Case N-432

WELDING PROCEDURE SPECIFICATION (WPS)

(SEE QW-201.1, SECTION IX, ASME BOILER AND PRESSURE VESSEL CODE)

WELDING PROCEDURE SPECIFICATION NO. WPS-3/8-T-001-NES REV. 0

SUPPORTING PQR NO.(S) PQR-3/8-T-001, 003, 004

WELDING PROCESS(ES) GTAW TYPE(S) Machine

(AUTOMATIC, MANUAL, MACHINE OR SEMI-AUTO)

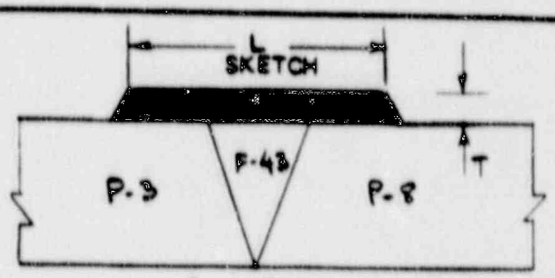
JOINTS (QW-402)

JOINT DESIGN Overlay

BACKING (YES) X (NO)

BACKING MATERIAL (TYPE) P-3, P-8, P-43 *

FULL OR PARTIAL PENETRATION N/A



L & T as req'd by design

* or equivalent weld metal (F-No.) types

*BASE METALS (QW-403)

P-NO. 8 GROUP NO. 1 TO P-NO. 3 GROUP NO. 3

OR

SPECIFICATION TYPE AND GRADE N/A

TO SPECIFICATION TYPE AND GRADE N/A

OR

CHEM. ANALYSIS AND MECH. PROP. N/A

TO CHEM. ANALYSIS AND MECH. PROP. N/A

THICKNESS RANGE:

BASE METAL THICKNESS: 1/2" and greater FILLET N/A

DEPOSITED WELD METAL: GROOVE N/A FILLET N/A

PIPE DIA. RANGE: GROOVE N/A FILLET N/A

OTHER

*FILLER METALS (QW-404)

F-NO. 43 OTHER N/A

A-NO. ER NiCr-3 OTHER N/A

SPEC. NO. (SFA) SFA 5.14

AWS NO. (CLASS) ER NiCr-3

SIZE OF FILLER METALS 0.035" Dia.

(ELECTRODE, COLD WIRE, HOT WIRE, ETC.)

ELECTRODE-FLUX (CLASS) N/A

FLUX TRADE NAME N/A

CONSUMABLE INSERT None

* EACH BASE METAL-FILLER METAL COMBINATION SHOULD BE RECORDED INDIVIDUALLY.

POSITIONS (QW-408)
POSITION(S) OF GROOVE 5G
WELDING PROGRESSION: UP ____ DOWN X
POSITION(S) OF FILLET N/A

POSTWELD HEAT TREATMENT (QW-407)
TEMPERATURE RANGE 450-550°F
TIME RANGE 2 Hrs. min. (after 3rd layer)

PREHEAT (QW-406)
PREHEAT TEMP. MIN. 300°F
INTERPASS TEMP. MAX. 450°F
PREHEAT MAINTENANCE 1/2 Hr. before welding. Hold preheat until PWHT of 3rd layer is started.

GAS (QW-408)
SHIELDING GAS(ES) Argon
PERCENT COMPOSITION (MIXTURES) 100% Welding Grade
FLOW RATE 20-45 CFH
GAS BACKING None
TRAILING SHIELDING GAS COMPOSITION None

ELECTRICAL CHARACTERISTICS (QW-409)
CURRENT AC OR DC Direct POLARITY Straight
AMPS (RANGE) 190-240 Peak * VOLTS (RANGE) 8.2-9.8 Peak and Backgr.
(AMPS AND VOLTS RANGE SHOULD BE RECORDED FOR EACH ELECTRODE SIZE, POSITION, AND THICKNESS, ETC. THIS INFORMATION MAY BE LISTED IN A TABULAR FORM SIMILAR TO THAT SHOWN BELOW.)
TUNGSTEN ELECTRODE SIZE AND TYPE 1/8" EWTh (PURE TUNGSTEN, 2% THORIATED, ETC.)
MODE OF METAL TRANSFER FOR GMAW N/A (SPRAY ARC, SHORT CIRCUITING ARC, ETC.)
ELECTRODE WIRE FEED SPEED RANGE 20-69 IPM

*100-140 Backgr.

TECHNIQUE (QW-410)
STRING OR WEAVE BEAD String for layers 1-3, weave for layers 4 and above.
ORIFICE OR GAS CUP SIZE #10, #12
INITIAL AND INTERPASS CLEANING (BRUSHING, GRINDING, ETC.) Brushing, grinding or combination with new equipment or that used on S.S. only.
METHOD OF BACK GOUGING None
OSCILLATION (YES) X (NO) ____ (FREQ.) ____ (WIDTH) 0" for 1st 3 layers
CONTACT TUBE TO WORK DISTANCE N/A 0-3/4" for remaining layers
MULTIPLE OR SINGLE PASS (PER SIDE) Multiple
MULTIPLE OR SINGLE ELECTRODES Single
TRAVEL SPEED (RANGE) 3.0 - 8.5 IPM arc speed
PEENING None (Peening of repair cavities permitted when required)
OTHER Water backed welding permitted after PWHT of 3rd layer.

WELD LAYER(S)	PROCESS	FILLER METAL CLASS	FILLER METAL DIA.	CURRENT TYPE POLAR.	CURRENT AMP RANGE BACKGR.	CURRENT AMP RANGE PEAK	VOLT RANGE BACKGR.	VOLT RANGE PEAK	TRAVEL SPEED RANGE (IPM)	OTHER
1	GTAW	ER NiCr3	0.035	Str.	100-120	190-210	8.2-9.8	9.2-9.8	7.6-8.5	13.8 Kj/in. max.
2	"	"	"	"	120-140	200-230	"	"	7.3-8.5	16.1 Kj/in. max.
3	"	"	"	"	"	200-240	"	"	5.3-8.5	17.7 Kj/in. max.
4 & remain. layers	"	"	"	"	100-140	190-230	8.2-8.6	9.4-9.6	3.0-3.5	33.9 Kj/in. max.

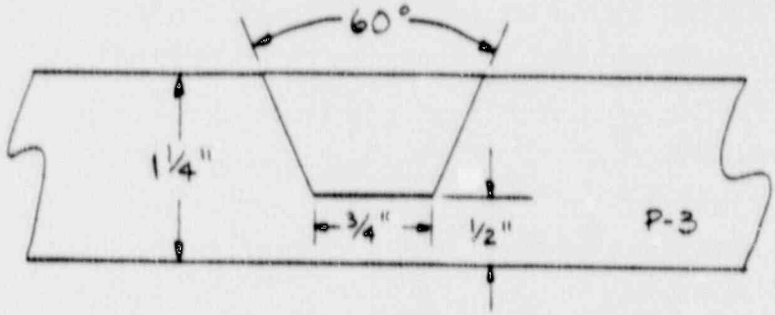
PREPARED BY: B. Chakravarti Bhowmik Chakravarti DATE 11/08/88
QUALIFICATION SUPERVISOR
REVIEWED BY: ____ DATE ____
QUALITY ASSURANCE ADMINISTRATOR

PROCEDURE QUALIFICATION RECORD (PQR)

(SEE QW-201.2, SECTION IX, ASME BOILER AND PRESSURE VESSEL CODE)
RECORD ACTUAL CONDITIONS USED TO WELD TEST COUPON.

PROCEDURE QUALIFICATION RECORD NO. PQR-3/8-T-001 DATE 12/14/88
WPS USED FOR TEST WELD WPS-3/8-T-001-NES REV. A
WELDING PROCESS(ES) GTAW
TYPES (MANUAL, AUTOMATIC, SEMI-AUTO.) Machine

JOINTS (QW-402)



GROOVE DESIGN OF TEST COUPON
(FOR COMBINATION QUALIFICATIONS, THE DEPOSITED WELD METAL THICKNESS WILL BE RECORDED FOR EACH FILLER METAL OR PROCESS USED)

BASE METALS (QW-403)
MATERIAL SPEC. SA 508
TYPE OR GRADE Class 2
P-NO. 3 GR-NO. 3
TO P-NO. N/A GR-NO. N/A
THICKNESS OF BACKING 1/2" (backing)
DIAMETER OF TEST COUPON 14" OD
OTHER See figure

FILLER METALS (QW-404)
WELD METAL ANALYSIS A-NO. ER NiCr-3
SIZE OF FILLER METAL 0.035" Dia.
FILLER METAL F-NO. 43
SFA SPECIFICATION 5.14
AWS CLASSIFICATION ER NiCr-3
OTHER

POSITION (QW-405)
POSITION OF GROOVE 5G
WELD PROGRESSION (UPHILL, DOWNHILL) Down
OTHER

PREHEAT (QW-406)
PREHEAT TEMPERATURE 300°F
INTERPASS TEMPERATURE 450°F max.
OTHER

POSTWELD HEAT TREATMENT (QW-407)
TEMPERATURE 450-550°F
TIME 2 Hrs. min. after 3rd layer
OTHER

GAS (QW-408)
TYPE OF GAS OR GASES Argon
COMPOSITION OF GAS MIXTURE 100%
OTHER 20-45 CFH Welding Grade

ELECTRICAL CHARACTERISTICS (QW-409)
CURRENT Direct
POLARITY Straight
AMPS. *200-240Peak VOLTS 9.4-9.8Peak**
TUNGSTEN ELECTRODE SIZE 1/8" EWTh
OTHER *110-140 Backgr.
**8.4-9.8 Backgr.

TECHNIQUE (QW-410)
TRAVEL SPEED 3.0 -7.6 IPM arc speed
STRING OR WEAVE BEAD String: layers 1-3*
OSCILLATION For weave beads 0-3/4"
MULTIPASS OR SINGLE PASS (PER SIDE) Multiple
SINGLE OR MULTIPLE ELECTRODES Single
OTHER Water Backed after PWHT

* Weave: layers 4 and above

DIN#83.30-02

TENSILE TEST (QW-150) PQR NO. PQR-3/8-T-001

SPECIMEN NUMBER	WIDTH	THICKNESS	AREA (in.^{2})	ULTIMATE TOTAL LOAD (lb.)	ULTIMATE UNIT STRESS (psi)	TYPE OF FAILURE & LOCATION
FDIT-1	N/A	N/A	0.197	17,950	91,100	Parent Metal
FDIT-2	N/A	N/A	0.187	16,400	88,000	Parent Metal

GUIDED BEND TESTS (QW-160)

TYPE AND FIGURE NUMBER	RESULT
180° Side Bend, 4T, Sample FDIS-1	Satisfactory
" " " FDIS-2	"
" " " FDIS-3	"
" " " FDIS-4	"

TOUGHNESS TESTS (QW-170)

SPECIMEN NUMBER	NOTCH LOCATION	NOTCH TYPE	TEST TEMP.	IMPACT VALUES	LATERAL EXP.		DROP WEIGHT	
					ENGLAND	MILS	BREAK	NO BREAK
FDIC-1	Base met.	V	40°F	178	100%	90	N/A	N/A
FDIC-2	"	"	"	151	79%	78	"	"
FDIC-1	Groove Side HAZ	"	"	112	100%	65	"	"
FDIC-2	"	"	"	111	100%	63	"	"
FDIC-1	Groove Bott. HAZ	"	"	168	100%	84	"	"
FDIC-2	"	"	"	156	100%	82	"	"

FILLET WELD TEST (QW-180)

RESULT - SATISFACTORY: YES N/A NO N/A PENETRATION INTO PARENT METAL: YES N/A NO N/A

MACRO - RESULTS N/A

OTHER TESTS

TYPE OF TEST N/A

DEPOSIT ANALYSIS N/A

OTHER N/A

WELDER'S NAME: Roy Button CLOCK NO. N/A STAMP NO. A

TESTS CONDUCTED BY: Anamet Laboratories LABORATORY TEST NO. 1188.299

WE CERTIFY THAT THE STATEMENTS IN THIS RECORD ARE CORRECT AND THAT THE TEST WELDS WERE PREPARED, WELDED AND TESTED IN ACCORDANCE WITH THE REQUIREMENTS OF SECTION IX OF THE ASME CODE.

CERTIFIED BY: Rhonda Chakrawarti DATE 12/15/88

QUALIFICATION SUPERVISOR

(DETAIL OF RECORD OF TESTS ARE ILLUSTRATIVE ONLY AND MAY BE MODIFIED TO CONFORM TO THE TYPE AND NUMBER OF TESTS REQUIRED BY THE CODE.)

DIN463-36-02

GROOVE WELD HARDNESS PROFILE
1/2" PREHEATED CASE (FDIM-1)

Sample A

Distance from Surface	HRC
Toe, .004 below surface	36, 38
Toe, .004 below surface	36 (.023" from weld)
.034, corner of lip	29, 40, 40
.034 - .074	46.5, 44, 46.5
.174	32
.274	25
.339	31

Sample B

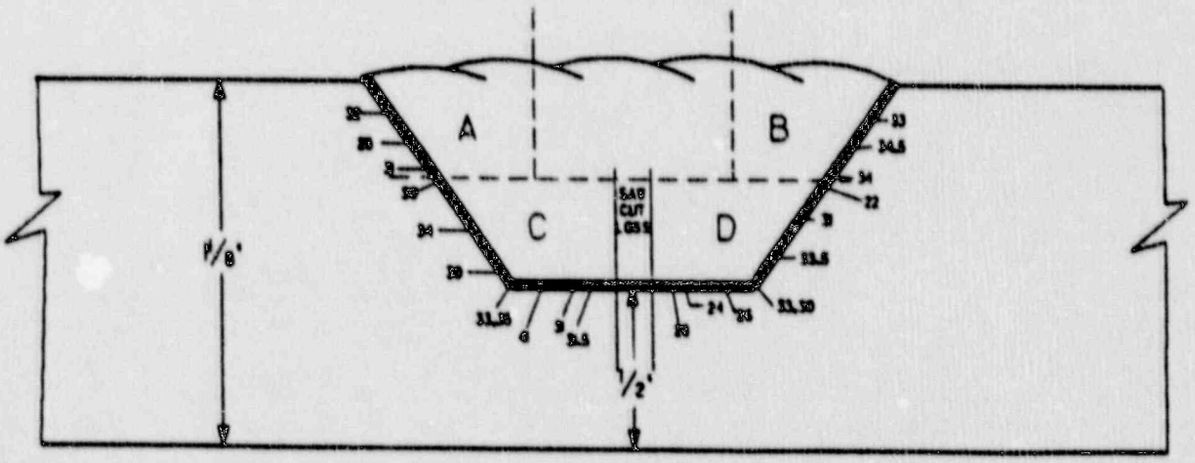
Distance from Surface	HRC
Toe, .003 below surface	36, 36
Toe, .003 below surface	31.5 (.024" from weld)
.034, under lip	33, 41
.034, large grains	34
.096	33
.196	34.5
.296	34

Sample C

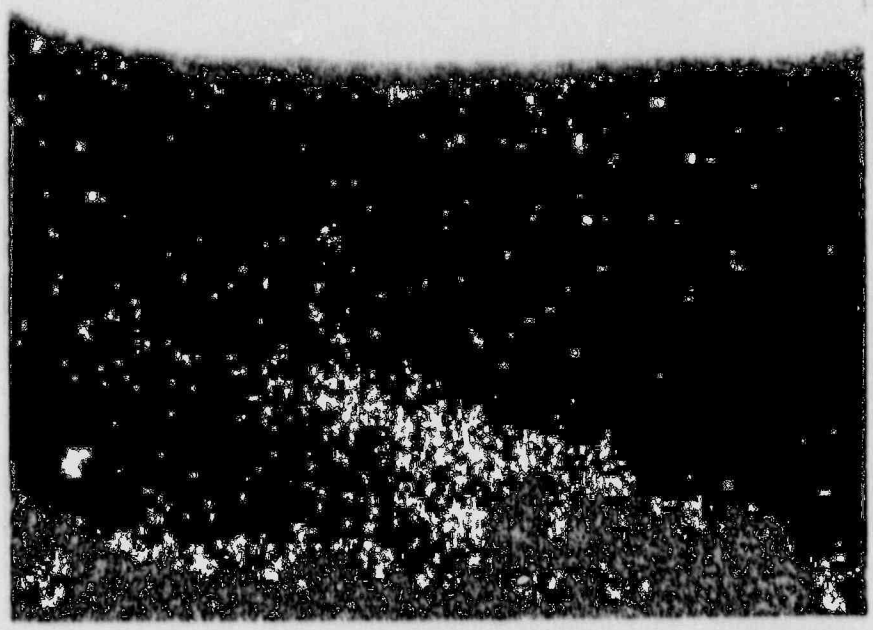
Distance from Surface	HRC
.004	30
.104	34
.204	30
.228 } at corner	33
.235 }	35
.100 from corner, Horiz.	41
.175 from corner, Horiz.	31
.190 from corner, Horiz.	31.5

Sample D

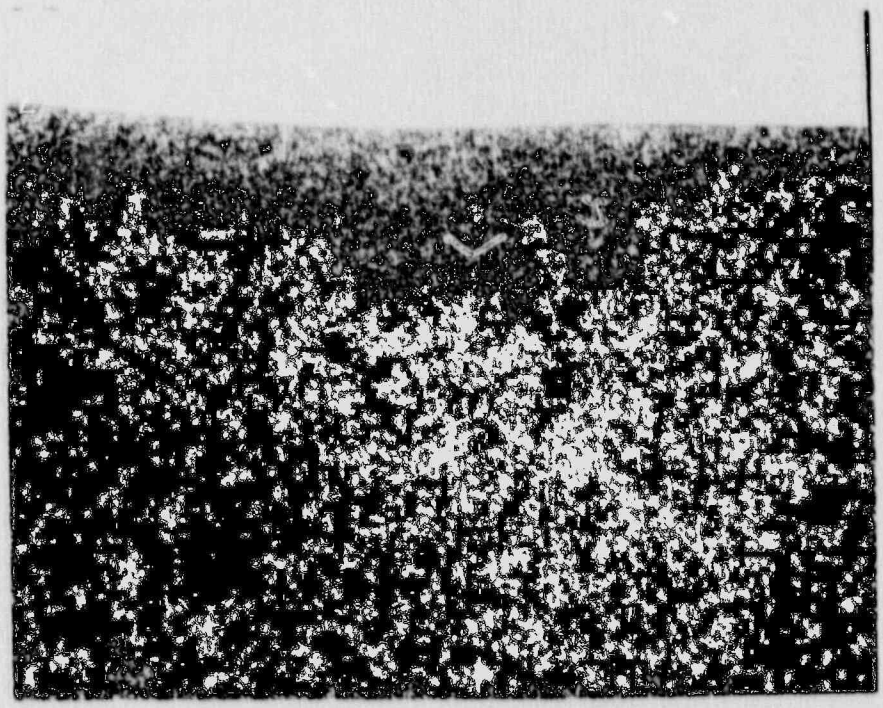
Distance from Surface	HRC
.004	22
.103	31
.203	33.5
.253, corner	33, 30
.100 from corner, Horiz.	26
.200 from corner, Horiz.	24
.202 from corner, Horiz.	28



BOTTOM HEAT AFFECTED ZONE MICROSTRUCTURES
1/2" PREHEATED



FD1M-1C
[illegible]X



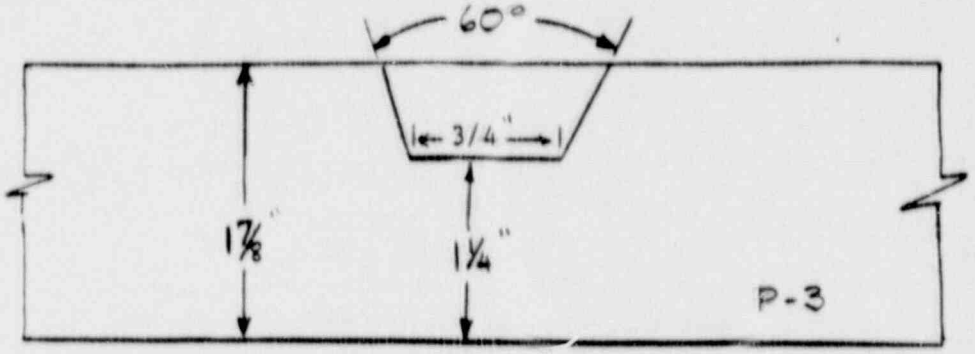
FDIM-1C
200X

PROCEDURE QUALIFICATION RECORD (PQR)

(SEE QW-201.2, SECTION IX, ASME BOILER AND PRESSURE VESSEL CODE)
RECORD ACTUAL CONDITIONS USED TO WELD TEST COUPON.

PROCEDURE QUALIFICATION RECORD NO. PQR-3/8-T-003 DATE 12/14/88
WPS USED FOR TEST WELD WPS-3/8-T-001-NES REV. A
WELDING PROCESS(ES) GTAW
TYPES (MANUAL, AUTOMATIC, SEMI-AUTO) MACHINE

JOINTS (QW-402)



GROOVE DESIGN OF TEST COUPON
(FOR COMBINATION QUALIFICATIONS, THE DEPOSITED WELD METAL THICKNESS WILL BE RECORDED FOR EACH FILLER METAL OR PROCESS WELD.)

BASE METALS (QW-403)
MATERIAL SPEC. SA 508
TYPE OR GRADE Class 2
P-NO. 3 GR-NO. 3
TO P-NO. N/A GR-NO. N/A
THICKNESS OF BACKING 1 1/4"
DIAMETER OF TEST COUPON 15 1/4" OD
OTHER See Figure

FILLER METALS (QW-404)
WELD METAL ANALYSIS A-NO. ER NiCr-3
SIZE OF FILLER METAL 0.035" Dia.
FILLER METAL F-NO. 43
SFA SPECIFICATION 5.14
AWS CLASSIFICATION ER NiCr-3
OTHER

POSITION (QW-405)
POSITION OF GROOVE 5G
WELD PROGRESSION (UPHILL, DOWNHILL) Down
OTHER

PREHEAT (QW-406)
PREHEAT TEMPERATURE 300°F
INTERPASS TEMPERATURE 450°F Max
OTHER N/A

POSTWELD HEAT TREATMENT (QW-407)
TEMPERATURE 450-550°F
TIME 2Hrs Mininum. after deposit
OTHER of layer No. 3

GAS (QW-408)
TYPE OF GAS OR GASES ARGON
COMPOSITION OF GAS MIXTURE 100% Weld Grade
OTHER 20-45 CFH

ELECTRICAL CHARACTERISTICS (QW-409)
CURRENT Direct
POLARITY Straight
AMPS.* 200-240Peak VOLTS 9.4 -9.8Peak**
TUNGSTEN ELECTRODE SIZE 1/8" EWTH.
OTHER *110-140 Backgr.
**8.4-9.8 Backgr.

TECHNIQUE (QW-410)
TRAVEL SPEED 3.0 -7.6 IPM arc speed
STRING OR WEAVE BEAD String for Layer 1-3 *
OSCILLATION 0-3/4inch for Weave Beads only.
MULTIPASS OR SINGLE PASS (PER SIDE) Multiple
SINGLE OR MULTIPLE ELECTRODES Single
OTHER Water Backed after PWHT.

*Weave for layers 4 and above

TENSILE TEST (QW-150)

POR NO. POR-3/8-T-003

SPECIMEN NUMBER	WIDTH	THICKNESS	AREA (sq. inch)	ULTIMATE TOTAL LOAD (lb.)	ULTIMATE UNIT STRESS (psi)	TYPE OF FAILURE & LOCATION
FD2T-1	N/A	N/A	0.199	16,900	84,900	Parent Metal
FD2T-2	N/A	N/A	0.192	17,000	88,500	Parent Metal

GUIDED BEND TESTS (QW-160)

TYPE AND FIGURE NUMBER	RESULT
180° Side Bend, 4T, Sample FD2S-1	Satisfactory
" " " , ", Sample FD2S-2	"
" " " , ", Sample FD2S-3	"
" " " , ", Sample FD2S-4	"

TOUGHNESS TESTS (QW-170)

SPECIMEN NUMBER	NOTCH LOCATION	NOTCH TYPE	TEST TEMP.	IMPACT VALUES	LATERAL EXP.		DROP WEIGHT	
					SHEAR	MILS	BREAK	NO BREAK
FD2C-2	Base Metal	V	40°F	122	76%	81	N/A	N/A
FD2C-3	"	"	"	120	100%	66	N/A	N/A
FD2C-2	Groove Side HAZ	"	"	102	84%	63	N/A	N/A
FD2C-3	"	"	"	100	87%	63	N/A	N/A
FD2C-2	Groove Bottom HAZ	"	"	70	61%	56	N/A	N/A
FD2-C-3	"	"	"	60	42%	49	N/A	N/A

FILLET WELD TEST (QW-180)

RESULT - SATISFACTORY: YES N/A NO N/A PENETRATION INTO PARENT METAL: YES N/A NO N/A

MACRO - RESULTS N/A

OTHER TESTS

TYPE OF TEST N/A

DEPOSIT ANALYSIS N/A

OTHER N/A

WELDER'S NAME Roy Button CLOCK NO. N/A STAMP NO. A

TESTS CONDUCTED BY: Anamet Laboratories LABORATORY TEST NO. 1188.299

WE CERTIFY THAT THE STATEMENTS IN THIS RECORD ARE CORRECT AND THAT THE TEST WELDS WERE PREPARED, WELDED AND TESTED IN ACCORDANCE WITH THE REQUIREMENTS OF SECTION IX OF THE ASME CODE.

