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April 20, 1994

U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

ATTENTION: Document Control Desk

SUBJECT: Calvert Cliffs Nuclear Power Plant
Unit No. 1; Docket No. 50-317; License No. DPR 53
Licensee Event Report 94-003
Pressurizer Heater Sleeve Cracking

The attached report is being sent to you as required under 10 CFR 50.73 guidelines. Should you have any questions regarding this report, we will be pleased to discuss them with you.

Very truly yours,

Charles H. Cruse

CHC/MDM/bjd
Attachment

cc: D. A. Brune, Esquire
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NRC FORM 366 (5-92) U. S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB NO. 3150-0104
EXPIRES: 5/31/95
ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS INFORMATION COLLECTION REQUEST: 50.0 HRS. FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE INFORMATION AND RECORDS MANAGEMENT BRANCH (MNBB 7714), U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC 20555-0001, AND TO THE PAPERWORK REDUCTION PROJECT (3150-0104), OFFICE OF MANAGEMENT AND BUDGET, WASHINGTON, DC 20503.

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Calvert Cliffs, Unit 1	05000 317	1 OF 11

TITLE (4)
Pressurizer Heater Sleeve Cracking

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAMES	DOCKET NUMBERS(S)
										05000
03	21	94	94	-- 003 --	00	04	20	94		05000

OPERATING MODE (9)	6	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR (Check one or more) (11)					
		20.402(b)		20.405(c)		50.73(a)(2)(iv)	73.71(b)
POWER LEVEL (10)	0	20.405(a)(1)(i)		50.36(c)(1)		50.73(a)(2)(v)	73.71(c)
		20.405(a)(1)(ii)		50.36(c)(2)		50.73(a)(2)(vii)	OTHER (Specify in Abstract below and in Text, NRC Form 366A)
		20.405(a)(1)(iii)		50.73(a)(2)(i)		50.73(a)(2)(viii)(A)	
		20.405(a)(1)(iv)	X	50.73(a)(2)(ii)		50.73(a)(2)(viii)(B)	
		20.405(a)(1)(v)		50.73(a)(2)(iii)		50.73(a)(2)(x)	

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER (include Area Code)
M. D. Milbradt, Nuclear Regulatory Analyst	410-260-4352

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS		CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS
B	AB	PZR	C490	Y						

SUPPLEMENTAL REPORT EXPECTED (14)				EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
	YES (If yes, complete EXPECTED SUBMISSION DATE)	X	NO				

ABSTRACT (Limit to 1400 spaces, i.e., approximately 15 single-space typewritten lines) (16)

At 1800 hours on February 16, 1994, during removal of insulation from the Unit 1 Reactor Coolant System (RCS) pressurizer (PZR) heater sleeve area, boron deposits were noticed on PZR heater sleeve B-3 indicating leakage from the RCS. At 1700 hours on February 23, 1994, upon completing insulation removal, boron deposits were also identified on PZR heater sleeve FF-1. After discovering the leaks, boroscopic and eddy current testing were performed and heater sleeve FF-1 was examined in the laboratory. The examination revealed a circumferential bulge approximately 0.5 inches long and 0.019 inches high (diametrical) in the area of the boric acid leaks. The most probable cracking mechanism is Primary Water Stress Corrosion Cracking. The bulge area and the axial scoring showed evidence of surface metal smearing and cold work. A search of fabrication records for the PZR turned up evidence that sleeve FF-1 had to be reworked due to the presence of a stuck reamer. The source of stress for the cracking was the bulging and axial scratches associated with the removal of the stuck reamer. Corrective Actions included plugging FF-1 with an Alloy 690 plug welded to the outer diameter of the PZR lower head and examining the remaining Unit 1 PZR heater sleeves.

I. DESCRIPTION OF EVENT

A. INITIAL DISCOVERY

At 1800 hours on February 16, 1994, during removal of insulation from the Unit 1 Reactor Coolant System (RCS) pressurizer (PZR) heater sleeve area, boron deposits were noticed on PZR heater sleeve B-3 indicating leakage from the RCS. At 1700 hours on February 23, 1994, upon completing insulation removal, boron deposits were also identified on PZR heater sleeve FF-1. The boric acid crystals were found at and below the area where the heaters penetrate the lower head of the PZR vessel (see Figure 1). There was no evidence of boron on the remaining 118 heater sleeves. At the time of both discoveries, Unit 1 was in a refueling outage (MODE 6).

