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Form 2

ENGINEERING EVALUATION REPORT

EER Number	Rev.	Q-list	System File Number	Reference Document(s)
94-0077	0	Class A	1005	G0250C

Title

Evaluation of Unit 2 Core Shroud Indications and Operability Assessment

CLASSIFICATION (refer to Section 6.2 for additional instructions)

Seismic Related? Yes / No (Yes underlined) Follow NED seismic Design Guides; NED management approval	**EQ Affected?** Yes / No (No underlined) Follow PLP-02; AI-71 EQ Review; ENP-34.1, Form 3 if required	**MOV per ENP-56?** Yes / No (No underlined) Consult NED Mech. or Component Eng. to address GL 89-10
Use As Is? Yes / No (Yes underlined)	**Parts Upgrade?** Yes / No (No underlined) Follow PMC 15.6	**Short Term Structural Integrity?** Yes / No (No underlined) Expiration Date N/A
Permanent Repair? Yes / No (No underlined) PLP-08 if ISI; Form 6 for Dwg/Doc changes	**Temporary Repair?** Yes / No (No underlined) Expiration Date N/A PLP-08 if ISI; Notify Temp Cond Coord	**Temporary Modification?** Yes / No (No underlined) Follow PLP-22 Notify Temp Cond Coord
50.59 Required? Yes / No (Yes underlined) Complete AI-109 Safety Review; PNSC & RCI-2.1 if unreviewed safety	**FSAR Affected?** Yes / No (No underlined) Two tech reviews if Class A; RCI-4.1 form; Corp. NSRG approval	**Operability Assessment?** Yes / No (Yes underlined) Complete within OI-04 time frame; T/S management approval

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List of Effective Pages/Attachments

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SECTION 2.0 EXECUTIVE SUMMARY

In October, 1990, RICSIL No. 054 reported cracking near the circumferential seam weld at the core beltline area of the shroud in a GE BWR/4 located outside the United States. Based on recommendations contained in this RICSIL, the BNP Unit 2 shroud was inspected during the 1991 refueling outage. No cracks were identified. The Unit 1 shroud was inspected in July, 1993, and a near 360° circumferential crack was confirmed on the inside diameter of the Top Guide Support Ring, at the weld to the shroud mid-section. The tapes of the Unit 2 shroud IVVI were re-examined based on the early July Unit 1 findings. Three small indications were noted. Unit 2 tapes were again examined in late September, based on lessons learned on Unit 1. One additional small indication was noted. Although this additional indication was bounded by the assumptions in the original evaluation, it was recognized that the quality of the 1991 tapes was insufficient to identify all of the types of cracks being confirmed on Unit 1. EER 93-0536 was issued to assess Unit 1 shroud structural integrity and to justify continued operation of Unit 2 until a detailed inspection could be performed during the Spring, 1994 RFO.

The Unit 2 inspections are complete and evaluated in this EER. This EER concludes that structural integrity of the core shroud will be maintained, with full FSAR safety margins, for at least the next 600 days of hot operation, and for welds H1, H4, and H5, for at least the next 1200 days of hot operation based on analysis of the inspection results. These durations allow operation at least through the next operating cycle, currently scheduled to end 2/2/96. However, the inspection plan for the next RFO will consider not only these inspection results, but will also consider continuing developments in the industry, to ensure utilization of the best information and technology to address the issue.

The inspection results confirm that the comparison presented in EER 93-0536 accurately reflected that Unit 2 was bounded by the Unit 1 analysis, and that continued operation was justified.

This EER is Quality Class A due to the quality classification of the shroud.

SECTION 3.0 SHROUD DESIGN DISCUSSION

The design of the reactor vessel internals was in accordance with applicable portions of Section III of the ASME Boiler and Pressure Vessel Code, 1965 Edition through Summer, 1967 Addenda (ref. 9.1). Although the shroud itself is not a Code component, the above Code was used as the design basis for determining limits for stress intensities.

SECTION 3.1 Shroud Design

The core shroud is a cylindrical assembly inside the reactor vessel, which provides a partition to properly distribute the flow of coolant delivered to the vessel. The safety design basis of the shroud is to:

a) Provide a floodable volume in which the core can be adequately cooled in the event of a breach in the nuclear system process barrier external to the reactor vessel.

b) Limit deflections and deformations of the reactor vessel internals to assure that the control rods and the core standby cooling systems can perform their safety functions during abnormal operational transients and accidents.

c) Assure that the safety design bases (1) and (2) above are satisfied so that the safe shutdown of the plant and removal of decay heat are not impaired.

The core shroud is composed of three regions: an upper shroud which is bounded by the shroud head and the top fuel guide; a central region which surrounds the fuel; and a lower region which surrounds the lower plenum and is welded to the reactor vessel shroud support ring. The three regions are of different diameters: the top region is approximately 15'-9" diameter; the central region is approximately 14'-9"; and the lower region is tapered from 14'-9" to 14'-3" (see Figures 1 and 2, and ref. 9.2). Roll out maps of the core shroud depicting the locations of horizontal welds H1-H9, vertical welds V1-V11, plates P1-P11 and shroud hold down bolt lugs are shown in Figures 3, 4, and 5. The weld and plate designations were assigned for inspection purposes.

The upper shroud consists of the separator support ring, the upper shroud cylindrical shell, and the top guide support ring. The separator support ring is constructed from 6 ring segments having a cross section of approximately 6" X 6", cut from rolled and annealed plate, welded together, then machined to final dimensions. The ring material is Type 304 stainless steel from three different heats, with a carbon content of 0.047 - 0.061 wt% (The ring material in Unit 1 was from a single heat, different from the above 3, with a carbon content of 0.078 wt%). Thirty-six pairs of shroud bolt hold down lugs are welded to this ring. This assembly is joined to the upper shroud shell at weld H1, which consists of a Double-J prep weld with a fillet on the inside.

The shell is formed from (2) 1½" thick semicircular plates, welded together using a Double-U prep. The carbon contents range from 0.049-0.060 wt%. These plates are from the same heats of material as the Unit 1 plates. The Top Guide Support Ring, with a cross section of 7½" X 3", is constructed and welded (H2) to the upper shroud shell in a manner similar to the separator support ring. The ring material has a carbon content of 0.064 wt%. The 6 ring segments were fabricated from a single heat of material, which was also used for 3 of the Unit 1 ring segments. These welds are oriented such that the axial residual stresses pull across the short transverse orientation (end grain) of the ring material.

The central region of the shroud consists of the mid-shroud barrel, the core support ring, and adjoining welds. The barrel is formed in the same manner as the upper shroud shell, but consists of three cylindrical sections joined together at welds H4 and H5. Carbon contents range from 0.046-0.061 wt%. The mid-shroud barrel is welded to the upper shroud assembly at H3, which consist of a Single-J prep weld from the inside, with a back gouge and a fillet reinforcement on the outside. It is welded to the core support ring at H6a, which is a Double-J prep weld with a fillet reinforcement on the inside. The core support ring is similar to the separator and top guide support rings, and has a carbon content range of 0.063-0.067 wt%. The 6 ring segments were fabricated from 2 heats at material. These are the same 2 heats used for the Unit 1 ring segments.

The lower region of the shroud consists of the lower shell course, shroud support ring, jet pump diffuser ring, and associated welds. The lower shell course is formed from (3) 1½" thick plates welded together using Double-U prep welds to form a conical section. Carbon contents range from 0.046-0.058 wt%. It is joined to the core support ring at weld H6b, which is similar to H6a. The shroud support ring, which transfers the shroud weight and other loads to the reactor vessel, is 2" thick Alloy 600. The lower shell course is joined to the shroud support ring using a bimetallic Single Bevel prep weld with a backing ring on the outside (H7). The jet pump diffuser ring is also made of Alloy 600, and is joined to the shroud support ring at H8, and to the reactor vessel wall at H9. H8 and H9 are Double-J prep welds with fillet reinforcement.

Refer to Table 3.1 and Figure 6 for shroud welds and materials detail.

SECTION 3.2 Miscellaneous Parts and Accessories

A number of miscellaneous parts and accessories are associated with the core shroud. The following listing describes some of these components and their function and location.

SECTION 3.2.1 Separator Support Ring and Attachments (Figure 7)

The Shroud Head Bolt Lugs are located around the circumference of the Separator Support Ring. There are 36 pairs of lugs that align with matching lugs on the Shroud Head. The Head Bolts secure the shroud head to the shroud by applying a clamping force between the two sets of bolt lugs. Therefore, the lugs function to provide the loading surfaces for the bolts.

SECTION 3.2.2 Shroud Access Manway Covers

The Shroud Access Manway Covers provided access to the bottom head plenum during installation of the vessel internals. The cover is an Alloy 600 plate that fits into an opening in the Jet Pump Diffusser Ring at the 0° and 180° azimuths (directly below the recirculation suction nozzle). The access cover is welded in place using the shielded metal arc welding process (SMAW). Once the access cover is welded in-place, the annulus between the shroud and the reactor vessel wall is secured for jet pump operation.

SECTION 3.2.3 Core Spray Spargers and Brackets

The core spray spargers and brackets are located inside the core shroud between welds H1 and H2. The brackets are 304 stainless steel, welded to the spargers and the core shroud, and provide alignment and support for the spargers. BWR's have experienced cracking in the spargers and have been inspecting in accordance with IEB 80-13. A recent inspection at another utility found cracking at the brackets supporting the spargers. BNP expanded its IVVI plan to incorporate these brackets.

SECTION 3.2.4 Jet Pump Beam Riser Braces

The jet pump riser braces are made of 304 stainless steel and welded to the reactor vessel on one end and the riser pipe on the other end. They are located at the upper part of the jet pump assembly. The braces provide lateral support to maintain jet pump alignment and structural integrity during operation. The jet pump beam riser braces were in the original vessel internals inspection plan as recommended by GE SIL 551.

TABLE 3.1 - SHROUD WELD DETAILS

COMPONENT DESCRIPTION and WELD NUMBER	PIECE NUMBERS* and WELD PREP	MATERIAL and CARBON WT%	COMMENTS
UPPER SHROUD			
SEPARATOR SUPPORT RING (SSR)	Piece 5	304 SS 0.047 - 0.061 wt%	SSR assembled from six plate segments, welded with 308L SS Double-U welds
WELD H1	Double-J; Fillet on ID	308L SS	ID welded first, OD back-chipped, then welded
UPPER SHROUD SHELL COURSE	Piece 1	304 SS 0.049 - 0.060 wt%	Assembled from 2 rolled plates, welded together by 308L SS Double-U welds V1 and V2
WELD H2	Double-J; Fillet on ID	308L SS	ID welded first, OD back-chipped, then welded
TOP GUIDE SUPPORT RING (TGSR)	Piece 6	304 SS 0.064 wt%	TGSR assembled from six plate segments, welded with 308L SS Double- U welds
WELD H3	Single-J on ID; Fillet on OD	308L SS	ID welded first, OD back-chipped, then welded

TABLE 3.1 - SHROUD WELD DETAILS			
COMPONENT DESCRIPTION and WELD NUMBER	**PIECE NUMBERS' and WELD PREP**	**MATERIAL and CARBON WT%**	**COMMENTS**
MID-SHROUD BARREL			
MID-SHROUD TOP SHELL COURSE	Piece 2 (Upper)	304 SS 0.051 -0.058 wt%	Assembled from 2 rolled plates, welded together by 308L SS Double-U welds V3 and V4
WELD H4	Double-J	308L SS	One of last two welds made to assemble shroud.
MID-SHROUD MIDDLE SHELL COURSE	Piece 3	304 SS 0.046 - 0.061 wt%	Assembled from 2 rolled plates, welded together by 308L SS Double-U welds V5 and V6
WELD H5	Double-J	308L SS	One of last two welds made to assemble shroud.
MID-SHROUD LOWER SHELL COURSE	Piece 2 (lower)	304 SS 0.051 - 0.056 wt%	Assembled from 2 rolled plates, welded together by 308L SS Double-U welds V7 and V8
WELD H6a	Double-J; Fillet on ID	308L SS	
CORE SUPPORT RING (CSR)	Piece 7	304 SS 0.063 - 0.067 wt%	CSR assembled from six plate segments, welded with 308L SS Double-U welds
WELD H6b	Double Bevel; Fillet on ID	308L SS	

TABLE 3.1 - SHROUD WELD DETAILS			
COMPONENT DESCRIPTION and WELD NUMBER	**PIECE NUMBERS* and WELD PREP**	**MATERIAL and CARBON WT%**	**COMMENTS**
LOWER SHROUD			
LOWER SHROUD TAPERED SHELL COURSE	Piece 4	304 SS 0.046 - 0.058 wt%	Assembled from 3 rolled plates, welded together by Double-U welds V9, V10, V11
WELD H7	Single Bevel on ID; Fillet Welded Backing Ring on OD	Alloy 82 root Alloy 182 filler	Gas Tungsten Arc Welded (GTAW) Root; Shielded Metal Arc Welded (SMAW) Fill
SHROUD SUPPORT RING (SSR)	N/A	Alloy 600	Plate thickness is 2.0".
WELD H8	Double-J with Fillets	Alloy 82 root Alloy 182 filler	GTAW root. SMAW fill.
JET PUMP DIFFUSER RING	N/A	Alloy 600	Plate thickness is 2.5".
WELD H9 (attaches Jet Pump Diffuser Ring to Reactor Vessel)	Double-J with Fillets	Alloy 82 root Alloy 182 filler	GTAW root. SMAW fill.