CERTIFIED BY: Bhaven Chaturvedi DATE 12/15/88

QUALIFICATION SUPERVISOR

(DETAIL OF RECORD OF TESTS ARE ILLUSTRATIVE ONLY AND MAY BE MODIFIED TO CONFORM TO THE TYPE AND NUMBER OF TESTS REQUIRED BY THE CODE.)

GROOVE WELD HARDNESS PROFILE
1 1/4" PREHEATED CASE (FD2M-1)

Sample A

Distance from Surface	HRC
Toe, .003 below surface	28 (large grains)
Toe, .003 below surface	33.5 (.013 from weld)
.003 below surface	28 (.025" from weld)
.025, lip	39.5, 40.0
	35.0
.058	32
.158	32
.258	30
.358	28

Sample B

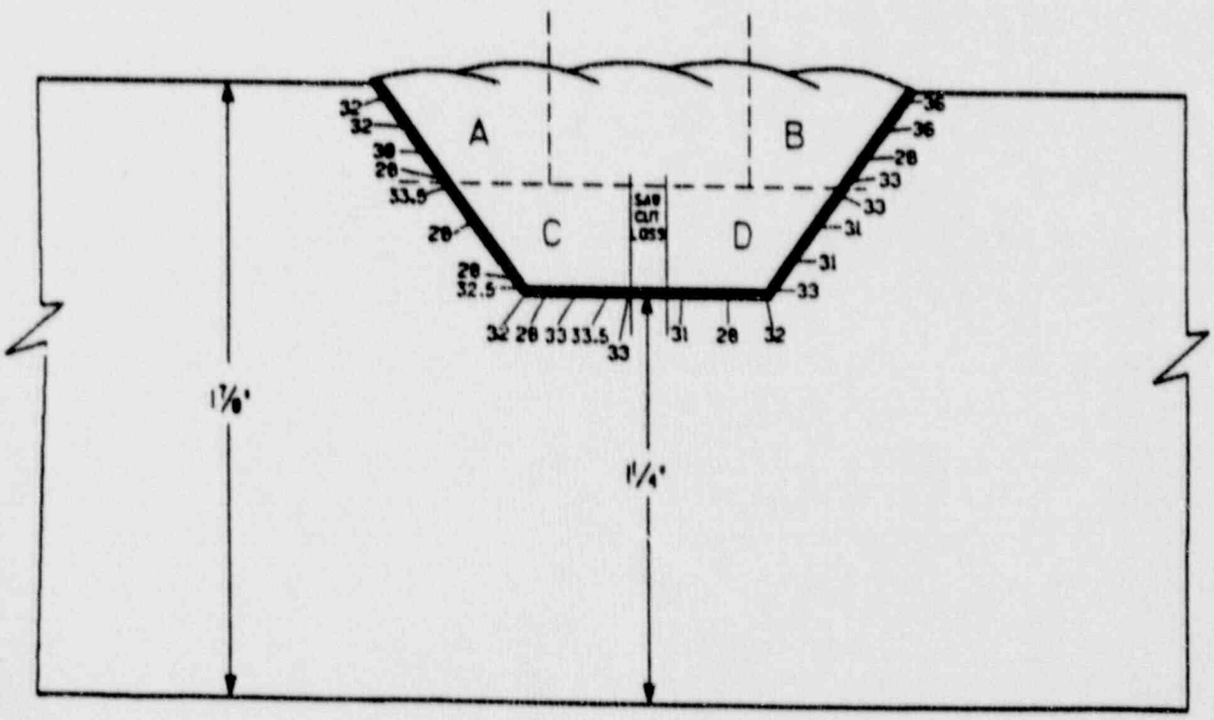
Distance from Surface	HRC
Toe, .003 from surface	36
.066	38, 38
.066	33 (large grains)
.066	41, 33
.166	36
.266	28
.321	33

Sample C

Distance from Surface	HRC
.003 from cut surface	33.5
.102 from cut surface	28
.162, corner, large bend radius	28
.182, corner, large bend radius	32.5
0.0, corner, Horiz	32
.100 from corner, Horiz	28
.200 from corner, Horiz	33
.300 from corner, Horiz	33.5
.363 from corner, Horiz	33

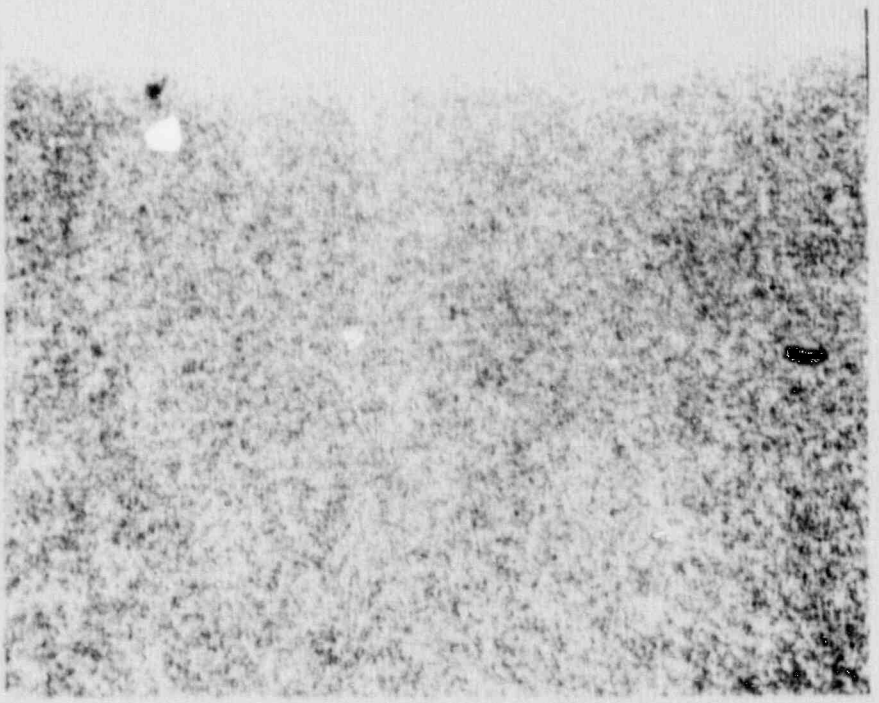
Sample D

Distance from Surface	HRC
.011 from cut surface	33
.111 from cut surface	31
.211 from cut surface	31
.311 from cut surface	33
0.00, corner, Horiz	32
0.100 from corner, Horiz	28
0.200 from corner, Horiz	31



BOTTOM HEAT AFFECTED ZONE MICROSTRUCTURES
1 1/4" PREHEATED

FD2M-1C
50X



FD2M-1C
200X

PROCEDURE QUALIFICATION RECORD (PQR)

(SEE QW-201.2, SECTION IX, ASME BOILER AND PRESSURE VESSEL CODE) RECORD ACTUAL CONDITIONS USED TO WELD TEST COUPON.

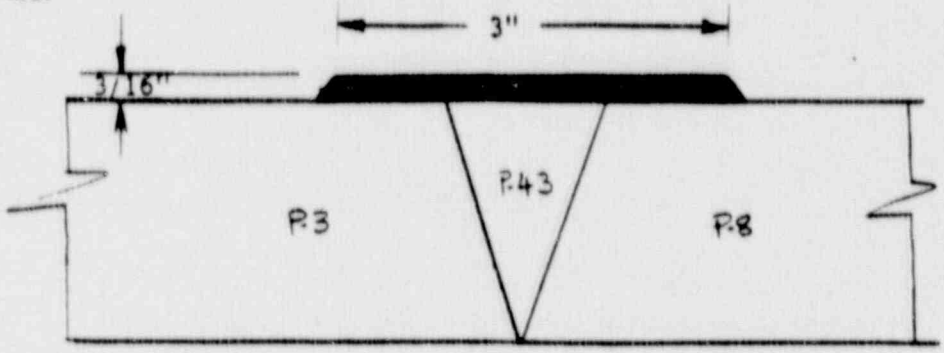
PROCEDURE QUALIFICATION RECORD NO. PQR-3/8-T-004 DATE 12/14/88

WPS USED FOR TEST WELD WPS-3/8-T-001-NES REV. A

WELDING PROCESS(ES) GTAW

TYPES (MANUAL, AUTOMATIC, SEMI-AUTO) MACHINE

JOINTS (QW-402)



GROOVE DESIGN OF TEST COUPON
(FOR COMBINATION QUALIFICATIONS, THE DEPOSITED WELD METAL THICKNESS WILL BE RECORDED FOR EACH FILLER METAL OR PROCESS WELD.)

BASE METALS (QW-403)

MATERIAL SPEC. SA508/Inconel 182/SA376

TYPE OR GRADE Class 2/ /Tp304

P-NO. 43 GR-NO. -

TO P-NO. 3 GR3/P43 GR-NO. P8, GR1

THICKNESS OF BACKING 1 1/4"

DIAMETER OF TEST COUPON 14" OD

OTHER See figure

FILLER METALS (QW-404)

WELD METAL ANALYSIS A-NO. ER NiCr-3

SIZE OF FILLER METAL .035" Dia

FILLER METAL F-NO. 43

SFA SPECIFICATION 5.14

AWS CLASSIFICATION ER NiCr-3

OTHER

POSITION (QW-405)

POSITION OF GROOVE 5G

WELD PROGRESSION (UPHILL, DOWNHILL) Down

OTHER

PREHEAT (QW-406)

PREHEAT TEMPERATURE 300°F

INTERPASS TEMPERATURE 450°F Max

OTHER

POSTWELD HEAT TREATMENT (QW-407)

TEMPERATURE 450-550°F

TIME 2Hrs Min. after deposit of Layer No. 3

OTHER

GAS (QW-408)

TYPE OF GAS OR GASES Argon

COMPOSITION OF GAS MIXTURE 100% Weld Grade

OTHER 20-45 CFH

ELECTRICAL CHARACTERISTICS (QW-409)

CURRENT DIRECT

POLARITY STRAIGHT

AMPS *200-240Peak VOLTS **9.4-9.8Peak

TUNGSTEN ELECTRODE SIZE 1/8" EWTH

OTHER *110 - 140 Backgr.
**8.4-9.8 Backgr.

TECHNIQUE (QW-410)

TRAVEL SPEED 3.0 - 7.6 IPM arc speed *

STRING OR WEAVE BEAD String for Layer 1-3.*

OSCILLATION 0-3/4" for weave beads.

MULTIPASS OR SINGLE PASS (PER SIDE) Multiple

SINGLE OR MULTIPLE ELECTRODES Single

OTHER Water Backed after PWHT

* Weave for layers 4 and above

TENSILE TEST (QW-150) PQR NO. PQR-3/8-T-004

SPECIMEN NUMBER	WIDTH	THICKNESS	AREA	ULTIMATE TOTAL LOAD (lb.)	ULTIMATE UNIT STRESS (psi)	TYPE OF FAILURE & LOCATION
N/A						
N/A						
N/A						
N/A						

GUIDED BEND TESTS (QW-160)

TYPE AND FIGURE NUMBER	RESULT
180° Side Bend, 4T, Sample FDOS-1	Satisfactory
" " " , " , Sample FDOS-2	"
" " " , " , Sample FDOS-3	"
" " " , " , Sample FDOS-4	"

TOUGHNESS TESTS (QW-170)

SPECIMEN NUMBER	NOTCH LOCATION	NOTCH TYPE	TEST TEMP.	IMPACT VALUES	LATERAL EXP.		DROP WEIGHT	
					SHEAR	MILS	BREAK	NO BREAK
FDOC-1	Overlay Toe HAZ	V	40°F	160	100%	92	N/A	N/A
FDOC-2	"	V	40°F	158	100%	88	N/A	N/A

FILLET WELD TEST (QW-180)

RESULT - SATISFACTORY: YES N/A NO N/A PENETRATION INTO PARENT METAL: YES N/A NO N/A

MACRO - RESULTS N/A

OTHER TESTS

TYPE OF TEST N/A

DEPOSIT ANALYSIS N/A

OTHER N/A

WELDER'S NAME: Roy Button CLOCK NO. N/A STAMP NO. A

TESTS CONDUCTED BY: Anamet Laboratories LABORATORY TEST NO. 1188.299

WE CERTIFY THAT THE STATEMENTS IN THIS RECORD ARE CORRECT AND THAT THE TEST WELDS WERE PREPARED, WELDED AND TESTED IN ACCORDANCE WITH THE REQUIREMENTS OF SECTION IX OF THE ASME CODE.

CERTIFIED BY: Bhavesh Chakravarti DATE 12/15/88

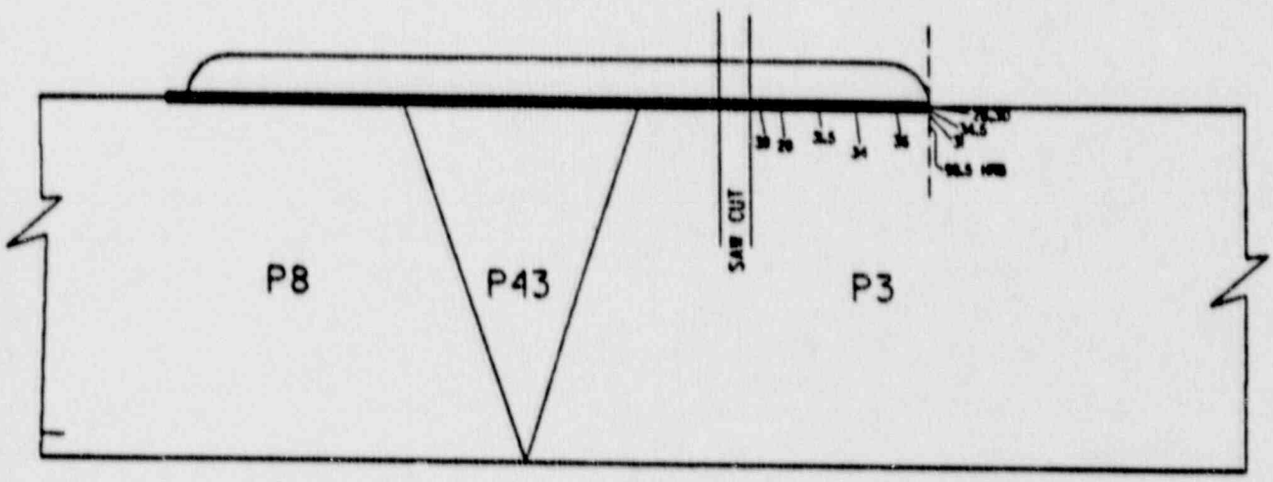
QUALIFICATION SUPERVISOR

(DETAIL OF RECORD OF TESTS ARE ILLUSTRATIVE ONLY AND MAY BE MODIFIED TO CONFORM TO THE TYPE AND NUMBER OF TESTS REQUIRED BY THE CODE.)

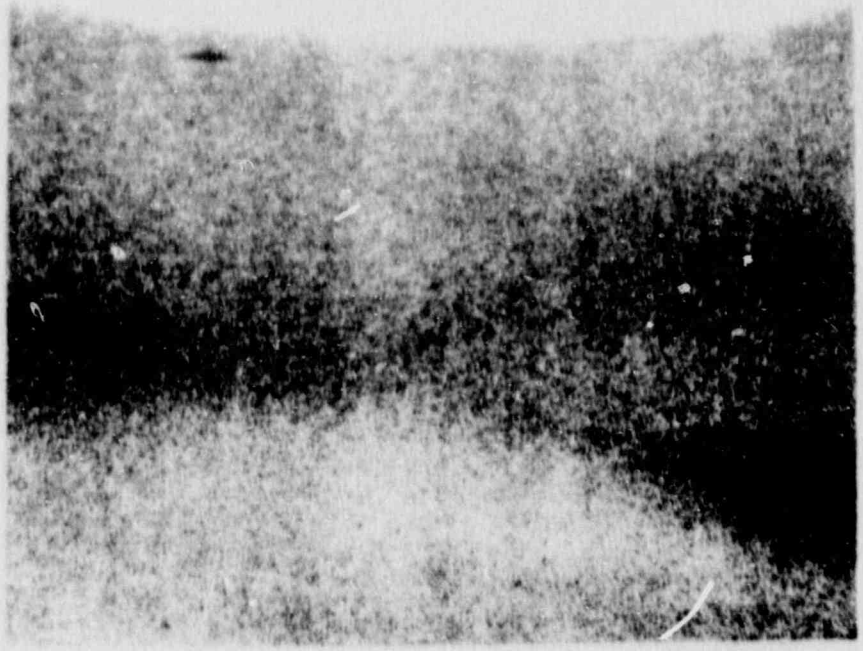
DIMMED.34.02

WELD OVERLAY HARDNESS PROFILE
1 1/4" PREHEATED CASE (D03)

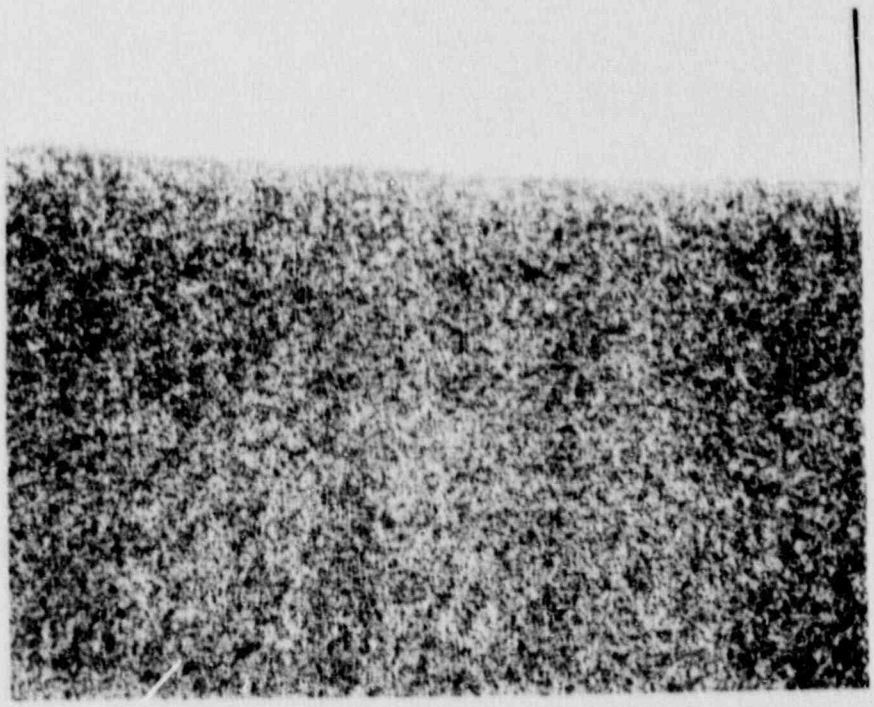
Horizontal Traverse in HAZ		Vertical Traverse at Toe Area	
Distance from Surface	HRC	Distance from Surface	HRC
Toe, .003 from surface	28, 30 (.028" from weld)	.040	24
.003 from surface	99 HRB (.052" from weld)	.090	98.5 HRB
.035 from surface	34.5	.100	97.5
.062 corner surface	31.0	Base Metal	93.5
.100 from corner, Horiz.	36		
.200 from corner, Horiz.	34		
.300 from corner, Horiz.	31.5		
.400 from corner, Horiz.	28		
.468 from corner, Horiz.	30 (cutting artifact)		



OVERLAY HEAT AFFECTED ZONE MICROSTRUCTURES
1 1/4" PREHEATED



D03
50X



D03
200X

FILLER METAL ISSUE SLIP

Welder's Name ROY BUTTON Symbol A

AWS Classification A 5.14, ER NiCr-3 Heat/Lot No. SNX 5446D

Weld Identification WPS-3/8-T-001-NES, Rev. A

Authorised by B. CHAKRAVARTI Date 11/9/88

Issued by B. CHAKRAVARTI Date 11/9/88 Time 8:00 AM

Quantity Issued: 3 (THREE), 2.5 lbs SPOOL OF 0.035" ø ER NiCr-3 WIRE, TOTAL = 7.5 lbs.

BC

FILLER METAL ISSUE SLIP

Welder's Name ROY BUTTON Symbol A

AWS Classification A 5.14, ER NiCr-3 Heat/Lot No. SNX 5446D

Weld Identification WPS-3/8-T-001-NES, Rev. A

Authorised by B. CHAKRAVARTI Date 11/10/88

Issued by B. CHAKRAVARTI Date 11/10/88 Time 8:00 AM

Quantity Issued: 3 (THREE), 2.5 lbs SPOOL OF 0.035" ϕ ER NiCr-3 WIRE, TOTAL = 7.5 lbs.

SANDVIK Steel

MATERIAL CERTIFICATE

SANDVIK STEEL CO.
P.O. BOX 1220, SCRANTON, PA. 18501 PH: 717 - 587-5191
PLANT LOCATION: INTERSTATE 81, WAVERLY EXIT 59

CUSTOMER PURCHASE ORDER NO	SANDVIK ORDER NO	ITEM	SPECIAL CODE	MARKS	CERTIFICATE DATE
XGU-5020	127394		52900		10/19/88

SOLD TO: NUTECH ENGINEERING
SAN JOSE CA

GAPCO INC
DIAMOND SPRINGS CA

SPECIFICATION AND MATERIAL
AWS A-5.14

NICKEL ALLOY WELDING WIRE TYPE ER NiCr-3 .035" x 2.5

Filler Metal Analysis, %

Heat	C	Si	Mn	P	S	Cr	Ni
SNX5446D	.050	.07	2.90	.005	.001	21.13	71.10

Fe	Mo	W	Co	V	Ti	Cu
1.39	.16		.04		.41	.14

Al	Cb/Nb	Cb/Nb+Ta	Ta	Others .5 max.
	2.59		.01	

Quantity shipped per packing note.

Inspected 2 boxes.
(1) Box 1 - Containing 10 spools, 2.5 lbs each of Heat SNX5446 D ER NiCr-3 wire, .035"ø.
(2) Box 2 - Containing 20 spools, 2.5 lbs each of Heat SNX5446 D, ER NiCr-3 wire, 0.035"ø.
Products accepted per this data sheet.
Bhaven Chahwanta

Bengt H. Berg, Manager, Product Quality and Metallurgy/emb

55(W-B-A-3, REV. 8)

APPENDIX B

WPS and PQRs for Semi-Automated GTAW Double Down Technique on Waterbacked Nozzles

WELDING PROCEDURE SPECIFICATION (WPS)

(SEE QW-201.1, SECTION IX, ASME BOILER AND PRESSURE VESSEL CODE)

WELDING PROCEDURE SPECIFICATION NO. WPS-3/8-T-002-NES REV. 0

SUPPORTING PQR NO.(S) PQR-3/8-T-002, 005, 006

WELDING PROCESS(ES) GTAW TYPE(S) Machine

(AUTOMATIC, MANUAL, MACHINE, OR SOME-AUTO)

JOINTS (QW-402)

JOINT DESIGN Overlay

BACKING (YES) X (NO)

BACKING MATERIAL (TYPE) P-3, P-43, P-8 *

FULL OR PARTIAL PENETRATION N/A

SKETCH

L & T as req'd by design

* or equivalent weld metal (F-No.) types.

*BASE METALS (QW-403)

P-NO. 8 GROUP NO. 1 TO P-NO. 3 GROUP NO. 3

OR

SPECIFICATION TYPE AND GRADE N/A

TO SPECIFICATION TYPE AND GRADE N/A

OR

CHEM. ANALYSIS AND MECH. PROP. N/A

TO CHEM. ANALYSIS AND MECH. PROP. N/A

THICKNESS RANGE:

BASE METAL THICKNESS: 1/2" and above FILLET N/A

DEPOSITED WELD METAL: GROOVE N/A FILLET N/A

PIPE DIA. RANGE: GROOVE All diameters FILLET N/A

OTHER

*FILLER METALS (QW-404)

F-NO. 43 OTHER N/A

A-NO. ER NiCr-3 OTHER N/A

SPEC. NO. (SFA) SFA 5.14

AWS NO. (CLASS) ER NiCr-3

SIZE OF FILLER METALS 0.035" Diameter

(ELECTRODE, COLD WIRE, HOT WIRE, ETC.)

ELECTRODE-FLUX (CLASS) N/A

FLUX TRADE NAME N/A

CONSUMABLE INSERT None

* EACH BASE METAL-FILLER METAL COMBINATION SHOULD BE RECORDED INDIVIDUALLY.

POSITIONS (QW-405)

POSITION(S) OF GROOVE 5G

WELDING PROGRESSION: UP _____ DOWN X

POSITION(S) OF FILLET N/A

POSTWELD HEAT TREATMENT (QW-407)

TEMPERATURE RANGE None

TIME RANGE N/A

PREHEAT (QW-406)

PREHEAT TEMP. MIN. 70°F

INTERPASS TEMP. MAX. Greater than 80°F

PREHEAT MAINTENANCE None

(CONTINUOUS OR SPECIAL HEATING WHERE APPLICABLE SHOULD BE RECORDED)

GAS (QW-408)

SHIELDING GAS(ES) Argon

PERCENT COMPOSITION (MIXTURES) 100% Welding Grade

FLOW RATE 20-45 CFH

GAS BACKING None

TRAILING SHIELDING GAS COMPOSITION None

ELECTRICAL CHARACTERISTICS (QW-409)

CURRENT AC OR DC Direct POLARITY Straight

AMPS (RANGE) 160-250 Peak * VOLTS (RANGE) 8.7-9.8 Peak, 8.4-9.8 Backgr.

* 110-160 Backgr.

