1992 THERMAL SHIELD

INSPECTION AND REPAIR

OMAHA PUBLIC POWER DISTRICT

FORT CALHOUN STATION

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1.0 DEFINITIONS

Ac	-	A control channel excore detector (Currently A Safety Channel)
Bc	-	B control channel excore detector (Currently D Safety Channel)
Bs	-	B safety channel excore detector
Cs	-	C safety channel excore detector
PSD	-	Power spectral density, a measure of signal power within discrete frequency bands over specified frequency ranges
0° Phase	-	In-phase data, used in COS 2θ excore detector information
180° Phase	-	Out-of-phase data, used in COS 3θ excore detector information

2.0 INTRODUCTION

2.1 Abstract

During the Spring 1992 (End of Cycle 13) Refueling Outage an inspection and repair of the Reactor Vessel Thermal Shield system was performed at the Omaha Public Power District (OPPD) Fort Calhoun Station. A complete visual inspection of the support lugs and positioning pins was first performed, followed by an "as-found" preload measurement of 11 of the 16 lower positioning pins. Based on analytical evaluations of the "as-found" preload state of the positioning pins, seven (7) lower and four (4) upper existing positioning pins were removed and replaced with new positioning pins and mechanical locknuts. The new positioning pins were preloaded to establish a long term coupled state between the thermal shield (TS) and core support barrel (CSB).

2.2 General Description

The TS is a 3" thick, 304 stainless steel cylindrical structure with an inside diameter of 127" and a height of 164" (Figure 1). The thermal shield is vertically supported at the top by eight equally spaced support lugs welded to the outer periphery of the CSB. The TS lug support pins were fitted during assembly to position the TS on the support lugs. The main function of the lugs is to support the weight of the TS. The TS is positioned and constrained radially by a total of twenty-four (24) positioning pins. Eight of the positioning pins are located below the support lugs and the remaining positioning pins are located approximately 10" from the bottom of the TS. At the lower positioning pin locations, stellite wear surfaces are welded to the CSB as bearing surfaces for the positioning pins. There is no stellite on the core support barrel at the top pin locations. The positioning pins are threaded into the TS and were originally torqued to 250 ft-lbs (approximately 8,000 - 10,000 lbs preload) against the CSB, thus coupling the TS and CSB.

In the original configuration, locking collars were threaded on the positioning pins and torqued against the TS, thereby preloading the locking collars and positioning pins to the TS. The locking collars were then lockwelded to the positioning pins and the TS to prevent rotation and provide a means of capture (Figure 2). The replacement positioning pins and locking collars are installed and preloaded in a similar manner. However, the replacement locking collars are mechanically crimped to the positioning pins and TS to prevent rotation and provide a means of capture (Figure 3).

2.3 Background

The first ten-year inservice inspection (ISI) of the reactor vessel and its internals was conducted at Fort Calhoun Station during late 1982 and early 1983. This inspection revealed that all accessible positioning pins, locking collars, and lock welds were intact with no evidence of abnormal wear. A ten-year inservice inspection was also carried out in 1982 on the reactor vessel and internals at Maine Yankee. This inspection revealed that three positioning pins were missing from their original positions. Similar inspections performed at St. Lucie Unit 1 in early 1983 revealed extensive damage to the thermal shield and its support structure. The St. Lucie 1 thermal shield was subsequently removed due to this damage.

As a result of these findings, in 1984 OPPD committed to an inspection of the Fort Calhoun Station reactor vessel thermal shield during the 1987 Refueling Outage (References 1 and 2). The purpose of this inspection was to ensure that the thermal shield and its support system were not degrading as observed at other Combustion Engineering (CE) plants. In 1986, results of comprehensive research and analysis of the thermal shield degradation phenomena led to new information and monitoring techniques which were not available in 1984. Based on the results of this new information, OPPD replaced the commitment for a 1987 inspection with a commitment to conduct an ongoing thermal shield monitoring program capable of detecting precursors to internals degradation. Should precursors to degradation be detected, OPPD committed to conduct an inspection and/or repair as needed. However, at the latest, an inspection of the reactor internals would be conducted as required for the second ten-year reactor vessel ISI during the 1993 Refueling Outage (References 3, 4, 5, and 6).

As part of the 1986 inspection deferral for the Fort Calhoun Station thermal shield, internals vibration monitoring (IVM) and loose parts monitoring (LPM) data were collected and analyzed on a routine basis. This would allow for the detection of early degradation of the thermal shield support system. In mid-1988, indications in the IVM data showed that the TS was exhibiting early signs of a loss of preload in some of the positioning pins. This loss of preload manifests itself as increased motion between the CSB and TS in the shell modes of vibration. Over a period of time, the increased motion has the potential to produce damage to the positioning pins and, ultimately, the support lugs.

A feasibility study was performed to investigate the engineering and tooling preparation required to tighten a partial or complete set of positioning pins to reinstate the desired coupling of the TS/CSB system. As a result of this study, an inspection and repair program was initiated by OPPD. The actual work was to be performed with diver assisted tooling.

The repair approach adapted was to visually inspect the condition of the positioning pins and to measure the amount of preload in the "as-found" state of the positioning pins. The results of measurements would then be used to establish the amount of preload required in the positioning pins to reinstate a long term coupled state between the TS and CSB. The calculation of the required positioning pin preload takes into account all factors affecting the positioning pin preload, including low leakage fuel management schemes, differential thermal expansion, radiation induced stress relaxation, and hydraulic loads. Any positioning pins requiring replacement would be replaced with a pin of similar design and function, but with preload of a higher value than that provided during initial installation. In essence, the changes to the TS were designed to reinstate the support system to its original coupled state with the CSB. A locking collar (as with the original design) was used to preload each positioning pin to the TS. The locking collar was secured to the positioning pin and TS by mechanical crimping (Figure 3).

3.0 INTERNALS VIBRATION MONITORING AND INDICATIONS OF PIN DEGRADATION

3.1 Thermal Shield Inspection Commitment

In 1984, OPPD committed to the NRC to perform an inspection of the Fort Calhoun Station reactor vessel thermal shield during the 1987 Refueling Outage (References 1 and 2). A deferral justification for this inspection was subsequently prepared which allowed OPPD to replace the commitment for the 1987 inspection with a commitment to conduct an ongoing thermal shield monitoring program capable of detecting precursors to thermal shield degradation (References 3, 4, 5 and 6). The cornerstone of the deferral was internals vibration monitoring (IVM) since:

A. Monitoring and data evaluation on a regular basis allows for detection of early stages of degradation of the thermal shield support system and,

B. Evaluation of the IVM data to date (up to 1986) had not indicated a change in the thermal shield support system.

Should indications of thermal shield degradation develop in IVM and LPM data, OPPD committed to conduct an inspection and/or repair as needed.

From mid-1988 through Fall of 1990, OPPD evaluated IVM data developments which indicated the early stages of loosening of the thermal shield positioning pins. Based on the evaluations and IVM indications, OPPD decided to inspect and repair the TS during the end of Cycle 13 refueling outage, rather than at the scheduled 20-year ISI refueling outage at the end of Cycle 14.

3.2 IVM Data Reduction Prior to End of Cycle 13 Inspection

Experience gained from the St. Lucie Unit 1 thermal shield program demonstrated that degradation in the thermal shield support system is detectable as frequency peak shifts in the spectra of the excore detector noise signals. Analytical models are used to establish the coupled and uncoupled frequency response of the thermal shield support system. In the case where the thermal shield uncouples from the core support barrel, there is a corresponding decrease in the frequency of the COS 2θ and COS 3θ modes of vibration (Table 1). The COS 2θ mode, which is in-phase for cross-core detector pair data, and the COS 3θ mode, which is out-of-phase for cross-core detector pair data, provide two identifiers of the condition of the thermal shield support system which can be tracked via a neutron noise monitoring program. The COS 2θ mode, with its much larger frequency decrease for loose positioning pins, is considered to be the main identifier of the condition of the TS support system. The actual corresponding frequency peaks in the IVM data can vary from the analytical predictions due to various neutronic factors associated with each fuel cycle. Figures 4 through 6 show the trends observed in the IVM data for the degraded condition identified in 1988.

