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SOUTHERN COMPANY

Energy to Serve Your World℠

November 14, 2003

Docket No.: 50-321

NL-03-2158

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555-0001

Edwin I. Hatch Nuclear Plant
Unit 1 Updated Analysis of Core Shroud Vertical Welds

Ladies and Gentlemen:

By letter dated May 7, 1996, Southern Nuclear Operating Company (SNC) provided to the NRC a description of the inspection plan, the results of the initial and expanded scope inspections, and an evaluation of the findings for the Edwin I. Hatch Nuclear Plant Unit 1 flawed Core Shroud Vertical welds. SNC also provided requested fracture mechanics analyses to the NRC on July 16, 1996. The evaluation was updated in 1999 and again in 2002. The 2002 evaluation used assumptions for fluence of less than $1 X 10^{21}$ n/cm^2. This is the fluence threshold referenced in BWRVIP-99 and 100 for higher crack growth rates and lower fracture toughness exhibited by irradiated stainless steel. The location of the flawed welds in a high fluence region called for confirmation of this assumption. Therefore SNC contracted to have a fluence estimate calculated for the shroud vertical welds. The results of this estimate showed that portions of the welds have exceeded the $1 X 10^{21}$ n/cm^2 threshold.

Accordingly, SNC contracted Structural Integrity Associates, Inc. (SIA) to perform an updated analysis using the crack growth and fracture toughness values for fluence greater than $1 X 10^{21}$ n/cm^2. The results of the evaluation indicate that the end of interval (EOI) for re-examination should be reduced from 10 years to 8 years. This 8 year EOI would require a re-examination no later than the twenty-second refueling outage as currently scheduled for 2006. BWRVIP-76 requires that for fluence exceeding $5 X 10^{20}$ n/cm^2, licensees should prepare a plant specific analysis and provide to the staff. Pursuant to this requirement, SNC is providing the results of the updated analysis.

SNC has scheduled a re-examination of the two flawed vertical welds for the twenty-first refueling outage currently scheduled in the spring of 2004. SNC will continue to follow BWRVIP requirements related to these welds.

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A summary of the analysis results is provided in Attachment 1. Also enclosed is the analysis performed by Structural Integrity Associates (Attachment 2). The Core Shroud Weld Identification drawing is Attachment 3.

This letter contains no NRC commitments. If you have any questions, please advise.

Sincerely,

H. L. Sumner, Jr.

HLS/WHC/daj

Enclosures: Attachment 1 – Executive Summary SIR-03-115 – Structural Integrity Associates, Incorporated Evaluation

Attachment 2 - SIR-03-115 – Structural Integrity Associates, Incorporated Evaluation, Revision 1

Attachment 3 - Drawing, Core Shroud Weld Identification Roll Out (Inside View)

cc: Southern Nuclear Operating Company
Mr. J. D. Woodard, Executive Vice President
Mr. G. R. Frederick, General Manager – Plant Hatch
Document Services RTYPE: CHA02.004

U. S. Nuclear Regulatory Commission
Mr. L. A. Reyes, Regional Administrator
Mr. S. D. Bloom, NRR Project Manager – Hatch
Mr. D. S. Simpkins, Senior Resident Inspector – Hatch

Attachment 1
Revised Analysis of Hatch Unit 1 Core Shroud Welds V-5 and V-6
Summary Information

Inspection/Flaw Evaluation History

The Unit 1 Core Shroud vertical welds V-5 and V-6 were found with indications during successive outages from 1996 through 1999. Included in the examinations were UTs performed in 1997 and two sided EVT-1s in 1999. The UT technique performed in 1997 did not indicate through wall flaws but no credit was taken for the examination because the technique had not been fully developed and demonstrated. The EVT-1 examinations performed in 1999 are the basis for all subsequent evaluations. This exam showed approximately 43% cracking on the OD surface of V-6 and approximately 22% cracking on the OD surface of V-5. Minor ID indications (<1") was also observed, but not in the same plane, elevation-wise with the OD surface indications.

Evaluations were performed that demonstrated acceptable flaw tolerance. In 2002 Structural Integrity Associates, Inc. (SIA) was requested to perform an analysis in order to establish a required end of interval (EOI) for re-examination, using the 1999 EVT-1 results and assumptions of fluence $<1x10^{21}$ n/cm^2.

Revised Fluence Calculation

A calculation of the estimated >1.0 MeV neutron fluence in the Hatch 1 shroud structure was performed for the affected shroud vertical welds. The purpose of the calculation was to ascertain a realistic estimate of the accumulated fluence at the flawed shroud vertical welds V-5 and V-6. The calculation was performed using the RAMA Fluence Methodology software currently under development by TransWare for the BWRVIP. Since the RAMA Code has not yet been approved for safety-related calculations, the TransWare calculations were characterized as an estimate. The calculation was also limited to an estimate of fluence in the flawed locations in order to make conservative analysis and inspection decisions with respect to revised fracture toughness values and crack growth rates reported in BWRVIP-99 and BWRVIP-100.

The fluence calculation estimated that portions of the inside diameter of the V-5 and V-6 welds would exceed the threshold fluence of $1x10^{21}$ n/cm^2 for reduced fracture toughness and increased crack growth rates before the ten year EOI. Therefore SNC contracted with SIA to perform an evaluation using the Elastic-Plastic Fracture Mechanics (EPFM) methodology to establish a revised EOI.

Revised Shroud Flaw Evaluation

SIA performed their analysis using BWRVIP-99 guidance for crack growth, BWRVIP-100 guidance for fracture toughness and the EPFM methodology referenced in BWRVIP-76 and 100. A crack growth of $5x10^{-5}$ in/hr was assumed. Since the examination method was two-sided EVT-1, the flaws were assumed through wall for the purpose of the analysis. SIA report SIR-03-115 is enclosed with this letter.

The existing flaws in V-5 and V-6 were grown for an assumed EOI of 10 years from the last inspection (1999). For weld V-6, the analysis resulted in a code allowed critical flaw at ten years, but with a safety factor less than the 1.5 required by ASME Section XI. The V-6 flaw was then re-iterated and with an assumed EOI of 8 years a safety factor of 1.64 at the critical flaw size resulted.

This 8 year EOI also bounds the V-5 welds since it is of similar fluence and contains much smaller flaws. This EOI would require the re-examination of the affected welds no later than 1R22 (2006). Currently SNC has scheduled the re-examination of the V-5 and V-6 welds for 1R21 (2004).