(AMPS AND VOLTS RANGE SHOULD BE RECORDED FOR EACH ELECTRODE SIZE, POSITION, AND THICKNESS, ETC. THIS INFORMATION MAY BE LISTED IN A TABULAR FORM SIMILAR TO THAT SHOWN BELOW.)

TUNGSTEN ELECTRODE SIZE AND TYPE 1/8" EWTh (PURE TUNGSTEN, 2% THORIATED, ETC.)

MODE OF METAL TRANSFER FOR GMAW N/A (SPRAY ARC, SHORT CIRCUITING ARC, ETC.)

ELECTRODE WIRE FEED SPEED RANGE 0-69 IPM

TECHNIQUE (QW-410)

STRING OR WEAVE BEAD String for layers 1-3, Weave for layers 4 and above.

ORIFICE OR GAS CUP SIZE #10, #12

INITIAL AND INTERPASS CLEANING (BRUSHING, GRINDING, ETC.) Brushing, grinding or combination with equipment that is new or has been used on S.S. only.

METHOD OF BACK GOUGING None

OSCILLATION (YES) X (NO) _____ (FREQ.) _____ (WIDTH) 0" for 1st 3 layers 0-3/4" for remaining layers

CONTACT TUBE TO WORK DISTANCE N/A

MULTIPLE OR SINGLE PASS (PER SIDE) Multiple

MULTIPLE OR SINGLE ELECTRODES Single

TRAVEL SPEED (RANGE) 3.0-8.5 IPM arc speed

PEENING None (Peening of repair cavities permitted when required)

OTHER Water Backed for all layers. Min. water temp. = 80°F.

WELD LAYER(S)	PROCESS	FILLER METAL CLASS	FILLER METAL DIA.	CURRENT TYPE POLAR.	CURRENT AMP RANGE BACKGR.	CURRENT AMP RANGE PEAK	VOLT RANGE BACKGR.	VOLT RANGE PEAK	TRAVEL SPEED RANGE (IPM)	OTHER (e.g. REMARKS, DESCRIPTION WIRE ADDITION, TECHNIQUE, TORCH ANGLE, % PEAK, % BACKGROUND)
1	GTAW	ER NiCr3	0.035	Str.	120-140	160-240	8.7-9.8	8.7-9.8	5.4-7.6	22.6 Kj/in max.
2	"	"	"	"	140-160	230-250	9.5-9.8	9.5-9.8	5.9-7.3	22.0 Kj/in max.
3	"	"	"	"	120-140	180-240	9.5-9.8	9.5-9.8	5.7-6.3	21.1 Kj/in max.
4 & remain. layers	"	"	"	"	110-140	200-230	8.4-8.6	9.4-9.6	3.0-3.5	33.9 Kj/in max.

PREPARED BY: B. Chakravarti Bhaven Chakravarti DATE 11/10/88

QUALIFICATION SUPERVISOR

REVIEWED BY: _____ DATE _____

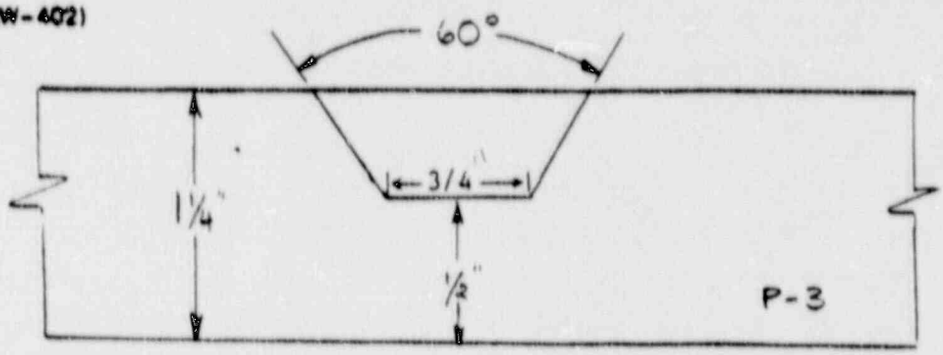
QUALITY ASSURANCE ADMINISTRATOR

PROCEDURE QUALIFICATION RECORD (PQR)

(SEE QW-201.2, SECTION IX, ASME BOILER AND PRESSURE VESSEL CODE)
RECORD ACTUAL CONDITIONS USED TO WELD TEST COUPON.

PROCEDURE QUALIFICATION RECORD NO. PQR-3/8-T-002 DATE 12/15/88
WPS USED FOR TEST WELD WPS-3/8-T-002-NES REV. A
WELDING PROCESS(ES) GTAW
TYPES (MANUAL, AUTOMATIC, SEMI-AUTO.) MACHINE

JOINTS (QW-402)



GROOVE DESIGN OF TEST COUPON
(FOR COMBINATION QUALIFICATIONS, THE DEPOSITED WELD METAL THICKNESS WILL BE RECORDED FOR EACH FILLER METAL OR PROCESS USED.)

BASE METALS (QW-403)
MATERIAL SPEC. SA508
TYPE OR GRADE Class 2
P-NO. 3 GR-NO. Gr. 3
TO P-NO. N/A GR-NO. N/A
THICKNESS OF BACKING 1/2 inch
DIAMETER OF TEST COUPON 14" OD
OTHER See Figure.

POSTWELD HEAT TREATMENT (QW-407)
TEMPERATURE None
TIME N/A
OTHER N/A

GAS (QW-408)
TYPE OF GAS OR GASES Argon
COMPOSITION OF GAS MIXTURE 100% Weld Grade
OTHER 35 CFH

FILLER METALS (QW-404)
WELD METAL ANALYSIS A-NO. ER NiCr-3
SIZE OF FILLER METAL 0.035" Dia.
FILLER METAL F-NO. 43
SFA SPECIFICATION 5.14
AWS CLASSIFICATION ER NiCr-3
OTHER

ELECTRICAL CHARACTERISTICS (QW-409)
CURRENT Direct
POLARITY Straight
AMPS. *160-250Peak VOLTS 8.8-9.8Peak**
TUNGSTEN ELECTRODE SIZE 1/8 EWTH
OTHER *110-160 Backgr.
**8.4-9.8 Backgr.

POSITION (QW-405)
POSITION OF GROOVE 5G
WELD PROGRESSION (UPHILL, DOWNHILL) Down
OTHER

TECHNIQUE (QW-410)
TRAVEL SPEED 3.0-7.6 IPM arc speed
STRING OR WEAVE BEAD Layer 1-3 String, *
OSCILLATION 0-3/4" for Weave Beads.
MULTIPASS OR SINGLE PASS (PER SIDE) Multiple
SINGLE OR MULTIPLE ELECTRODES Single
OTHER Water Backed for all layers.
Minimum Water Temp.: 80°F.
* Layers 4 and above, Weave.

PREHEAT (QW-406)
PREHEAT TEMPERATURE 70°F Min.
INTERPASS TEMPERATURE Higher than 80°F.
OTHER

PQR NO. PQR-3/8-T-002

TENSILE TEST (QW-150)

SPECIMEN NUMBER	WIDTH	THICKNESS	AREA (sq. inch)	ULTIMATE TOTAL LOAD (lbs)	ULTIMATE UNIT STRESS (psi)	TYPE OF FAILURE & LOCATION
FW1T-1	N/A	N/A	0.199	18,100	91,000	Base Metal
FW1T-2	N/A	N/A	0.198	18,075	91,300	Base Metal

GUIDED BEND TESTS (QW-160)

TYPE AND FIGURE NUMBER	RESULT
180° Side Bend, 4T, Sample FW1S-1	Satisfactory
" " " , " " FW1S-2	Satisfactory
" " " , " " FW1S-3	Satisfactory
" " " , " " FW1S-4	Satisfactory

TOUGHNESS TESTS (QW-170)

SPECIMEN NUMBER	NOTCH LOCATION	NOTCH TYPE	TEST TEMP.	IMPACT VALUES	LATERAL EXP.		DROP WEIGHT	
					SHEAR	MILS	BREAK	NO BREAK
FW1C-1	Base Metal	V	40°F	175	100%	88	N/A	N/A
FW1C-2	"	"	"	150	79%	78	N/A	N/A
FW1C-1	Groove Side HAZ	"	"	138	100%	70	N/A	N/A
FW1C-2	"	"	"	130	96%	61	N/A	N/A
FW1C-1	Bottom HAZ	"	"	72.5	66%	50	N/A	N/A
FW1C-2	"	"	"	57	58%	40	N/A	N/A

FILLET WELD TEST (QW-180)

RESULT - SATISFACTORY: YES N/A NO N/A PENETRATION INTO PARENT METAL: YES N/A NO N/A

MACRO - RESULTS N/A

OTHER TESTS

TYPE OF TEST N/A

DEPOSIT ANALYSIS N/A

OTHER N/A

WELDER'S NAME: Roy Button CLOCK NO. N/A STAMP NO. A

TESTS CONDUCTED BY: Anamet Laboratories LABORATORY TEST NO. 1188.299

WE CERTIFY THAT THE STATEMENTS IN THIS RECORD ARE CORRECT AND THAT THE TEST WELDS WERE PREPARED, WELDED AND TESTED IN ACCORDANCE WITH THE REQUIREMENTS OF SECTION IX OF THE ASME CODE.

CERTIFIED BY: Warren Chatterwarth DATE 12/19/88

QUALIFICATION SUPERVISOR

(DETAIL OF RECORD OF TESTS ARE ILLUSTRATIVE ONLY AND MAY BE MODIFIED TO CONFORM TO THE TYPE AND NUMBER OF TESTS REQUIRED BY THE CODE.)

GROOVE WELD HARDNESS PROFILE
1/2" WATER BACKED CASE (FWIM-1)

Sample A

Distance from Surface	HRC
Toe, .003 below surface	31, 31, 38
Toe, .003 below surface	35.5 (.010 from weld)
.030, lip	42.5, 43, 39
.075	42
.155	37
.215	38

Sample B

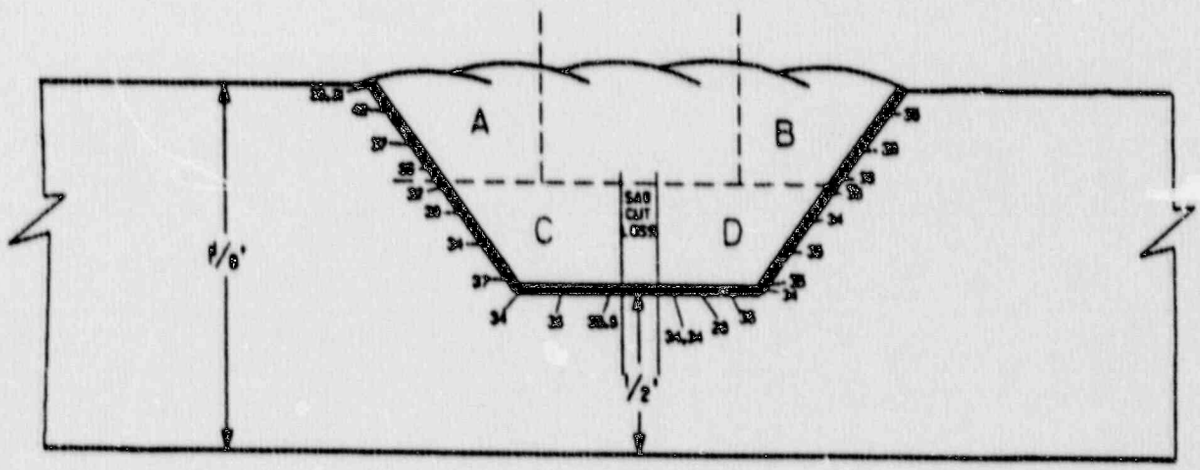
Distance from Surface	HRC
Toe, .003 below surface	40, 42, 41
.034, lip area	39, 34, 36, 40
.070	35
.170	35
.245	36

Sample C

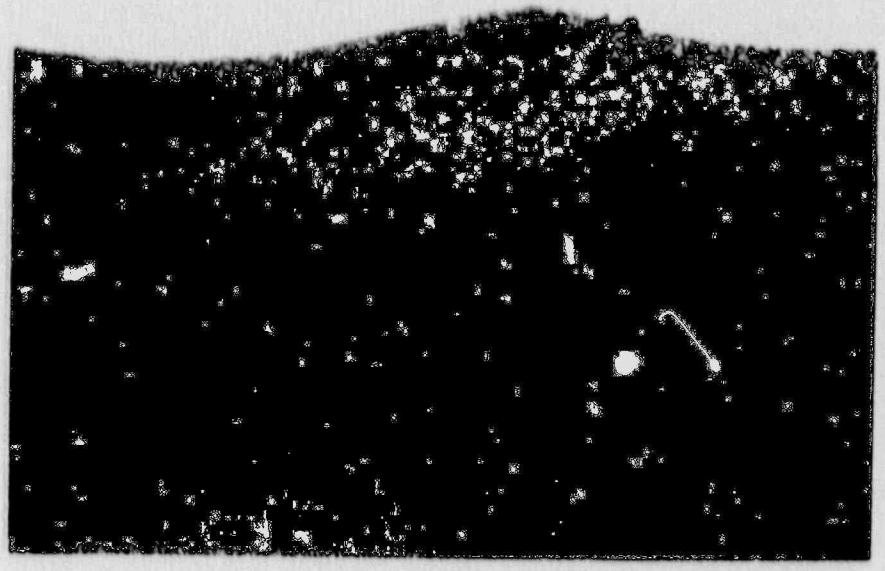
Distance from Surface	HRC
.004 from edge	32
.103	38
.203	34
.303, at corner	37
.328, at corner	34
.100 from corner, Horiz	36
.200 from corner, Horiz	35.5

Sample D

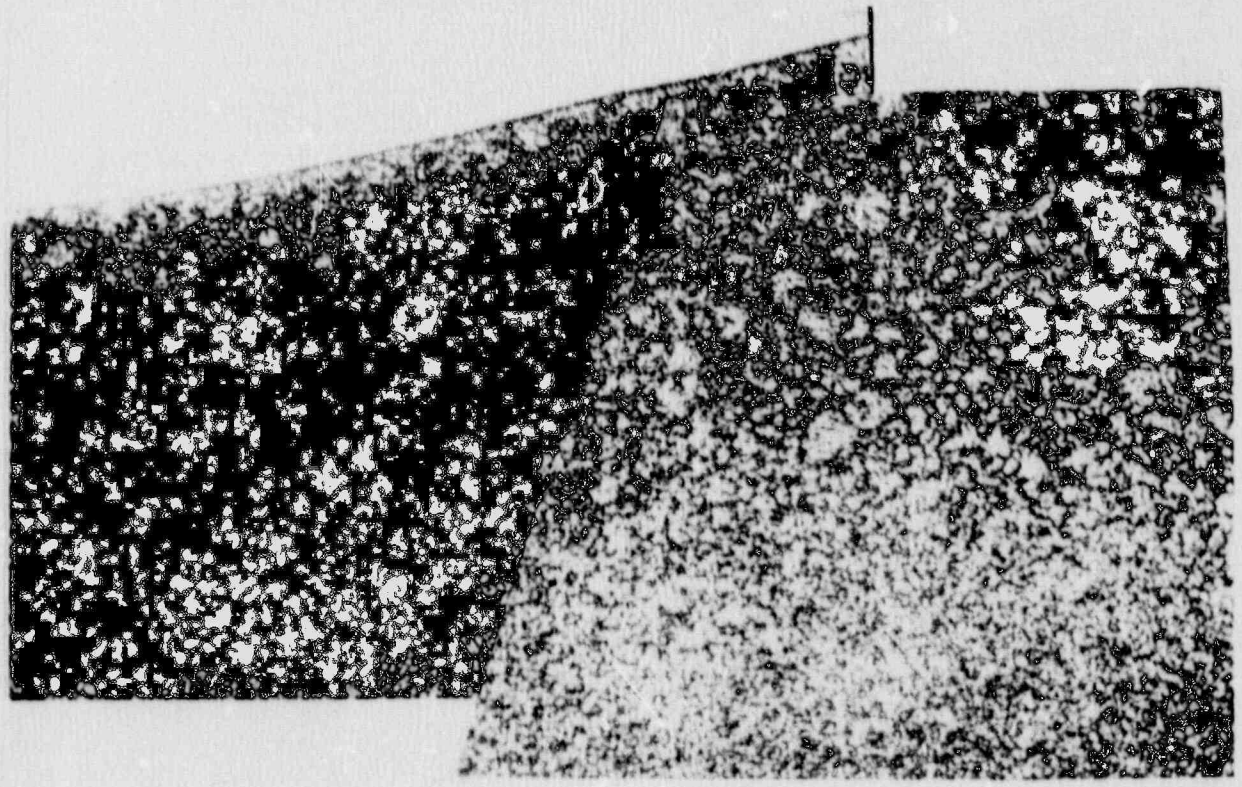
Distance from Surface	HRC
.003 from cut surface	36
.007	35.5
.052	38
.102	34
.202	35
.302	35
.341, corner	34
.100 from corner, Horiz	35, 36
.200 from corner, Horiz	28
.300 from corner, Horiz	34
.315 from corner, Horiz	34



BOTTOM HEAT AFFECTED ZONE MICROSTRUCTURE
1/2" WATERBACKED



FWIM-1D
50X



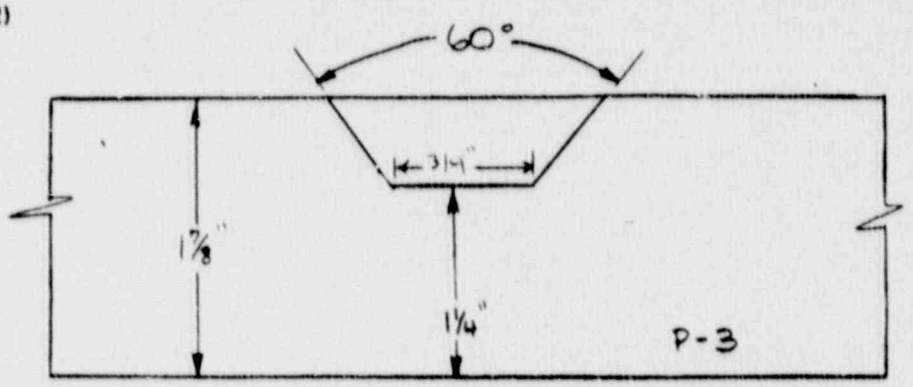
FWIM-1D
200X

PROCEDURE QUALIFICATION RECORD (PQR)

(SEE QW-201.2, SECTION IX, ASME BOILER AND PRESSURE VESSEL CODE)
RECORD ACTUAL CONDITIONS USED TO WELD TEST COUPON.

PROCEDURE QUALIFICATION RECORD NO. PQR-3/8-T-005 DATE 12/15/88
WPS USED FOR TEST WELD WPS-3/8-T-002-NES REV. A
WELDING PROCESS(ES) GTAW
TYPES (MANUAL, AUTOMATIC, SEMI-AUTO.) MACHINE

JOINTS (QW-402)



GROOVE DESIGN OF TEST COUPON
(FOR COMBINATION QUALIFICATIONS, THE DEPOSITED WELD METAL THICKNESS WILL BE RECORDED FOR EACH FILLER METAL OR PROCESS WELD.)

BASE METALS (QW-403)
MATERIAL SPEC. SA 508
TYPE OR GRADE Class 2
P-NO. 43 GR-NO. -
TO P-NO. 3 GR-NO. 3
THICKNESS OF BACKING 1 1/4 inches
DIAMETER OF TEST COUPON 15 1/8 inches
OTHER See Figure

FILLER METALS (QW-404)
WELD METAL ANALYSIS A-NO. ER NiCr-3
SIZE OF FILLER METAL 0.035" Dia
FILLER METAL F-NO. 43
SFA SPECIFICATION 5.14
AWS CLASSIFICATION ER NiCr-3
OTHER

POSITION (QW-405)
POSITION OF GROOVE 5G
WELD PROGRESSION (UPHILL, DOWNHILL) Down
OTHER N/A

PREHEAT (QW-406)
PREHEAT TEMPERATURE 70°F Min.
INTERPASS TEMPERATURE Higher than 80°F.
OTHER N/A

POSTWELD HEAT TREATMENT (QW-407)
TEMPERATURE NONE
TIME N/A
OTHER N/A

GAS (QW-408)
TYPE OF GAS OR GASES Argon
COMPOSITION OF GAS MIXTURE 100% Weld Grade
OTHER 35 CFH

ELECTRICAL CHARACTERISTICS (QW-409)
CURRENT Direct
POLARITY Straight
AMPS. *160-240Peak VOLTS 8.7-9.8 Peak**
TUNGSTEN ELECTRODE SIZE 1/8 EWTH
OTHER *110 -140 Backgr.
**8.4-9.8 Backgr.

TECHNIQUE (QW-410)
TRAVEL SPEED 3.0-7.6 IPM arc speed
STRING OR WEAVE BEAD Layer 1-3 String. *
OSCILLATION 0-3/4 inch for Weave Beads.
MULTIPASS OR SINGLE PASS (PER SIDE) Multiple
SINGLE OR MULTIPLE ELECTRODES Single
OTHER Water Backed for all Layers.
Minimum Water Temp = 80°F.
*Layers 4 and above, Weave.

TENSILE TEST (QW-150)

FOR NO. POR-3/8-005

SPECIMEN NUMBER	WIDTH	THICKNESS	AREA Square Inch	ULTIMATE TOTAL LOAD (lb.)	ULTIMATE UNIT STRESS (psi)	TYPE OF FAILURE & LOCATION
FW2T-1	N/A	N/A	0.177	15,725	88,800	Base Metal
FW2T-2	N/A	N/A	0.198	17,125	86,500	Base Metal

GUIDED BEND TESTS (QW-160)

TYPE AND FIGURE NUMBER	RESULT
180°F Side Bend, 4T, Sample FW2S-1	Satisfactory
" " " " " FW2S-2	Satisfactory
" " " " " FW2S-3	Satisfactory
" " " " " FW2S-4	Satisfactory

TOUGHNESS TESTS (QW-170)

SPECIMEN NUMBER	NOTCH LOCATION	NOTCH TYPE	TEST TEMP.	IMPACT VALUES	LATERAL EXP.		DROP WEIGHT	
					SHEAR	MILS	BREAK	NO BREAK
FW2C-2	Base Metal	V	40°F	103.5	76%	65	N/A	N/A
FW2C-3	"	"	"	97.0	76%	60	N/A	N/A
FW2C-2	Groove Side HAZ	"	"	115.0	100%	60	N/A	N/A
FW2C-3	"	"	"	94.0	82%	59	N/A	N/A
FW2C-2	Groove Bottom HAZ	"	"	52.5	54%	43	N/A	N/A
FW2C-3	"	"	"	56.5	56%	40	N/A	N/A

FILLET WELD TEST (QW-180)

RESULT - SATISFACTORY: YES N/A NO N/A PENETRATION INTO PARENT METAL: YES N/A NO N/A

MACRO - RESULTS N/A

OTHER TESTS

TYPE OF TEST N/A

DEPOSIT ANALYSIS N/A

OTHER N/A

WELDER'S NAME: Roy Burton CLOCK NO. N/A STAMP NO. A

TESTS CONDUCTED BY: Anamet Laboratories LABORATORY TEST NO. 1188.299

WE CERTIFY THAT THE STATEMENTS IN THIS RECORD ARE CORRECT AND THAT THE TEST WELDS WERE PREPARED, WELDED AND TESTED IN ACCORDANCE WITH THE REQUIREMENTS OF SECTION IX OF THE ASME CODE.

CERTIFIED BY: Bhavin Chakravarti DATE 12/19/88

QUALIFICATION SUPERVISOR

(DETAIL OF RECORD OF TESTS ARE ILLUSTRATIVE ONLY AND MAY BE MODIFIED TO CONFORM TO THE TYPE AND NUMBER OF TESTS REQUIRED BY THE CODE.)

