BAW 1784
May 1983

B&W OWNERS GROUP

BOLTING TASK FORCE

SUMMARY REPORT OF
NUCLEAR REGULATORY COMMISSION/
BABCOCK & WILCOX OWNERS GROUP
MEETING ON
REACTOR VESSEL INTERNALS BOLTING
MAY 6, 1983

Arkansas Power & Light
Consumers Power Co.
Duke Power Co.
Florida Power Corp.
GPU Nuclear
Sacramento Municipal Utility District
Toledo Edison Co.

SUMMARY REPORT OF

NUCLEAR REGULATORY COMMISSION /

BABCOCK & WILCOX OWNERS GROUP

MEETING ON

REACTOR VESSEL INTERNALS BOLTING

MAY 6, 1983

BAW 1784

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

As a result of failures discovered at Oconee in July of 1981 in the bolts fastening the lower portion of the reactor vessel internals thermal shield to the lower grid assembly, a program for reactor vessel internal bolt inspection and repair was initiated. This program resulted in the discovery in March 1983 at Rancho Seco similar failures of bolts in the upper core barrel to core support shield joint. In April of 1983, ultrasonic tests at Crystal River 3 showed abnormal indications in 4 lower core barrel bolts and a number of upper core barrel bolts. The discovery of the additional anomalies in core barrel joints led the B&W Owners Group (B&WOG) Steering Committee to direct the formation of a special Task Force on internals bolts (see Figure 1.0). This task force is made up of representatives of all B&W designed 177 FA plant Owners and is chaired by C.W. Hendrix, Jr. of Duke Power Company.

The Task Force mission is to provide a forum for sharing information on inspections, testing, and repairs related to the internals bolting problem and thereby maintaining cognizance of all activities pertaining to internals bolt failures. The Task Force will also maintain a consistent licensing posture for generic safety issues that may be raised. It will provide a means of monitoring generic issues and will provide a means to expedite of the performance of necessary generic activities.

Thus, the B&W Owners Group has taken two immediate actions related to the internals bolting concern. One action was to provide an initial evaluation that currently operating facilities provide no undue risk to the public health and safety. This is based on the assessments that there are large design margins in reactor vessel internals bolting systems, that current inspections reveal bolt failure levels well below those required for joint failures and that even should joint failure occur no significant safety hazard will result. The second action was to establish an organization among the B&W Owners (i.e., the Bolting Task Force) to continue to investigate and evaluate new information for resolution of problems found. The Bolting Task Force reports to the Steering Committee.

B&W Owners Group Organization

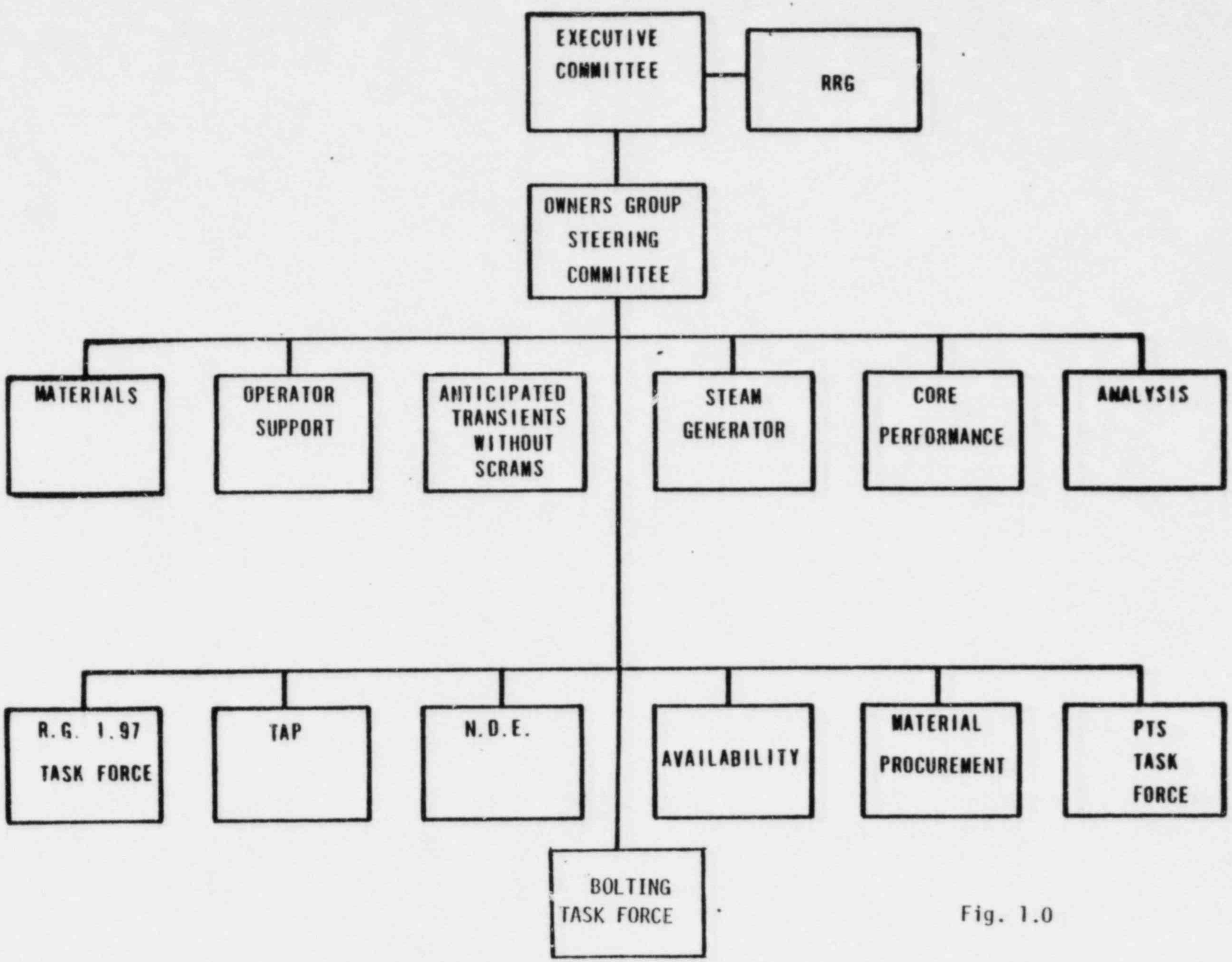


Fig. 1.0

The results of the initial evaluation were presented to the NRC on May 6, 1983. The handouts for that meeting are contained in Appendix A and the remainder of this report provides a summary of this initial evaluation and the additional information requested by the NRC after the May 6th meeting. The May 6, 1983 presentation included specific statements by Toledo Edison and Duke Power concerning their justification for continued operation of the Davis Besse and Oconee Units. A statement was also made by representatives of Arkansas Power and Light regarding their restart plans for ANO-1.

The purpose of this document is to formalize the information presented during the May 6, 1983, meeting.

2. TECHNICAL BACKGROUND

2.1 General Description

The reactor vessel internals, shown in Figure 2.1, are designed primarily to support and restrain the core while maintaining fuel assembly alignment and alignment between the fuel assemblies and the control rod assemblies. Secondarily, the internals direct the flow of reactor coolant through the core, provide gamma and neutron shielding and guides for incore instrumentation. Lastly, the internals support internals vent valves and, in some plants, surveillance specimen holder tubes.

The internals are designed to withstand loading from normal operation and upset conditions as well as design basis accidents. All reactor vessel internals have five bolted joints using A286 bolting material located as shown in Figure 2.2. These are:

- upper core barrel to core support shield, (Figure 2.3)
- upper thermal shield to upper core barrel, (Figure 2.4)
- lower thermal shield to lower grid assembly, (Figure 2.5)
- lower core barrel to lower grid assembly, (Figure 2.5)
- lower grid assembly to flow distributor. (Figure 2.6)

Additionally, four plants - Davis Besse 1, Crystal River 3, and Midland 1 and 2 - have surveillance specimen holder tubes bolted to the thermal shield.

Of these joints, only the upper core barrel (UCB) and lower core barrel (LCB) bolting has core support significance. Should the bolts in either of these joints fail, the core and internals would drop onto guide lugs welded to the inside wall of the reactor vessel. These twelve (12) guide lugs are equally spaced around the internal circumference of the reactor vessel. The essentially L-shaped lugs are machined from Inconel ASME SB168 plate and are attached to the inner reactor vessel wall below the core and reactor vessel internals by full penetration welds. The lugs have a 3-1/4" thick 13-1/2" long horizontal leg and a 9" high vertical leg, tapering from 3" thick at the bottom to 2-5/8" at the top. (See Figure 2.7) As mentioned, these lugs

