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Evaluation of Flaw Indications on H. B. Robinson Steam Generators A and C

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STRUCTURAL INTEGRITY ASSOCIATES, INC.

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5.0	15	1	3/12/91	New Section
---	33	1	3/12/91	New Figure Note: The above changes and minor editorial changes throughout were made to incorporate client and NRC comments.

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1.0 INTRODUCTION AND BACKGROUND

During regularly scheduled inservice inspection of steam generator girth welds, Carolina Power & Light (CP&L) identified non-reportable indications in the transition cone to upper shell girth weld on the H. B. Robinson Unit 2 B steam generator. As a result, CP&L decided to inspect the similar weld on the A and C steam generators, although these welds had not originally been scheduled for inspection. Ultrasonic inspection of these welds identified several short (2" or less), shallow (0.47" on C, 0.293" on A), circumferentially oriented flaws on each generator. Because the flaw indications exceeded ASME Section XI [1] IWB-3500 acceptance standards, CP&L contracted Structural Integrity Associates to evaluate these flaws in accordance with ASME Section XI IWB-3600 to determine whether continued operation with the observed indications is acceptable.

In addition to the ultrasonic examination of these locations, CP&L elected to perform internal fluorescent magnetic particle examination of a portion of the weld on A generator, as a check on both UT sizing and the nature of the indications. This examination confirmed that the indications were in fact short, and suggested that they were fabrication related, since the indications had the appearance of weld porosity in some locations, and all indications were confined to the weld metal in the girth weld. The location of the indications was re-welded in 1984 as part of the steam generator replacement program.

This report summarizes the analyses performed by SI. The analyses include stress and fracture mechanics studies, including fatigue crack growth calculations. The conclusion of these analyses is that the observed indications will not grow to a depth which will violate Code margins on structural integrity of the steam generator shells over the next 18 month operating cycle, assuming a conservative transient cycle definition.

Section 2 summarizes the component geometry and material properties used in the evaluation. Section 3 presents the results of stress analyses performed to generate input for the fracture mechanics analysis in Section 4. Justification for not grinding out observed surface indications is summarized in Section 5, and conclusions and recommendations are presented in Section 6.

2.0 COMPONENT DESCRIPTION

The flaw indications were identified in the vicinity of the transition cone to upper shell weld in the H. B. Robinson steam generators A and C. A sketch of the component geometry, based upon data in Reference 3, is included as Figure 1. At the indication, the steam generator shell has an inside radius of 79.5", and a wall thickness of 3.62". The transition cone joins the upper shell at a nominal angle of 13.6°, determined from figures in Reference 2. The observed flaw indications are short, shallow, and oriented circumferentially.

The transition cone is fabricated from SA-533 Grade A, Class 2 material. Material properties for this material were taken from Reference 3 and from the ASME Section III Appendices at 500°F. The properties used in the analysis are summarized in Table 1. Fracture mechanics material properties (Fracture Toughness and Crack Growth Rates) were taken from ASME Section XI, Appendix A. While strict applicability of the Fracture Toughness data is limited to SA-533, Grade B plate material, it is believed that the lower bound toughness curves give reasonable estimates for SA-533, Grade A plate and associated weldment material as well.

The operating pressure of the steam generator shell is 800 psi, and the operating temperature is 518°F [3].

3.0 STRESS ANALYSES

The flawed location is in the transition cone to upper shell weld of the steam generator. For this location, the governing stress components are due to internal pressure and thermal transients. For the purpose of evaluating the observed flaws, it was necessary to determine through-wall stress distributions due to applied pressure and limiting thermal transients. The analyses used both theoretical and finite element methods, as discussed below.

The resulting stress distributions were used in fracture mechanics evaluations to determine predicted flaw growth rates and to determine the structural adequacy of the shell with the as-grown flaws, as presented in Section 4.

3.1 Pressure Stress

Since the observed flaw indications are circumferentially oriented, the axial component of pressure stress is of interest in evaluating the flaws. For a capped cylinder under internal pressure, Reference 4 gives a theoretical solution for axial stress. This results in:

$$\sigma_{axial} = \frac{qb^2}{a^2-b^2} = 8589\ psi$$

where: q = internal pressure = 800 psi
b = inside radius = 79.5"
a = outside radius = 83.12"

Because the affected region is in the transition cone to upper shell junction, bending stresses are also expected due to the geometric discontinuity. A two-dimensional axisymmetric finite element analysis of the component was performed to assess the pressure bending effects. The model is shown in Figure 2. The

finite element pressure stress results are shown in Figure 3, and compare well with the above theoretical result except for the bending effect.

3.2 Thermal Stress Analysis

Review of the stress report provided by CP&L [3] showed that the most severe thermal transient designed for under normal operation is due to injection of 70°F feedwater with the shell at an operating temperature of 518°F. This transient was conservatively modeled as a step change in fluid temperature of 448°F, as shown in Figure 4. Thermal stress analysis of this transient was performed using two independent analytical techniques to determine the worst case through-wall stress distributions for use in flaw evaluation and fatigue crack growth analyses.

The first analysis method used the SI in-house computer program PIPE-TS3 [5], which performs thermal transient and thermal stress analyses based upon an infinite cylinder model. The temperature history generated in this analysis is presented in Figure 4. This figure also illustrates the assumed fluid temperature transient, which was a decrease from 518° to 70° in 20 seconds. This transient is assumed to conservatively bound all thermal transients likely to be experienced by this location in the steam generator shell. Figure 5 presents the thermal stress history during this transient at the inside and outside surfaces, and Figure 6 presents the through-wall stress distribution at the time of maximum bending stress due to the transient.

In addition to this infinite cylinder analysis, a transient thermal stress finite element analysis of the location was performed. The purpose of this second analysis was to assess the effects of the transition cone to shell geometry. The same material properties and transient definition were used as in the PIPE-TS3 analysis described above. The finite element model for the thermal stress

analysis is illustrated in Figure 7. The resulting finite element thermal stresses at the time of maximum bending stress are illustrated in Figure 8. Once again, the stress distribution results from the two analyses were not significantly different, as can be seen by comparing the two stress cases presented in Figure 8.

The pressure stresses calculated by the finite element method were slightly more severe than those calculated by closed form methods due to discontinuity bending effects. The thermal stresses determined by two distinct methods are essentially the same. The results from finite element analyses for the pressure stress case were combined with the PIPE-TS3 results for the thermal cases and were used in the fracture mechanics analyses summarized in the next section.

3.3 Fatigue Cycle Definition

For the purpose of fracture mechanics/fatigue crack growth calculations, the thermal and pressure cases were combined as follows. The plant is assumed to experience five heat-up/cool-down transients per year, according to the stress report [3]. This transient is modeled as a complete pressure cycle (0 to 800 psi to 0), plus a complete thermal cycle (518° to 70°F). In addition, the shell is assumed to experience 625 (25000/40) complete thermal cycles (518° to 70°F) while at operating pressure, per year [3]. This transient definition is believed to conservatively bound expected steam generator operating transients, both in magnitude and number of cycles.

3.4 Residual Stress

During the fatigue crack growth analysis, the assumption was implicitly made that the residual stresses in the weld joint were zero, due to the post weld heat treatment which this weld received

in 1984. This assumption is considered to be a reasonable representation of the actual condition in the weld, but it is expected that actual residual stress distribution may be slightly different from this assumed uniform distribution. For a non-zero distribution, there must be a balance of tensile and compressive regions in the throughwall stress distribution. Tensile regions would tend to accelerate crack growth, while compressive regions would tend to retard growth. The magnitudes of such residual stresses have not been calculated, but their effects are not expected to be significant. Welding Research Council Bulletin 175 (WRC 175, August, 1972) notes that effects of residual stresses are not considered in pressure vessel design fracture toughness computations because:

"1. Peak values in a post weld heat treated component are less than 20% of the yield strength.
2. Service stresses and radiation effects both tend to reduce residual stresses during the life of the component.
3. Conservatisms throughout the whole recommended procedure and the safety factors applied appear to be ample to cover any incalculable adverse effects."

3.5 Local Stress Calculations

The stress report applicable to the H. B. Robinson Steam generator as of the replacement in 1984 (Reference 3) provides minimum wall thickness calculations based upon hoop stress for the upper shell and the transition cone regions. The reported minimum thicknesses are: Upper shell (SA-302 Grade B, SM = 26700 psi), t = 3.31"; Transition cone (SA-533 Grade A, Class 2, SM = 30000 psi), t = 3.01".

The flaw indications observed on the H. B. Robinson Steam generators appear to be confined to the weld material joining the

two components. Because this location is essentially cylindrical, it is reasonable to evaluate the minimum wall using the cylindrical formula. Therefore, Code minimum wall at the flaw location is assumed to be 3.31".

It should be noted that the observed flaw indications were oriented predominantly in a circumferential direction and seemed to consist primarily of minor fabrication defects, based upon observations made during the internal MT examination of steam generator A. Such flaws are not expected to have significant effects of the hoop stress capacity of the steam generator vessel.

IWB-3610(d)(2) requires that the primary stress limits of Section III, NB-3000 be satisfied, assuming a local area reduction of the pressure retaining membrane equal to the area of the detected flaws.

Calculations have been performed demonstrating that this criterion is satisfied. The indications are extremely small in length, and, therefore will not influence the general primary membrane or bending stress in the shell, regardless of their depth. Even if the indications are considered to be a ground zone of 360° around the circumference, analyses have shown that the Section III primary stress limits can be satisfied for grind depths as deep as 1.0 inches.

4.0 FRACTURE MECHANICS ANALYSIS

Fracture mechanics analyses of the limiting flaw indications reported by inspection were performed. These analyses are summarized below. The end result of the analyses is a series of fatigue crack growth calculations to predict the expected depth of the observed flaws at the end of the next fuel cycle (approximately 18 months), and to assess the acceptability of this size flaw in accordance with ASME Section XI [1] flaw evaluation criteria. (In the absence of flaw evaluation rules for Class 2 vessels in Reference 1, the Class 1 vessel requirements are applied, as recommended in Reference 1.)

The conclusion of the studies is that the observed flaws are not predicted to grow to a depth which will impair the structural adequacy of the steam generator shells in the next 18 months of operation.

4.1 Flaw Modeling

The indications in the A and C steam generators are relatively shallow and short. The limiting flaws were modeled as semi-circular, inside surface cracks with an aspect ratio $a/\ell = 0.5$. A second set of analyses was also performed assuming semi-elliptical surface cracks with $a/\ell = 0.2$. The former case is representative of the actual flaw characterizations at H. B. Robinson, Unit 2, as reported by UT. The latter is more conservative and representative of longer flaws, such as have been observed at other plants. The distinction between the two cases is significant, since a flaw model with $a/\ell = 0.2$ will predict higher crack growth rates under the same stress conditions than will an $a/\ell = 0.5$ model. Use of the 0.5 model for the Robinson steam generator flaws is consistent with the reported lengths of the limiting flaws determined by UT, supported by the MT observed flaw lengths on A generator. Also, large aspect ratio flaws would be expected if fabrication was the

cause, as is believed to be the case for the subject flaw indications.

The SI fracture mechanics computer program **pc-CRACK** [6] was used to analyze both flaw models.

4.2 Stress Intensity Factor Calculation

The stress cases described in Section 3 (FEM pressure and PIPE-TS3 thermal) were used to generate through wall axial stress distributions. Axial stresses were used because the observed flaws are circumferentially oriented.

Stress intensity factor (K) calculations using the above stress distributions with each flaw model (a/ℓ = 0.2,0.5) were performed using **pc-CRACK**. The K versus a (depth) distribution for each stress case is shown in Figure 9 for a/ℓ = 0.5, and in Figure 10 for a/ℓ = 0.2. These figures illustrate the K due to pressure stress calculated by FEM and the K due to thermal stress at 110 seconds into the transient (time of maximum bending stress). Residual stresses are assumed to be zero since the vessel was post weld heat treated as part of the 1984 replacement program. The pressure finite element results will be used in the following analysis.

It is worth noting that the K calculated for each stress case is much higher for the long flaw (a/ℓ = 0.2) model. Consequently, a longer flaw would be expected to grow faster than a shorter flaw of the same initial depth.

4.3 Allowable Flaw Size Determination

Section XI of the ASME Code [1], IWB-3610 and Appendix A, provide methods for assessing the acceptability of flaws which exceed the acceptance criteria of IWB-3500. The techniques are directed at

acceptance of flaws in Class 1 components which exceed 4" in thickness. However, application to other components is permissible pending incorporation of evaluation standards for these components into the Code.

The evaluation criteria in Section XI define the allowable flaw size under normal operating conditions as that flaw depth where the applied stress intensity factor just equals the material fracture toughness parameter K_{Ia} divided by $\sqrt{10}$. For emergency and faulted conditions, the allowable flaw depth is that where the applied stress intensity factor just equals the toughness parameter K_{Ic} divided by $\sqrt{2}$. The purpose of these limits is to provide margin against unstable flaw propagation under applied loading. Figure A-4200-1 of Section XI Appendix A gives K_{Ia} and K_{Ic} data as a function of temperature for materials which are assumed to represent the lower bound performance of the materials used in the H. B. Robinson steam generator transition cone girth weld and base materials.

Material test documentation contained in Reference 3 gives the maximum RT_{NDT} for the transition cone material as 60°F. This value was used along with the K_{Ia} and K_{Ic} curves in Figure A-4200-1 to determine fracture toughness estimates for the steam generator material as functions of distance through the vessel wall, and transient temperature history.

The transient thermal stress analyses discussed above predicts through-wall temperature distributions for each time step in the transient analyzed. Using these distributions with the Section XI, Appendix A curves and the RT_{NDT} of 60°F, K_{Ia} and K_{Ic} were calculated as a function of depth. The maximum value for these properties was taken as 200 ksi $\sqrt{in}$, as shown in the Appendix A figure.

For the purpose of evaluating allowable flaw depth under normal operating conditions, both calculated toughness parameters were divided by $\sqrt{10}$. The applied stress intensity factors due to

pressure and the assumed thermal transient were determined as described above. The total stress intensity factor (pressure plus thermal) as a function of depth was compared to the factored toughness functions for representative time steps during the assumed transient.

Figure 11 presents the results for the time at which the peak stress occurs during the assumed transient (43 seconds). For this case, the applied K curve does not exceed either the K_{Ia} or K_{Ic} curve (divided in both cases by $\sqrt{10}$) for any flaw depth. Figure 12 presents the results at the time of the maximum bending stress due to the transient (110 seconds). Figure 13 presents the results later in the transient (200 seconds). In Figures 12 and 13, the total K curve exceeds the factored K_{Ia} curve slightly for shallow flaws, then falls below this curve for deeper flaws. This effect is due to the fact that the K_{Ia} is a function of the difference between local temperature and RT_{NDT}. As the temperature transient propagates into the shell, this difference is reduced. In neither Figures 12 nor 13 does the applied K curve exceed the K_{Ic} curve (factored by $\sqrt{10}$) for any flaw depth.

It is judged that for the H. B. Robinson steam generator shell flaw evaluation, it is appropriate to use the $K_{Ic}/\sqrt{10}$ curve to determine allowable flaw size for normal operating conditions. This is because the component is a Class 2 vessel with wall thickness less than 4". In addition the factor of $\sqrt{10}$ on K_{Ic} gives adequate margin to critical flaw size as determined from K_{Ic}. The fact that $K_{Ia}/\sqrt{10}$ is slightly exceeded for shallow flaw depths is not significant, since for deeper flaw depths this margin is restored. This effect is common in thermal transient driven analyses such as the present, where thermal effects are significant for shallow flaws.

Evaluation of emergency and faulted condition allowable flaw size is bounded by the normal condition evaluation. The allowable flaw size for emergency and faulted conditions is governed by $K_{Ic}/\sqrt{2}$,

which is a factor of 2.24 greater than the $K_{Ic}/\sqrt{10}$ used for normal evaluation. However, review of the design transient definitions in Reference 3 indicates that stress intensity factor due to emergency/faulted thermal loads at the affected location will be essentially the same as for normal conditions, while applied pressure will less than double. Therefore, the normal condition case is governing.

As illustrated in Figures 11, 12 and 13, the IWB-3612(a) criterion ($K_{applied} < K_{Ia}/\sqrt{10}$) is satisfied for all flaw depths greater than 0.8 inches. Thus, the IWB-3612(a) criterion is satisfied for the deepest flaw at the end-of-evaluation period, under the worst case crack growth assumptions used.

However, at some times during the assumed transient, $K_{Ia}/\sqrt{10}$ is exceeded for smaller flaw depths. This fact is not considered significant, since for deeper flaws this margin is restored. Also, in no case is K_{Ia} or $K_{Ic}/\sqrt{10}$ ever exceeded, therefore demonstrating adequate margin for structural failure even for the smaller flaw sizes.