* Sun Shipbuilding & Dry Dock Fabrication piece reference numbers.

SECTION 4.0 SHROUD FABRICATION AND INSTALLATION

The core shroud was designed by General Electric and fabricated by Sun Shipbuilding & Dry Dock Company from January 1970 to June 1971 for Unit 2 and January 1970 to November 1971 for Unit 1. The Unit 2 core shroud was installed in October 1973, and the Unit 1 shroud was installed in February 1974, with fit-up and welding provided by Brown & Root. CP&L has performed a detailed review of the fabrication and installation records (Ref. 9.3). No significant fabrication or installation details were discovered that would indicate any material conditions unique to either of the units. However, the weld material used to assemble the shrouds for each Unit was different.

The weld material was 308 SS for Unit 1 and 308L SS for Unit 2, for both the circumferential welds (H1, H2, H3, H4, H5, H6a, and H6b) and the vertical welds (V1 - V11) using automatic Submerged Arc Welding (SAW) and/or manual Shielded Metal Arc Welding (SMAW) procedures. This low carbon weld material has no appreciable effect on the resistance to IGSCC since the welding process is the same and the plate material is Type 304 in both Units.

Welds H7, H8, and H9 are constructed of similar materials and processes on both Units. There are no significant differences.

SECTION 5.0 CAUSAL FACTORS

The factors that affect IGSCC and their relation to the core shroud are detailed in EER 93-0356. Unit 2 was compared to Unit 1, to demonstrate that the histories of both units are similar. This comparison considered water chemistry, shroud materials and fabrication techniques, and critical hours of operation. Cracking histories of other components are also compared.

Both Units had variances in conductivity in the early years, followed by a trend of smaller variances and lower conductivity for recent years. Unit 1 has geometric and calculated mean conductivities of 0.333 μS/cm and 0.959 μS/cm, respectively. Unit 2 has corresponding values of 0.328 μS/cm and 0.915 μS/cm.

The Hydrogen Water Chemistry (HWC) system for Unit 2 has more cumulative operation than Unit 1. HWC mitigates the environmental conditions that are favorable to crack formation and growth.

No significant differences were identified during the review of the materials, fabrication and installation techniques for the core shrouds for Unit 1 and Unit 2.

Cumulative hot operating hours on both units are within one operating cycle of each other, with Unit 2 having a slightly longer total operating time.

A comparison was made of IGSCC experience for recirculation system pipe and the shroud head bolts. Accounting for recirculation system pipe replacement and on-line months, Unit 1 and Unit 2 experienced similar cracking events in the recirculation system piping and shroud head bolts.

SECTION 6.0 INSPECTION RESULTS

Inspections of various components within the reactor are routinely performed each refueling outage in accordance with the requirements of ASME Code Section XI, and the plant In-Service Inspection (ISI) Program.

The inspection plan for Unit 2 was based on the experience and observations from Unit 1 and the current understanding of the causal factors contributing to the cracking being seen. Accordingly, the initial inspection plan provided extensive inspections for the regions where the most cracking had been observed (above the core plate (H1-H5) where neutron fluence and the oxidizing environment are most prominent), and sampled the regions where little or no cracking was present (below the core plate (H6-H9) and vertical welds). Evaluation and screening was to be performed in accordance with GENE-523-123-0993, Revision 2, "Evaluation and Screening Criteria for the Brunswick 1 Shroud Indications," dated 11/93 (Reference 9.9). The design criteria and safety margins in this document are the same for both Units and, therefore, this document is applicable to Unit 2. Visual examinations involved cleaning the weld area to remove surface film which might hinder detection of very tight indications. The distance to the shroud surface for visual examinations was established to discern a 1 mil wire in order to ensure detection of tight cracks.

The inspection plan was revised to reflect the decision to install the modification at H2/H3, and to take advantage of weld specific analyses that had been performed - RAM-94-092/SIR-94-029, "Addendum to the Brunswick Unit 1 Screening Criteria" dated 4/6/94 (Reference 9.1); and RAM-94-099/SIR-94-031, "Minimum Required Unflawed Core Shroud Material at Brunswick, Units 1 and 2, dated 4/11/94 (Reference 9.11). A sampling inspection for weld H1 established four symmetric inspection windows picked to cover 4 of the 6 ring segments, and at least 2 of the 3 material heats used to fabricate the ring. Analysis indicated that the allowable length for an axial flaw exceeded the width of any of the plate material, so inspection of vertical welds was eliminated.

The inspection plan was again revised during the course of the shroud inspections, to take advantage of the successful utilization of the automated ultrasonic scanner at another utility. The scanner offered the advantage of providing both length and depth characterization of detectable cracking, with only an OD inspection and without having to clean the welds. The automated scanner worked reasonably well on the H4 weld, but was unable to function properly on the H5 weld and could not be used. H5 was inspected visually.

A final change was made to the inspection plan due to reports of cracking at the lower core plate found at another utility. The sample plan for welds below the core plate was doubled to include areas at both 0° and 180°. Sample locations were chosen to cover at least 4 of the six ring segments comprising the lower core support ring, and at least one sample from each heat of material used to fabricate the ring.

The results of the inspection found no indications in the areas sampled on H1, and in the lug welds examined. H2 was inspected at the area of previously identified indications, and cracking was determined to extend across all of the area inspected. H4 and H5 indicated moderate degrees of cracking. Minor cracking was seen in the H6a and H6b areas, and no cracking seen on H7. Based on the observation at H6a - H7, absence of any indications at the access hole covers, and simi'ar findings on Unit 1, H8 and H9 were not inspected. Table 6.1 provides a detailed account of the inspection findings. Reference 9.12 contains the specific Inservice Inspection results.

TABLE 6.1 - UNIT 2 DETAILED INSPECTION RESULTS

WELD	RESULTS	
H1	VISUAL INSPECTIONS:	75°-85°, 165°-175°, 255°-265°, 345°-355° OD areas were inspected on the top and bottom of the weld. Additional weld metal, 39.5" top and 7" bottom toe of the weld was inspected as part of the shroud hold down bolt lug weld inspection. A total of 17.7% of the top and 12.3% of the bottom of the weld was inspected. No indications were identified.
	UT INSPECTIONS:	None performed.
H2	VISUAL INSPECTIONS:	40°-50° OD area was inspected to confirm four indications identified from a previous RFO tape. A circumferential crack was identified in the TGSR that ran continuously through the inspection zone. The other indication, in the plate, was determined to be in-line pitting.
	UT INSPECTIONS:	None performed.
H3	VISUAL INSPECTIONS:	None performed.
	UT INSPECTIONS:	None performed.
H4	VISUAL INSPECTIONS:	350° - 10° OD area was inspected and no indications were identified.
	UT INSPECTIONS:	Approximately 78% was inspected from the OD using an automated UT device. 23 circumferential indications were identified, 9 in the top toe and 14 in the bottom toe. Lengths of indications ranged from 0.3" to 13.6". The depth ranged from 0.10" to 0.86" with an average of 0.53". Cracking was in the heat affected zone of the weld.
H5	VISUAL INSPECTIONS:	9[illegible].8% of ID was inspected with 7 circumferential and 3 axial cracks identified. The longest circumferential cracks ranged from 0.25 to 12". The axial cracks were less than 1.25" long. 30.6% of the OD was inspected with 1 circumferential and 2 axial cracks identified. The circumferential crack was 11" long. The axials were less than 0.5". All circumferential cracking was in the heat affected zone of the weld.
	UT INSPECTIONS:	None performed.

TABLE 6.1 - UNIT 2 DETAILED INSPECTION RESULTS		
WELD	**RESULTS**	
H6a and H6b	VISUAL INSPECTIONS:	350°-10° and 170°-190° areas (11%) were inspected from the OD. 4 axial cracks, 2" and less in length, were identified in the CSR. One circumferential crack 1.5" long was identified in the plate above H6a, in the heat affected zone.
	UT INSPECTIONS:	None performed.
H7	VISUAL INSPECTIONS:	350°-10° and 170°-190° areas (11%) were inspected from the OD. No indications were identified.
	UT INSPECTIONS:	None performed.
H8	VISUAL INSPECTIONS:	None performed.
	UT INSPECTIONS:	None performed.
H9	VISUAL INSPECTIONS:	None performed.
	UT INSPECTIONS:	None performed.
V1 - V11	VISUAL INSPECTIONS:	None performed.
	UT INSPECTIONS:	None performed.
PLATES	VISUAL INSPECTIONS:	None performed.
	UT INSPECTIONS:	None performed.
ATTACH-MENTS and COMPON-ENTS	VISUAL INSPECTIONS:	Additional inspections performed include: - Top Guide Upper and Lower Beams. No reportable indications. - Shroud Head Bolt Lugs (8 pairs on the Shroud). No reportable indications. - Manway Access Hole Covers (0° and 180° azimuths). No reportable indications. - Jet Pump Beam Riser Braces. No reportable indications. - Core Spray bracket welds. No reportable indications. - Core Spray Sparger has a crack emanating from a flow nozzle tack weld.
	UT INSPECTIONS:	UT inspections were performed on the Manway Access Hole Covers and no indications were noted.

SECTION 7.0 ANALYSIS AND RESULTS

The cracks were analyzed for structural significance by initially screening them in accordance with Reference 9.9. The screening process conservatively assumes that the cracks are through-wall, and provides guidance that is more conservative than ASME Code Section XI criteria by combining the lengths of cracks that are relatively close together (effective crack length). It then provides a bounding crack length for initial screening. Cumulative effective crack lengths which are smaller than the bounding crack length are not a structural concern and are screened from a specific evaluation. Effective crack lengths that are larger than the bounding crack length must be specifically analyzed.

For the purposes of this analysis, the Unit 2 core was assumed to be critical 7/2/94 and run continuously until the next refueling outage 2/2/96. This is approximately 580 days. The analysis used 600 days in assessing crack growth to bound this period.

BNP also developed a weld-specific structural analysis to determine more precisely the allowable crack size (Reference 9.10 and 9.11). The allowable flaw in a vertical weld is 106". Since this allowable length is less than the width of any of the shroud assembly plates, vertical welds were not included in the inspection plan.

Table 7.1 is a detailed account of the analysis results for each weld joint. Table 7.2 and 7.3 provide a summary of H4 and H5 cracking for comparison to the Screening Criteria.