B. EQUIPMENT DESCRIPTION

The heater sleeves (see Figure 2) extend through 1.156 inch diameter hillside penetrations in the lower head of the PZR. The lower head is a 48-7/16 inch inside radius hemispherical head fabricated from A-533, Grade B, Class 1 steel. The lower head is 3-7/8 inch thick. An Inconel weld overlay, approximately 3/8 inch thick, was applied to the inside surface of the lower head prior to stress relief of the vessel. The heater sleeves are Inconel 600 (SB-167-64) tubing (Figure 3). The initial dimensions of the tubing were 1.25 inch outer diameter (OD) and 0.905 inch inner diameter (ID). The outside diameter of the length of the tubing which inserts in the vessel was machined down to 1.156 inch. After stress relief of the vessel, the heater sleeves were inserted into the lower head and an Inconel "J" shaped partial penetration weld (J-weld) was made between the vessel Inconel weld overlay and the Inconel sleeve.

In the fabrication of the Unit 1 heater penetrations, the ID of the Inconel sleeve was specified to be reamed after welding to accept a 0.895 inch rod and to remove any distortion or melt-through in the tube caused by welding. The reaming was less than the nominal heater sleeve ID of 0.905 inch.

Heater Sleeve Examination and Results

Heater Sleeves B-3 and FF-1:

After discovering the leaks, boroscopic and eddy current testing (ECT) were performed on heater sleeves B-3 and FF-1. It was concluded that the leakage in sleeve B-3 originated from an axially oriented flaw located near the heater sleeve-to-PZR weld on the inside surface of the PZR. This type of defect has

previously been observed in a number of heater sleeves in the Calvert Cliffs Unit 2 PZR (LER 50-318/89-007, Revision 2). As noted for Unit 2, the safety significance of such defects has been found to be small.

Eddy current testing of heater sleeve FF-1 identified no defects near the PZR weld, but did identify axial indications approximately one inch below the outside surface of the pressurizer. In addition, some volumetric or lift-off indications in the vicinity of the axial indications was detected. Circumferential and volumetric or lift-off indications were observed all the way down to the locking bar area (Figure 4).

Boroscopic examination of FF-1 revealed the presence of a circumferential wear band in the vicinity of the axial indications and axial scores from that point to the bottom of the sleeve. Circumferential cracking was observed in the vicinity of the axial scoring.

Heater sleeve FF-1 was cut just below the weld and examined in the laboratory. A visual examination of the as-received sleeve revealed a circumferential bulge approximately 0.5 inches long and 0.019 inches high (diametrical) in the area of the boric acid leaks. Liquid penetrant testing identified three axial indications in the bulge region of the sleeve, each about 0.25 inches long (Figure 4).

After sectioning the sleeve, liquid penetrant testing was performed on the inside diameter surface in the region of the bulge and in the axially scored area. The testing revealed the three axial indications in the bulge area and a large number of circumferential crack-like indications in the areas with axial scoring (Figure 5). Circumferential cracks were evenly spaced, and were oriented on two sides of the sleeve only, 180 degrees apart in the area of the scoring. Dimensioning of the sleeve indicated that it was approximately 0.014 inches out-of-round just below the bulge, and 0.005 inches out-of-round near the locking bar.

Metallographic examination of the indications was performed and revealed intergranular cracks in all cases. The axial flaws were through-wall and many of the circumferential cracks extended approximately 70 percent through the wall. Most cracks had very little branching and were heavily oxidized, which indicates they had been in service for some time. Microchemistry (XPS and Auger) results from the crack surfaces showed levels of contaminants and corrosion film composition which indicate some sulfur compounds on the surfaces, with the highest concentrations at the crack tips. Some caustics were also observed. However, it is not clear if contaminants played a role in the

cracking. The most probable cracking mechanism is Primary Water Stress Corrosion Cracking (PWSCC).

The microstructure of the heater sleeve was rated as susceptible to primary water stress corrosion cracking. Modified Huey test results showed that the material was not sensitized.

The bulge area and the axial scoring showed evidence of surface metal smearing and cold work. A search of fabrication records for the PZR turned up evidence that sleeve FF-1 and one other (which was later replaced) had to be reworked due to the presence of a stuck reamer. Reaming was performed to provide clearance for the heater and was performed in the weld area due to weld shrinkage. Combustion Engineering records indicate that removing the stuck reamer caused raised metal in the sleeve.