177 FA PLANT REACTOR VESSEL INTERNALS ASSEMBLY

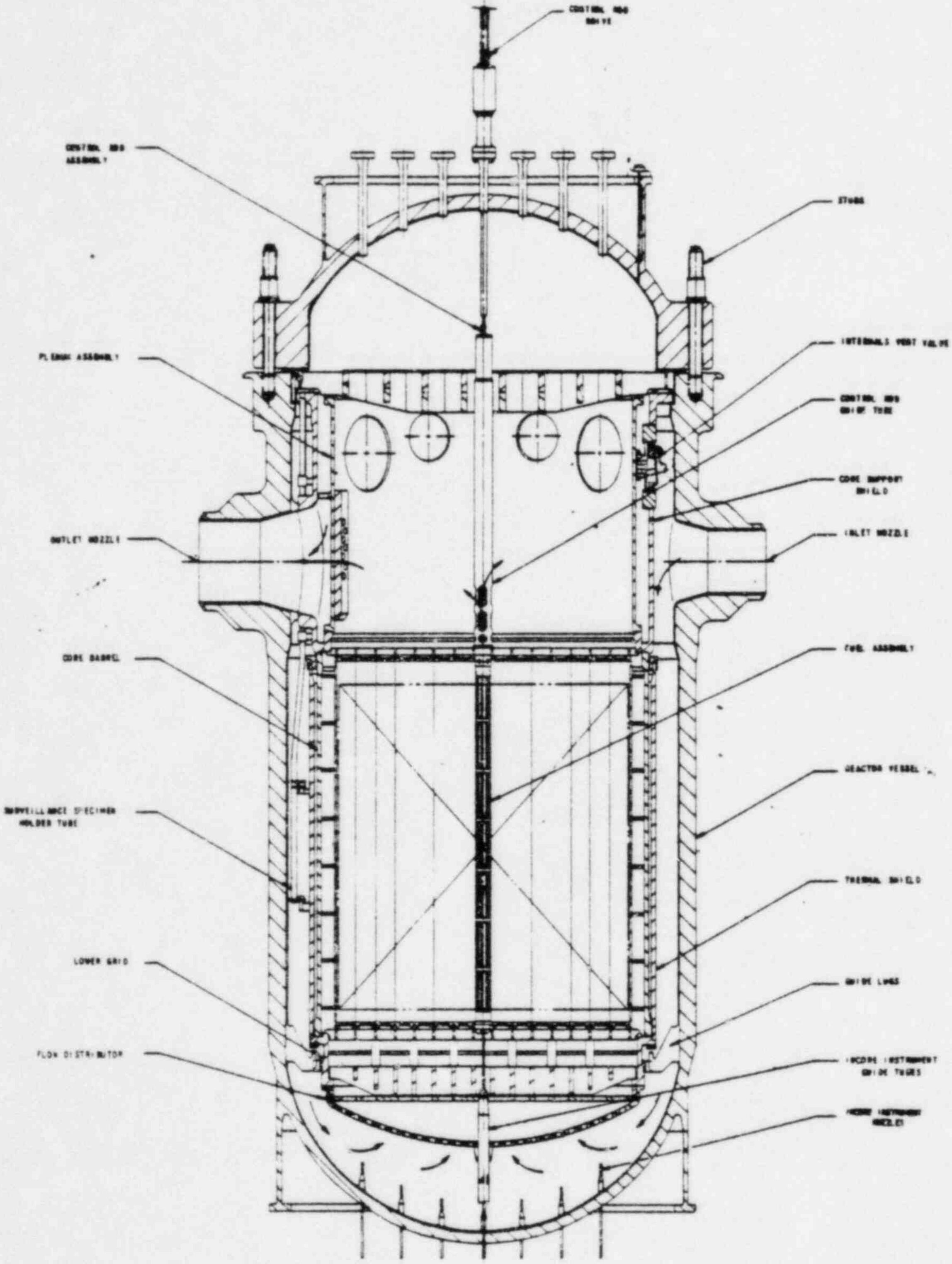


Fig. 2.1

177 FA PLANT RV INTERNALS
A286 BOLTED JOINTS

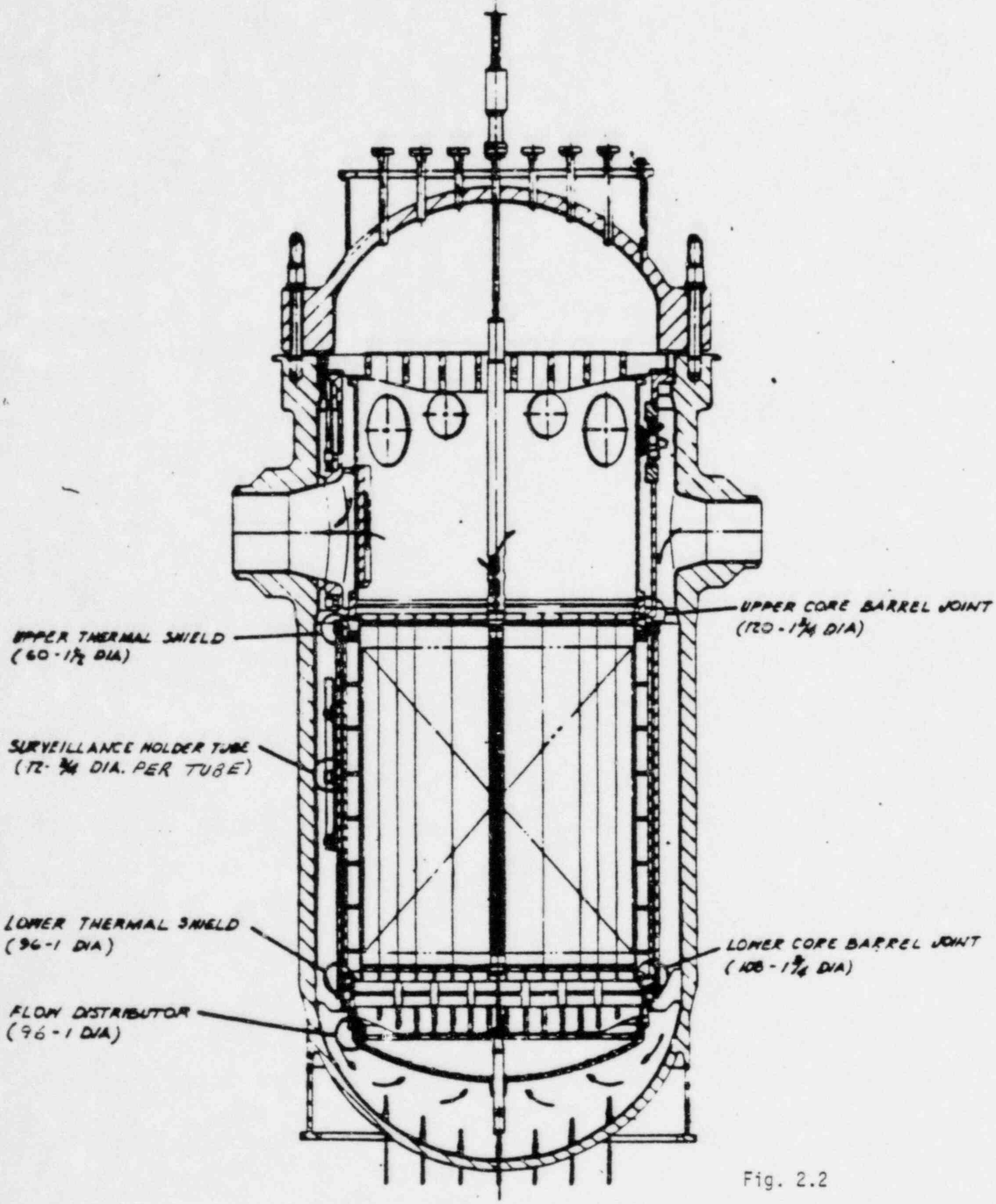


Fig. 2.2

UPPER CORE BARREL TO CORE SUPPORT
SHIELD BOLTED JOINT DETAIL

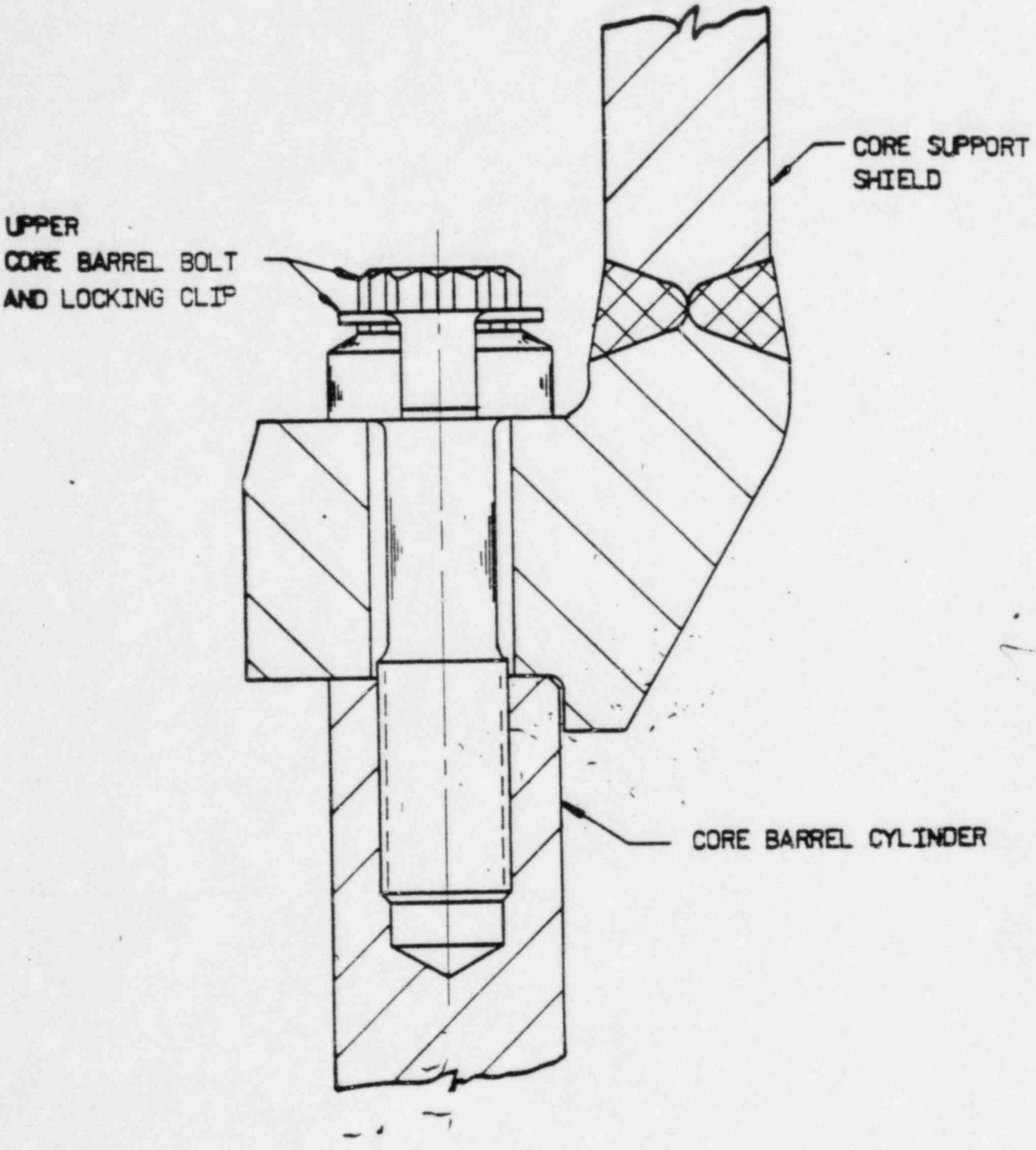


Fig. 2.3

UPPER THERMAL SHIELD RESTRAINT

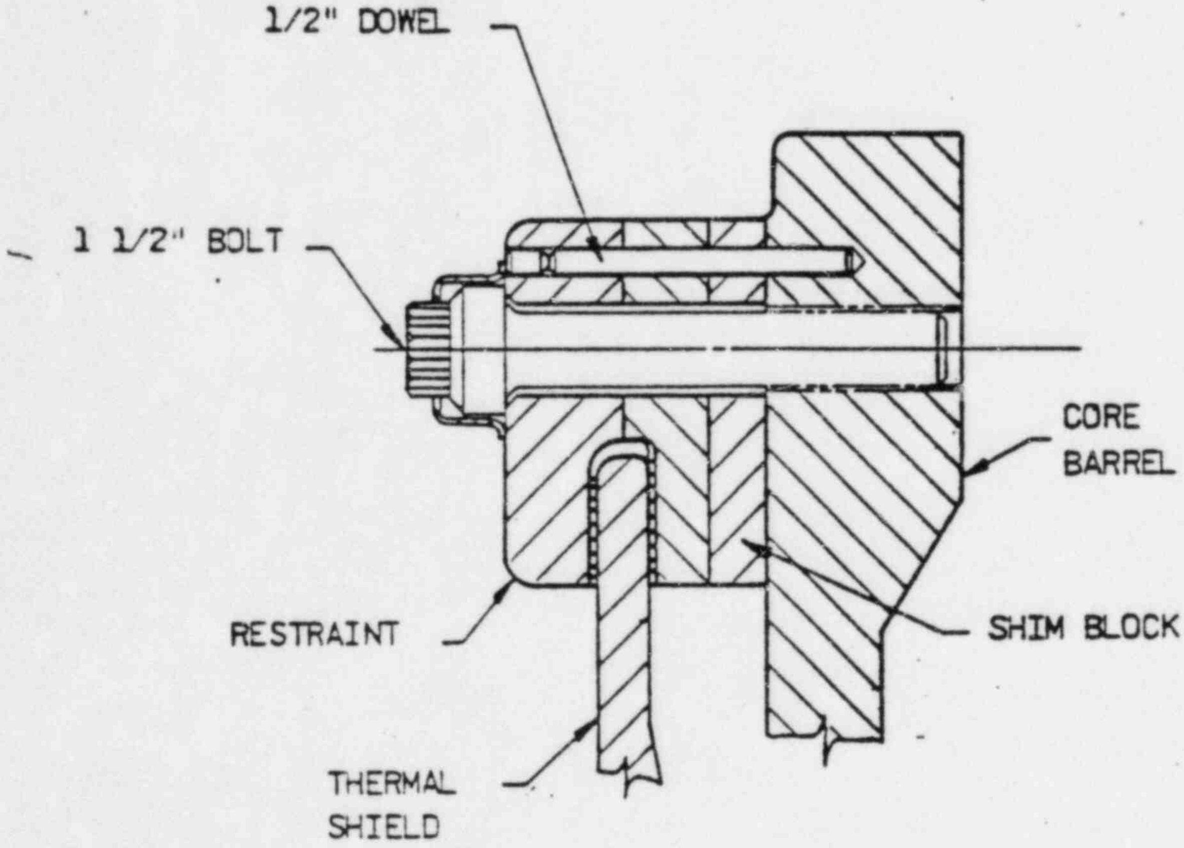


Fig. 2.4

LOWER CORE BARREL TO LOWER GRID JOINT DETAIL

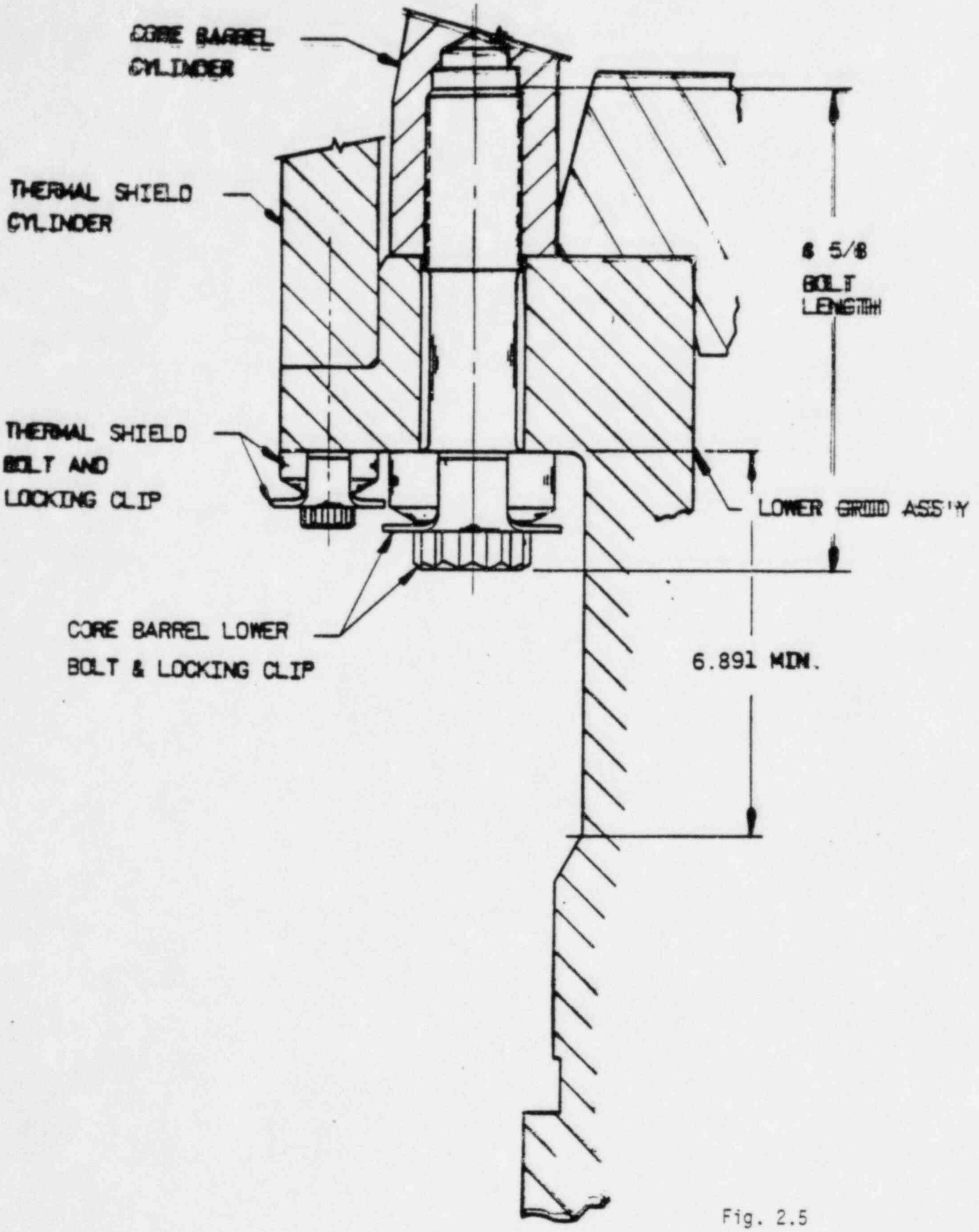


Fig. 2.5

LOWER GRID FLOW DISTRIBUTOR BOLT JOINT DETAIL

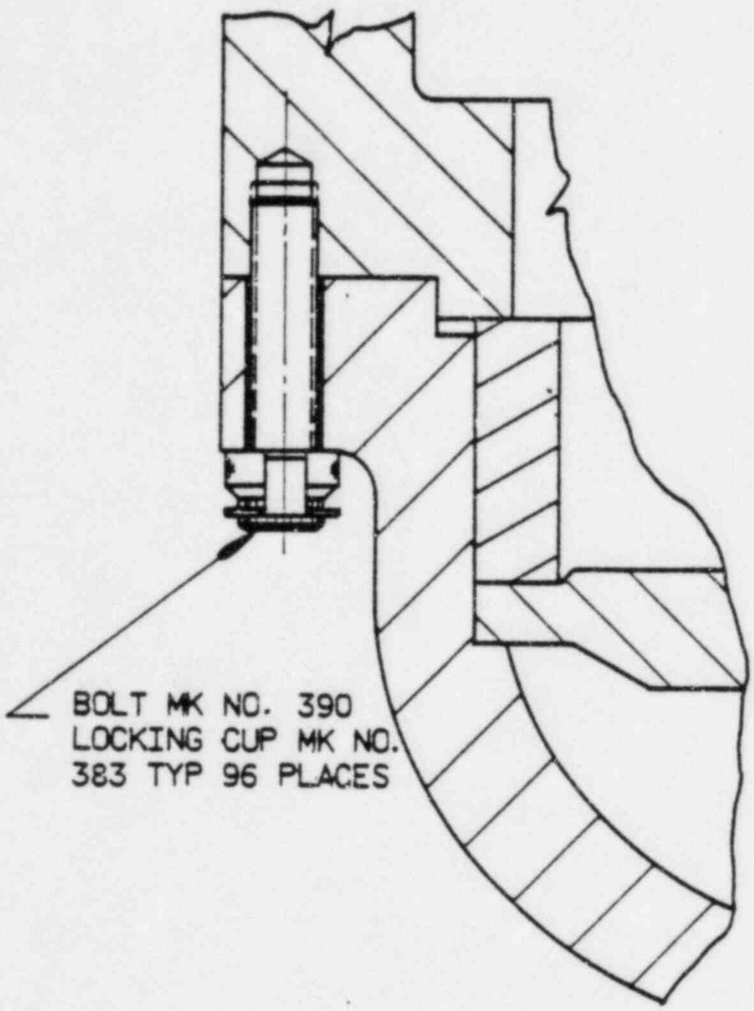


Fig. 2.6

provide support of the core and reactor vessel internals should either the upper core barrel to core support shield or the lower core barrel to lower guide assembly joint fails and the core drops. The guide lugs, together with guide block positioned on either side of each lug and fastened to the internals, provide restraints to horizontal or rotational motion of the core in either the normal or dropped core positions.

The bolting in the first five joints listed above is made of a nickel/chrome steel (A286) designated as SA 453 GR660, Condition A material (solution treated at 1650F for 2 hours and age hardened at 1325F for 16 hours). The quantity, location and size of these bolts are shown in Table 2.1. All bolts originally installed in these joints were hot headed. In addition, the thermal shield bolts were heavily cold worked before head forming or threading. All bolts in these five joints have welded locking clips to capture the bolt and prevent bolt rotation.

The sixth joint on the four plants with surveillance specimen holder tubes is also A286 material but is Condition B (solution treated at 1800F for 1 hr and age hardened at 1325F for 16 hrs) with the heads machined instead of hot headed.

B&W-designed 177 FA plants that use A286 material for internals bolting are:

Plant	NSS ASME Code Edition
o Oconee 1, 2 & 3	Summer 1967
o ANO-1	Summer 1967
o Crystal River 3	Summer 1967
o Rancho Seco	Summer 1967
o Davis Besse 1	Summer 1968
o Midland 1 & 2 (under construction)	Summer 1968

TABLE 2.1

BOLTED JOINTS WITH A-286 MATERIAL

UPPER CORE BARREL (120 - 1 3/4 DIA.)

LOWER CORE BARREL (108 - 1/ 3/4 DIA.)

FLOW DISTRIBUTOR TO LOWER GRID (96 - 1 DIA.)

UPPER THERMAL SHIELD (60 - 1 1/2 DIA.)

LOWER THERMAL SHIELD (96 - 1 DIA.)

*SURVEILLANCE HOLDER TUBE (12 - 3/4 DIA. PER TUBE)

SA 453 GR 660 (A-286) IS AN AGE HARDENED, HIGH STRENGTH, CORROSION RESISTANT MATERIAL. BOLTS ARE CONDITION A/UPSET HEADED EXCEPT THE SURVEILLANCE HOLDER TUBE BOLTS WHICH ARE CONDITION B/MACHINED.

*DB-1, CR-3 (6 TUBES) AND MIDLAND 1 & 2 (3 TUBES)

LUG & GUIDE BLOCK LOCATIONS

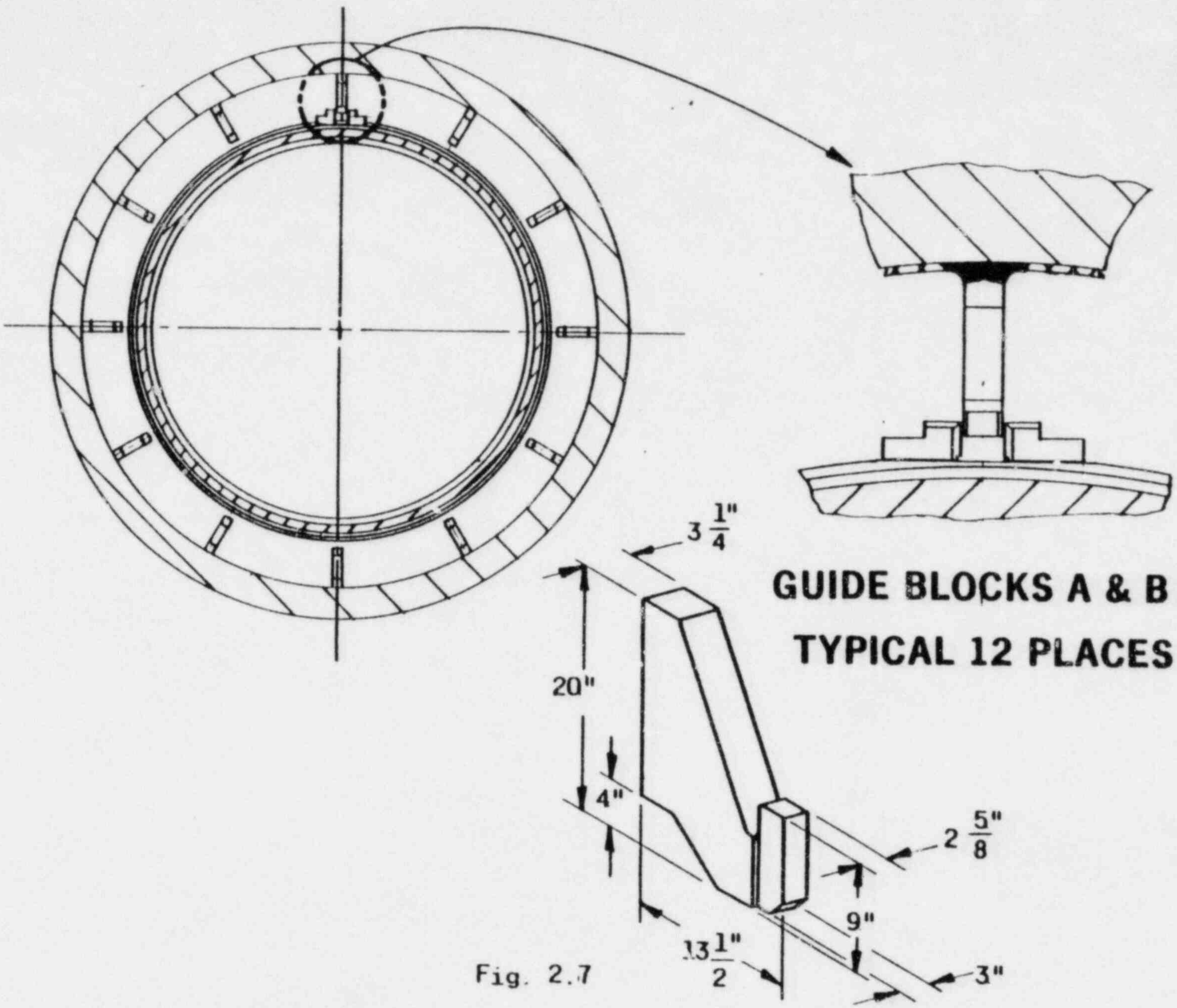


Fig. 2.7

2.2 Problem Definition

Cracking in A286 bolting material was first noted in the lower thermal shield (LTS) bolts during ISI inspection at Oconee 1 in July of 1981. As a result of the LTS bolt failures found at Oconee 1, a program for inspection and repair of LTS bolts was initiated for the Oconee units. In addition to the LTS bolt examinations during late 1981 and the first half of 1982, a sampling, by U.T. examination, was made of upper and lower core barrel bolts for all three Oconee units. No abnormal indications were noted. Following these examinations, Rancho Seco, in March of 1983 during their refueling outage, noted 19 of 120 upper core barrel bolt failures. In April of 1983 during the Crystal River 3 refueling outage, 51 of 120 upper core barrel bolts and 4 of 108 lower core barrel bolts showed abnormal indications on U.T. examination. These findings led ANO-1 to extend their refueling outage to U.T. examine their UCB bolts. Only 7 of 120 abnormal indications were noted.

TMI-1 is not included in this concern because the bolting for their reactor vessel is made from Inconel X750. Specifically, the material is ASTM A637-70, Grade 688, Type 2 (solution annealed at greater than 1800°F). General Public Utilities Nuclear had UT examinations made of 96 of 120 of their UCB bolts and no abnormal indications were found.

2.3 Upper and Lower Core Barrel Bolts Design Basis

The upper and lower core barrel bolts were designed to withstand the loads generated during normal operation and upset conditions due to joint prestress, dead weight, thermal, flow induced vibration and operating basis earthquake. The UCB and LCB bolts were also analyzed for faulted conditions considering the loads generated by a large break LOCA and core bounce, a safe shutdown earthquake and dead weight of the core and internals.

Examination of these analyses indicates that large design margins exist for the UCB/LCB bolt rings. The minimum number of bolts need to maintain bolt integrity has been calculated for both normal operation and faulted conditions. The results are shown in Table 2.2 and 2.3. In the calculation of the minimum number of bolts for normal operation as shown in these tables, prestress was included in the loads considered. Thus, credit was taken for the compressive forces between the flanges of the joint produced by this prestress. This results in joints with higher prestress requiring fewer bolts to maintain joint integrity. This is not the case for faulted conditions. Prestress was not included in the faulted condition calculation since the joint was assumed to be open with the loads being carried only by the bolts themselves.

Tables 2.2 and 2.3 show that a large number of either the UCB bolts or the LCB bolts can fail before joint integrity is lost. These large margins exist because the bolting rings were originally designed for low strength bolting. Changes in design loadings for faulted conditions, and the original design requirement to maintain the joint closed, resulted in the selection of high strength bolting. With high strength bolting at higher initial prestress, considerable additional margin for normal operating and faulted conditions was achieved.

2.4 Ultrasonic Examinations

Special procedures were developed from laboratory test work done at B&W's Lynchburg Research Center. These procedures and a brief description of the laboratory backup for these examinations are provided in Appendix C of this report.

The technique used three calibration bolts, one bolt with no notch, one bolt with a 15% notch, and one bolt with a 50% notch. A 2.25 MHz transducer was used. The transducers were 1/2", 3/4", or 1" diameter, depending on bolt size, was used. Signal response from head to shank at 40% of full screen height was used to set sensitivity.

TABLE 2.2

MINIMUM NUMBER OF UCB BOLTS

TO MAINTAIN JOINT INTEGRITY

120 UCB BOLTS

PLANT	PRESTRESS-PSI	NORMAL[1] OPERATION	FAULTED[2] CONDITIONS
		OPERATING PLANTS	
OCONEE 1	10,000	27	50
OCONEE 2	24,000	12	45
OCONEE 3	36,500	8	43
DAVIS BESSE[3]	36,500	8	46
		PLANTS RECENTLY INSPECTED	
RANCHO SECO	36,500	8	45
CRYSTAL RIVER 3	36,500	8	45
ANO-1	36,500	8	45

(1) NORMAL OPERATION LOADS CONSIDERED PRESTRESS, THERMAL, DEAD WEIGHT, AND FIV

(2) FAULTED CONDITION LOADS CONSIDERED LBLOCA, SSE, DEAD WEIGHT, AND CORE BOUNCE. CALCULATION CONSIDERED ACTUAL ULTIMATE STRENGTHS RATHER THAN CODE MINIMUMS.

(3) DB-1 HAS A RAISED REACTOR COOLANT LOOP RATHER THAN A LOWERED REACTOR COOLANT LOOP DESIGN USED IN ALL OTHER 177 FA UNITS.

TABLE 2.3

MINIMUM NUMBER OF LCB BOLTS

TO MAINTAIN JOINT INTEGRITY

108 LCB BOLTS

PLANT	PRESTRESS-PSI	NORMAL (1) OPERATION	FAULTED (2) CONDITIONS
		OPERATING PLANTS	
OCONEE 1	10,000	24	21
OCONEE 2	19,000	13	18
OCONEE 3	28,000	9	18
DAVIS BESSE (3)	28,000	9	16
		PLANTS RECENTLY INSPECTED	
RANCHO SECO	19,000	13	18
CRYSTAL RIVER 3	28,000	9	18
ANO-1	19,000	13	19

(1) NORMAL OPERATION LOADS CONSIDERED PRESTRESS, THERMAL, DEAD WEIGHT, AND FIV.

(2) FAULTED CONDITION LOADS CONSIDERED LBLOCA, SSE, DEAD WEIGHT, AND CORE BOUNCE. CALCULATION CONSIDERED ACTUAL ULTIMATE STRENGTHS RATHER THAN CODE MINIMUMS.

(3) DB-1 HAS A RAISED REACTOR COOLANT LOOP RATHER THAN A LOWERED REACTOR COOLANT LOOP DESIGN USED IN ALL OTHER 177 FA UNITS.

Results of examinations correlated well with field observations of bolts with abnormal indications. Similarly, laboratory destructive analysis of two bolts with abnormal indications and one bolt with no indications taken from the Rancho Seco UCB bolt ring correlated well with the field UT results. Bolt (#79) from Rancho Seco which showed no indication by field UT did show a small anomaly in the shank during the laboratory examination. This anomaly was not the result of intergranular attack nor located in a part of the shank where such attack has been noted on failed bolts (see Section 3.2.2). In addition, the anomaly would not significantly reduce the load carrying capability of the bolt and was well below the minimum field UT detection threshold of 15% of the shank diameter set by the calibration.

3. INSPECTIONS AND EXAMINATIONS

3.1 Site Inspections

To date, UT examinations have been made at the three Oconee units, Rancho Seco, Crystal River 3, and ANO-1 for bolts with A286 material and at TMI-1 on bolts made from Inconel X750. Table 3.1 shows a summary of these tests by plant and joint location. Figure 3.1 shows the pattern of abnormal indications found in the UCB bolt ring at Rancho Seco. Figure 3.2 and 3.3. show the pattern of UT indications at Crystal River 3 for the UCB and LCB bolt rings, respectively. Figure 3.4 shows the 7 abnormal indications in the UCB bolt ring found at ANO-1. The inspection to date indicates a fairly evenly distributed and random pattern. There also appears to be no orientation that coincides with reactor coolant flow patterns or component design geometry. Table 3.2 summarizes the results of field inspections performed to date on UCB, LCB, SSHT and flow distributor bolts.

3.2 Laboratory Examination

3.2.1 Oconee 1 & 2 Examinations

In the late summer and fall of 1981, 8 samples were taken of lower thermal shield (LTS) bolts from Oconee 1 and 19 LTS bolts were taken from Oconee 2 in January 1982. Visual examination, fluorescent penetrant tests, scanning electron microscope (SEMs) and metallography examinations were made on each bolt from Oconee 1 and a similar set of tests were run on the 19 Oconee 2 bolts. However, a UT examination was used instead of PT for the Oconee 2 bolts. Test results showed intergranular attack at the head to shank transition region each of the bolts that showed abnormal indications by site UT examination.

Three upper thermal shield and two upper core barrel bolts from Oconee 1 were also examined. No cracking was noted by visual examination, fluorescent penetrant test, or SEM surface examination of any of these bolts. This confirmed field UT examination results made during the Oconee 1 refueling outage.

Lastly, one flow distributor bolt from Oconee 1 was visually examined and fluorescent penetrant tested and no cracking was noted.

TABLE 3.1

UT INSPECTION RESULTS (# CRACKED/ # INSPECTED)

BOLTED JOINT	OCONEE 1 (9-81)	OCONEE 2 (1-82)	OCONEE 3 (6-82)	ANO-1 (5-83)	RANCHO SECO (3-83)	CR-3 (4-83)
UPPER CORE BARREL (120 - 1-3/4 DIA.)	0/21	0/30	·0/30	7/120	19/120	51/120
LOWER CORE BARREL (108 - 1-3/4 DIA.)	0/16	0/24	0/24	----	0/108	4/108
FLOW DIST/LOWER GRID (96 - 1 DIA.)	0/22	0/25	0/25	----	0/93	0/96
UPPER THERMAL SHIELD (60 - 1½ DIA.)	0/25	0/20	0/20	----	0/60	0/60
LOWER THERMAL SHIELD (96 - 1 DIA.)	11/13 94 HEADS TWISTED OFF	28/93 SEVERAL HEADS TWISTED OFF	53/96 SEVERAL HEADS TWISTED OFF	51/96 48 HEADS TWISTED OFF	77/96 75 HEADS TWISTED OFF	74/96 71 HEADS TWISTED OFF
SURVEILLANCE HOLDER TUBE (72 - 3/4 DIA.)*	----	----	----	----	----	25/72

DAVIS BESSE 1 PERFORMED VISUAL INSPECTIONS DURING THEIR 1982 REFUELING OUTAGE OF AND FOUND NO ABNORMAL INDICATIONS

*DB-1 AND CR-3 ONLY

TABLE 3.2

TOTAL UT INSPECTION RESULTS

(UCB, LCB, FLOW DISTRIBUTOR)

BOLTED JOINT	TOTAL BOLTS INSPECTED	TOTAL INDICATIONS	%
UPPER CORE BARREL	441	77	17.5
LOWER CORE BARREL	280	4	1.4
FLOW BIST/LOWER GRID	261	0	0
SSHT (CR-3 ONLY)	72	25	34.7

UPPER CORE BARREL BOLTS
WITH ABNORMAL INDICATIONS

RANCHO SECO

BOLT NOS.

8	32	48	78
12	38	58	92
14	39	62	93
24	40	73	116
31	41	75	

Good Bolt Sample 79

Denotes bolts sent for Laboratory Examinations

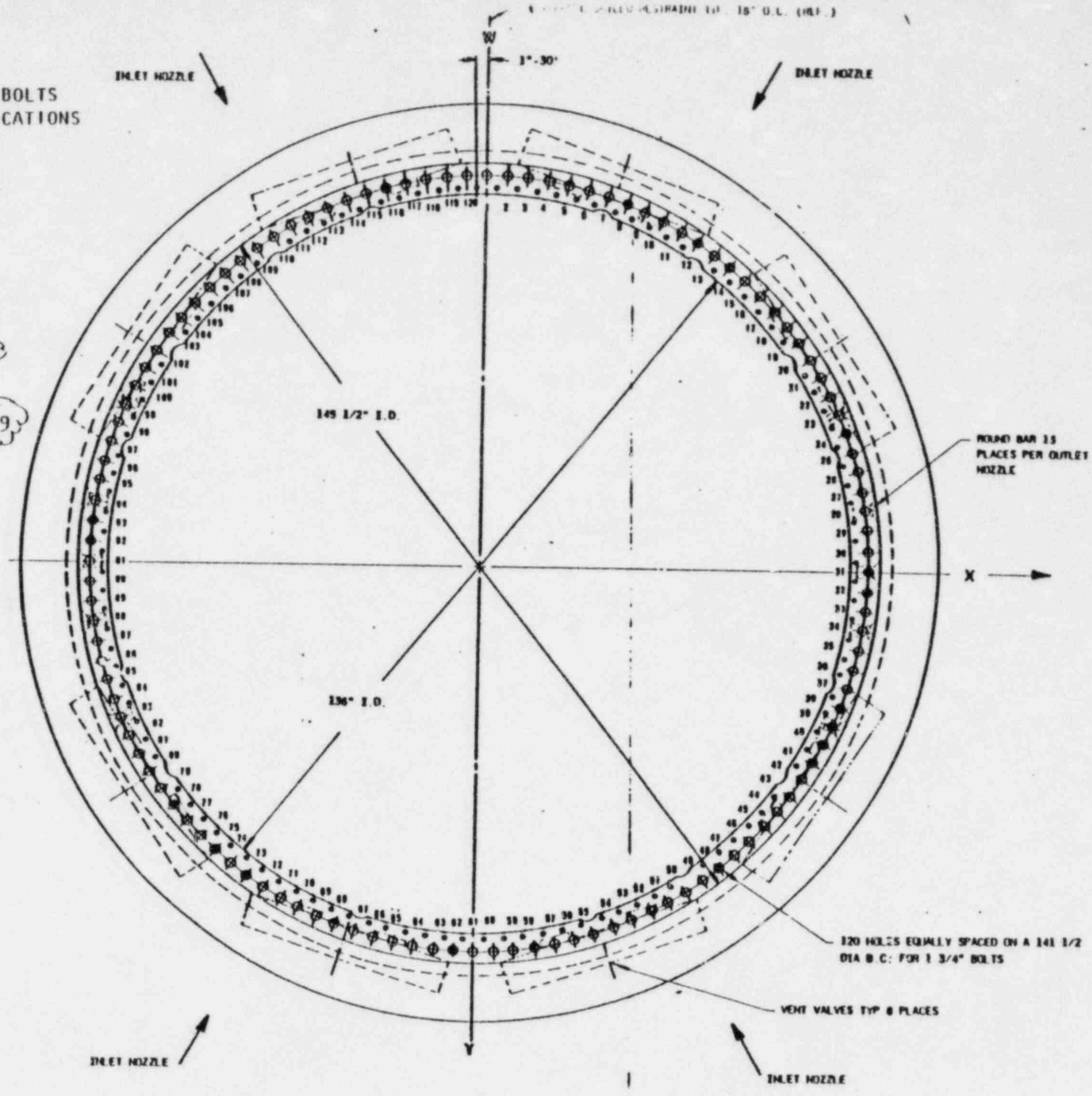


FIG. 3.1

UPPER CORE BARREL BOLTS WITH ABNORMAL INDICATIONS

CR-3

Bolt Nos.