4.4 Fatigue Crack Growth Predictions

Fatigue crack growth calculations were performed for the limiting flaw depths in each generator (0.47" in C, 0.3" in A), using the above stress intensity factor calculations. The ASME Section XI Appendix A crack growth law for carbon and low alloy steels in reactor water environment was used [1]. The cyclic loading scheme discussed in section 3.3 was used.

The results of the analysis are presented for an 18 month operating cycle in Figure 14 for all four cases. From this figure, it is seen that a 0.47" deep flaw with $a/\ell = 0.5$ is predicted to grow to a depth of about 0.7" over 18 months. In comparison, the same flaw

is predicted to grow to nearly 1" deep if the aspect ratio is taken as 0.2.

Faster growth would be predicted if a flaw model with aspect ratio of 0.1 was used. This observation allows this analysis to be benchmarked against observed flaw growth at similar locations in other steam generators, in which service induced cracking was believed to have been observed. These flaws were originally reported with lengths as long as 9", and were observed to grow in depth by about 0.75" in one operating cycle [7]. Comparable or larger growth would be predicted using a model with $a/\ell = 0.1$ (long flaw) and the analysis approach described above for the H.B. Robinson generators.

This suggests that the Section XI crack growth law, together with the assumed cycling and calculated stress distributions used above for the analysis of the H.B. Robinson generators, would reasonably represent the behavior of service induced flaws in steam generators if larger aspect ratio flaws were present. Because the Robinson flaws are very short and shallow, and because of the chemistry control which Robinson has successfully implemented in these generators since the replacement activities in 1984, it is believed that the analyses summarized here are reasonably conservative.

A deeper starting flaw would lead to a deeper final flaw after the prediction period using the same flaw propagation curve. For example, an initial flaw depth of 0.78" would be predicted to grow to a depth of approximately 0.95" after 18 months assuming $a/\ell=0.5$, and to a depth of approximately 1.2" after 18 months assuming $a/\ell=0.2$. A deeper initial flaw would not affect the calculated K vs a curves presented in the report.

5.0 JUSTIFICATION FOR NOT GRINDING OUT OBSERVED SURFACE FLAWS

Experience with girth weld flaws in steam generators in other plants has shown that grinding flaws without subsequent weld repairs can lead to accelerated flaw initiation and growth, probably due in part to local stresses and material conditions resulting from grinding. Figure 15 from a study by EPRI illustrates stresses which can result from grinding of various types and intensities (EPRI Report NP-944, December, 1978, Reference 8). The data presented is for stainless steels, but is assumed to be indicative of what could be expected with grinding in locations such as the H. B. Robinson steam generator girth welds. Because of the relatively minor reported character of the flaw indications at Robinson, it was considered to be more prudent to avoid grinding until a confirmed environmental cracking mechanism is observed, or until indications large enough to require weld repairs are observed.

6.0 RECOMMENDATIONS AND CONCLUSIONS

The observed indications in the steam generator A and C girth welds are acceptable for continued operation without repair for the next 18 month operating cycle. This conclusion is based upon conservative stress and fracture mechanics analyses performed in accordance with the requirements of ASME Section XI, Appendix A. The indications were characterized as short and shallow, and do not compromise the structural integrity of these steam generators. The internal MT inspection by CP&L , which confirmed that the observed indications are short in length and have characteristics of fabrication defects, supports continued operation without repair of the observed flaws.

In accordance with ASME Section XI requirements, the areas of the observed flaws must be re-examined during each of the next three inspection periods, since they exceeded the Section XI IWB-3500 acceptance standards and required an IWB-3600 flaw evaluation. Because of the generic concern regarding service-induced flaws in steam generator shells, which have in some cases resulted in large crack growth rates, a mid-cycle inspection of the worst indication may be advisable prior to the next refueling outage, if the plant experiences an extended shutdown for other reasons.

7.0 REFERENCES

1. ASME Boiler & Pressure Vessel Code, Section III Appendices and Section XI, 1986 Edition.

2. Westinghouse Electric Corporation, "Vertical Steam Generator Instructions for Carolina Power and Light Company H. B. Robinson Unit No. 2, Hartsville, South Carolina", Technical Manual 144-C346, September, 1983.

3. Westinghouse Steam Generator Stress Report for Carolina Power & Light Company, H. B. Robinson Unit 2. WNEP-8323, SG-84-04-037, Revision 0, April, 1984.

4. Roark, R., Young, W., Formulas for Stress and Strain, Table 32, Fifth Edition, McGraw-Hill, 1982.

5. Structural Integrity Associates, "PIPE-TS3", Version 1.0, 1990.

6. Structural Integrity Associates, pc-CRACK, Version 2.0, August, 1989.

7. Westinghouse Electric Corporation, "Indian Point Unit 2 Steam Generator Girth Weld Repair Report, Fall 1987 Outage" WCAP-12095, Westinghouse Proprietary Class 3, January, 1989.

8. Giannuzzi, A.J., EPRI Report NP-944, "Studies on AISI Type-304 Stainless Steel Piping Weldments for Use in BWR Application," December, 1978.

Table 1

Material Properties Used on Analysis
of H. B. Robinson Steam Generator Indications
(all taken at 500°F)

E, ksi (1)	28.0×10^3
ν	0.3
α, in/in/°F (1)	7.96×10^{-6}
K Btu/hr-ft-°F (2)	24.2
S_m, Ksi (1)	30
S_y, Ksi (1)	62.4
S_u, Ksi (1)	90
ρC_p, Btu/ft^3 (2)	64.2

(1) Taken from Reference 3.

(2) Taken from ASME Section III 1986 Appendices [1].

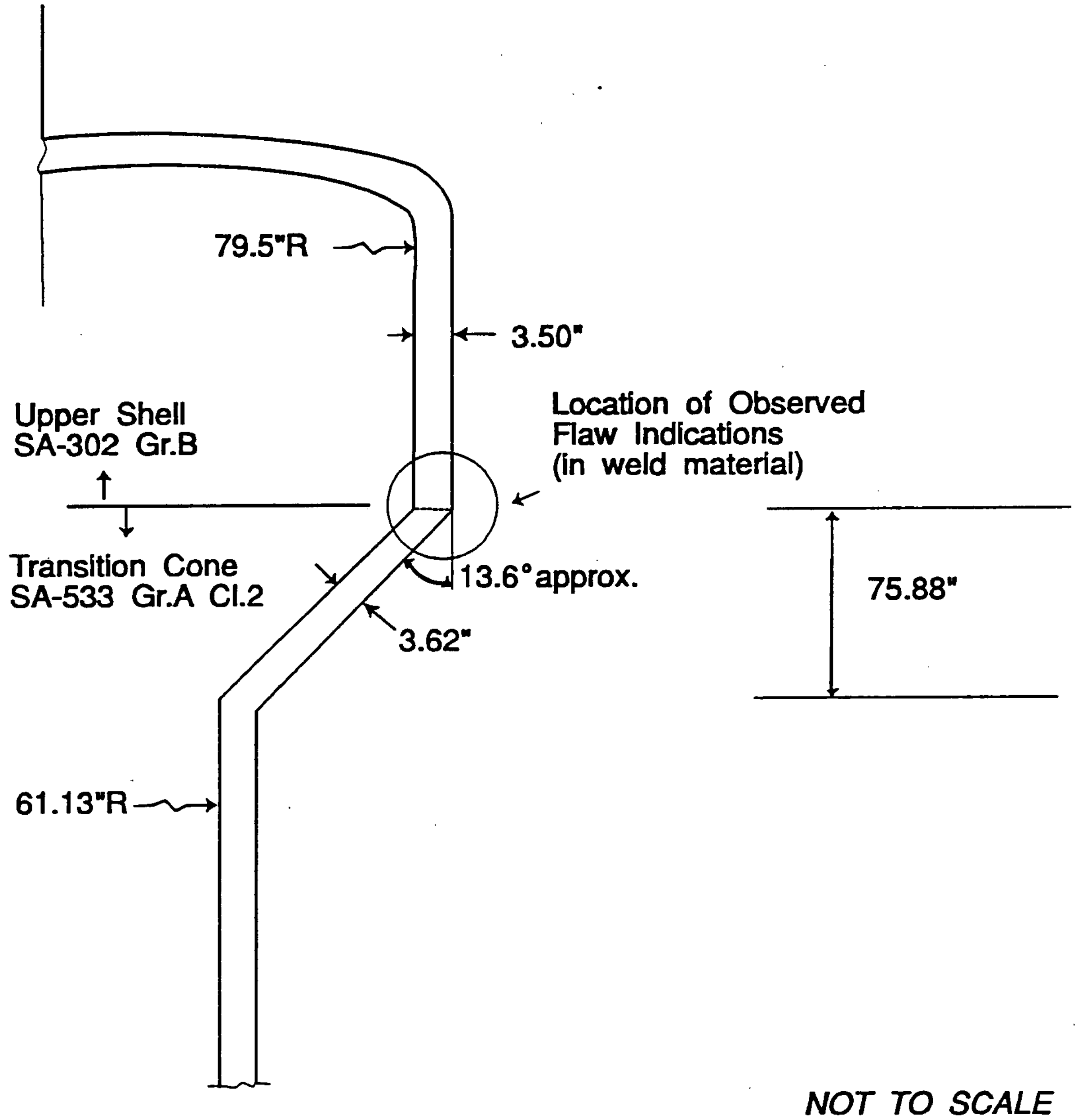

Figure 1. H.B. Robinson Steam Generator Geometry: Transition Cone to Upper Shell Junction

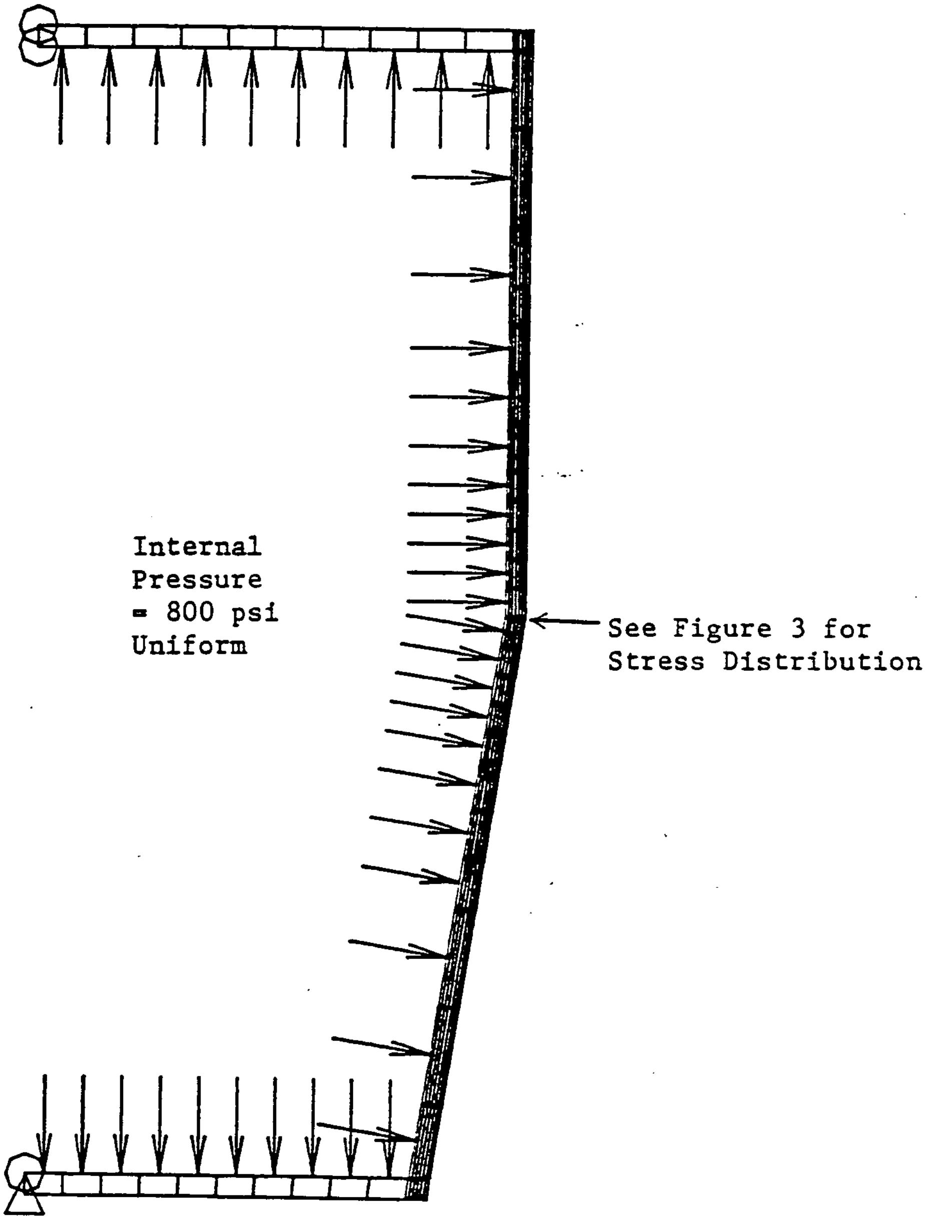

Figure 2. Finite Element Model for Pressure Stress Analysis

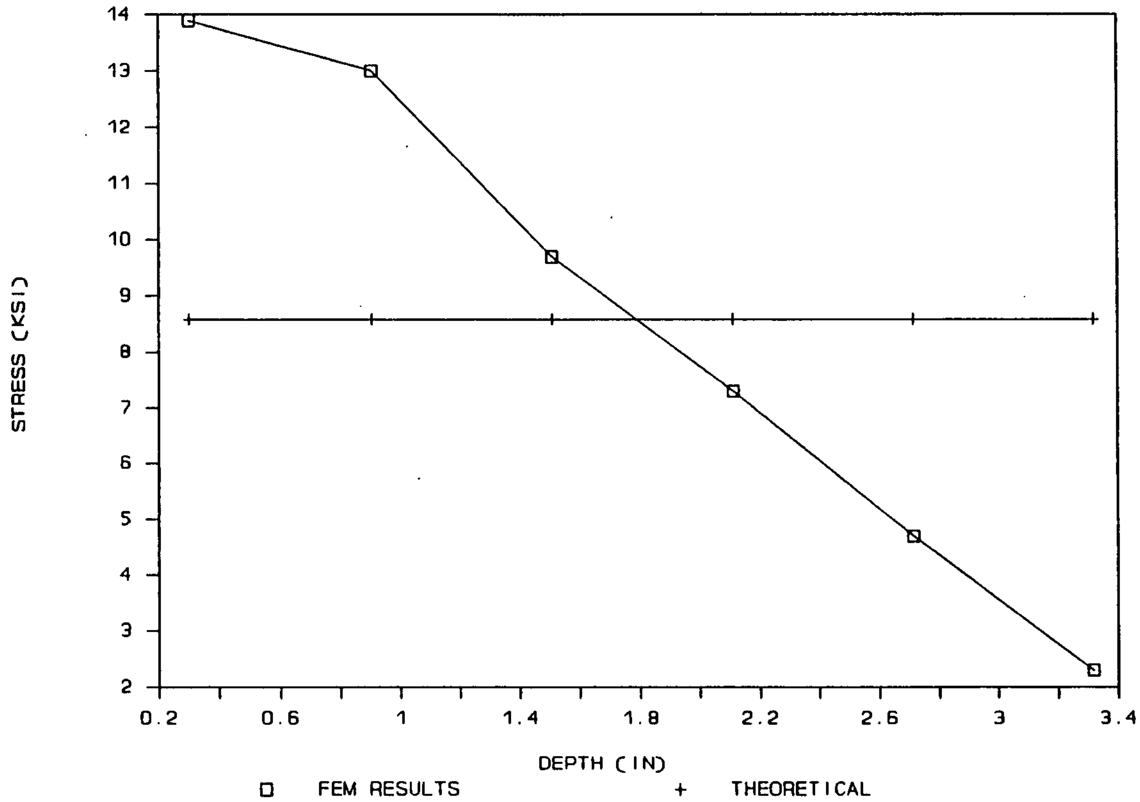

Figure 3. Comparison of Finite Element Through-Wall Pressure Stress Distribution With Theoretical Solution