The baseline response was taken from IVM data obtained on September 16, 1987. At this point, frequency peaks were found at 11 Hertz for the COS 2θ in-phase mode. Also, frequency peaks were found as expected at 16 Hertz for the COS 3θ out-of-phase mode. The figures also show that after June 1988, a clear peak was also seen in the 8 to 9 Hertz range for the COS 2θ mode (Figures 4 and 5). Also, the 16 Hertz peak decreased for the COS 3θ mode with a corresponding increase in the 14 Hertz range (Figure 6). Subsequent IVM data up to December 1991 showed similar trends. The IVM data indicated loosening of the thermal shield positioning pins. LPM data from 1988 through December 1991 did not show signs of impacting of the positioning pins against the CSB. Therefore, although the IVM data showed signs of loosening, the LPM data indicated that a complete loss of preload had not occurred.

4.0 DESCRIPTION OF THE REPAIR APPROACH

The approach developed for the Fort Calhoun Station thermal shield was to first perform a visual inspection of the thermal shield support features (i.e., support lugs and positioning pins), followed by a measurement of the "as-found" preloads in the positioning pins. The inspection information was evaluated by ABB/Combustion Engineering (ABB/CE) and a repair plan that provided long term structural integrity for the TS/CSB support system was presented to OPPD. Upon acceptance of the repair plan by OPPD, it was implemented by ABB/CE. The repair involved the replacement and preloading of seven lower positioning pins and four upper positioning pins.

5.0 "AS-FOUND" INSPECTION RESULTS

5.1 Visual Inspection

A complete external visual inspection of the support features (lugs and positioning pins) was conducted during the End of Cycle 13 outage. The following summarizes the findings of the visual inspection:

A. The external visual inspection of the lower sixteen (16) positioning pins indicated no noticeable cracks, weld cracks, missing parts, misalignment, gaps, looseness, or wear. The lower positioning pins were found in their correct position and in good condition.

B. The external visual inspection of the upper eight (8) positioning pins indicated no noticeable cracks, weld cracks, missing parts, misalignment, gaps, looseness, or wear. The upper positioning pins were found in their correct position and in good condition.

C. The external visual inspection of the eight (8) support lugs indicated no noticeable cracks, weld cracks, missing parts, misalignment, gaps, looseness, or wear. The support lugs and support pins were found in their correct position and in good condition.

In general, the overall condition of the thermal shield support system was found to be good. There was no apparent shifting or damage that would indicate a change from the initial installed condition.

5.2 Preload Inspection

Due to tooling difficulties, "as-found" pin preloads on all 24 positioning pins were not taken as planned. Backup preload measuring equipment (electrical resistance coil method) was used and could access only 11 of 16 lower positioning pins and none of the eight upper positioning pins. The "as-found" positioning pin preload measurements which were taken are listed in Table 2. Two pins were determined not to be in contact with the CSB. Three additional positioning pins were found to have less than 25% of their original load. The inspection data indicated an overall condition that required repair.

6.0 DESCRIPTION OF REPAIR RECOMMENDATION

Based on the preload information obtained for the lower positioning pins, ABB/CE recommended an 11 pin repair to provide a high confidence, long term repair for the thermal shield. The recommendation specified a set of odd numbered top positioning pins in addition to a set of seven lower odd numbered positioning pins. OPPD accepted this recommendation and an 11 pin repair was performed.

With the absence of initial preload information for the top positioning pins, the following justification was given for working on the top positioning pins:

A. The key to preventing loss (failure) of the thermal shield is to minimize relative motion between the support lug and the thermal shield and thus minimize wear. The restraint provided by the positioning pins fulfills that function. Both bottom positioning pins and top positioning pins provide restraint against cantilever beam motion of the thermal shield relative to the lugs; the bottom pins play a larger part in this than the top pins. The top and bottom pins both provide restraint against shell motion of the thermal shield relative to the lugs; the top pins play a larger part in this than the bottom pins.

B. Based on fluence and temperature gradients acting on the top and bottom positioning pins for the first 20 years of operation, it was calculated that the radiation induced loss in preload in the top positioning pins could be considerably higher than that in the bottom positioning pins. Therefore, more preload loss would be expected at the top.

C. At the top positioning pins elevation, the pins (with stellite face) bear directly against the core support barrel (304 stainless steel). The stellite to 304 stainless steel interface at the top positioning pins can result in higher wear rates as a result of relative motion, which further increases the likelihood of gaps at the top positioning pins.

D. In 1984, a thermal shield repair was conducted at Maine Yankee. During this repair, eight out of 17 lower positioning pins were tightened and four of nine upper positioning pins were repaired. Three upper positioning pins that had worked their way out of the thermal shield were replaced and one upper positioning pin that had a gap was tightened. The lower positioning pin repair at Fort Calhoun Station in 1992 (seven out of 16 lower positioning pins) is similar to the 1984 lower positioning pin repair at Maine Yankee (eight out of 17 lower positioning pins). Due to the lack of preload information, these similarities were also considered in the upper positioning pins, where a four pin repair was required at Maine Yankee.

E. Full power (100%) operation was calculated to result in a 24°F temperature gradient across the top positioning pins. This temperature gradient causes a 0.014" increase in length of the top positioning pins that works in the direction of keeping the pins tight. If gaps exist, the gaps plus the effects of hydraulic loads and radiation induced relaxation could exceed the 0.014" and the positioning pins would be loose during operation. It is only necessary for gaps at the top positioning pins to be on the order of 0.009" for this to occur. Gaps on the order of several mils were found at the bottom positioning pins. It was expected that larger gaps could occur at the top positioning pins (see wear discussion and Maine Yankee experience), and that these gaps could increase with time due to wear. It was, therefore, considered likely that no action on the top positioning pins and continuous full power operation would not provide a high confidence, long term repair.

For the above reasons, in order to provide a high confidence long term thermal shield repair, ABB/CE recommended that a set of four top positioning pins (every other pin) be repaired in addition to the seven bottom positioning pins. The ABB/CE analysis indicated that repair of additional pins beyond the selected four would not provide a significant benefit. Since upper pin location 4 (UP4) was found to be obstructed for electrical discharge machining (EDM), the odd pins (UP1, UP3, UP5, and UP7) were chosen for repair.

7.0 REPAIR RESULTS

7.1 Pin Removal

As part of the repair, seven (7) lower positioning pins were removed and replaced (Figure 7). After the removal, a visual inspection was performed on the pin contact face and the stellite pad on the CSB. In all seven of the lower positioning pins wear was discovered as evidenced by shiny surfaces on the pin face and CSB stellite pads. A direct measurement of the amount of wear was not possible. With close video camera examinations of the CSB stellite surface, the amount of wear was noticeable and judged to be on the order of several mils.

As part of the repair, four (4) upper positioning pins were removed and replaced (Figure 7). After removal, a visual inspection was performed on the pin contact face and the bearing surface of the CSB. There is no stellite on the CSB at the top positioning pin location. In all four cases, wear was not noticeable. The condition of the CSB was such that a lightly burnished surface was noticeable. No noticeable wear was noted on the removed top positioning pins.

In order to remove locknuts, a larger than anticipated EDM cut depth was required because of the larger than expected locknut welds. In some cases, locknuts/positioning pins had to be removed together. This made usage of the old positioning pins impossible and all 11 positioning pins were replaced (Table 3).

During the removal of the lower positioning pins, six positioning pins were found not to be in contact with the CSB and one was found to be slightly loaded (Table 2). During the removal of the top positioning pins, it was found that the odd pins had marginal preload (approximately 5,000 pounds). The marginal loads found in the odd upper positioning pins indicates a condition better than was expected. Sufficient preload had decreased from initial installation values (approximately 10,000 pounds) to warrant reloading. The positive preload reinstatement at the odd positioning pins ensures long term integrity for the support system. The reinstating of high preload on the odd positioning pins also had the effect of closing potential gaps and increasing the existing preload at the even positioning pin locations.

7.2 Repair Preloads

The repair consisted of replacing and advancing bottom positioning pins LP1, LP3, LP5, LP7, LP9, LP13 and LP15 to 9.45 mils of preload, and of replacing and advancing top positioning pins UP1, UP3, UP5, and UP7 to 18.3 mils of preload. After accounting for positioning pin compression, this results in nine mils of pin advancement in the bottom locations and 18 mils at the top. The nine mils advancement of the lower positioning pins correlates to approximately 25,000 to 28,000 pounds of preload in the lower pins (Table 4). The wear found at the lower positioning pin locations implies that the initial preload should be as high as possible in order to achieve added margin against wear. It was decided to install preloads higher than the desired minimum to include margin for wear and measurement uncertainties.

Preloading of odd numbered positioning pins resulted in increased preload or gap closure in even numbered positioning pins. The non-repaired pins "pick up" approximately 58% of the repaired positioning pin displacement at the top and approximately 16% at the bottom. Comparison between the as-found readings of the accessible even numbered lower positioning pins (Table 2) and the calculated preloads after repair (Table 4) show the increase of the non-repaired positioning pins.