TABLE 7.1 - UNIT 2 ANALYSIS AND RESULTS SUMMARY

WELD	DISPOSITION	ANALYSIS AND RESULTS
H1	SPECIFIC ANALYSIS PERFORMED	Four 10° symmetric locations were inspected with no cracks identified. This amounts to 16.5" of uncracked metal at each location. The minimum required ligament at each location is 7.25" to justify operation for one fuel cycle. Each 600 day operating cycle has an assumed crack growth of 1.44". At the end of one 600 day operating cycle, any cracking in the uninspected areas would not grow to sufficient length to violate design margins. This weld requires no further inspection and is qualified for a minimum of one 600 day operating cycle.
H2	REPAIR	40° - 50° VT indicated that the weld had significant cracking in the area inspected.
H3	REPAIR	N/A
H4	ACCEPTABLE BY SCREENING CRITERIA	The summed effective lengths of circumferential cracks in the limiting 90° sector after 600 days of operation is 52.2". UT depth measurements ranged from 0.10" and 0.86". Table 7.2 summarizes the most limiting 90° sweep of circumferential cracks on H4.
H5	ACCEPTABLE BY SCREENING CRITERIA	The summed effective lengths of circumferential cracks in the limiting 90° sector after 600 days of operation is 61.4". The axial cracks were less than 1.25". Table 7.3 summarizes the most limiting 90° sweep of circumferential cracks on H5.
H6a and H6b	ACCEPTABLE BY SCREENING CRITERIA	Inspections on the OD identified 4 short axial indications in the CSR. No indication exceeded 2" in length. One circumferential crack 1.5" long was identified in the plate. This is consistent with the cracking identified on Unit 1, where similar water chemistry, material, and fabrication processes exist. The cracking identified in the 40° of inspection is assumed to be representative of the remaining uninspected areas, for analysis purposes. The total projected cracking is 13.5" (1.5" * 360°/40°). The separation between cracks is projected to be at least 10°, so the maximum effective crack length in any one 90° sector after one 600 day operating cycle is expected to be 26.5" (9 * [1.5 " + .72" + .72"] = 26.5"). This is less than the 74.5" allowable and passes the screening criteria.
H7	ACCEPTABLE BY SCREENING CRITERIA	No indications were identified in either the backing ring fillet or H7 weld. This inspection is supported by the detailed inspection of the manway access hole covers. No indications were identified by VT or UT. (See the addendum at the end of this table for more detailed discussion).

TABLE 7.1 - UNIT 2 ANALYSIS AND RESULTS SUMMARY

WELD	DISPOSITION	ANALYSIS AND RESULTS
H8	N/A	Not inspected. This is an Inconel weld. This weld is similar to Unit 1 H8, in material and fabrication, where no cracking was identified. The Manway Access Hole Covers are in the shroud support plate and are also Inconel welds but in addition have a crevice. This design is more susceptible to IGSCC by crevice corrosion and is expected to show evidence of cracking before H8. The VT and UT inspection of these covers found no indications. Therefore, the H8 weld was not expected to be cracked and was not inspected.
H9	N/A	Not inspected. This is an Inconel weld. This weld is similar to Unit 1 H9, in material and fabrication, where no cracking was identified. The Manway Access Hole Covers are in the shroud support plate and are also inconel welds but in addition have a crevice. This design is more susceptible to IGSCC by crevice corrosion and is expected to show evidence of cracking before H9. The VT and UT inspection of these covers found no indications. Therefore, the H9 weld was not expected to be cracked and was not inspected.
V1 - V11	N/A	Not inspected. The allowable axial flaw size to maintain structural integrity is greater than the width of the widest plate. Therefore, the vertical flaws are bounded by analysis, and are not inspected .
PLATES	N/A	Not inspected. Only one crack was found in the Unit 1 plate. The IGSCC rate used in the analysis is 5.0 E -5 in/hr or 0.72"/600 days of operation. Since plate cracks are expected to be the result of local cold work, a plate crack will not have a predetermined direction. If a crack initiated at plant start-up and grew for life of the plant, it would be less than 2 * 0.72"(600 days/cycle) * 40 cycles or 57.6". This is less than the allowable length for horizontal and axial cracks in the screening criteria.
ATTACH-MENTS and COMPON-ENTS	As Noted	No cracking was observed in the - manway access hole covers - separator hold down bolt lugs - jet pump beam riser braces - top guide upper and lower beams - core spray sparger brackets Cracking was identified in a core spray sparger flow nozzle. EER 94-0137 was issued which evaluated the crack as acceptable with a follow-up inspection at the next RFO.

ADDENDUM TO TABLE 7.1: DISCUSSION OF WELD H7

The juncture of the core shroud (1½" thickness) and the shroud support ring (2" thickness) is a field installation weld known as H7. This weld is different from the other shroud welds for several reasons as follows:

- Welding process is different (GTAW and SMAW versus SAW).
- Dissimilar metal weld (Type 304 stainless steel/Alloy 600). Alloy 600 backing ring applied to outer surface of joint and left in-place after welding. Technique different from conventional backing ring approach in that the ends are tapered towards the shroud, a fillet weld is used to seal the upper end of the backing ring (SMAW process with Alloy 182 filler), and the bottom of the backing ring is fused to the Alloy 600 shroud support ring using the GTAW process (Alloy 82 filler added). Proper fusion using this method eliminates the potential for a crevice on either edge of the backing ring. The weld cavity was filled from the ID using the SMAW process (Alloy 182 coated electrodes)
- Liquid penetrant examination was performed on the root weld and the completed weld and on the final surface of the backing ring fillet weld.
- No grinding could have been made to the outer surface after welding because of restricted access.
- Similarities to other welds included substantial fit-up stresses and probable grinding of the ID weld crown after completion of welding.
- This weld is difficult to inspect from the inside of the shroud due to restricted access through core structures. It is difficult to inspect from the outer surface because inspection is restricted by jet pump diffusers except for the limited area below the suction lines. The presence of the backing ring is a limiting factor on the outer side as well.

The concern for this weld is that the Alloy 182 filler material is susceptible to IGSCC, especially if the location is creviced.

The H7 weld is believed to be <u>without cracking</u> for the following reasons:

- No indications were seen in the IVVI inspection performed on the outer surface at the 0° and 180° azimuths (11% of shroud periphery). Extra care was taken with cleaning and with positioning of the camera to maximize quality of the inspection. In addition, visual evidence of uniform backing ring melting and tie-in to the shroud support ring indicates either that no crevice exists or at least the crevice characteristics are minimal.
- The coolant has a low oxidizing power on both sides of the shroud at this location. This means that the environment is much less aggressive than it is higher on the shroud.
- The shroud manway access covers were inspected by IVVI and ultrasonic inspection during the current outage. The shroud manway access covers had no reportable indications. The shroud manway access cover is more constrained than the H7 weld and

has higher residual stress. Additionally, the welds for the covers are ground, creviced and use the same welding process as the H7 weld. The shroud manway access cover welds are therefore a conservative comparison for the H7 weld.

- There were no reportable indications for the H8 and H9 welds on Unit 1.

- Nickel based materials are highly resistant to attack in chloride environments. Since chlorides were the major source of the high coolant conductivity for the first five years of operation, the nickel based materials would be very resistant to crack initiation during that period. As discussed in the root cause section, this was believed to be a factor in the extent of cracking seen higher on the shroud. Therefore, the H7, H8, H9 and access cover welds would have been more resistant to degradation from the high conductivity condition in the early years of operation.

- The root of the H7 weld was made using the GTAW process. Alloy 82 filler material was used for the first three passes of the weld. The weld was completed using the SMAW process using Alloy 182 filler metal. This means that the Alloy 182 material is not exposed to the coolant on the shroud OD except at the fillet on the upper side of the backing ring. This weld is low stress because of the low degree of constraint. Alloy 82 material is known to be highly resistant to IGSCC because of a higher chromium content than Alloy 182. The Alloy 182 material on the shroud ID is not creviced.

CONCLUSION:

The H7 weld is not believed to be cracked based on an evaluation of the factors above.

TABLE 7.2 H4 EVALUATION							
IND. #	AZIMUTH START	AZIMUTH STOP	LENGTH in	EFFECTIVE LENGTH	REMAINING LIGAMENT	THRU-WALL DIMENSION	ORIENTATION
1	33	37.5	7.0	15.3	1.09	0.41	circ upper
2	35	42.3	11.2		.74	0.76	circ lower
3	93.3	102	13.6	15.1	1.29	0.21	circ upper
4	108.1	113.3	8.0	9.5	1.09	0.41	circ upper
5	131.7	133.7	3.2	25.5	1.00	0.50	circ upper
6	135.3	142.9	11.8		0.92	0.58	circ upper
7	143.9	147.2	4.4		0.64	0.86	circ upper
8	199.4	200.3	1.4	2.9	1.37	0.13	circ upper
9	208.5	211.9	5.4	6.9	1.09	0.41	circ lower
10	220.3	223.0	4.1	5.6	0.85	0.65	circ lower
11	231.0	231.5	0.7	2.2	1.28	0.22	circ upper
12	241.5	244.0	3.8	10.5	0.79	0.71	circ lower
13	245.2	247.1	3.0		0.71	0.79	circ lower
14	249.9	252.1	3.3	10.1	0.76	0.74	circ lower
15	252.3	255.5	4.8		0.71	0.79	circ lower
16	261.2	262.3	1.7	6.2	1.04	0.46	circ lower
17	263.5	264.2	1.0		1.40	0.10	circ upper
18	275.6	275.8	0.3	1.8	1.38	0.12	circ lower
19	299.2	300.9	2.6	4.1	0.93	0.57	circ lower
20	308.4	310.2	2.5	4.0	1.00	0.50	circ lower
21	316.1	323.5	11.5	13.0	0.65	0.85	circ lower
22	329.9	332.4	3.8	5.3	0.79	0.71	circ lower
23	340.6	343.9	4.5	6.0	0.77	0.73	circ lower
OD -VT	350	010					none
			113.60	143.9			

Indications 12 through 22 combine for the longest total effective crack in a 90° sector, 52.2", at the end of one 600 day operating cycle. This is less than the allowable flaw size of 74.5" in a 90° sector in the screening criteria, therefore, the weld is qualified for at least one 600 day operating cycle.

TABLE 7.3 H5 EVALUATION							
CELL	AZIMUTH START	AZIMUTH STOP	LENGTH in	EFFECTIVE LENGTH	CRACK START	CRACK STOP	ORIENTATION
30-51	005	013	1.5		012	012	axial
34-51	013	025					none
38-47	025	035					none
42-47	035	045	0.5		041	041	axial
46-43	045	055					none
46-39	055	065					none
50-35	065	075					none
50-31	075	085	0.25	1.7	084	084	circ
50-27	085	095					none
50-23	095	105					none
50-19	105	115					none
46-15	115	125					none
46-11	125	135					none
42-07	137	147	0.5		138	138	axial
38-07	145	155	0.25		148	148	axial
34-03	155	167	1.0	2.5	163	163	circ
34-03	155	167	1.0		164	164	axial
34-03	155	167	1.0		156	156	axial
30-03	167	175	0.25		174	174	axial
30-03	167	175	9.3		168	175	circ
26-03	175	185	5.0	24.8	175	178	circ
26-03	175	185	4.5		179	183	circ
22-03	185	193	2.0		187	187.5	circ (below)
22-03	185	193	3.0	10.8	190	192	circ
22-03	185	193	3.5		186	188	circ
18-03	193	203	2.5	4.0	197	199.5	circ
14-07	210	215	3.0	4.5	210	212	circ
10-07	215	223					none
06-11	227	235	0.25	3.8	230.5	230.5	circ
06-11	227	235	1.0		231.5	232	circ
06-15	235	240					none
02-19	248	260	12.0	13.5	249	257	circ
02-23	257	267	0.25		262.5	262.5	axial
02-23	257	267	1.5	3.0	260	261	circ
02-27	265	275					none
02-31	275	283					none
02-35	283	295					none
06-39	295	305	1.0		297	297	axial

TABLE 7.3 H5 EVALUATION							
CELL	AZIMUTH START	AZIMUTH STOP	LENGTH in	EFFECTIVE LENGTH	CRACK START	CRACK STOP	ORIENTATION
06-43	303	315	6.0	7.5	308	312	circ
06-43	303	315	0.5	2.0	305	305	circ (below)
10-47	315	325	7.5	9.0	318	322.5	circ
14-47	325	330	1.2		325	325	axial
18-51	335	345					none
22-51	345	355					none
26-51	355	005					none
OD	010	020					none
OD	040	050					none
OD	070	080					none
OD	100	110					none
OD	130	140					none
OD	160	170					none
OD	220	230	0.25		227	227	axial
OD	220	230	0.38		226	226	axial
OD	280	290					none
OD	340	350	11.0	12.5	341	348	circ
OD	350	010					none
			81.88	99.6			

Indications between 168° and 257° combine for the longest effective crack, 61.4", at the end of 600 days of operation. This is less than the allowable flaw size of 74.5" in a 90° sector in the screening criteria, therefore, the weld is qualified for at least one 600 day operating cycle.