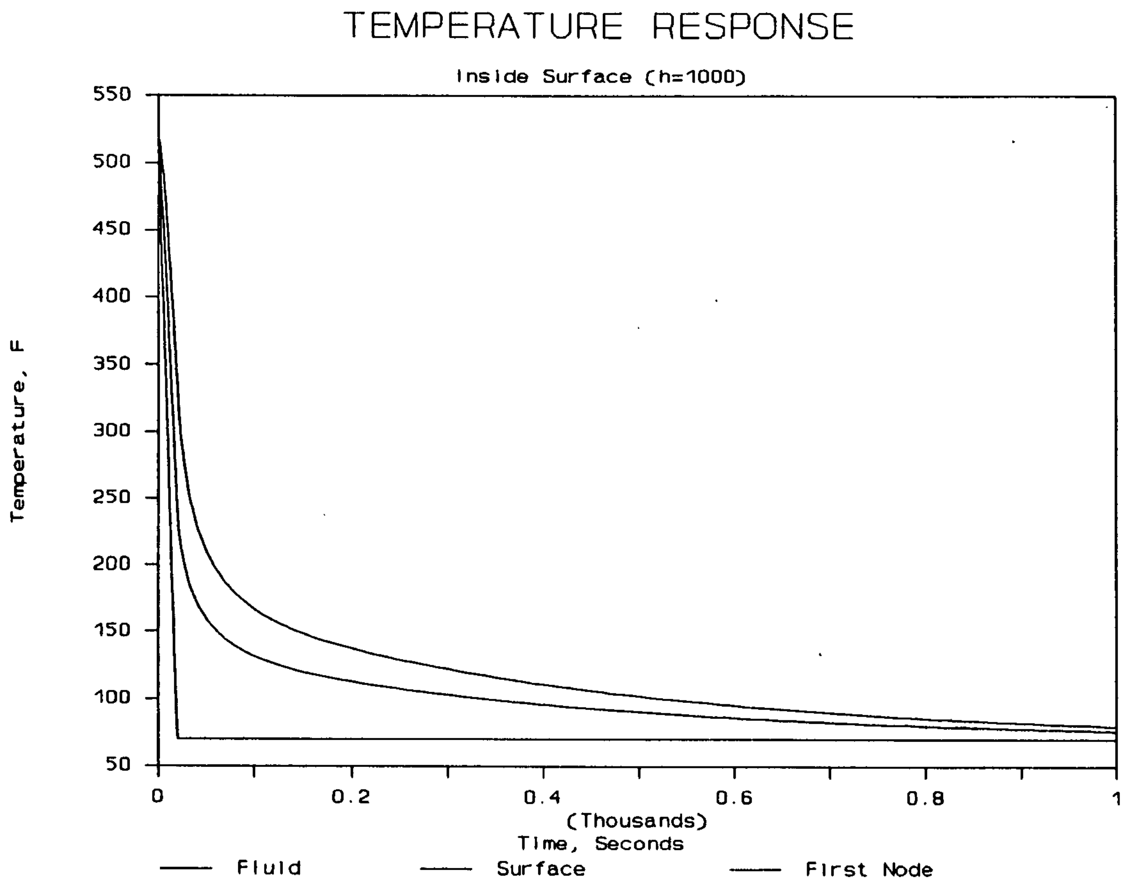

Figure 4. Transient Temperature History at Inside Surface

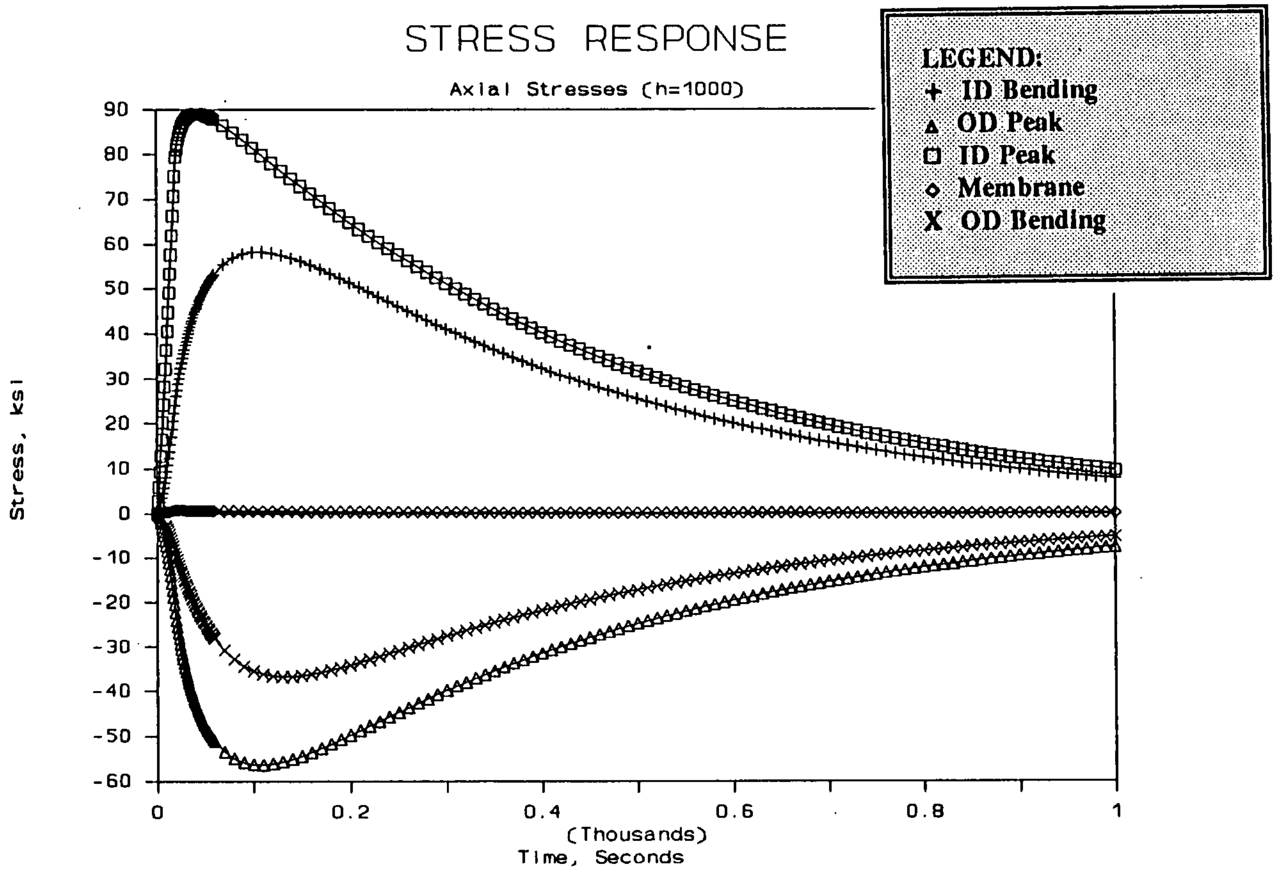

Figure 5. Transient Stress Results (PIPE-TS3)

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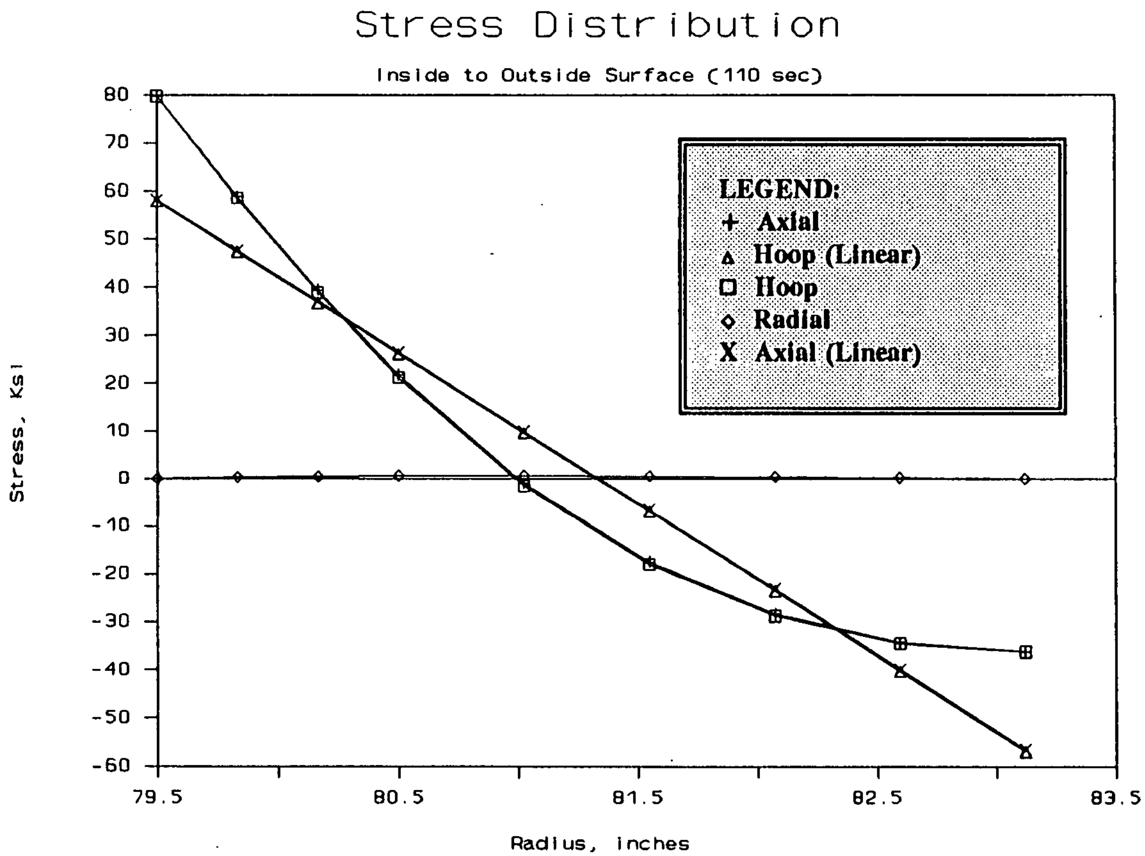

Figure 6. Through-wall Stress Distribution at t=110 sec. (Maximum Bending Stress)

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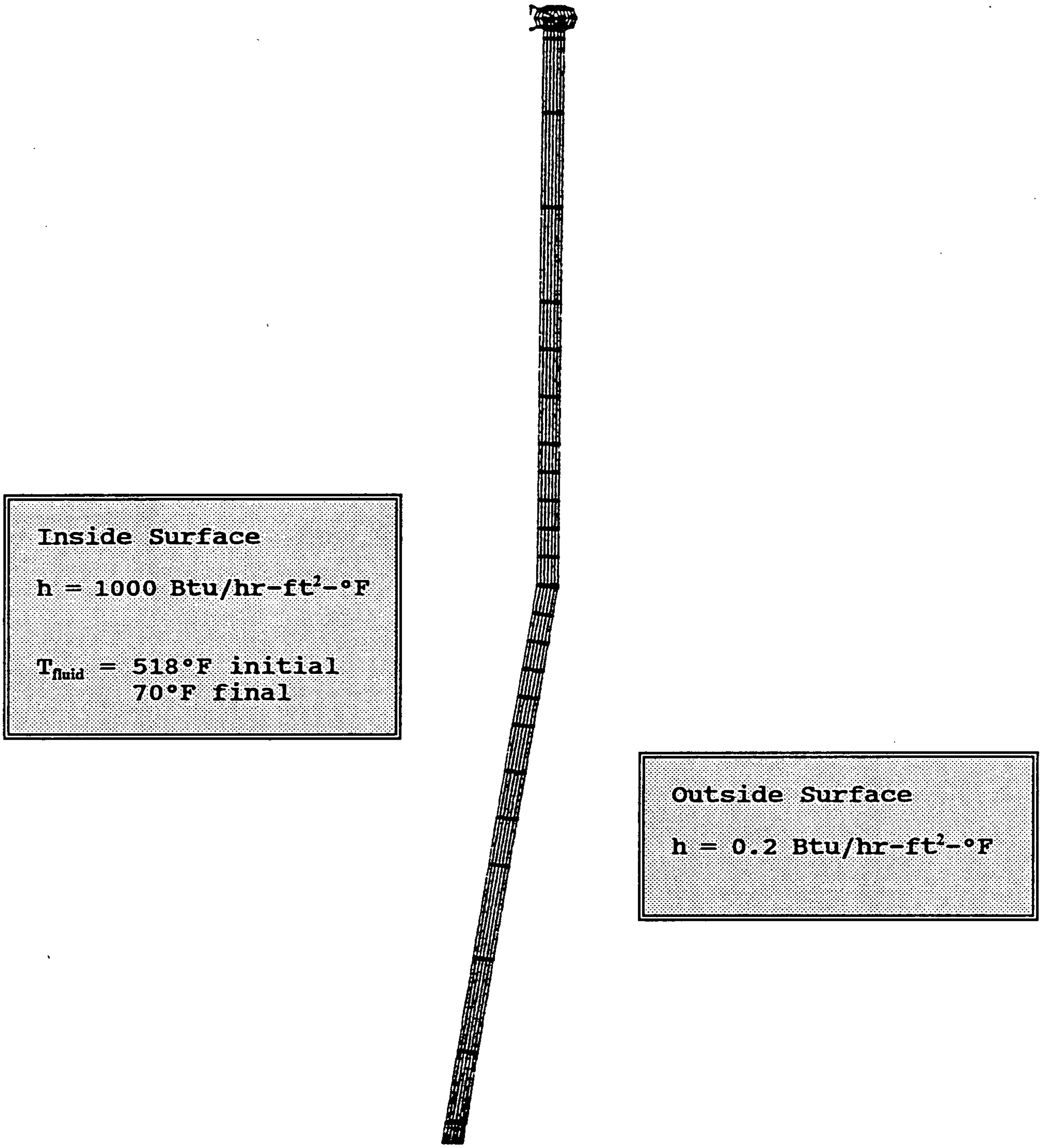

Figure 7. Finite Element Model for Thermal Stress Analysis

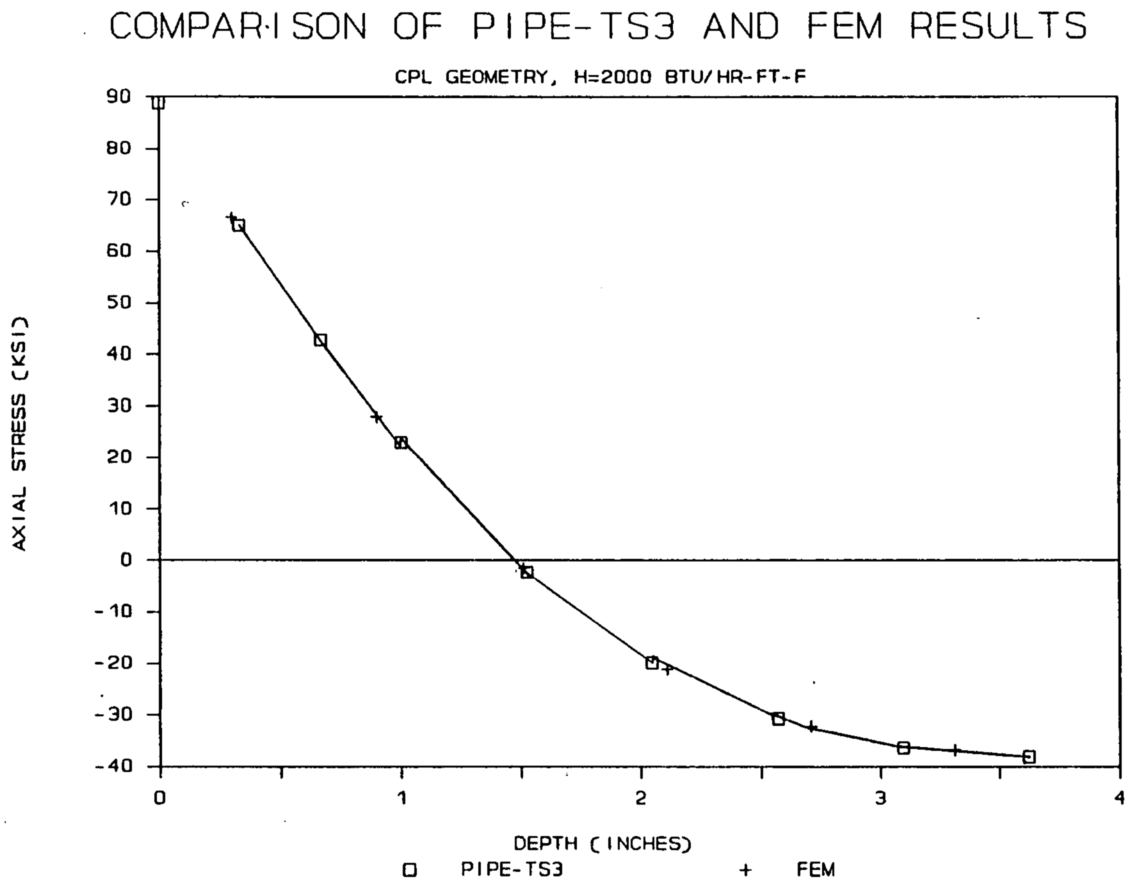

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Figure 8. Comparison of PIPE-TS3 and FEM Thermal Stress Results for Test Case Robinson Geometry and Transient, H = 2000 Btu/hr-ft^2-°F