Since no as-found preload data were available for the top positioning pins, calculated preloads for the repaired top positioning pins with 18 mils of installed displacement range between 9,300 - 14,000 lbs of preload. Depending upon the initial condition of the non-repaired upper positioning pins, the calculated 10.4 mils displacement "picked up" by tightening the odd numbered positioning pins may range from 0 lbs (pin still gapped) to increasing the positioning pin loading by 8,100 pounds above the initial pre-repair load (Table 4).

7.3 Repair Evaluation

Evaluation of the repair indicates that a long term fix with adequate margins has been instituted on all of the repaired positioning pins, and that life on non-repaired pins has been extended or margin improved. It is concluded that all of the design objectives of the recommended partial repair have been met:

A. The repair provided a coupled CSB and TS system,

B. The repair introduces little concern for lug wear, and

C. The natural frequencies of the repaired CSB and TS system do not differ from those associated with the system at original installation.

Post repair IVM results support the objectives of the field repair. The thermal shield repair is reflected in positive spectral changes in the COS 2θ and COS 3θ shell modes of vibration (Figures 8 - 11). It is concluded that these positive spectral changes support the fact that significant thermal shield to core support barrel tightening was achieved.

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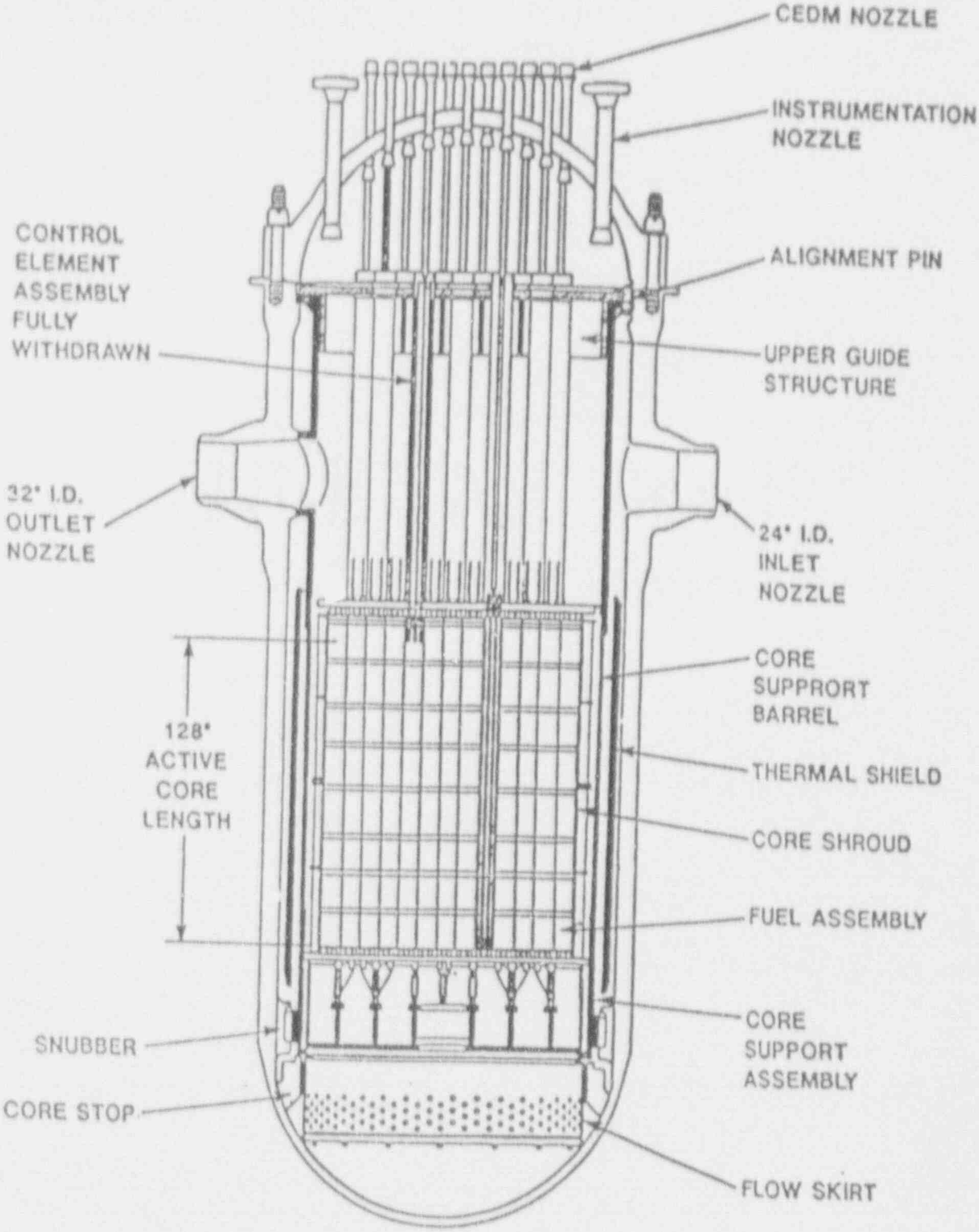