Other Heater Sleeves:

A visual examination using a boroscope was performed on all heater sleeves in the Unit 1 PZR. No scoring or wear bands as seen in sleeve FF-1 were recorded. Six sleeves characterized by boroscopic examination or previous (1989) ECT as having the most susceptibility to cracking were selected for ECT. These sleeves had no indications. Another 23 sleeves were selected for ECT (for a total of 29) and no indications were observed. Based on this sample and the lack of reported problems with stuck reamers in other sleeves (other than the one that was replaced), there is high confidence that this type of cracking does not exist in any of the other Unit 1 PZR heater sleeves.

II. CAUSE OF EVENT

The cracks and resulting leaks in FF-1 were caused by PWSCC. The source of stress for the cracking was the bulging and axial scratches associated with the removal of the stuck reamer. The microstructure of FF-1 is rated as susceptible to PWSCC, and the sleeve heat is the same as that which cracked previously in Calvert Cliffs Unit 2 (LER 50-318/89-007, Revision 2). Sufficient temperature exists to allow the observed cracking, since the thermal insulation on this unit extends below the locking collar. While chemical contaminants (sulfur) could have contributed to the cracking, they were not observed in sufficient quantities to be a major contributor.

III. ANALYSIS OF EVENT

The leakage identified is considered RCS pressure boundary leakage as defined by the plant's Technical Specifications. Technical Specification 3.4.6.2 requires that RCS leakage includes no pressure boundary leakage. This Technical Specification is applicable in MODES 1-4 and the Action requirement requires taking the plant to cold shutdown. At the time of discovery Unit 1 was in cold shutdown in a refueling outage.

The axial cracks found in sleeve B-3 presents a minor RCS leakage path, while the circumferential cracking found in sleeve FF-1 could have potentially caused the complete severance of the heater sleeve. It is impossible to determine when the cracking began to take place so it must be assumed the potential for complete severance has existed since initial plant operation.

The heater sleeve failure resulted in one of the plant's principal safety barriers being seriously degraded and could have lead to a small break loss-of-coolant accident (LOCA). However, Calvert Cliffs Unit 1 is analyzed for all break sizes. The size of the leak path is smaller than the most limiting size small break LOCA assumed in the accident analysis. Therefore the potential safety consequences associated with this event are bound by the accident analysis.

The leaking sleeves described in this event were found during an inspection of the lower Unit 1 PZR head. The inspection was being performed prior to commencing heater sleeve nickel plating. The remaining 118 Unit 1 sleeves have been nickel plated in response to the axial cracking concerns identified with Unit 2's sleeves in 1989 (LER 50-318/89-007, Revision 2). Nickel plating the Unit 1 sleeves will minimize the potential for cracks in the area of the J-weld from PWSCC.

The event date for this LER was March 21, 1994, the day the laboratory results were reported to the Operations Shift Supervisor. This event is considered reportable in accordance with 10 CFR 50.73(a)(2)(ii) due to the circumferential crack found in heater sleeve FF-1.

IV. CORRECTIVE ACTIONS

A. As described above heater sleeve FF-1 was removed and examined in a laboratory. Sleeve locations B-3 and FF-1 have been plugged with an Alloy 690 plug welded to the outer diameter of the PZR lower head.

B. As described above, the remaining heater sleeves in the Unit 1 PZR were examined for indications of the conditions present in FF-1. There were no other cracking or abusive machining conditions observed.

As stated above, the circumferential cracking in sleeve FF-1 was due to the reaming process and a records review showed there were no other sleeves with the reaming concern. Therefore, we do not expect to see any future circumferential cracking in the PZR heater sleeves.

V. ADDITIONAL INFORMATION

A. Failed Component Identification

Component	IEEE 803 EIIS Funct	IEEE 805 System ID
Pressurizer	PZR	AB
Heater	EHTR	AB
Reactor Coolant System	AB	CE
Heater Sleeve	PEN	AB

B. Previous Similar Events

As stated above, Unit 2's (LER 50-318/89-007 Rev. 2) PZR heater sleeves were found to be leaking in 1989. These leaks were due to axial cracking, not circumferential cracking due to the removal of a stuck reamer.