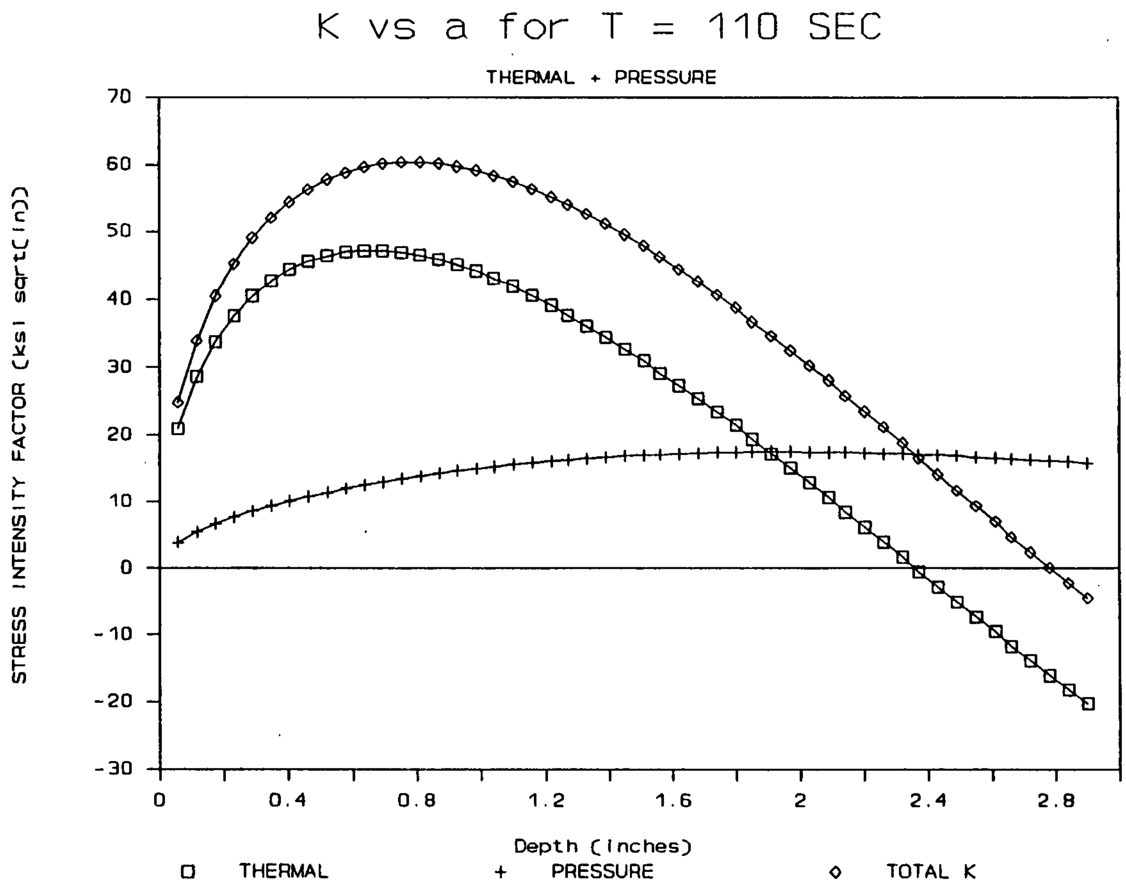

Figure 9. K vs. A for Pressure and Thermal Stress Cases ($a/\ell = 0.5$)

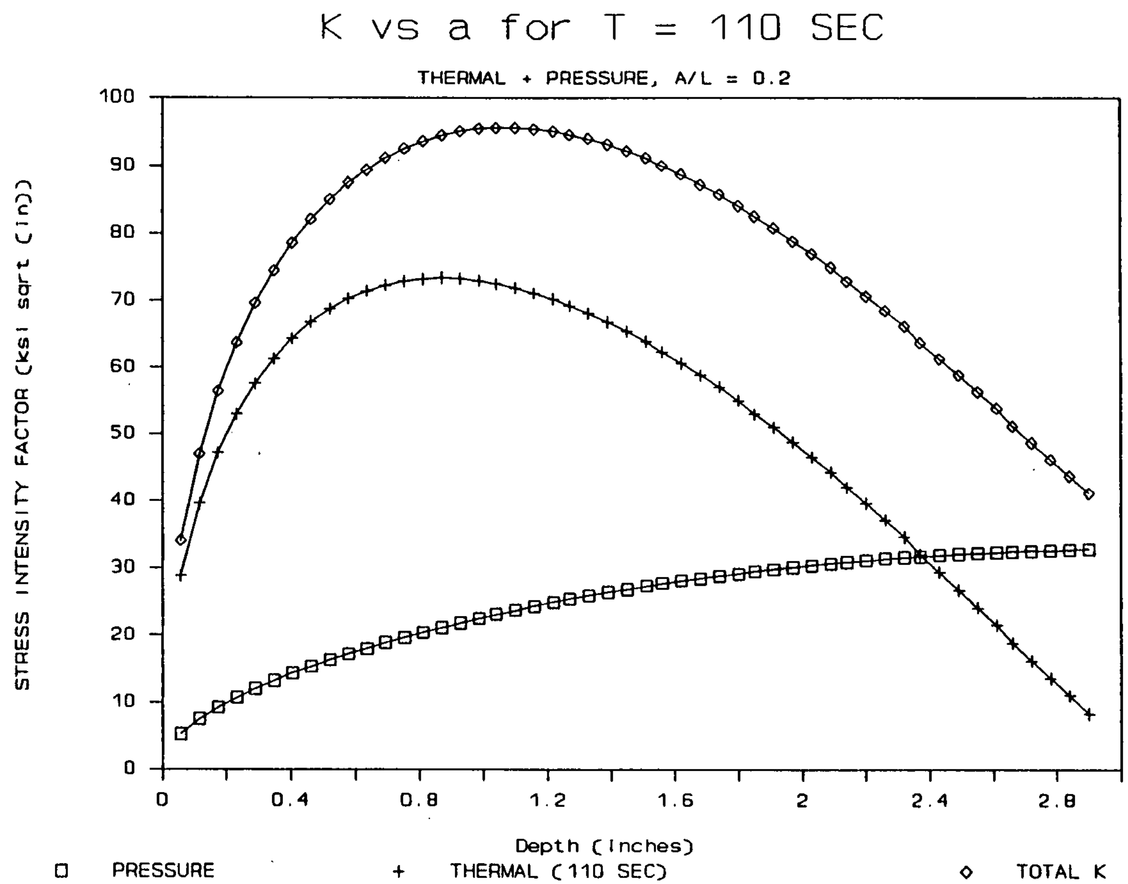

Figure 10. K vs. A for Pressure and Thermal Stress Cases (a/ℓ = 0.2)

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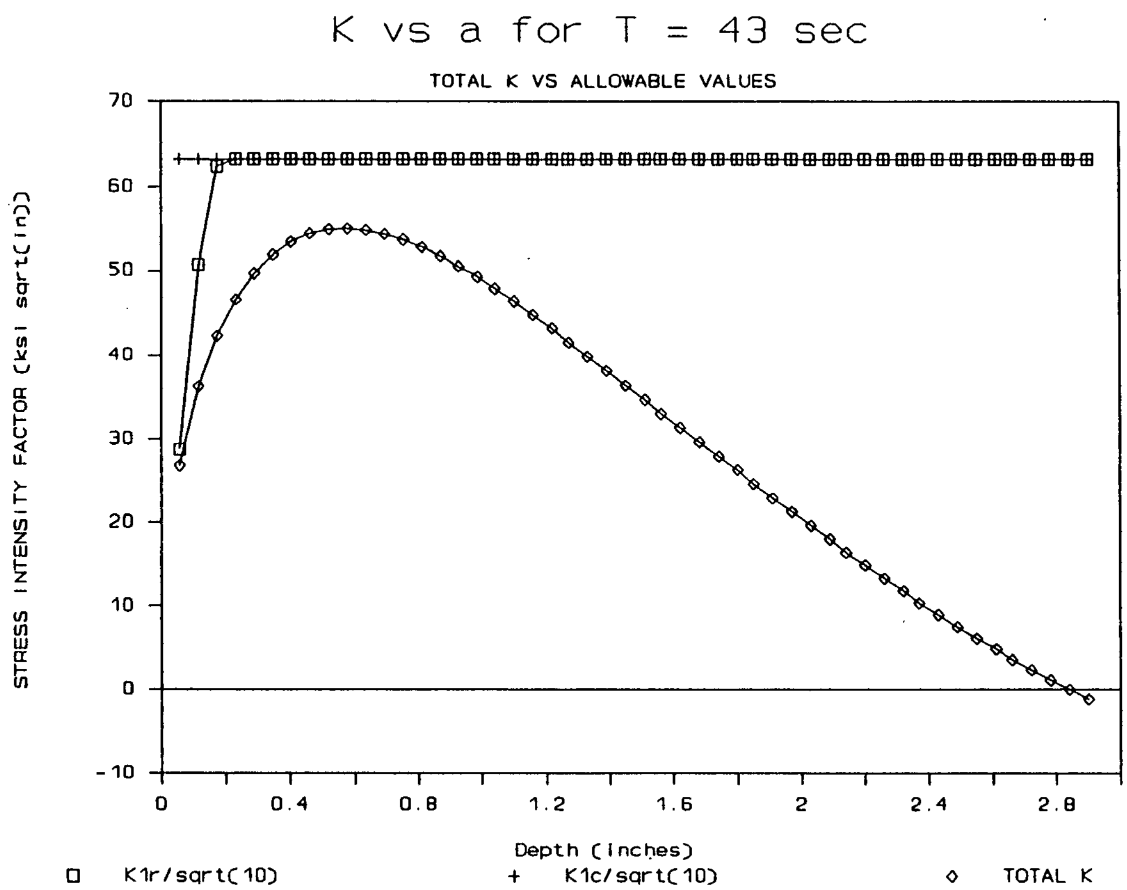

Figure 11. Comparison of Applied K with Section XI Allowable Values at t = 43 sec

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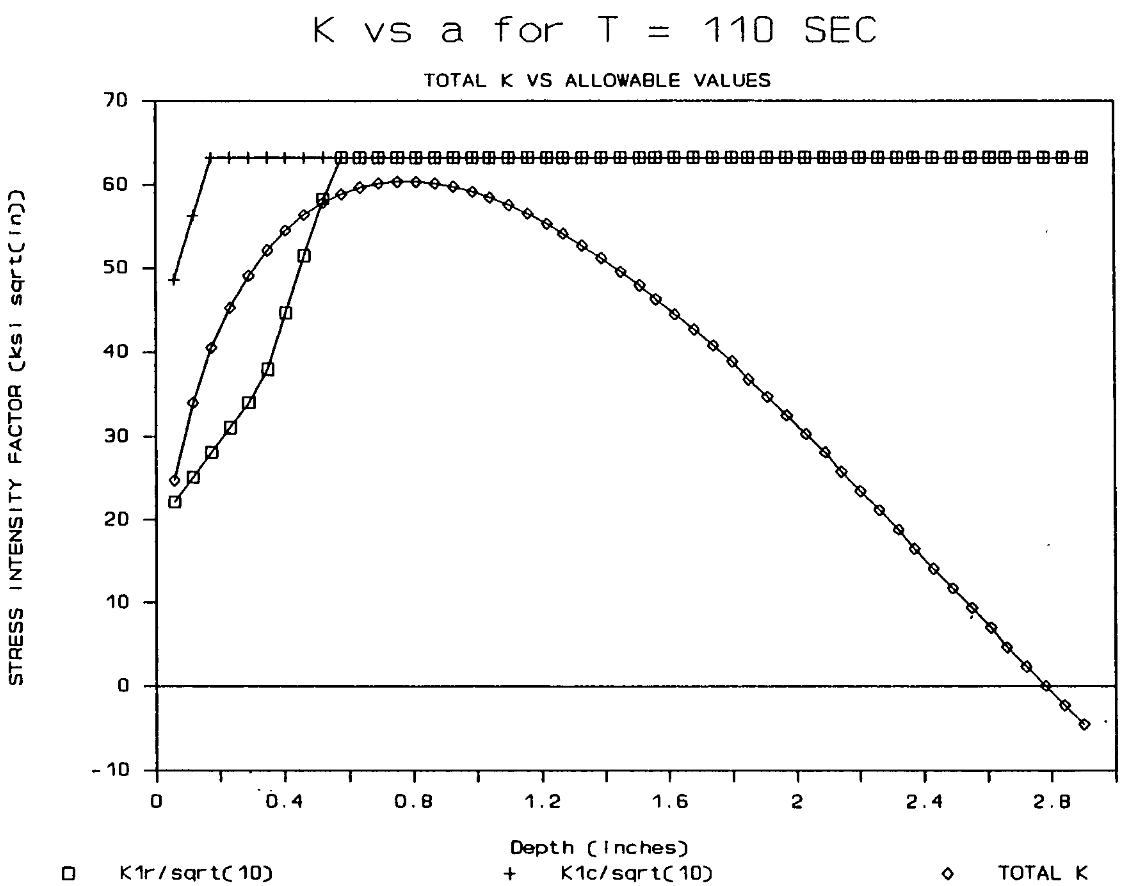


Figure 12. Comparison of Applied K with Section XI Allowable Values at t = 110 sec

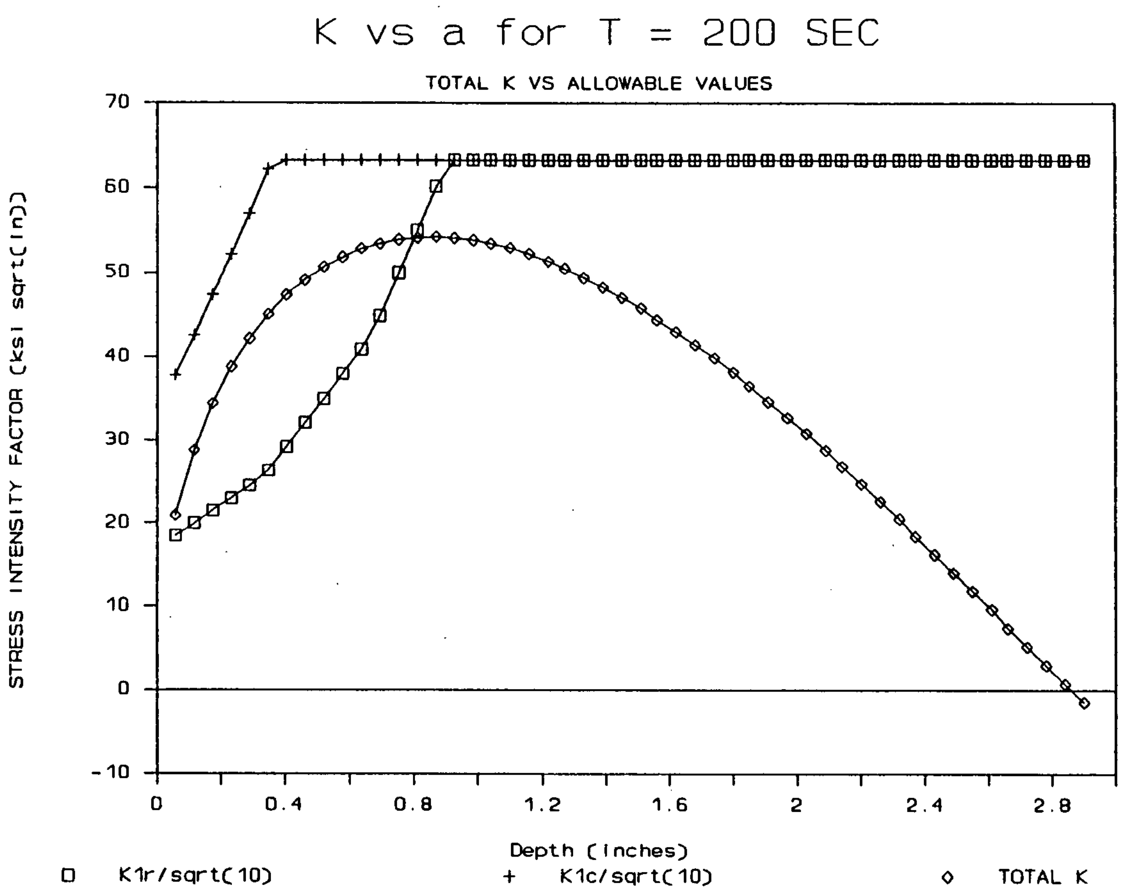


Figure 13. Comparison of Applied K with Section XI Allowable Values at t = 200 sec