FIGURE 1
REACTOR INTERNAL ARRANGEMENT

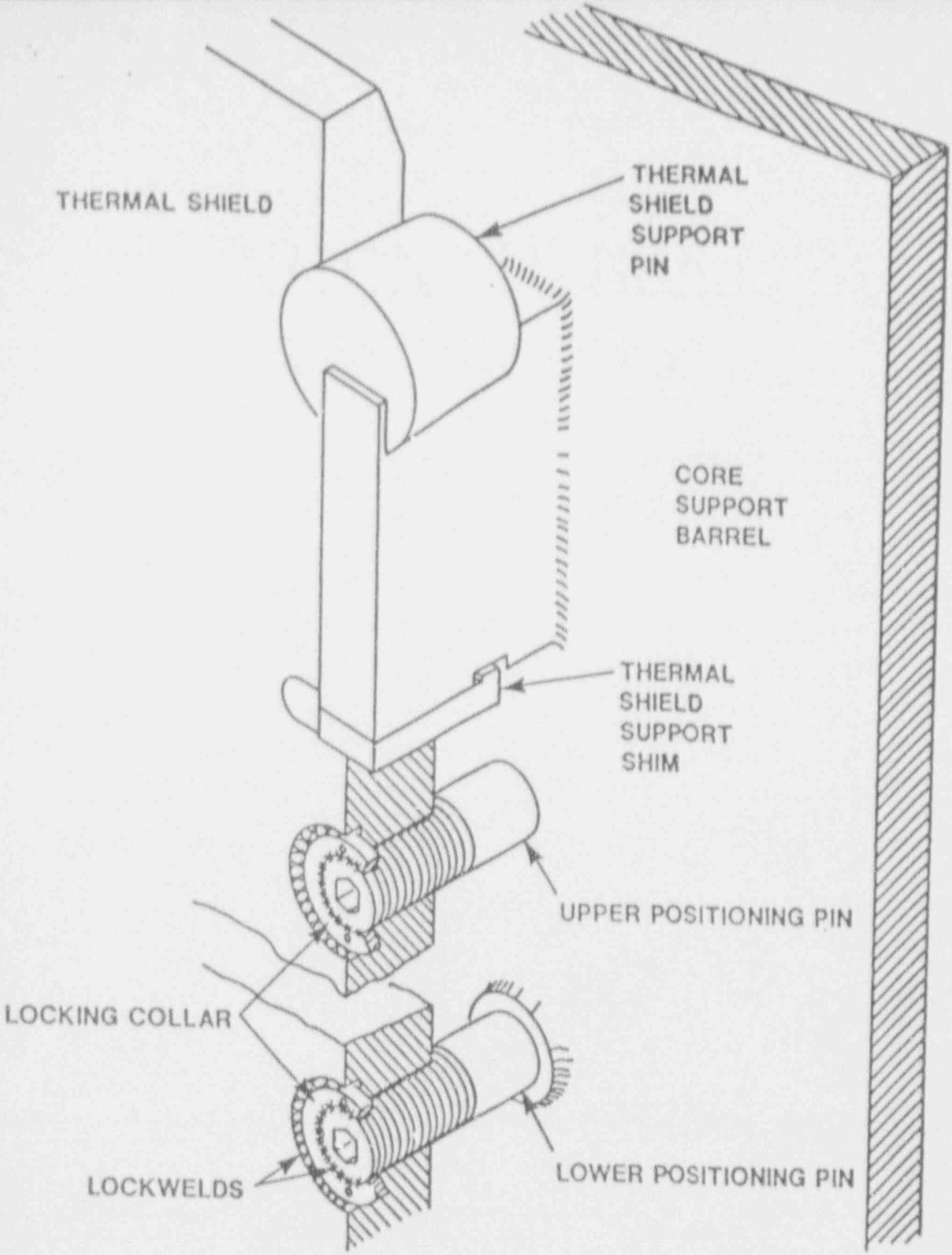


FIGURE 2
THERMAL SHIELD SUPPORT SYSTEM
ORIGINAL INSTALLATION

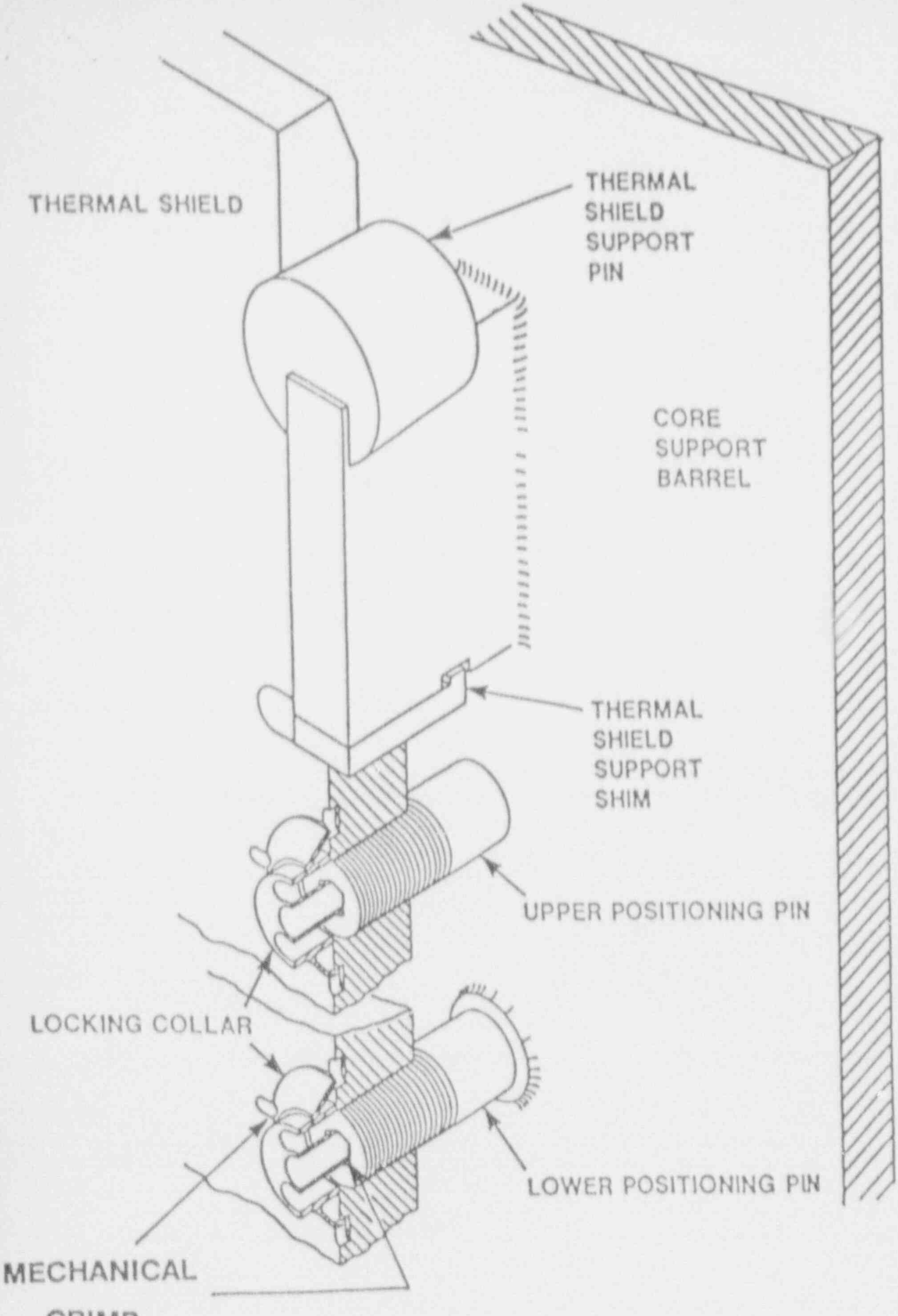


FIGURE 3
THERMAL SHIELD SUPPORT SYSTEM
REPLACEMENT PINS AND LOCKNUTS

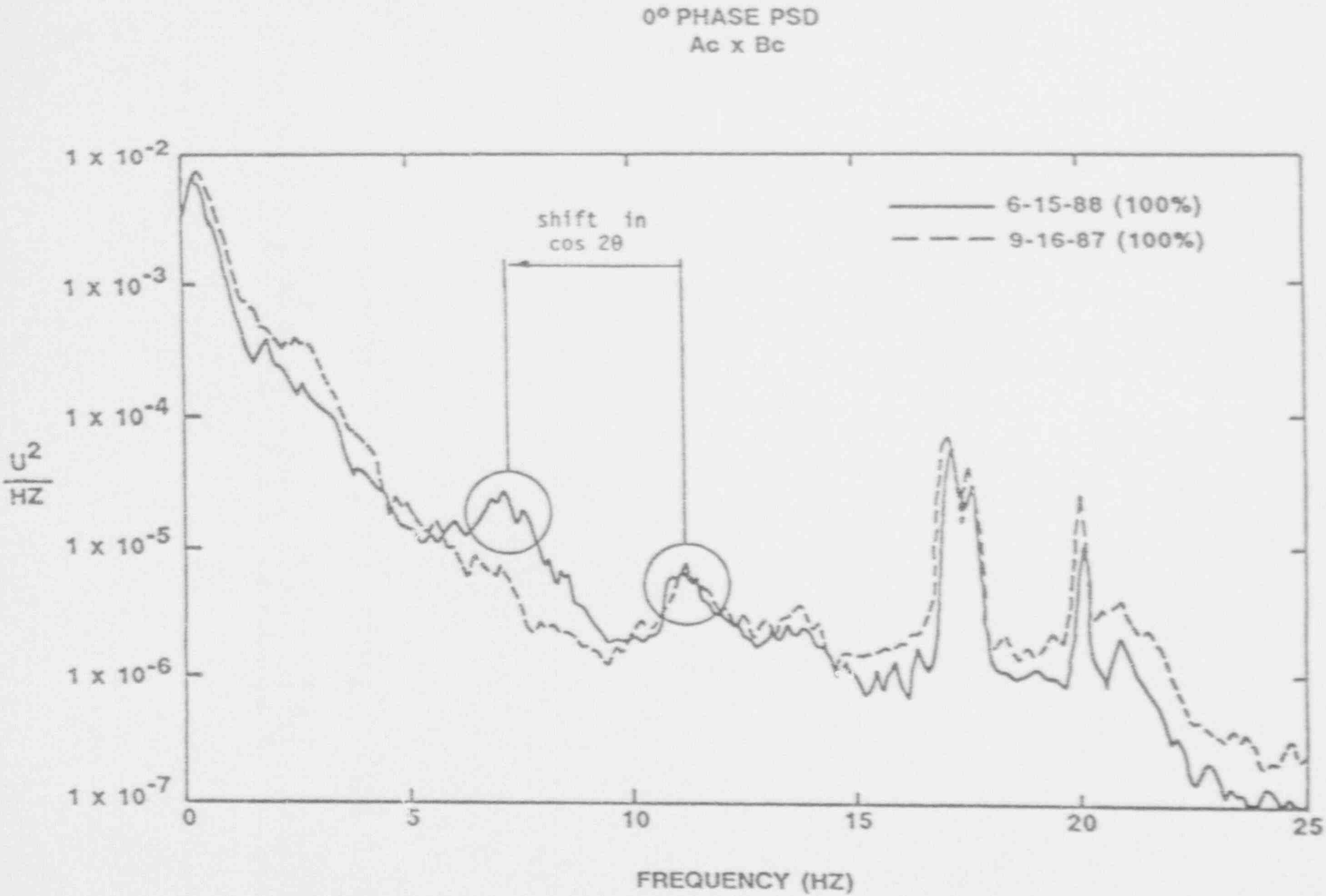

0° PHASE PSD
Ac x Bc
1 x 10-2
1 x 10-3
1 x 10-4
1 x 10-5
1 x 10-6
1 x 10-7
U2
HZ
shift in
cos 2θ
6-15-88 (100%)
9-16-87 (100%)
0
5
10
15
20
25
FREQUENCY (HZ)