A leakage assessment is not necessary per the requirements of BWRVIP-76 due to no *observed* through wall indications. Flaws assumed through wall for the purpose of analysis due to the examination method do not require leakage assessment.

Report No.: SIR-03-115
Revision No.: 1
Project No.: HTCH-06Q
File No.: HTCH-06Q-401
October 2003

Elastic-Plastic Fracture Mechanics Evaluation of the Plant Hatch Unit 1 Core Shroud V6 Weld

Prepared for:

Southern Nuclear Operating Company
Birmingham, AL

Prepared by:

Structural Integrity Associates, Inc.
San Jose, California

Prepared by: ____________________ Date: 10/17/03
M.L. Herrera, P.E.

Reviewed by: ____________________ Date: 10/17/03
S. S. Tang, P.E.

Approved by: ____________________ Date: 10/17/03
M.L. Herrera, P.E.

REVISION CONTROL SHEET

Document Number: SIR-03-115

Title: Elastic-Plastic Fracture Mechanics Evaluation of the Plant Hatch Unit 1 Core Shroud V6 Weld

Client: Southern Nuclear Operating Company

SI Project Number: HTCH-06Q

Section	Pages	Revision	Date	Comments
1.0	1-1 – 1-2	0	09/26/03	Initial Issue
2.0	2-1 – 2-2			
3.0	3-1 – 3-2			
4.0	4-1 – 4-8			
5.0	5-1 – 5-6			
6.0	6-1			
7.0	7-1			
7.0	7-1	1	10/17/03	Corrected Reference 11.

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1.0 INTRODUCTION

This report presents the elastic-plastic fracture mechanics (EPFM) evaluation of the Plant Hatch Unit 1 Core Shroud V6 weld. The EPFM analysis is consistent with the current Boiling Water Reactor Vessel and Internals Program (BWRVIP) documents pertaining to shroud cracking. Indications have been reported in the Plant Hatch, Unit 1 shroud vertical welds V5 and V6, with the most recent inspection occurring in the Spring of 1999. Using the methodology provided in BWRVIP-76 [1], Southern Nuclear Operating Company (SNOC) has requested that an elastic-plastic fracture mechanics analysis be performed to determine the re-inspection interval for the limiting vertical weld, V6.

An evaluation of the flaws was previously performed using the BWRVIP methodology for evaluating shroud cracking [2]. Based on fluence calculations available at that time, a limit load evaluation was performed to justify continued operation.

Recently, the fluence calculations were revised. Based on the results of this fluence analysis [3], an EPFM analysis was performed by Structural Integrity Associates (SI). According to BWRVIP-76 [1], if the fluence exceeds $3x10^{20}$ n/cm^2, linear elastic fracture mechanics (LEFM) or EPFM with limit load analysis is required.

This EPFM analysis uses a crack growth rate of $5x10^{-5}$ in/hr for the assumed through-wall flaws. This crack growth rate was used to determine the flaw geometry for operation over a prescribed time from the 1999 inspection.

The EPFM analysis uses the J-integral – Tearing Modulus (J-T) approach with the use of a detailed elastic-plastic finite element model. Crack tip opening displacements (CTOD) were taken from the limiting location and used in the J-T analysis. The material J-T curves were obtained for the approximate fluence at the end of the prescribed operating time from the time of inspection in 1999.

Based on the results of the analysis, a safety factor can be calculated depending on the selected operating period to the next re-inspection. Results of the analysis for a re-inspection period of 8 years show a safety factor of 1.64, which exceeds the required 1.5. These results indicate that continued operation for eight calendar years (assuming 8,000 hours per year) is justified. The safety factor for 10 years was 1.18, less than the required safety factor of 1.5 for the faulted condition.

2.0 VERTICAL WELD CRACK CONFIGURATION

Figure 2-1, from Reference 2, shows the crack dimensions for the V6 weld based on the results of the 1999 inspection. All flaws were assumed through-wall. The calculations for the EPFM analysis evaluated the shroud condition for future crack growth using a crack growth rate in the length direction of $5x10^{-5}$ in/hr. After accounting for crack growth, the ligament between neighboring flaws must be evaluated to determine if the flaws need to be combined. Based on BWRVIP guidelines [1], two neighboring flaws must be combined if the ligament between them is less than two times the thickness of the shroud after accounting for crack growth.

For purposes of this calculation, no credit was taken for any un-cracked portions of the H4 weld since insufficient inspection information was available for the horizontal welds. If credit could be taken, this would reduce the loading at the crack tip location. Thus, the results of these calculations are considered conservative.

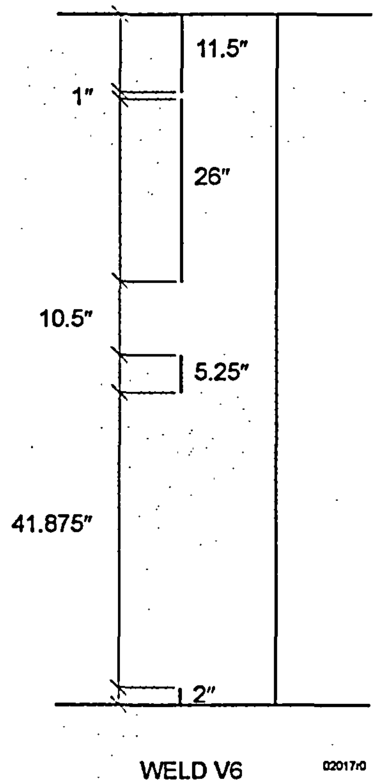


Figure 2-1. 1999 Inspection Results

3.0 TECHNICAL APPROACH

This section describes the technical approach used to perform the EPFM analysis. The purpose of the analysis was to determine the required re-inspection interval for the V6 weld with the flaws found in 1999 assuming a crack growth rate in the length direction of 5×10^{-5} in/hr. The initial re-inspection interval was selected as 10 years. Based on the results for ten years, additional re-inspection intervals were considered if structural integrity could not be demonstrated. The general process used in the evaluation is outlined below:

1. Using crack dimensions from Reference 2 and a crack growth rate in the length direction of 5×10^{-5} in/hr, determine the crack dimensions for 10 years (assuming 8,000 hours/year).