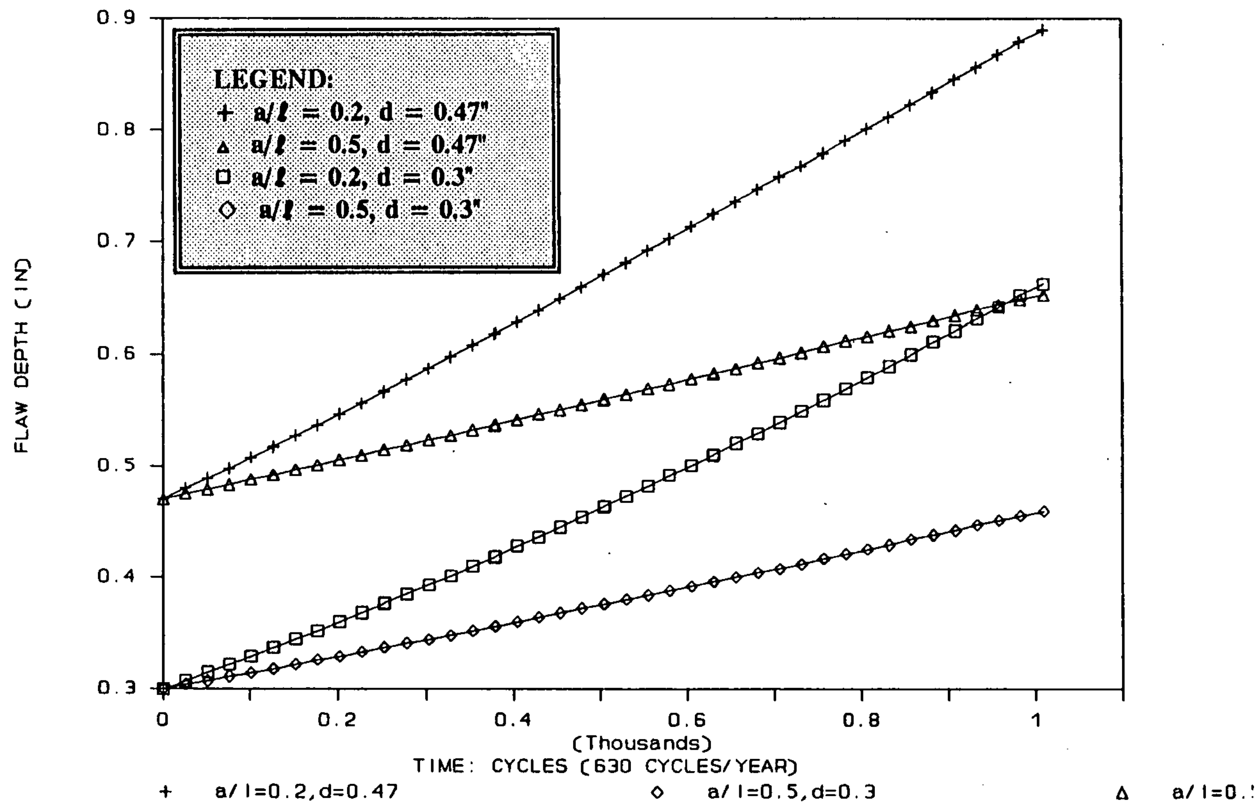


Figure 14. Predicted Fatigue Crack Growth (18 months) a/ℓ = 0.2 and 0.5, Initial Flaw = 0.3" and 0.47"

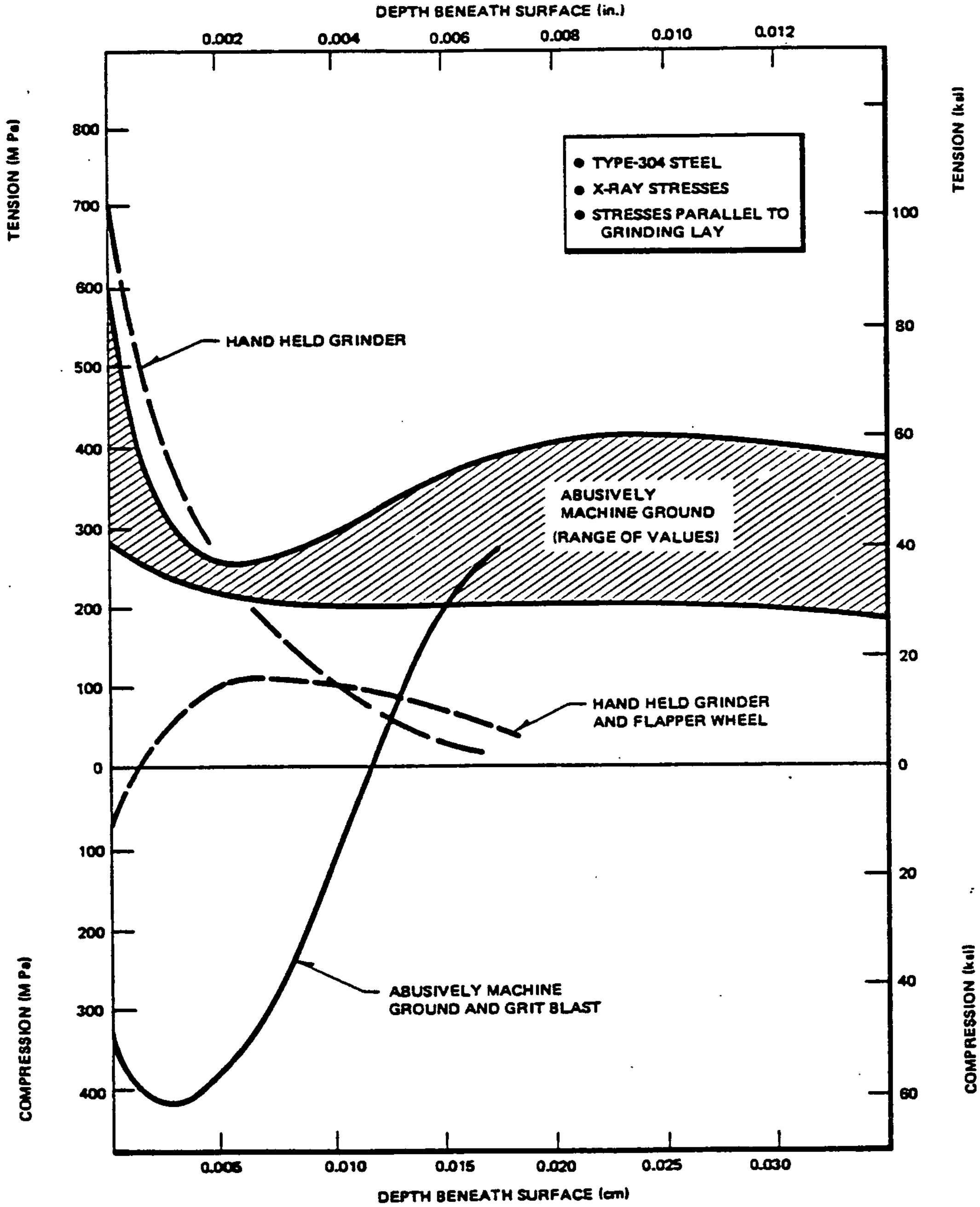


Figure 15. Comparison of Various Grinding and Post-Grinding Procedures for Type-304 Stainless Steel Coupons. X-Ray Surface and Subsurface Stresses Parallel to Lay (from Reference 8)

ATTACHMENT 2

C. H. Griffin Report, "Evaluation of MT Indications in the H. B. Robinson "A" Steam Generator"

Form 244

Carolina Power & Light Company

Company Correspondence

DEC 14 1990

File: RET RNP-90-207

NED-R-5236

MEMORANDUM TO: Mr. R. Hanford

FROM: C. H. Griffin

SUBJECT: Evaluation of MT Indications in the HBR "A" Steam Generator

During the current 10 year ISI, UT reflectors were detected while inspecting the girth weld located between the transition-cone to the "A" Steam Generator head. To further evaluate these reflectors, selected areas along the inside diameter (ID) surface of this girth weld were subsequently MT examined (wet fluorescent MT) by Westinghouse/CP&L personnel. Four MT indications were detected which were believed to be associated with UT reflectors. It was requested that I examine these reported MT indications and determine if they were actually cracks or some other type of indication.

Since the NDE technicians had originally MT examined only two short regions of the girth weld, it was requested by RNP Tech. Support that they proceed on with examining a 10-foot length of the girth weld circumference which had already been cleaned by plant personnel. This 10-foot length of weld included the regions in which previously noted MT indications had been detected. It was planned that any additional MT indications, detected during this examination, would also be marked to allow my further evaluation. Harry Ackerman (Westinghouse NDE tech.) and Larry Jernigan (CP&L NDE tech. Level II) performed the MT examination. Ed Black (CP&L NDE supervisor Level II) was also involved with the re-examination and evaluation of detected indications. Relative to this inspection, the following was observed:

* The ID weld crown had been ground during fabrication, apparently to better facilitate RT examination. This weld joint and the base metal immediately adjacent did exhibit numerous "heavy" grind marks. It is worth noting that since wet fluorescent MT is a very sensitive technique, some of the grinding marks could be observed as MT indications under the "black light." However, they were easily resolved as nonrelevant indications once observed under normal lighting and/or after polishing with an end grinder equipped with a flapper wheel and re-examining.

  Although the weld joint had been ground, there remained enough crown reinforcement that the weld edge/toe location could visually be approximately determined. After polishing, however, the weld

toe was observable by the MT (difference in magnetic permeability between the weld metal and the base metal).

* The reported MT indications which were believed to be related to the most significant UT reflector were determined to be associated with weld porosity in the weld joint. These indications correlate with the 45° UT reflector Number 5 and 60° UT reflector Number 1 (Azimuth Location 28).

One of these indications (for the purpose of this memo, denoted as indication "A") was approximately 1/4 - 3/8 inch in from the weld toe and the other (indication "B") was just inside the weld toe region. Indications "A" and "B" were within approximately 5/8 inch of each other.

When I first observed the indications, prior to MT, "A" appeared as a cluster of weld porosity and "B" appeared as a short (approx. 1/8 inch) linear indication. MT showed "A" to also have a linear indication (approx. 1/4 inch long) associated with the porosity (appearing to link-up some of the porosity). Light polishing failed to remove either of the indications (removing approx. 1/64 inch of metal), although a spot of weld porosity was also uncovered which was connected to one end of "B."

Indications "A" and "B" are both associated with welding-related flaws from the original fabrication (1984) of this weld joint. This should not be mistaken as corrosion pitting.

Except for the grind marks immediately adjacent to the weld joint, the base metal in this localized region appeared visually to be relatively smooth with little evidence of pitting.

* With the exception of one linear (discussed below), other MT indications observed during this activity were resolved as nonrelevant (i.e., grind marks, gouges, etc.) by myself and Ed Black, including the remaining two indications previously detected by Mike Hart (CP&L NDE tech., Level II).

One small 1/8-inch linear (indication "C") was detected within the weld metal (approximately 1/2 inch from the weld toe at Azimuth Location 17). After light polishing with a flapper wheel, it appeared that this indication was also associated with a fabrication flaw, most probably entrapped slag. This indication was not associated with a confirmed, recordable UT reflector. It was not removed.

* I also took time to examine the total circumference of this weld joint looking for any evidence of conditions not previously reported. Occasional minor surface pitting was observed in the steam generator head base material (similar conditions were reported in NCRs and resolved during the construction/fabrication activities in 1984 for the steam generators). The ID weld crown varied in width from approx. 1 1/2 inch to 4 inches wide. The surface preparation of this weld joint was less than desirable for an ISI finish (grind marks, gouges, base metal undercutting / overgrind at weld toes) although it is presumed that this was evaluated and also accepted during fabrication.

Replicas of indications "A" and "B" (45° UT reflector number 5 at Azimuth Location 28) were taken, using visible MT powder and transparent tape. A photocopy of these replicas is attached. Also attached is a copy of the "Information Only" NDE report for this MT activity.

In conclusion, an approximate 10-foot length of the girth weld ID was examined by MT. Three relevant MT indications were detected in the weld metal, two of which (indications "A" and "B") were related to a UT reflector at Azimuth Location 28. These two MT indications at Azimuth Location 28 were determined to be associated with weld porosity. The third MT indication (indication "C" at Azimuth Location 17) was not related to a confirmed, recordable UT reflector and was also determined to most probably be a welding imperfection such as slag (etc.).

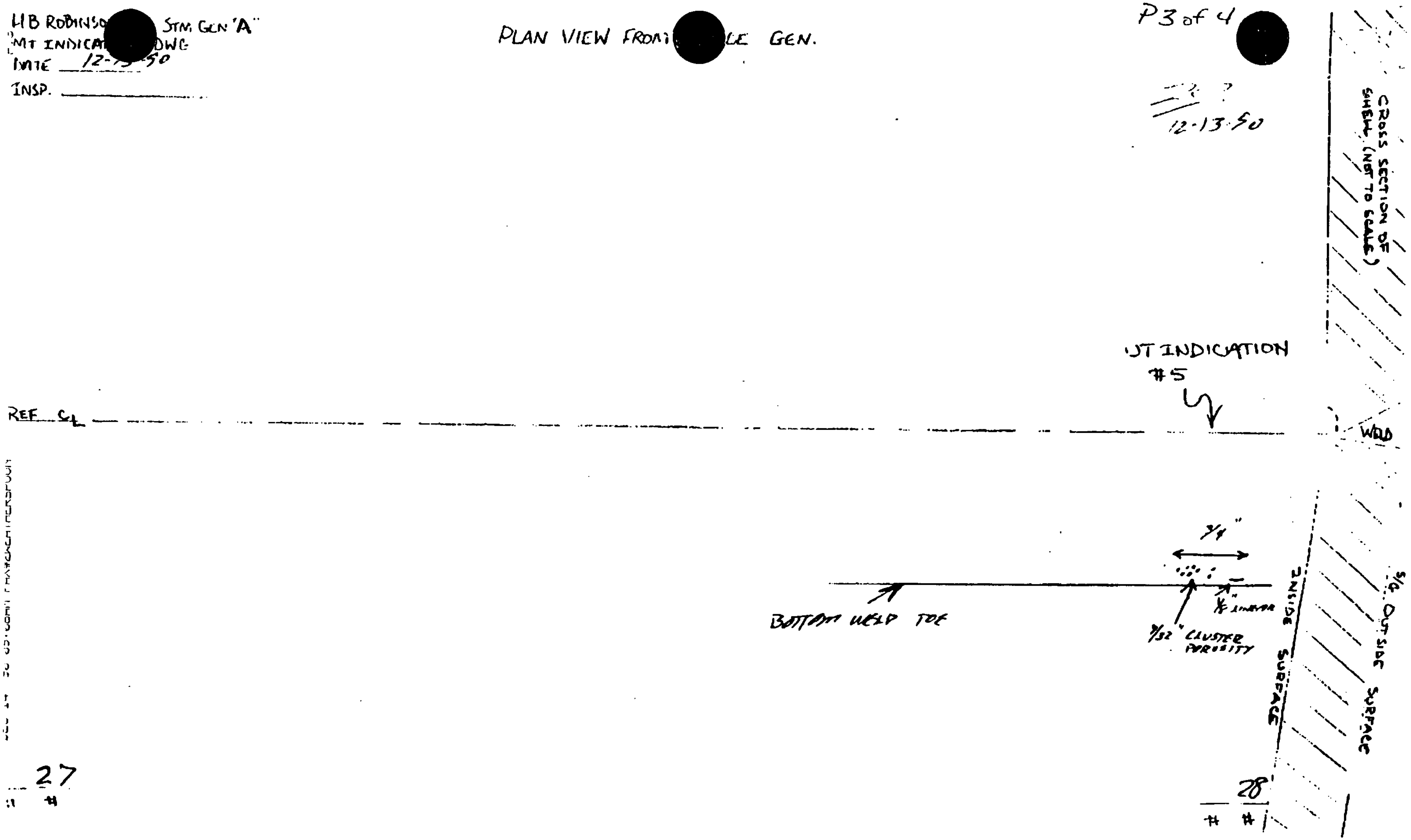
CHG

cc: Mr. P. A. Bauer
Mr. E. Black

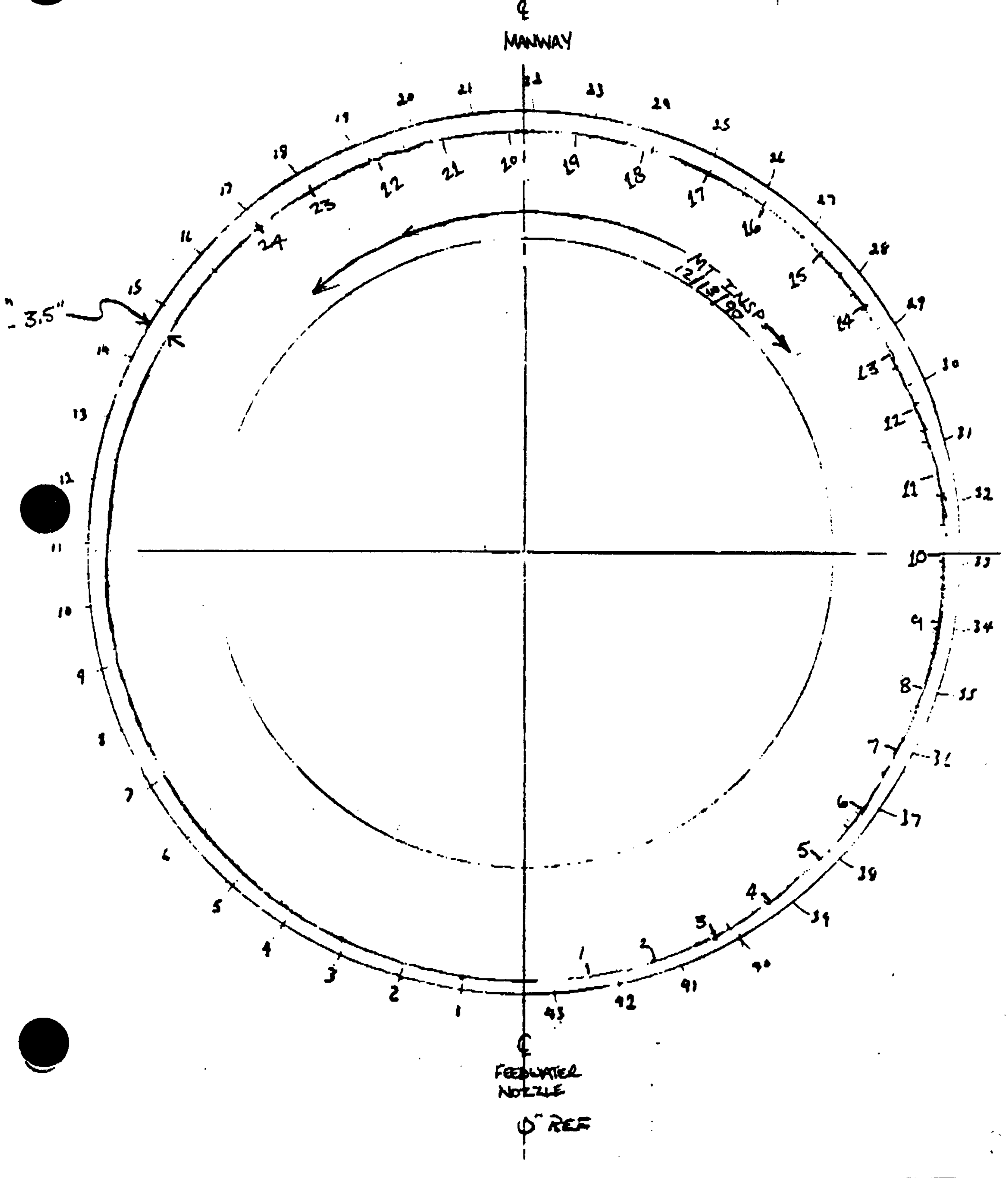
HB ROBINSO STM GEN "A"
MT INDICAT DWG
DATE 12-13-50
INSP. ____________

PLAN VIEW FROM LE GEN.