GROOVE WELD HARDNESS PROFILE
1 1/4" WATERBACKED CASE (FW2H-1)

Sample A

Distance from Surface	HRC
Toe, .003 below surface	27.5 } large grains
Toe, .005 below surface	32 }
.032, lip area	44, 41.5, 44.2
.100	38
.200	33
.300	33
.400	35
.435	33

Sample B

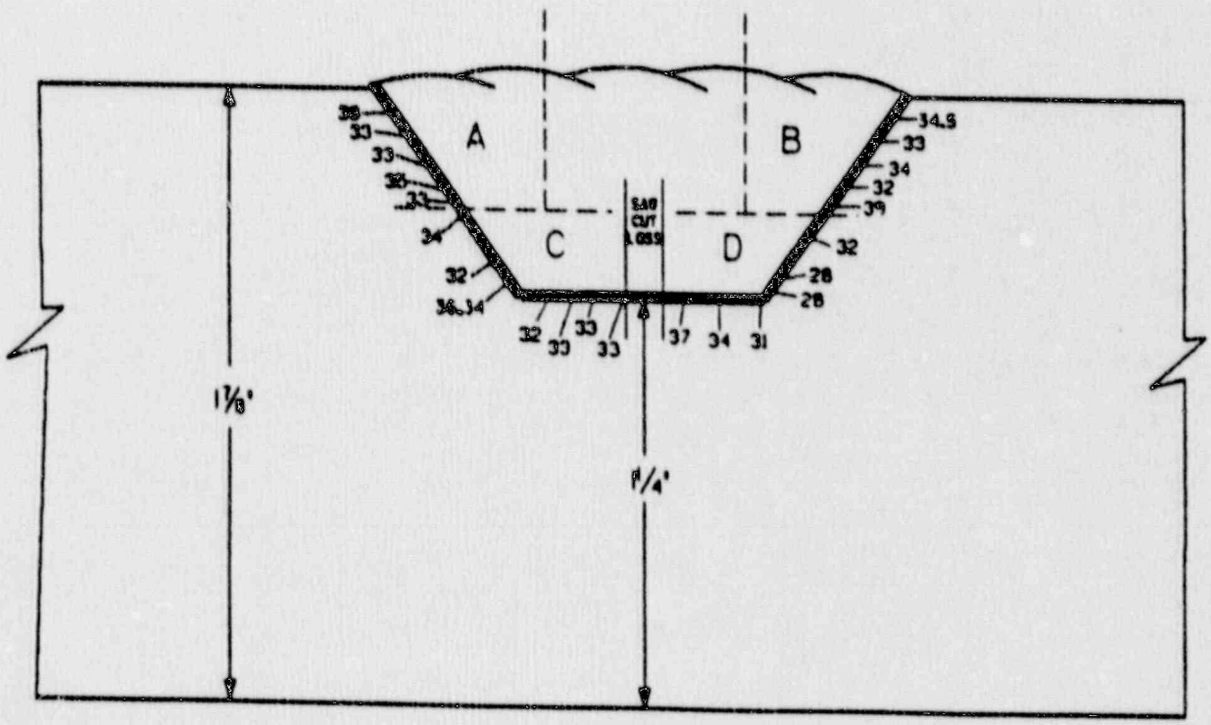
Distance from Surface	HRC
Toe, .025 below surface	37.5
.065	34.5
.165	33
.265	34
.340	32
.383	38
.390	39

Sample C

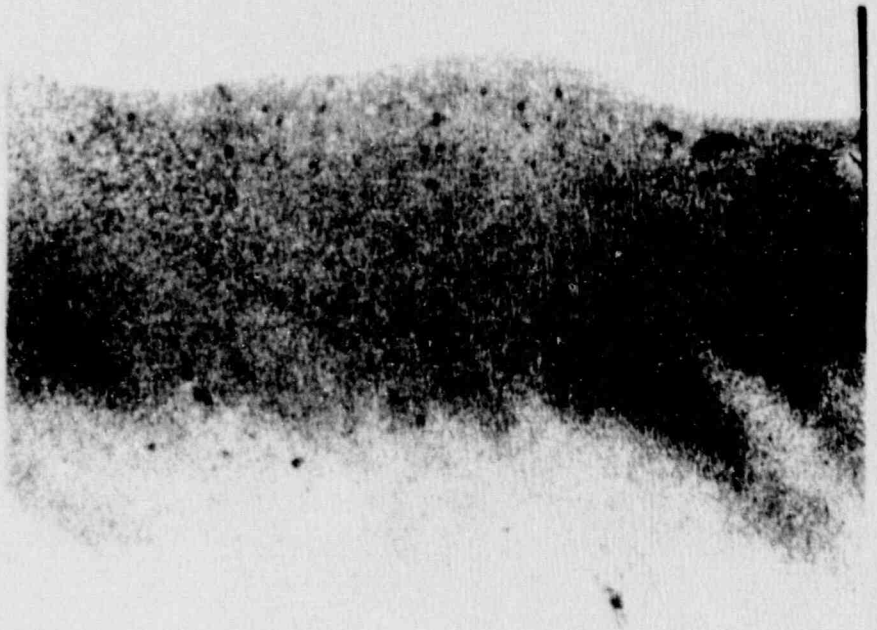
Distance from Surface	HRC
.003	34
.100	32
.143, corner	35, 34
.100 from corner, Horiz.	32
.200	33
.300	33
.400	33

Sample D

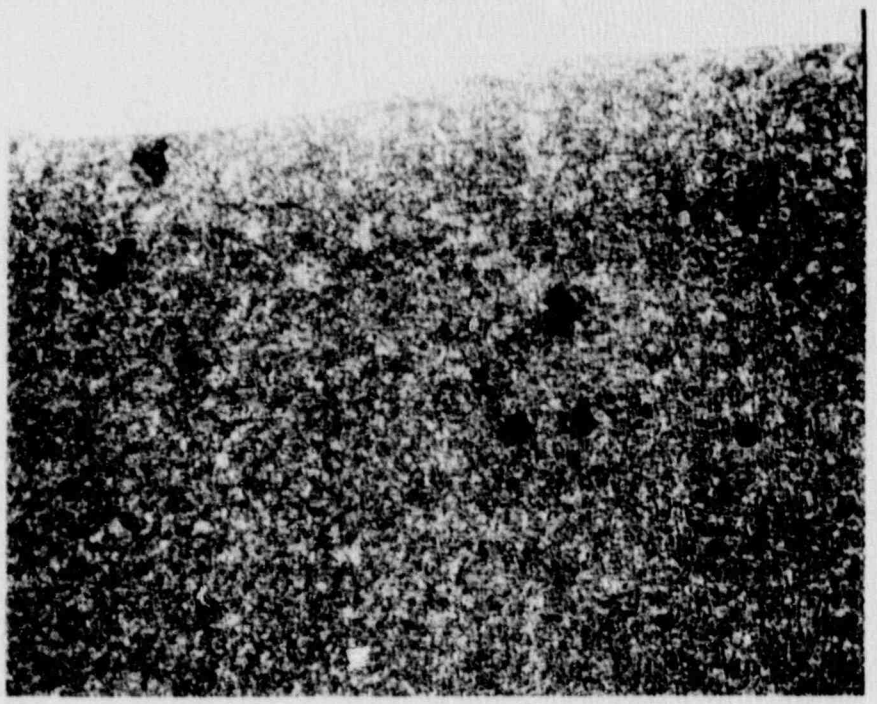
Distance from Surface	HRC
.003	31.5
.043	32
.143	28
.149, corner	28
.000, corner	31
.100 from corner, Horiz.	34
.200 from corner, Horiz.	37



BOTTOM HEAT AFFECTED ZONE MICROSTRUCTURES
1 1/4" WATERBACKED



FW2M-1D
50X



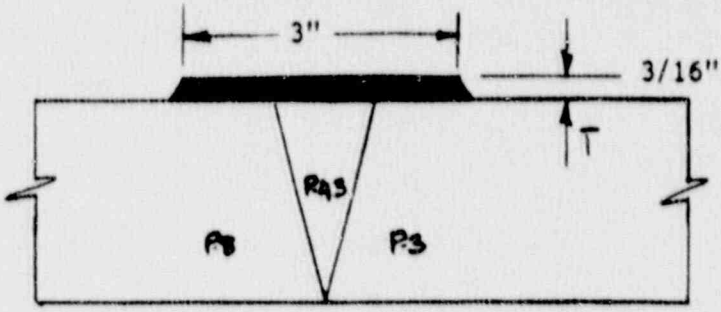
FW2M-1D
200X

PROCEDURE QUALIFICATION RECORD (PQR)

(SEE QW-201.2, SECTION IX, ASME BOILER AND PRESSURE VESSEL CODE)
RECORD ACTUAL CONDITIONS USED TO WELD TEST COUPON.

PROCEDURE QUALIFICATION RECORD NO. PQR-3/8-T-006 DATE 12/15/88
WPS USED FOR TEST WELD WPS-3/8-T-002-NES REV. A
WELDING PROCESS(ES) GTAW
TYPES (MANUAL, AUTOMATIC, SEMI-AUTO.) MACHINE

JOINTS (QW-402)



GROOVE DESIGN OF TEST COUPON
(FOR COMBINATION QUALIFICATIONS, THE DEPOSITED WELD METAL THICKNESS WILL BE RECORDED FOR EACH FILLER METAL OR PROCESS WELD.)

BASE METALS (QW-403)
MATERIAL SPEC. SA508/Inconel/SA376
TYPE OR GRADE Class 2/182/TP 304
P-NO. 43 GR-NO. -
TO P-NO. 3 Gr.3/43/8 Gr.1
THICKNESS OF BACKING 1 1/4 inch
DIAMETER OF TEST COUPON 14" OD
OTHER See Figure

FILLER METALS (QW-404)
WELD METAL ANALYSIS A-NO. ER NiCr-3
SIZE OF FILLER METAL 0.035" Dia
FILLER METAL F-NO. 43
SFA SPECIFICATION 5.14
AWS CLASSIFICATION ER NiCr-3
OTHER

POSITION (QW-405)
POSITION OF GROOVE 5G
WELD PROGRESSION (UPHILL, DOWNHILL) Down
OTHER

PREHEAT (QW-406)
PREHEAT TEMPERATURE 70°F min
INTERPASS TEMPERATURE Higher than 80°F.
OTHER

POSTWELD HEAT TREATMENT (QW-407)
TEMPERATURE NONE
TIME N/A
OTHER N/A

GAS (QW-408)
TYPE OF GAS OR GASES ARGON
COMPOSITION OF GAS MIXTURE 100% Weld Grade
OTHER 35 CFH

ELECTRICAL CHARACTERISTICS (QW-409)
CURRENT Direct
POLARITY Straight
AMPS. *160-240Peak VOLTS 9.4-9.8 Peak**
TUNGSTEN ELECTRODE SIZE 1/8" EWTH
OTHER *110 -140 Backgr.
**8.4-9.8 Backgr.

TECHNIQUE (QW-410)
TRAVEL SPEED 3.0-7.6 IPM arc speed
STRING OR WEAVE BEAD Layer 1-3 String. *
OSCILLATION 0-3/4 inch for Weave Beads.
MULTIPASS OR SINGLE PASS (PER SIDE) Multiple
SINGLE OR MULTIPLE ELECTRODES Single
OTHER Water Backed for all layers.
Min. Water Temp = 80°F.
*Layers 4 and above, Weave.

TENSILE TEST (QW-150) PQR NO. PQR-3/8-T-006

SPECIMEN NUMBER	WIDTH	THICKNESS	AREA	ULTIMATE TOTAL LOAD (lb.)	ULTIMATE UNIT STRESS (psi)	TYPE OF FAILURE & LOCATION
N/A						
N/A						
N/A						
N/A						

GUIDED BEND TESTS (QW-160)

TYPE AND FIGURE NUMBER	RESULT
180° Side Bend, 4T, Sample FWQS-1	Satisfactory
" " , " " " -2	"
" " , " " " -3	"
" " , " " " -4	"

TOUGHNESS TESTS (QW-170)

SPECIMEN NUMBER	NOTCH LOCATION	NOTCH TYPE	TEST TEMP.	IMPACT VALUES	LATERAL EXP.		DROP WEIGHT	
					SHEAR	MILS	BREAK	NO BREAK
FWQC-1	Overlay Toe HAZ	V	40°F	148	79%	84	N/A	N/A
FWQC-2	"	"	"	164	100%	89	N/A	N/A

FILLET WELD TEST (QW-180)

RESULT - SATISFACTORY: YES N/A NO N/A PENETRATION INTO PARENT METAL: YES N/A NO N/A

MACRO - RESULTS N/A

OTHER TESTS

TYPE OF TEST N/A

DEPOSIT ANALYSIS N/A

OTHER N/A

WELDER'S NAME: Roy Button CLOCK NO. N/A STAMP NO. A

TESTS CONDUCTED BY: Anamet Laboratories LABORATORY TEST NO. 1188.299

WE CERTIFY THAT THE STATEMENTS IN THIS RECORD ARE CORRECT AND THAT THE TEST WELDS WERE PREPARED, WELDED AND TESTED IN ACCORDANCE WITH THE REQUIREMENTS OF SECTION IX OF THE ASME CODE.

CERTIFIED BY: Bhaven Chakravarti DATE 12/19/88

QUALIFICATION SUPERVISOR

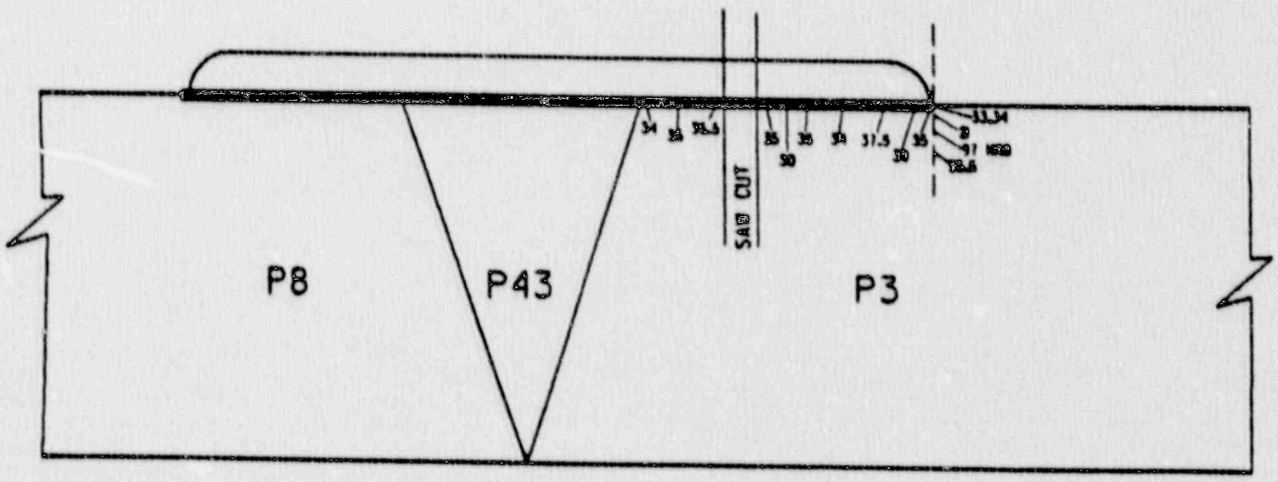
(DETAIL OF RECORD OF TESTS ARE ILLUSTRATIVE ONLY AND MAY BE MODIFIED TO CONFORM TO THE TYPE AND NUMBER OF TESTS REQUIRED BY THE CODE.)

DIMMES.34-02

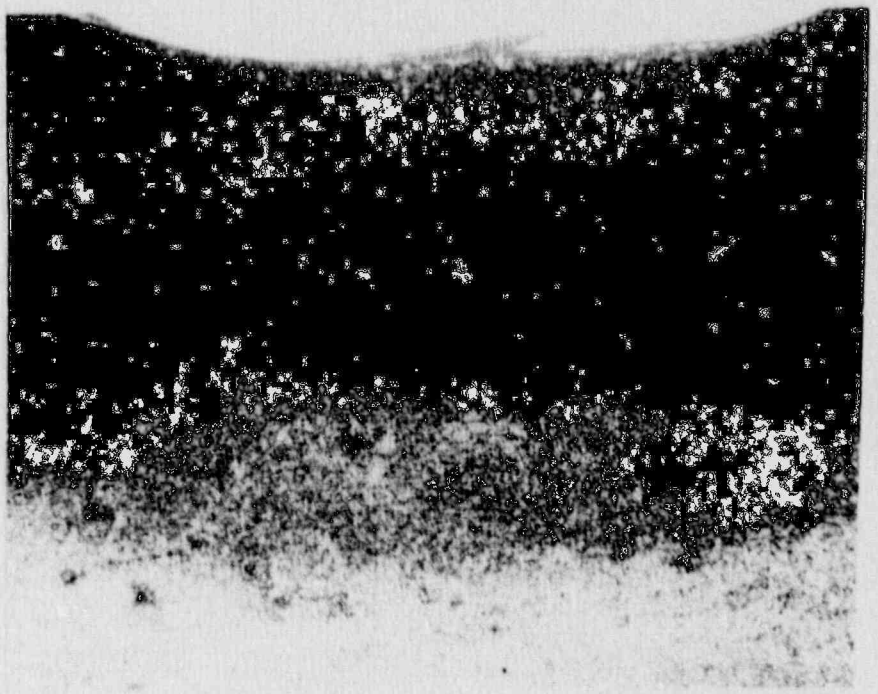
WELD OVERLAY HARDNESS PROFILE
1 1/4" WATERBACKED CASE (W03)

Horizontal Traverse in HAZ	
Distance from Surface	HRC
Toe, .000 from corner	34
.044	38
.130	37.5
.230	34
.330	36
.377	30
.430	35
.004, Sample W043	31.5
.079, Sample W043	35.5
.104	35.5
.204	36
.304	36
.404	34
.504, corner, 182 weld	31

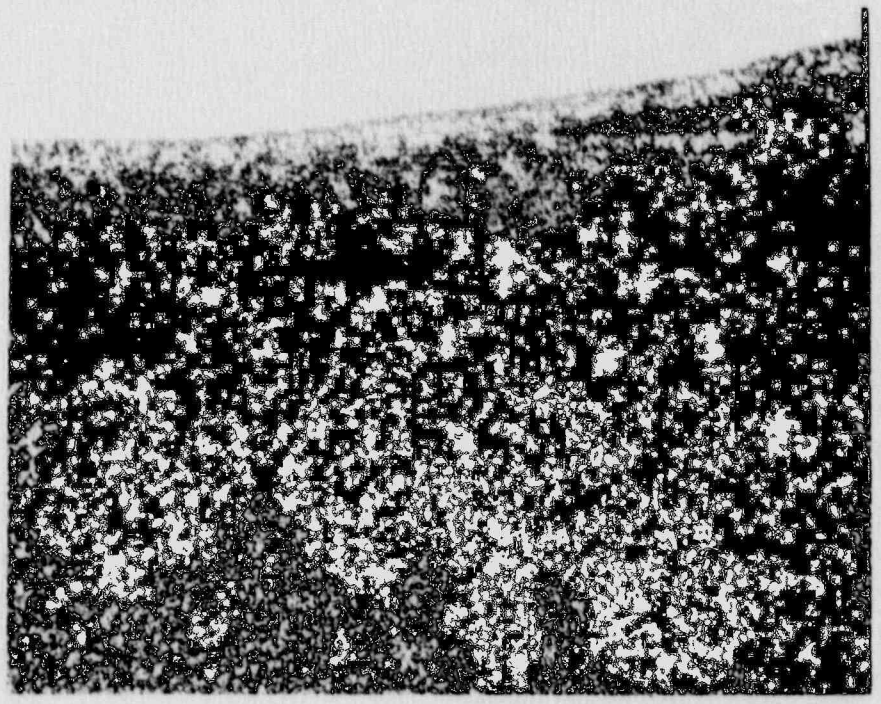
Vertical Traverse at Toe Area	
Distance from Surface	HRC
.001 from surface	33, 34
.00[illegible]	34
.012	34
.037	35
.062	21
.087	97 HRB
.137	95.5



OVERLAY HEAT AFFECTED ZONE MICROSTRUCTURES
1 1/4" WATERBACKED



W03
50X



W03
200X

FILLER METAL ISSUE SLIP

Welder's Name ROY BUTTON Symbol A

AWS Classification A 5.14, ERNiCr-3 Heat/Lot No. SNX 5446D

Weld Identification WPS-3/8-T-002-NES, Rev. A

Authorised by B. CHAKRAVARTI Date 11/12/88

Issued by B. CHAKRAVARTI Date 11/12/88 Time AM

Quantity Issued: THREE (3) - 2.5 lbs of REEL OF ERNiCr-3 0.035 Ø (SFA 5.14) wire.

RC

FILLER METAL ISSUE SLIP

Welder's Name ROY BUTTON Symbol A

AWS Classification A 5.14, ERNiCr-3 Heat/Lot No. SNX 5446D

Weld Identification WPS-3/8-T-008-NES, Rev. A

Authorized by B. CHAKRAVARTI Date 11/14/88

Issued by B. CHAKRAVARTI Date 11/14/88 Time AM

Quantity Issued: THREE (3) - 2.5 lbs Spools of ERNiCr-3 WIRE, 0.035" ϕ, SFA 5.14.

FILLER METAL ISSUE SLIP

Welder's Name ROY BUTTON Symbol A

AWS Classification A 5.14, ERNiCr-3 Heat/Lot No. SNX 5446D

Weld Identification WPS-3/8-T-002-NES, Rev. A

Authorized by B. CHAKRAVARTI Date 11/15/88

Issued by B. CHAKRAVARTI Date 11/15/88 Time AM

Quantity Issued: THREE (3) - 2.5 Lbs Spools of ERNiCr-3 WIRE, 0.035" Ø, SFA 5.14.

BC

SANDVIK Steel

MATERIAL CERTIFICATE

SANDVIK STEEL CO.
P.O. BOX 1220, SCRANTON, PA. 18501 PH: 717 - 587-3191
PLANT LOCATION: INTERSTATE 81, WAVERLY EXIT 59

CUSTOMER PURCHASE ORDER NO	SANDVIK ORDER NO	ITEM	SPECIAL CODE	MARKS	CERTIFICATE DATE
XGU-5020	127394		52900		10/19/88

SOLD TO: NUTECH ENGINEERING
SAN JOSE CA

GAPCO INC
DIAMOND SPRINGS CA

SPECIFICATION AND MATERIAL:
AWS A-5.14

NICKEL ALLOY WELDING WIRE TYPE ER NiCr-3 .035" x 2.5

Filler Metal Analysis, %

Heat	C	Si	Mn	P	S	Cr	Ni
SNX5446D	.050	.07	2.90	.015	.001	21.13	71.10

Fe	Mo	W	Co	V	Ti	Cu
1.39	.16		.04		.41	.14

Al	Cb/Nb	Cb/Nb+Ta	Ta	Others .5 max.
	2.59		.01	

Quantity shipped per packing note.

Inspected 2 Boxes.
(1) Box 1 - Containing 10 spools, 2.5 lbs each of Heat SNX5446D ER NiCr-3 Wire, .035"
(2) Box 2 - Containing 20 spools, 2.5 lb each of Heat SNX5446D, ER NiCr-3 Wire, 0.035"
Product accepted per this data sheet
Bhaven Chaturvedi

Bengt H. Berg, Manager, Product Quality and Metallurgy/emb

55(N-B-A-3, REV. 8)

APPENDIX C

Mockup Nozzle - Safe End Assembly Chemical and Physical Properties, Heat Treatments, and QA Test Results

THE BABCOCK & WILCOX COMPANY
POWER GENERATION GROUP

TECHNICAL PROCEDURE

NUMBER
12-HT-100, Rev. 5

SECTION	SUBJECT
MOUNT VERNON QUALITY ASSURANCE	POSTWELD HEAT TREATMENT OF NUCLEAR WELDMENTS
RELEASE NO. 344	APPROVED BY: [signature] DATE: March 3, 1977

1. SCOPE:

1.1 This Technical Procedure shall govern the postweld heat treatment of weldments on nuclear components made to Sections III and IX of the ASME Boiler and Pressure Vessel Code. This includes weldments joining ferritic pressure parts, nonpressure parts to pressure parts, cladding on ferritic materials, and repairs in ferritic weld and base materials.

1.2 Postweld heat treatment shall not be required for welds joining austenitic materials or for welds to cladding on ferritic materials provided that the cladding is a minimum of 1/8" thick.

2. BASE MATERIALS:

The base materials used in the fabrication of weldments to be postweld heat treated in accordance with this procedure shall be those listed under P-Numbers 1 and 3 of Section IX of the ASME Boiler and Pressure Vessel Code or other similar approved materials.

3. METHODS OF POSTWELD HEAT TREATMENT:

The weldments shall be postweld heat treated by any of the following methods:

3.1 Heating the complete assembly as a unit in the furnace.

3.1.1 Prior specific approvals of Quality Assurance shall be required in the event the entire unit will not be put into the furnace at one time. This operation shall also require approval by Engineering.

4. CLEANNESS PRIOR TO HEAT TREATMENT:

Immediately prior to any heat treatments, all Inconel and stainless steel wrought materials shall be free of oil, grease and other sulfur and chloride-bearing compounds. The remaining surfaces of the component shall be broom cleaned.

Prior to final heat treatment, all weld spatter shall be removed.

5. TEMPERATURE MEASUREMENTS:

5.1 Thermocouples and their installation: Thermocouples shall be in contact with the vessel surface and shall be protected against flame impingement or direct radiant heating of resistance elements.

Issued: 9-7-72	Revisions: Revised paragraphs 1.2, 2,4 and 8. Added new sentence at end of paragraph 5.1.1.	Revised: 11-6-76
Prepared by: GF/CRP		Page 1 of 3

5.1.1 Intermediate postweld heat treatment shall be governed by readings obtained with thermocouples attached to the anticipated hottest and coldest points on each component in the furance charge. Thermocouples are required only on a minimum of four components in a furnace charge provided these components are distributed to represent the entire furnace charge.

5.1.2 Final postweld heat treatment shall be governed by readings obtained with thermocouples attached to the anticipated hottest and coldest points on each weldment in the furnace charge.

5.1.3 Temperature calibration shall be in accordance with Quality Assurance Technical Procedure 12-2-HT-1.

5.2 Temperature Control: Temperature control shall be accomplished with the aid of automatic strip chart recording controllers in conjunction with manual control. Temperature shall be recorded on strip chart recorders, or, when a potentiometer is employed, the operator shall maintain a log of the temperature readings taken at 15 minute intervals.

5.3 Records: Heat treatment charts or temperature logs shall be maintained in the files of the Babcock & Wilcox Company for three (3) years. Copies of these records shall be furnished to the customer and Authorized Inspector at their request.

6. FURNACE PROCEDURE:

6.1 When weldments are placed in the furnace, the temperature of the furnace shall not be less than the temperature of the weldments, nor shall the furnace temperature exceed 600 degrees F.

6.2 During the heating and holding periods, the furnace atmosphere shall be so controlled as to avoid excessive oxidation of the surface of the vessel. The furnace shall be of such design as to prevent direct impingement of the flame on the vessel.

6.3 Above 800 degrees F., the rate of heating shall not exceed 400 degrees F. per hour divided by the maximum weld thickness in inches, but shall not exceed 400 degrees F. per hour. The heating rates need not be less than 100 degrees F. per hour. At all times the temperature differentials shall not exceed that established by Engineering. During the heating period, there shall not be a variation in temperature greater than 250 degrees F. within any 15 ft. interval of length throughout the portion of the vessel being heated.