5	25	54	73	96
6	26	57	76	97
12	28	58	79	101
13	34	60	82	108
14	35	61	83	109
15	43	62	87	110
16	44	64	88	111
17	46	66	92	113
18	48	67	93	118
19	52	72	94	119

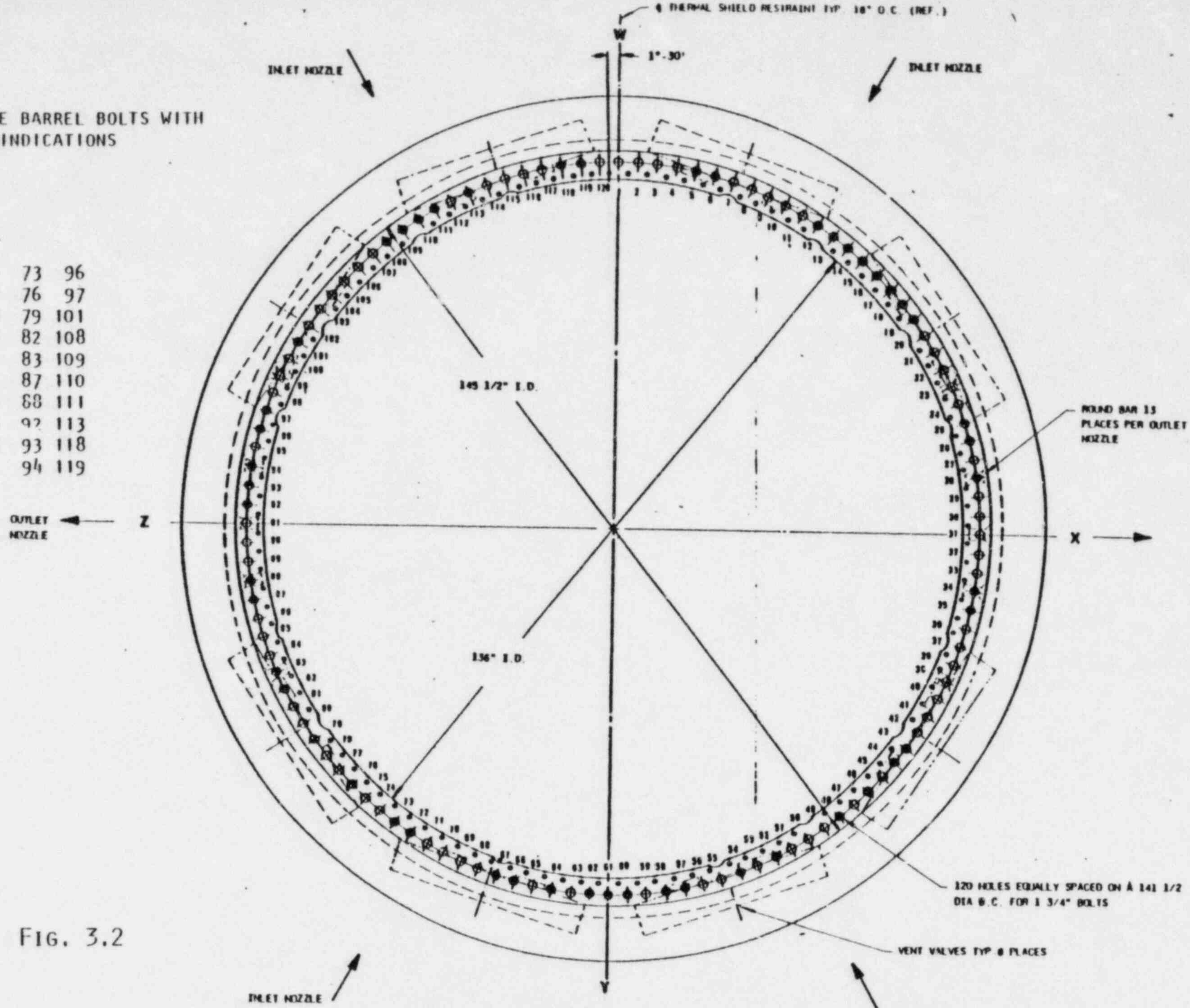
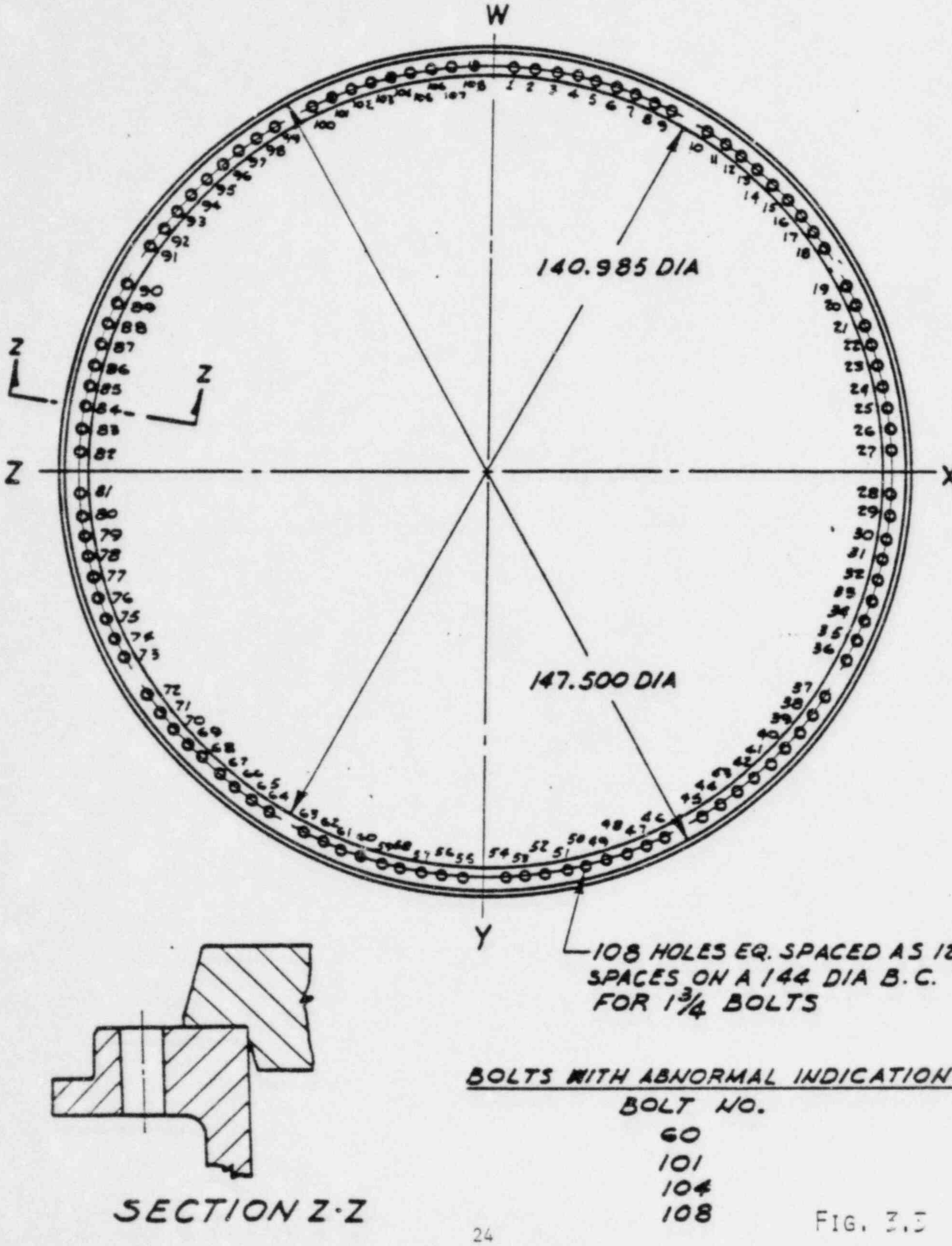


FIG. 3.2

CORE BARREL/LOWER GRID BOLT LOCATIONS
CRYSTAL RIVER-3



BOLTS WITH ABNORMAL INDICATIONS

BOLT NO.
60
101
104
108

FIG. 3.3

UPPER CORE BARREL BOLTS WITH
ABNORMAL INDICATIONS

ANO-1

BOLT NOS.

20	90
49	107
65	112
88	

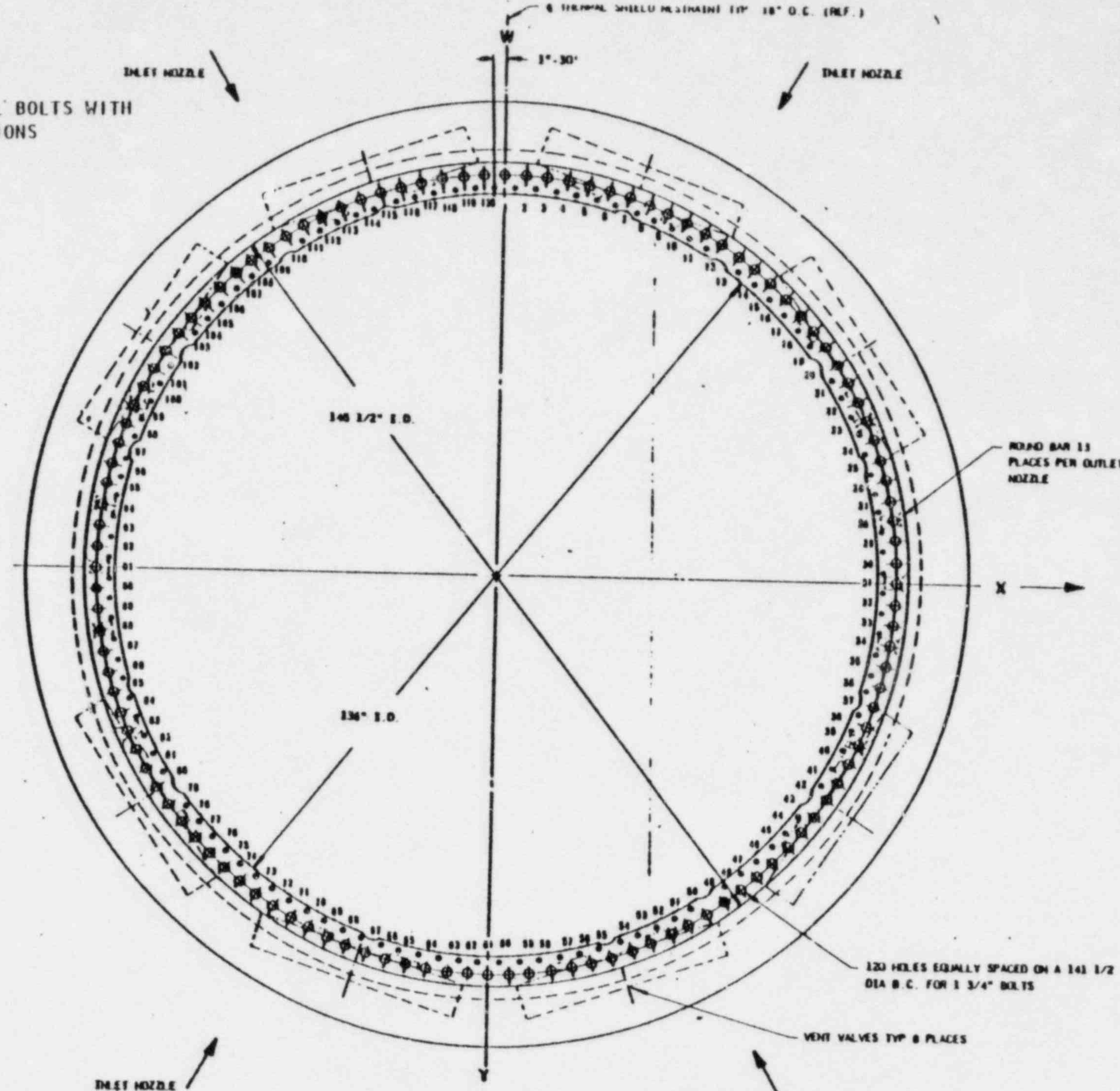


FIG. 3.4

All failures noted in the LTS bolts from Oconee 1&2 were in the head to shank transition region and were attributed to intergranular stress assisted cracking. Also, no cracking was detected n the thread regions. It was also concluded that bolts that were acceptable by site UT were verified to have no flaws by laboratory examinations.

3.2.2 Rancho Seco UCB Bolt Examinations

Two bolts (Bolt Nos. 41 & 116) that showed abnormal indications and one bolt that showed no indications (Bolt 79) from the upper core barrel ring were examined in the laboratory. All three bolts were visually and ultrasonically examined in the laboratory. Metallographic examinations were made on one good bolt and one bolt with cracking. SEM/EDX fracture surface examination was made of bolt 116.

Bolt 79, the bolt showing no indications by field UT, was fluorescent penetrant tested and SEM/EDX examined. Small flaws containing localized deposits were noted in the upper shank region, see Figure 3.6. The surfaces between the flaws opened by ductile rupture when pulled apart. The flaw was not intergranular in nature and showed no secondary cracking. The flaw size was well below the minimum 15% site UT calibration standard and, therefore, would not be expected to be noted by the field UT examination.

The results of the examination of the two cracked bolts showed both bolts to have cracking initiated in the head to shank transition region similar to that found in the lower thermal shield bolts and that the cracking propagated through 95% of the shank area (see Figure 3.5) the cracking noted was typical of intergranular fracture and showed extensive secondary cracking.

These results led to the conclusion that Rancho Seco UCB failures are typical of previously noted LTS bolt failures. It was also judged that the flaw in the bolt that showed no indications by site UT was an anomaly not associated with the other bolt failures and is metallurgically inert showing no evidence of cracking or propagation and no significant loss of load carrying capability.

SKETCH OF UPPER CORE BARREL BOLT
SHOWING LOCATION OF FRACTURE

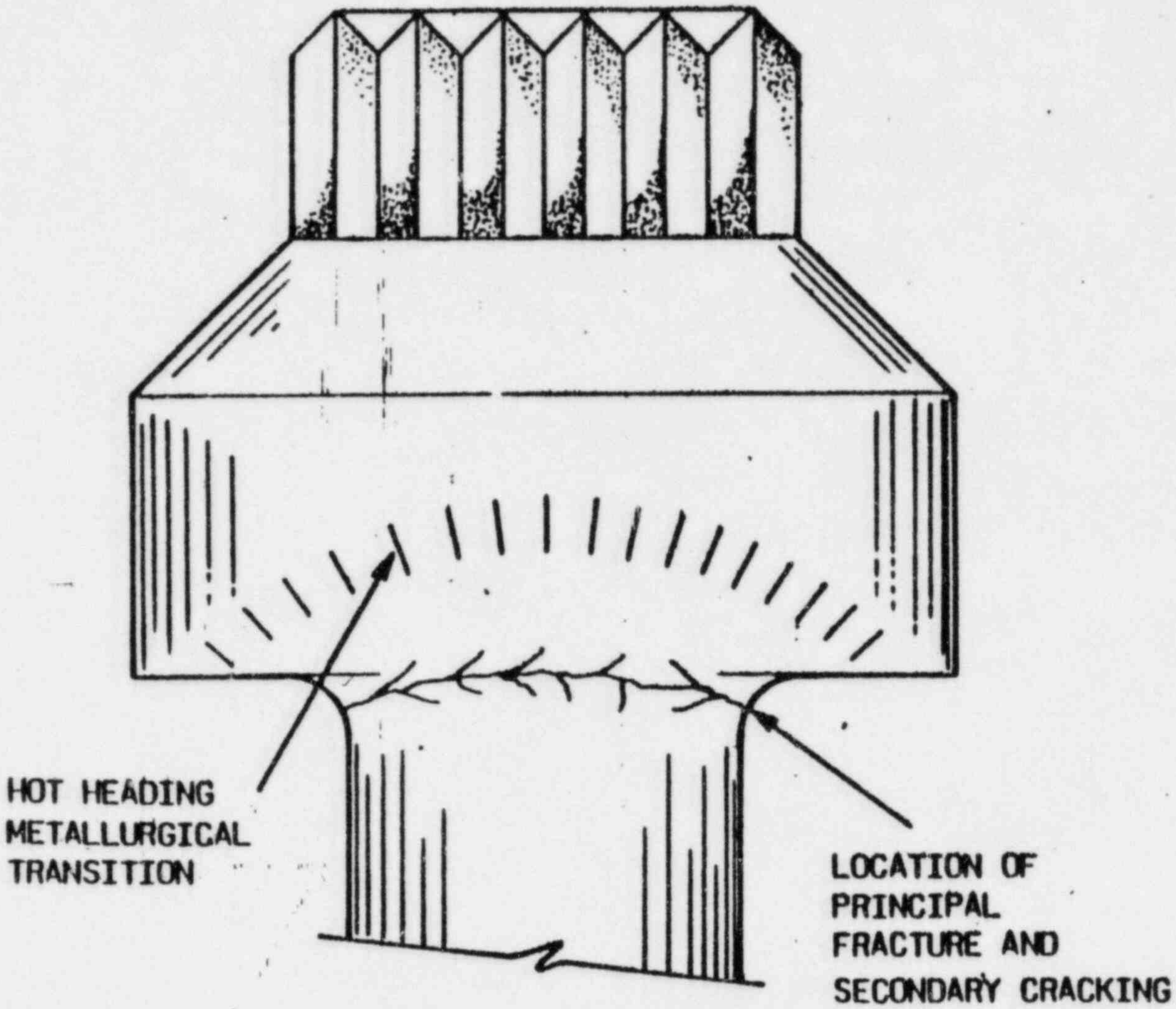


FIG. 3.5

RANCHO SECO UPPER CORE BARREL
BOLT #79

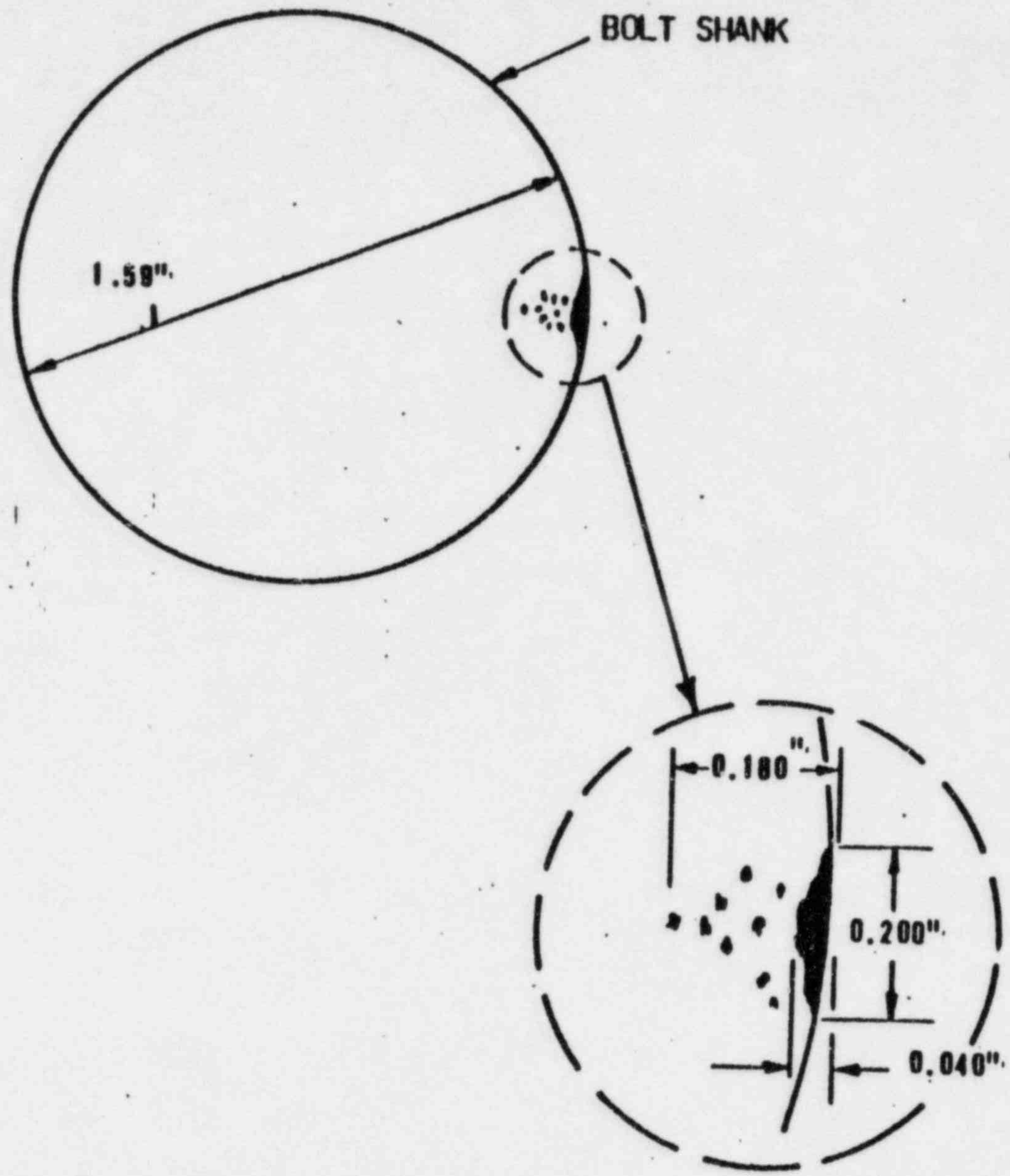


Fig. 3.6

3.2.3 Overall Conclusions

The results of the laboratory examinations of internals bolting from Oconee 1 and 2 and Rancho Seco indicate that all bolt failures in the reactor vessel internals seen to date are due to intergranular stress assisted cracking located in the bolt head to shank transition region. In addition, the laboratory examinations have confirmed the findings of the field ultrasonic examinations.

4. SAFETY IMPLICATIONS

4.1 UCB/LCB Design Margins & Joint Failure Consequences

The justification for the continued operation of the three Oconee plants and Davis Besse 1 and the restart of ANO-1, is based on several factors. Briefly stated, the present conditions are considered satisfactory. Large structural margins exist, severe degradation is detectable, and even if it were not detected, the consequences of core barrel joint failure do not constitute a significant reduction in public health and safety. Further discussion of these factors is presented below.

The upper core barrel and lower core barrel joints have large structural margins which reduce greatly the likelihood in the span time remaining for operation of these plants, that either the upper or lower core barrel joint would fail allowing the core to drop on to the guide lugs. The results of Rancho Seco, Crystal River 3, and ANO-1 inspections shown in Table 4.1, indicated that only 7% of the UCB bolts are needed for joint integrity during normal operation. This may be compared to the results of site UT examinations which showed the following percent of the UCB bolts to have no abnormal indications.

Rancho Seco	84%
CR3	58%
ANO-1	94%

Similarly for the lower core barrel joints during normal operation, only 11% of the bolts are needed for the LCB joint to remain intact at R/S while 100% of the bolts showed good UT examination, while at CR-3 only 8% of the bolts are needed and 96% show to be good.

Despite the large structural margins should severe UCB or LCB bolt degradation occur it is very likely to be detected by periodic neutron noise monitoring. If it were not detected and should the core drop, the dropped condition would be detected by loose parts monitoring backed by possible changes in self powered neutron detector (SPND) and incore thermocouple readouts and reactor coolant activity levels.

TABLE 4.1

LIKELIHOOD OF CORE DROP VERY LOW
BASED ON STRUCTURAL MARGINS AND
RESULTS OF UT INSPECTIONS

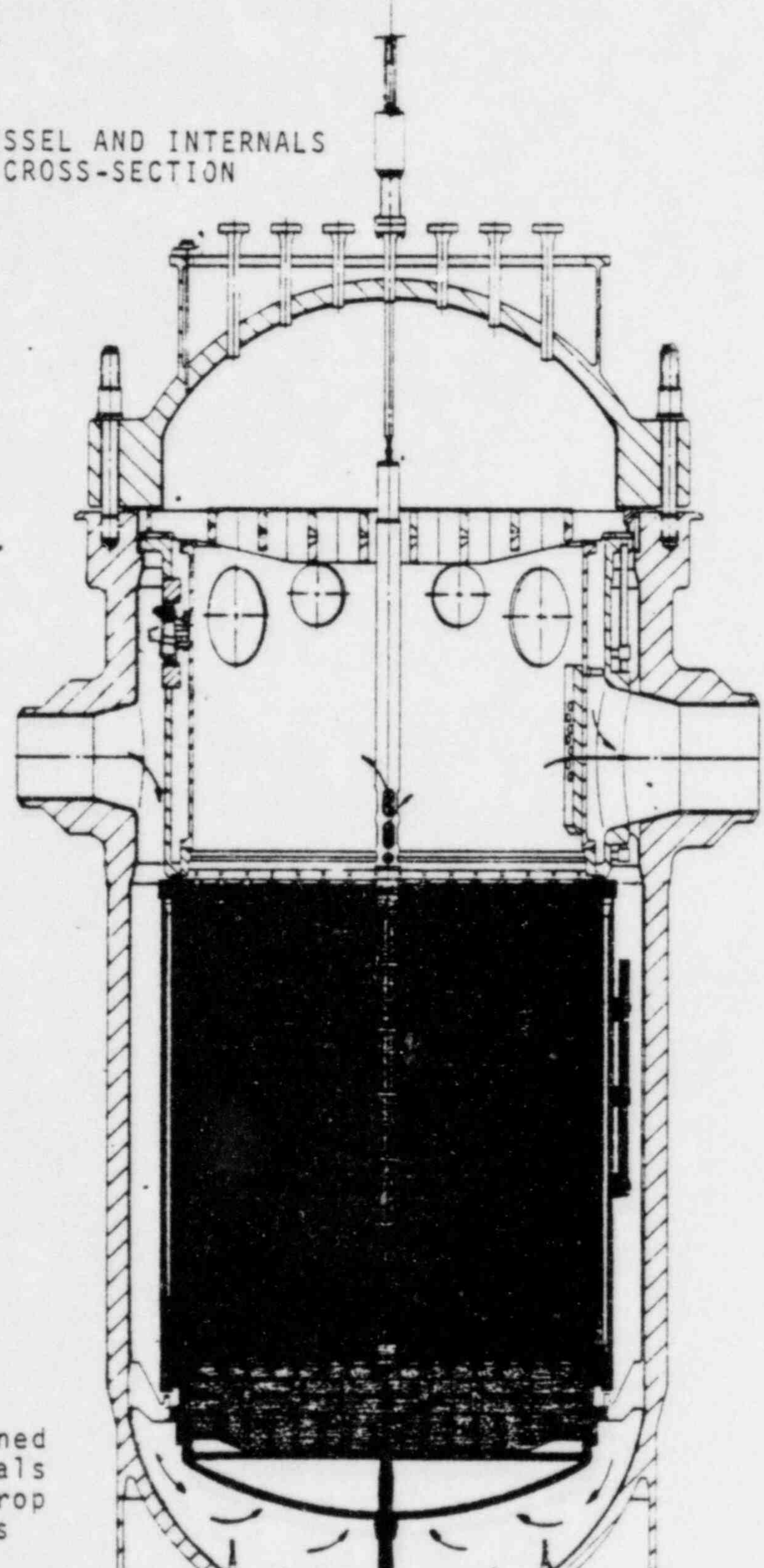
UPPER CORE BARREL (120 BOLTS)

PLANT	MIN # BOLTS REQUIRED FOR NORMAL OPER	RESULTS OF UT INSPECTIONS GOOD BOLTS	DEFECTIVE BOLTS
RANCHO SECO	8	101	19
CR-3	8	69	51
ANO-1	8	113	7

LOWER CORE BARREL (108 BOLTS)

PLANT	MIN # BOLTS REQUIRED FOR NORMAL OPER	GOOD BOLTS	DEFECTIVE BOLTS
RANCHO SECO	13	108	0
CR-3	9	104	4

REACTOR VESSEL AND INTERNALS
ELEVATION CROSS-SECTION



With UCB Joint failure blackened part of internals and the core drop onto guide lugs