SECTION 8.0 EVALUATION AND SUMMARY

The Unit 2 circumferential cracking was "tight" and followed the HAZ of the horizontal welds. There was evidence of heavy machining and grinding at the welds. The UT reflectors at H4 were indicative of IGSCC flaws. The cracking had characteristics similar to that found in Unit 1 where metallography confirmed the cracking to be IGSCC. Therefore, the root cause of cracking in the Unit 2 core shroud is believed to be the same root cause as in Unit 1, i.e., IGSCC.

Based on similarity of fabrication and operation with Unit 1, Unit 2 was expected to be susceptible to similar cracking in the core shroud welds. An inspection plan was developed around the Unit 1 Screening Criteria (ref. 9.9). From experience in Unit 1, it was recognized that all areas of the welds would not be accessible for inspection. Each weld was evaluated for the most appropriate inspection technique and the appropriate sample size to qualify the core shroud for at least one 600 day operating cycle.

H1 is accessible for VT from the OD but the ID configuration does not permit camera and lighting angles to readily detect IGSCC cracking. A sampling strategy similar to that of ASME Section XI was used, in that approximately 10% of the weld was selected for VT. There were four sample sites symetrically located about the circumference. If the cracking was as extensive as found in Unit 1, the inspection scope would expand to the balance of the weld. No indications were identified. To provide additional assurance of structural integritry, a weld-specific analysis was performed using the inspection results. The analysis concluded that, if all uninspected areas are assumed cracked, H1 would maintain full structural design margins for at least one 600 day operating cycle.

H2 was inspected at the 40°-50° OD area to confirm two indications identified from a previous RFO tape. A circumferential crack was identified in the TGSR that ran continuously through the inspection zone. The other indication, in the plate, was determined to be in-line pitting. H3 was not inspected, since modification of the shroud was planned (PM 94-007).

H4 was inspected by an initial VT from the OD at 350° - 10° in conjunction with a UT from the OD at all accessible areas. The UT provided data which demonstrated that the weld was qualified by the Screening Criteria for at least one 600 day operating cycle. (The cracks were conservatively assumed through-wall for the Screening Criteria analysis).

H5 was inspected for approximately 100% by VT from the ID. VT on the OD was performed on accessible areas which were not cracked on the ID. The UT device was not able to track behind the jet pumps due to tight clearences and therefore was not used. The VT provided data which demonstrated that the weld was qualified by the Screening Criteria for at least one 600 day operating cycle.

H6a and H6b were inspected at two locations and compared to the inspection results from Unit 1. The cracking was primarily axial with one short circumferential crack. This is similar to the cracking experienced in Unit 1, which was fabricated from the same heats of materials as the Unit 2 ring. The cracking

was assumed to be representative of the uninspected areas and was qualified by the Screening Criteria for at least one 600 day operating cycle.

H7 was inspected at two locations and compared to the inspection results from Unit 1. No indications were found at H7 in Unit 1. H7 is not as susceptible to IGSCC as the Access Hole Covers (AHC). A VT and UT inspection found no indication at the AHC welds, which further confirms that the H7 weld is not cracked. The weld was qualified by the Screening Criteria for at least one 600 day operating cycle.

Welds H8 and H9 were not inspected based on the lack of indications in Unit 1 and the results from the AHC inspection. The weld was qualified by the Screening Criteria for at least one 600 day operating cycle.

The vertical welds were not inspected. The allowable axial flaw size to maintain structural integrity is greater than the widest plate. Therefore, the vertical flaws are bounded by analysis.

The surface area of the plates was not inspected. If a crack were to have initiated at plant start-up and grow for life of the plant, it would be less than 2* 0.72"(600 days/cycle) * 40 cycles or 57.6". This is less than the allowable length for horizontal and axial cracks in the screening criteria. Therefore, the plate surfaces are bounded by analysis.

SECTION 9.0 REFERENCES

9.1 Brunswick Updated FSAR, Table 3.9.5-6

9.2 FP-50096, Sheet 1 of 2, "Assembly and Finish Machining Shroud Core Structure," Revision 2.

9.3 Technical Memorandum, "Comparison of Brunswick Units 1 & 2 Core Shroud Fabrication and Installation," TM-B-1005-003, dated October 21, 1993.

9.4 EER 93-0536, Evaluation of Unit 1Core Shroud Indications and Operability Assessment of Unit 1 and 2.

9.5 GE Report NEDC 32300-P, "Brunswick Unit 1 Shroud Sample Metallurgical Evaluations," dated October 1993.

9.6 Fluence Reference for Shroud OD and ID: Flux at Shroud Wall Versus Azimuth, Tables, October 16, 1993.

9.7 Westinghouse Report WCAP-10903, "Reactor Cavity Neutron Measurement Program For Carolina Power And Light Company Brunswick Unit 2," December 1986.

9.8 EPRI Report NP-944, "Studies on AISI Type-304 Stainless Steel Piping Weldments for Use in BWR Applications," December 1978.

9.9 GE Report GE-NE-523-123-0993, Rev. 2, "Evaluation and Screening Criteria for the Brunswick 1 Shroud Indications," November 1993.

9.10 RAM-94-092/SIR-94-029, "Addendum to the Brunswick Unit 1 Screening Criteria", dated 4/6/94.

9.11 RAM-94-099/SIR-94-031, "Minimum Required Unflawed Core Shroud Material at Brunswick, Units 1 and 2", dated 4/11/94.

9.12 OPT-90.5, In-Vessel Visual Examination, Rev 11, dated 3/25/94.

9.13 System Description SD-01, "Nuclear Boiler," Revision 26, dated Nov. 1, 1993.

Form 3

ENGINEERING ACTION ITEM

Page 1

EAI Number **94-0077-1**	**Priority** 3b	**Due Date** 2/10/96

Assigned Manager Paul Cafarella	Concurrence Name/Date Paul Cafarella - 6/3/94

Action Required

In January, 1996, review the B212R1 schedule against the analysis period of this EER (600 days with the core critical) to assure that any changes are bounded. Issue a revision if necessary.

Originator/Group (print)	Ext.	Date	Supervisor Signature/Date	Tracking Entry (initials)
Steve Bertz	3182	06-03-94	Paul C. Cafarella 6/3/94	

Resolution

☐ Close; provide documentation
☐ Transfer to ____________;obtain concurrence
☐ Extend to ____________; provide basis
(PGM approval to extend temp conditions
________________________________)

Responsible Individual Signature/Date	Responsible Manager Signature/Date
ROUTE TO TECHNICAL SUPPORT ENGINEERING DATA COORDINATOR	Tracking Updated (initials)

REVISION 3

10CFR50.59 PROGRAM MANUAL
ATTACHMENT A
CP&L SAFETY REVIEW PACKAGE
SAFETY REVIEW COVER SHEET

DOCUMENT NO. EER 94-0077 REV. NO. 0
DESCRIPTION OF TITLE: Evaluation of U2 Core Shroud Indications and O. A.

1. Assigned Responsibilities:
   Safety Analysis Preparer: Steven L. Bertz
   Lead 1st Safety Reviewer: Steven L. Bertz
   2nd Safety Reviewer: Roger Steckel

2. Safety Analysis Preparer: Complete PART I, SAFETY ANALYSIS

   Safety Analysis Preparer [signature] Date 6/2/94

3. Lead 1st Safety Reviewer: Complete Part II, Item Classification.

4. Lead 1st Safety Reviewer: III may be completed. If either question 1 or 2 is "yes," then Part IV is not required.

5. Lead 1st Safety Reviewer: Determine which DISCIPLINES are required for review of this item (including own) and mark the appropriate blocks below.

DISCIPLINES Required:	(Print Name)	Signature/Date (Step 7)
[ ] Nuclear Plant Operations		
[ ] Nuclear Engineering		
[X] Mechanical	Steven Bertz	[signature] 6/2/94
[ ] Electrical		
[ ] Instrumentation & Control		
[ ] Structural		
[X] Metallurgy	Steve Williams	PER TELECON [signature] 6/2/94
[ ] Chemistry/Radioc' :istry		
[ ] Health Physics		
[ ] Administrative Controls		

6. A QUALIFIED SAFETY REVIEWER will be assigned for each DISCIPLINE marked in step 5 and his/her name printed in the space provided. Each person shall perform a SAFETY REVIEW and provide input into the Safety Review Package.

7. The Lead 1st Safety Reviewer will assure that a Part III or Part IV is completed (see step 4 above) and a Part VI if required (see 9.d of Part II) Each person listed in step 5 shall sign and date next to his/her name in step 5, indicating completion of a SAFETY REVIEW.

8. 2nd Safety Reviewer: Perform a SAFETY REVIEW in accordance with Section 8.0

   2nd Safety Reviewer [signature] Date 6/3/94
   DISCIPLINE: Mechanical

9. PNSC review required? If "yes" attach Part V and mark reason below: Yes [ ] No [X]
   [ ] Potential UNREVIEWED SAFETY QUESTION
   [ ] Question 9 of Part IV answered "Yes"
   [ ] Other (specify): ______

PART I: SAFETY ANALYSIS
(See instructions in Section 8.4.1)
(Attach additional sheets as necessary)

DOCUMENT NO. EER 94-0077 REV. NO. 0

DESCRIPTION OF CHANGE:

Based on RICSIL No. 054, the BNP Unit 2 shroud was inspected during the 1991 refueling outage. No cracks were identified. The Unit 1 shroud was inspected in July, 1993, and a near 360° circumferential crack was confirmed on the inside diameter of the Top Guide Support Ring, in the heat affected zone of the weld. Additional In-Vessel Visual Inspections (IVVI) were conducted, and confirmed additional circumferential and axial indications elsewhere in the shroud on both the inside and outside diameter. The tapes of the Unit 2 shroud IVVI were re-examined based on the July, 1993 Unit 1 findings. Three small indications were noted. The indications were assumed to be cracks (although not confirmed) and were conservatively evaluated in Engineering Evaluation Report 93-0477. Unit 2 tapes were again re-examined in late September, based on lessons learned on Unit 1. One additional small indication was noted. Although this additional indication was bounded by the assumptions in the original evaluation, it was recognized that the quality of the 1991 tapes was insufficient to identify all of the types of cracks being confirmed on Unit 1.

Unit 2 has completed a inspection of the core shroud welds using visual and ultrasonic techniques. The observed cracking was similar to Unit 1 with the exception that no cracking was observed at H1 or the shroud head lug welds. H2 was inspected at one location to confirm indications called from previous outage tape. No further inspections were performed on these welds since they will be repaired prior to start-up. The comparison presented in EER 93-0536 accurately reflected that Unit 2 was bounded by Unit 1.

The purpose of this EER is to evaluate the significance of cracking observed in the Unit 2 shroud with respect to operation of the unit for one 600 day operating cycle.