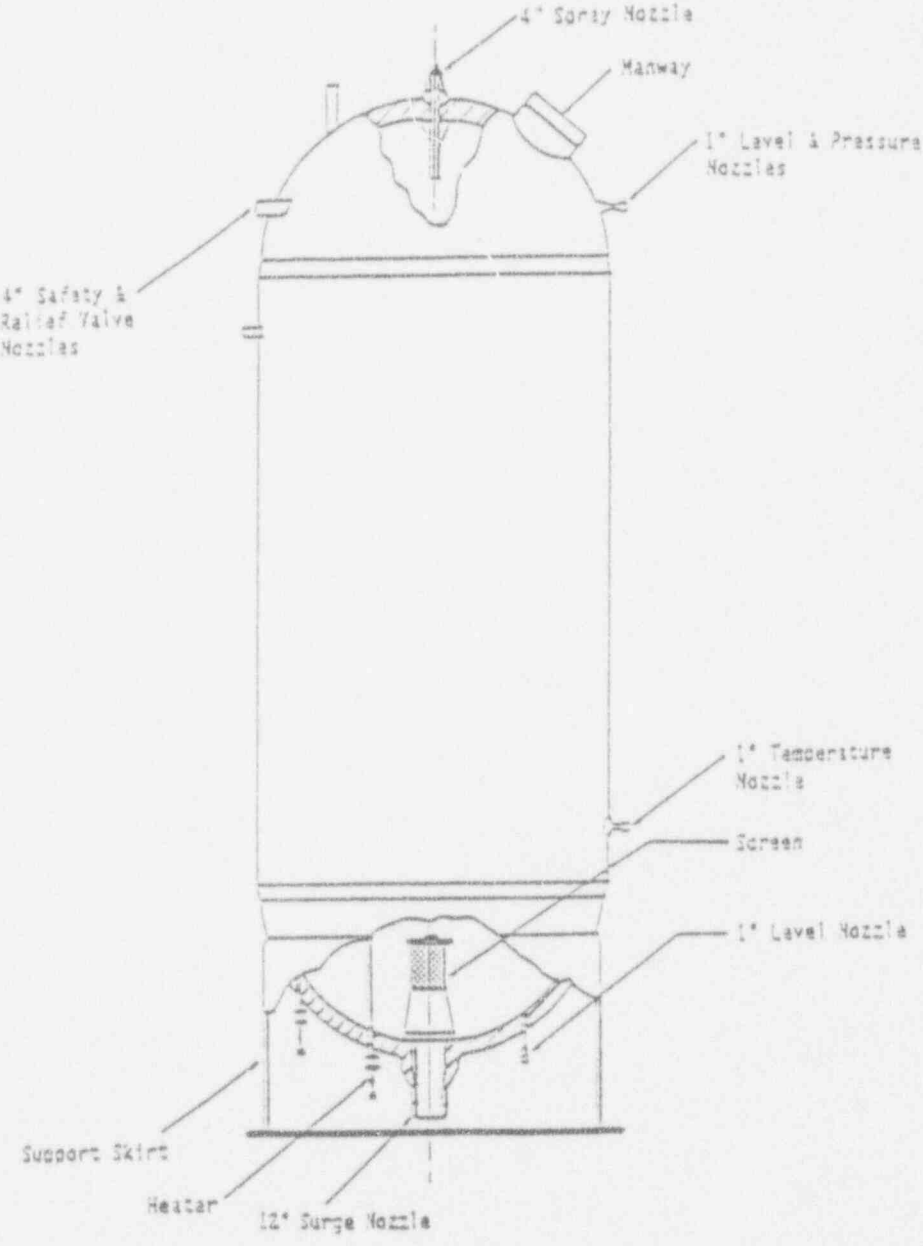

FIGURE 1

CALVERT CLIFFS NUCLEAR POWER PLANT
UNITS 1 AND 2 PRESSURIZER