Fig. 4.1

UPPER CORE BARREL WITH
JOINT FAILURE

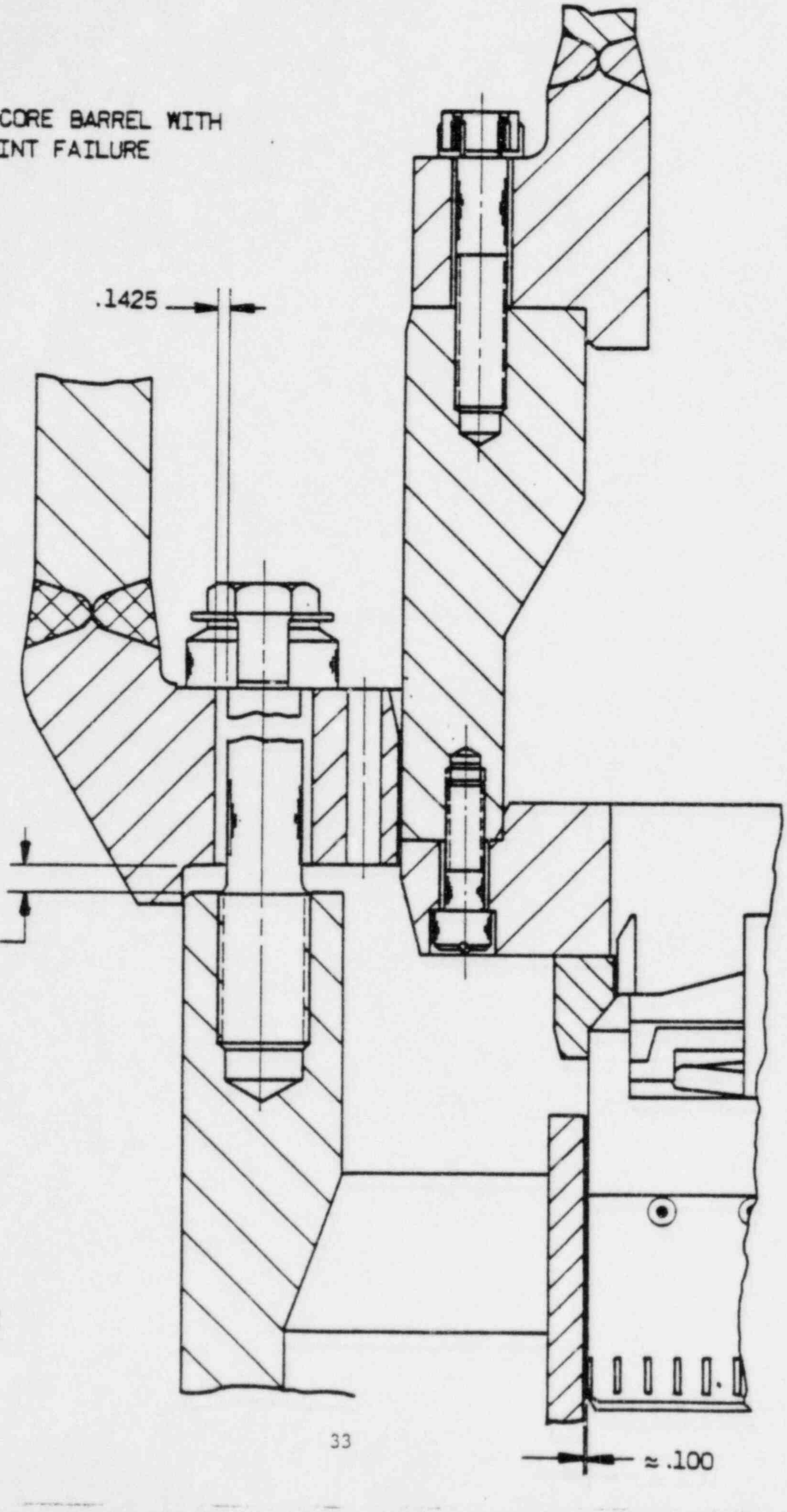


Fig. 4.2

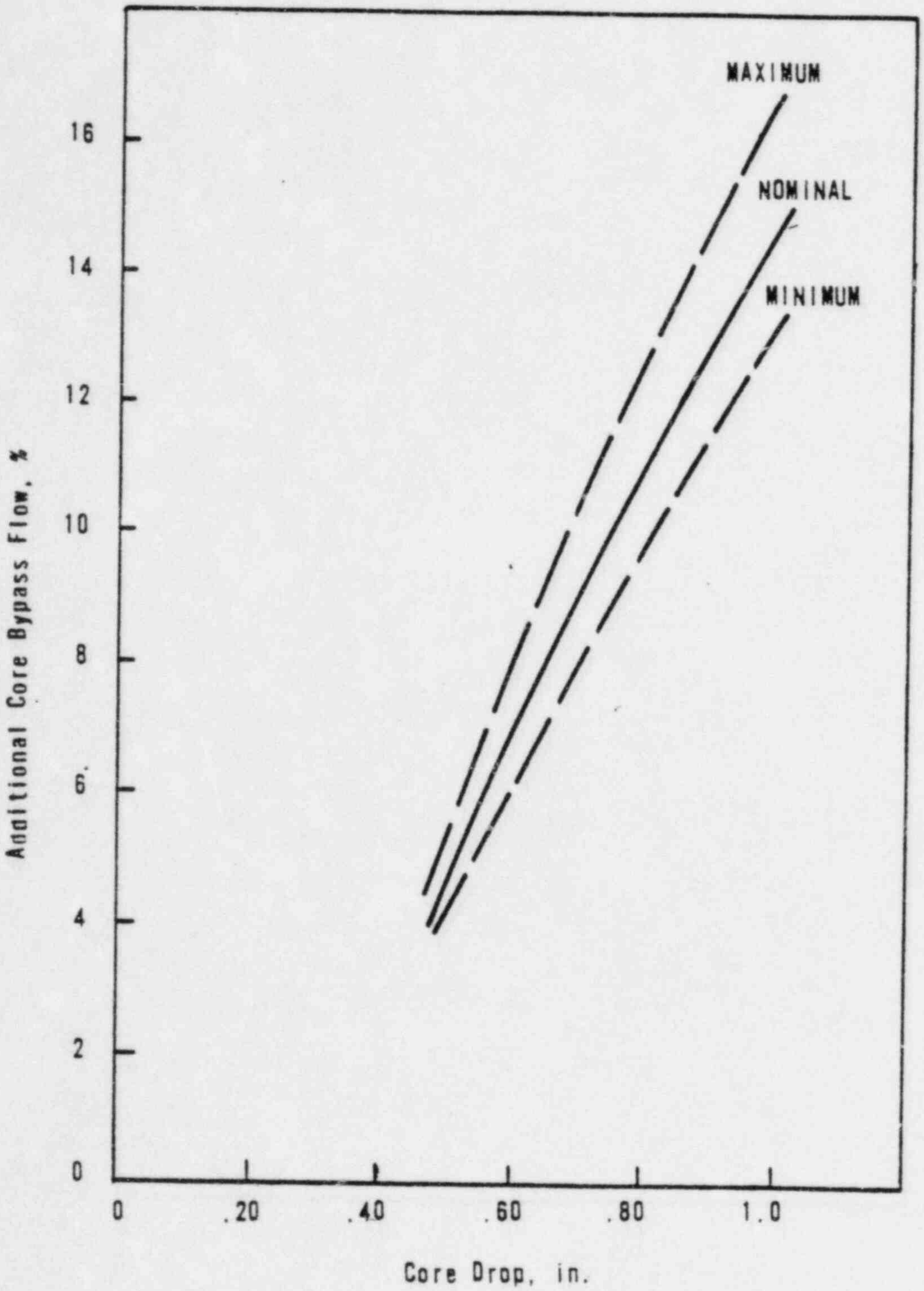
The consequences of both upper and lower core barrel joint failure have been assessed. Upper core barrel joint failure during normal operation will cause the core to drop .54" (the gap present at normal operating conditions) onto the reactor vessel guide lugs. Figure 4.1 shows a cross-section of the core and internals with the darkened portion representing components that would drop on UCB joint failure and Figure 4.2 shows the UCB bolt and joint detail in the failed condition.

After core drop, the bolt heads would be held in place by the locking clips, thus precluding becoming loose parts and the bolt shanks would remain captured within the core support shield bolt holes. The nominal radial clearance between the bolt shank and the bolt hole is 0.142". While there may be some damage to peripheral fuel assemblies by contact between the baffle plate and upper end fitting of the fuel assemblies, both lateral and rotation motion of the upper core barrel and core would be restrained by the bolt shanks and coolable core geometry would be maintained. Likewise the guide lugs and guide blocks with a 25 mil maximum (range 0.20-0.25 mils) clearance would provide similar restraint at the bottom of the core (See Fig. 2.7). In addition, the combination of bolt shanks at the upper end of the core barrel and guide lugs and guide blocks at the lower end would prevent core tilt in the dropped condition.

With the core in the dropped condition, approximately 5% added bypass flow is predicted (see Figure 4.3) which is within existing thermal margins. The fuel assembly upper end fittings remain engaged in the upper grid assembly and since the control rods penetrate 6-1/2" into the fuel assembly guide tubes, control rod insertion would be possible.

A preliminary assessment of the ability of the core guide lugs to support the core in the unlikely event of a complete severance of the UCB or LCB bolted joint has been made and the effects of the drop on the guide lugs for normal operation, and accident conditions have been evaluated.

- <u>Core Drop</u> - The worst case lug load would occur if the UCB bolt ring failed during hot standby. This was analyzed using a non-linear dynamic analysis of the lugs. The results indicate a maximum stress intensity of 36 ksi in the critical areas of the lug. This can be compared to a minimum ultimate material strength of 80 ksi.



CORE DROP VS ADDITIONAL BYPASS FLOW

Fig. 4.3

Should the drop occur simultaneously with a LBLOCA, the additional load would increase the critical guide lug stress to 52 ksi. This is still well below the guide lug ultimate strength.

- Normal Flow - In the dropped condition, the core is held up by flow forces which result in a net downward load on the lugs of only 3,400 pounds. The random turbulence flow excitation of the core would result in low cyclic loads on the guide lugs which could be tolerated indefinitely.

- Accident Condition - A combined LBLOCA and SSE can be resisted by a horizontal load on the end of the guide lugs, in the plane of the lug and by the shanks of the 120 severed 1-3/4" bolts. A safety factor of approximately 2.3 and 11.9 exists for the lugs and the bolts, respectively.

- Conclusions - Based on the above preliminary assessments, it is concluded that a dropped core can withstand normal and accident loads with the core remaining in a coolable geometry.

The conclusion that can be reached from these considerations is that while UCB bolt ring failure is likely to cause mechanical damage, a significant safety concern does not exist since the core can be shut down, restrained, and cooled without loss of reactor coolant pressure boundary integrity.

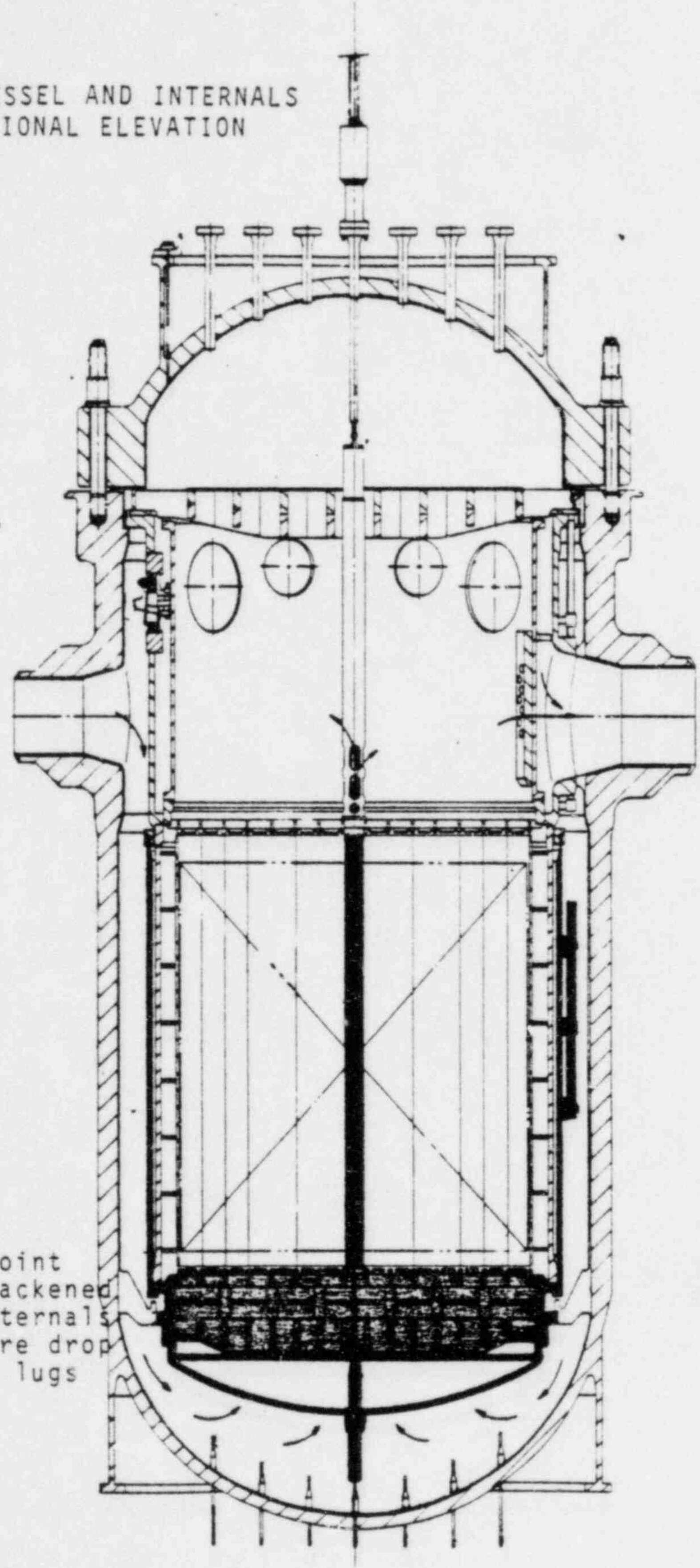
Similar conclusions can be reached for failure of the lower core barrel joint since the considerations are the same for this failure mode as for the UCB joint failure, with only two exceptions. Since the core barrel to core support shield joint remains intact no core bypass flow is expected and the load on the guide lugs is reduced by the weight of the core barrel. Figures 4.4 and 4.5 depict the lower core barrel joint failure and in the core dropped condition.

4.2 Justification for Continued Operation

4.2.1 Davis Besse 1

As discussed in the previous section, both the upper and lower core barrel bolting have large structural design margins before loss of joint integrity.

REACTOR VESSEL AND INTERNALS
CROSS-SECTIONAL ELEVATION



With LCB Joint
failure blackened
part of internals
and the core drop
onto guide lugs

Fig. 4.4

CORE AND INTERNALS IN DROPPED CONDITION
FROM
LOWER CORE BARREL JOINT FAILURE

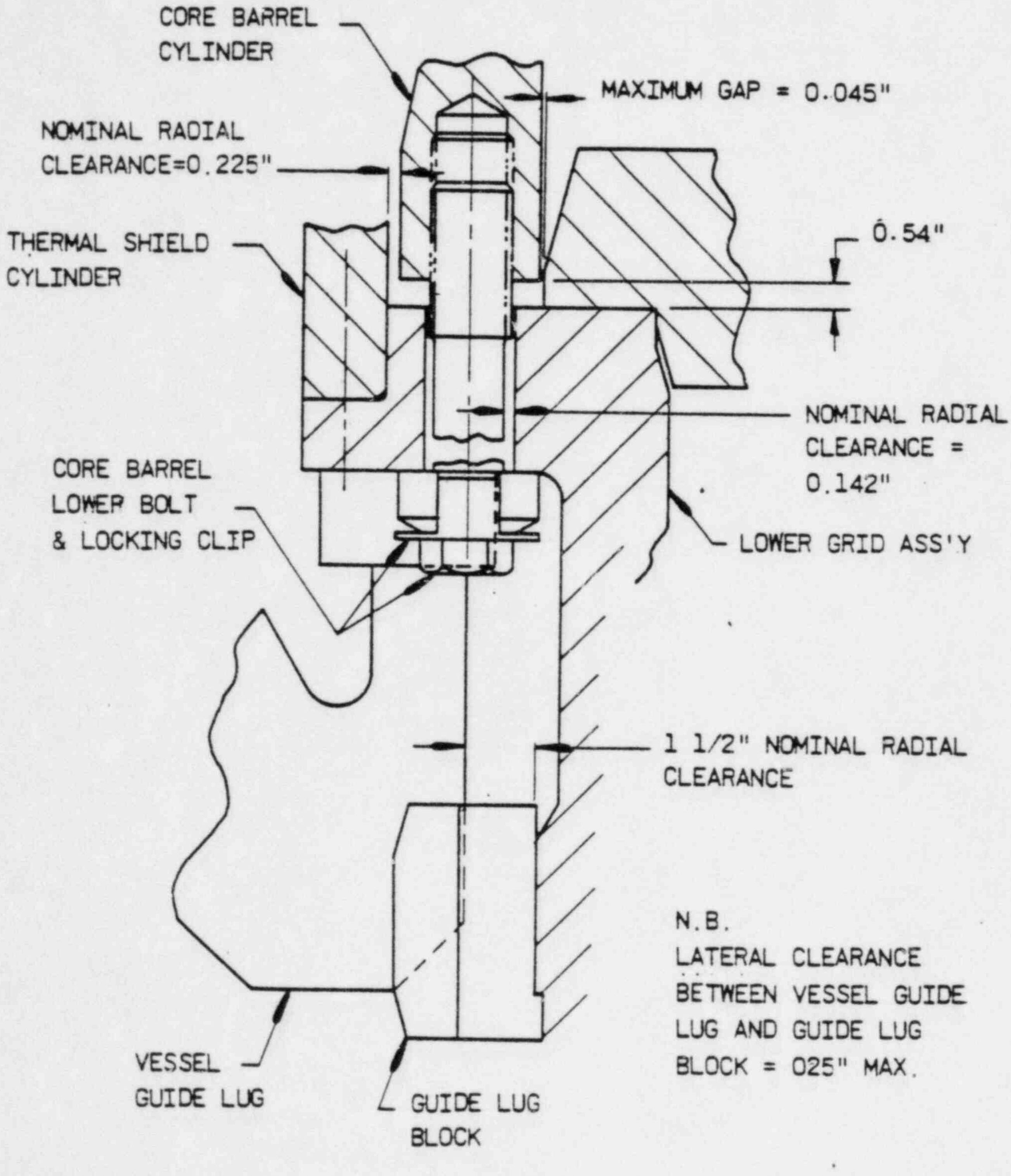


FIGURE 4.5

In addition, inspections to date at other plants show failures well below the maximum allowable.

Neutron noise monitoring analysis on May 5, 1983, shows no change in the signature from that recorded at the beginning of the cycle. Consequences of joint failure for both normal operation and the very low probability large break LOCA event have been examined and found to be acceptable from a safety standpoint. Lastly, since the Davis Besse refueling outage is scheduled to begin July 29, 1983, there is very limited time for operation. These considerations lead to the judgement that continued operation of the Davis Besse plant is safe and justifiable.

4.2.2 Oconee Nuclear Station

The justification for continued operation of the three Oconee units is as follows. As shown in Table 4.2 and 4.3, between 15 to 25% of the upper and lower core barrel joints were inspected in late 1981 and the first half of 1982 and found to have no abnormal field UT indications. Backing this is confirming laboratory analysis of bolt samples taken from Oconee 1 and the verification of the UT technique by the bolt samples from Rancho Seco.

As was demonstrated in Section 4.1 and 4.2, there is a similar large structural margins for UCB/LCB bolt ring integrity at these three units as at Davis Besse. In addition, neutron noise analysis is presently being performed at regular intervals for all three units. Duke Power Co. considers that the beam mode vibration of the core barrel is present for all three units. An anomalous spectral indication has been noted at Oconee 1 but detailed analysis shows no significant vibrations in excess of those expected and the signals have not changed significantly stable since 200 EFPD.

In addition, there is an extremely low probability of occurrence of either a large break LOCA or a severe seismic event that would cause significant loading to be applied to the core support structure for the short term for operation of these units (i.e., shutdown for refueling is expected within the next 6 weeks at Oconee 1, within about 5 months at Oconee 2 and in about one year at Oconee 3).

Table 4.2

OCONEE

UPPER CORE BARREL BOLTS

INSPECTION RESULTS

STATION	QUANTITY	NUMBER INSPECTED[1]	NUMBER OF DEFECTS FOUND
OCONEE 1	120	21 (17.5%)	0
OCONEE 2	120	30 (25%)	0
OCONEE 3	120	30 (25%)	0

NOTE 1 - INSPECTED BY ULTRASONIC TESTING

Table 4.3

OCONEE

LOWER CORE BARREL BOLTS

INSPECTION RESULTS

STATION	QUANTITY	NUMBER INSPECTED[1]	NUMBER OF DEFECTS FOUND
OCONEE 1	108	16 (15%)	0
OCONEE 2	108	24 (22%)	0
OCONEE 3	108	24 (22%)	0

NOTE 1 - INSPECTED BY ULTRASONIC TESTING

These considerations led to the conclusion that continued operation of the three Oconee units until their next refueling outage is justified. Strengthening this judgement are the inspection plans being put in place for the Oconee station: 1) Neutron noise surveillance will continue on all three units at a three-week interval. 2) UT inspection of 100% of the Oconee 1 UCB bolts during the refueling outage with additional examinations depending on the results of the UT of the UCB bolts. Additionally, the continued operation of the Oconee 2 and 3 units will be reassessed based on the results of the Oconee 1 inspection.

4.2.3 ANO-1

ANO-1 prolonged their present refueling outage to UT inspect their upper core barrel bolts. Only 7 UT indications were noted. These favorable results together with the large structural margins in the UCB/LCB bolt rings justify restart without repair or further inspections. In addition, Arkansas is installing neutron noise analysis equipment and will periodically monitor the signature to insure satisfactory behavior. Also supporting this judgement will be the increasing data base for understanding the bolting failures that will be obtained from near term inspections performed for Davis Besse and the Oconee units.

5. FUTURE ACTIONS

Future actions by specific utilities and the Bolting Task Force may be summarized as follows:

- o Crystal River and Rancho Seco are proceeding with repair plans and will keep NRC informed.

- o AP&L plans to restart ANO-1 shortly.

- o Oconee 1 will be shutting down soon for refueling and inspection to be followed shortly after by DB-1. UCB bolts will be inspected and results will be provided to the NRC.

- o B&W Owners Group Task Force is developing their long range plans. A Task Force meeting dedicated to the development of such plans is presently scheduled for May 24. The plan, when formalized, will be provided to the NRC.