ANALYSIS:

The reactor internals perform the following safety related design basis functions as specified in the UFSAR:

1. Provide a floodable volume in which the core can be adequately cooled in the event of a breach in the nuclear system process barrier external to the reactor vessel.

2. Limit deflections and deformation to assure that the control rods and the core standby cooling systems can perform their safety functions during abnormal operational transients and accidents.

3. Assure that the safety design bases (1) and (2) above are satisfied so that the safe shutdown of the plant and removal of decay heat are not impaired.

Intergranular stress corrosion cracking (IGSCC) of the type and form experienced with recirculation piping and related systems in Boiling Water Reactors (BWRs) is the cause of cracking. Crack extension is possibly assisted by neutron fluence and "oxide wedging" at certain locations. Susceptible material conditions, high residual stress from fabrication, and exposure to a strong oxidizing environment are sufficient to produce the cracking observed. Because these factors are not consistently present across the shroud, the location and degree of cracking varies across the shroud.

PART I: SAFETY ANALYSIS
(CONT'D.)

ANALYSIS (Cont'd.):

The core shroud must maintain a floodable volume above the two-thirds core height elevation. The cracks are caused by intergranular stress corrosion cracking, and inherently are tight. Any through wall cracks would result in negligible leakage into the downcomer region and be contained by the reactor pressure vessel. The Emergency Core Cooling systems provide sufficient make-up and cooling capacity to ensure that the fuel will remain covered.

EER 93-0536 was issued to assess Unit 1 shroud structural integrity and to justify continued operation of Unit 2 until a detailed inspection could be performed at the next RFO. The Unit 2 inspection is complete and this EER provides results of the analysis of the cracking on the Unit 2 shroud. Welds H4, H5, H6a, H6b, and H7 meet the original screening criteria and will remain within the criteria for at least one 600 day operating cycle. The screening criteria assumes that the cracks are through-wall, and provides guidance that is more conservative than ASME Code Section XI criteria. Effective crack lengths which are smaller than the screening criteria are not a concern and require no further evaluation. Effective crack lengths that are larger than the screening criteria must be specifically analyzed. A location specific analysis was performed for weld H1 demonstrating structural integrity for at least two 600 day operating cycles (maximum recommended by SIL 572). H2 and H3 did not receive a full inspection because a permanent mechanical repair of these Top Guide Support Ring welds will be made prior to Unit 2 startup (this avoids continued inspection and evaluations at this area). H8 and H9 were not inspected based on finding no indications in the access hole cover welds, and similar findings on Unit 1.

Structural integrity of the core shroud will be maintained, with full FSAR safety margins, for a minimum of one 600 day operating cycle based on analysis of the inspections performed. Permanent mechanical repair of the H2 and H3 weld areas at the Top Guide Support Ring will be made prior to Unit 2 startup. This avoids continued inspection and evaluations at this area.

PART I: SAFETY ANALYSIS
(CONT'D.)

ANALYSIS (Cont'd.):

REFERENCES:

The Brunswick Updated FSAR was reviewed for information on the design functions of the shroud. Numbers in parentheses () refer to UFSAR paragraph number.

(3.2.1) Structures and equipment are classified as Seismic Class 1 if they are essential for safe shutdown or if their failure could result in the release of radiation with dose consequences potentially exceeding the guidelines of 10CFR100.

(3.2.1.2) The core shroud is classified as Seismic Class 1.

(3.9.2.5.1) The reactor core structural components are designed so that deformations produced by accident loadings do not prevent insertion of control rods.

(3.9.5.1) The core shroud is a part of the reactor vessel internals. The core shroud up to the level of the jet pump nozzles is a part of the floodable inner volume of the reactor vessel.

(3.9.5.2.1) The following load combinations and safety factors were used:

1. The OBE plus upset pressure difference load combination should be evaluated with a safety factor of 2.25.
2. The DBE plus normal operating pressure difference load combination should be evaluated with a safety factor of 1.50.
3. The load combination of DBE plus LOCA plus normal loads should be evaluated with a safety factor of 1.125.
4. The load combination of LOCA plus normal loads should be evaluated with a safety factor of 1.50.

(3.9.5.3) The design of the reactor vessel internals was in accordance with applicable portions of the ASME B & PV Code Section III 1965 edition through Summer 1967 Addenda.

NOTE: There are no applicable portions of Section III for the core shroud.

Where applicable Codes and Standards did not exist, the reactor vessel internals were designed to the criteria in Section 3.9.5.2 and to the limits in Tables 3.9.5-1 through 3.9.5-4.

(3.7.1.1.2) The DBE ground horizontal acceleration is 0.16g. The vertical DBE ground acceleration is equal to two-thirds of the horizontal acceleration. OBE ground acceleration is one-half of the DBE accelerations.

REFERENCES: FSAR Chapters 1.2.2.5.11, 3.2.1.2, 3.9.2.5.1, 3.9.5.1, 5.3.1, 5.3.3.1.2.3, 5.4.1,

PART I: SAFETY ANALYSIS
(CONT'D.)

ANALYSIS (Cont'd.):

REFERENCES: FSAR Chapters 1.2.2.5.11, 3.2.1.2, 3.9.2.5.1, 3.9.5.1, 5.3.1, 5.3.3.1.2.3, 5.4.1, 7.3.3.1.3.5, 7.7.1.1.2.2, 7.3.3, 9.3.4.2, Ch. 15; Tech Spec. 3/4.3.3 and associated basis.

PART II: ITEM CLASSIFICATION

DOCUMENT NO. EER 94-0077 REV. NO. 0

	Yes	No
1. Does this item represent:		
a. A change to the facility as described in the SAFETY ANALYSIS REPORT?	[ ]	[X]
b. A change to the procedures as described in the SAFETY ANALYSIS REPORT?	[ ]	[X]
c. A test or experiment not described in the SAFETY ANALYSIS REPORT?	[ ]	[X]
2. Does this item involve a change to the individual plant Operating License or to its Technical Specifications?	[ ]	[X]
3. Does this item require a revision to the FSAR?	[ ]	[X]
4. Does this item involve a change to the Offsite Dose Calculation Manual?	[ ]	[X]
5. Does this item constitute a change to the Process Control Program?	[ ]	[X]
6. Does this item involve a major change to a Radwaste Treatment System?	[ ]	[X]
7. Does this item involve a change to the Technical Specification Equipment List?	[ ]	[X]
8. Does this item impact the NPDES Permit (all 3 sites) or constitute an "unreviewed environmental question" (SHNPP Environmental Plan Section 3.1) or a "significant environmental impact" (BSEP)?	[ ]	[X]
9. Does this item involve a change to a previously accepted:		
a. Quality Assurance Program	[ ]	[X]
b. Security Plan (including Training, Qualification, and Contingency Plans)?	[ ]	[X]
c. Emergency Plan?	[ ]	[X]
d. Independent Spent Fuel Storage Installation license? (If yes, refer to Section 8.4.2, "Question 9," for special considerations. Complete Part VI in accordance with Section 8.4.6)	[ ]	[X]

SEE SECTION 8.4.2 FOR INSTRUCTIONS FOR EACH "YES" ANSWER.

REFERENCES. List FSAR and Technical Specification references used to answer questions 1-9 above. Identify specific reference sections used for any "Yes" answer.

See Safety Evaluation references.

PART III: UNREVIEWED SAFETY QUESTION DETERMINATION SCREEN

DOCUMENT NO. EER 94-0077 REV. NO. 0

	YES	NO
1. Is this change fully addressed by another completed UNREVIEWED SAFETY QUESTION determination? (See Section 7.2.1, 7.2.2.5, and 7.9.1.1)	[ ]	[X]

REFERENCE DOCUMENT: ______ REV. NO. ______

	YES	NO
2. For procedures, is the change a non-intent change which only (check all that apply): (See Section 7.2.2.3)	[ ]	[X]

[ ] Correct typographical errors which do not alter the meaning or intent of the procedure; or,

[ ] Add or revise steps for clarification (provided they are consistent with the original purpose or applicability of the procedure); or,

[ ] Change the title of an organizational position; or,

[ ] Change names, addresses, or telephone numbers of persons; or,

[ ] Change the designation of an item of equipment where the equipment is the same as the original equipment or is an authorized replacement; or,

[ ] Change a specified tool or instrument to an equivalent substitute; or,

[ ] Change the format of a procedure without altering the meaning, intent, or content; or

[ ] Deletes a part or all of a procedure, the deleted portions of which are wholly covered by approved plant procedures?

If the answer to either Question 1 or Question 2 in PART III is "Yes," then PART IV need not be completed.

PART IV: UNREVIEWED SAFETY QUESTION DETERMINATION

DOCUMENT NO. EER 94-0077 REV. NO. 0

Using the SAFETY ANALYSIS developed for the change, test or experiment, as well as other required references (LICENSING BASIS DOCUMENTATION, Design Drawings, Design Basis Documents, codes, etc.), the preparer of the SAFETY EVALUATION must directly answer each of the following seven questions and make a determination of whether an UNREVIEWED SAFETY QUESTION exists.

A WRITTEN BASIS IS REQUIRED FOR EACH ANSWER — Yes / No

1. May the proposed activity increase the probability of occurrence of an accident evaluated previously in the SAFETY ANALYSIS REPORT? [ ] [X]
   See attached.

2. May the proposed activity increase the consequences of an accident evaluated previously in the SAFETY ANALYSIS REPORT? [ ] [X]
   See attached.

3. May the proposed activity increase the probability of occurrence of a malfunction of equipment important to safety evaluated previously in the SAFETY ANALYSIS REPORT? [ ] [X]
   See attached.

4. May the proposed activity increase the consequence of a malfunction of equipment important to safety evaluated previously in the SAFETY ANALYSIS REPORT? [ ] [X]
   See attached.

5. May the proposed activity create the possibility of an accident of a different type than any evaluated previously in the SAFETY ANALYSIS REPORT? [ ] [X]
   See attached.

PART IV (Continued)

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	Yes	No
6. May the proposed activity create the possibility of a malfunction of equipment important to safety of a different type than any evaluated previously in the SAFETY ANALYSIS REPORT?	[ ]	[X]

See attached.

	Yes	No
7. Does the proposed activity reduce the margin of safety as defined in the basis of any Technical Specification?	[ ]	[X]

See attached.

	Yes	No
8. Based on the answers to questions 1 - 7, does this item result in an UNREVIEWED SAFETY QUESTION? If the answer to any of the questions 1-7 is "Yes", then the item is considered to constitute an UNREVIEWED SAFETY QUESTION.	[ ]	[X]
9. Is PNSC review required for any of the following reasons?	[ ]	[X]

If, in answering questions 1 or 3 "No", it was determined that the probability increase was small relative to the uncertainties; or, in answering question 2 or 4 "No", it was determined that the doses increased, but that the dose was still less than the NRC ACCEPTANCE LIMIT; or in answering question 7 "No", a parameter would be closer to the NRC ACCEPTANCE LIMIT, but the end result was still within the NRC ACCEPTANCE LIMIT; then PNSC review is required.

REFERENCES: See Safety Evaluation references.

This Unreviewed Safety Question Determination is for the following DISCIPLINE(s): (Additional Part IV forms may be included as appropriate.)

- [ ] Nuclear Plant Operations
- [ ] Nuclear Engineering
- [X] Mechanical
- [ ] Electrical
- [ ] Instrumentation & Control
- [ ] Structural
- [X] Metallurgy
- [ ] Chemistry/Radiochemistry
- [ ] Health Physics
- [ ] Administrative Controls

PART IV: UNREVIEWED SAFETY QUESTION DETERMINATION (Cont'd.) Page 10 of 11

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1. **May the proposed activity increase the probability of occurrence of an accident evaluated previously in the SAFETY ANALYSIS REPORT?**

The core shroud cracking patterns evaluated in this EER will not increase the probability of occurrence of an accident as defined in the UFSAR. The EER demonstrates the structural integrity of the core shroud and affirms that the core internal geometric alignment will be maintained. Therefore, structural integrity margin is maintained throughout the cycle of operation.