FIGURE 4

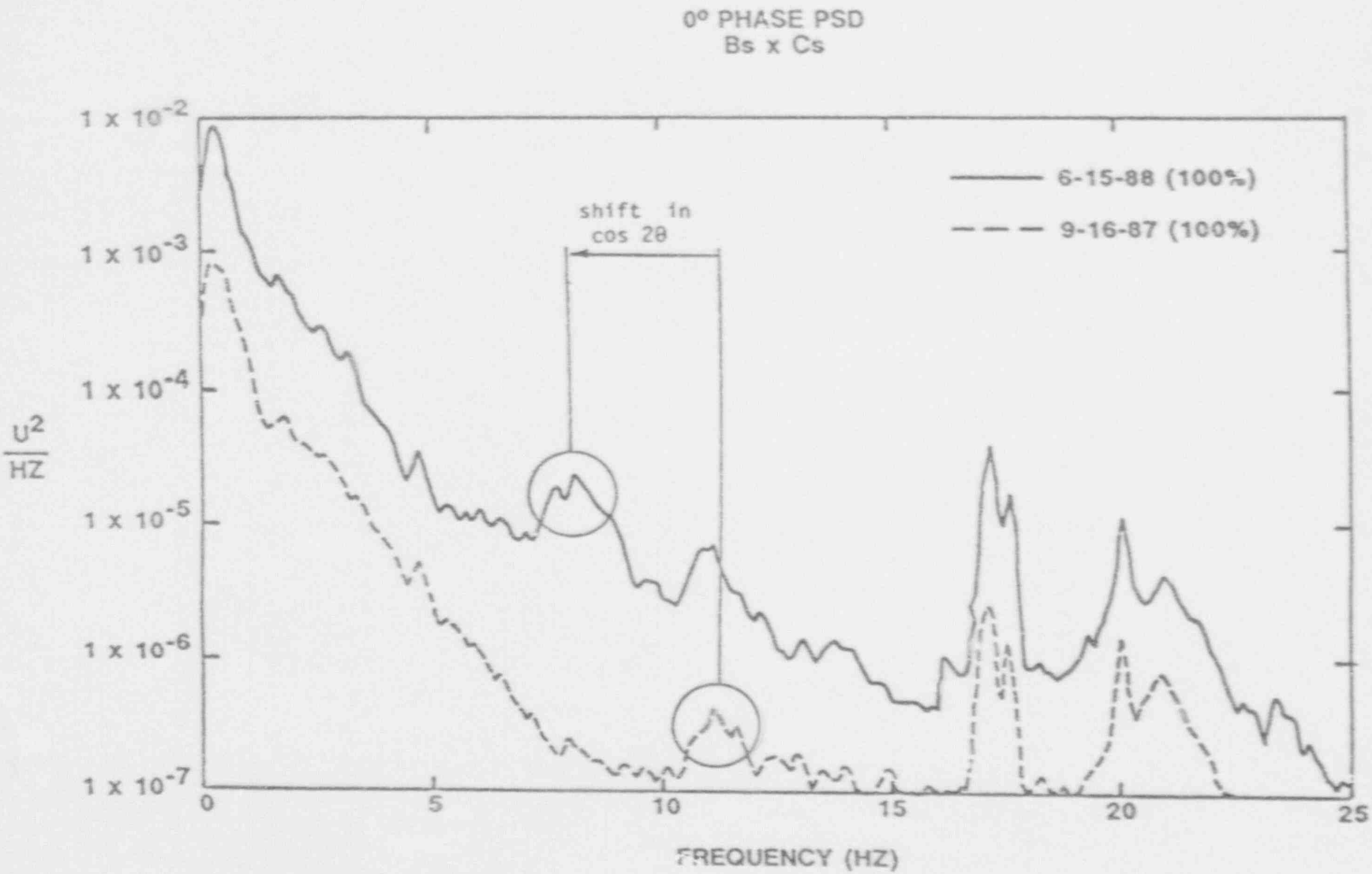

0º PHASE PSD
Bs x Cs
1 x 10-2
1 x 10-3
1 x 10-4
1 x 10-5
1 x 10-6
1 x 10-7
U2
HZ
shift in
cos 2θ
6-15-88 (100%)
9-16-87 (100%)
0
5
10
15
20
25
FREQUENCY (HZ)

FIGURE 5

180° PHASE PSD
Ac x Bc

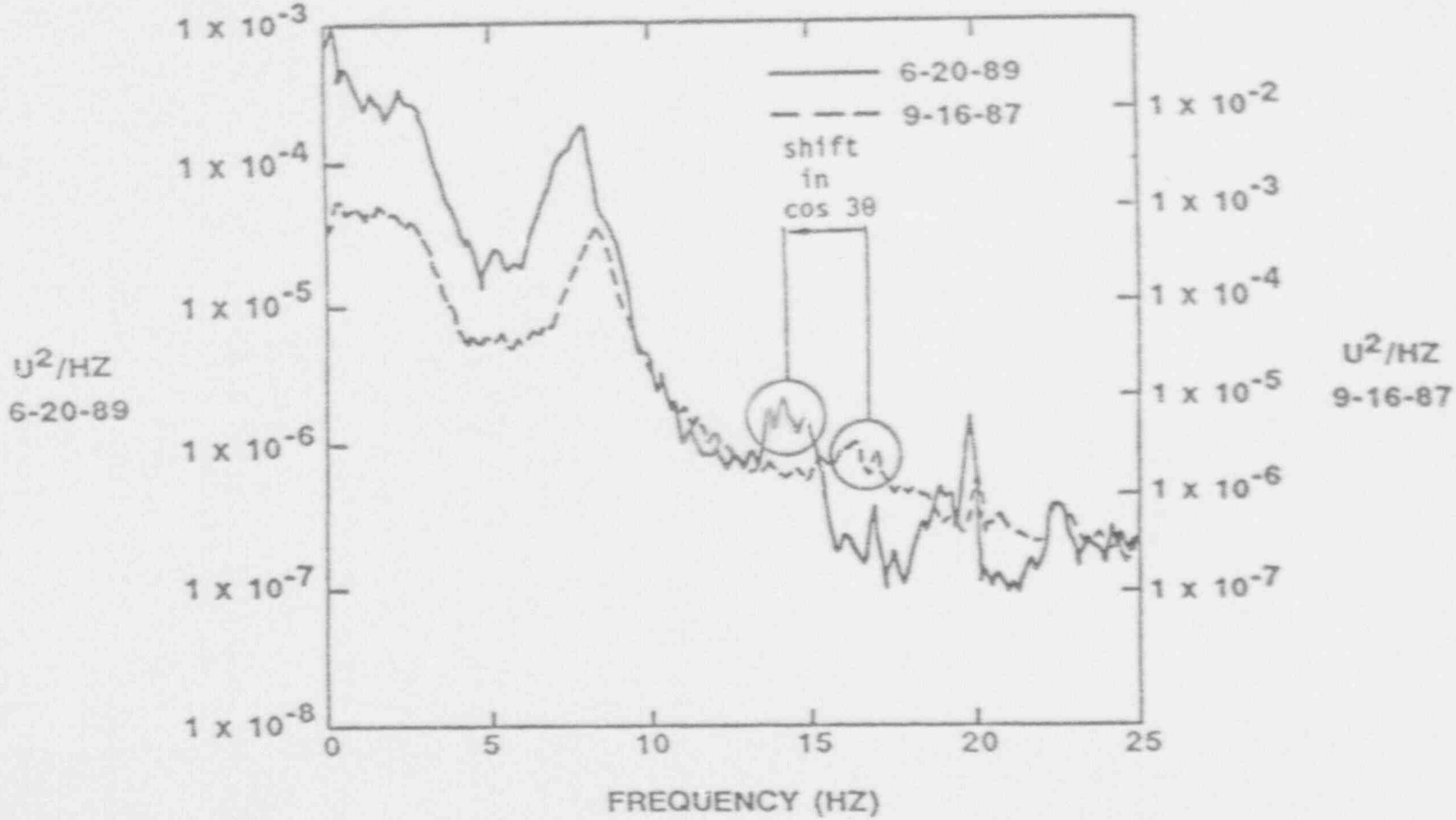
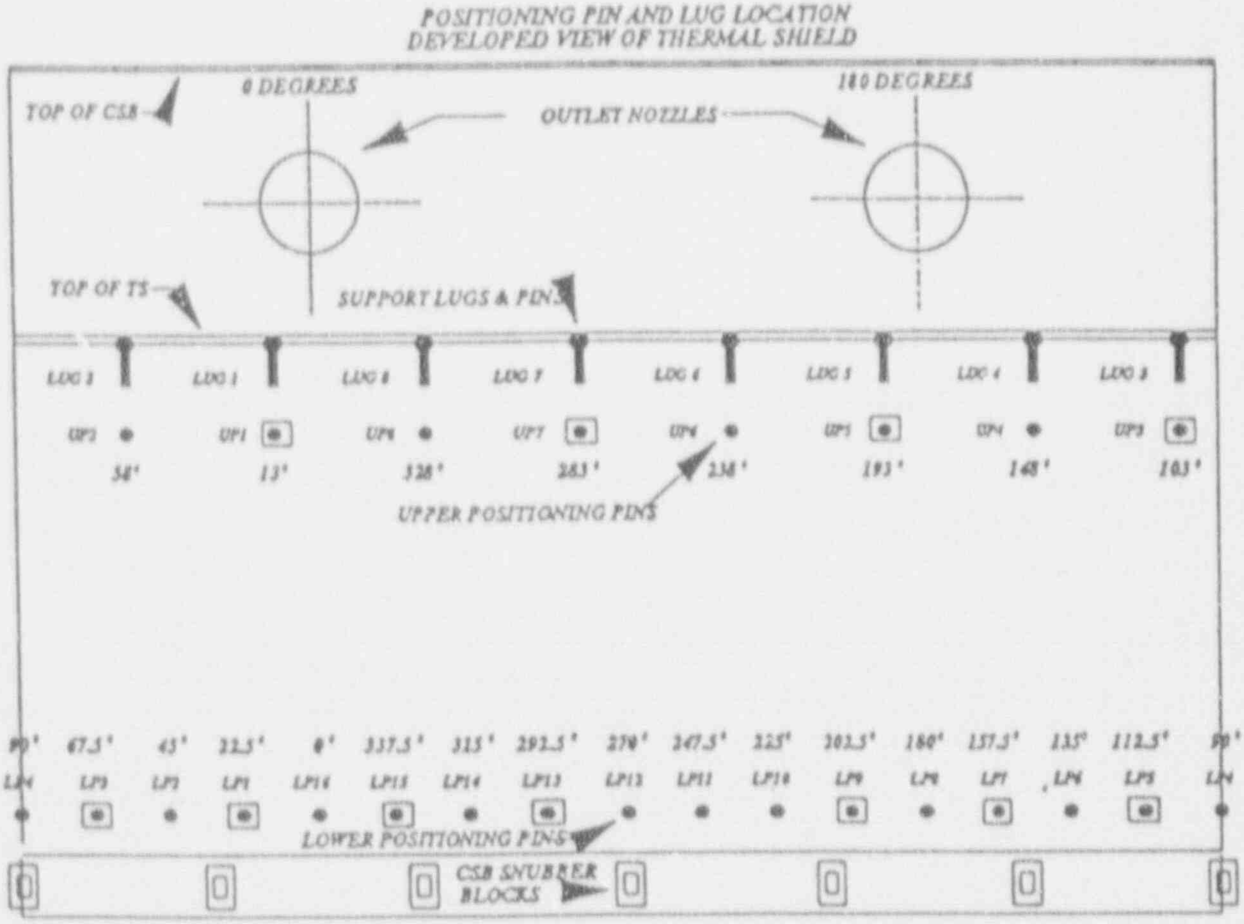