12-13-50

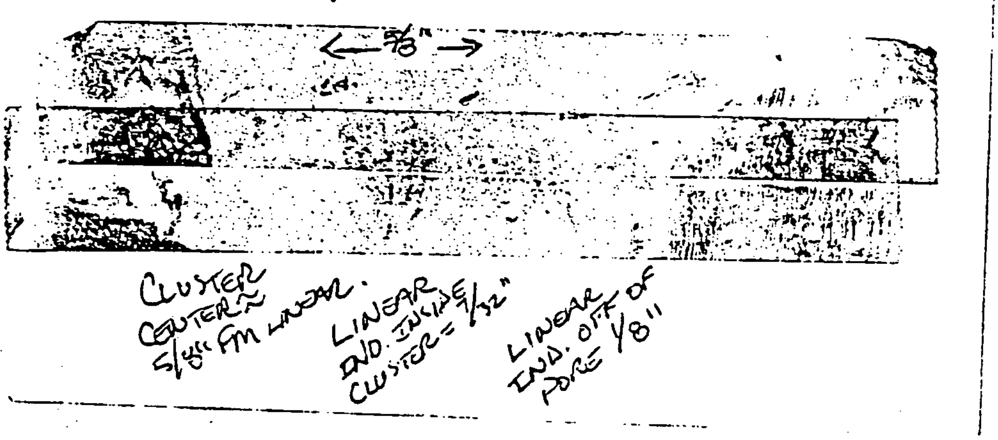


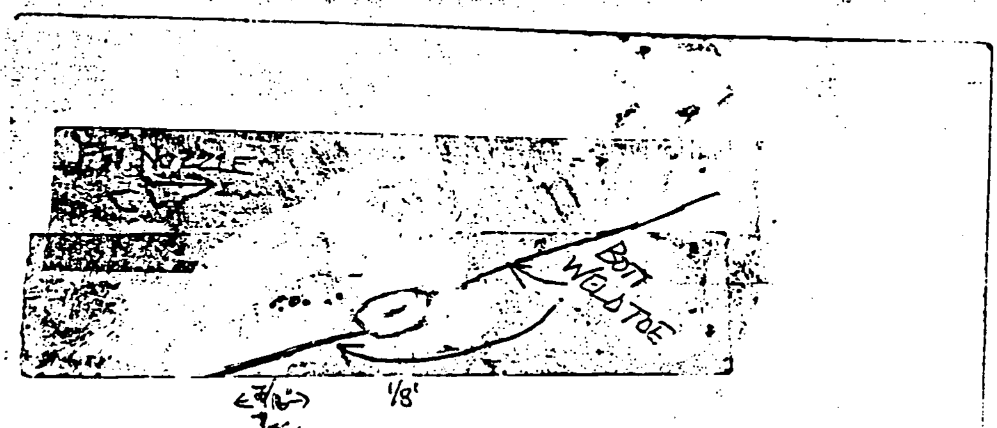
H.B. ROBINSON U/2
S/G "A" WELD #5



Replicas Representing MT indications
At Azimuth 28 (Generator "A")
(Girth Weld ID)

RI #5 AT





RI #5 AT L-28 FT

Note: this photocopy of the replicas has been enhanced to better show indications size, orientation, and spacing.

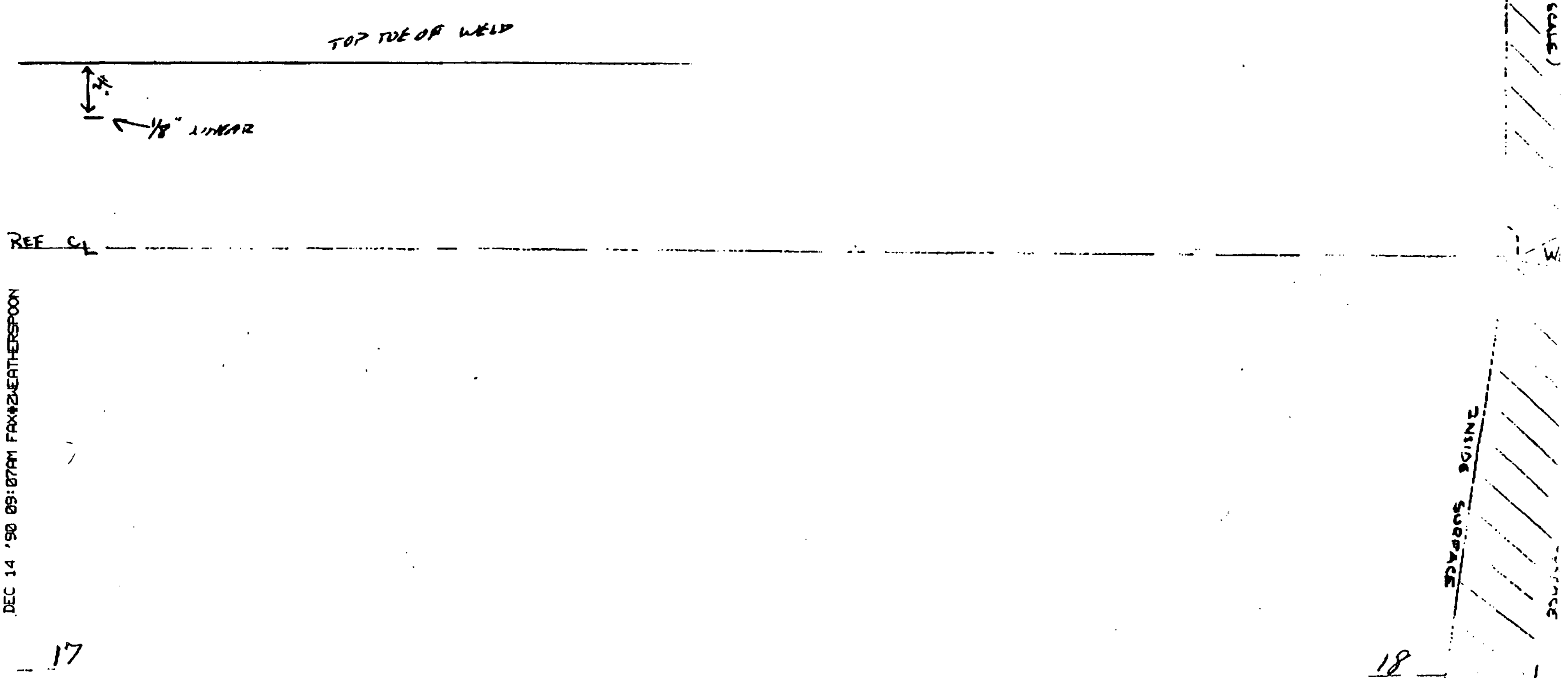
HB ROBINSON U/2 STM GEN "A"
UT INDICATION DWG
DATE 12-13-90
INSP. ______

PLAN VIEW FROM INSIDE GEN.

P 2 of 4

INDICATION
NOT REPORTED BY UT

12-13-90



XEROX TELECOPIER 295 ; ??-??-??;??:?? ??: DEC 14 '90 09:07AM FAX#2WEATHERSPOON

CCITT G3 ; #2

17

18

REV. 5/8/81 MT

CP&L
Carolina Power & Light Company

MAGNETIC PARTICLE NDE REPORT

PROJECT: HBR JOB NO.: NA UNIT: 1☐ 2☒ 3☐ 4☐ DATE: 12-13-90

DRAWING	SYSTEM	LINE	WELD/ITEM NUMBER
CBL 205 R/0	STEAM GEN "A"	NA	WELD #5

DESIGN CLASS/CATEGORY: CLASS 2
ACCEPTANCE STANDARD: ☐ASME III ☐VIII ☐B31.1 ☐AWSD1.1 ☒OTHER INFO

MTL. TYPE: C/S MTL. THICKNESS: 3.5 O.D./LENGTH: ID 13 FT 3 IN.
SURFACE FINISH: ☐AS-WELDED ☒GROUND ☐OTHER
NDE PROCEDURE NO. 303 REV 8
STAGE OF MFG.: ☐ROOT ☐INTERMEDIATE ☒INFO ☐REPAIR ☒FINAL
JOINT DESIGN: ☐N/A ☐BRN ☐BKS ☐INS ☒GRV. BT ☐SOCKET ☐OTHER

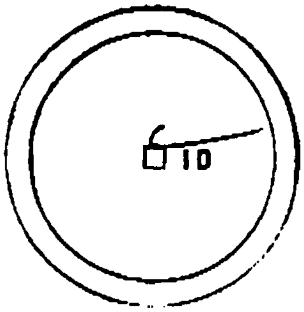
CP&L EQUIPMENT IDENT NUMBER: NDE 88012
COMPLETE FOLLOWING EQUIPMENT INFO. IF SUBCONTRACT MT: MFG NA | MODEL NA | SERIAL NO. NA

☒AC ☐DC PRODS ☐ YOKE ☒ SPACING 6" COIL NA TURNS NA HEADS☐ NA
AMPERAGE USED: NA
PARTICLES: ☐GREY ☐BLACK ☐RED ☒FLORESCENT ☒WET ☐DRY

SKETCH & REMARKS

~~WET~~

MT TEST WEIGHT
CPL 5343B



WELD/ITEM NUMBER	REMARKS	ACC.	REJ.	INFO ONLY
WELD #5	INSPECTED I.D. SURFACE OF WELD 5 FROM 14 FT TO 22 FT COUNTERCLOCKWISE (FACING BOTTOM) FROM FEEDWATER NOZZLE, EXAMINATION COVERAGE INCLUDED WELD AND APPROX. 3 TO 4" OF BASE METAL ABOVE AND BELOW THE WELD. SKETCHES OF EXAM AREA AND INDICATIONS ARE ATTACHED	X	X	✓

INSPECTOR: [signatures] CERTIFICATION LEVEL: II DATE: 12-13-90

(TO BE COMPLETED AS INDICATED)

IF APPLICABLE CONTRACTOR REVIEWER: | TITLE:
REVIEW DATE: | COMMENTS:
IF APPLICABLE CP&L QA REVIEW: DATE: / / IF APPLICABLE A.N.I./A.I.: DATE: / /

ATTACHMENT 3

CP&L NDE Report, "H. B. Robinson Unit 2, Steam Generator A, B, C Weld #5, Summary/Discussion of NDE Testing" (summary portion only)

H.B.ROBINSON UNIT 2
STEAM GENERATOR A,B,C WELD#5
SUMMARY/DISCUSSION OF NDE TESTING

DURING THE 1990 REFUELING OUTAGE WESTINGHOUSE NSD TECHNICIANS PERFORMED ULTRASONIC TESTING (UT) ON GENERATOR B UPPER TRANSITION WELD #5 (SEE ATTACHMENT A) AND DETECTED 3 LOW AMPLITUDE, INSIDE DIAMETER (ID) CONNECTED REFLECTORS WHICH, BASED ON DESIGN DRAWINGS,WERE PLOTTED WITHIN THE BASE METAL ADJACENT TO THE WELD. (SEE ATTACHMENT B FOR LOCATION) WESTINGHOUSE PROCEDURE CPL-ISI-47 REQIRES DIMENSIONING OF REFLECTORS THAT EQUAL OR EXCEED 50% OF REFERENCE AMPLITUDE; THESE REFLECTORS DID NOT REQUIRE DIMENSIONING. SINCE OTHER UTILITIES HAD EXPERIENCED CORROSION FATIGUE CRACKING IN SIMILAR AREAS MANAGEMENT MADE THE DECISION TO UT INSPECT WELD 5 ON GENERATORS A AND C.

INSPECTION RESULTS:

"A" GENERATOR: THIS EXAMINATION PRODUCED (5) 45 DEGREE AND (3) 60 DEGREE UT REFLECTORS THAT EXCEEDED ASME SECTION XI ALLOWABLE SIZE. (5) 45 AND (1) 60 DEGREE INDICATIONS WERE IDENTIFIED AS ID CONNECTED AND, BASED ON DESIGN DRAWINGS, WERE PLOTTED WITHIN THE BASE METAL ADJACENT TO THE WELD. THE REMAINING (2) 60 DEGREE REFLECTORS WERE EMBEDDED.

"C"GENERATOR: THIS EXAMINATION PRODUCED (17) 45 DEGREE AND (13) 60 DEGREE REFLECTORS THAT EXCEEDED ASME SECTION XI ALLOWABLE SIZE. (14) 45 DEGREE AND (6) 60 DEGREE INDICATIONS WERE IDENTIFIED AS ID CONNECTED AND,BASED ON DESIGN DRAWINGS, PLOTTED WITHIN THE BASE METAL ADJACENT TO THE WELD. THE REMAINING (3) 45 DEGREE AND (7) 60 DEGREE REFLECTORS WERE EMBEDDED.

INVESTIGATION OF ID CONNECTED REFLECTORS:

A DECISION WAS MADE TO ENTER GENERATOR "A" PRIOR TO COMPLETION OF UT ON GENERATOR "C". THE PURPOSE OF THIS ENTRY WAS TO VERIFY THE PRESENCE OF THE REPORTED ID CONNECTED REFLECTORS AND TO EVALUATE THE CONDITION OF THE ADJACENT BASE MATERIAL.
DUE TO ACCESS RESTRICTIONS AND ALARA CONSIDERATIONS THE FIRST AREA EXAMINED ON THE ID WAS AT THE 28' AREA WHERE INDICATIONS 5,6,7 (45DEGREE) AND INDICATION 1 (60 DEGREE) WERE LOCATED. NOTE: 45 DEGREE INDICATION 5 CORRESPONDS TO 60 DEGREE INDICATION 1)
THIS AREA CONTAINED THE HIGHEST CONCENTRATION OF RECORDABLE REFLECTORS. ALSO, INDICATION 5 PRODUCED THE HIGHEST AMPLITUDE (80%) OF ALL REPORTED REFLECTORS. INDICATION 5 WAS LOCATED BY FINGER DAMPING THE UT SIGNAL FROM THE REFLECTOR. A FLUORESCENT MAGNETIC PARTICLE INSPECTION (FMT) PERFORMED AT THE ID LOCATION OF INDICATION 5 PRODUCED A SERIES OF ALIGNED PORES AND A LINEAR INDICATION THAT TOTALLED .750".