2. **May the proposed activity increase the consequences of an accident evaluated previously in the SAFETY ANALYSIS REPORT?**

The core shroud cracking patterns evaluated in this EER will not increase the consequences of an accident previously evaluated in the UFSAR. The core shroud must maintain a floodable volume above the two-thirds core height elevation. The cracks are caused by intergranular stress corrosion cracking, and inherently are tight. Any through wall cracks would result in negligible leakage. The ECC systems provide sufficient make-up and cooling capacity to ensure that the fuel will remain covered. The EER also demonstrates the structural integrity of the core shroud which insures that the core geometry will be maintained. Maintenance of core alignment and floodable volume assure that design basis will be maintained.

3. **May the proposed activity increase the probability of occurrence of a malfunction of equipment important to safety evaluated previously in the SAFETY ANALYSIS REPORT?**

The core shroud structural integrity is not compromised by the presence of the cracks evaluated in the EER. The depth of the cracks projected at the end of the operating cycle will be less than the allowable crack size. Therefore, structural integrity margin is maintained throughout the cycle of operation.

4. **May the proposed activity increase the consequence of a malfunction of equipment important to safety evaluated previously in the SAFETY ANALYSIS REPORT?**

The core shroud cracking pattern described in the EER will not increase the consequence of a previously evaluated malfunction of equipment important to safety. The core shroud functions to maintain a floodable volume above two-third core height, and to maintain core alignment to insure control rod insertion. This function is assured since structural integrity is demonstrated. In addition, the mitigating functions of the ECC system will not be measureably affected by any reasonably assumed leakage through the cracks.

5. **May the proposed activity create the possibility of an accident of a different type than any evaluated previously in the SAFETY ANALYSIS REPORT?**

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The cracking pattern described in the EER will not create the possibility of an accident different than any evaluated previously in the UFSAR. The structural integrity will be maintained, assuring alignment of the core internals. The ability of the control rods to insert will not be impaired. The cracks are IGSCC which inherently provide a narrow torturous path for leakage. Any through wall cracks would result in negligible leakage. The ECC systems provide sufficient make-up and cooling capacity to ensure that the fuel will remain covered.

6. **May the proposed activity create the possibility of a malfunction of equipment important to safety of a different type than any evaluated previously in the SAFETY ANALYSIS REPORT?**

   The cracking pattern described in the EER will not create the possibility of a malfunction of equipment important to safety of a different type than any evaluated previously in the UFSAR. Maintaining structural integrity ensures that the core shroud performs its functional requirements and thus no equipment important to safety will be adversely influenced and no new failure modes will be introduced.

7. **Does the proposed activity reduce the margin of safety as defined in the basis of any Technical Specification?**

   The cracking pattern described in the EER does not reduce the safety margin as defined in the Technical Specification Bases. Structural integrity will be maintained which assures the ability to insert the control rods and maintain a floodable volume.

Will the evaluation, on either a temporary or permanent basis:

1. Justify the deletion of equipment/common components from the BSEP EQ program? [ ] Yes [X] No

2. Justify the addition of (already existing) equipment/common components to the BSEP EQ program? [ ] Yes [X] No

3. Authorize the repair of EQ equipment/common components with other than qualified like-in-kind equipment/components parts? [ ] Yes [X] No

4. Affect the existing installation or interface (of EQ equipment/common component applications) as may be designated in EDBS and/or in the qualification data package (including changing the type of interface/installation)? [ ] Yes [X] No

5. Justify the (quality class) upgrade of equipment/common components or component parts which could be utilized in EQ applications? [ ] Yes [X] No

6. (Re)Define qualification parameters (e.g., normal or LOCA/HELB environmental conditions, post-accident operating time requirements, essential passive/active post-accident operating requirements, qualified life assumptions/results, etc.) for specific EQ equipment? [ ] Yes [X] No

7. Provide an EQ-related justification for continued operation (as required per PLP-02, Section 4.4.3.3 or 4.4.4)? [ ] Yes [X] No

8. Provide the resolution of a qualification problem (as required per PLP-02, Section 4.4.4)? [ ] Yes [X] No

Notes:

1. If all no, then no further EQ consideration is required. Mark the EER Traveler accordingly as required by ENP-12 and include this completed EER-EQIF within the EER package. An EQ Technical Review is not required.

2. If any yes, an EQ impact assessment (per Section 5.3) must be performed during the evaluation process. Mark the EER Traveler accordingly and include this completed EER-EQIF within the EER package. An EQ technical review is required.

ILLEGIBLE RECORD ACCEPTANCE FORM

Originator requests acceptance of this document and accepts responsibility for the illegible condition of this data.

Document Identity FER 94-0077 Rev 0
Figures

NOTE: The identity of the illegible record or illegible page(s) within the record shall be provided by the originator of this form by identifying and inserting this form preceding the illegible data. In cases where the entire record is considered illegible, this form precedes the record. Please complete Part A or B.

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PART A

The attached record is suitable for microfilming because:

It is non-Q or non-vital records or the data which is relevant to the identification of the item is legible and/or the data can be provided from other sources.

Signed: [signature]

Title: Senior Specialist / 2/6/94 NPS 6/7/94
Date

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
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PART B

The attached record is the most legible copy available and may be retained in the RFR.