2. The final crack lengths are input into a three-dimensional finite element model. The finite element model is used in an elastic-plastic stress analysis that includes crack tip elements. The applied loading is comprised of the internal pressure only for the faulted condition. The faulted condition is the limiting condition [2].

3. For the crack dimension used, determine the J-integral for the applied loading (internal pressure only).

4. Determine $J_{applied}$-$T_{applied}$ curves based on 3), by incrementing the crack size.

5. Obtain J_{mat}-T_{mat} curves from BWRVIP-100 [10] for the shroud material at the appropriate fluence levels. Fluence levels at the crack tip at the end of the selected re-inspection interval were estimated by extrapolating using the results of Reference 3.

6. Determine if flaw pattern is stable by using J-T criterion.

7. Determine safety factor.

8. If the 10-year re-inspection interval calculation does not result in a safety factors required by Reference 11 (1.5), the re-inspection interval needs to be reduced and the process repeated.

4.0 ANALYSES

This section presents calculations and additional information required for the EPFM analysis.

4.1 Applied J-Integral and Tearing Modulus ($J_{applied}$-$T_{applied}$)

BWRVIP-76 [1] provides for EPFM analysis above fluences of $3x10^{20}$ n/cm^2. EPFM considers ductile crack extension in determining the load carrying capability of a cracked component such as the core shroud. The J-T approach considers the intensity of the plastic stress-strain field surrounding the crack tip (through the J-integral) and tearing stability theory, which examines the stability of ductile crack growth (through the tearing modulus).

The J-integral, can be calculated from the crack tip opening displacement (CTOD), Reference 4. The instability of unstable crack growth can be determined based on Tearing Modulus Method, Reference 5.

The relationship between J and CTOD is based on satisfying the Hutchinson, Rice and Rosengren (HRR) singularity presented in Reference 4, Appendix B, and summarized here. The definition of δ_t is the crack opening distance between the intercept of two 45° lines, drawn back from the crack tip with the deformed profile as shown in Figure 4-1. The value of δ that satisfies the displacements along the crack edge is given by

$$\delta_t = d_n \frac{J}{\sigma_o} \qquad (4\text{-}1)$$

where

$$d_n = \left(\frac{\alpha\sigma_o}{E}\right)^{\frac{1}{n}} \left(\tilde{u}_x + \tilde{u}_y\right)^{\frac{1}{n}} \frac{\tilde{\delta}}{I_n} \qquad (4\text{-}2)$$

and

$$\tilde{\delta} = 2\tilde{u}_y \quad (4\text{-}3)$$

E = Young's Modulus

σ_o = yield stress

α, n = Ramberg-Osgood stress strain law parameters

The above equations are valid for both plane strain and plane stress conditions; with values of I_n tabulated by Hutchinson [6], and $\tilde{u}_x$ and $\tilde{u}_y$ are available for a wide range of n for plane strain and plane stress conditions [7,8]. The value of d_n determined from Equation 4-2 for a wide range of n and σ_o/E for the plane stress and plane strain conditions are shown in Reference 7 and 8.

The Tearing Modulus is defined in Reference 5 as

$$T = \frac{E}{\sigma_o^2}\frac{dJ}{da} \quad (4\text{-}4)$$

The condition for unstable crack growth is expressed as

$$T_{applied} \geq T_{material} \quad (4\text{-}5)$$

or

$$\frac{d(J_{applied})}{da} \geq \frac{d(J_{material})}{da} \quad (4\text{-}6)$$

The $\frac{dJ}{da}$ can be calculated using a finite element model by incrementing the initial crack size to obtain the J-integral, and using the gradient to calculate the Tearing Modulus.

4.2 Material J-Integral and Tearing Modulus (J_{mat}-T_{mat})

The material J-T behavior is determined experimentally. Reference 10 contains information to determine the J_{mat}-T_{mat} curve for Type 304 stainless steel. Figure 4-2 shows the J-Δa curves for stainless steel at different fluence levels [10]. Using this data, the tearing modulus can be determined from the following equation,

$$T_{mat} = (E/\sigma_f^2)(dJ_{mat}/da) \qquad (4\text{-}7)$$

4.3 Elastic Plastic Finite Element Analysis

A detailed finite element model was developed using the predicted crack pattern for the selected re-inspection period. The finite element model generated is shown in Figures 4-3 and 4-4. Figure 4-3 is the model used for the 10-year re-inspection interval and Figure 4-4 shows the model for the 8-year re-inspection interval. The results of the crack growth calculations are discussed in Section 5.

4.3.1 Applied Loads

The applied loads are those corresponding to the limiting loading condition. Based on the loads in Reference 2, the bounding condition is the faulted condition and the stresses for which the internal pressure is 30 psi.

4.3.2 Stress-Strain Law

The material Ramberg-Osgood stress-strain law for irradiated stainless steel was obtained from Reference 9. The neutron fluence was estimated to be 2.0×10^{21} n/cm^2 for an additional 10 years of operation beyond the 1999 inspection. This fluence was determined by extrapolating the

fluence results of Reference 3 to the end of the selected re-inspected interval. The Ramberg-Osgood stress-strain law for typical irradiated stainless steel at a fluence of 2.0×10^{21} n/cm^2 is,

$$(\varepsilon/\varepsilon_o) = (\sigma/\sigma_o) + \alpha(\sigma/\sigma_o)^n \qquad (4\text{-}8)$$

where $\alpha = 17.09$

$n = 3.78$

$\sigma = 86$ ksi

$\sigma_u = 97$ ksi

4.4 Crack Growth Rate

In this evaluation, a constant crack growth rate was used for crack extension in the length direction. Since the flaws were assumed through-wall, this is the only crack extension considered. The crack growth rate used was 5×10^{-5} in/hr. The actual crack length growth is determined by adding the product of 5×10^{-5} in/hr and re-inspection interval (in hours) to the crack lengths shown in Figure 2-1.