6.4 The vessel or vessel part shall be held within the temperature range and for the time specified in the applicable portion of Section 7.

6.5 Above 800 degrees F., cooling shall be done in a closed furnace or cooling chamber at a rate not greater than 400 degrees F. per hour divided by the

maximum weld thickness, but shall not exceed 400 degrees F. per hour. The cooling rate need not be less than 100 degrees F. per hour. At all times the temperature differentials shall not exceed that established by Engineering.

6.6 When pressure parts of two different P-Number groups are joined by welding, the postweld heat treatment shall be that applicable for the material requiring the higher postweld temperature. When nonpressure parts are welded to pressure parts, the postweld heat treatment temperature of the pressure part shall control.

6.7 During the holding period of postweld heat treatment, the maximum temperature of any vessel component shall not exceed the lowest tempering temperature of that component.

6.8 The sulfur content of furnace fuels used in heat treatments involving Inconel materials shall be limited to 30 grains per 100 cubic feet of gas and 0.5 percent by weight for oil.

7. POSTWELD HEAT TREATMENT:

7.1 Intermediate: To prevent welding or dimensional problems, weldments may be given an intermediate postweld heat treatment if it is considered necessary by the welding or the manufacturing engineer. This shall be done by heating the weldment to a temperature of 1100 degrees F. to 1150 degrees F. and holding at that temperature for 15 minutes. Furnace procedure shall be in accordance with Paragraph 6 except the maximum rate of temperature rise and fall need not be less than 200 degrees F. per hour. These weldments shall receive a subsequent final heat treatment at the temperature and minimum time specified in Paragraph 7.2 of this Technical Procedure.

7.2 Final: Final postweld heat treatment is by definition the last heat treatment of the component, either as an individual component or part of an assembly, prior to placing the component into service. Heat treatment shall be accomplished by heating the component to a temperature of 1100 degrees F. to 1150 degrees F. The minimum holding time at temperature shall be for one hour per inch of weld thickness up to and including 2 inches. For thicknesses exceeding 2 inches the minimum holding time shall be 2 hours, plus an additional 15 minutes for each additional inch or fraction thereof of thicknesses over 2 inches. The time at temperature shall be determined by the greatest thickness of weld requiring final postweld heat treatment, which is in the furnace charge. The furnace procedure shall be in accordance with Paragraph 6.

8. DEFINITION OF HOLD TIME:

Hold time is defined as the cumulative time at postweld heat treatment temperature, that is, total time between the last thermocouple to enter the heat treating temperature range and the first thermocouple to leave the range permanently minus the time that any thermocouple is out of the range.

CERTIFICATE OF TEST ON PIPE MATERIAL

Cameron IRON WORKS, INC.
P. O. BOX 1212
HOUSTON, TEXAS 77001

SOLD TO
THE BABCOCK & WILCOX CO.
POWER GENERATION GROUP
91 STIRLING AVE.
BARBERTON, OH 44203

ASME QUALITY SYSTEM CERTIFICATE (MANUFACTURER)
NO. N-1261 EXPIRES 10-27-78

620-0031-50-22 Date 19 May 1978

Customer Order No.	C.I.W. Sales Order No.	
384337 JT	F-9216	ASME SA376 TP304 Sec. III, Class 1 thru Winter 1974 with .20% Cobalt

Description of Material O.D. 14" x I.D. ____ x WALL SCH 160

C.I.W. Part No. 06-9216-140-112

Heat No.	Location or Serial No.	CHEMICAL ANALYSIS C	MN	P	S	SI	CR	NI	TI	Nb+Ta	Co	N
J 6456		.049	1.65	.020	.015	.37	18.60	9.53	.01	(.01	.07	.14

ALL OPERATIONS WERE PERFORMED BY CIW & MEET THE REQUIREMENTS OF THE LISTED MATERIAL SPECIFICATION AND SEC. III, DIV. 1.

P-8, Gr 1

Quantity or Serial No.	Heat No.	TEst Loc.	MECHANICAL PROPERTIES Tensile PSI	.2 % Offset Yield PSI	% Elong. in. 2	% Red. Area	Macro Etch	Bend Test	Flattening Test	Specimen Size	Test Lot#
3	J 6456	Trans.	86,100	45,200	51.8	68.8			OK	.505	687

Forg. Ser.#	Test Lot#	Heat#
30352Y	687	J 6456
30352Z	"	"
30353	"	"

TEST REPORT APPROVED BY MT. VERNON MATERIALS ENGINEERING 6-7-78

One length of pipe per heat per heat treat lot has been tested for intergranular corrosion in accordance with practice "E" of ASTM A262-70 and found acceptable.

Pipe has been ultrasonically examined in accordance with approved CIW Procedure PU-33, Rev. 'A' and found acceptable. Report attached.

Hydrostatic Test: Pipe has been hydrostatically tested at 2800 psi for 5 sec. and found acceptable.

Heat Treatment:
1925°F., hold 1.50 hrs. at temp. Water Quenched.
Heat Treat Charts attached.

Subscribed and Sworn to before me this 7th Day of June 1978

G. A. LOUCHLON
Notary Public in And for Harris County, Texas
My Commission Expires June 1, 1979

I certify these tests to be correct as contained in the records of the company.

Metallurgical Representative O. WRIGHT

XGU-05-211
Revision 0

C.5

2311

E.Lamb UT-4

UT-12

Cameron
IRON WORKS, INC.

P. O. BOX 1212 HOUSTON, TEXAS 77001

ULTRASONIC EXAMINATION REPORT

CIW INSPECTOR: R.Reichardt DATE: 5-12-78

SNT-TC-1A Level II

CUSTOMER: Babcock & Wilcox U.T. PROCEDURE: PU-33 Rev. A PART NO.: 86-9216-140-112

SPECIFICATION: ASME SA376 TP304 SEC. III, CL.I MATERIAL: 304 S/S
thru WINTER 1974 With .20% Cobalt

INSTRUMENT: Ultrasonoscope Series 10

METHOD: Contact TECHNIQUE: Pulse Echo COUPLANT: Water

OVERLAP: 10% SCANNING SPEED (MAX.) 60' 1 minute

INDEXING: Automatic Helical Scan

SCANNING: Pipe rotated on rolls with search units in fixed position

CIW PCS.	HEAT #	LENGTH	INSP
30352-Y	J 6456	11' 4 3/4"	4
30352-Z	"	12' 11"	4
30353	"	17' 7"	12

MIN. WALL 1.230"

REF. WALL 1.475"

NOTCH (I.D.) .074"

NOTCH (O.D.) .074"

LONGITUDINAL MODE

SURFACE SCANNED	SEARCH UNIT	REFERENCE STANDARD	STANDARDIZATION

SHEAR MODE

SURFACE SCANNED	SEARCH UNIT	REFERENCE STANDARD	STANDARDIZATION
O.D. (2) Shear Wave circ. direction	Branson 2.25 MHZ 1"x1" (2) 45°	5% I.D. & O.D. NOTCH	80% on O.D. NOTCH

REPORTABLE INDICATIONS

IND. #	DISTANCE FROM END "A"	CIRCUM. LENGTH	AXIAL LENGTH	DEPTH FROM OD	CLOCK POSITION	INDICATION AMPLITUDE	LOSS OF B. R.	REMARKS
	1							

TEST REPORT APPROVED BY MT. VERNON
MATERIALS ENGINEERING L. J. Hutton 6-19-78

RESULTS: ☐ REPORTABLE INDICATIONS RESOLVED ARE INCLUDED IN THIS REPORT. ☐ ACCEPT ☐ REJECT

☒ NO REPORTABLE INDICATIONS AND NO REPORTABLE LOSS OF BACK REFLECTION WERE NOTED.

☒ THE PARTS WERE TESTED IN ACCORDANCE WITH THE ABOVE PROCEDURE AND FOUND TO BE ACCEPTABLE.

SIGNED: Joe Ellers

SNT-TC-1A Level III

552

XGU-05-211
Revision 0

C.6

Lenape Forge Division
Energy Products Group
GULF-WESTERN MANUFACTURING COMPANY

P.O. Box 638, West Chester, Pennsylvania 19380
PHONE 215-793-1500 TWX 510-663-0372 TELEX 083-5453

S.O. No. 2768-4

MATERIAL TEST REPORT

DATE December 2, 19 75

Purchaser The Babcock & Wilcox Company

Purchaser's Order No. P.O. 635595 Contract 620-0030-55-10

Distributor

Distributor's Order No.

ITEM NO.	QTY.	PRODUCT	SPEC.	HEAT OR CODE NO.	FORGING NO.	HEAT TREATMENT	FCE. CHARTS ATTACHED YES	FCE. CHARTS ATTACHED NO
1	4	Feedwater Inlet Nozzle per B&W Dwg. 133947D-2 MATERIAL INCLUDED ON THIS TEST REPORT WAS MANUFACTURED UNDER ASME QUALITY SYSTEMS CERTIFICATE (MATERIALS) NO. N-892 EXPIRES OCTOBER 28, 1977.	SA508-2 per B&W Spec. CE-NPS-004, Rev. 2 ASME Code 1971 Ed. Sect. III thru Summer '73 Add.	Q2QL8QT P-3 Gr 3	61F-1, 2, 3, 4	HT-12, Rev. 2 1660°F±15°F for 8 hrs.-air cool 1560°F±15°F for 4½ hrs.-water quench 1290°F±15°F for 4½ hrs.-air cool Test specimens were stress relieved as follows: Held @1125°F±25°F for 50 hrs. Cooling to 600°F @ a furnace cool.		X

CHEMICAL ANALYSIS AND MECHANICAL PROPERTIES

FORGING NO.	HEAT NO.	C	MN	P	S	SI	CR	NI	MO	V			NDT REPORTS ATTACHED U.T.	M.P.	D.P.	REMARKS
61F-	Q2QL8QT	.20	.76	.010	.009	.28	.35	.83	.60	.02	Ladle		X	X		P-3 dropweight specimens, four (4) no breaks per forging two (2) each @180° apart @+50°F to qualify an NDTT of +40°F.
1		.24	.71	.011	.010	.26	.32	.80	.55	.01	Check		NDT Procedure #'s			
2		.18	.72	.012	.010	.29	.34	.81	.57	.01	Check		UT-71-1, Rev. 3 dated 10/25/73			
3		.19	.75	.015	.009	.28	.33	.83	.57	.01	Check		MP-2543-3, Rev. 0, Mod. 2 dated 11/16/73			
4		.19	.76	.017	.010	.28	.34	.84	.57	.01	Check					

TEST REPORT APPROVED BY MT. VERNON

MATERIALS ENGINEERING [illegible] 12-18-75

IT-2768-41, Rev. 3

FORGING NO.	HEAT NO.	Axial Testing TEST TEMP.	TENSILE PSI x 1000	YIELD PSI x 1000	ELONG. % in 2"	R.A. %	S.H.N.	(V-Notch at See Below) IMPACT TESTS (Keyhole @) ENERGY (ft-lbs.)	LATERAL EXP. (in.)	% SHEAR
61F-1	Q2QL8QT	R.T. 0°	89.262	67.716	26.0	70.8	Axial	208-213-223	.085-.097-.090	100-100-100 @+40°F
		180°	93.545	70.225	24.0	70.7		210-217-192	.089-.102-.093	100-100-100 @+40°F
		0°					Tang.	103-107-111	.078-.077-.083	100-100-100 @+100°F
		180°						110-99-112	.082-.077-.080	100-100-100 @+100°F
-2		0°	88.660	66.950	25.5	73.4	Axial	233-240-240	.084-.068-.094	100-100-100 @+40°F
		180°	86.788	65.057	27.0	75.2		240-240-240	.090-.090-.086	100-100-100 @+40°F
		0°					Tang.	96-99-107	.076-.069-.078	100-100-100 @+100°F
		180°						102-110-111	.079-.083-.075	100-100-100 @+100°F

"Major direction of working is axial." RT

NDT = +40°F.

F. P. Fitting

We hereby certify the above results to be correct as contained in the records of the Company.

XGU-05-211
Revision 0

C.7

Lehigh Forge Division
Energy Products Group
GULF+WESTERN MANUFACTURING COMPANY

P.O. Box 638, West Chester, Pennsylvania 19380
PHONE 215-793-1500 TWX 510-663-0372 TELEX 083-5493

S.O. No. 2768-4

MATERIAL TEST REPORT

DATE December 2, 19 75

Purchaser The Babcock & Wilcox Company

Purchaser's Order No. P.O. 635595CR Contract 620-0030-55-10

Distributor

Distributor's Order No.

ITEM NO.	QTY.	PRODUCT	SPEC.	HEAT OR CODE NO.	FORGING NO.	HEAT TREATMENT	PCE. CHARTS ATTACHED YES	PCE. CHARTS ATTACHED NO
		MATERIAL INCLUDED ON THIS TEST REPORT WAS MANUFACTURED UNDER ASME QUALITY SYSTEMS CERTIFICATE (MATER ALS) NO. N-002. EXPIRES OCTOBER 22, 1977.						

CHEMICAL ANALYSIS AND MECHANICAL PROPERTIES

FORGING NO.	HEAT NO.	C	MN	P	S	SI	CR	NI	MO				NDT REPORTS ATTACHED U.T.	M.P.	D.P.	REMARKS

IT-2768-41, Rev. 3

Axial Testing

FORGING NO.	HEAT NO.	TEST TEMP.	TENSILE PSI x 1000	YIELD PSI x 1000	ELONG. % in 2"	R.A. %	S.M.N.	IMPACT TESTS (V-Notch at Sea Below; Keyhole @) ENERGY (ft-lbs)	LATERAL EXP. (in")	% SHEAR
51F-3	Q20L8QT	R.T. 0°	92.619	70.518	26.0	73.7	Axial	206-192-203	.087-.100-.090	100-100-100 @ +40°F
		180°	92.836	70.747	24.0	73.1		180-182-191	.093-.093-.096	100-100-100 @ +40°F
		0°					Tang.	121-120-100	.090-.080-.076	100-100-100 @ +100°F
		180°						113-112-110	.079-.086-.079	100-100-100 @ +100°F
-4		0°	93.438	70.470	24.5	73.1	Axial	192-206-203	.090-.090-.098	100-100-100 @ +40°F
		180°	91.780	69.420	26.0	73.4		197-223-184	.109-.089-.092	100-100-100 @ +40°F
		0°					Tang.	116-122-103	.080-.083-.081	100-100-100 @ +100°F
		180°						106-94-118	.082-.075-.086	100-100-100 @ +100°F

TEST REPORT APPROVED BY MT. VERNON SHEET 2 of 2

MATERIALS ENGINEERING D Bergmann 12-18-75

F. P. Fitzgerald

We hereby certify the above results to be correct

GW Lenape Forge Division
Energy Products Group
GULF+WESTERN MANUFACTURING COMPANY

P.O. Box 630, West Chester, Pennsylvania 19380
PHONE 215-793-1500 TWX 510-663-0372 TELEX 083-5493

ULTRASONIC INSPECTION RECORD

Report Date December 3, 1975

7355950R
Contract No. 620-0030-55-1

Mill Order No. 61F

S.O. No. 2768-4

Heat No. 02018QT Pc. No 1, 2, 3, 4 Item No. 1

Procedure No. UT-71-1, Rev. 3

Identification of piece (s) Feedwater Inlet Nozzle per B&W Dwg. 133947D-2

INSTRUMENT USED	TRANSDUCER	SIZE	FREQUENCY	ANGLE	COUPLANT
Krautkramer USIP-11	Aerotech	½" x 1" 1"	1.00 MHz 2.25 MHz	45° Shear Long'l	Oil

Results Forgings were ultrasonically tested in accordance with the above procedure and were found to be acceptable with no reportable or rejectable indications.

TEST REPORT APPROVED BY MT. VERNON MATERIALS ENGINEERING 12-18-75

Witnessed by [illegible]

Inspected by Edward J. Mohr

Date of Examination 12/3/75

GW Lenape Forge Division
Energy Products Group
GULF+WESTERN MANUFACTURING COMPANY

P.O. Box 838, West Chester, Pennsylvania 19380
PHONE 215-793-1500 TWX 510-663-0372 TELEX 083-5453

MAGNETIC PARTICLE INSPECTION RECORD

Report Date December 3, 1975 100% X Other Contract No. 635595CR 620-0030-55-10

Mill Order No. 61F S. O. No. 2768-4

Heat No. Q2QL8QT Pc. No. 1, 2, 3, 4 Item No. 1

Procedure No. MP-2543-3, Rev. 0, Mod. 2

Identification of Piece(s) Feedwater Inlet Nozzle per B&W Dwg. 133947D-2

MACHINE USED Sonoflux AH-15 PROD SPACING 6" AMPS 125 amps./in. D.C.

RESULTS Forgings were magnetic particle tested in accordance with the above procedure and were found to be acceptable with no reportable or rejectable indications.

TEST REPORT APPROVED BY MT. VERNON MATERIALS ENGINEERING 12-18-75

Witnessed by L. K. Lift B&W

Inspected by Edmund J. Mohr

Date of Examination 12/2/75 & 12/3/75

XGU-05-211
Revision 0

C.10

HUNTINGTON ALLOYS, INC.

HUNTINGTON, WEST VIRGINIA 25720

Welding Products

TEST REPORT

SHIP TO: HAI - CLEVELAND OHIO
ATTN-R.J. REAGY-MATERIALS PROCUREMENT DEPT
POWER GENERATION DIV
BABCOCK & WILCOX CO
P O BOX 351
BARBERTON OHIO 44203

CHARGE ORDER NO. 317934-CL

PRIME CONTRACT NUMBER

QPL NUMBER

DATE 10-17-75 PAGE 1 OF 1

MARK ORDER NO. E51609 INSP BY HAI

PREPARED PRIOR TO [ ] AFTER [X] SHIPMENT

CERTIFICATE OF [ ] CHEMICAL ANALYSIS [ ] COMPLIANCE [X] WELD DEP [ ] TEST

SPECIFICATIONS: ASME BOILER & PRESSURE VESSEL CODE 197 EDITION SECTION 2 PART C SFA 5.11 CLASS ENICrFe-3 (MARKING WAIVED) ASME SECTION 3 - 1971 EDITION - 1973 WINTER ADDENDA EXCEPT SUB SECTION NA 3700 WAIVED.

THIS IS TO CERTIFY THAT ALL REQUIRED INSPECTIONS AND TESTS HAVE BEEN COMPLETED IN ACCORDANCE WITH THE ORDER REQUIREMENTS AND THAT THE VALUES SHOWN ARE CORRECT AND TRUE BASED ON THESE TESTS. THE MATERIAL COMPLIES WITH THE ORDER REQUIREMENTS.

R. J. Reagy
QUALITY CONTROL DEPARTMENT

STATE OF WEST VIRGINIA COUNTY OF CABELL. SUBSCRIBED AND SWORN TO BEFORE ME THIS 20 DAY OF OCT 1975. MY COMMISSION EXPIRES NOV. 8, 1984.
NOTARY PUBLIC K Hodges

ITEM	DESCRIPTION OF MATERIAL SHIPPED
4	INCONEL WELDING MACHINE 182 RT .156" X 14.000" FOLIO #959001

HEAT NO	C	MN	FE	S	SI	CU	NI (1)	CR	AL	TI		CO	MO	CB + TA	TA %	P %	OTHERS < %
CONTROL NO																	
4537	0 04	06 66	09 42	008	00 44	00 10	67 52	14 69		0 47		00 05	00 13		CB 01 61	TA 00 01	0 50
							* INCLUDED IN THE NICKEL PERCENT REPORTED.										

ITEM	QUANTITY	HEAT NO	TENSILE RESULTS (AS SHIPPED) - ROOM TEMP: YIELD STRENGTH .2% OFFSET PSI (KSI)	TENSILE STRENGTH PSI (KSI)	ELONG %	R.O.A. %	BEND TESTS (GUIDED OR OTHERWISE): SIDE 1	SIDE 2	SIDE 3	SIDE 4	SIDE 5	SIDE 6	TEST 7 OVERLAY	GOOT: TEST 0	GOOT: TEST 1	GOOT: TEST 2	PACE: TEST 0	PACE: TEST 1	PACE: TEST 2	COVERING CONCENTRICITY MAXIMUM DEVIATION
		CONTROL NO																		
4		4537																		

OCT 31 1975
R. REAGY

REMARKS AND RESULTS OF FURTHER EXAMINATION: NOTE: NI(1) UNLESS OTHERWISE SHOWN %NI INCLUDES A SMALL AMOUNT OF COBALT

WELDING CURRENT AMPS [ ] DCSP [ ] DCRP VOLTS [ ] CAST AND HELIX COMPLY WITH SPECIFICATION REQUIREMENTS.

FISSURES WERE MEASURED AND DO NOT EXCEED SPECIFICATION LIMITS EITHER IN NUMBER OR SIZE.

[ ] 5 [ ] 8 [ ] 8A [ ] 9 [ ] FIGURE 1 NOIL S 21562 ◀ WELD TESTS

RADIOGRAPHIC EXAMINATION PERFORMED IN ACCORDANCE WITH SPECIFICATION REQUIREMENTS ON TESTS INDICATED AT LEFT AND RESULTS WERE SATISFACTORY

VISUAL AND DIMENSIONAL EXAMINATION OK

MATERIAL AS SHIPPED FROM HUNTINGTON PLANT FREE FROM CONTAMINATION BY HG, RA AND ALPHA SOURCE

H-525
(10-69) INCO _ CLEVELAND

MIL-E-0022200/1C(SHIPS)
CHG. TO-

INCO ORDER # E51609-4

CERTIFICATION OF QUALITY CONFORMANCE TESTS

CHG. ORDER #

Manufacturer or Distributor: HUNTINGTON ALLOY PRODUCTS DIV. THE INTERNATIONAL NICKEL CO INC

INSPECTION- INCO

Address: HUNTINGTON W. VA. 25720

Customer's Name: B&W BARBERTON OHIO

Customer's Order No.: 317934-CL

Date: 03/07/75

Core Wire Heat No.: HT1858MD

Specification MIL-E-0022200/3C AMEND 1 DTD 7-23-70 INT CHG 1 DTD 9-21-72 CLASS 2

Lot Identification MIL-E-0022200E Para. 4.4.2.1

Type MIL-8N12 (WEIGHT 2730#)

Diameter & Length .156" X 14.000"

Inspection Level A

Lot No. 4537

Chemical Analysis (Complete)

*Nickel (including cobalt)	67.52		
*Copper	0.10	*Titanium	0.47
*Manganese	6.66	Aluminum	N/A
*Iron	8.42	Columbium	1.61
*Silicon	0.44	Cobalt	0.03
*Carbon	0.04	*Tantalum	0.01
*Sulphur	0.008	Molybdenum	N/A
*Chromium	14.69	Phosphorus	N/A
*Total Other Elements	< 0.50		

Chemistry was taken from: X Chem Pad
FOLIO NO. 959001
N/A Groove Weld

X-ray Results: TEST #3-O.K.

Concentricity (%): .005

Mechanical Test

	As Welded	Heat Treat
Yield Strength (0.2% offset method)	53500	
Tensile Strength	92500	
Elongation (%)	46	
Reduction in Area	59	
Hardness (Average)	N/A	

Bend Test

Side Bend #1- 0 #2- 0 #3- 0

Transverse Face Bend: N/A

Groove Weld Test

Test No.	3	8a	Chemical P
Amperage	120	N/A	120

Pass and Layer Sequence: N/A (When required to be reported)

Grinding during 8a Test Plate Preparation Operation Error (Layer[s]): N/A

MATERIAL AS SHIPPED FROM HUNTINGTON PLANT FREE FROM CONTAMINATION BY HG, RA, & ALPHA SOU

We hereby certify that the above material has been tested in accordance with the listed specification and is in conformance with all requirement

MATERIAL WAS METAL SORTED IN ACCORDANCE WITH HAPD QCP 0066 REV 0 DTD 11-03-65. RESULTS WERE SATISFACTORY.

H. H. Wilson

STATE OF WEST VIRGINIA COUNTY OF CABELL AND WAYNE. SUBSCRIBED AND SWORN TO BEFORE ME THIS 07TH DAY OF MARCH 1975. MY COMMISSION EXPIRES JAN 16 1983. Mary D. Lorenzano NOTARY PUBLIC.

Figure 3 - Certification of Quality Conformance Tests

Notes to Figure 3:

1. Items not applicable to the type electrode involved or exempte by the procurement document shall be marked N/A.

2. This form is applicable to the quality conformance tests requi for each lot. A copy of the quality conformance test certification for lot shall be forwarded with each shipment regardless of the identificat of the wet mixes of covering mixture represented in this shipment.

... 2.0 of MIL-E-0022200E.

XGU-05-211
Revision 0

C.12

THE BABCOCK & WILCOX COMPANY
POWER GENERATION GROUP
MT. VERNON, INDIANA

RECORD OF FILLER WIRE QUALIFICATION TEST

TEST NO: EL-318

Q.C. TECHNICAL PROCEDURE	REV. NO.	WELDING PROCESS	ELECTRODE							
			SFA SPEC.	CLASSIFICATION	DIAMETER (IN.)	PURCHASED FOR CONTRACT	FOLIO NO.	VENDOR	PURCHASE ORDER NO.	HEAT OR LOT NO.
12-2-WQI-IX1C	0	Shielded Metal-Arc	5.11	ENiCrFe-3	5/32	610-0234	567-355	Huntington Alloys	317934CL	4537
12-2-WQI-IS1J	0		FLUX							
12-2-WQI-IA1J	0		SFA SPEC.	CLASSIFICATION	PARTICLE SIZE	PURCHASED FOR CONTRACT	FOLIO NO.	VENDOR	GRADE	LOT NO.