Originating Supervisor / Date

Reviewed: Supervisor - Nuclear Records Management / Date

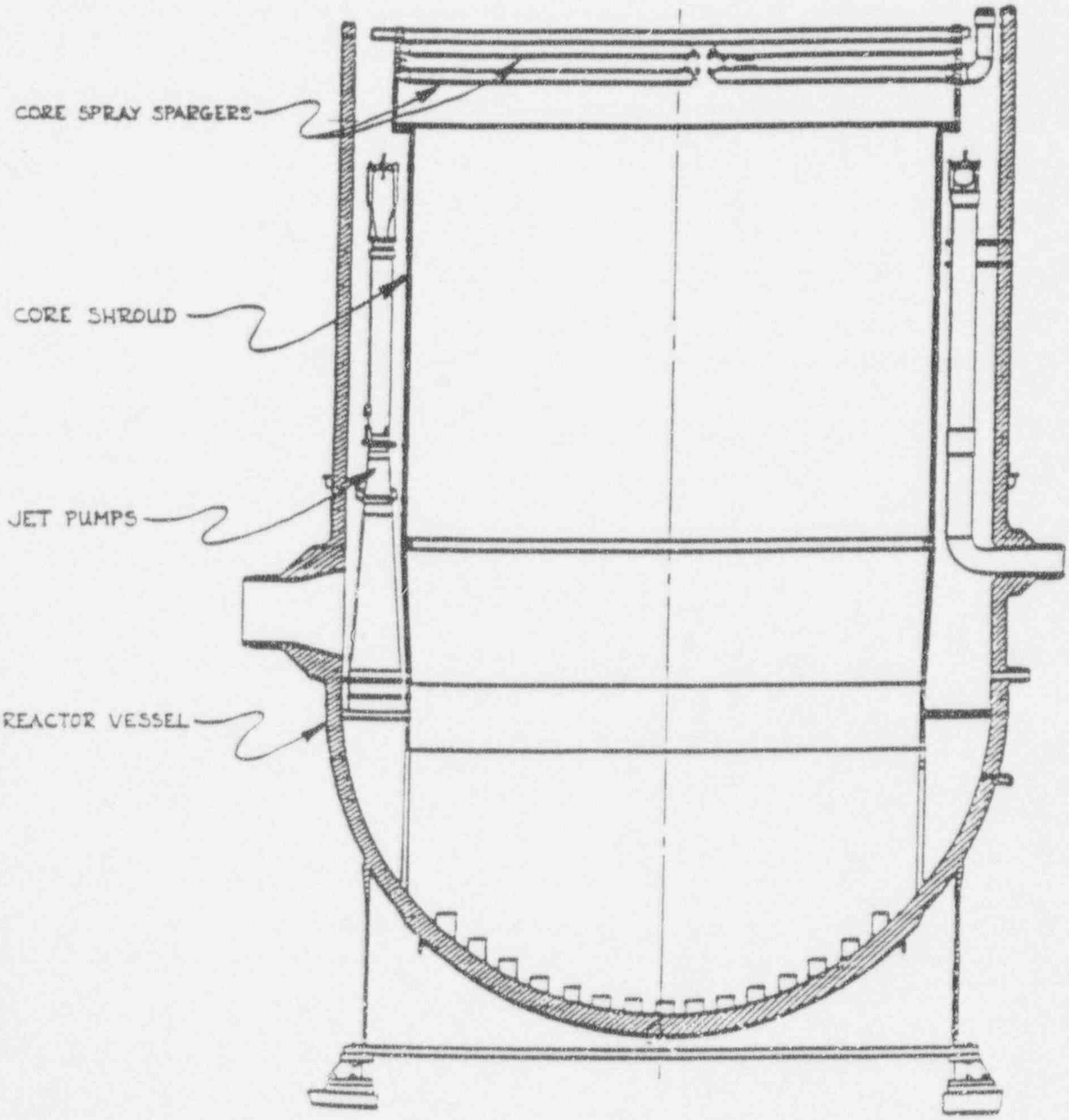

FIGURE 1 - Reactor Vessel Cross-Section Showing Reactor Internals

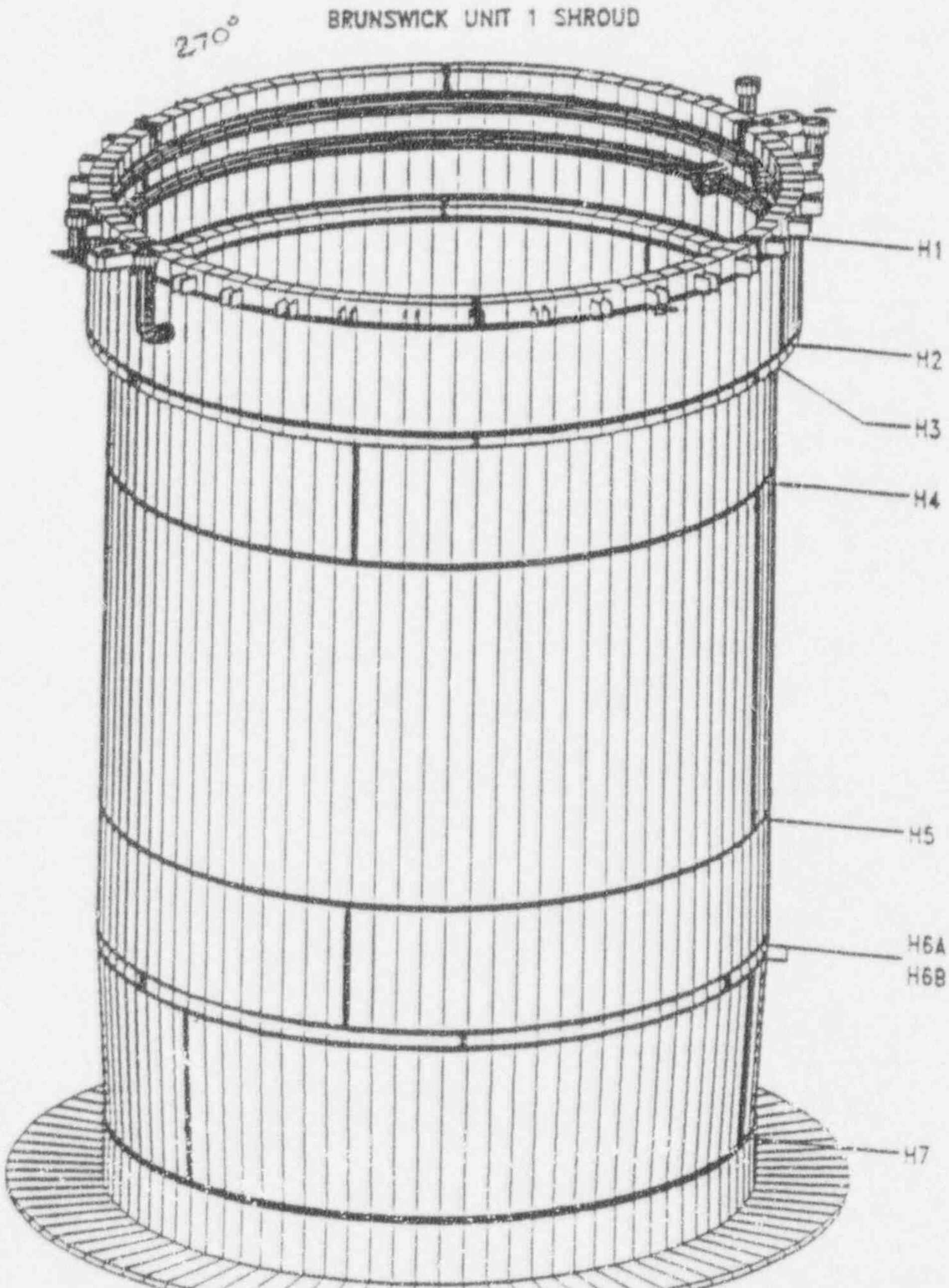

FIGURE 2 - Reactor Shroud Three - Dimensional View

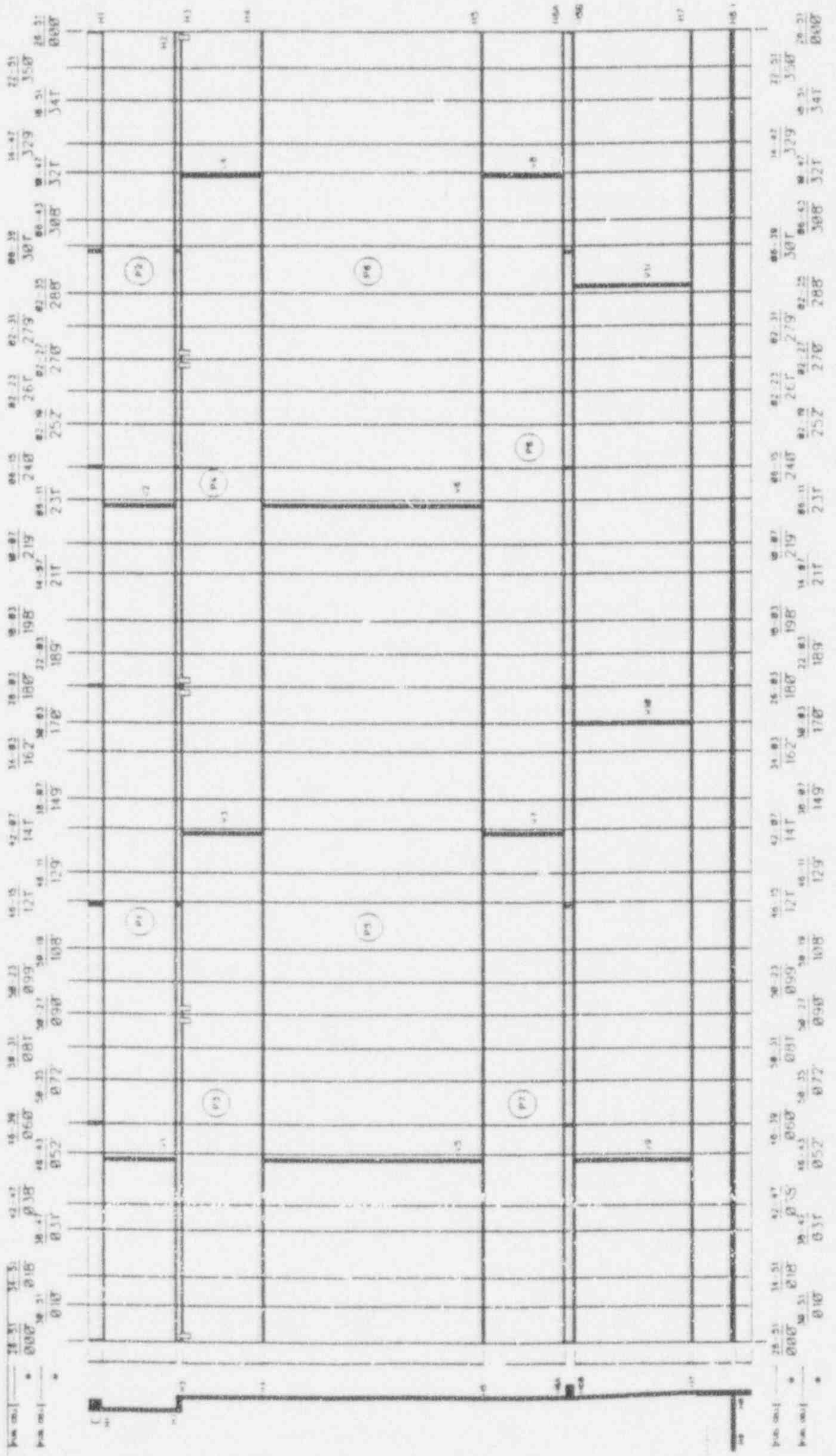

FIGURE 3 - Roll-Out View of Inside Shroud Surface

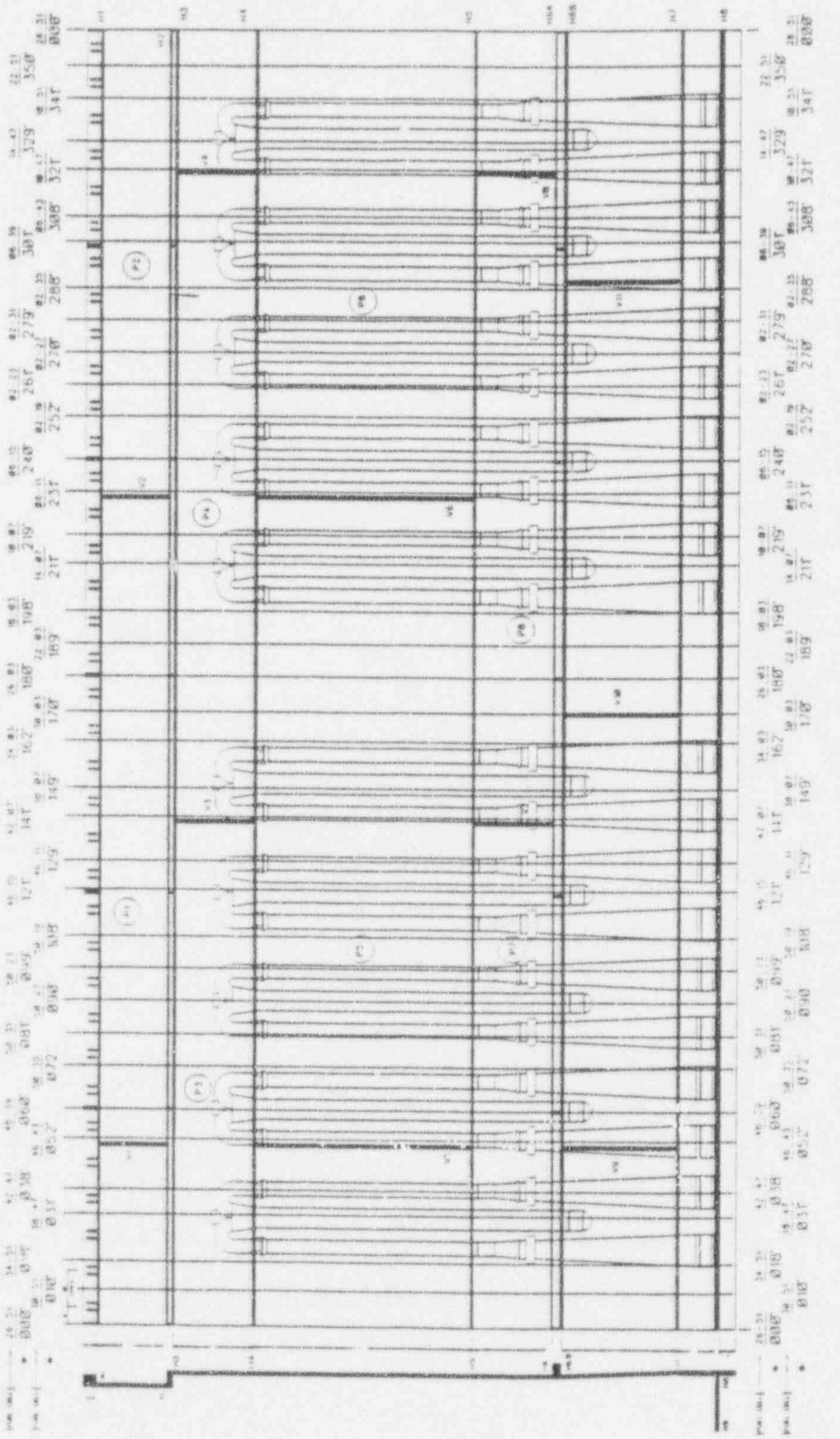