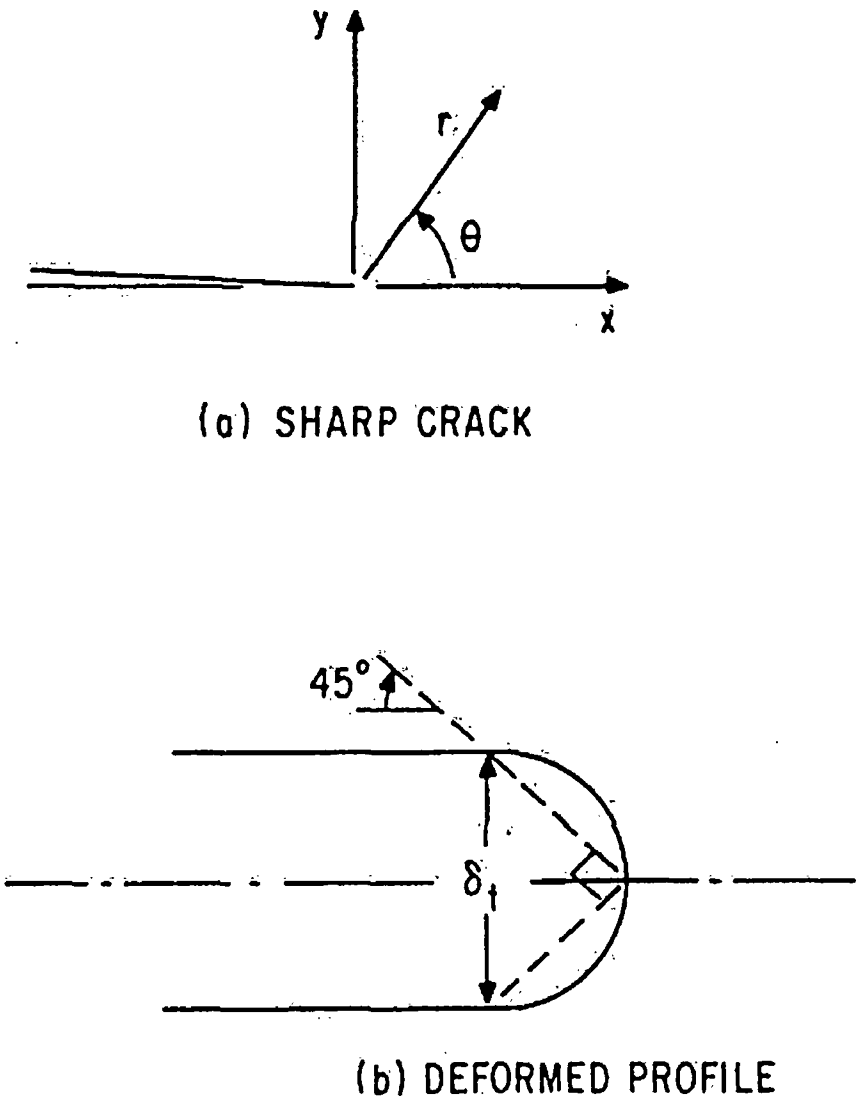


Figure 4-1. Schematic of Crack Opening Displacement

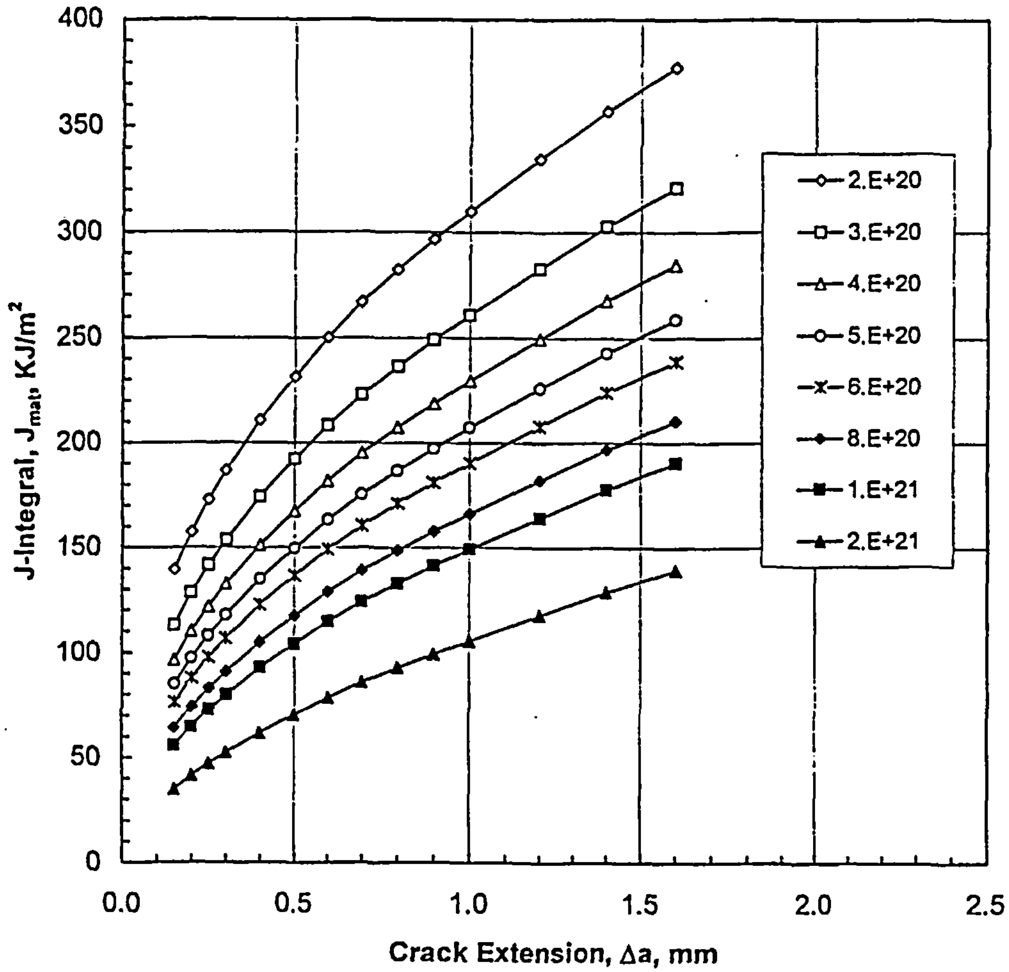


Figure 4-2. J-R Curves as a Function of Neutron Fluence for Structural Integrity Assessments of Stainless Steel