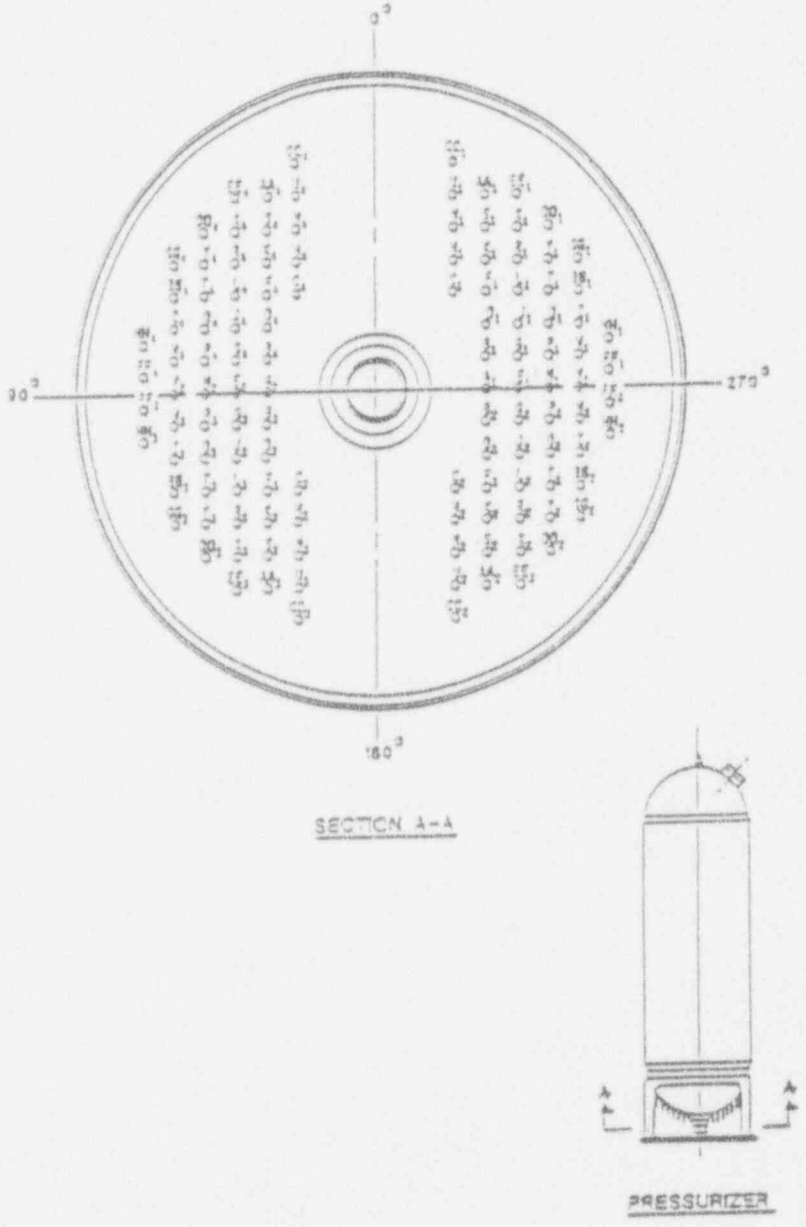

FIGURE 2

PRESSURIZER HEATER PENETRATIONS

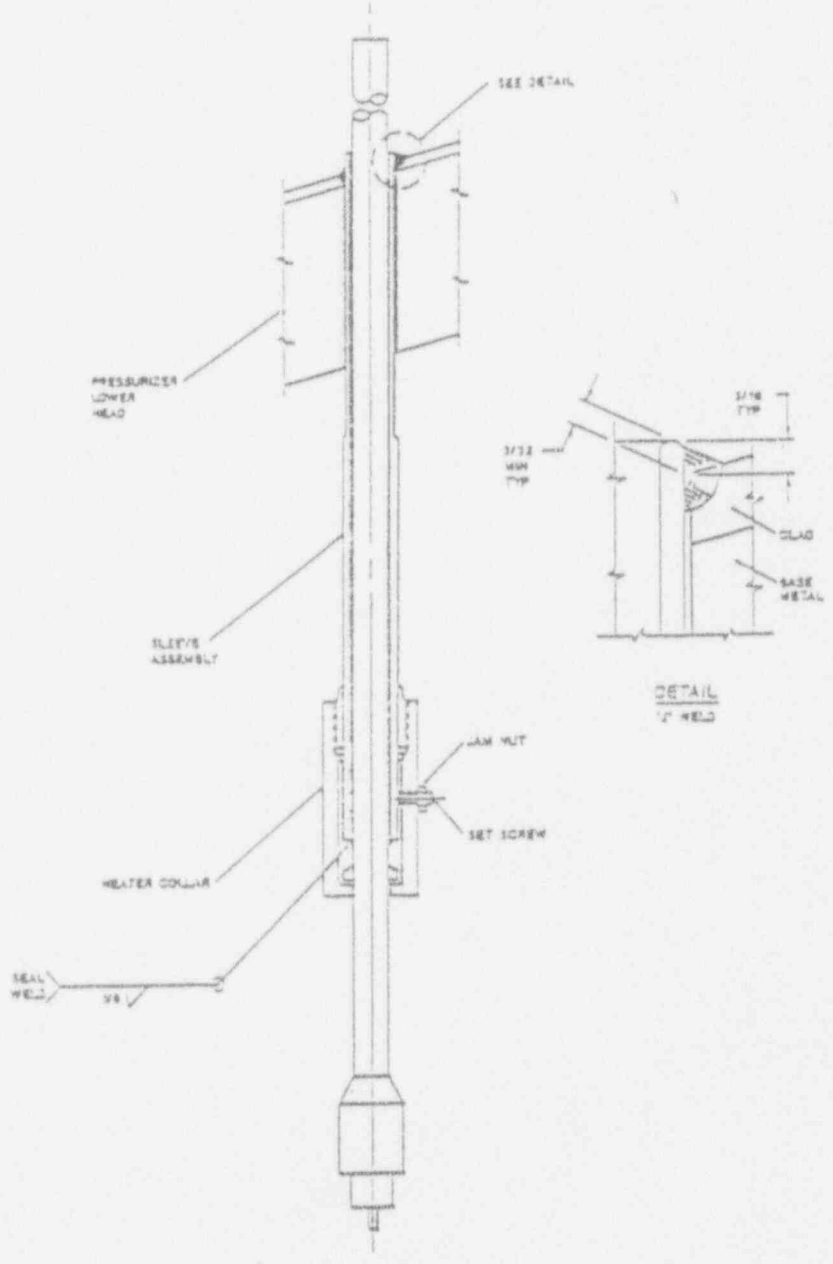