APPENDIX A

NRC - B&W OWNERS GROUP MEETING

SLIDES

REACTOR VESSEL INTERNALS BOLTING

MAY 6, 1983

NRC - B&W OWNERS GROUP

MEETING AGENDA

REACTOR VESSEL INTERNALS BOLTING

MAY 6, 1983

I.	INTRODUCTION	
	A. B&WOG ACTIONS	TED MYERS-TED
	B. B&WOG TASK FORCE APPROACH	SKIP HENDRIX - DUKE
II.	TECHNICAL BACKGROUND	
	A. PROBLEM IDENTIFICATION AND INTERNALS JOINTS DESIGN BASIS	DOUG LEE - B&W
	B. INSPECTION METHODS	GARY ABELL - B&W
III.	INSPECTION AND EXAMINATION RESULTS	
	A. SITE	LARRY TITTLE - FPC
	B. LABORATORY	BOB PIASCIK - B&W
IV.	SAFETY IMPLICATIONS	DOUG LEE - B&W
V.	PLANT STATUS	LARRY YOUNG - TED PAUL GUILL - DUKE DAN HOWARD - AP&L
VI.	FUTURE ACTIONS	

TASK FORCE MISSION

I. MAINTAIN COGNIZANCE OF ALL ACTIVITIES RELATED TO INTERNAL BOLT FAILURES.

II. PROVIDE FORUM FOR SHARING OF INFORMATION.

III. MAINTAIN CONSISTENT LICENSING POSTURE.

IV. CONSIDER ALL GENERIC ASPECTS ADDRESSING BOTH SAFETY AND ECONOMIC ISSUES.

V. EXPEDITE PERFORMANCE OF NECESSARY ACTIVITIES.

B&W OWNERS ACTIONS TO DATE

- o INITIAL EVALUATION

  - THERE ARE LARGE DESIGN MARGINS IN THE REACTOR VESSEL BOLTING SYSTEMS

  - CURRENT INSPECTIONS STATUS REVEALS BOLT FAILURE LEVELS WELL BELOW THOSE REQUIRED FOR JOINT FAILURES

  - EVEN IF JOINT FAILURE OCCURS THERE IS NO SIGNIFICANT SAFETY HAZARD INVOLVED

  THEREFORE CURRENTLY OPERATING FACILITIES PROVIDE NO UNDUE RISK TO PUBLIC HEALTH AND SAFETY

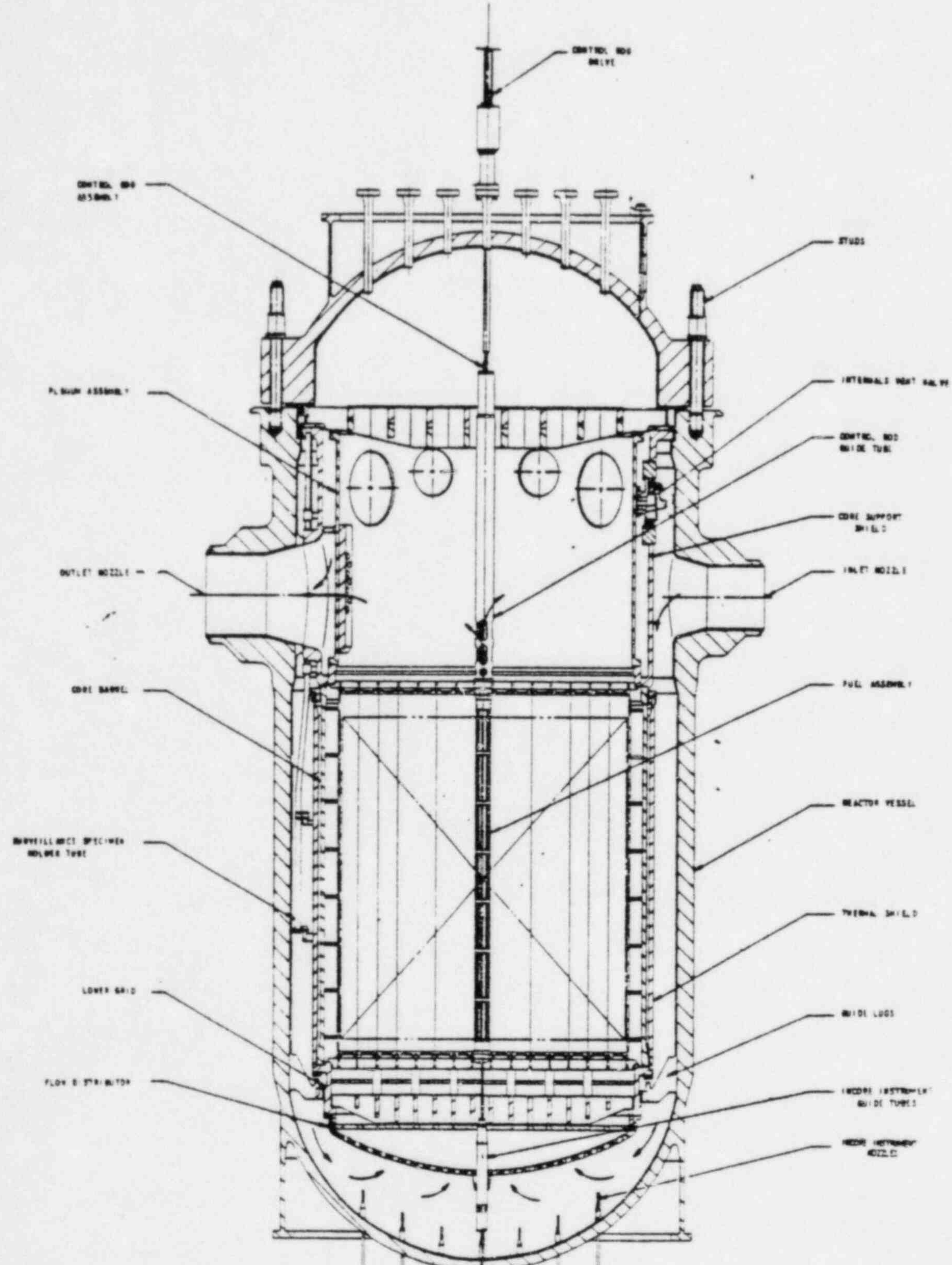
- o ESTABLISHED AN ORGANIZATION AMONG THE B&W OWNERS TO CONTINUE TO INVESTIGATE AND EVALUATE NEW INFORMATION AND WILL CONTINUE TO RESOLVE THE PROBLEMS WE HAVE FOUND

A 286 BOLT CHRONOLOGY

		DATE
o	THERMAL SHIELD BOLT FAILURES AT OCONEE 1	JULY 15, 1981
o	THERMAL SHIELD REPAIRS	
	OCONEE 1	NOVEMBER 1981
	OCONEE 2	FEB. 22, 1982
	OCONEE 3	JULY 7, 1982
	ANO-1	JAN. 10, 1983
	RANCHO SECO	UNDERWAY
	CR-3	UNDERWAY
	DB-1	1984
o	UPPER CORE BARREL BOLT DEFECTS AT RANCHO SECO	MARCH 25, 1983
o	UPPER CORE BARREL BOLT DEFECTS AT CR-3	APRIL 10, 1983

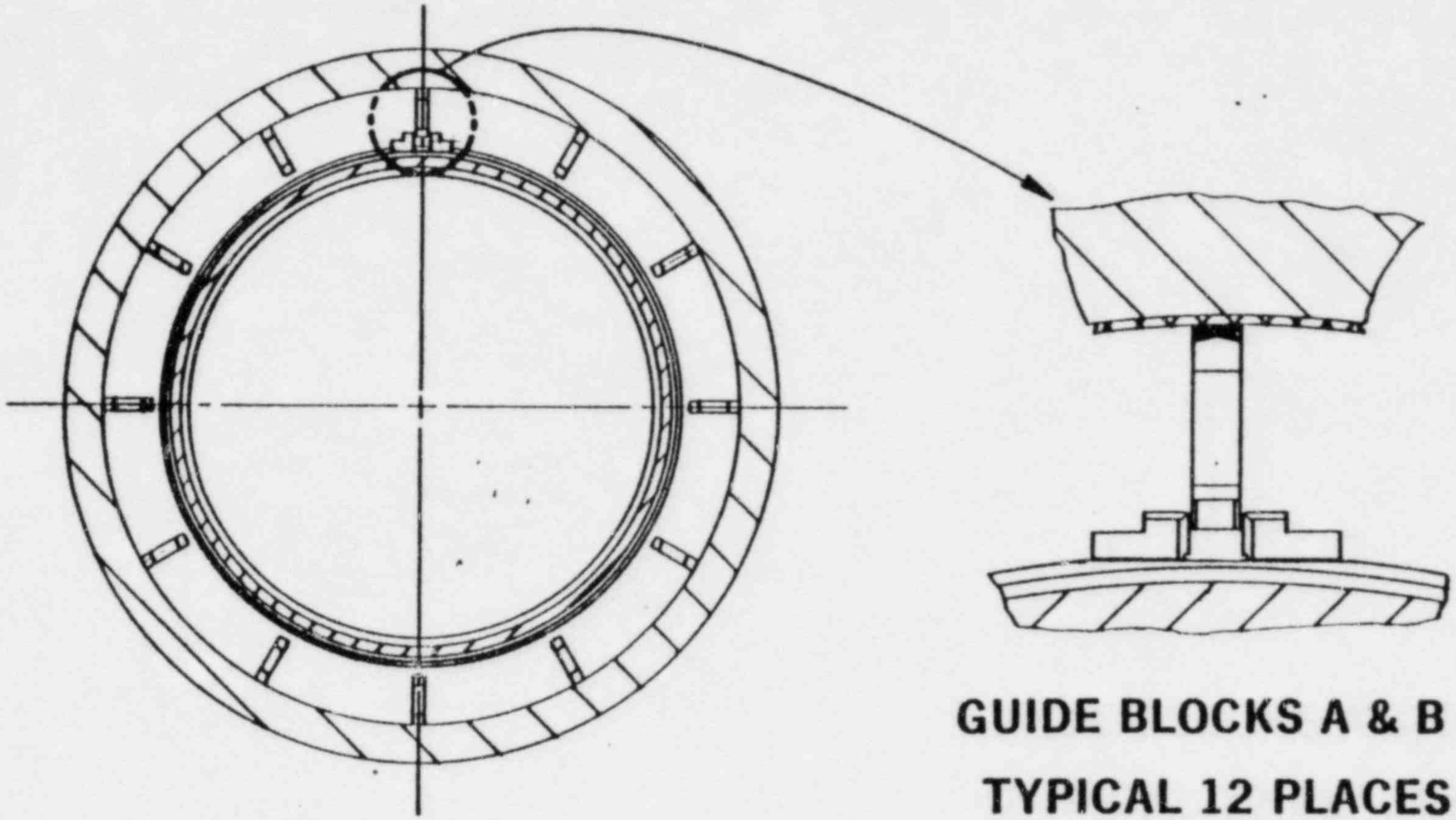
PROBLEM DEFINITION

- UT INDICATIONS WERE DETECTED AS EXPECTED IN THE LOWER THERMAL SHIELD BOLTS IN THE PROCESS OF MAKING PLANNED REPAIRS.
- UNEXPECTED UT INDICATIONS WERE DETECTED IN THE FOLLOWING BOLTING RINGS:
  - UPPER CORE BARREL
  - LOWER CORE BARREL
  - SURVEILLANCE HOLDER TUBE
- INDICATIONS WERE FOUND IN SA453 GR660 (A-286) BOLTS
- THE UPPER CORE BARREL AND LOWER CORE BARREL BOLTING RINGS HAVE CORE SUPPORT STRUCTURAL SIGNIFICANCE
- CONCERNS ARE APPLICABLE TO 177FA PLANTS EXCEPT TMI-1


CONTROL ROD DRIVE
CONTROL ROD ASSEMBLY
STUDS
PLENUM ASSEMBLY
INTERNALS VENT VALVE
CONTROL ROD GUIDE TUBE
CORE SUPPORT SHIELD
OUTLET NOZZLE
INLET NOZZLE
CORE BARREL
FUEL ASSEMBLY
REACTOR VESSEL
SURVEILLANCE SPECIMEN HOLDER TUBE
THERMAL SHIELD
LOWER GRID
GUIDE LUGS
FLOW DISTRIBUTOR
INCORE INSTRUMENT GUIDE TUBES

Slide 6

LUG & GUIDE BLOCK LOCATIONS



GUIDE BLOCKS A & B
TYPICAL 12 PLACES

BOLTED JOINTS WITH A-286 MATERIAL

UPPER CORE BARREL (120 - 1 3/4 DIA.)

LOWER CORE BARREL (108 - 1/ 3/4 DIA.)

FLOW DISTRIBUTOR TO LOWER GRID (96 - 1 DIA.)

UPPER THERMAL SHIELD (60 - 1 1/2 DIA.)

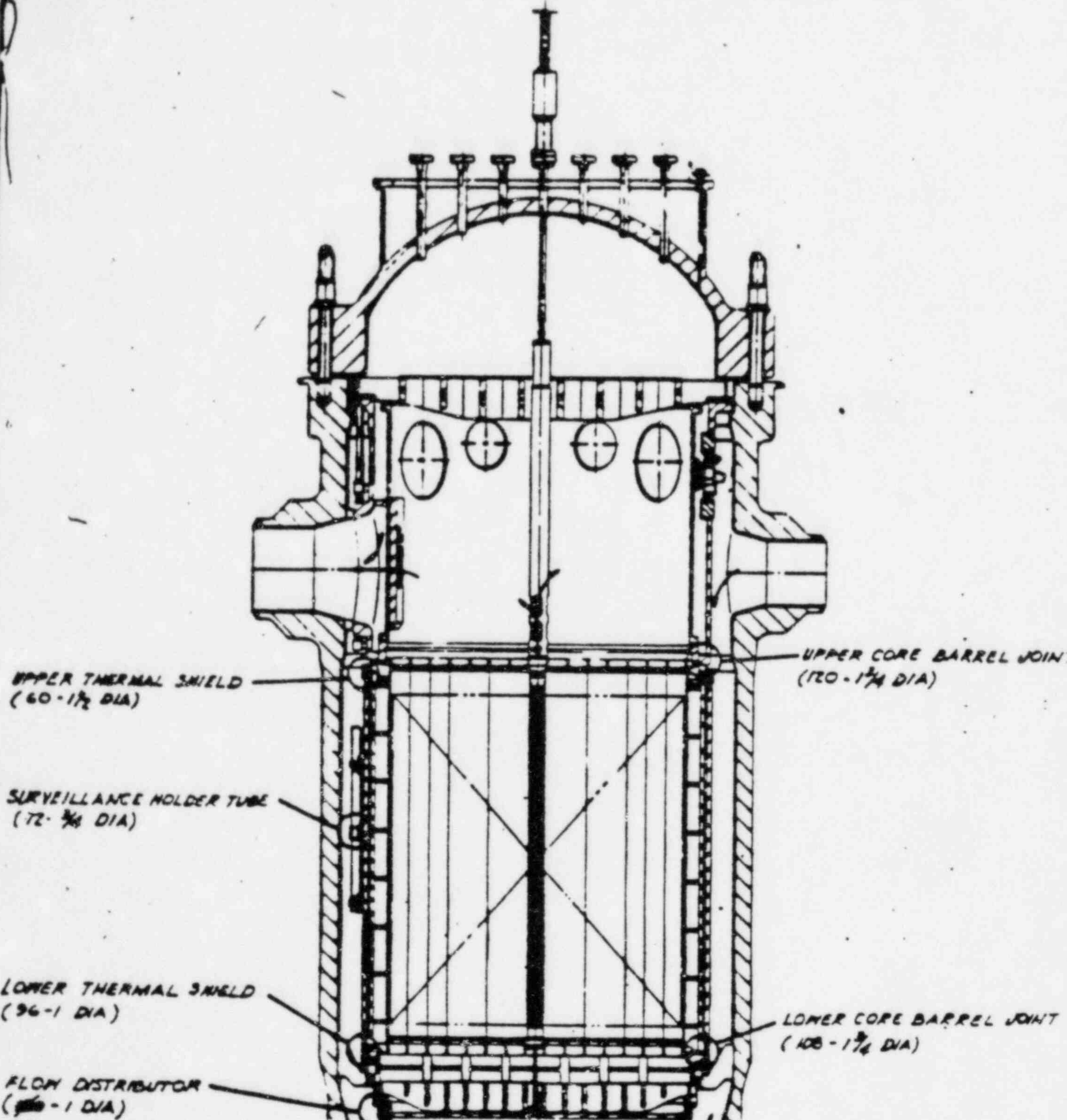
LOWER THERMAL SHIELD (96 - 1 DIA.)

*SURVEILLANCE HOLDER TUBE (73 - 3/4 DIA.)

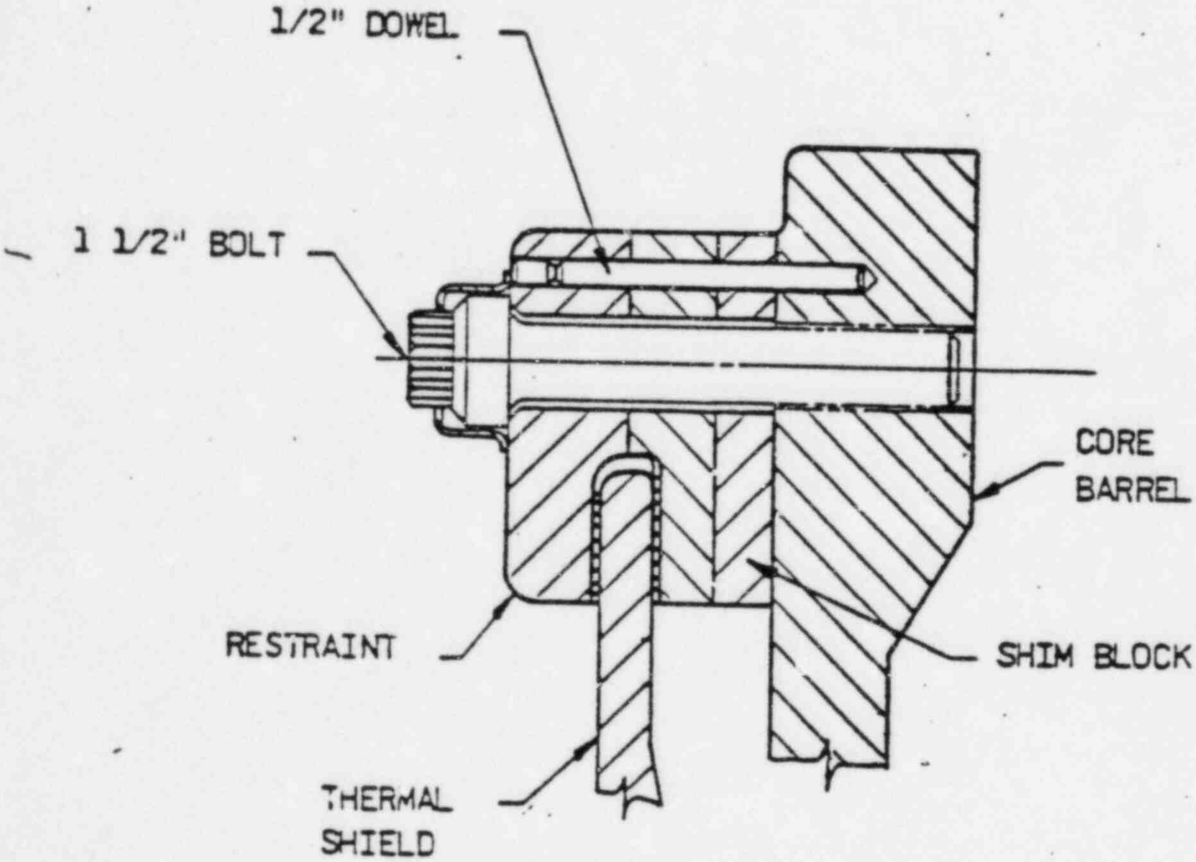
SA 453 GR 660 (A-286) IS AN AGE HARDENED, HIGH STRENGTH, CORROSION RESISTANT MATERIAL. BOLTS ARE CONDITION A/UPSET HEADED EXCEPT THE SURVEILLANCE HOLDER TUBE BOLTS WHICH ARE CONDITION B/MACHINED.

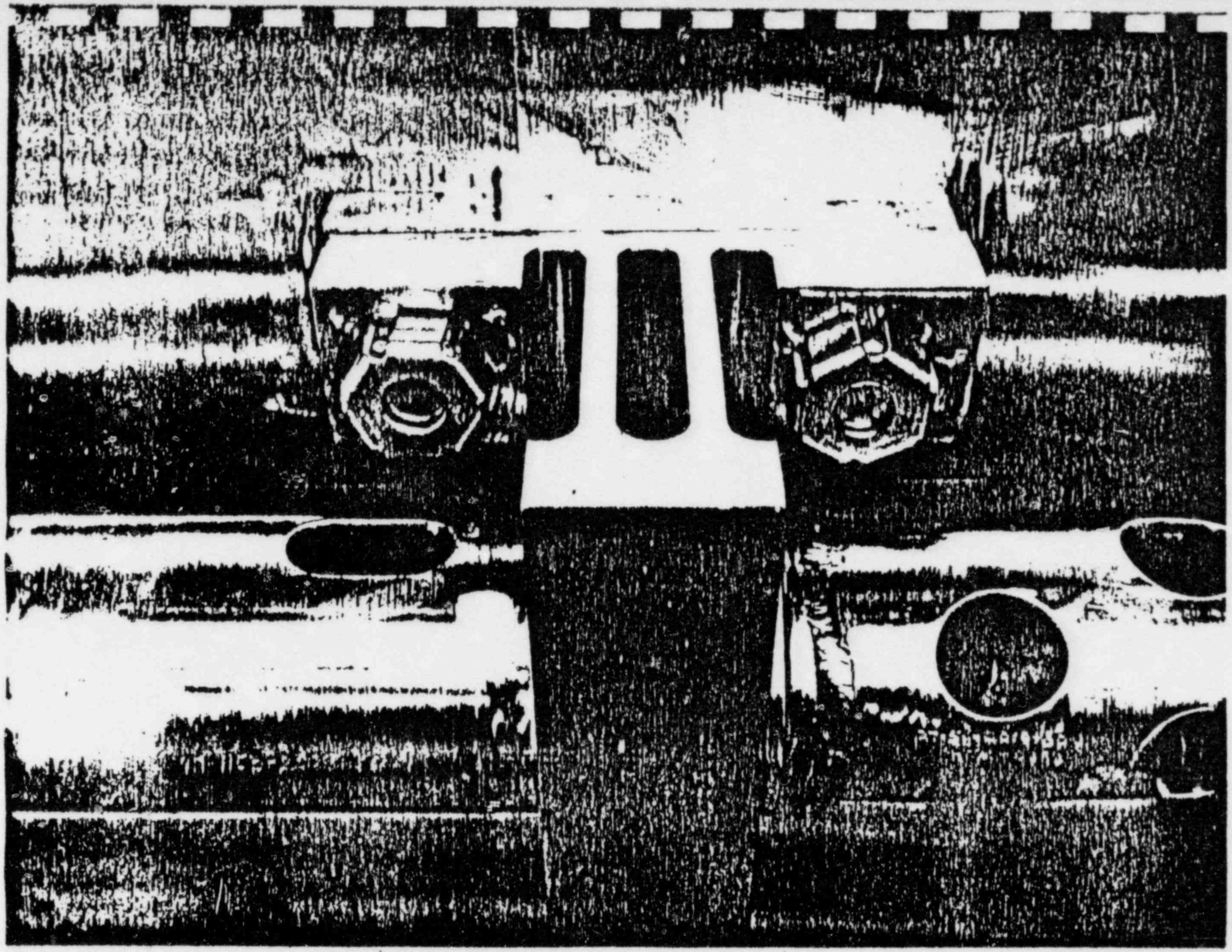
*DB-1, CR-3 AND MIDLAND 1 & 2

DEL
5/4/83

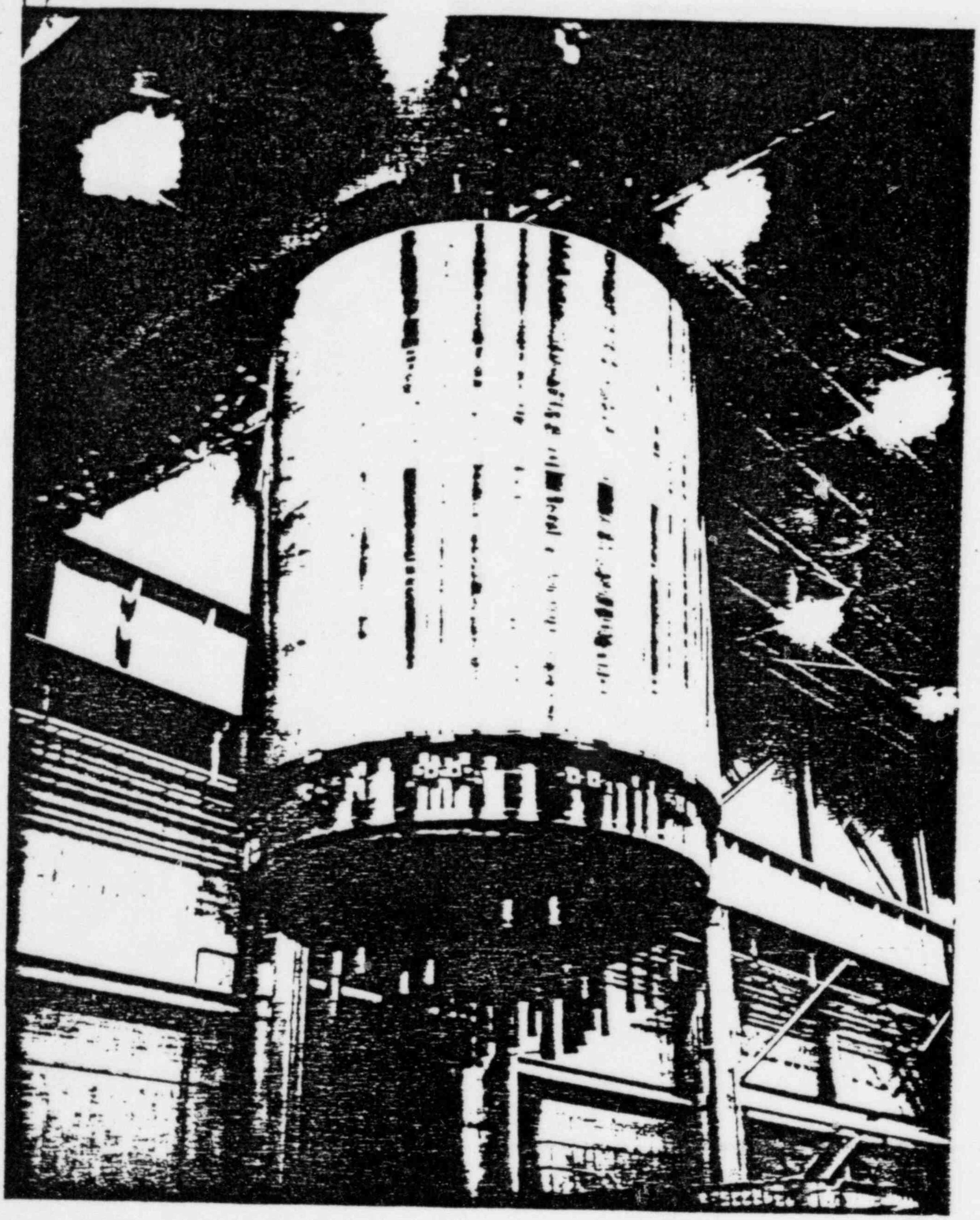

UPPER THERMAL SHIELD
(60 - 1½ DIA)
SURVEILLANCE HOLDER TUBE
(72 - ¾ DIA)
LOWER THERMAL SHIELD
(96 - 1 DIA)
FLOW DISTRIBUTOR
(- 1 DIA)
96
UPPER CORE BARREL JOINT
(120 - 1¾ DIA)
LOWER CORE BARREL JOINT
(108 - 1¾ DIA)

UPPER THERMAL SHIELD RESTRAINT





Slide 11



Lower Sect of Core

Slide 12

23

DESIGN BASIS

* DESIGNED TO WITHSTAND LOADINGS RESULTING FROM NORMAL AND UPSET CONDITIONS:
    - PRESTRESS
    - DEAD WEIGHT
    - THERMAL
    - OBE
    - VIBRATION

* DESIGNED TO WITHSTAND LOADING RESULTING FROM DESIGN BASIS ACCIDENT (FAULTED) CONDITIONS.
    - SSE
    - LOCA
    - DEAD WEIGHT
    - CORE BOUNCE

* ALLOWABLE STRESS CRITERIA FOR NORMAL AND UPSET CONDITIONS WAS SECTION III, SUBSECTION NB.

  ALLOWABLE STRESS CRITERIA FOR FAULTED CONDITIONS WAS AS PRESENTED IN FSAR.

* JOINT DESIGN CRITERIA WAS NO SEPARATION DURING FAULTED CONDITION LOADINGS.

* SIGNIFICANT MARGINS ARE INCLUDED IN THE DESIGN (ALLOWABLE STRESS AND NUMBER OF BOLTS REQUIRED TO CARRY LOADINGS).