FIGURE 4 - Roll-Out View of Outside Shroud Surface

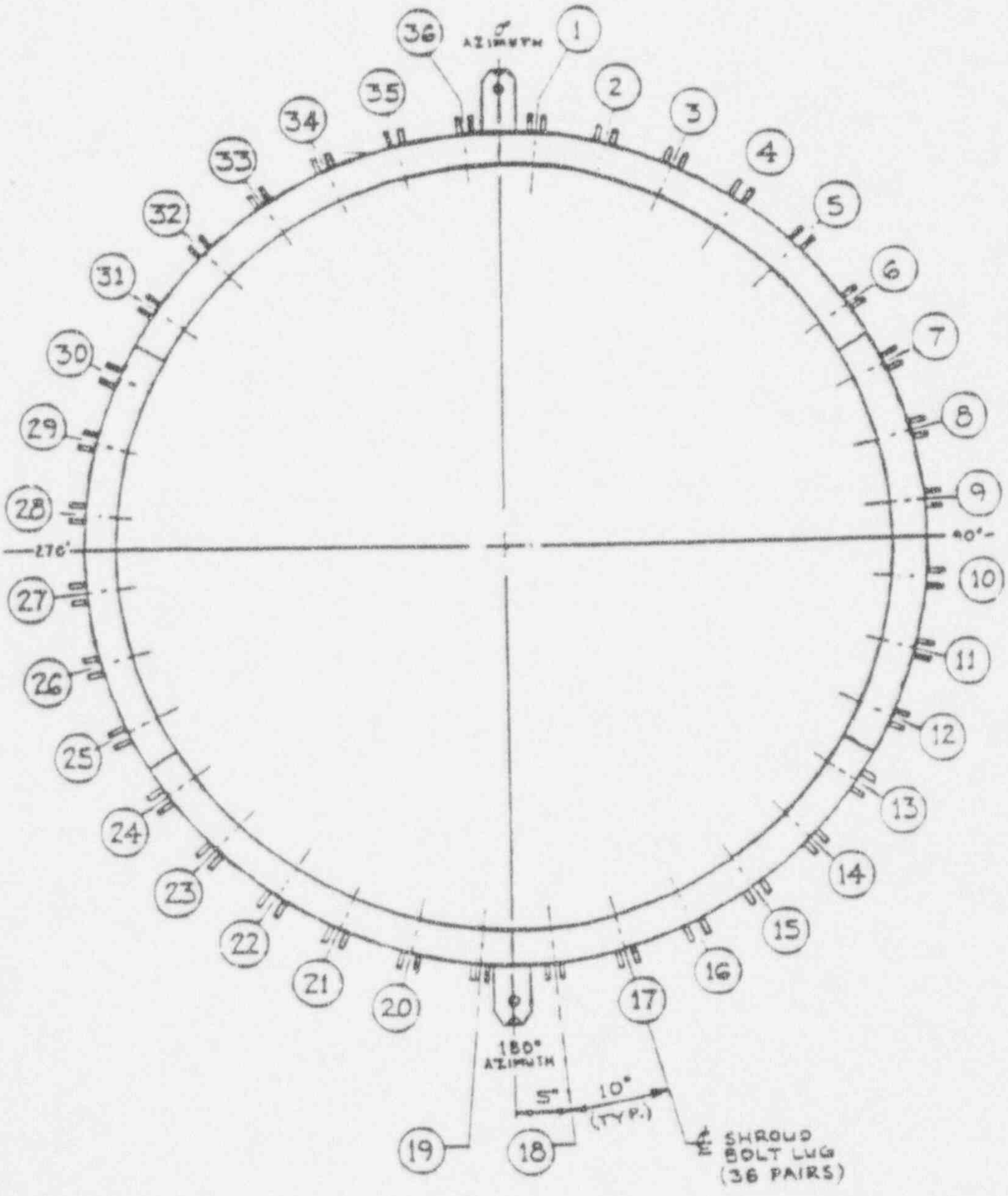

FIGURE 5 - Brunswick Shroud Plan View

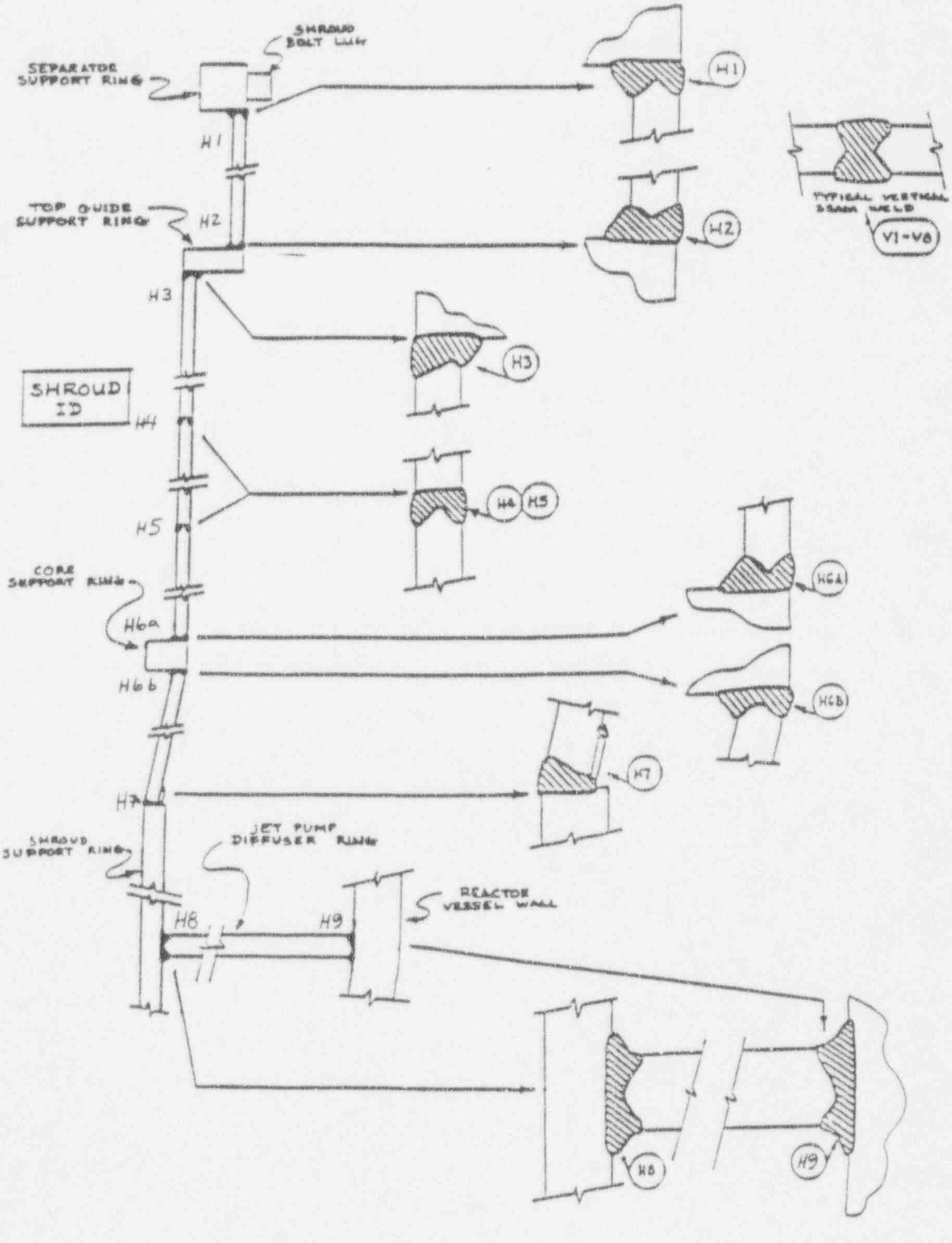

FIGURE 6 - Shroud Cross-Section Showing Welds

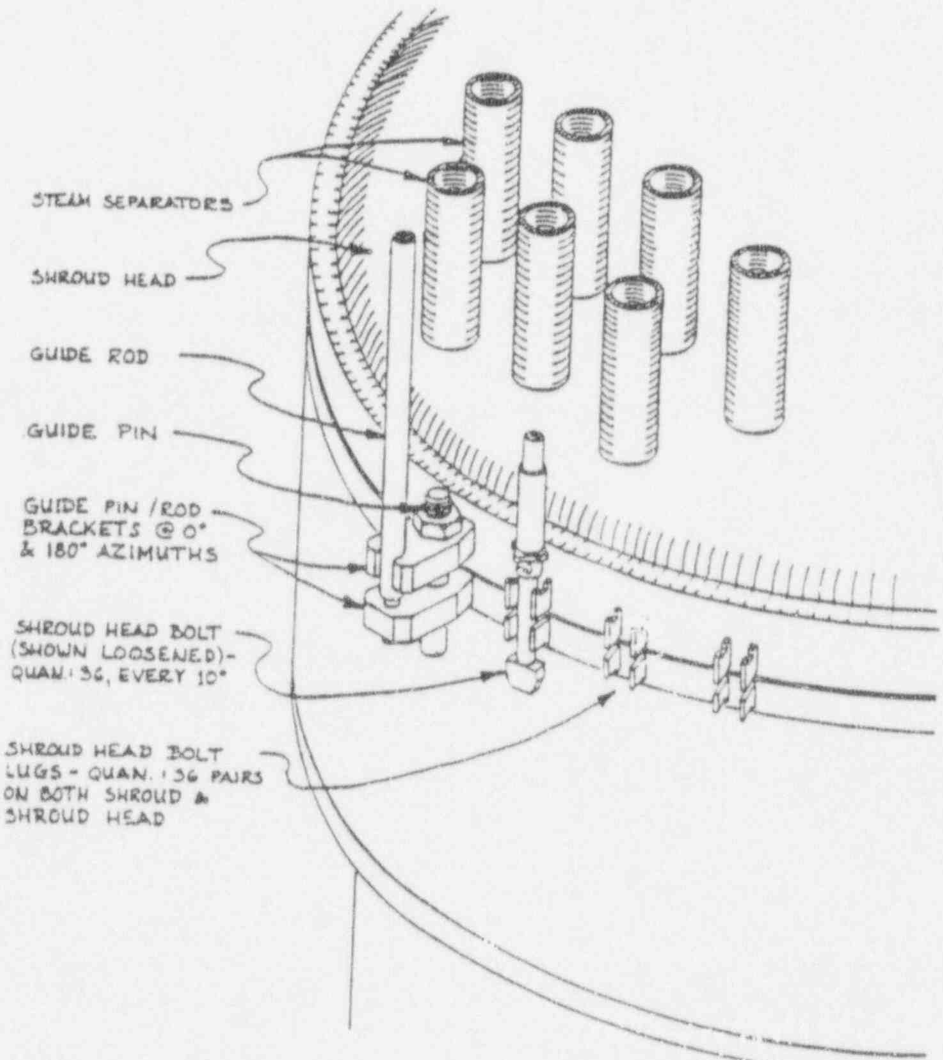

FIGURE 7 - Separator Support Ring and Attachments

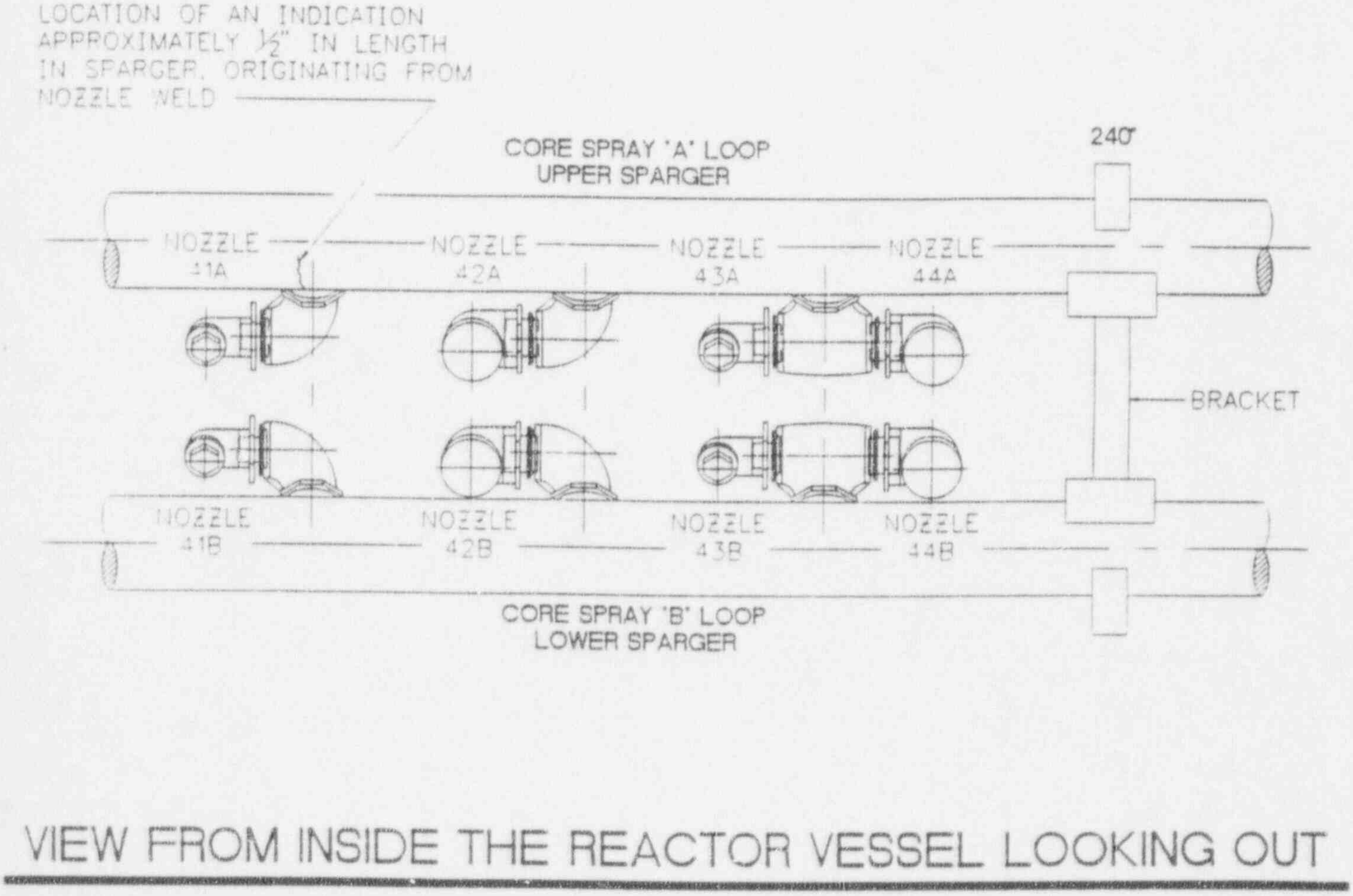

FIGURE 8 - Core Spray Sparger Bracket