WELDING PARAMETERS

LOCATION	AMPERAGE			VOLTAGE			TRAVEL SPEED (IPM)	WIRE FEED SPEED (IPM)	CONTACT TO WORK (IN)	SHIELDING GAS		WELDING POSITION	
	DCSP	DCRP	AC	DCSP	DCRP	AC				TYPE	FLOW RATE (CFH)		
Undiluted Pad		130			23							Flat	
Joint		130			23							Flat	

CHEMICAL ANALYSIS

LOCATION	LAB NO.	C	Mn	P	S	Si	Cr	Ni	Mo	Cu	Cb	Ta	Co	N	Ti	Fe	Other
Undiluted Pad	Vendor	.04	6.66	.01	.005	.44	14.69	67.52	.13	.10	1.61	.01	.03		.47	8.42	<.50
Undiluted Pad	33184	.039	7.3	.017	.012	.66	15.0	66.0	.11	.14	1.66	.03	.06		.41	8.2	
Joint	33229	.039	7.3	.017	.012	.69	15.0	65.9	.11	.16	1.60	.05	.07		.55	6.4	
		V	Al														
Undiluted Pad	33184	.06	.05														
Joint	33229	.06	.06														

APPLICATION APPROVED

GOVERNING CODES	WELDING MATERIAL CODE	REJECT
NAVSHIPS 250/1500		
ASME CODE CODE'L. NUCLEAR	IX1C IS1J IA1J	
ASME CODE FOSSIL		
CONTRACT NO.	IX1C, IS1J & IA1J (610-0234 EWS)	

APPLICATIONS(S) APPROVED

All Positions

WE HEREBY CERTIFY THAT THE ABOVE LISTED MATERIAL HAS BEEN TESTED IN ACCORDANCE WITH THE ABOVE LISTED SPECIFICATION(S) AND IS IN CONFORMANCE WITH ALL APPLICABLE REQUIREMENTS. THE TEST DATA IS CORRECTLY REPORTED USING MACHINES AND INSTRUMENTATION WITH AVAILABLE RECORDS OF PERIODIC CALIBRATION.

FERRITE ANALYSIS

LOCATION	PERCENT			WRC FERRITE NUMBER		
	S.D.	1973 D.D.	F.S.	1973 D.D.	F.S.	M.G.

INITIATOR/DATE	REV. NO.	0	1	2	3	4
		11-29-78	12-22-78			
WELD LAB.						
MAT'L. ENGR.		11/30/78	1-2-79			
		12-4-78	1-4-79			

PDS 9353F-3 Reverse

RECORD OF MECHANICAL TEST RESULTS

LOT NO. EL-318

POST WELD HEAT TREATMENT

1100-1150	°F FOR	50	HOURS	
	°F FOR		HOURS	
15	°F PER HOUR RATE OF COOLING TO	800	°F	

ASTM E208 DROP WEIGHTS SPECIMEN TYPE P-3

TEMP.	RESULTS	TEMP.	RESULTS	TEMP.	RESULTS	TEMP.	RESULTS	TNDT °F

ASTM E8 TENSILE PROPERTIES

LOCATION	TEST TEMPERATURE (°F)	SPECIMEN SIZE (IN.)	ULTIMATE STR. PSI	YIELD PT. PSI .2% OFFSET	%ELONG. 2" GAGE LENGTH	% RED. OF AREA
Joint 1/2T	Ambient	.500	113,000	71,500	35.0	36.5

SA-370 CHARPY V-NOTCH IMPACT TEST 240 FT./LB. ENERGY LOAD SPECIMEN TYPE A

TEMP.	FT./LBS.	LAT. EXP.	% SHEAR	TEMP.	FT./LBS.	LAT. EXP.	% SHEAR	TEMP.	FT./LBS.	LAT. EXP.	% SHEAR
UPPER SHELF ENERGY (FT/LBS)								RTNDT (°F)			

GUIDED BEND TESTS

ORIENTATION	FACE	SIDE
TRANSVERSE		(2) ACCEPTABLE
LONGITUDINAL		

MICRO OR MACRO OR FISSURE ANALYSIS

LOCATION	RESULTS

COMMENTS OR MISCELLANEOUS RESULTS

NON-DESTRUCTIVE EXAMINATION

TYPE	ACCEPT	REJECT
P.T.	Final Surface	
	Joint	
M.T.		
R.T.	Final Joint	
U.T.		
VISUAL	Throughout	

DATE 11-29-78

SIGNED Richard L. Monnelin

ELDING DATA SHEET — BABCOCK & WILCOX COMPANY - MT. VERNON, IND.

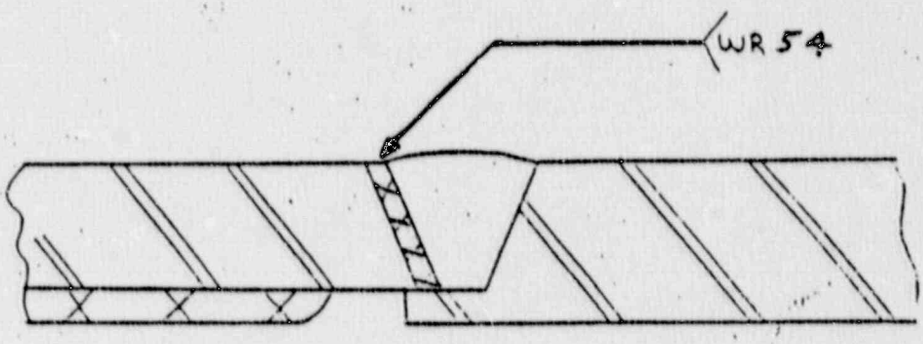
This data sheet shall be used in conjunction with Quality Control Specification 12-2-WP-5 PDM-9348-

SCRIPTION OF WELD: INCONEL BUTTERING TO 508 CLASS 2 FORGING P-3	CARBON STEEL P-1 / LOW ALLOY P-3 / STAINLESS P-8	INCONEL P-43 / OTHER	TYPE OF WELD: Pressure	
PER UNIT: Two	MAINTAIN INTERPASS TEMPERATURE AS SPECIFIED BELOW / SEE PWHT BOX BELOW / UNDER PREHEAT, FINISH WELD COMPLETE		PROCEDURE QUAL: 3672	
	PREHEAT MAY BE DROPPED AFTER WELD IS COMPLETE & RAISED TO 400°F FOR PWHT & ALL STRESS RELIEVING REQUIRED			
ING POSITION: Flat, Vertical	PREHEAT °F MIN. 150	INTERPASS °F MAX. 350	C OVERLAP: NA / B HEADWIDTH: NA	HEAD SPECIAL INDEX: NA / OSCILLATION WIDTH: NA

E MATERIAL: SA 508 CLASS 2 (P-3)

	FILLER METAL SPEC.	DIA.	70/8015-A1	TU/80/110IA	STAINLESS	INCONI	
MANUAL METAL ARC	SFA-5.11 E-NiCrFe-3	1/32					
		1/8				X	80-1
		5/32				X	105-1
		3/16					
		1/4				X	DCRP

emarks or Sketch



N-DESTRUCTIVE TESTING

NIMUM REQUIRED POSTWELD HEAT TREATMENT

STRESS RELIEF ONE CYCLE AT 1100-1150°F FOR (1) HOUR.

MPLING INSTRUCTIONS
SKETCH

CONTRACT NO.	DWG. NO.	

IMMEDIATELY AFTER THE BEAD TO BE SAMPLED HAS BEEN DEPOSITED, THE SAMPLE SHALL BE REMOVED AND PROMPTLY SENT TO QUALITY CONTROL.

ISSUED 11/11/75	SALES CLASS 620	CURVE NO.
REVISED	REVISION NO. 11	WR-54

WELDING DATA SHEET — BABCOCK & WILCOX COMPANY - MT. VERNON, IND. — PDM-9341

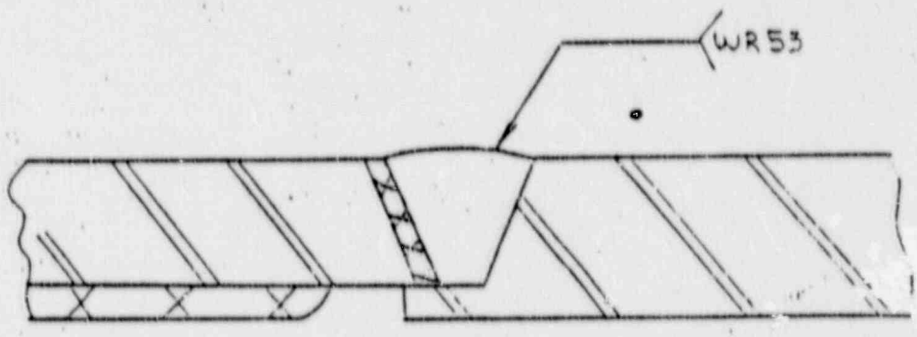
This data sheet shall be used in conjunction with Quality Control Specification 12-2-WP-5

Description of Weld: Safe end to core flooding Nozzle	Carbon Steel / Low Alloy / Stainless:	Inconel / Other:	Type of Weld: Pressure
No. per Unit: Two	Maintain Interpass Temperature [ ] See Remarks Below [ ] Drop Preheat, Burn Weld Complete		Postweld Heat Treatment:
Welding Position: Flat, Vertical	Preheat °F Min.: 60	Interpass °F Max.: 350	Overlap: NA; Bead Width: NA; Bead Spacing Index: NA; Oscillation Width: NA

Base Material: SA376 TP 304 To INCONEL Buttering

Manual Metal Arc	Filler Metal Spec.	Dia	70/80S-6	70/80/110S	Stainless	Inc	
	SFA-5.11	5/32					
		1/8				X	80
	E-NiCrFe-3	5/32				X	105
		3/16					
		1/4				X	DCRP

Remarks or Sketch



Non-Destructive Testing

—

Minimum Required Postweld Heat Treatment

None Required.

Sampling Instructions & Sketch

IMMEDIATELY AFTER THE BEAD TO BE SAMPLED HAS BEEN DEPOSITED, THE SAMPLE SHALL BE REMOVED AND PROMPTLY SENT TO QUALITY CONTROL.

Contract No.	Dwg. No.	

Issued 11/1/75

THE BABCOCK & WILCOX COMPANY
POWER GENERATION GROUP

TECHNICAL PROCEDURE

NUMBER
12-2-WP-5, Rev. 3

SECTION	SUBJECT
MOUNT VERNON WELDING TECHNOLOGY	GENERAL PROCEDURE FOR MANUAL METAL ARC WELDING FOR COMMERCIAL NUCLEAR OR SPECIAL APPLICATIONS
	APPROVED BY: R.D. Kunz By [illegible] DATE: 11/12/76

1. SCOPE:

This Technical Procedure shall govern the manual metal arc welding of Carbon, Low-Alloy, Nickel-Chromium-Iron, and Stainless Steels in accordance with the ASME Boiler and Pressure Vessel Code. This Technical Procedure is supplemented by a Weld Data Sheet.

2. BASE MATERIAL PREPARATION:

2.1 Joint preparation shall be prepared by mechanical methods or thermal cutting in accordance with Technical Procedure 12-2-WP-3.

2.2 The weld preparation and adjoining base metal for a minimum distance of 1" from the welding groove shall be kept free of oil, grease, dirt, moisture, and other materials that would affect the integrity of the weld. Joints that will not be welded immediately shall be adequately protected to prevent contamination.

2.3 Weld preparations shall be inspected by the magnetic particle or liquid penetrant methods as required by Section III of the ASME Boiler and Pressure Vessel Code. Visual inspection shall be performed in accordance with Technical Procedure 12-2-WQI-3.

2.4 Backing Strips, Backing Rings, and Spacer Blocks:

2.4.1 Materials for backing strips, backing rings, and spacer blocks shall be compatible with the base material.

3. WELDING CHARACTERISTICS:

Welding parameters and electrode type shall be in accordance with the weld data sheet for the base material to be welded. Welding shall be performed using alternating current or direct current, reverse polarity at 19 to 26 volts. The range of travel speed shall be 3-9 i.p.m. for 3/32 and 1/8", 3 1/2-11 i.p.m. for 5/32", 3 1/2-14 i.p.m. for 3/16", and 5-12 i.p.m. for 1/4" electrodes.

4. WELDING TECHNIQUE:

The welder shall maintain a short arc. A slight weave may be used. The width of weave shall be limited to that which produces a sound weld of good appearance. At no time shall the arc be directed into solidified slag. When welding in positions other than flat, the welding progression shall be uphill.

4.2 After each bead of weld metal is deposited all slag shall be removed from the surface of the weld. The welder shall visually examine each bead. Special attention shall be exercised at starts and stops. All defects such as cracks, blowholes, porosity, undercuts and overlap shall be removed by chipping, grinding, or air-arc. Weld spatter and oxide shall be removed from the side-walls of the groove.

4.3 When wire brushes are used on stainless steels and nickel-chromium-iron alloys, they shall be stainless steel.

5. THERMAL TREATMENT:

Preheat, interpass temperatures, and postweld heat treating shall be in accordance with the applicable approved Technical Procedure.

6. QUALIFICATION OF PROCEDURES:

All welders and procedures shall be qualified in accordance with the ASME Boiler and Pressure Vessel Code, Section IX, III, and contract requirements.

HUNTINGTON ALLOYS
An INCO company

HUNTINGTON ALLOYS, INC.
HUNTINGTON, WEST VIRGINIA 25720

CLEVELAND, OHIO

H33134	702700-REL-702762	702700-REL-702762	DATE 10/20/70 PAGE 1 OF 1
TEST		BEFORE SHIPMENT	
MAI			

1	3000 #	INCONEL WELDING ELECTRODE 182 .1250 DI 12.000 IN

SPEC ASME SFA 5.11 SECT 2 1977 EDITION SUMMER 1978 ADDENDA CLASS
CATION ENICRFE-3 EXCEPT COBALT 10% MAX SEE NOTE

STATE OF WEST VIRGINIA COUNTY OF CABELL. SUBSCRIBED AND SWORN TO BEFORE ME THIS 20TH DAY OF OCT. 1970. MY COMMISSION EXPIRES APRIL 16 1979
NOTARY PUBLIC-

VISUAL AND DIMENSIONAL EXAMINATION - OK

ASME NCA QUALITY SYSTEM CERTIFICATE (MATERIALS) NUMBERS N-2970 AND N-2973 EXPIRES 3/31/01.

CHARGE
ATTN JOHN L. FINN - PURCH. DEPT.
POWER GENERATION DIV
BABCOCK & WILCOX CO
PO BOX 351 STIRLING AVE
BARBERTON OHIO 44203

SHIP
BABCOCK & WILCOX CO
HCUY 69 WEST
MT VERNON IND
47620

CHEMICAL ANALYSIS

HEAT NO(4)	C	MN	FE	S	SI	CU	NI(1)	CR	TI	CO@	NB@	CB	TA	P @	OTHERS %
0007	.02	6.93	0.56	.011	.30	.19	67.69	14.11	.36	.02	.04	1.69	.01	.007	10.30

@ INCLUDED IN NICKEL % REPORTED
PERCENT OF NO. REPORTED FOR INFORMATION ONLY
SPEC CONTD - ASME SECTION II 1977 ED SUMMER 1978 ADD.
P.O. 702700AK-REL 702762 ITEM 10 FOLIO NO. 567-343

R. FEARING
NOV 1 0 1978

C.18

XGU-05-211
Revision 0

C.19

93538-3

THE BABCOCK & WILCOX COMPANY
POWER GENERATION GROUP
MT. VERNON, INDIANA

RECORD OF FILLER WIRE QUALIFICATION TEST

TEST NO: EL-333

Q.C. TECHNICAL PROCEDURE	REV. NO.	WELDING PROCESS
12-2-WQI-IX1C	0	SHIELDED METAL-ARC
12-2-WQI-IS1J	1	
12-2-WQI-IA1J	1	

ELECTRODE

SFA SPEC.	CLASSIFICATION	DIAMETER (IN.)	PURCHASED FOR CONTRACT	FOLIO NO.	VENDOR	PURCHASE ORDER NO.	HEAT & LOT NO.
5.11	ENiCrFe-3	1/8	610-0234	567-343	HUNTINGTON ALLOYS	782762	0047

FLUX

SFA SPEC.	CLASSIFICATION	PARTICLE SIZE	PURCHASED FOR CONTRACT	FOLIO NO.	VENDOR	GRADE	LOT NO.

WELDING PARAMETERS

LOCATION	AMPERAGE			VOLTAGE			TRAVEL SPEED (IPM)	WIRE FEED SPEED (IPM)	CONTACT TO WORK (IN)	SHIELDING GAS		WELDING POSITION	
	DCSP	DCRP	AC	DCSP	DCRP	AC				TYPE	FLOW RATE (CFH)		
UNDILUTED PAD		80-110			19-26							FLAT	
JOINT		80-110			19-26							FLAT	

CHEMICAL ANALYSIS

LOCATION	LAB NO.	C	Mn	P	S	Si	Cr	Ni	Mo	Cu	Cb	Ta	Co	Al	Ti	Fe	V
UNDILUTED PAD		.02	6.95	.007	.011	.50	16.11	67.69	.06	.19	1.60	.01	.02		.36	8.56	
UNDILUTED PAD	33818	.022	7.3	.009	.011	.69	16.4	67.2	.05	.22	1.54	.01	.04	.02	.27	8.4	.04
JOINT	33918	.020	7.3	.011	.011	.53	14.4	67.0	.05	.24	1.56	.01	.05	.02	.36	8.4	.04

APPLICATION APPROVED

GOVERNING CODES	WELDING MATERIAL CODE	REJECT
NAVSHIPS 250/1500		
ASME CODE CLASS'L. NUCLEAR	IX1C IS1J IA1J	
ASME CODE FOSSIL		
CONTRACT NO. 610-0234(EVST)	IX1C, IS1J & IA1J	
APPLICATION(S) APPROVED		
ALL POSITIONS		

WE HEREBY CERTIFY THAT THE ABOVE LISTED MATERIAL WAS BEEN TESTED IN ACCORDANCE WITH THE ABOVE LISTED SPECIFICATION(S) AND IS IN CONFORMANCE WITH ALL APPLICABLE REQUIREMENTS. THE TEST DATA IS CORRECTLY REPORTED USING MACHINES AND INSTRUMENTATION WITH AVAILABLE RECORDS OF PERIODIC CALIBRATION.

FERRITE ANALYSIS

LOCATION	PERCENT			DEC FERRITE NUMBER		
	S.D.	1973 D.D.	F.S.	1973 D.D.	F.S.	M.G.

INITIATED/DATE	REV. NO.	0	1	2	3	4
		9-3-79				
WELD LAB.						
MAT'L. ENGR.		1-3-79				
		9-3-79				

RECORD OF MECHANICAL TEST RESULTS

TEST NO. EL-333

POST WELD HEAT TREATMENT

1100-1150	°F FOR	50	HOURS	
	°F FOR		HOURS	
15 °F PER HOUR RATE OF COOLING TO		800	°F	

ASTM E208 DROP WEIGHTS SPECIMEN TYPE P-3

TEMP.	RESULTS	TEMP.	RESULTS	TEMP.	RESULTS	TEMP.	RESULTS	TNDT °F

ASTM E8 TENSILE PROPERTIES

LOCATION	TEST TEMPERATURE (°F)	SPECIMEN SIZE (IN.)	ULTIMATE STR PSI	YIELD PT. PSI 2% OFFSET	%ELONG. 2" GAGE LENGTH	% RED. OF AREA
JOINT ½T	AMBIENT	.500	103,750	65,000	35.0	47.0

SA-370 CHARPY V-NOTCH IMPACT TEST 240 FT./LB. ENERGY LOAD SPECIMEN TYPE A

TEMP.	FT./LBS.	LAT. EXP.	% SHEAR	TEMP.	FT./LBS.	LAT. EXP.	% SHEAR	TEMP.	FT./LBS.	LAT. EXP.	% SHEAR
UPPER SHELF ENERGY (FT/LBS)								ΔTNDT (°F)			

GUIDED BEND TESTS

ORIENTATION	FACE	SIDE
TRANSVERSE		ACCEPTABLE (2)
LONGITUDINAL		

MICRO OR MACRO OR FISSURE ANALYSIS

LOCATION	RESULTS

COMMENTS OR MISCELLANEOUS RESULTS

NON-DESTRUCTIVE EXAMINATION

TYPE	ACCEPT	REJECT
P.T.	FINAL SURFACES-JOINT	
M.T.		
R.T.	FINAL JOINT	
U.T.		
VISUAL	THROUGHOUT	

DATE 1-3-79

SIGNED M Mirza Tenn

NUTECH, INC.
145 Martinvale Lane
San Jose, CA 95119
Phone: (408) 629-9600
Telex (RCA): 278971 NUTC UR
Fax: (408) 281-6186

Operating Subsidiaries:

NUTECH Engineers Atlanta
1301 Highlower Trail, Suite 205
Atlanta, GA 30350
Phone: (404) 642-8215
Fax: (404) 642-8213

NUTECH Engineers Bethesda
Three Bethesda Metro Center, Suite 430
Bethesda, MD 20814
Phone: (301) 652-1610
Fax: (301) 951-0966

NUTECH Engineers Chicago
1111 Pasquinelli Drive, Suite 100
Westmont, IL 60559
Phone: (312) 789-2900
Telex: 704210
Fax: (312) 789-4343

NUTECH Engineers Minneapolis
3258 Annapolis Lane
Plymouth, MN 55447
Phone: (612) 559-4600
Fax: (612) 559-2807

NUTECH Engineers San Jose
145 Martinvale Lane
San Jose, CA 95119
Phone: (408) 629-9600
Telex (RCA): 278971 NUTC UR
Fax: (408) 281-6186

NUTECH International, INC.
145 Martinvale Lane
San Jose, CA 95119
Phone: (408) 629-9600
Telex (RCA): 278971 NUTC UR
Fax: (408) 281-6186

NUTECH International Madrid
Orense, 69
6th Floor
Madrid-28020, Spain
Phone: 011-341-270-6804/-6900
Telex: 46942 RATS
Fax: 011-341-279-3629

NUTECH International Rome
Via G. Vasari, 4
00196 Rome, Italy
Phone: 011-396-360911/-360799
Telex: 626026 SIRGI I
Fax: 011-396-320-642

NUTECH International Seoul
204-6 Nonhyun-Dong Kangnam-Ku
Seoul 135-010, Korea
Phone: 011-82-2-547-6987
Telex: K86149 NUTECKL
Fax: 011-82-548-7915

NUTECH International Taipei
1st Floor, Chia Hsin Bldg.,
69, Chung Shan N. Rd.
Section 2
Taipei, Taiwan ROC
Phone: 011-886-2-521-0128
Telex: 22839 CHSINCO
Fax: 011-886-2-521-0129

NUTECH, INC.
145 Martinvale Lane
San Jose, CA 95119
Phone: (408) 629-9800
Telex (RCA): 278971 NUTC UR
Fax: (408) 281-6186

Operating Subsidiaries:

NUTECH Engineers Atlanta
1301 Hightower Trail, Suite 205
Atlanta, GA 30350
Phone: (404) 642-8215
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Three Bethesda Metro Center, Suite 430
Bethesda, MD 20814
Phone: (301) 652-1610
Fax: (301) 951-0966

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Westmont, IL 60559
Phone: (312) 789-2800
Telex: 704210
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3955 Annapolis Lane
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Phone: (612) 559-4400
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NUTECH Engineers San Jose
145 Martinvale Lane
San Jose, CA 95119
Phone: (408) 629-9800
Telex (RCA): 278971 NUTC UR
Fax: (408) 281-6186

NUTECH International, INC.
145 Martinvale Lane
San Jose, CA 95119
Phone: (408) 629-9800
Telex (RCA): 278971 NUTC UR
Fax: (408) 281-6186

NUTECH International Madrid
Orense, 68
4th Floor
Madrid-28020, Spain
Phone: 011-341-270-6604/-5600
Telex: 46642 FATS
Fax: 011-341-279-3598

NUTECH International Rome
Via G. Vasari, 4
00196 Rome, Italy
Phone: 011-396-390611/-390788
Telex: 626026 SIRGI I
Fax: 011-396-390-842

NUTECH International Seoul
204-6 Nonhyun-Dong Kangnam-Ku
Seoul 135-010, Korea
Phone: 011-82-2-547-5887
Telex: K28143 NUTEKSL
Fax: 011-822-549-7915

NUTECH International Taipei
1st Floor, Chia Hsin Bldg.,
96, Chung Shan N. Rd.
Section 2
Taipei, Taiwan ROC
Phone: 011-886-2-561-5198
Telex: 25839 CHWINN
Fax: 011-886-2-581-8320

CONTINGENCY PLAN FOR REPAIR WELDING OF NOZZLE-TO-SAFE END WELDS GEORGIA POWER COMPANY PLANT HATCH DECEMBER 13, 1985

- INTRODUCTION - L. GUCWA
- DEVELOPMENT PROGRAM - W. CHILDS
- DEVELOPMENT DETAILS
  - METALLURGICAL/MOCK UP - P. NORRIS
  - ANALYTICAL DETAILS - P. RICCARDELLA
- CONCLUSION - L.T. GUCWA

CONTINGENCY PLAN FOR TEMPER BEAD WELD OVERLAY OF SAFE-END TO NOZZLE WELDS

PREPARED BY

GEORGIA POWER COMPANY
AND
STRUCTURAL INTEGRITY ASSOCIATES

PARTIALLY FUNDED BY

ELECTRIC POWER RESEARCH INSTITUTE

DECEMBER 13, 1985

INTRODUCTION

- CONTINGENCY PLANNING FOR REPAIR OF POTENTIAL IGSCC FLAWS IN SAFE-END TO INLET NOZZLE WELDS

- TRADITIONALLY, TWO ALTERNATIVES FOR REPAIR

  - REPAIR/REPLACE AND PWHT
  - TEMPER BEAD REPAIR USING SMAW

- CURRENT PROGRAM FOCUSED ON DEVELOPMENT OF A THIRD ALTERNATIVE:

  - TEMPER BEAD, INCONEL 82 WELD OVERLAY REPAIR USING MACHINE GTAW

  - PROGRAM PARTIALLY FUNDED BY EPRI FOR GENERIC USE - EPRI REPORT WILL BE ISSUED.