IN ADDITION, APPROXIMATELY 10 FEET OF WELD ID AND ADJACENT BASE MATERIAL (APPROX.3" ABOVE AND BELOW) WAS FMT TESTED TO VERIFY THE PRESENCE OR ABSENSE OF FLAWS NOT RECORDABLE BY UT.(SEE REPORTS-ATTACHMENT C FOR DESCRIPTION OF INDICATIONS FOUND)
THE FMT TEST PRODUCED NO INDICATIONS THAT APPEARED TO BE CRACK-LIKE OR SERVICE INDUCED FLAWS.
(SEE STRUCTURAL INTEGRITY REPORT-ATTACHMENT D FOR FURTHER DISCUSSION ON THE FMT EXAM)
A VISUAL EXAM WAS ALSO PERFORMED ON THE ENTIRE CIRCUMFERENCE OF THE WELD/BASE METAL ID TO OBSERVE CONDITIONS THAT MIGHT CAUSE UT REFLECTORS (I.E. GOUGES, PITS.ROUGH WELD CONTOUR AS NOTED ON ATTACHMENT E)

CONCLUSION:

RESULTS OF THE ID INSPECTIONS DISCLOSED THAT THE ID CONNECTED REFLECTORS WERE FROM WELD DISCONTINUITIES,NOT
BASE MATERIAL FLAWS,AS PREVIOUSLY CONCLUDED FROM REVIEW OF DESIGN DRAWINGS. THE WELD WAS MUCH WIDER AND BUILD-UP MUCH HEAVIER THAN ANTICIPATED FROM REVIEW OF DESIGN DRAWINGS.
THE UT LENGTHS APPEARED TO BE CONSERVATIVE (INDICATION 5 UT LENGTH=1.125" MT LENGTH=.750" TOTAL.
AMPLITUDE SIZING TECHNIQUES WERE USED FOR THROUGH WALL DIMENSIONS SINCE IT COULD NOT BE DETERMINED THAT THESE WERE PLANAR FLAWS.IT IS BELIEVED THAT THE THROUGH WALL DIMENSIONS ALSO WERE CONSERVATIVE BASED ON THE FOLLOWING:
AN ON-SITE PRACTICAL DEMONSTRATION WAS PERFORMED ON THE .070" ID NOTCH ON CPL CAL BLOCK 50 (STEAM GENERATOR WELD 5 BLOCK) USING THE SAME TRANSDUCERS/WEDGES THAT WERE USED TO SIZE THE REFLECTORS IN QUESTION.
THE FOLLOWING RESULTS WERE OBTAINED:
THE 45 DEGREE SIZED THE NOTCH AT .380" DEEP;
THE 60 DEGREE SIZED THE NOTCH AT .625" DEEP.
BASED ON INDUSTRY EXPERIENCE AND CONVERSATIONS WITH FRANK AMAROTTO,EPRI NDE CENTER, IT IS BELIEVED THAT THE 45 DEGREE MEASUREMENTS,ALTHOUGH CONSERVATIVE, ARE THE MOST ACCURATE FOR THIS APPLICATION.

BASED ON REVIEW/COMPARISON WITH THE RADIOGRAPHS MADE DURING INSTALLATION AND REFLECTOR LOCATIONS THE EMBEDDED REFLECTORS ARE BELIEVED TO BE FABRICATION INCLUSIONS (I.E. SLAG).

SIGNED: [signature], 14 DEC, 1990

NDE SERVICES,CP&L

ATTACHMENT 4

Westinghouse Assessment of UT Recorded Indications for Steam Generator "A," Weld No. 5

HB ROBINSON #2 11-16-90

W ASSESSMENT OF
UT RECORDED INDICATIONS (RI'S)
FOR ST. GEN. A, WELD 5
BASED ON 1977 SEC XI - TABLE IWB-3511

EXAMINERS DATA FOR 45° INDICATES 9 RI'S, WHICH ARE ASSESSED AS FOLLOWS.

IND. NO.	LOCATION START	LENGTH "l"	THRUWALL "a"	THICK. "t"	CALCULATED a/t %	SEC. XI ALLOW. a/t %	NOTE
1	3'5"	0"	SPOT INDICATION — NO MEASURABLE SIZE				(1)
2	12'5.875	.25	.175	3.62	4.8	3.7	(2)
3	14'6.0	0"	SPOT INDICATION - NO MEASURABLE SIZE				(1)
4	17' 8.275"	0.975	0.146	3.62	4.0	2.6	(2)
5	27' 11.625	1.125	.292	3.62	8.1	3.3	(2)
6	28'4.0"	.437	.175	3.62	4.8	3.7	(2)
7	28' 0"	.8125	.233	3.55	6.6	3.6	(2)
8	33' 3.50"	0"	SPOT INDICATION - NO MEASURABLE SIZE				(1)
9	36' 7.750"	0"	SPOT INDICATION - NO MEASURABLE SIZE				(1)

EXAMINERS DATA FOR 60° INDICATES 5 RI'S, WHICH ARE ASSESSED AS FOLLOWS

1.	28' ~~27' 7.625"~~	.437	.788	3.62	21.75	3.7	(2)
2.	30' 7.0"	0"	SPOT INDICATION - NO MEASURABLE SIZE				(1)
3	32' 5.50"	0"	SPOT INDICATION - NO MEASURABLE SIZE				(1)
4	38' 2.75"	.5"	.583	3.62	16.1	3.7	(2)
5	38' 0.75"	.687	.408	3.62	16.42	3.7	(2)

(1) DOES NOT EXCEED SECTION XI - ACCEPTABLE PER IWB-3112

(2) EXCEEDS SECTION XI - RECOMMEND FURTHER INVESTIGATION.

B. J. Lefebvre

B.J. LEFEBVRE

LEV. III

ATTACHMENT 5

Westinghouse Assessment of UT Recorded Indications for Steam Generator "C," Weld No. 5

H B ROBINSON #2

W ASSESSMENT OF UT RECORDED INDICATIONS (RI's)

STEAM GEN. C WELD 5 (45°)

BASED ON 1977 SECTION XI, TABLE IWB-3511

IND. #	LOCATION START	LENGTH "l" IN.	THRU-WALL "a"/"2a"	THICK "t"	CALCULATED a/t %	SEC. XI ALLOW a/t %	NOTES
1	2' 11"	.94	.23	3.5	6.67	3.7	2
2	3' 3.25"	1.25	.47	3.5	13.33	3.7	2
3	5' 11.75"	2.0	.41	3.55	11.50	2.9	2
4	9' 2.25"	1.0	.18	3.5	5.0	2.4	2
5	14' 4"	.56	.23	3.5	6.67	3.7	2
6	20' 0.25"	1.5	.35	3.55	4.93	2.4	2
7	21' 6.875	.5	.41	3.55	11.50	3.7	2
8	21.75	.5	.12	3.55	3.29	3.0	2
9	23' 11.875"	.88	.23	3.55	6.57	3.4	2
10	25' 11.75"	.38	2a .18	3.55	2.46	3.0	1
11	26' 3.625	.38	NO MEASURABLE THRU-WALL DIM.				1
12	27' 11.75"	.125	2a .35	3.55	4.93	3.7	2
13	28' 8.75"	.625	.47	3.55	13.15	3.7	2
14	28' 10.75	.625	.29	3.55	8.22	3.7	2
15	28' 8.75	.25	.09	3.5	2.50	3.7	1
16	28' 9.5"	.625	.32	3.5	9.17	3.7	2
17	28' 8.875	.625	.12	3.5	3.33	2.8	2
18	29' 9"		NO MEASURABLE THRU-WALL DIM.				1
19	29' 2.75"		NO MEASURABLE THRU-WALL DIM.				1
20	34' 2"	.25	.23	3.55	6.57	3.7	2
21	34' 1.5"	.5	.41	3.5	11.67	3.7	2
22	34' 3.5"	.75	.23	3.5	6.67	3.7	2
23	41' 0.75"	2.0	NO MEASURABLE THRU-WALL DIM.				1
24	41' 8"	1.0	NO MEASURABLE THRU-WALL DIM.				1

NOTES: 1. DOES NOT EXCEED SECTION XI — ACCEPTABLE PER IWB-3112

2. EXCEEDS SECTION XI - RECOMMEND FURTHER INVESTIGATION

B. J. Lefebvre LEV. III

H B ROBINSON #2
ST. GEN. C WELD 5 (60°)

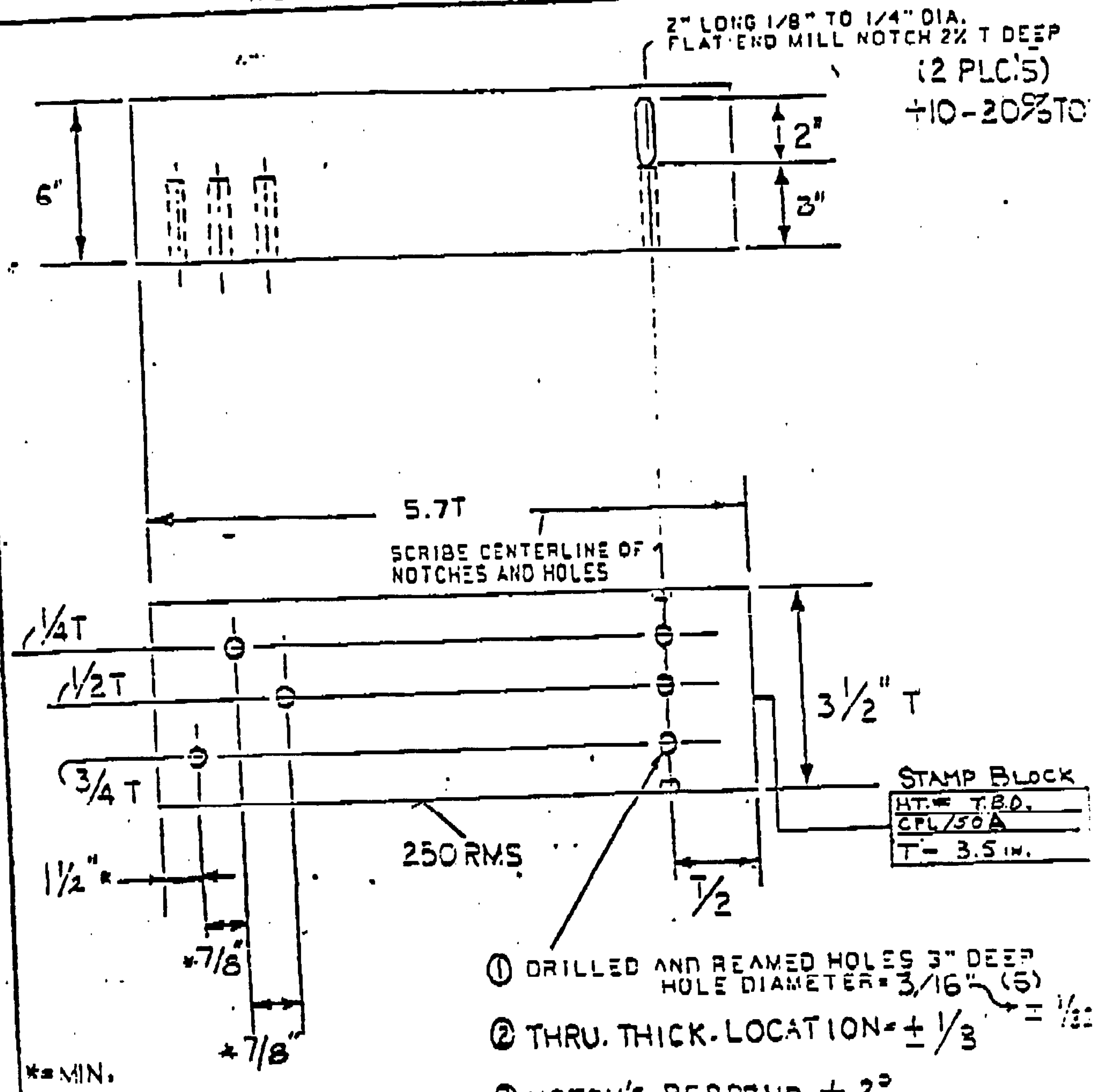
NO. #	LOCATION START	LENGTH "l" IN.	THRU-WALL "a"/"2a"	THICK "t"	CALCULATED a/t %	SEC. XI ALLOW a/t%	NOTES
1	2' 1"	2.5	.23	3.55	6.57	2.2	2
2	3' 4.625"	.25	.58	3.55	16.43	3.7	2
3	7' 8"		NO MEASURABLE THRU-WALL DIM.				1
4	9' 2.062"	1.44	2a .50	3.55	6.98	2.2	2
5	9' 8.25"	.75	2a .58	3.55	8.22	3.7	2
6	9' 4"	.06	NO MEASURABLE THRU-WALL DIM.				1
7	12' 3"	1.25	.29	3.5	8.33	3.0	2
8	13' 4.375"	1.5	2a .35	3.55	4.93	2.4	2
9	14' 3.812"	.69	.23	3.5	6.67	3.7	2
10	15' 0.75"	.63	2a .41	3.55	5.75	3.7	2
11	15' 9.75"	.75	2a .18	3.55	2.46	2.4	2
12	21' 6.25	.75	.64	3.55	18.08	3.7	2
13	28' 9.5	1.75	.35	3.5	10.00	2.9	2
14	36' 11"	.5	.23	3.5	6.67	3.7	2
15	38' 11.5"	.75	.53	3.5	14.79	3.7	2

B. J. Lefebv[illegible] Lev. III

ATTACHMENT 6

H. B. Robinson Unit 2 Cal Block No. 50A, Steam Generator (drawing)

WESTINGHOUSE ELECTRIC CORPORATION



① DRILLED AND REAMED HOLES 3" DEEP HOLE DIAMETER = 3/16" (5) ± 1/32

② THRU. THICK. LOCATION = ± 1/3

③ NOTCH'S PERPEND. ± 2°

④ TOL. ON HOLE & NOTCH LOCATION ± .010 UNL... MIN. IS SPECIFIED.

⑤ ALL OTHER TOL. ± .010 in.

HB ROBINSON UNIT 2
CAL BLOCK # 50A
STEAM GENERATOR

MAT'L: A-533, Gr B, Cl 1

USE: STM GEN.

APPROVALS	
INITIATOR	Brent D. [signature] 5/22/84

ATTACHMENT 7

Steam Generator Chemistry Summary Data

Form 244

CP&L

Carolina Power & Light Company

January 24, 1991

Company Correspondence

File No: 10510H5B

Memorandum To: Mr. R. W. Prunty

From: Mr. E. A. Morgan

Subject: RNP Steam Generator Chemistry Summary

The risk of corrosion mechanisms in the new RNP steam generators is low due to effective layup practices during idle periods, low bulk water steam generator chemical contaminant inventories during operation, and low steam generator hideout return and the nature of the chemical return.

Since start-up with the new replacement steam generators, RNP steam generator chemistry has been maintained well within the EPRI and vendor guidelines for all volatile treatment (AVT) of recirculating steam generators during operation. These guidelines contain normal values for critical contaminant control parameters that have been established for long-term system reliability. Operation below these values will provide a greater degree of assurance that corrosive conditions will be avoided.[1] These parameters are listed below.

Feedwater Parameter	**Normal Value**
Dissolved oxygen, ppb	≤ 5
Steam Generator Blowdown Parameter(s)	
Cation conductivity, uS/cm	≤ 0.8
Sodium, ppb	≤ 20
Chloride, ppb	≤ 20
Sulfate, ppb	≤ 20

Beginning with completion of installation, the RNP replacement steam generators have been protected from oxygen during idle periods with a wet layup system including chemical injection, recirculating system and nitrogen blanketing. Hydrazine

[1]EPRI NP-6239, PWR Secondary Water Chemistry Guidelines, Revision 2, December 1988

(75-200 ppm) and pH (adjusted to >9.8) with ammonia provides an adequate reducing environment during these periods.

Table 1 provides average in-line (cation conductivity, sodium, chloride) monitor data and laboratory grab sample data (sulfate) for steam generator blowdown. Table 3 provides average in-line monitor data for feedwater oxygen at power operation. Trend graphs for 1985 have been provided except on the initial start-up period of operation (1/9/85 through 3/31/85). Succeeding years trend graphs show improved chemistry control. Trend graphs for 1990 are also provided.

RNP uses deep bed, full-flow condensate polishing for start-up and normal operation to establish and maintain feedwater chemistry control. As a result of rigorous attention to feedwater chemistry during start-up and operation, steam generator sludge inventories and steam generator hideout have been low. Table 2 provides amounts of sludge removed from each steam generator by sludge lancing. Sludge lancing was not performed during Cycle 12 refueling outage due to the low amounts accumulated in previous operational periods. Sludge analysis for 1990 is not yet available; however, copper is reducing as expected since copper has been replaced in the secondary system balance of plant (except for the gland steam condenser).

Hideout return was documented during the 1990 refueling outage shutdown confirming low hideout during operation. See Tables 4 and 5. Based on MULTEQ, French, and Westinghouse evaluation approaches, the overall hideout return indicates a neutral crevice chemistry.