DEL
5/4/83

MINIMUM NUMBER OF BOLTS

REQURIED FOR NORMAL OPERATION

UPPER CORE BARREL

120 BOLTS PER RING

(3 BOLTS REQUIRED TO SUPPORT CORE)

PLANT	NUMBER OF BOLTS
RANCHO SECO	8
CR-3	8
ANO-1	8
OCONEE 1	27
OCONEE 2	12
OCONEE 3	8
DAVIS-BESSE 1	8
MIDLAND 1 & 2	8

* DEPENDS ON INSTALLATION TORQUE

MINIMUM NUMBER OF BOLTS

REQUIRED FOR NORMAL OPERATION

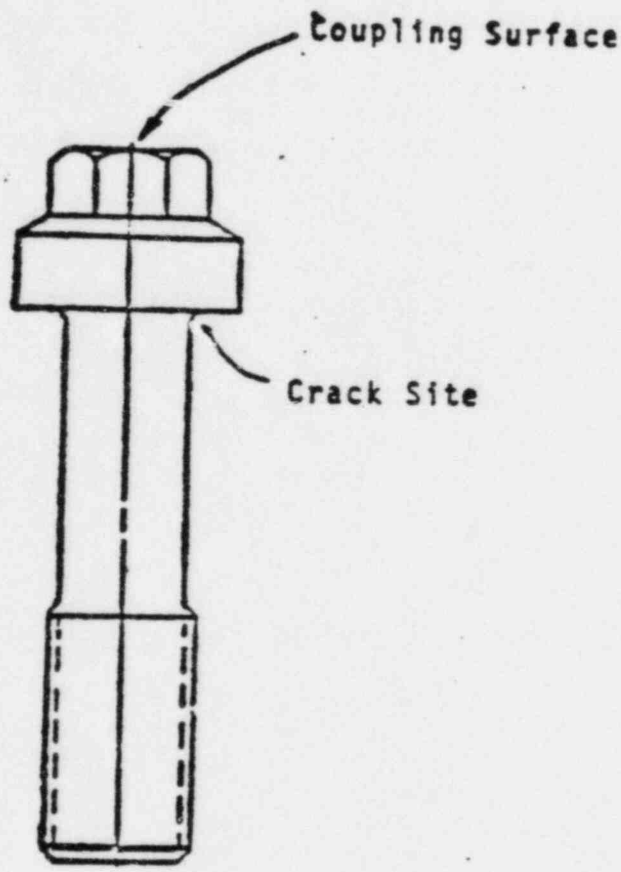
LOWER CORE BARREL

108 BOLTS PER RING

PLANT	NUMBER OF BOLTS
RANCHO SECO	13
CR-3	9
ANO-1	13
OCONEE 1	24
OCONEE 2	13
OCONEE 3	9
DAVIS-BESSE 1	9
MIDLAND 1 & 2	9

* DEPENDS ON INSTALLATION TORQUE

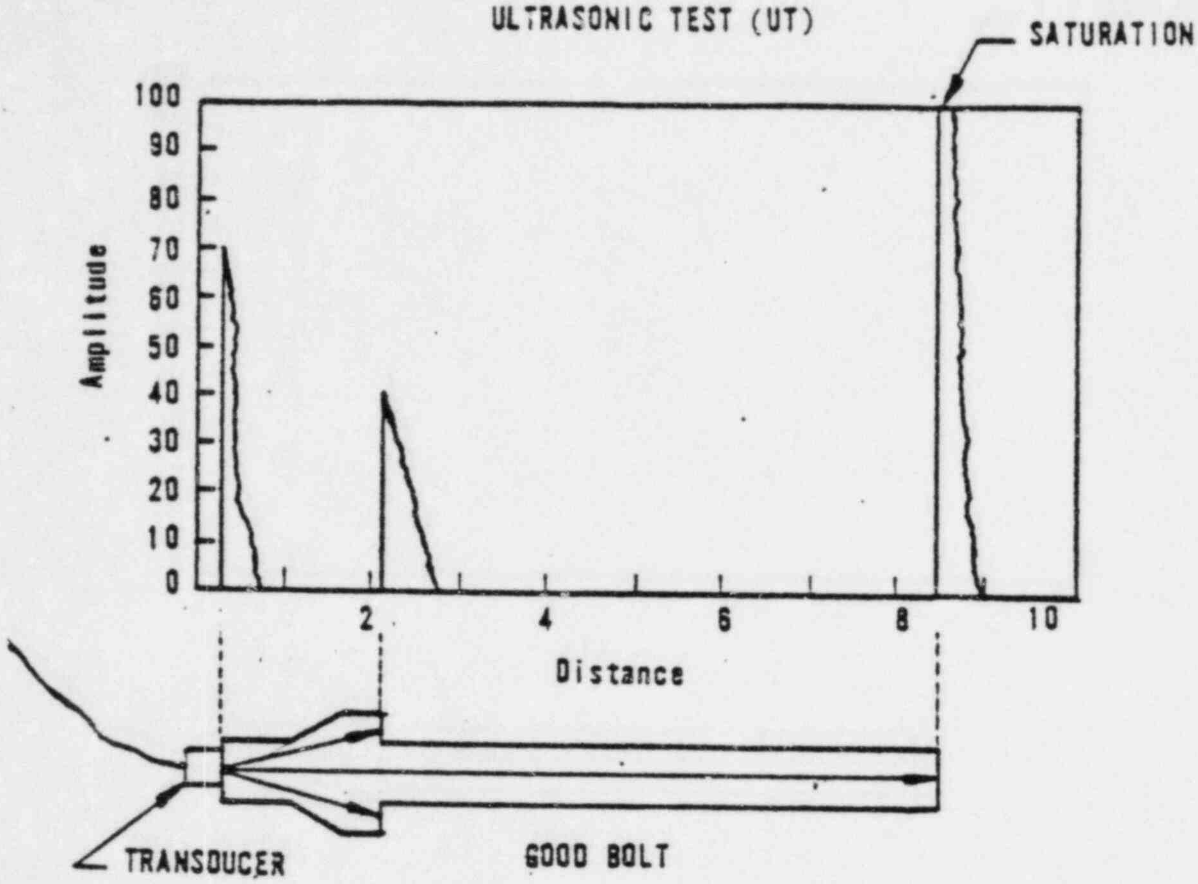
GENERIC BOLT CONFIGURATION

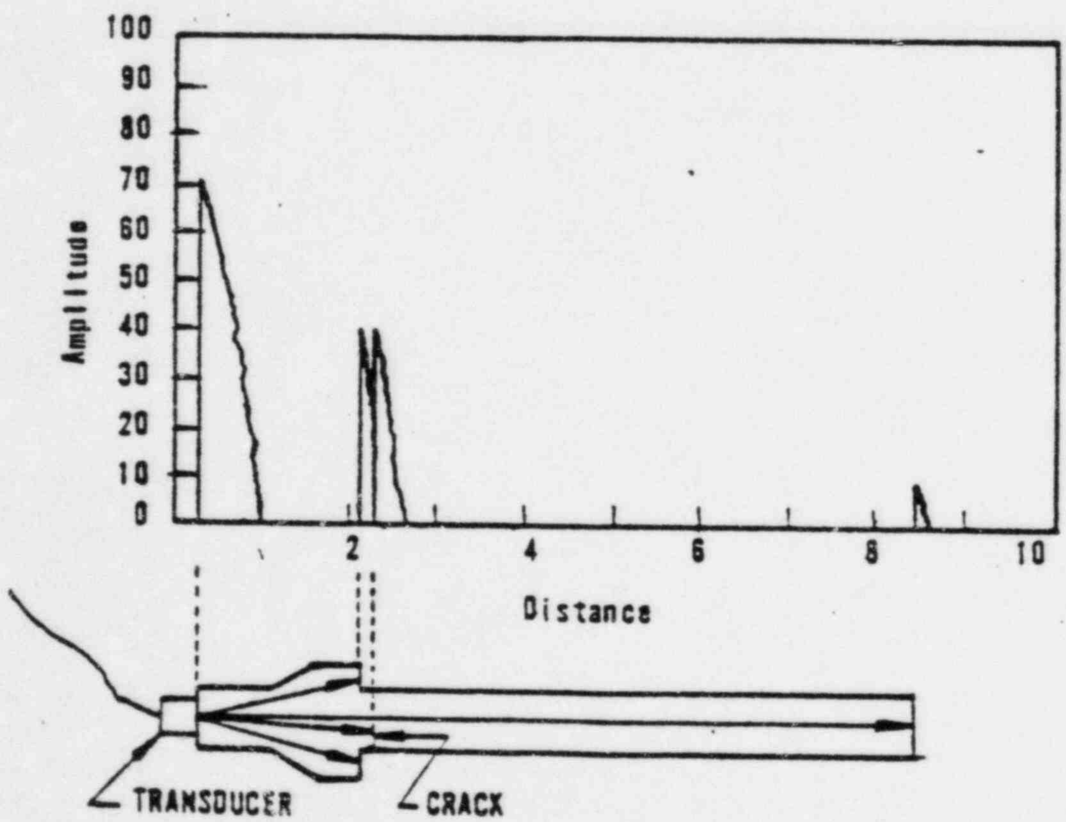


ULTRASONIC CALIBRATION TECHNIQUE

- POSITION TRANSDUCER ON GOOD BOLT STANDARD AND SET SIGNAL RESPONSE FROM HEAD TO SHANK AT 40% FULL SCREEN HEIGHT (FSH). RECORD DB REQUIRED FOR THIS SENSITIVITY.
- REPEAT WITH TRANSDUCER ON 15% NOTCH STANDARD.
- REPEAT WITH TRANSDUCER ON 50% NOTCH STANDARD.

ULTRASONIC TEST (UT)

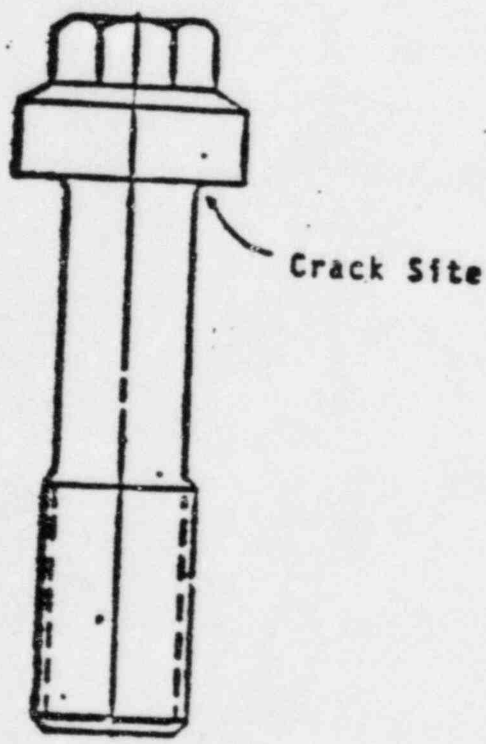


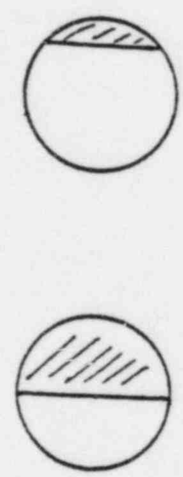


CRACKED BOLT

CALIBRATION STANDARDS

- o BOLTS OF SAME NOMINAL MATERIAL AND SIZE.
- o THREE BOLT STANDARDS - ONE CLEAN; ONE 15% NOTCH; ONE 50% NOTCH.
- o NOTCHES CUT IN SHANK JUST BELOW HEAD.





RESULTS TO DATE

- o ALL FIELD OBSERVED INFORMATION CORRELATES WITH UT RESULTS (BROKEN HEADS)
- o ALL LABORATORY DESTRUCTIVE ANALYSIS OF BOLTS PULLED FROM SITES CORRELATES WITH UT RESULTS

5-4-83

UT INSPECTION RESULTS (# CRACKED/ # INSPECTED)

BOLTED JOINT	OCONEE 1 (9-81)	OCONEE 2 (1-82)	OCONEE 3 (6-82)	ANO-1 (5-83)	RANCHO SECO (3-83)	CR-3 (4-83)
UPPER CORE BARREL (120 - 1-3/4 DIA.)	0/21	0/30	0/30	7/120	19/120	51/120
LOWER CORE BARREL (108 - 1-3/4 DIA.)	0/16	0/24	0/24	----	0/108	4/108
FLOW DIST/LOWER GRID (96 - 1 DIA.)	0/22	0/25	0/25	----	0/93	0/96
UPPER THERMAL SHIELD (60 - 1½ DIA.)	0/25	0/20	0/20	----	0/60	0/60
LOWER THERMAL SHIELD (96 - 1 DIA.)	11/13 94 HEADS TWISTED OFF	28/93 SEVERAL HEADS TWISTED OFF	53/96 SEVERAL HEADS TWISTED OFF	51/96 48 HEADS TWISTED OFF	77/96 75 HEADS TWISTED OFF	73/96 69 HEADS TWISTED OFF
SURVEILLANCE HOLDER TUBE (72 - 3/4 DIA.)*	----	----	----	----	----	25/72

*DB-1 AND CR-3 ONLY

TOTAL UT INSPECTION RESULTS

(UCB, LCB, FLOW DISTRIBUTOR)

BOLTED JOINT	TOTAL BOLTS INSPECTED	TOTAL INDICATIONS	%
UPPER CORE BARREL	441	77	17.5
LOWER CORE BARREL	280	4	1.4
FLOW DIST/LOWER GRID	261	0	0

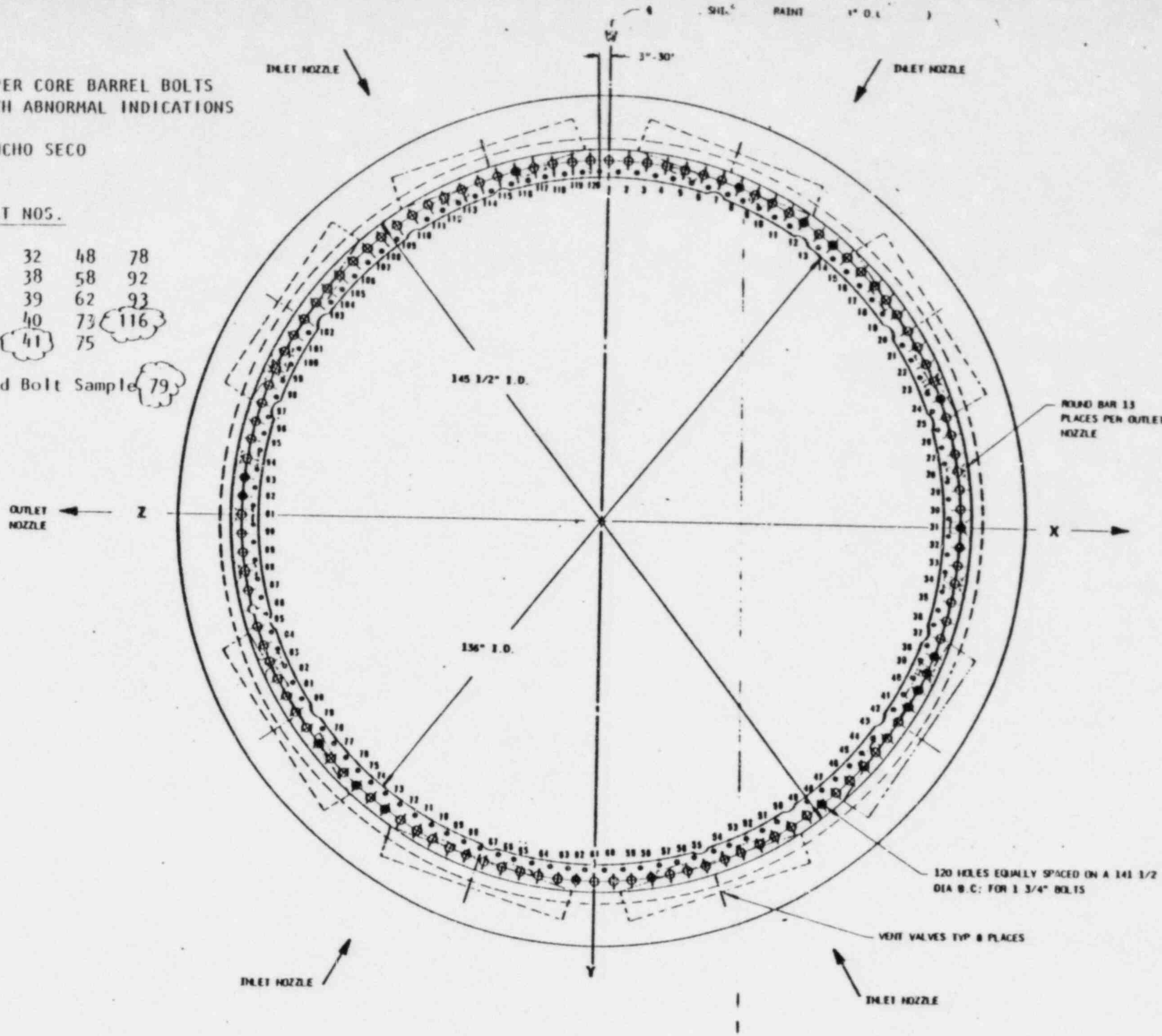
UPPER CORE BARREL BOLTS
WITH ABNORMAL INDICATIONS

RANCHO SECO

BOLT NOS.

8	32	48	78
12	38	58	92
14	39	62	93
24	40	73	116
31	41	75	

Good Bolt Sample 79

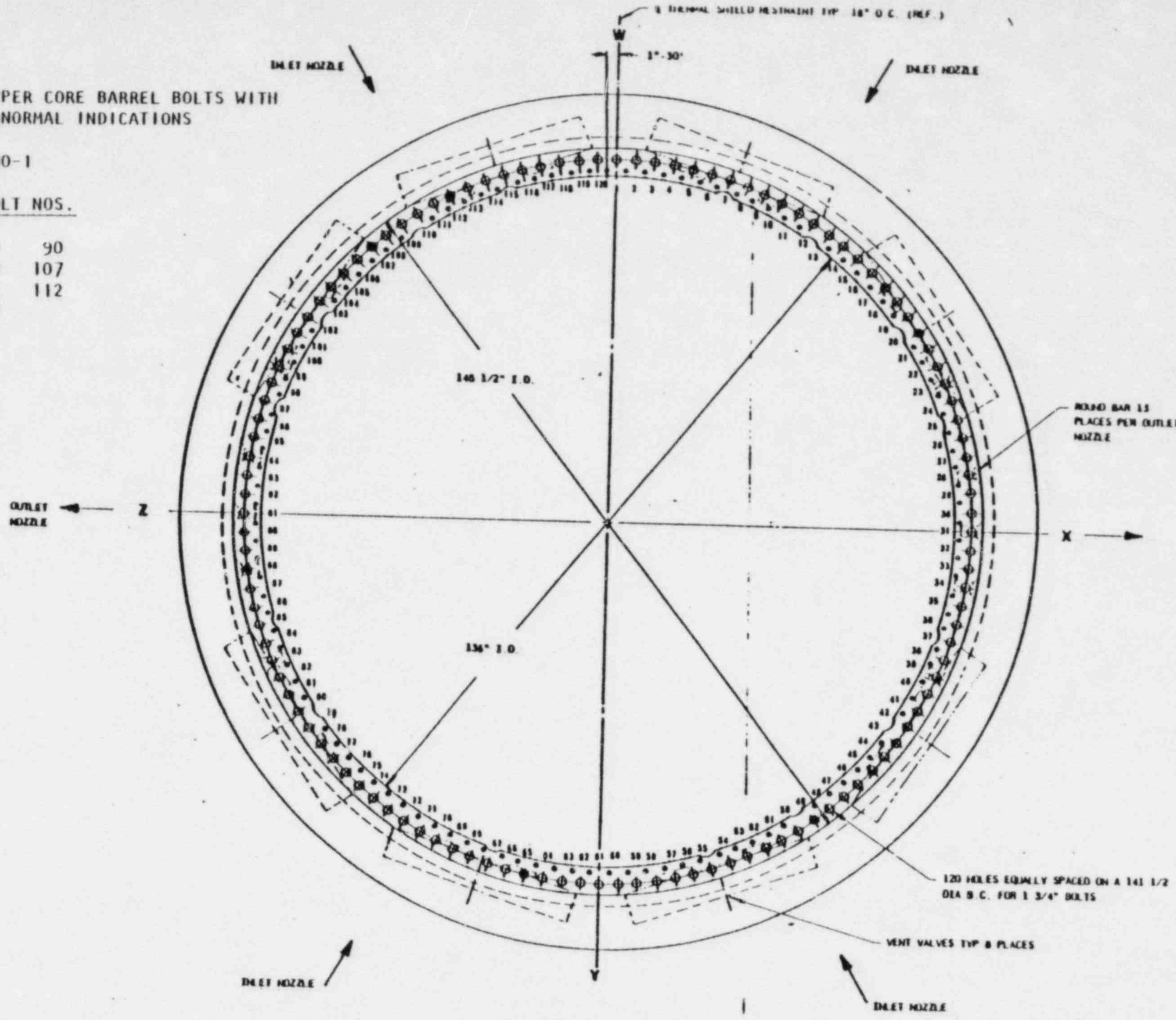


UPPER CORE BARREL BOLTS WITH
ABNORMAL INDICATIONS

ANO-1

BOLT NOS.

20	90
49	107
65	112
88	

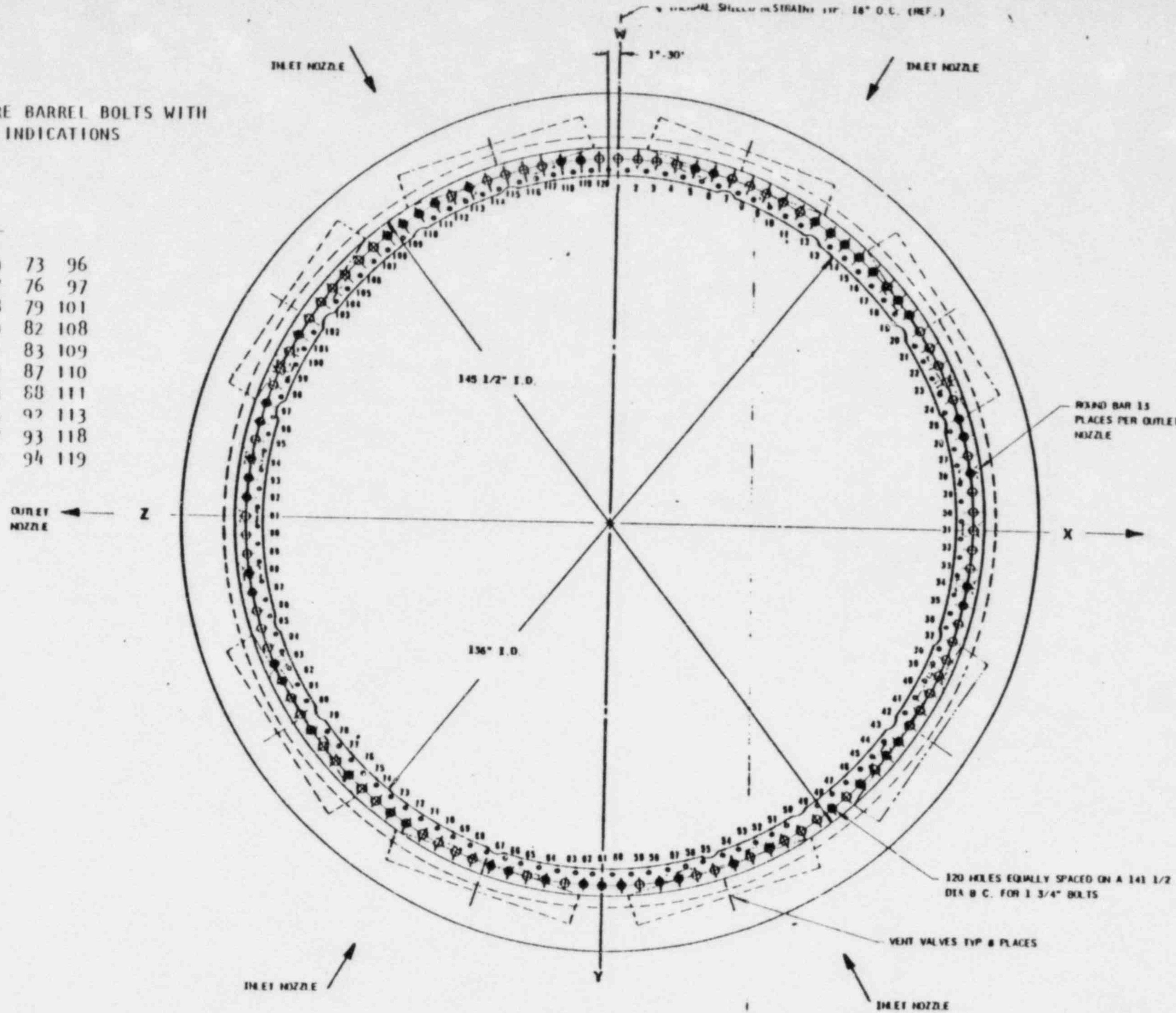


UPPER CORE BARREL BOLTS WITH
ABNORMAL INDICATIONS

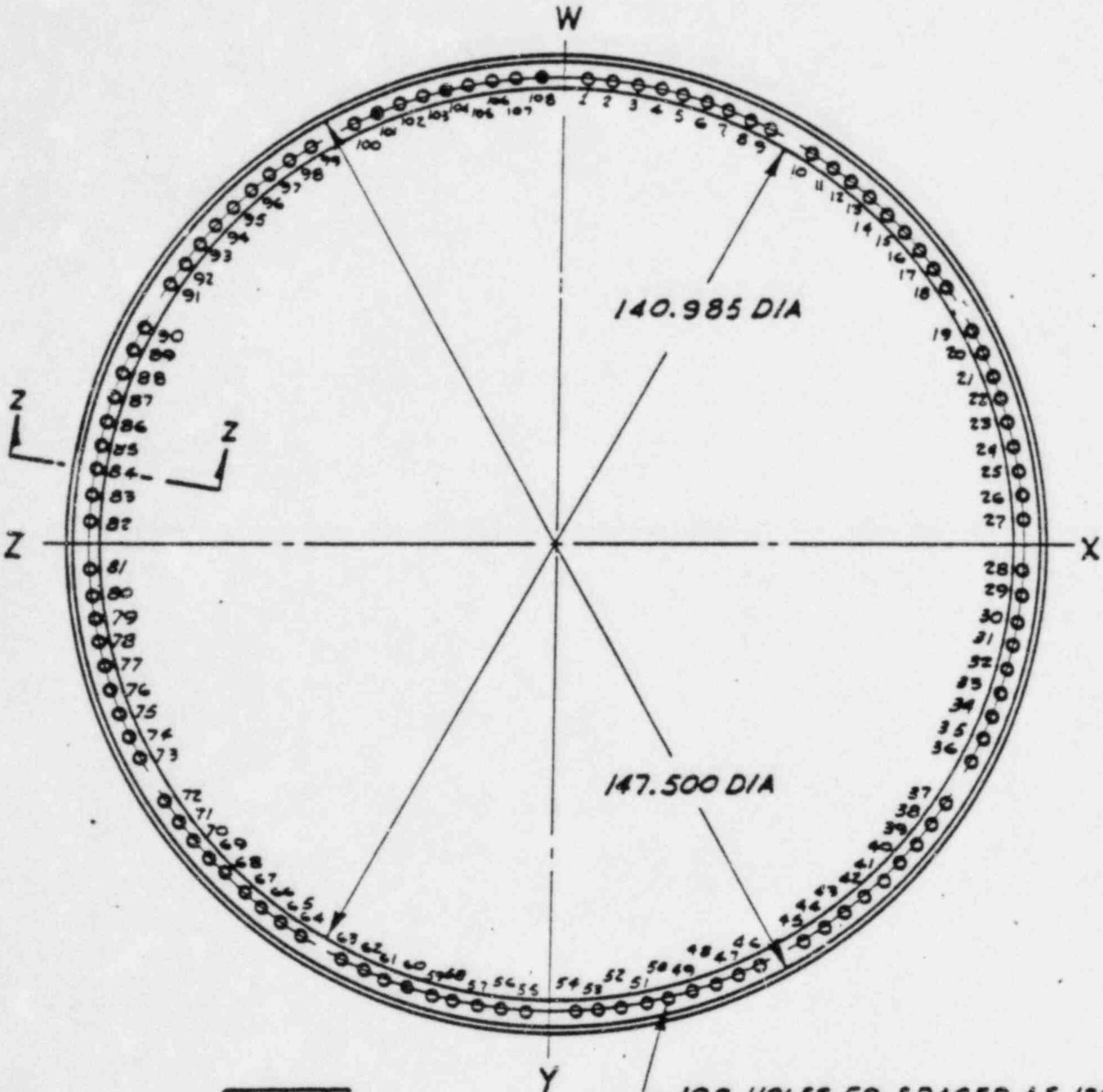
CR-3

Bolt Nos.