COMPARISON OF ALTERNATIVES

- PWHT:
  - COSTLY AND DIFFICULT PROCESS TO IMPLEMENT ON OPERATING PLANT VESSEL
  - LONG OUTAGE, HIGH EXPOSURE
  - POTENTIAL FOR INTRODUCING HIGH RESIDUAL STRESSES ELSEWHERE IN VESSEL IF IMPROPERLY DONE
  - APPLICABLE PRIMARILY TO REPLACEMENT PROGRAM
  - EXPERIENCE OF OTHER UTILITIES SUPPORTS ABOVE

- TEMPER BEAD REPAIR USING SMAW:
  - PERFORMED LOCALLY AT PILGRIM DURING N2 SAFE-END REPLACEMENT
  - ASME SECTION XI PROCEDURE CURRENTLY IN PLACE
  - DIFFICULT PROCESS TO CONTROL SINCE MANUAL PROCESS
  - ALMOST EXCLUSIVELY USED WITH REPLACEMENT
  - MANUAL SMAW OVERLAY WOULD HAVE HIGH MAN-REM IMPACT AT SAFE-END LOCATION

COMPARISON OF ALTERNATIVES
(CONTINUED)

- TEMPER BEAD/WELD OVERLAY USING GTAW:
  - PARAMETERS DEVELOPED BY B & W IN EPRI PROGRAM TO GIVE PROPER TEMPERING
  - RECENTLY APPROVED SECTION XI CODE CASE INCORPORATES THESE RESULTS
  - PROPOSED OVERLAY PROCEDURE MEETS INTENT OF CODE CASE (TEMPERED P3 MATERIAL)
  - CAN BE SHOWN EFFECTIVE FOR AT LEAST ONE FUEL CYCLE (PROBABLY SEVERAL)
  - ALLOWS PLANNING OF ORDERLY PIPE REPLACEMENT IF NECESSARY
  - MINIMUM IMPACT ON OUTAGE LENGTH

METALLURGICAL TESTING PERFORMED TO QUALIFY PROPOSED OVERLAY PROCEDURE

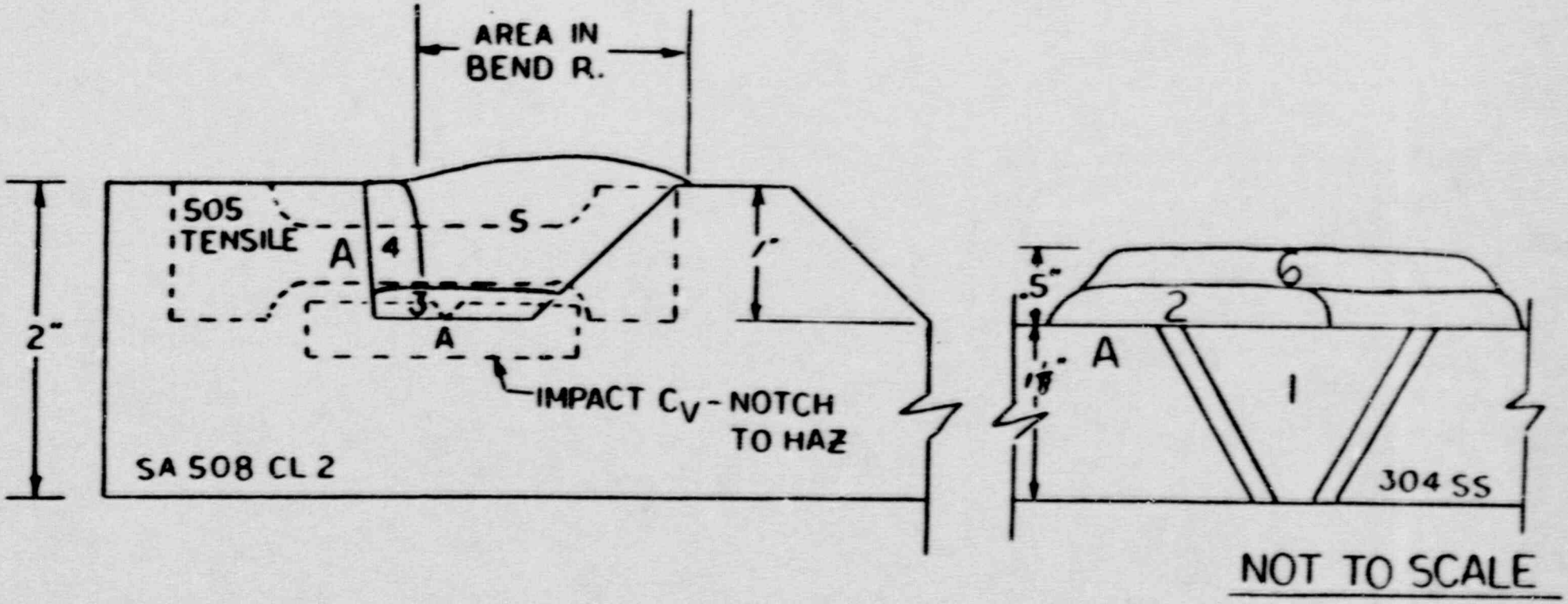
- FABRICATED MOCKUP FOR PROCEDURE QUALIFICATION
  - OBTAINED B & W NOZZLE (FROM CANCELLED PLANT)
  - WELDING @ G.E. SOUTHEAST WELDING SERVICES UNDER GEORGIA POWER DIRECTION
- PERFORMING PROCEDURE QUALIFICATION TESTS IN ACCORDANCE WITH CODE CASE
  - IMPACT TESTING (C.E.-CHATTANOOGA)
  - MICROHARDNESS TRAVERSES (J.A. JONES)
  - TENSILE TESTING (C.E.-CHATTANOOGA)
  - BEND BARS (GEORGIA POWER)
- PROGRAM TO DATE DEMONSTRATES THAT GPC PROCEDURE AND RESULTS ARE CONSISTENT WITH EPRI/B & W PROGRAM
  - SATISFACTORY TEMPERING OF HAZ

1. NOZZLE TO SAFEND WELD-INCONEL BUTTER AND BUTT WELD

2-4. THREE LAYER TEMPER BEAD WELD

5-6. OVERLAY AND GROOVE COMPLETED WITH WATER BACKING

A. LOCATION OF MICROHARDNESS SURVEY



NOT TO SCALE

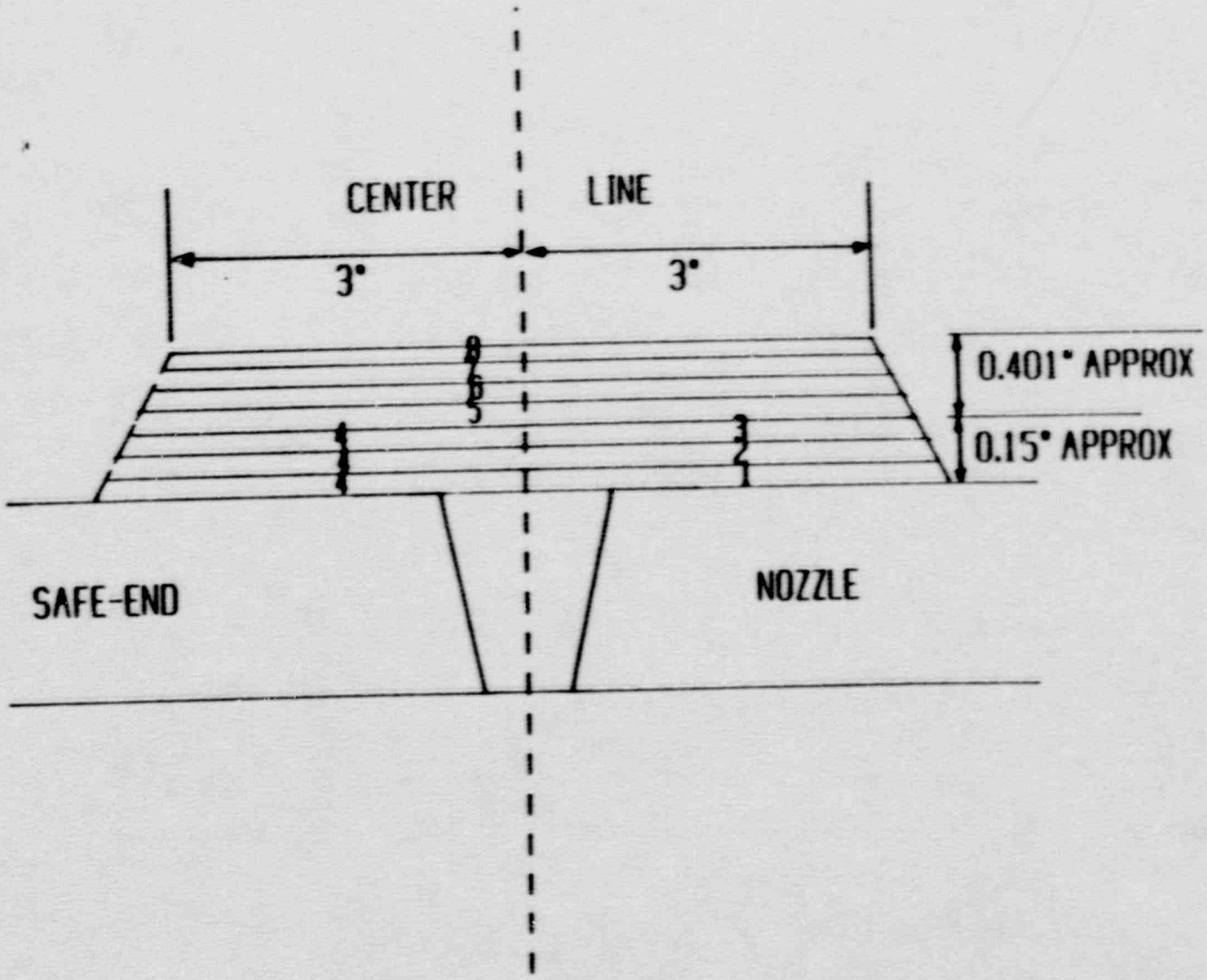
NOZZLE/SAFEND OVERLAY WELD PROCEDURE QUALIFICATION

SEQUENCE OF OPERATION (OVERLAY MOCK-UP AND GROOVE)

TEMPER BEAD (NOTE 1)

1. PREHEAT TO 350°F-HOLD 1/2 HOUR
2. DEPOSIT FIRST TEMPER BEAD LAYER (AS SHOWN ON SKETCH)
3. DEPOSIT SECOND TEMPER BEAD LAYER
4. DEPOSIT THIRD TEMPER BEAD LAYER
   - REPEAT STEPS 2 THROUGH 4 FOR THREE AREAS AS SHOWN ON SKETCH
5. HOLD PREHEAT TO POSTHEAT
6. POSTHEAT 450-500°F FOR 3 HOURS-SLOW COOL
7. FILL MOCK UP WITH WATER, FLOW APPROX 3 GPM
8. WELD BALANCE OF OVERLAY AND GROOVE WITH PARAMETERS FROM STEP 3 (SECOND TEMPER BEAD LAYER) WITH PREHEAT-INTERPASS 70-110°F

NOTE 1 - NOZZLE AND BUTTER ON NOZZLE WERE HEAT TREATED AT 1150°F + 25°F FOR 20 HOURS TO SIMULATE AS-INSTALLED CONDITION OF VESSEL



OVERLAY DIMENSIONS AND WELDING SEQUENCE

WELDING PARAMETERS

Modified Procedure F from EPRI NP-3614, Volume 2, July, 1984

	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5+
Current (A)	180	200	220	180	200
Voltage (V)	11	11	11	11	11
Wire Feed (ipm)	39	59	65	39	59
Travel (ipm)	8.5	7	6	8.5	7
Bead Overlap (%)	50	50	50	50	50
Preheat (°F)	300	300	300	300	300
Max. Interpass (°F)	500	500	500	500	500
Jules/in	14,000	18,900	14,200	14,000 (Water Backed)	18,900

Wire Diameter -- 0.035 Inch
Shielding Gas -- AR 18 CFH
Electrode -- 2% Thoria Tungsten; 5/32-Inch Diameter;
2-1/2-Inch Total Stick-out (With Long Gas Cup);
Tip: 22.5° Included Angle

NOTES:

1. NO LAYER 3 PARAMETERS ON STAINLESS STEEL SIDE OF WELD

2. PREHEAT (250-350°F) ON FIRST 3 LAYERS AND POST WELD BAKING (450-550°F) AFTERWARDS

3. PIPE FILLED WITH WATER AFTER FIRST 3 LAYERS

CHARPY "V" TEST RESULTS 40°F

CV	FT-LB	%SHEAR	LATERAL EXPANSION
A	67	60%	56 MILS
B	88	70%	66 MILS
C	69	50%	51 MILS

BEND TEST NOTE - 7 BEVEL FUSION LINE IS NOT SUITABLE FOR SIDE BEND TEST BECAUSE THE BASE METAL AND WELD METAL DIFFER MARKEDLY IN BENDING PROPERTIES. BOTTOM OF GROOVE HAZ IS REPRESENTED IN THE SIDE BEND SIMILAR TO AN ASME SECTION IX QW-161.5 LONGITUDINAL BEND TEST.

TENSILE TEST RESULTS:

TWO SAMPLES (93.2 KSI, 92.8 KSI)
BOTH FAILED IN BASE METAL

Hardness Values*: Match Overlay Weld

Sample #0-5 OVERLAY HAZ IN A508 CL 2

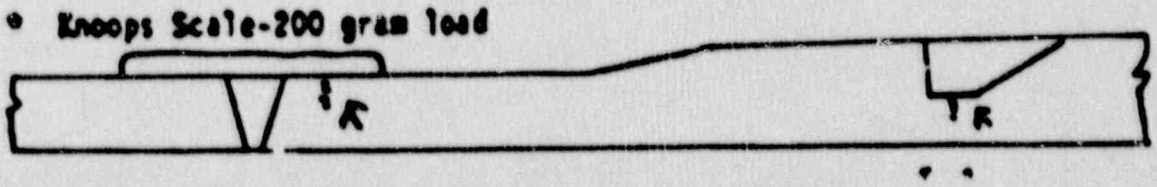
Distance from Weld Fusion Line	Row 1	Row 2	
100 μm	315	302	
300	302	290	
500	296	290	
800	305	292	Base Metal 227
1000	290	279	
1200	266	256	
1400	248	243	
1600	246	229	
1800	231	---	

Sample #1-2 GROOVE WELD HAZ AT ROOT

area beside weld

Distance from Weld Fusion Line	Row 1	Row 2	
100 m	349	351	
300	330	340	
500	319	332	Base Metal 226
700	364	329	
900	332	351	
1100	334	312	
1300	285	287	
1500	248	259	
1700	---	---	

* Knoops Scale-200 gram load



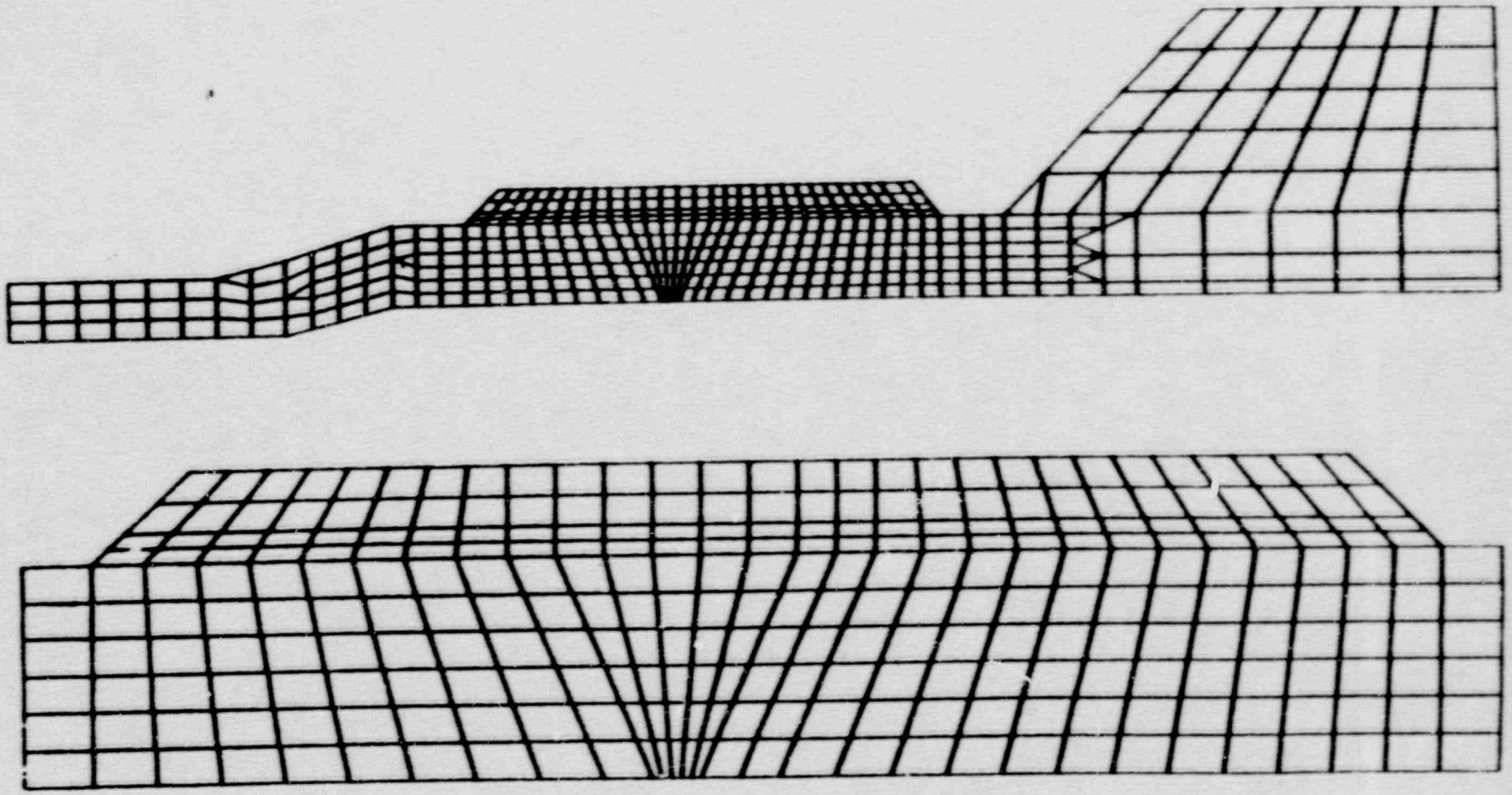
ANALYSES PERFORMED TO QUALIFY PROPOSED OVERLAY PROCEDURE

- RESIDUAL STRESS ANALYSIS
  - SIMULATED BUTT WELD RESIDUAL STRESSES IN WELDS-2 FINITE ELEMENT MODEL
  - TEMPER BEAD OVERLAY PROCESS PRODUCES COMPRESSIVE STRESSES FOR SIGNIFICANT PORTION OF PIPE WALL

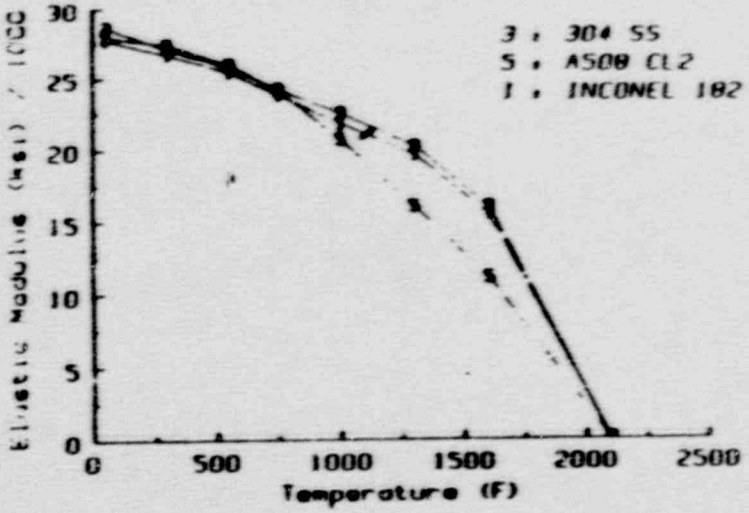
- CRACK GROWTH ANALYSIS
  - CORRELATION BASED UPON LIMITED EPRI DATA FOR CREVICED INCONEL SAMPLES IN AGGRESSIVE ENVIRONMENT

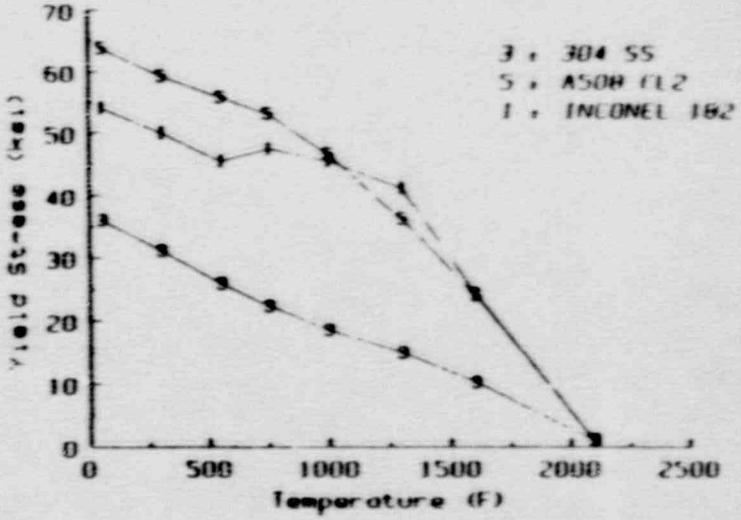
    $DA/DT = 1.08 \times 10^{-8} K^{2.26}$