FIGURE 6



Pin Replaced in 1992 Repair

FIGURE 7

Bc x Ac

PHASE PSD
LOWERS

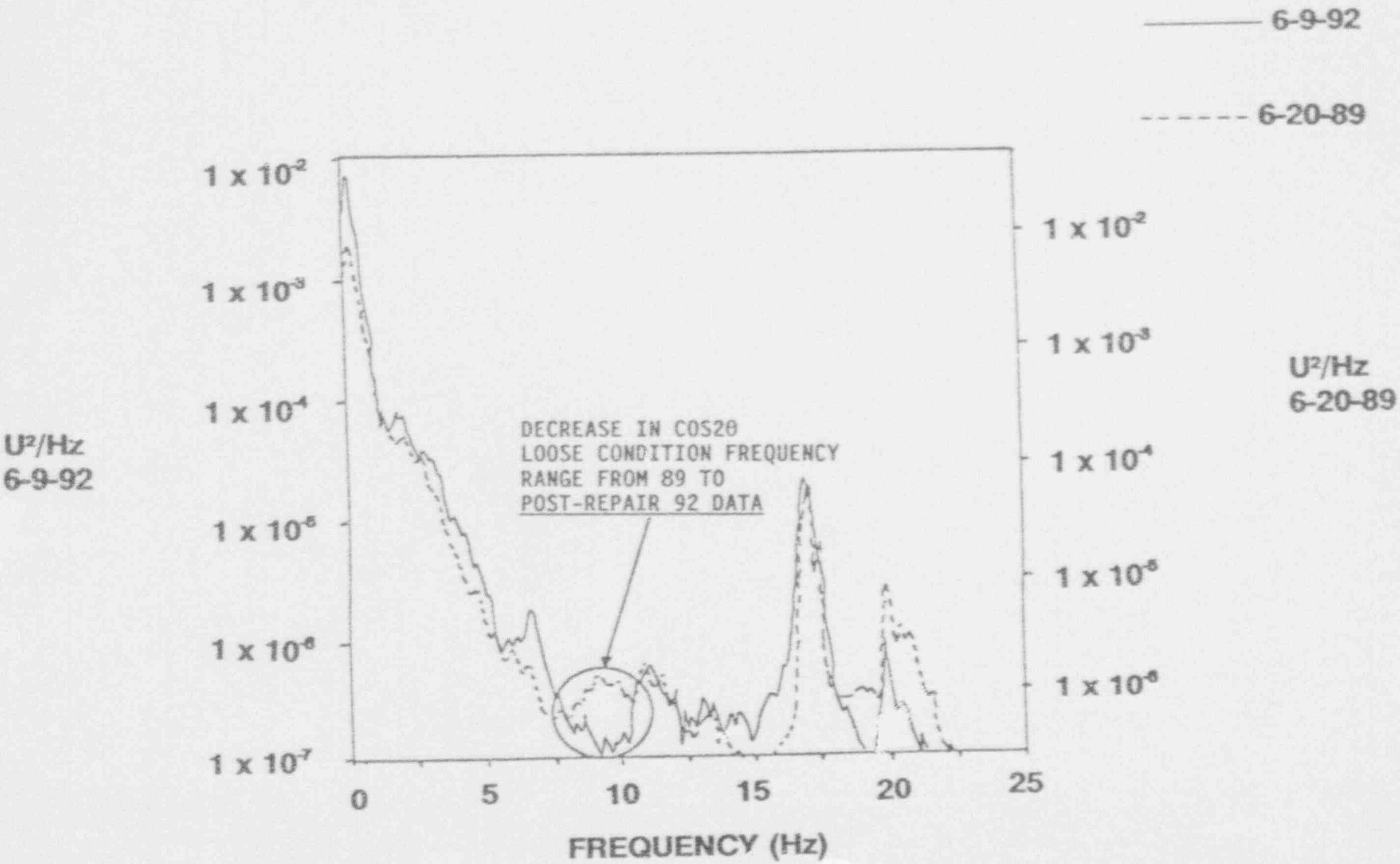


FIGURE 8

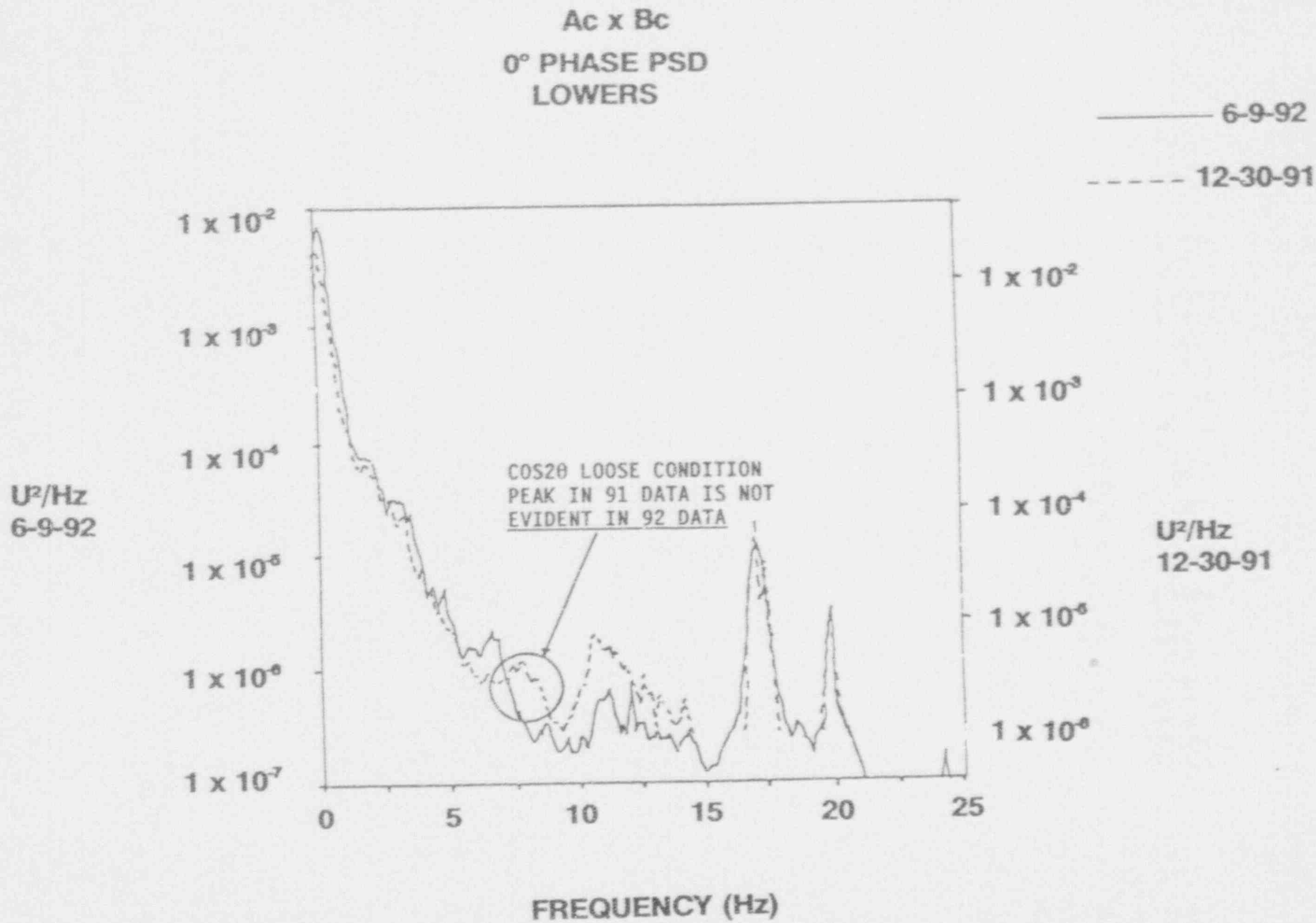

Ac x Bc
0° PHASE PSD
LOWERS
6-9-92
12-30-91
1 x 10⁻²
1 x 10⁻³
1 x 10⁻⁴
1 x 10⁻⁵
1 x 10⁻⁶