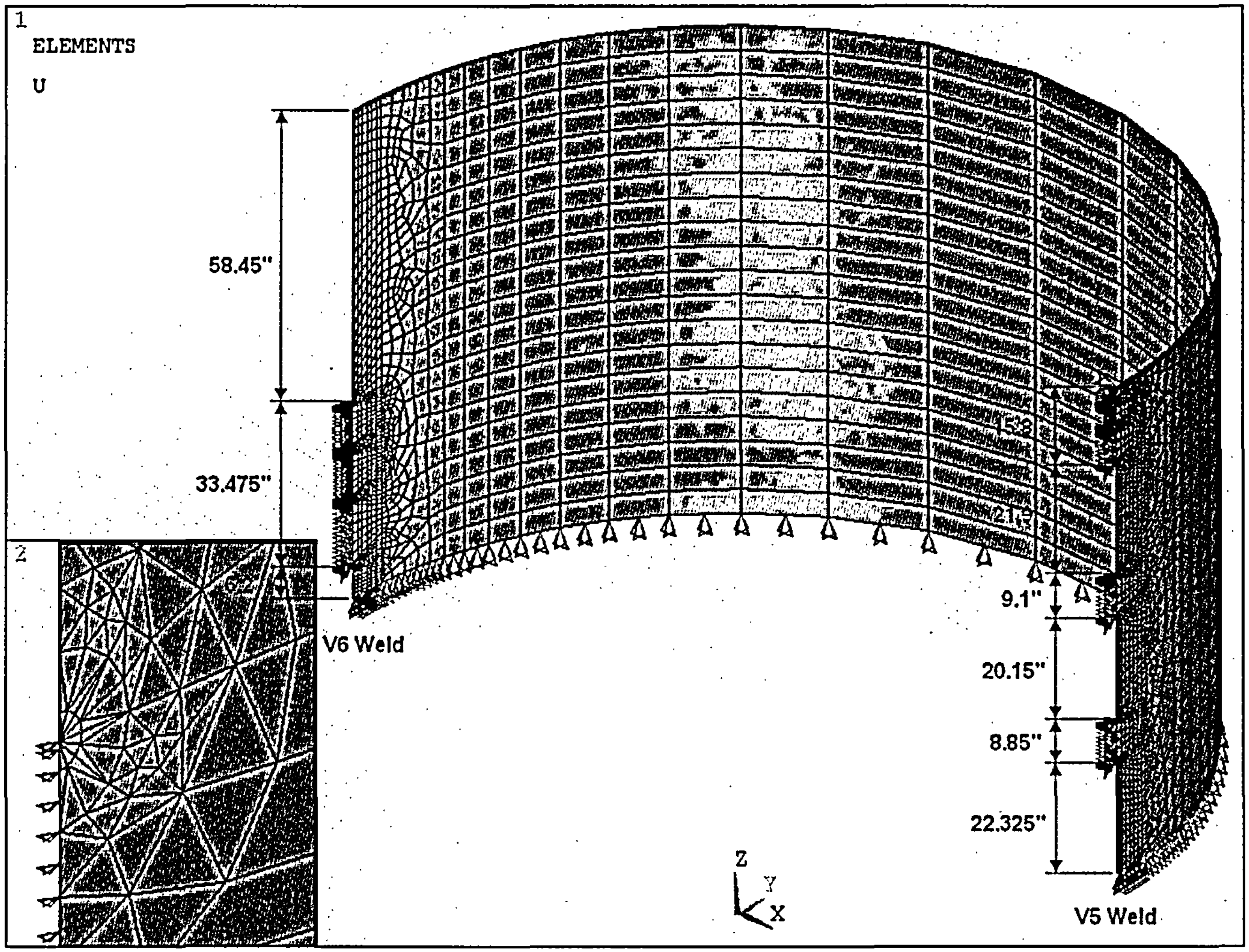


Figure 4-3. Finite Element Model for 10-Year Re-inspection Interval

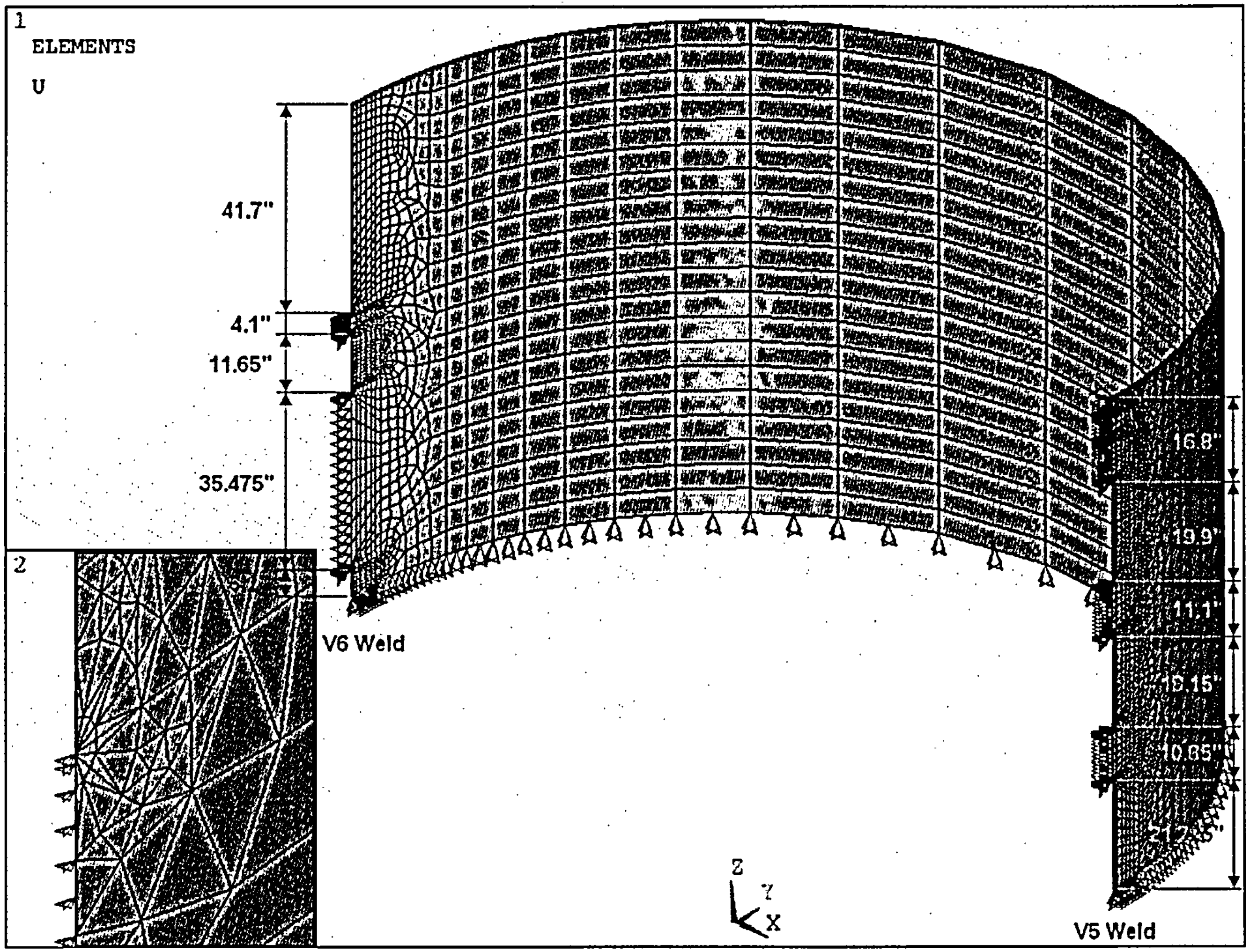


Figure 4-4. Finite Element Model for 8-Year Re-inspection Interval

5.0 RESULTS

The initial re-inspection interval selected was 10 years. For this case, crack growth at the end of each flaw in Figure 2-1 was 4 inches= ($5x10^{-5}$ in/hr)(80,000hr). Adding the growth to the end of each flaw causes the top three flaws in Figure 2-1 to be combined into a single long flaw. Figure 5-1 shows the crack pattern for 10 years using a crack growth rate of $5x10^{-5}$ in/hr starting with the 1999 inspection results shown in Figure 2-1. For the 8-year re-inspection case, the length added to the end of each flaw in Figure 2-1 was 3.2 inches=($5x10^{-5}$ in/hr)(64,000hrs). Figure 5-2 shows the crack pattern for 8 years. Note that for the eight-year case, only the top two flaws in Figure 2-1 need to be combined. The third flaw from the top in Figure 2-1 remains separate since the remaining ligament is 4.1 inches, which is greater than two times the thickness of the shroud (2t = 2x1.5in = 3in).

Using the results of the finite element analysis, the J_{appied}-$T_{applied}$ curve can be superimposed on the J_{mat}-T_{mat} curve. The intersection of the $J_{applied}$-$T_{applied}$ curve with the J_{mat}-T_{mat} curve defines the instability point for this crack configuration, material and loading.

Figure 5-3 shows the J-T diagram. The diagram shows the material J-T curve and the applied J-T curve. The intersection denotes the instability points. Tables 5-1 through 5-3 summarize the results of the J-T calculation, which is illustrated in Figure 5-3.

Based on the results of this J-T evaluation, the safety margins can be estimated for the critical location. The safety factor is 1.18 for the 10-year re-inspection interval. Since the safety factor for the 10-year re-inspection interval case did not satisfy the safety factor requirements in Reference 