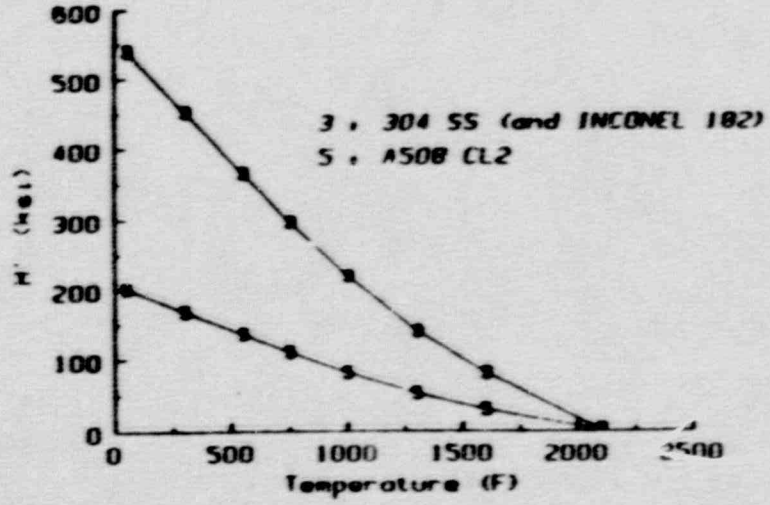
  - CRACK GROWTH RESULTS SHOW AT LEAST ONE FUEL CYCLE OF REPAIR LIFE

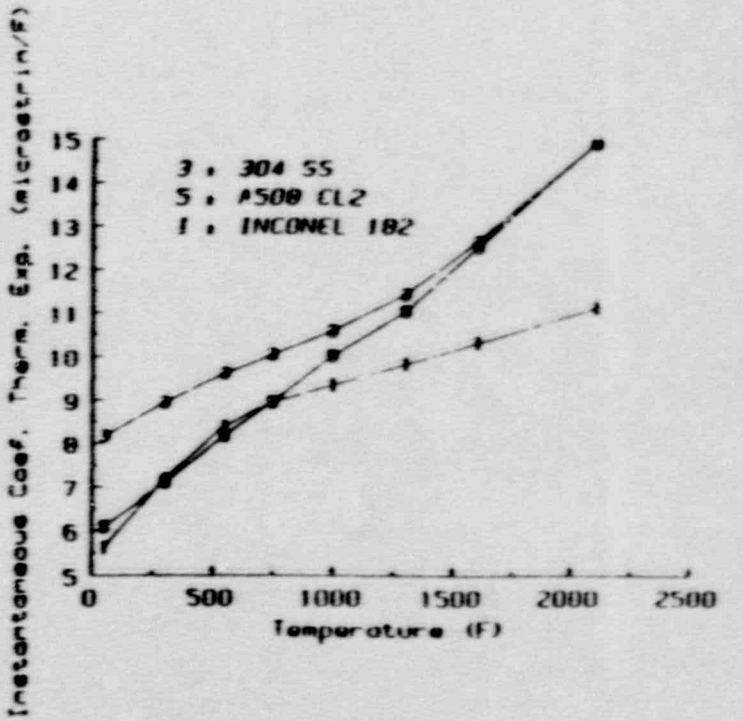


FINITE ELEMENT MODEL USED FOR RESIDUAL STRESS EVALUATION

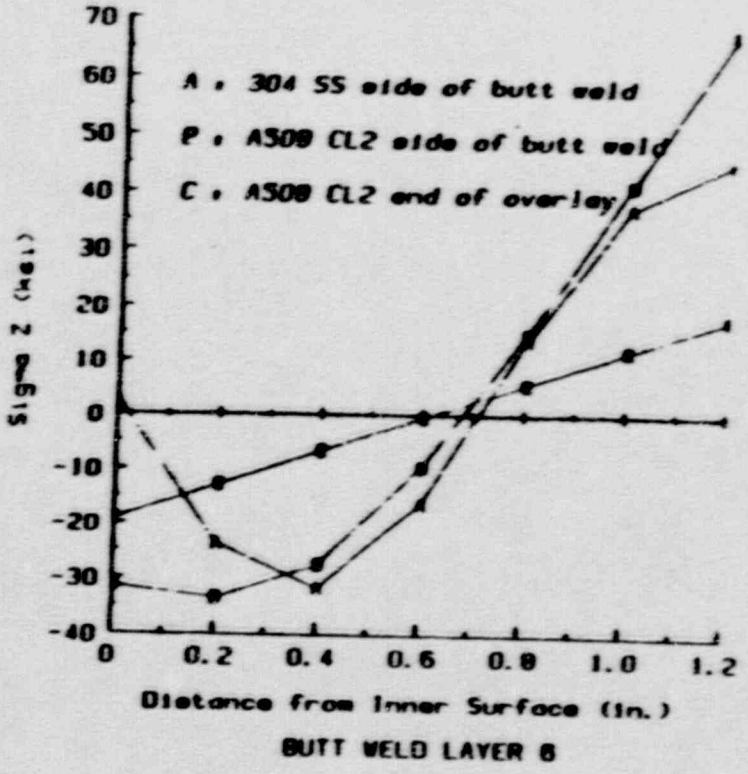


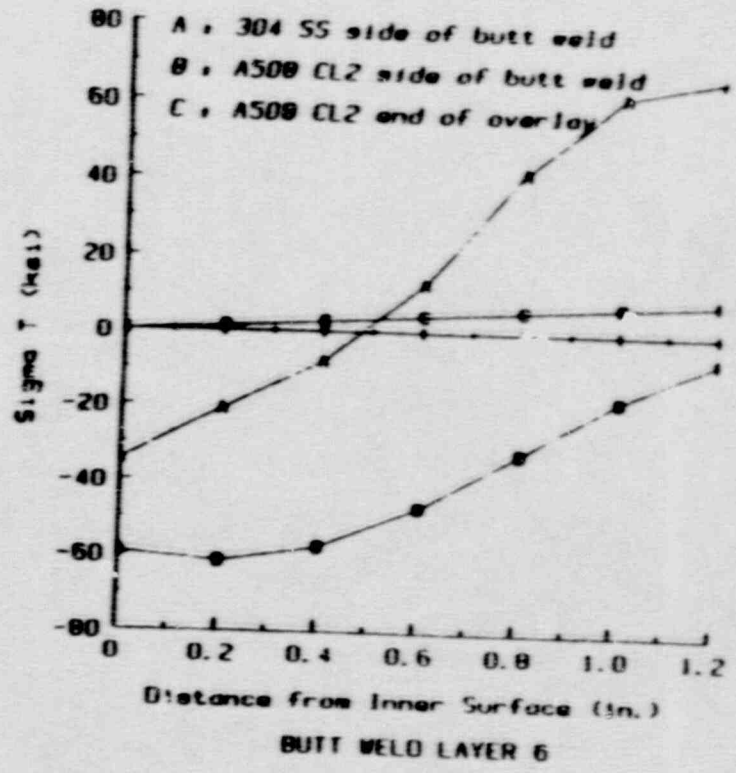




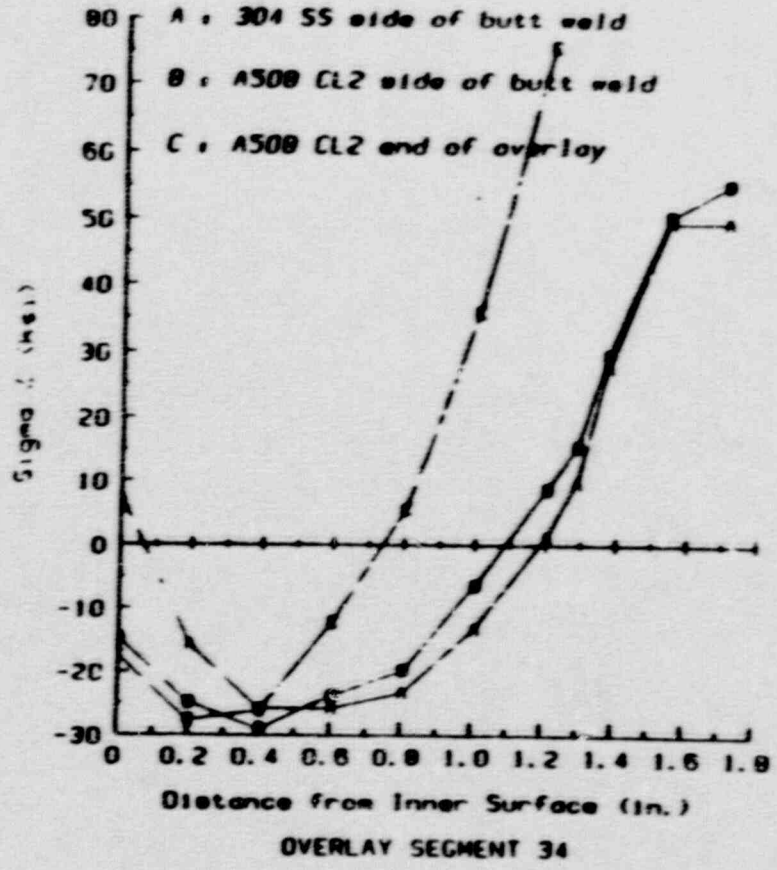


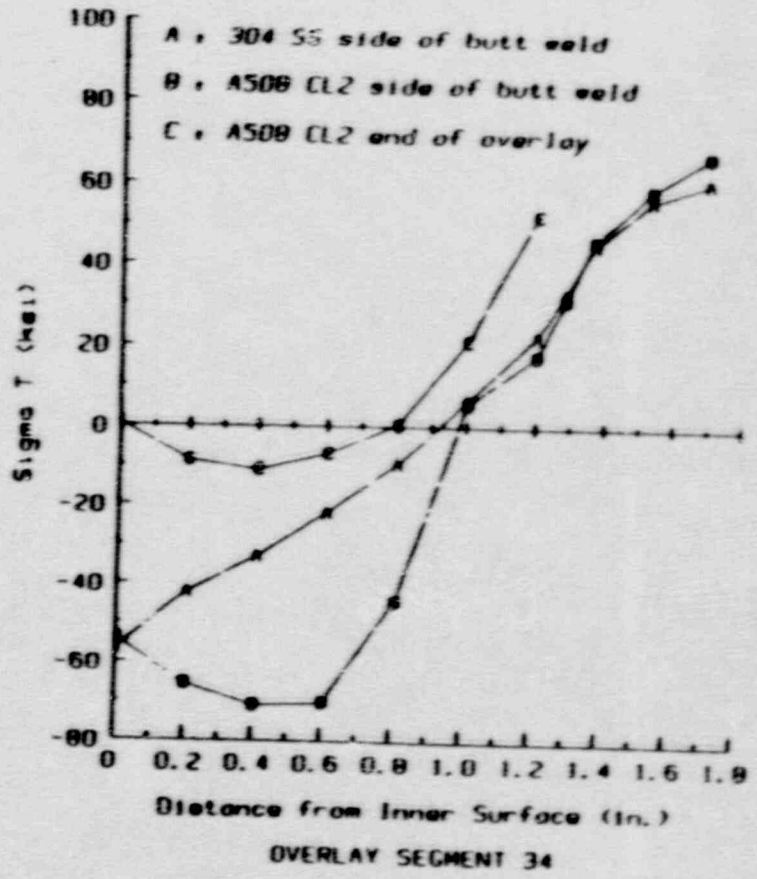
MATERIAL PROPERTIES USED IN FINITE ELEMENT RESIDUAL STRESS EVALUATION



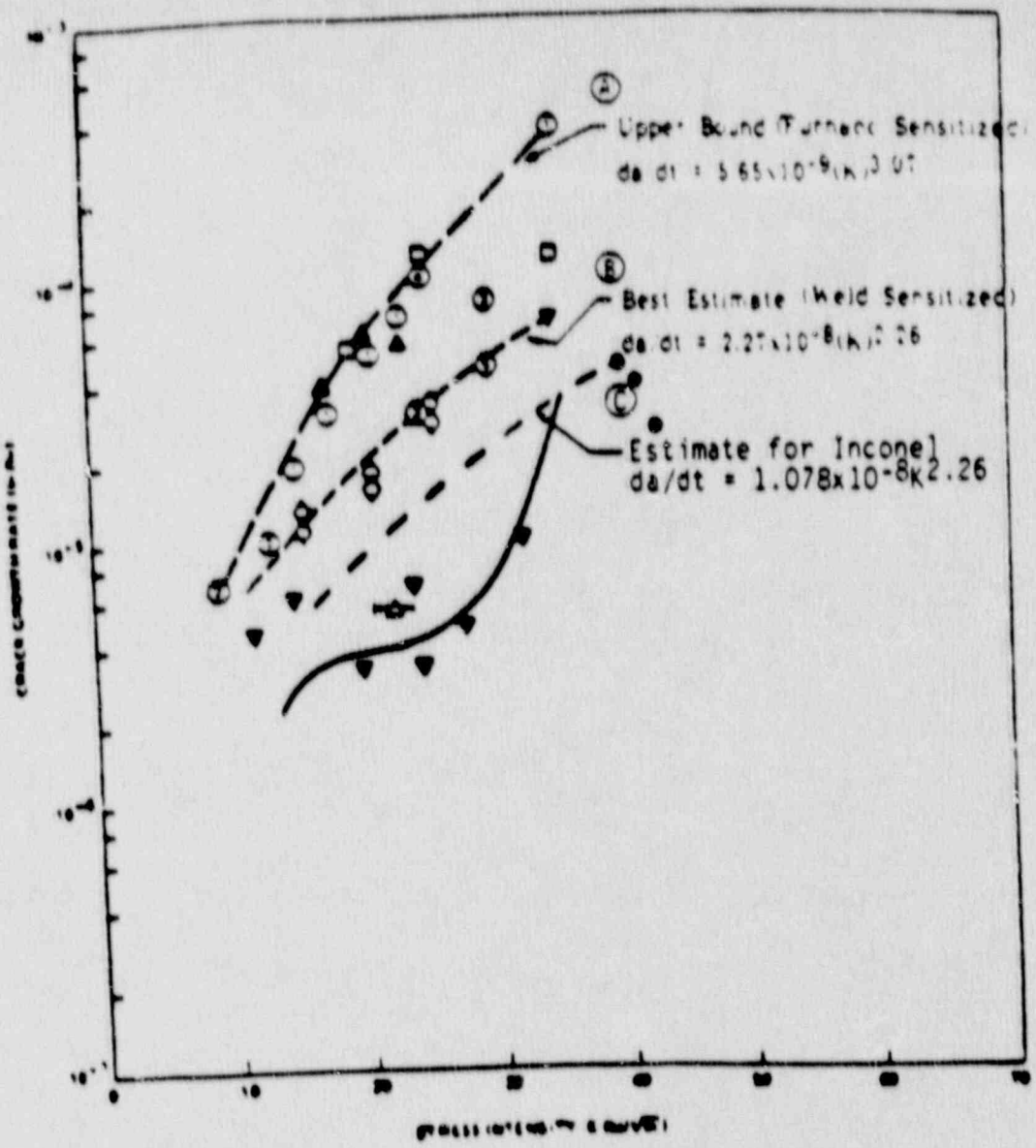


FINITE ELEMENT RESULTS - RESIDUAL STRESSES AFTER BUTT WELD



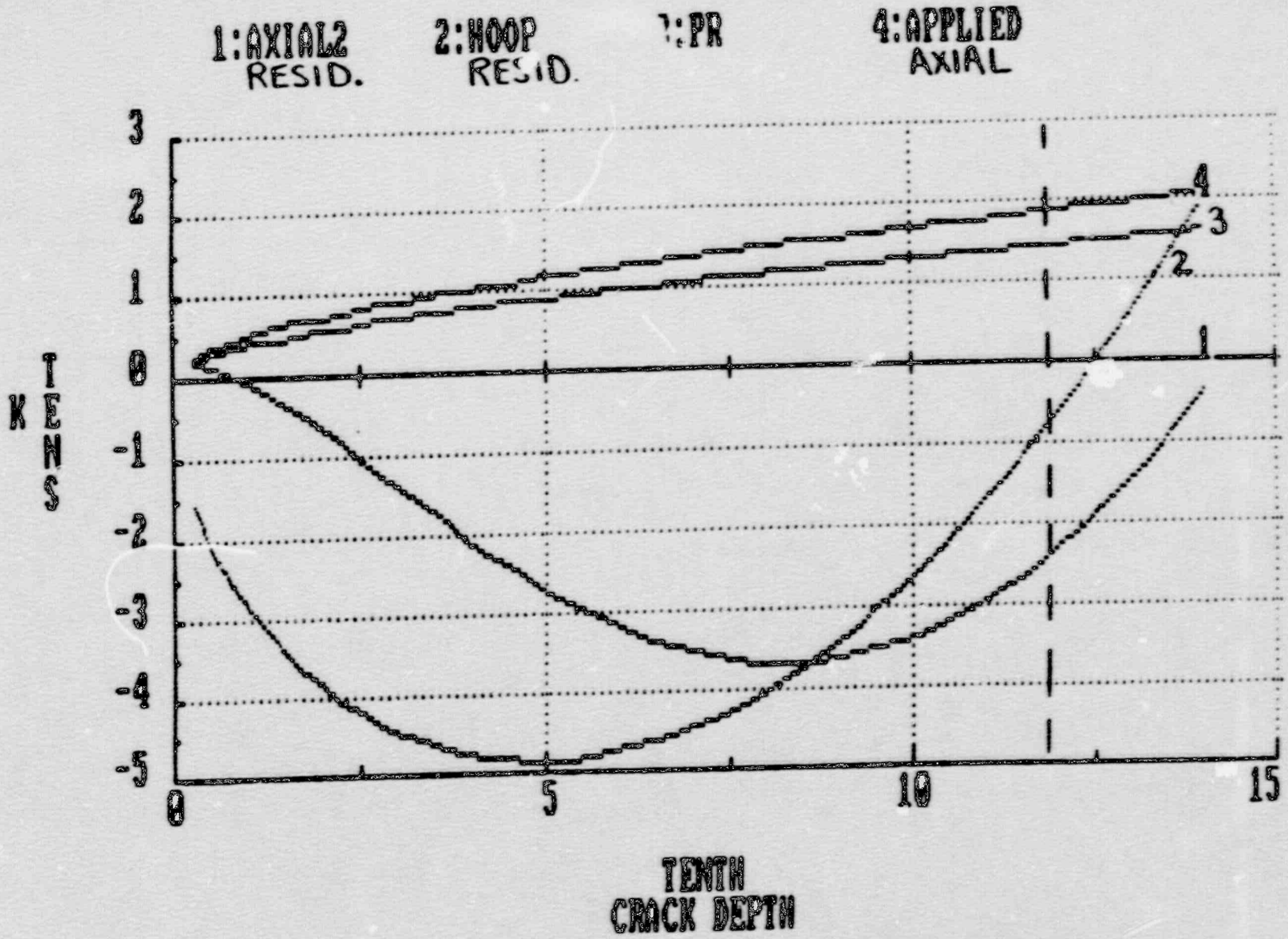


FINITE ELEMENT RESULTS - RESIDUAL STRESSES AFTER WELD OVERLAY

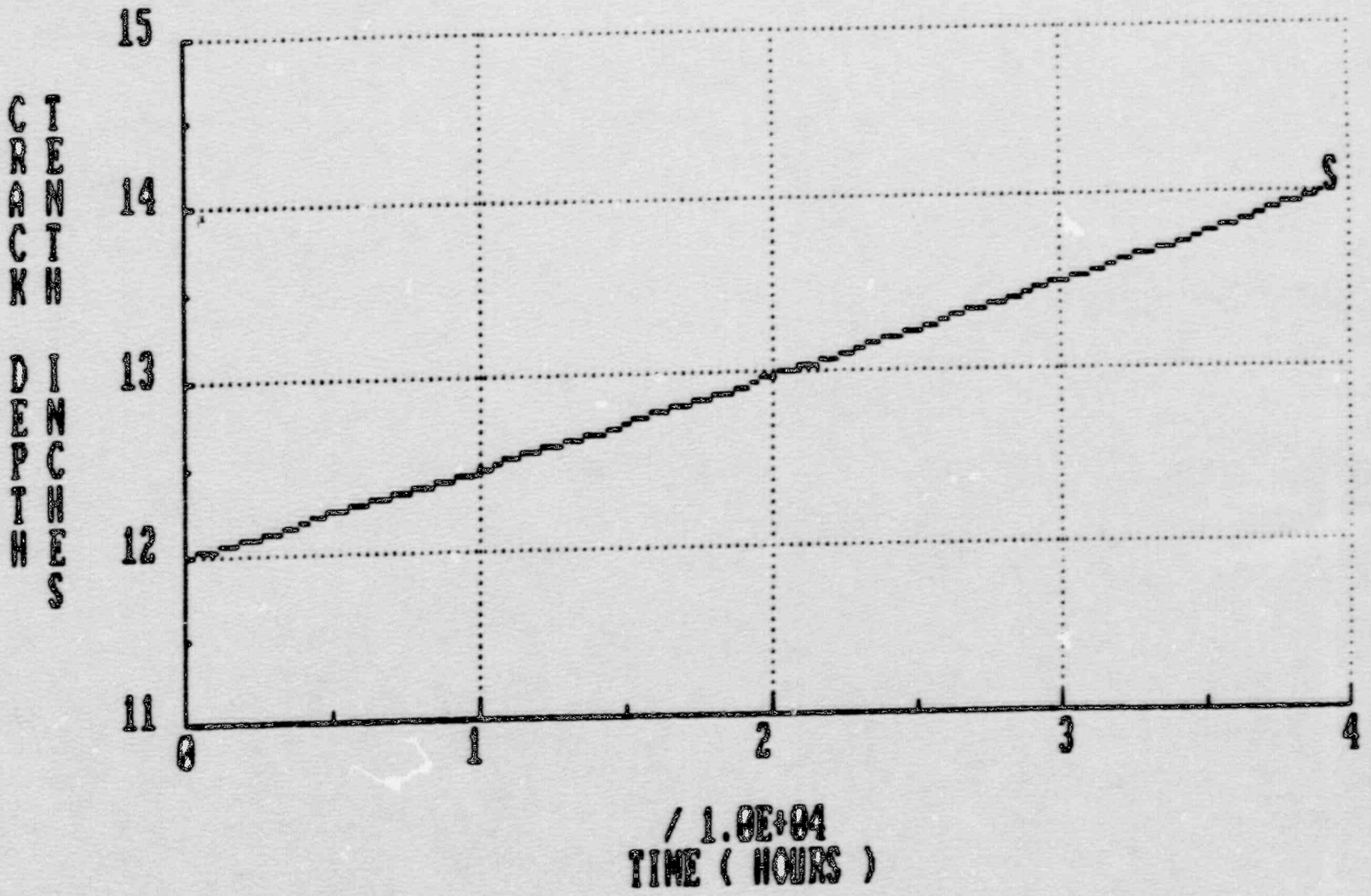


Crack Growth Rate Curves to be Used in Flaw Evaluation Analysis and Supporting Data (From [PRI NP-2472)

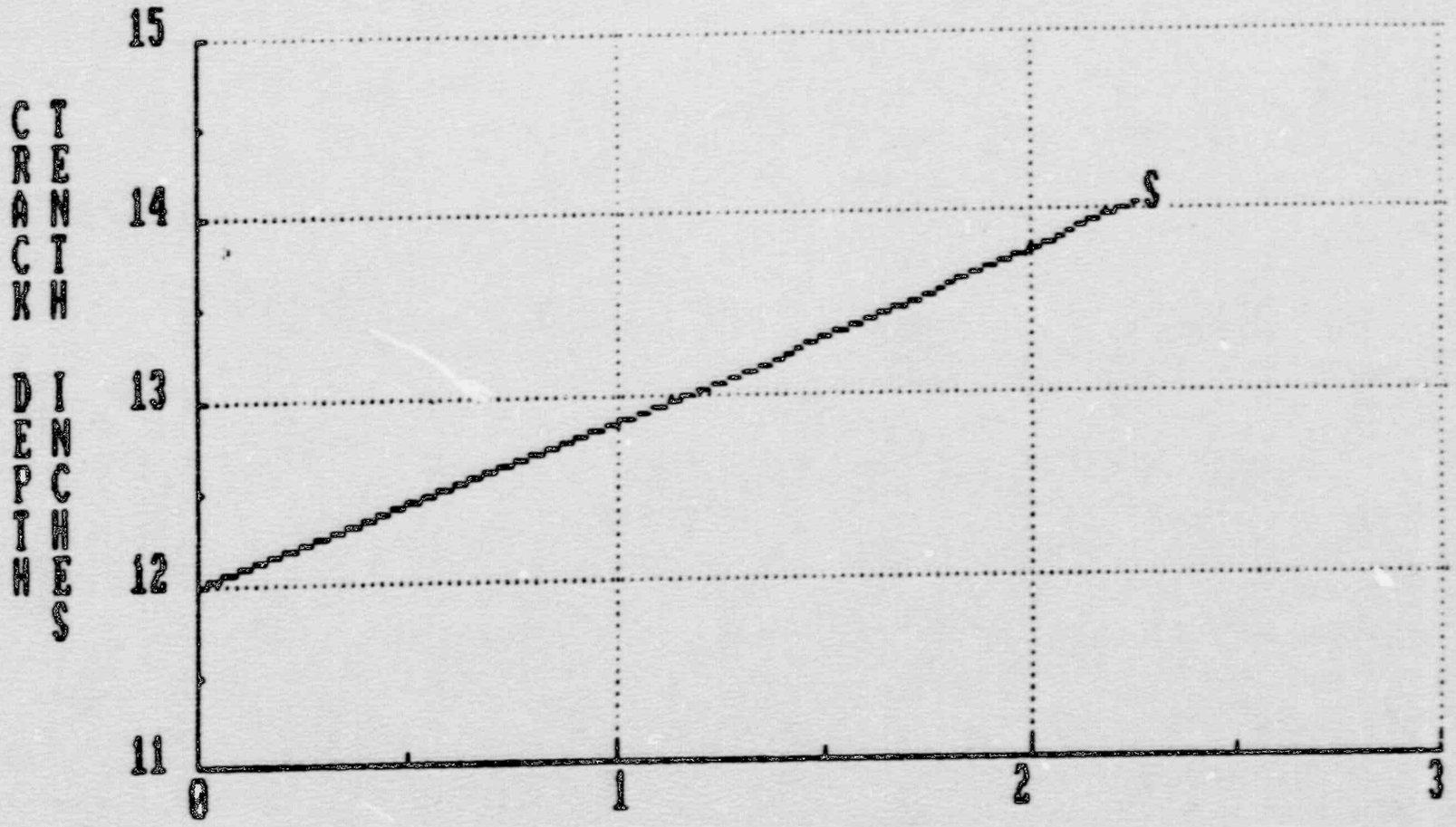
- Incunel at 288°C in 7ppm O_2, 1ppm H_2SO_4 (EPRI-1566-2, Interim Report)


1:AXIAL2 RESID.
2:HOOP RESID.
3:PR
4:APPLIED AXIAL
KTENS
3
2
1
0
-1
-2
-3
-4
-5
0
5
10
15
4
3
2
1
TENTH CRACK DEPTH

MODEL 0



AXIAL CRACK WITH NO RESIDUAL STRESS



CIRCUMFERENTIAL CRACK GROWTH WITH NO RESIDUAL STRESS

RESULTS/CONCLUSIONS

- A CONTINGENCY REPAIR PROCEDURE IS BEING DEVELOPED AND QUALIFIED FOR INCONEL- 82 WELD OVERLAY REPAIR OF NOZZLE TO SAFE-END WELDS.

- PROCEDURE USES GTAW TEMPER BEAD PROCESS SIMILAR TO THAT DEVELOPED UNDER EPRI SPONSORED PROGRAM AND RECENTLY APPROVED SECTION XI CODE CASE.

- METALLURGICAL TESTING SHOWS THAT HEAT AFFECTED ZONE IS TEMPERED WITHOUT PWHT, AND IS CONSISTENT WITH THE RESULTS OF ABOVE EPRI PROGRAM/CODE CASE.

- ANALYSIS SHOWS THAT:
  - RESIDUAL STRESSES ARE HIGHLY FAVORABLE (SIMILAR TO CONVENTIONAL OVERLAYS)
  - CRACK GROWTH IN INCONEL- 82 OVERLAY MATERIAL ACCEPTABLE FOR AT LEAST ONE FUEL CYCLE UNDER WORST CASE ASSUMPTIONS.

March 23, 1990
XGU-05-263

Attachment "B"

YANKEE ATOMIC N/SE WELD OVERLAY REPAIR PACKAGE

nutech