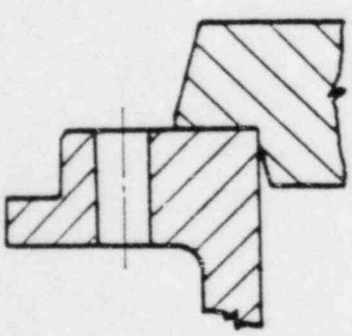
5	25	54	73	96
6	26	57	76	97
12	28	58	79	101
13	34	60	82	108
14	35	61	83	109
15	43	62	87	110
16	44	64	88	111
17	46	66	92	113
18	48	67	93	118
19	52	72	94	119



CORE BARREL/LOWER GRID BOLT LOCATIONS
CRYSTAL RIVER-3



108 HOLES EQ. SPACED AS 120
SPACES ON A 144 DIA B.C.
FOR $1\frac{3}{4}$ BOLTS



SECTION Z·Z

BOLTS WITH ABNORMAL INDICATIONS
BOLT NO.
60
101
104
108

OCONEE I EXAMINATIONS

1. LOWER THERMAL SHIELD BOLT (8)

   - VISUAL, PT, SEM, METALLOGRAPHY

   RESULTS - INTERGRANULAR FRACTURE IN THE BOLT HEAD TO SHANK TRANSITION REGION.

2. UPPER THERMAL SHIELD RESTRAINT BOLT (3)

   - VISUAL, PT, SEM SURFACE EXAM

   RESULTS - NO CRACKING.

3. UPPER CORE BARREL BOLT (2)

   - VISUAL, PT, SEM SURFACE EXAM

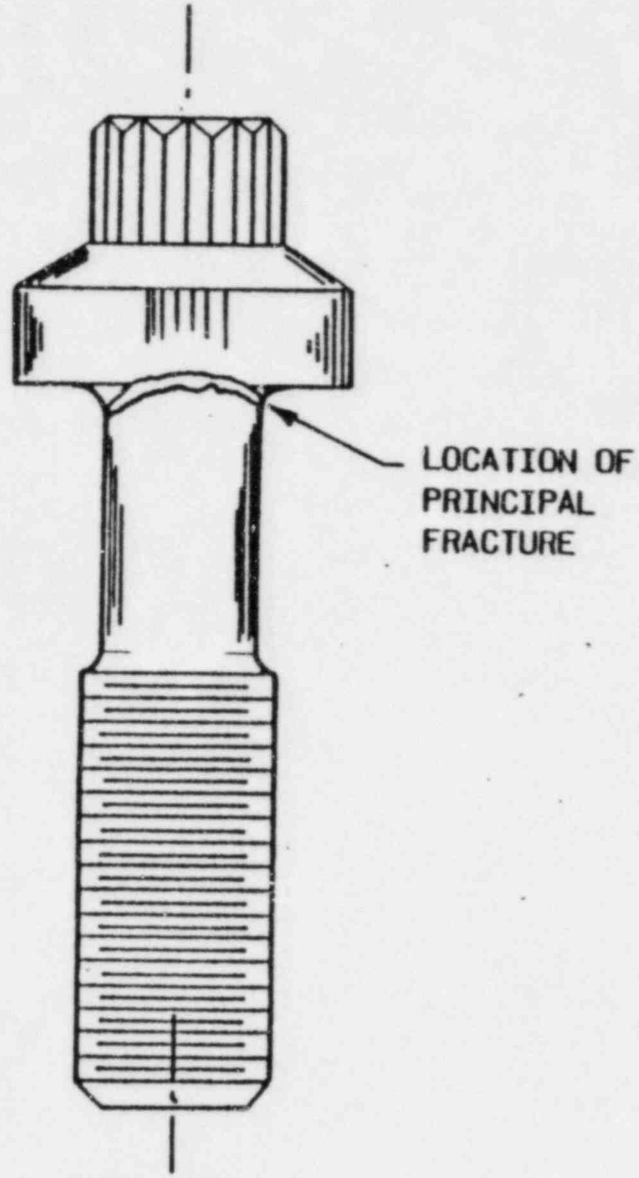
   RESULTS - NO CRACKING.

4. FLOW DISTRIBUTOR BOLT (1)

   - VISUAL, PT

   RESULTS - NO CRACKING.

SKETCH OF LOWER THERMAL SHIELD BOLT SHOWING LOCATION OF FRACTURE



OCONEE II EXAMINATIONS

LOWER THERMAL SHIELD BOLTS (19)

- VISUAL, UT, SEM, METALLOGRAPHY
- RESULTS - INTERGRANULAR CRACKING IN THE BOLT HEAD TO SHANK TRANSITION REGION.

CONCLUSIONS

(OCONEE EXAMS)

1. ALL FAILURE DUE TO INTERGRANULAR STRESS ASSISTED CRACKING.

2. ALL FAILURES LOCATED IN THE HEAD TO SHANK TRANSITION REGION.

3. BOLTS WHICH CONTAINED NO SITE U/T INDICATIONS WERE VERIFIED TO HAVE NO FLAWS (CRACKS) USING DETAILED LABORATORY EXAMINATIONS.

RANCHO SECO UPPER CORE BARREL BOLT

MATERIAL - ALLOY A-286

CONDITION A

PROCESSING - HOT HEADED

- SOLUTION TREATED

  1650°F FOR 2 HOURS

- AGE HARDENED

  1325°F FOR 16 HOURS

- THREADS ROLLED

RANCHO SECO EXAMINATIONS

BOLT TYPE: UPPER CORE BARREL BOLT

QUANTITY: 2 BOLTS WITH SITE U/T INDICATIONS (41, 116)

1 BOLT WITH NO SITE U/T INDICATIONS (79)

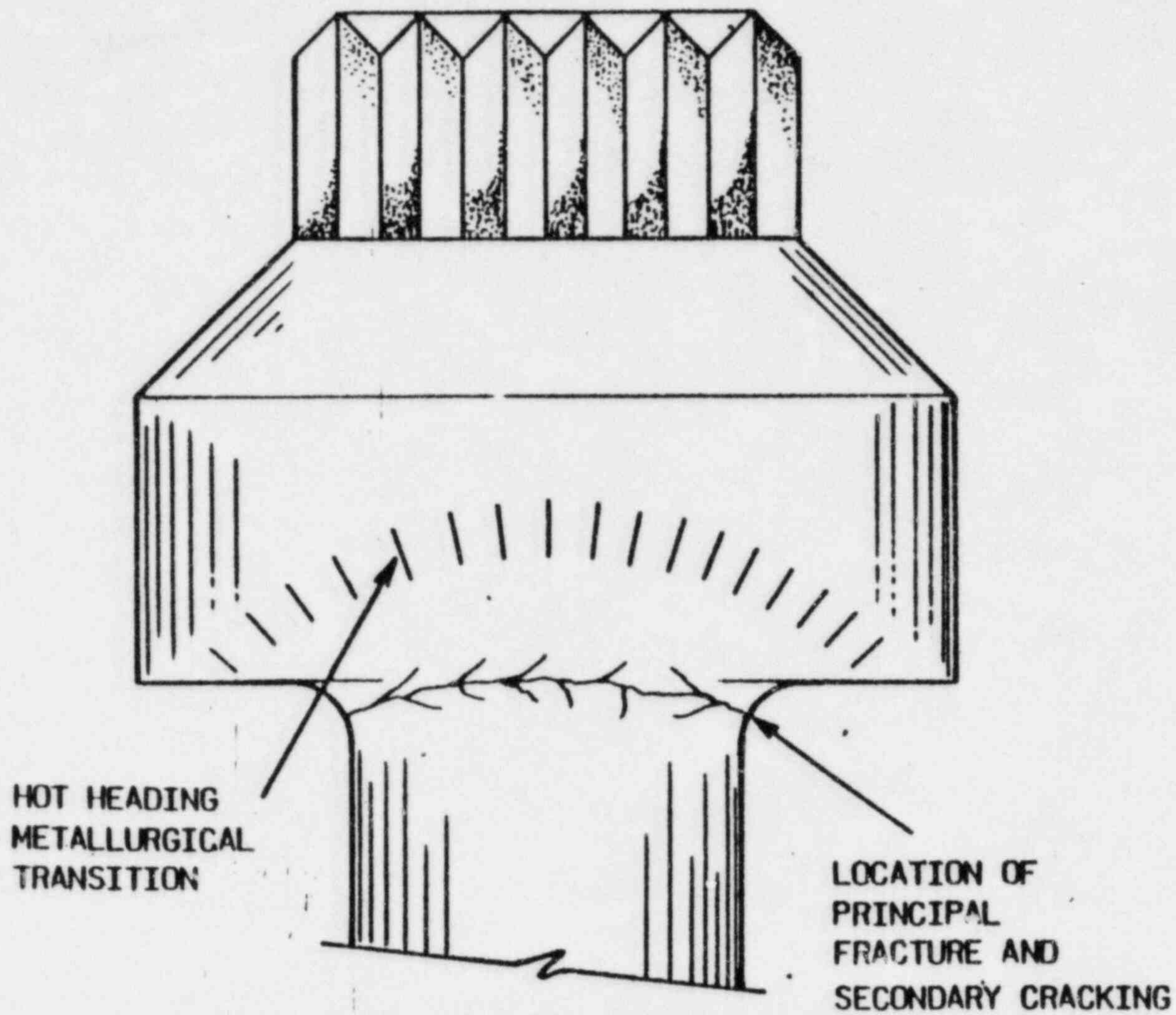
EXAMINATIONS:
- VISUAL (ALL)
- U/T (ALL)
- PT (BOLT 79)
- SEM/EDX FRACTURE SURFACE (BOLT 116)
- SEM/EDX OF SMALL DEFECT AREA OPEN BY TENSILE LOADING (BOLT 79)
- METALLOGRAPHY (BOLT 41 & 79)

RANCHO SECO EXAMINATION RESULTS

BOLT #41, #116 (CONTAINING SITE U/T INDICATIONS)

1. INTERGRANULAR FRACTURE WITH EXTENSIVE SECONDARY CRACKING (BRANCHING).
2. CRACKING INITIATED IN THE HEAD TO SHANK TRANSITION REGION.
3. CRACK PROPAGATION SIMILAR TO THAT FOUND IN THE LOWER THERMAL SHIELD BOLT, I.E., FOLLOWED HAZ CURVATURE.
4. THE HEADS OF BOTH BOLTS WERE ATTACHED BY SMALL LIGAMENTS FORMED BY THE SECONDARY CRACKING. (CRACKING PROPAGATED THROUGH ~ 95% OF BOLT SHANK.)

SKETCH OF UPPER CORE BARREL BOLT
SHOWING LOCATION OF FRACTURE



RANCHO SECO EXAMINATION RESULTS

BOLT #79 (CONTAINING NO SITE U/T INDICATIONS)

1. FLAW CONTAINS LOCALIZED DEPOSITS

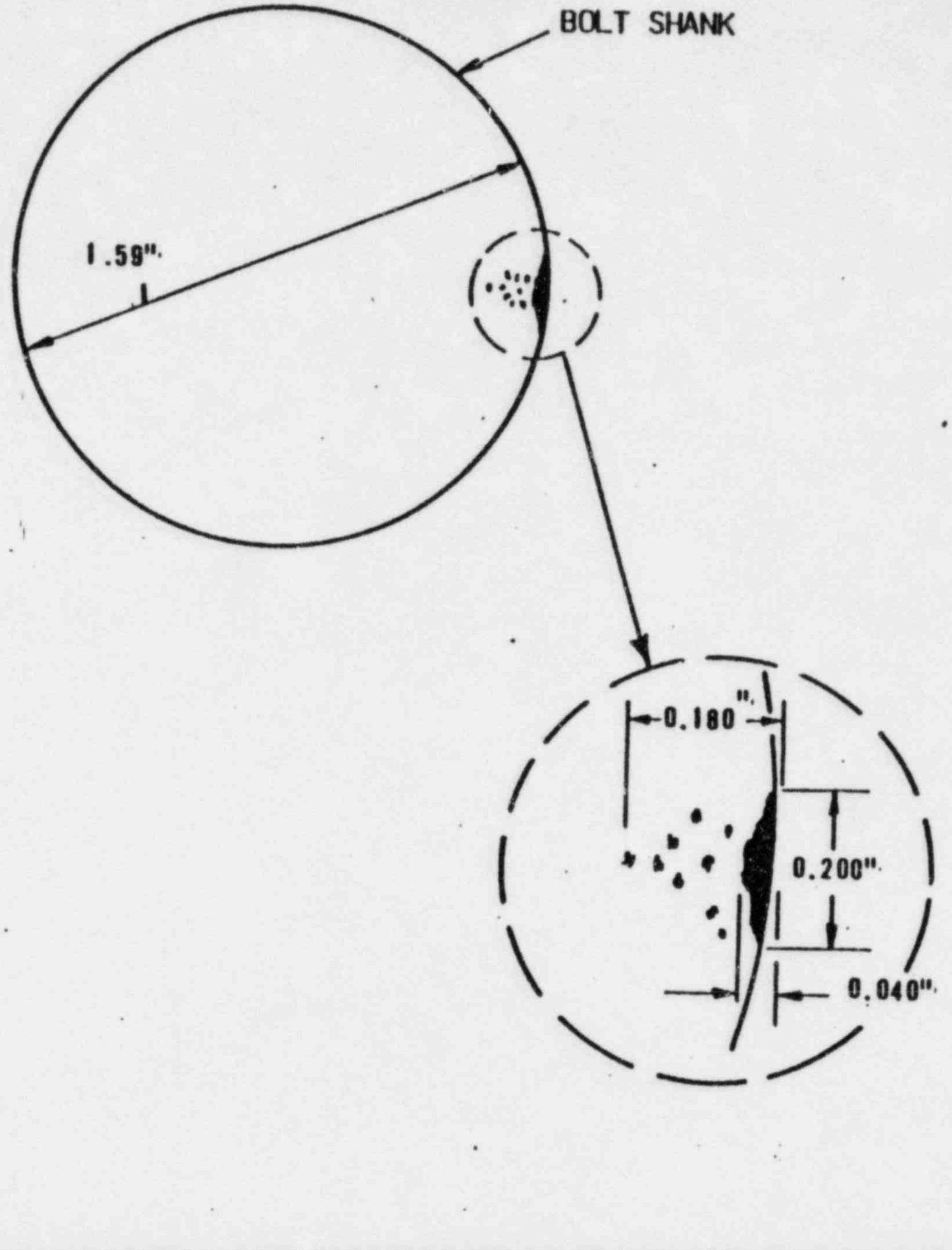
2. FLAW IS NOT INTERGRANULAR IN NATURE.

3. NO SECONDARY INTERGRANULAR CRACKING WAS OBSERVED.

4. SURFACES BETWEEN FLAWS OPENED BY DUCTILE RUPTURE WHEN PULLED APART.

5. TOTAL FLAW SIZE MUCH LESS THAN 15% SITE U/T CALIBRATION STANDARD.

RANCHO SECO UPPER CORE BARREL
BOLT #79



RANCHO SECO EXAMINATION CONCLUSION

1. RANCHO SECO UPPER CORE BARREL BOLT FAILURES ARE TYPICAL OF PREVIOUS BOLT FAILURES.

2. BOLT #79 FLAW IS AN ANOMALLY AND NOT ASSOCIATED WITH BOLT FAILURES. THE FLAW IS METALLURGICALLY INERT SHOWING NO EVIDENCE OF PROPAGATION.

OVERALL CONCLUSIONS

1. ALL BOLT FAILURES ARE DUE TO INTERGRANULAR STRESS ASSISTED CRACKING LOCATED IN THE BOLT HEAD TO SHANK TRANSITION REGION.

2. DETAILED LABORATORY EXAMINATIONS CONFIRM SITE UT FINDINGS.

LIKELIHOOD OF CORE DROP VERY LOW
BASED ON STRUCTURAL MARGINS AND
RESULTS OF UT INSPECTIONS

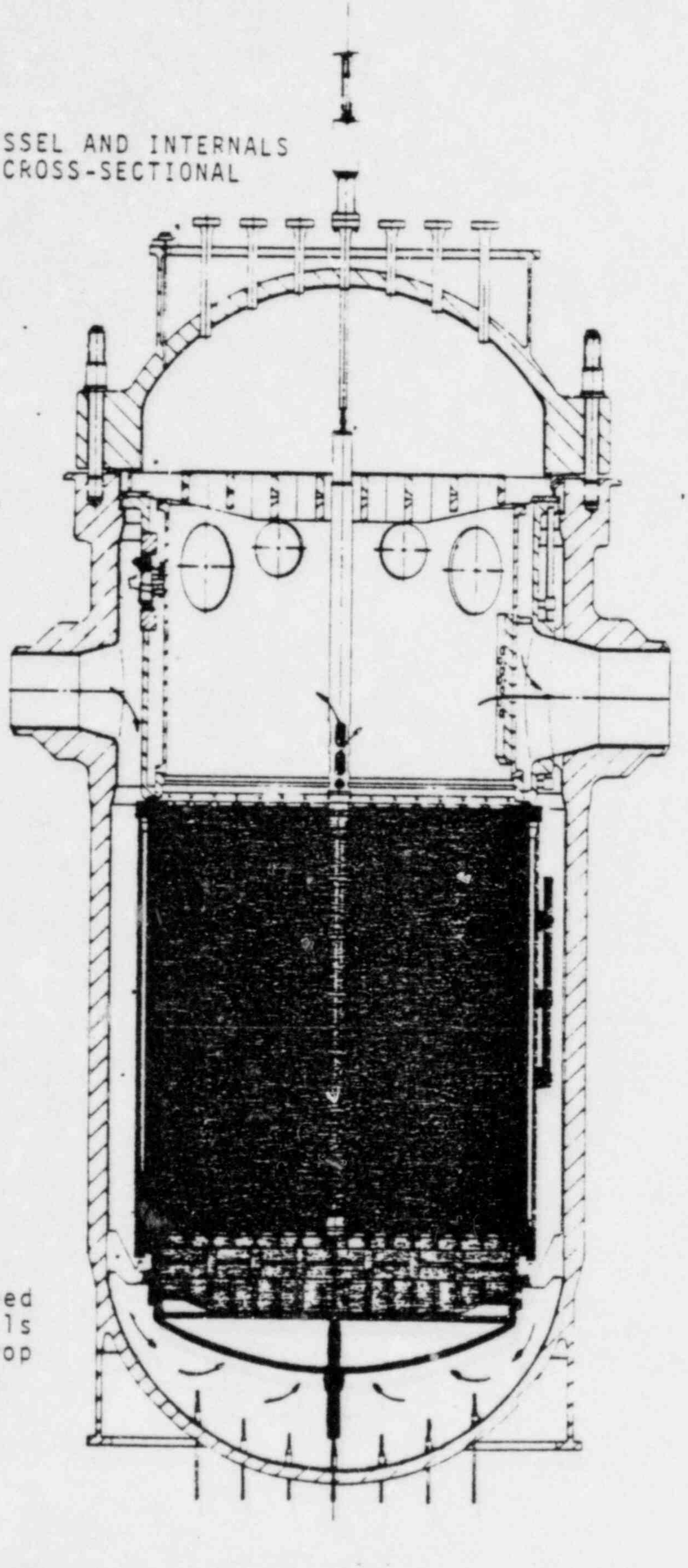
UPPER CORE BARREL (120 BOLTS)

PLANT	MIN # BOLTS REQUIRED FOR NORMAL OPER	RESULTS OF UT INSPECTIONS GOOD BOLTS	DEFECTIVE BOLTS
RANCHO SECO	8	101	19
CR-3	8	69	51
ANO-1	8	113	7

LOWER CORE BARREL (108 BOLTS)

RANCHO SECO	13	108	0
CR-3	9	104	4

REACTOR VESSEL AND INTERNALS
ELEVATION CROSS-SECTIONAL



With UCB Joint
failure blackened
part of internals
and the core drop
onto guide lugs

UPPER CORE BARREL BOLTING RING

FAILURE CONSEQUENCES

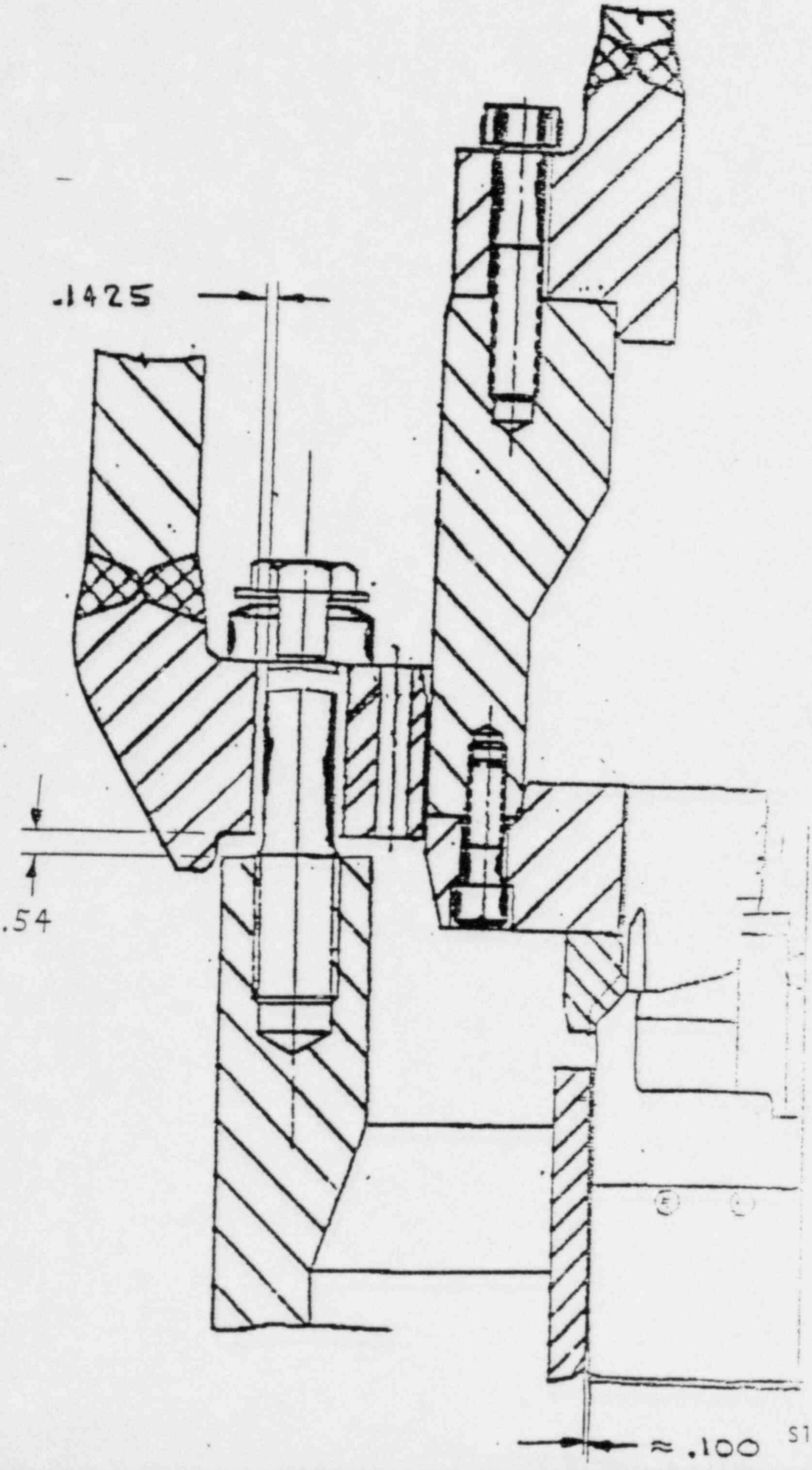
- o BOLTS FAIL UNDER THE HEAD AS DETERMINED FROM LABORATORY EXAMINATIONS
- o CORE BARREL ASSEMBLY AND FUEL DROPS .54" AND IS SUPPORTED BY GUIDE LUGS
- o BOLT HEAD REMAINS CAPTURED BY LOCKING DEVICE PRECLUDING LOOSE PARTS
- o BOLT SHANKS REMAIN ENGAGED (2½") IN CORE SUPPORT SHIELD THUS RESTRAINING CORE BARREL ASSEMBLY. RADIAL CLEARANCE BETWEEN SHANK AND HOLE IS .142".
- o NOMINAL RADIAL GAP BETWEEN CORE BARREL CYLINDER AND CORE SUPPORT SHIELD IS .170". FLOW BYPASS AROUND CORE IS 5%. ADEQUATE THERMAL MARGIN EXISTS.
- o FUEL ASSEMBLY UPPER END FITTING REMAINS ENGAGED IN UPPER GRID
- o CONTROL RODS CAN BE INSERTED SINCE IN FULLY WITHDRAWN POSITION, THEY PENETRATE INTO FUEL ASSEMBLY GUIDE TUBES 6-½ INCHES.
- o CORE BARREL BAFFLE PLATE LIKELY TO CONTACT PERIPHERAL FUEL ASSEMBLIES AT THE UPPER END FITTING WHICH ARE CAPABLE OF CARRYING HIGH LOADS IN SHEAR.
- o LATERAL LOADS (INCLUDING ASSYMETRIC LOCA LOADS) ARE RESISTED BY:
  - THE BOLT SHANKS AT THE UPPER SEVERED JOINT
  - THE GUIDE LUGS AT THE BOTTOM

UPPER CORE BARREL BOLTING RING
FAILURE CONSEQUENCES, CONT'D.