11 of 1.5 for an axial flaw, the re-inspection interval was reduced to eight years. The crack pattern for the eight-year case is shown in Figure 5-2. The safety factor for the eight-year case was determined to be 1.64, which exceeds the required minimum safety factor of 1.5. The safety factor was determined by the following expression:

$$SF = (J_{instability}/J_{applied})^{1/2} \qquad (5\text{-}1)$$

Note that the square root appears in Equation 5-1 due to the relationship between the J-integral and stress intensity factor as given in Equation 5-2:

$$J \propto K^2 \propto \sigma^2 \qquad (5\text{-}2)$$

Table 5-1

Calculated J-T Values for the 10-Year Re-inspection Interval

a (in)	Δa (in)	J-Integral (psi-in)		dJ/da		Tearing Modulus	
		Plane Strain	Plane Stress	Plane Strain	Plane Stress	Plane Strain	Plane Stress
58.45	0.0077558	1284.80	983.68	–	–	–	–
58.50	0.0077762	1288.18	986.27	67.59	51.75	0.2330	0.1784
58.55	0.0077874	1290.04	987.69	52.35	40.08	0.1805	0.1382
58.60	0.0078006	1292.22	989.36	49.48	37.88	0.1706	0.1306
58.65	0.0078144	1294.51	991.11	48.54	37.16	0.1673	0.1281
Average:		1291.24	988.61			0.1879	0.1438

Table 5-2

Calculated J-T Values for the 8-Year Re-inspection Interval

a (in)	Δa (in)	J-Integral (psi-in)		dJ/da		Tearing Modulus	
		Plane Strain	Plane Stress	Plane Strain	Plane Stress	Plane Strain	Plane Stress
41.70	0.003936	652.03	499.21	–	–	–	–
41.75	0.003957	655.51	501.87	69.58	53.27	0.2399	0.1837
41.80	0.003979	659.15	504.66	71.23	54.54	0.2456	0.1880
41.85	0.004003	663.16	507.73	74.21	56.82	0.2559	0.1959
41.90	0.004029	667.43	511.00	77.03	58.98	0.2656	0.2033
Average:		661.31	506.32			0.2517	0.1927

Table 5-3

Safety Factor Calculation

Inspection Interval	J applied (in-lb/in)	J instability (in-lb/in)	Safety Factor
10 Years	1291	1790	1.18
8 Years	661	1770	1.64

Safety Factor = $\sqrt{[(J\ instability)/(J\ applied)]}$
Square root since $J \propto load^2$

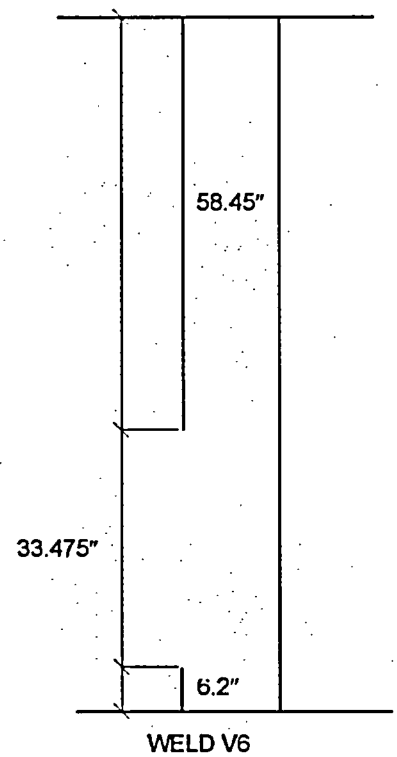


Figure 5-1. End-of-Evaluation Period Flaw Characterization (10 Years)