1 x 10⁻⁷
U²/Hz
6-9-92
U²/Hz
12-30-91
COS2θ LOOSE CONDITION
PEAK IN 91 DATA IS NOT
EVIDENT IN 92 DATA
0
5
10
15
20
25
FREQUENCY (Hz)

FIGURE 9

Ac x Bc
180° PHASE PSD
LOWERS

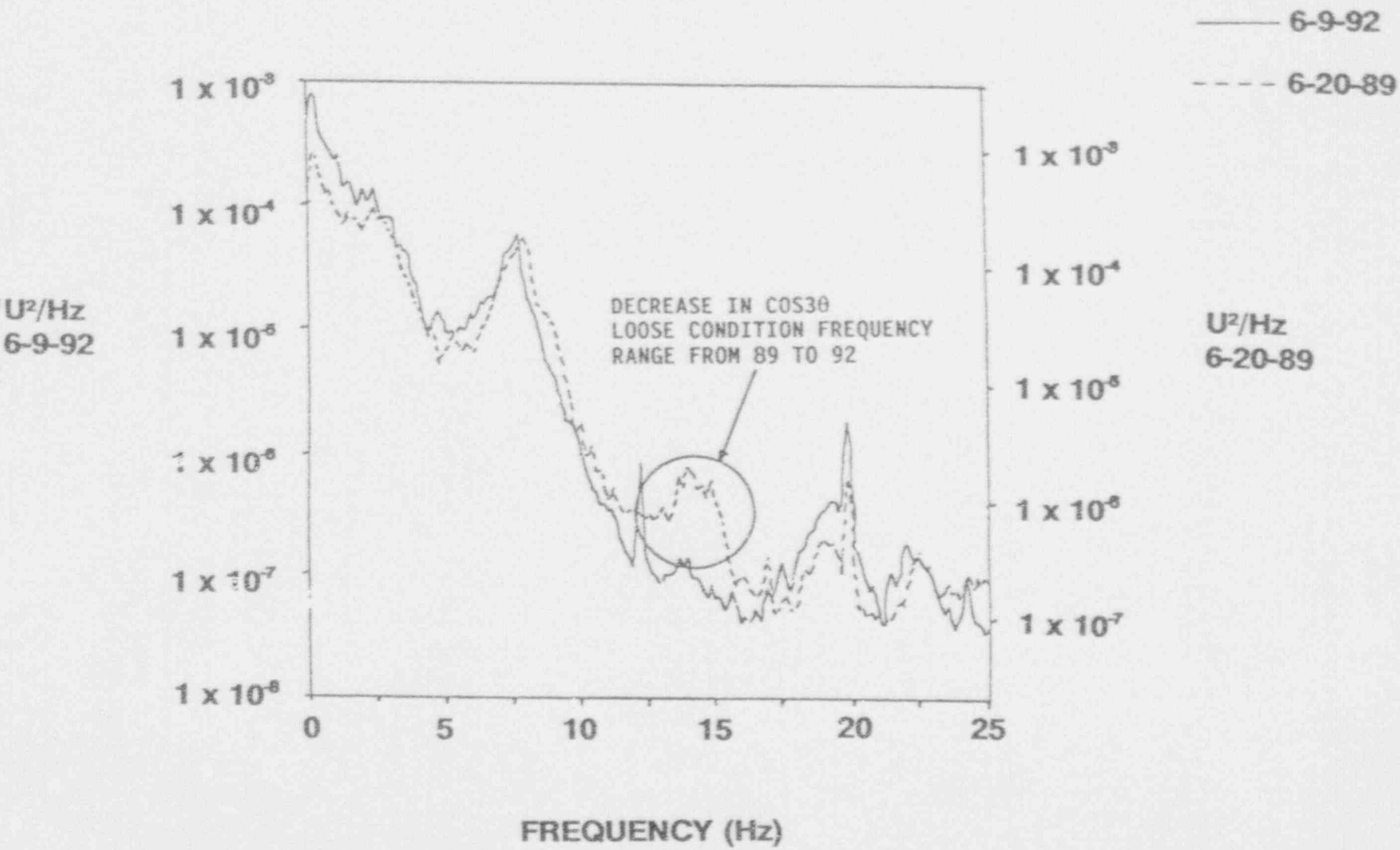
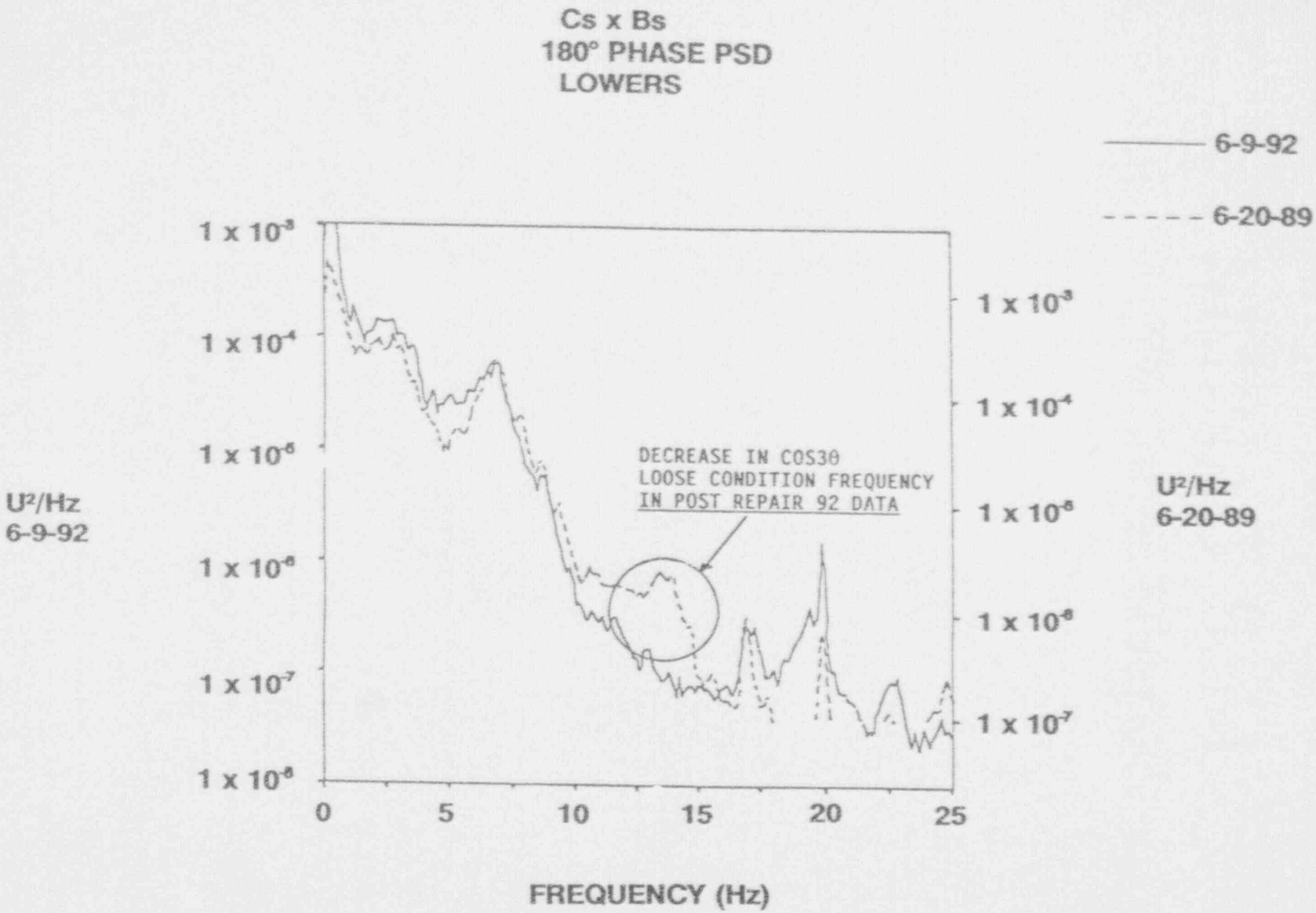