FIGURE 3

TYPICAL HEATER ARRANGEMENT

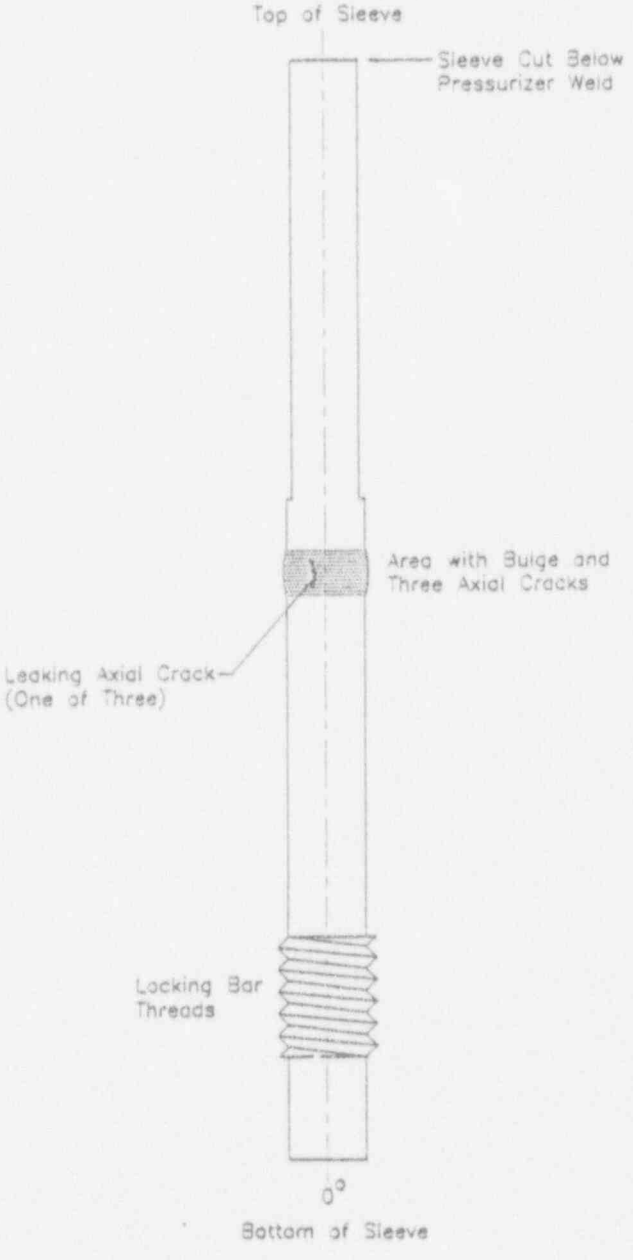

FIGURE 4