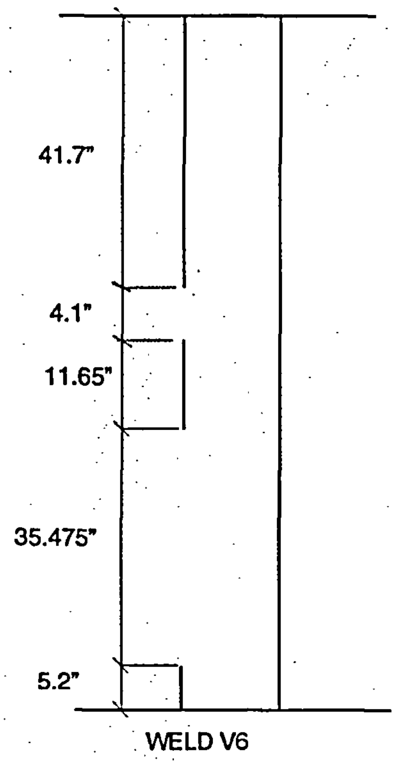


Figure 5-2. End-of-Evaluation Period Flaw Characterization (8 Years)

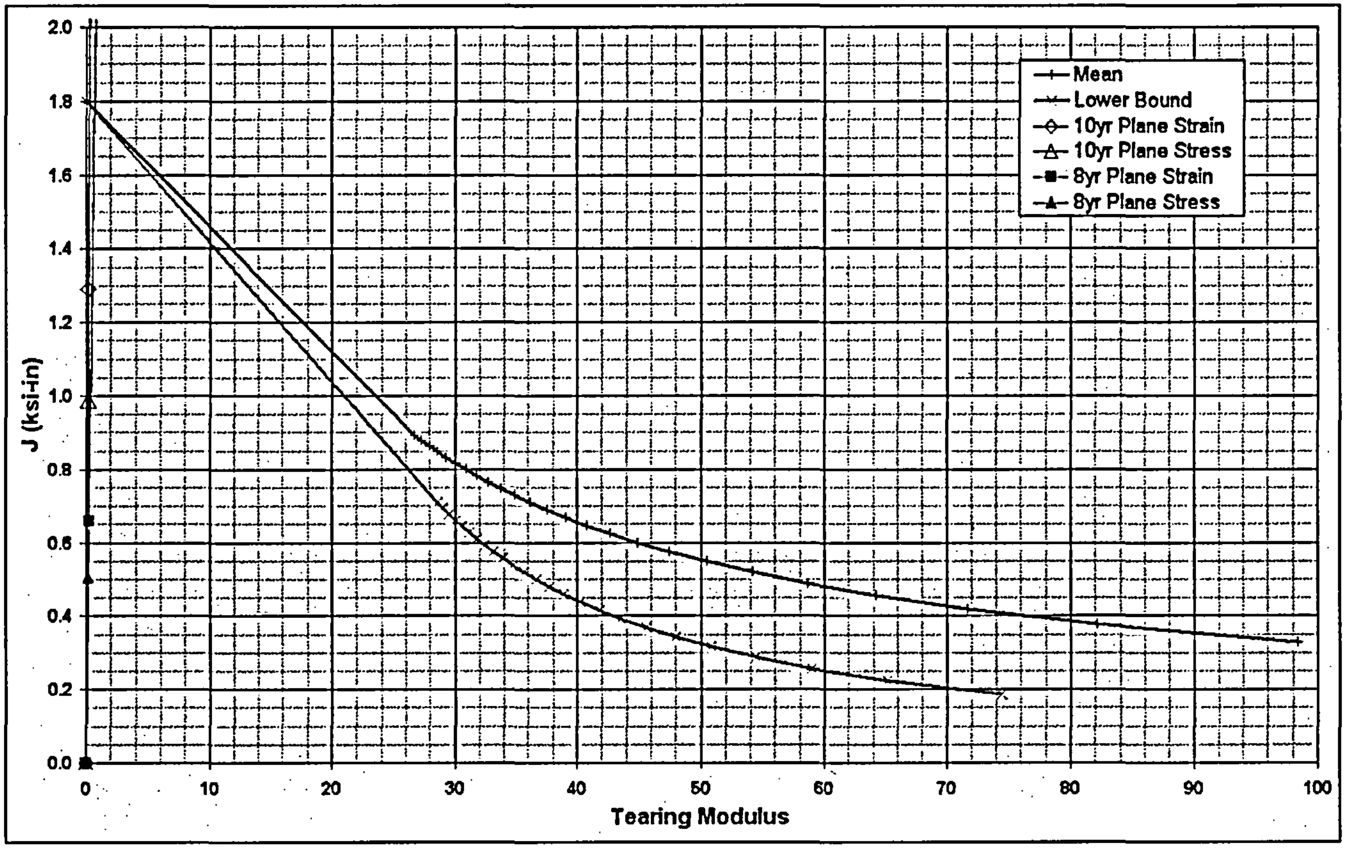


Figure 5-3. J-T Diagram

6.0 CONCLUSIONS

An EPFM analysis has been performed of the Plant Hatch Unit 1 core shroud V6 weld. This weld is subjected to significant fluence and cracking was detected during the shroud inspection in 1999.

The crack growth rate was independent of the stress intensity factor. The crack growth rate used was $5x10^{-5}$ in/hr. A detailed three-dimensional finite element model was generated using the 1999 inspection crack profiles and adding crack growth for selected re-inspection intervals. The faulted condition limiting loading was applied to the model to determine the acceptability of the flaws.

Results of the analysis showed a safety factor of 1.64 for eight years of operation beyond the 1999 inspection, which compares against the required safety factor of 1.5 for the faulted condition. The eight years of operation is equivalent to 64,000 hours assuming 8,000 hours per year. Thus, a re-inspection interval of eight years (or 64,000 hours) is acceptable since the required structural integrity safety factors are satisfied.

7.0 REFERENCES

1. Boiling Water Reactor Vessel and Internals Project Report, "BWR Core Shroud Inspection and Flaw Evaluation Guidelines (BWRVIP-76)," EPRI TR-114232, November 1999.