Ewell A. Morgan

Ewell A. Morgan
Manager - Chemistry Services Unit

EAM/BAF/

Attachment

cc: Mr. P. A. Bauer
Mr. W. A. Christensen
Mr. J. M. Curley
Mr. J. A. Eaddy
Mr. M. D. Hill
Mr. K. T. Kirkland

Table 1
RNP Steam Generator Blowdown
Chemistry Summary

Item	Year	SGA	SGB	SGC
Cation Conductivity [1]	1985	0.28	0.29	0.30
	1986	0.34	0.21	0.24
	1987	0.20	0.22	0.18
	1988	0.14	0.15	0.15
	1989	0.22	0.22	0.23
	1990	0.19	0.17	0.16
ppb Sodium [2]	1985	4.4	4.7	4.2
	1986	3.5	3.3	3.3
	1987	3.5	3.8	3.1
	1988	2.0	1.7	1.9
	1989	2.0	2.5	1.9
	1990	1.6	2.1	2.0
ppb Chloride [2]	1985	3.7	5.3	4.9
	1986	4.1	4.9	5.1
	1987	2.8	3.2	2.9
	1988	2.1	2.0	2.4
	1989	2.5	3.0	2.6
	1990	2.1	2.7	1.4
ppb Sulfate [3]	1985	6.5	6.8	7.0
	1986	7.6	6.8	6.9
	1987	7.7	8.0	7.1
	1988	9.2	11.7	10.0
	1989	6.8	7.2	6.2
	1990	8.7	8.1	10.1

Notes:
[1] uS/cm at 25° C.
[2] Data from the in-line monitor.
[3] Grab sample data from the laboratory ion chromatograph (IC).

Table 2
RNP Steam Generator Sludge Summary
Sludge Amounts And Percent Composition

March 1986 – After Cycle 10

Steam Generator	Pounds	Percent Magnetite	Percent Copper
SGA	75	50	35
SGB	50	50	30
SGC	88	45	35

April 1987 – After Cycle 11

Steam Generator	Pounds	Percent Magnetite	Percent Copper
SGA	45	60	25
SGB	28	55	26
SGC	16	85	5

September 1990 – After Cycle 13

Steam Generator	Pounds	Percent Magnetite	Percent Copper
SGA	40	---	---
SGB	96	---	---
SGC	96	---	---

Table 3
RNP Feedwater Chemistry Summary
Dissolved Oxygen Concentration

Item	Year	Value
ppb Oxygen [1]	1985	2.2
	1986	1.8
	1987	1.0
	1988	1.0
	1989	1.0
	1990	1.2

Notes:

[1] Data from the in-line monitor.

Table 4
RNP Steam Generator Hideout Return Summary
Observed Peak Concentrations

	Steam Generator (Concentrations In ppb)		
Species	A	B	C
Sodium	23.6	45.7	24.3
Potassium	0.5	0.5	0.5
Calcium	28.0	41.0	47.0
Magnesium	16.0	21.0	35.0
Chloride	3.9	3.9	4.4
Sulfate	176.5	197.1	150.0
Fluoride	0.5	0.5	0.5
Nitrate	5.4	4.8	1.9
Phosphate	60.0	13.9	17.8
Formate	0.5	0.5	0.5
Acetate	0.5	0.5	0.5
Silica	235	494	336

Table 5
RNP Steam Generator Hideout Return Summary
Calculated Total Amounts

	Steam Generator (Amounts In Grams)			
Species	A	B	C	Total
Sodium	5.02	10.06	6.09	21.17
Potassium	0.14	0.14	0.14	0.42
Calcium	5.70	7.11	7.35	20.16
Magnesium	3.17	4.45	6.82	14.44
Total Cations	14.03	21.76	20.40	56.19
Chloride	0.44	0.48	0.46	1.38
Sulfate	31.86	38.23	28.26	98.35
Fluoride	0.15	0.15	0.15	0.45
Nitrate	0.39	0.32	0.20	0.91
Phosphate	7.34	2.93	2.62	12.89
Formate	0.15	0.15	0.15	0.45
Acetate	0.15	0.15	0.15	0.45
Silica	40.97	90.97	62.56	194.50
Total Anions				
Without Silica	40.48	42.41	31.99	114.43
With Silica	81.45	133.38	94.55	309.38
Grand Total				
Without Silica	54.51	64.17	52.39	170.62
With Silica	95.48	155.14	114.95	365.57

ATTACHMENT 8

NDE Certifications

Westinghouse
Form PD0541 (183)

NDE CERTIFICATION RECORD

Name: H. M. Ackerman

Method/Level: UT/Level I

Education & Experience:

1) Graduated Donora HS, 1955
2) Performed UT in Trainee and Level I capacities since 6/86

Statement of Training:

1) Westinghouse NDE TI, 80 hours training in UT

EXAM DATE	General XWT.	Specific XWT.	Practical XWT.	COMP. GRADE
9/15/89	95 x .3	85 x .3	100 x .4	94

Certification Limitation:

None.

Remarks:

Certification record reissued on 10/23/89 to correct weighting factors and composite grade.

~~Certification~~/Recert. Date: 9/15/89

Expiration Date: 9/14/92

Certified By: Jack L Wilder NSD Level III

Westinghouse
Form PD0541 (183)

NDE CERTIFICATION RECORD

Name:	Method/Level:
G. A. Morini	UT/Level II

Education & Experience:

1) Graduated Ambridge Area HS, 1968
2) Performed UT in Level II capacity since 8/82

Statement of Training:

1) United States Steel, 80 hours training in UT
2) Westinghouse NSID, 40 hours training in UT sizing and detection

EXAM DATE	General XWT.	Specific XWT.	Practical XWT.	COMP. GRADE
6/1/88	92.5 x .4	90 x .3	100 x .3	94

Certification Limitation:

None.

Remarks:

Certification record re-issued on 10/10/88 to include 40 hours of W NSID UT training.

~~Certification~~/Recert. Date:	Expiration Date:
6/1/88	6/1/91

Certified By: [redacted] NSD NDE Level III

Form No. 80384
QA PQ-6
Revision 2
3/87

CP&L
Carolina Power & Light Company

CERTIFICATE OF NDE PERSONNEL QUALIFICATION

Ultrasonic METHOD-LEVEL II

1. ADMINISTRATIVE/EDUCATIONAL INFORMATION

NAME			SSN	
Black, Edwin M.			251-02-0505	
COMPANY	DEPARTMENT	UNIT	DATE EMPLOYED	DATE ASSIGNED
CP&L	Technical Services	NDE Services	03/14/83	03/14/83
HIGH SCHOOL	LOCATION		DATE GRADUATED	
Eau Claire High School	Columbia, SC		06/72	
COLLEGE	COURSE	DEGREE	YEAR	
N/A	N/A	N/A	N/A	

2. ORGANIZED TRAINING/INSTRUCTION

Training Completed 546 (Hours) Under Direction of US Navy
CP&L
EPRI

☒ Training Requirements Per NDEP-10/20 Satisfied C.R. Osmon

Remarks:

3. WORK TIME EXPERIENCE

6 Years 1 1/2 Months Under Direction of US Navy
CP&L

Remarks:

4. QUALIFICATION EXAMINATIONS

	EXAM NO.	DATE COMPLETED	RAW SCORE	WEIGHT	WEIGHTED GRADE
GENERAL	UT-II-G-1, R.1	07/26/90	90.0	0.3	27.00
SPECIFIC	UT-II-S-6, R.0	07/26/90	95.5	0.3	28.65
PRACTICAL	UT-II-P-5, R.0	08/10/90	100.0	0.4	40.00
				COMPOSITE GRADE:	95.65

Completed Examinations:
☒ Retained/Maintained by Nuclear Training Section, New Hill, NC
☐ Sent To ______ for retention.

Remarks:

5. CERTIFICATION

This ☐ Initial Certification ☒ Recertification meets the requirements of:
☒ NDEP-10 "Training, Qualification and Certification of Nondestructive Examination Personnel"
☐ NDEP-20 "Training, Qualification and Certification of Visual Examination Personnel for Inservice Inspection"

Level II Qualifications Certified by: Carl R. Osmon, Level III
Principal NDE Specialist
Metallurgical Services Section
New Hill, NC

Certifications Reviewed/Accepted by:
(When Applicable)

DATE OF CERTIFICATION 08/17/90 DATE CERTIFICATION EXPIRES 08/16/93

TRANSCRIPT OF CONTINUING EDUCATION ACTIVITIES

ELECTRIC POWER RESEARCH INSTITUTE

NONDESTRUCTIVE EVALUATION CENTER

1300 Harris Blvd. • P.O. Box 217097
CHARLOTTE, NC 28221
704/547-6110

Name: Edwin M. Black
Company: Carolina Power And Light
Address: P.O. Box 327
(SHE&EC - RHS)
New Hill .NC 27562

SS#: 251-02-0505

Date: 12-OCT-1988

Signature:

Dr. George Pherigo
Training Manager

DATE	COURSE NO. AND DESCRIPTION	EXAMINATIONS	LOCATION	CEU'S AWARDED	FILE
3-OCT-1988 7-OCT-1988	911 -UT Operator Training for Sizing of IGSCC Level II-Special	General (CE-0308) Specific 83 Manual Practical PASSED Slope 0.79 Correl Coef. 0.88 Mean of Dev. 13.58 PDS# 0505-100788	EPRI NDE Center	4.0	CE-0428

Not official without raised seal

TRANSCRIPT OF CONTINUING EDUCATION ACTIVITIES

ELECTRIC POWER RESEARCH INSTITUTE

NONDESTRUCTIVE EVALUATION CENTER

1300 Harris Blvd. • P.O. Box 217097
CHARLOTTE, NC 28221
704/547-6110

Name: Edwin M. Black
Company: Carolina Power And Light
Address: P.O. Box 327
(SHEXEC - MRS)
New Hill, NC 27562

SS#: 251-02-0505

Date 12-OCT-1988 PAGE 1 of 2

Signature:

Dr. George Pherigo
Training Manager

DATE	COURSE NO. AND DESCRIPTION	EXAMINATIONS		LOCATION	CEU'S AWARDED	FILE
7-OCT-1985 11-OCT-1985	101 -Visual Examination - Level I	General Specific Practical	90 86 98	NES/CP&L	4.0	CE-0213
14-OCT-1985 18-OCT-1985	102 -Visual Examination - Level II	General Specific Practical	83 90 94	NES/CP & L	4.0	CE-0214
7-JUL-1986 11-JUL-1986	200 -Ultrasonic Examination - Trainee	General Specific Practical	94 96 93	EPRI NDE Center	4.0	CE-0279
11-AUG-1986 15-AUG-1986	201 -Ultrasonic Examination - Level I	General Specific Practical	80 80 95	EPRI NDE Center	4.0	CE-0291
27-OCT-1986 7-NOV-1986	202 -Ultrasonic Examination - Level II	General Specific Practical Data Rec. 98 False Calls 84 Flaws Found 100	92 90 PASSED	EPRI NDE Center	8.0	CE-0308
11-JUL-1988 20-JUL-1988	910 -UT Operator Training for the Detection of Intergranular Stress Corrosion Cracking Level II-Special	General (CE-0308) Specific	 86	EPRI NDE Center	6.4	CE-0413
27-JUL-1988	910 -UT Operator Training for the Detection of Intergranular Stress Corrosion Cracking Level II-Special (Examination Only)	Manual Practical PDS# 0505-072788	89/100	EPRI NDE Center	---	EO-3196

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Form No. 80384
QA PQ-6
Revision 2
3/87

CP&L
Carolina Power & Light Company

CERTIFICATE OF NDE PERSONNEL QUALIFICATION

MAGNETIC PARTICLE METHOD-LEVEL II

1. ADMINISTRATIVE/EDUCATIONAL INFORMATION

NAME			SSN	
Hart, Michael D.			138-42-7323	
COMPANY	DEPARTMENT	UNIT	DATE EMPLOYED	DATE ASSIGNED
CP&L	Tech. Services	NDE Services	6/20/83	6/20/83
HIGH SCHOOL	LOCATION		DATE GRADUATED	
East	Cheyenne, Wyoming		5/77	
COLLEGE	COURSE	DEGREE	YEAR	
N/A	N/A	N/A	N/A	

2. ORGANIZED TRAINING/INSTRUCTION

Training Completed 36 (Hours) Under Direction of CP&L

[X] Training Requirements Per NDEP-10/20X Satisfied [signature]

Remarks:

3. WORK TIME EXPERIENCE

- Years - Months Under Direction of

Remarks: 717½ Hours OJT

4. QUALIFICATION EXAMINATIONS

	EXAM NO.	DATE COMPLETED	RAW SCORE	WEIGHT	WEIGHTED GRADE
GENERAL	MT-II-G-3, R:1	2-7-90	85.00	.3	25.50
SPECIFIC	MT-II-S-2, R:0	2-7-90	86.33	.3	25.90
PRACTICAL	MT-II-P-2, R:0	2-8-90	91.00	.4	37.60
				COMPOSITE GRADE:	89.00

Completed Examinations:
[X] Retained/Maintained by Nuclear Training Section, New Hill, NC
[ ] Sent To for retention.
Remarks:

5. CERTIFICATION

This [X] Initial Certification [ ] Recertification meets the requirements of:
[X] NDEP-10 "Training, Qualification and Certification of Nondestructive Examination Personnel"
[ ] NDEP-20 "Training, Qualification and Certification of Visual Examination Personnel for Inservice Inspection"

Level II Qualifications Certified by: [signature], Level III
Principal NDE Specialist
NDE Services
New Hill, NC

Certifications Reviewed/Accepted by:
(When Applicable)

DATE OF CERTIFICATION 2/15/90 DATE CERTIFICATION EXPIRES 2/14/93

Form No. 80384
QA PQ-6
Revision 2
3/87

CP&L
Carolina Power & Light Company

CERTIFICATE OF NDE PERSONNEL QUALIFICATION

MAGNETIC PARTICLE **METHOD-LEVEL** II

1. ADMINISTRATIVE/EDUCATIONAL INFORMATION

NAME			SSN	
Jernigan, Larry P.			237-74-9055	
COMPANY	**DEPARTMENT**	**UNIT**	**DATE EMPLOYED**	**DATE ASSIGNED**
CP&L	Corporate QA	MQS (NDE)	1/24/83	1/24/83
HIGH SCHOOL		**LOCATION**		**DATE GRADUATED**
GED-Wake Tech		N.C.		1/74
COLLEGE		**COURSE**	**DEGREE**	**YEAR**
N/A		N/A	N/A	N/A

2. ORGANIZED TRAINING/INSTRUCTION

Training Completed 48 (Hours) Under Direction of Rockwell
CP&L

☒ Training Requirements Per NDEP-10/20X Satisfied

Remarks:

3. WORK TIME EXPERIENCE

14 Years - Months Under Direction of Rockwell
CP&L

Remarks:

4. QUALIFICATION EXAMINATIONS

	EXAM NO.	DATE COMPLETED	RAW SCORE	WEIGHT	WEIGHTED GRADE
GENERAL	MT-II-G-2 ,R:1	2 - 8 - 89	72.50	.3	21.75
SPECIFIC	MT-II-S-2 ,R:0	2 - 8 - 89	98.33	.3	29.50
PRACTICAL	MT-II-P-2 ,R:0	2 -10 - 89	92.00	.4	36.80
				COMPOSITE GRADE:	88.05

Completed Examinations:
☒ Retained/Maintained by Nuclear Training Section, New Hill, NC
☐ Sent To ______ for retention.

Remarks:

5. CERTIFICATION

This ☐ Initial Certification ☒ Recertification meets the requirements of:
☒ NDEP-10 "Training, Qualification and Certification of Nondestructive Examination Personnel"
☐ NDEP-20 "Training, Qualification and Certification of Visual Examination Personnel for Inservice Inspection"

Level II Qualifications Certified by: ______, Level III
Principal NDE Specialist
Materials Quality Section
New Hill, NC

Certifications Reviewed/Accepted by:
(When Applicable)

DATE OF CERTIFICATION 2/10/89 DATE CERTIFICATION EXPIRES 2/9/92

ATTACHMENT 9

Material Sulfur Contents

CAROLINA POWER & LIGHT COMPANY
H. B. ROBINSON PLANT
STEAM GENERATORS

Material Sulfur Contents

		Range Percent Sulfur
1.	Filler Metals (E8018 NM)	
		.018 - .022 percent
2.	Transition Cones (SA533 Gr. A Class 2)	
	Stm. Generator "A" (W# 10365)	.008 - .013 percent
	Stm. Generator "B" (W# 10366)	.012 - .016 percent
	Stm. Generator "C" (W# 10367)	.009 - .016 percent
3.	Upper Assembly Lower Barrel (A302-66)	
	Stm. Generator "A"	.017 - .018 percent
	Stm. Generator "B"	.015 - .018 percent
	Stm. Generator "C"	.016 - .018 percent

NOTES:

1. Sulfur contents obtained from material test reports.
2. Items # 1 and #2 were installed in 1984 with the Steam Generator replacement work. Item #3 was installed during original plant construction (initial plant operation 1970).

(5578NED.RNP/slb)