HEATER SLEEVE FF-1

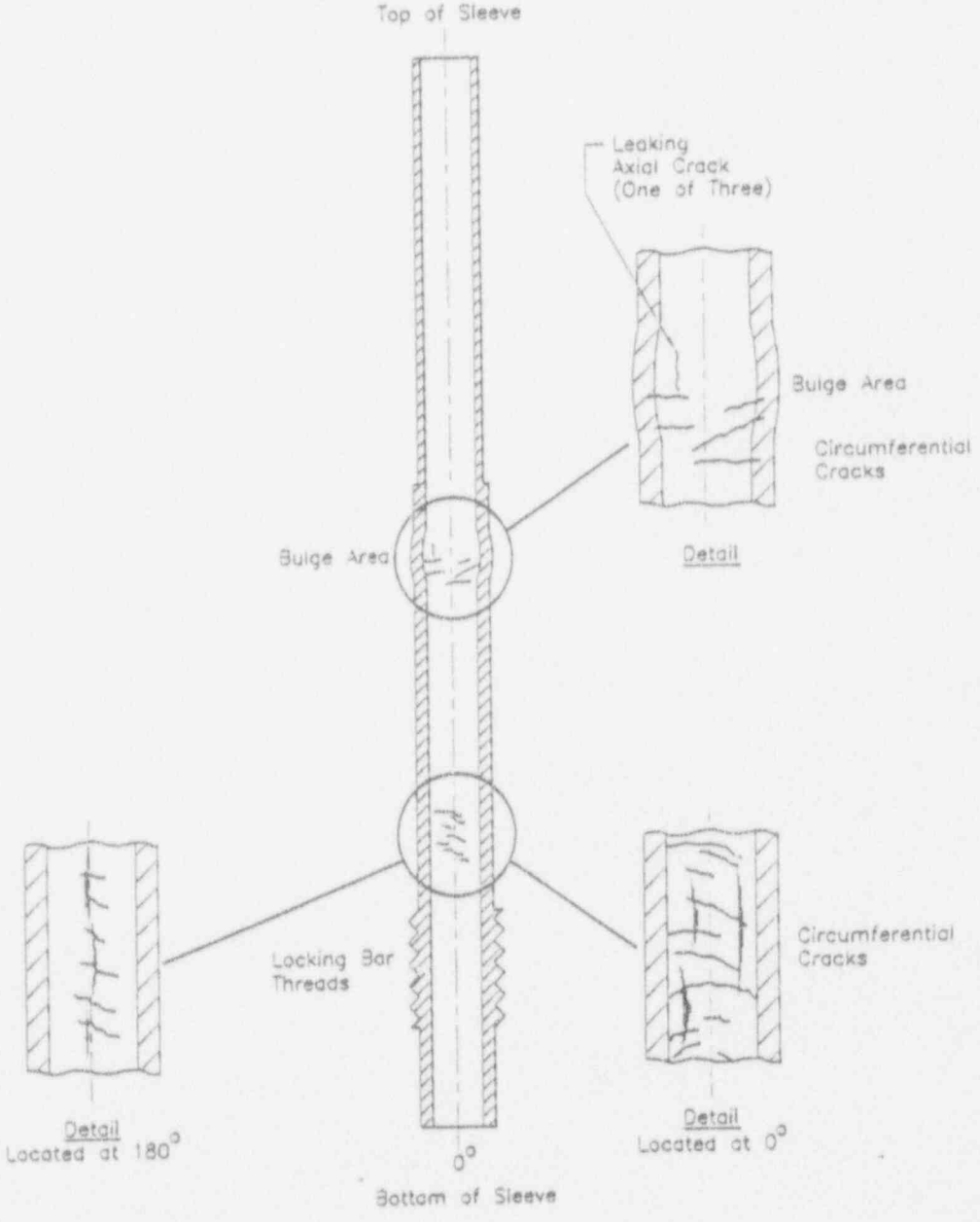

FIGURE 5

CROSS-SECTION OF SLEEVE FF-1 SHOWING CRACKS