2. Structural Integrity Report, SIR-02-029, "Re-inspection Interval for Hatch, Unit 1 Shroud Vertical Welds V5 and V6," February 2002.

3. TransWare Report TWE-HATCH1-001-R-001 Rev. 0, dated September 10, 2003. "Evaluation of >1.0 MEV Fluence in the Hatch 1 Shroud".

4. EPRI Report NP-1735, "Methodology for Plastic Fracture," Project 601-2, March 1981.

5. Paris, P. C., Tada, H., Zahoor, A., and Ernst, H., " The Theory of Instability of the Tearing Mode of Elastic-Plastic Crack Growth, " Elastic-Plastic Fracture, ASTM STP 668, J. D. Landes, J. A. Begely, and G. A. Clarke, Eds., American Society for Testing and Materials, 1979, pp5-36.

6. Hutchinson, J. W., Journal of Mechanics and Physics of Solids, Vol. 16, 1968, pp. 13-31, and pp. 337-347.

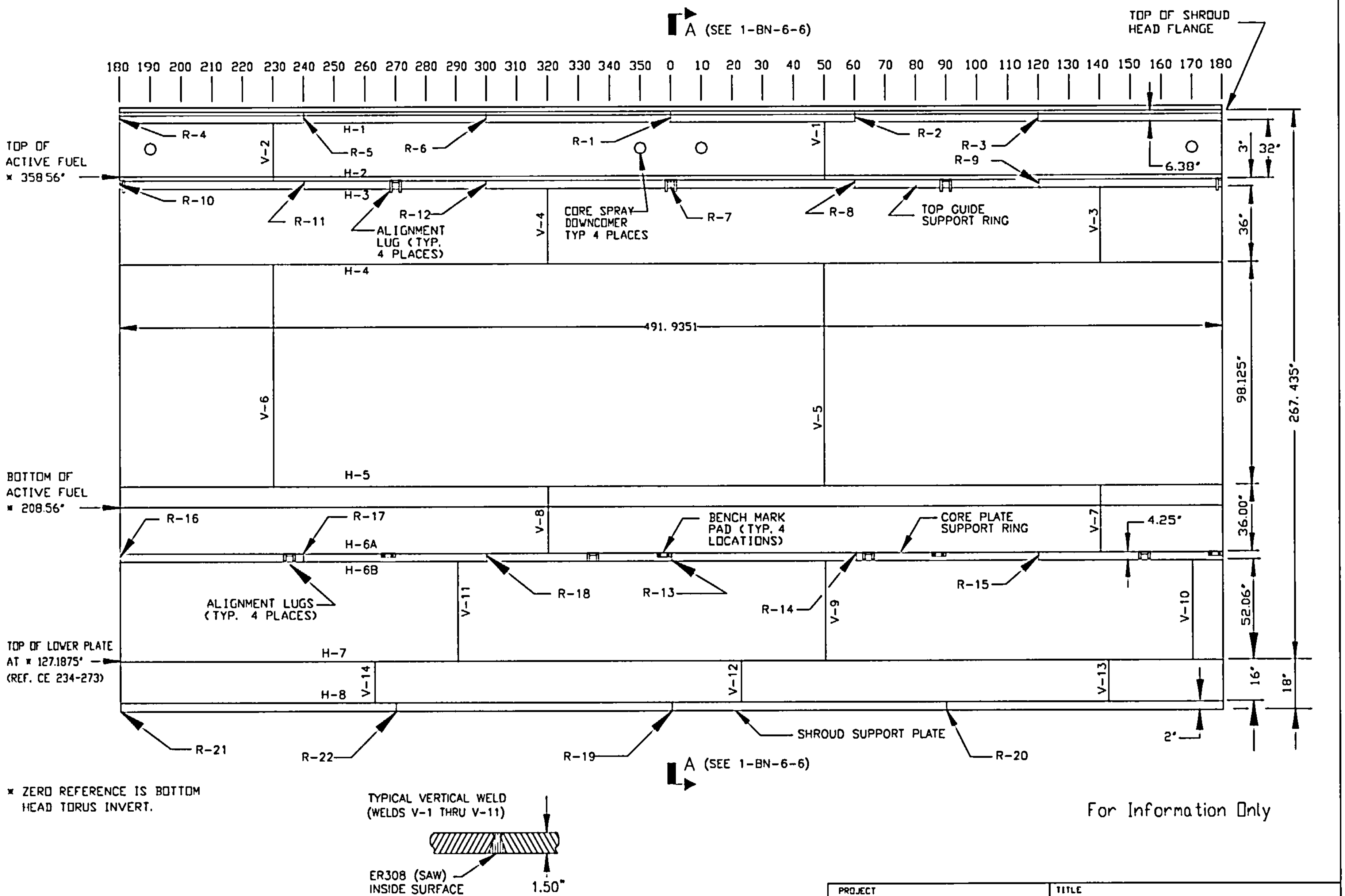
7. Shih, C. F., Fracture Analysis, ASTM STP 560, American Society for Testing and Materials, 1974, pp. 187-210.

8 Shih, C. F., "Elastic-Plastic Analysis of Combined Mode Crack Problems," Ph. D. Thesis, Harvard University, 1973.

9. Boiling Water Reactor Pressure Vessel and Internals Project Report "Fracture Toughness Properties of Irradiated Austenitic Stainless Steel Components Removed from Service (BWRVIP-35)," EPRI Report TR-108279, June 1997.

10. Boiling Water Reactor Pressure Vessel and Internals Project Report, "BWRVIP-100, BWR Vessel and Internals Project Updated Assessment of the Fracture Toughness of Irradiated Stainless Steel for BWR Core Shrouds," EPRI-1003016, December 2001.

11. American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section XI, Appendix C, 1995 Edition.



PROJECT	E I HATCH UNIT 1
TITLE	CORE SHROUD WELD IDENTIFICATION ROLL OUT (INSIDE VIEW)

SOUTHERN NUCLEAR COMPANY

REFERENCE DRAWINGS
S-15122 (COMBUSTION ENGINEERING)
S-17857 (SUN SHIPBUILDING & DRYDOCK CO.)
S-18749 THRU S-18754 (SUN SHIPBUILDING & DRYDOCK CO.)
S-19622 (GENERAL ELECTRIC)