FIGURE 10



Cs x Bs
180° PHASE PSD
LOWERS
6-9-92
6-20-89
1 x 10^-3
1 x 10^-4
1 x 10^-5
1 x 10^-6
1 x 10^-7
1 x 10^-8
U²/Hz
6-9-92
U²/Hz
6-20-89
DECREASE IN COS3θ
LOOSE CONDITION FREQUENCY
IN POST REPAIR 92 DATA
0
5
10
15
20
25
FREQUENCY (Hz)

FIGURE 11

IN-WATER MODAL FREQUENCIES (HERTZ) VS. SUPPORT SYSTEM CONDITIONS

MODE	TIGHT NOMINAL CONDITION (COUPLED)	1992 AS-LEFT NOMINAL CONDITION	ALL PINS NOT TOUCHING CSB (UNCOUPLED)
COS 2θ	12.5	12.5	7.9
COS 3θ	16.3	16.2	14.9

TABLE 1

COMPARISON OF AS-FOUND LOADS FROM COIL INSPECTION AND FOUND CONDITIONS

Pin design.	As-found load from coil inspection, lbs	Condition found during the removal step of the repair
LP1	NO ACCESS	GAP
LP2	14038	N/A
LP3	GAP	GAP
LP4	NO ACCESS	N/A
LP5	GAP	GAP
LP6	5883	N/A
LP7	2052	GAP
LP8	7689	N/A
LP9	NO ACCESS	GAP
LP10	9838	N/A
LP11	12009	N/A
LP12	11984	N/A
LP13	1769	LIGHT LOAD
LP14	259	N/A
LP15	NO ACCESS	GAP
LP16	NO CALL	N/A
UP1	NO ACCESS	4900 lbs
UP2	NO CALL	N/A
UP3	NO ACCESS	NO ESTIMATE, PIN LOADED
UP4	NO CALL	N/A
UP5	NO ACCESS	NO ESTIMATE, PIN LOADED
UP6	NO CALL	N/A
UP7	NO ACCESS	6529 lbs
UP8	NO ACCESS	N/A

TABLE 2

REPAIRED CONDITIONS

Pin design.	Degree location	I.D. letter (note 1)	Pin replace S/N	Locknut S/N	New pin cut length "L" (note 2)
LP1	22.5	L	02	03	4.250
LP2	45	M	N/A	-	-
LP3	67.5	N	10	10	4.625
LP4	90	O	N/A	-	-
LP5	112.5	P	03	02	4.718
LP6	135	A	N/A	-	-
LP7	157.5	B	04	04	4.417
LP8	180	C	N/A	-	-
LP9	202.5	D	08	08	4.292
LP10	225	E	N/A	-	-
LP11	247.5	F	N/A	-	-
LP12	270	G	N/A	-	-
LP13	292.5	H	09	09	4.700
LP14	315	I	N/A	-	-
LP15	337.5	J	11	11	4.219
LP16	360	K	N/A	-	-
UP1	13	R	06	06	4.656
UP2	58	S	N/A	-	-
UP3	103	T	07	07	4.688
UP4	148	U	N/A	-	-
UP5	193	V	05	05	4.615
UP6	238	W	N/A	-	-
UP7	283	X	01	01	4.760
UP8	328	Y	N/A	-	-

1) Letter ID of each pin location corresponding to the markings used during initial construction

2) Indicates "as built" dimension of the replacement pin length "L"

TABLE 3

REPAIRED PRELOADS AND DISPLACEMENTS

Pin design.	Calculated preload, lbs	Displacement, mils	
		Installed	Calculated
LP1	27,900	9.0	-
LP2	15,331	-	4.8
LP3	28,200	9.0	-
LP4	* UNKNOWN	-	?
LP5	28,050	9.0	-
LP6	8,303	-	2.6
LP7	26,700	9.0	-
LP8	10,250	-	3.2
LP9	25,050	9.0	-
LP10	16,919	-	5.2
LP11	28,375	-	9.0
LP12	20,820	-	6.5
LP13	24,600	9.0	-
LP14	2,508	-	0.8
LP15	27,750	9.0	-
LP16	* UNKNOWN	-	?
UP1	9,300-14,000	18.0	-
UP2	** +(0-8100)	-	** +10.4
UP3	9,300-14,000	18.0	-
UP4	** +(0-8100)	-	** +10.4
UP5	9,300-14,000	18.0	-
UP6	** +(0-8100)	-	** +10.4
UP7	9,300-14,000	18.0	-
UP8	** +(0-8100)	-	** +10.4

* The unknown values were assumed to be gapped for conservatism

** Loads and displacements in addition to existing preloads and displacements

TABLE 4

REFERENCES

1. Letter No. LIC-84-090 to J. R. Miller (NRC) from W. C. Jones (OPPD) Dated April 4, 1984, Fort Calhoun Station Thermal Shield Inspection

2. Docket No. 50-285, Letter to W. C. Jones (OPPD) from J. R. Miller (NRC) Dated May 4, 1984, Fort Calhoun Station Thermal Shield Inspection

3. Letter No. LIC-86-421 to A. C. Thadani (NRC) from R. L. Andrews (OPPD) Dated August 28, 1986, Fort Calhoun Thermal Shield Support System Inspection Deferral

4. Docket No. 50-285 Letter to R. L. Andrews (OPPD) from W. A. Paulson (NRC) Dated February 12, 1987, Thermal Shield Support System Inspection Deferral - Fort Calhoun Station, Unit No. 1

5. Letter No. LIC-83-189 to R. A. Clark (NRC) from W. C. Jones (OPPD) Dated August 2, 1983, Evaluation of the Impact of a Thermal Shield Support System Failure in the Fort Calhoun Reactor

6. Letter No. LIC-87-673 to NRC Document Control from R. L. Andrews (OPPD) Dated October 13, 1987, Additional Information on the Fort Calhoun Internals Vibration Monitoring System