- o VERTICAL LOADS (INCLUDING CORE BOUNCE) ARE RESTRAINED IN:
  - THE UPWARD DIRECTION BY THE INTACT CORE SUPPORT SHIELD AND UPPER GRID STRUCTURE
  - THE DOWNWARD DIRECTION BY THE GUIDE LUGS WITH A 30% MARGIN TO CODE ALLOWABLES
- o FATIGUE EVALUATION OF GUIDE LUGS RESULTS IN LOW CYCLE LOADS (3400 LBS) WHICH COULD BE TOLERATED INDEFINITELY

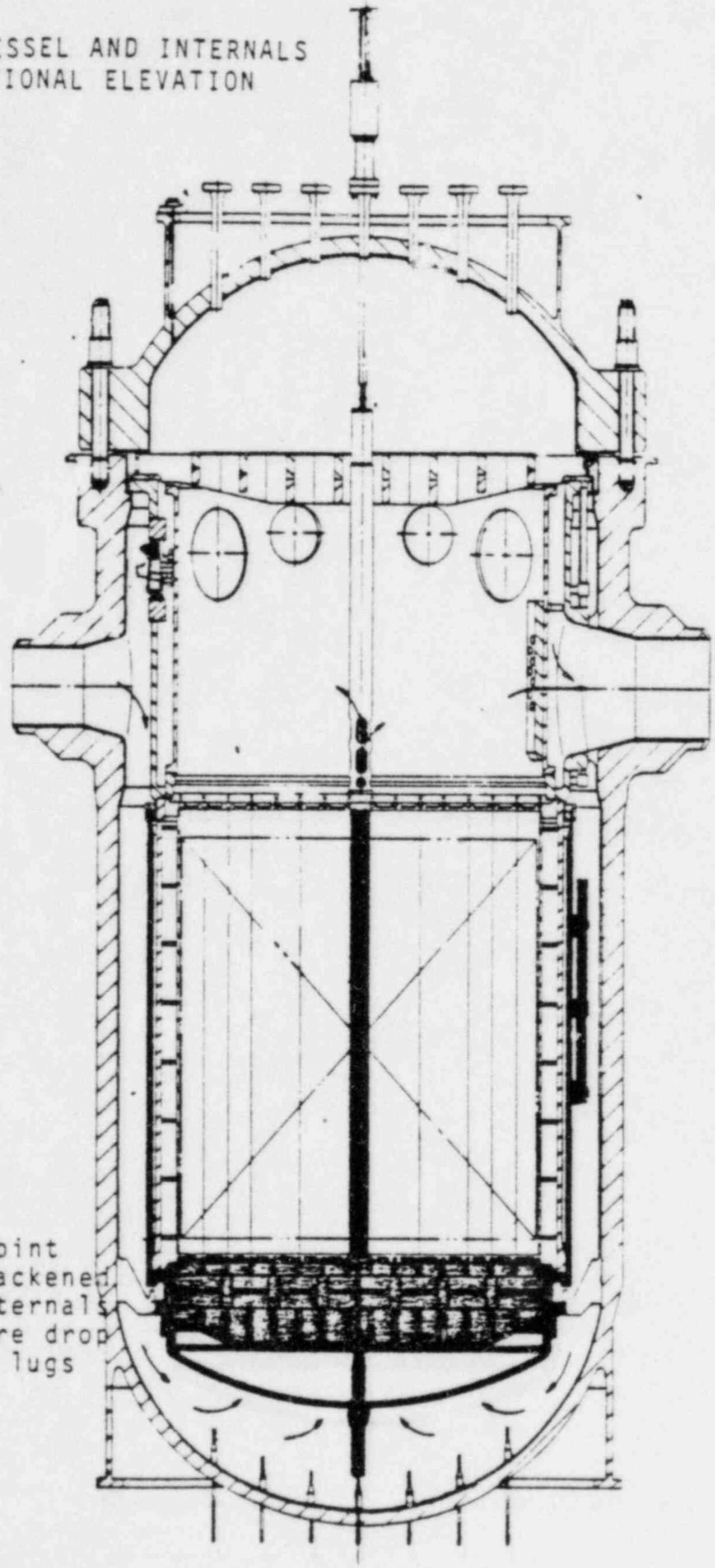
<u>CONCLUSION</u>: UPPER CORE BARREL BOLTING RING FAILURE IS LIKELY TO CAUSE MECHANICAL DAMAGE BUT IT IS NOT A SAFETY CONCERN BECAUSE:

- CORE CAN BE SHUTDOWN
- CORE WILL BE RESTRAINED AND COOLED
- REACTOR COOLANT PRESSURE BOUNDARY WILL BE MAINTAINED



Slide 42

REACTOR VESSEL AND INTERNALS
CROSS-SECTIONAL ELEVATION



With LCB Joint
failure blackened
part of internals
and the core drop
onto guide lugs

LOWER CORE BARREL BOLTING RING
FAILURE CONSEQUENCES

- o BOLTS FAIL UNDER THE HEADS
- o FUEL AND LOWER GRID ASSEMBLY DROPS .54" AND IS SUPPORTED BY GUIDE LUGS
- o BOLT HEADS REMAIN CAPTURED BY LOCKING DEVICES
- o BOLT SHANKS REMAIN ENGAGED IN LOWER GRID ASSEMBLY
- o FUEL ASSEMBLY ENGAGEMENT AND CONTROL ROD INSERTION CAPABILITIES IS MAINTAINED
- o LATERAL MOTION OF THE LOWER GRID ASSEMBLY RESTRAINED BY THE GUIDE BLOCKS AND GUIDE LUGS (.020 TO .040 INCH CLEARANCE)
- o VERTICAL MOTION RESTRAINED BY THE CORE BARREL AND GUIDE LUGS.
- o LOADINGS ON GUIDE LUGS ARE LESS SEVERE THAN FOR UPPER CORE BARREL BOLTING RING FAILURE

CONCLUSION: SAME AS FOR UPPER CORE BARREL BOLTING RING FAILURE

BASIS FOR CONTINUED DAVIS-BESSE OPERATION

- LARGE STRUCTURAL MARGINS
- OTHER PLANT INSPECTION RESULTS
- SATISFACTORY PRESENT CONDITION
  - NEUTRON NOISE (VERIFIED ON MAY 4, 1983)
  - LOOSE PARTS
  - COOLANT ACTIVITY
- JOINT LOOSENING IS DETECTABLE
- ACCEPTABLE SAFETY CONSEQUENCES DUE TO CORE DROP DURING NORMAL OPERATION
- VERY LOW PROBABILITY OF COMBINED CORE DROP PLUS HIGH LOAD (LBLOCA) ACCIDENT
- ACCEPTABLE SAFETY CONSEQUENCES DUE TO CORE DROP PLUS HIGH LOAD ACCIDENT
- LIMITED PLANT OPERATION UNTIL REFUELING (JULY 29, 1983)

JUSTIFICATION FOR CONTINUED OPERATION
FOR OCONEE NUCLEAR STATION

- PAST UT EXAMINATIONS
- LAB EXAM OF BOLT SAMPLES
- SIGNIFICANT STRUCTURAL MARGIN
- NNA RESULTS
- ABILITY TO DETECT CORE DROP
- CONSEQUENCES OF CORE DROP
- LOW PROBABILITY OF DBA
- FUTURE INSPECTION PLANS

UPPER CORE BARREL BOLTS

INSPECTION RESULTS

STATION	QUANTITY	NUMBER INSPECTED[1]	NUMBER OF DEFECTS FOUND
OCONEE 1	120	21 (17.5%)	0
OCONEE 2	120	30 (25%)	0
OCONEE 3	120	30 (25%)	0

NOTE 1 - INSPECTED BY ULTRASONIC TESTING

LOWER CORE BARREL BOLTS
INSPECTION RESULTS

STATION	QUANTITY	NUMBER INSPECTED[1]	NUMBER OF DEFECTS FOUND
OCONEE 1	108	16 (15%)	0
OCONEE 2	108	24 (22%)	0
OCONEE 3	108	24 (22%)	0

NOTE 1 - INSPECTED BY ULTRASONIC TESTING

LAB EXAMINATION

OF

BOLT SAMPLES

- REMOVED 2 UCB BOLTS FROM O-1 DURING 1981 REFUELING OUTAGE (#1, #60)
- FIELD UT SHOWED BOTH BOLTS ~~INTERACT~~ INTACT
- BOLT #60: HAD NO INDICATIONS OF FAILURE PER THE FOLLOWING TESTS:
  - FLUORESCENT DYE PENETRANT
  - SCANNING ELECTRON MICROSCOPE
- BOLT #1: HAD NO INDICATIONS OF FAILURE PER THE FOLLOWING TESTS:
  - FLUORESCENT DYE PENETRANT
  - ENHANCED LAB ULTRASONIC TECHNIQUE

NNA RESULTS

- NO ANOMALOUS SPECTRAL BEHAVIOR HAS BEEN OBSERVED FOR UNITS 2, 3.
- ANOMALOUS SPECTRAL BEHAVIOR HAS BEEN OBSERVED FOR UNIT 1.
    - NOT INDICATIVE OF A CORE DROP
    - ANOMALY HAS STABILIZED FOR 200 EFPD
- BEAM MODE VIBRATION OF THE CORE BARREL IS PRESENT FOR ALL THREE UNITS.

ABILITY TO DETECT CORE DROP

- NEUTRON NOISE SURVEILLANCE
- LOOSE PARTS MONITOR
- SPNDs, INCORE T/C
  - POSSIBLE DETECTABLE GLOBAL CHANGE IN THESE INSTRUMENTS

PROBABILITY OF DBA

- ACCIDENTS WITH POTENTIAL FOR SIGNIFICANT LOADING ON CORE SUPPORT STRUCTURE ARE LBLOCA AND SEVERE SEISMIC EVENTS.

- THE PROBABILITY OF OCCURRENCE OF THESE RARE EVENTS FOR THE LIMITED PERIOD OF INTERIM OPERATION IS ACCEPTABLY SMALL.

- PERIOD OF INTERIM OPERATION:

  - 2 WEEKS FOR UNIT 1
  - 5 MONTHS FOR UNIT 2
  - 1 YEAR FOR UNIT 3

ANTICIPATED SCHEDULE

FOR

OCONEE NUCLEAR STATION

UNIT 1 — SHUTDOWN FOR REFUELING AFTER COMPLETION OF UNIT 2's MAINTENANCE OUTAGE.

UNIT 2 — MAINTENANCE OUTAGE TO BEGIN THIS WEEKEND. SHUTDOWN FOR REFUELING EARLY OCTOBER.

UNIT 3 — SHUTDOWN FOR REFUELING APRIL 1984

INSPECTION PLANS
FOR
OCONEE NUCLEAR STATION

- o CONTINUE NNA SURVEILLANCE
  - SURVEILLANCE FREQUENCY OF 3 WEEKS
- o PERFORM 100% UT OF UCB DURING O1 REFUELING OUTAGE
- o PERFORM ADDITIONAL EXAMINATIONS BASED ON THE ABOVE RESULTS
- o RE-EVALUATE OPERATION OF O2, O3 BASED ON THE ABOVE RESULTS

SUMMARY

- o UT's SHOW NO BOLT FAILURE
- o NNA RESULTS INDICATE BEAM MODE VIBRATION IS PRESENT FOR ALL THREE UNITS
- o SUBSTRUCTURAL UPPER JOINT FAILURE IS NOT EXPECTED FOR INTERIM PERIOD OF OPERATION
- o HEALTH AND SAFETY OF GENERAL PUBLIC IS NOT ENDANGERED BY A CORE DROP SCENARIO

ANO-1

- PLANT STATUS
  - SHUTDOWN FOR REFUELING 11/82
  - STARTUP DELAYED ON 4/25/83 TO PERFORM INSPECTION OF UCB BOLTS
  - INSPECTION COMPLETED 5/3/83
  - PREPARATIONS FOR RESTART IN PROGRESS
- INSPECTION RESULTS
  - 7 OF 129 UCB BOLTS EXHIBITED UT INDICATIONS
- BASIS FOR RESTART
  - FAVORABLE INSPECTION RESULTS
  - AVAILABLE MARGIN
  - EVALUATION OF CONSEQUENCES OF POTENTIAL FAILURE
- FUTURE ACTIONS
  - CONTINUED PARTICIPATION IN TASK FORCE ACTION
  - FUTURE INSPECTIONS/REPAIRS TO BE EVALUATED
  - NEUTRON NOISE ANALYSIS EQUIPMENT BEING INSTALLED FOR USE THIS CYCLE

FUTURE ACTIONS

- THE UTILITIES PLAN TO FORMALLY DOCUMENT THE INFORMATION PRESENTED TODAY (WITH 2 WEEKS)
- CRYSTAL RIVER AND RANCHO SECO ARE PROCEEDING WITH REPAIR PLANS AND WILL KEEP SYD MINER INFORMED
- AP&L PLANS TO RESTART ANO-1 SHORTLY
- OCONEE 1 WILL BE SHUTTING DOWN SOON FOR REFUELING AND INSPECTION; BOLTS WILL BE INSPECTED AND RESULTS WILL BE PROVIDED TO THE NRC
- B&W OWNERS GROUP TASK FORCE IS DEVELOPING THEIR LONG RANGE PLANS WHICH WILL BE COMMUNICATED TO THE NRC

APPENDIX B

SITE ULTRASONIC EXAMINATION PROCEDURE

Development of Upper Core Barrel Bolt U.T. Procedure

The procedure for the ultrasonic examination of upper core barrel bolts was developed as a special case of a general procedure for examining bolts used on reactor internals. The initial objectives of the development were positive identification of bolts with no cracks or cracks extending 50% or more through the shank. A probable identification of bolts with cracks from 15% to 50% through the shank was also desired.

Because of physical constraints imposed on the examination by radiation considerations, the examination was to be conducted with the reactor internals immersed in at least 20 ft. of water. This implied that the transducer must be positioned remotely and that detailed scanning of the transducer was not practical.

Several transducer frequencies and sizes were considered, the selected parameters were chosen so that with the transducer centered on the bolt head, a small amount of ultrasound would impinge on the shank to head fillet region, where failures were apparently initiating. A small amount of ultrasound is required to provide sensitivity to small defects, but the amount must be small or the sensitivity would be low.

The selected technique was based on measuring the change in gain required to bring the shank-to-head fillet signal to 40% screen height while monitoring the reflection from the threaded end of the bolt. Cracks would cause a reduction in gain.

Calibration was performed using bolts with sawcuts made into the shank immediately under the head. The depths were approximately 0, 15% and 50% of the shank diameter.

SUBJECT: ULTRASONIC EXAMINATION OF UPPER RESTRAINT BLOCK BOLTS, FLOW DISTRIBUTOR BOLTS, CORE BARREL BOLTS & LOWER THERMAL SHIELD BOLTS	ISI-165, Rev. 1

1. SCOPE: This procedure shall govern the ultrasonic method of
detecting and evaluating bolt defects in the head to shank region of 1
upper restraint block bolts, flow distributor bolts, core barrel
bolts, and lower thermal shield bolts.

2. EXAMINER QUALIFICATIONS:

2.1 Examiner: The examiner performing the examination shall be qualified to Level II in accordance with the Babcock & Wilcox Company Administrative Procedure ISI-21. The Level II shall be responsible for and shall accept the results of the
examination. The examiner shall have a minimum of 1 hour 1
training in the technique described in this procedure.

2.2 Assistant: The assistant shall be qualified to at least Trainee or Level I in accordance with the Babcock & Wilcox Company Administrative Procedure ISI-21. The assistant shall not independently evaluate or accept the results of the examination. The assistant shall perform the examination in accordance with
this procedure under the guidance of an examiner defined in 2.1. 1
When the examination is performed by a Trainee, the Level II or Level III shall observe the performance of the examination to ensure that the requirements of this procedure are met.

3. EQUIPMENT: The equipment required to perform the measurements shall include at least the following:

3.1 UT Scope: A pulse-echo type ultrasonic flaw detection instrument shall be used.

3.2 Cables: Coaxial or microdot cables or a combination thereof
may be used. 1

3.3 Search Units: Nominal 2.25 MHz 1/2" or 1" round transducer applicable to the bolt size and mounted in a spring loaded fixture (Figure 1) for remote operation.

3.4 Couplant: A suitable liquid couplant medium such as borated, demineralized, or distilled water shall be used. Water which meets the station specifications for compatability with the reactor vessel internal surfaces shall be considered adequate. The couplant temperature for calibration shall be within 25°F (14°C) of the couplant temperature used for the examination.

ADMINISTRATIVE APPROVAL	TECHNICAL APPROVAL (LEV. III)		QA APPROVAL
DMKoruek 12-2-82	M. G. Hacker		N/A
ISSUED/REVISED BY GAT	ISSUE DATE 8-6-81	REVISION DATE 11-29-82	PAGE NO. 1 OF 5

4. CALIBRATION BLOCK:

4.1 Material: The calibration block or blocks shall be of the same nominal composition as the component to be examined.

4.2 Size: The diameter of the calibration block or blocks shall be of the same nominal diameter as the component to be examined. The minimum length of the calibration blocks shall be the length of the bolt being examined.

4.3 Reflectors: Three blocks (Figure 2) shall be used for each bolt examination performed. One bolt shall have no flaws (Figure 2A). One bolt shall have a transverse notch cut to a depth of approximately 15% of the bolt's shank diameter (Figure 2B). One bolt shall have a transverse notch cut to a depth of approximately 50% of the bolt's shank diameter (Figure 2C).

5. SYSTEM CALIBRATION:

5.1 Range: The sweep range shall be established by using either an IIW block, a step wedge, the actual calibration block, or a combination of these.

5.2 Sensitivity: The sensitivity level for the examination shall be established by positioning the search unit on the bolt head of the good bolt. The gain should be adjusted to provide a 40% (± 5%) FSH response from the head to shank radius of the bolt. Record the calibration settings on the calibration/data sheet (Figure 3).

The calibration sensitivity shall be demonstrated capable of detecting cracks in the head to shank region of the bolt by positioning the search unit on the bolt heads of the standards which are notched at 15% and 50%. Record the gain setting 1
required to set the notches at 40% (± 5%) FSH on the calibration/data sheet.

6. EXAMINATION REQUIREMENTS:

Position the search unit housing fixture securely over the head of the bolt to be examined. Adjust the gain to provide a 40% (± 5%) FSH response from the head to shank radius of the bolt. A cracked bolt will generally provide a defect signal at or near the signal from the head to shank radius and will display an amplitude greater than 40% FSH. The amplitude of the back reflection will generally decrease in proportion to the size of the crack. This, in addition to the results of the sensitivity demonstration on the 15% and 50% notches, should be the basis for determining the condition of the bolt. The bolt number and the results of the examination should be recorded on the calibration/data sheet.

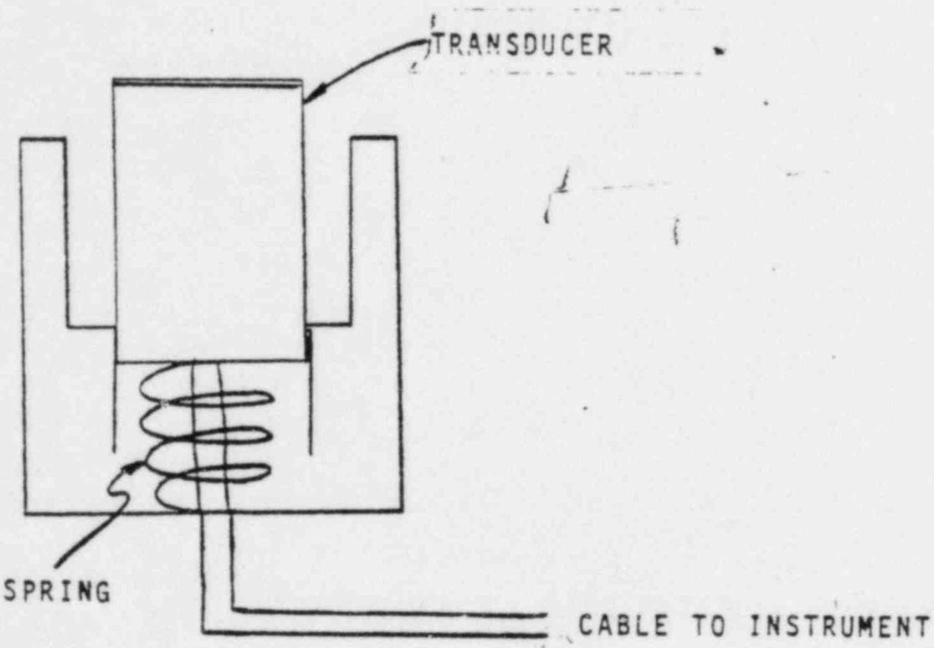
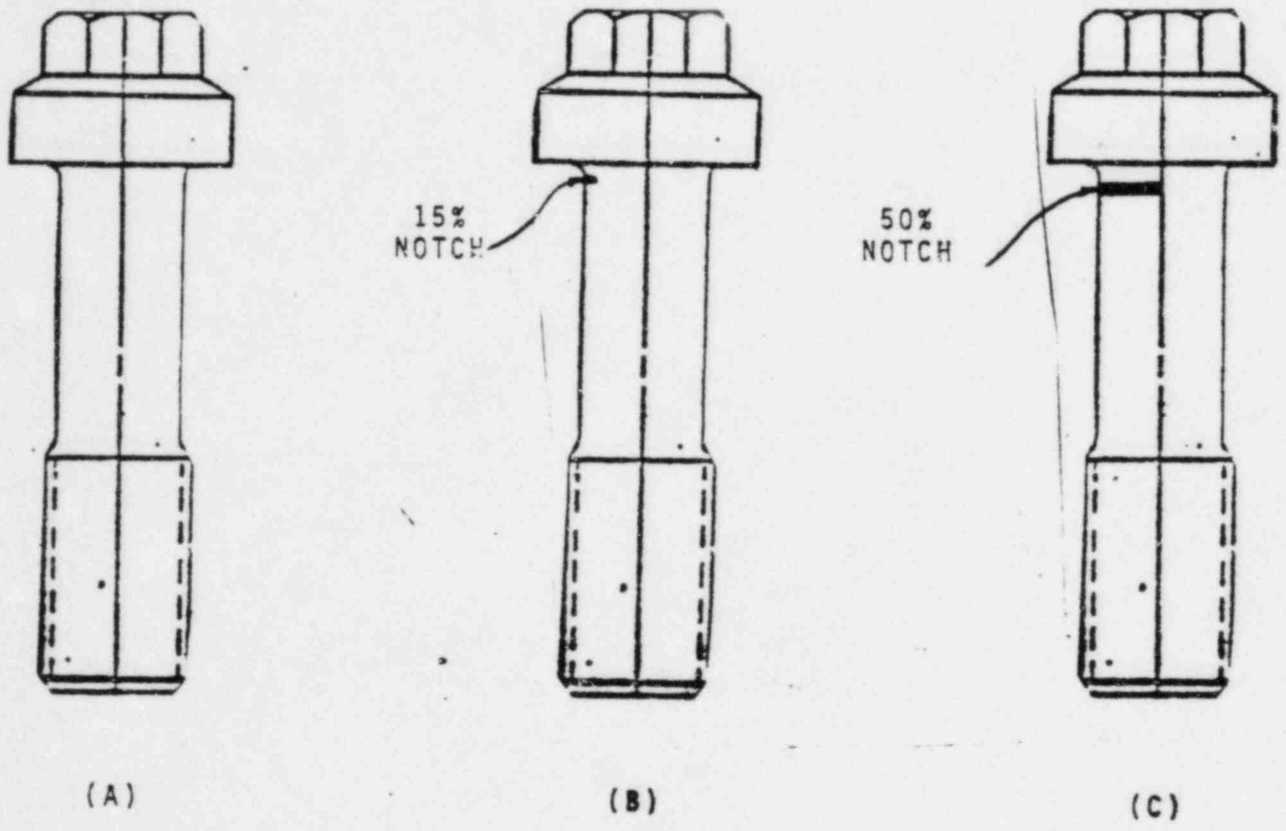


Figure 1. Springloaded Fixture

CALIBRATION BLOCK FIGURES

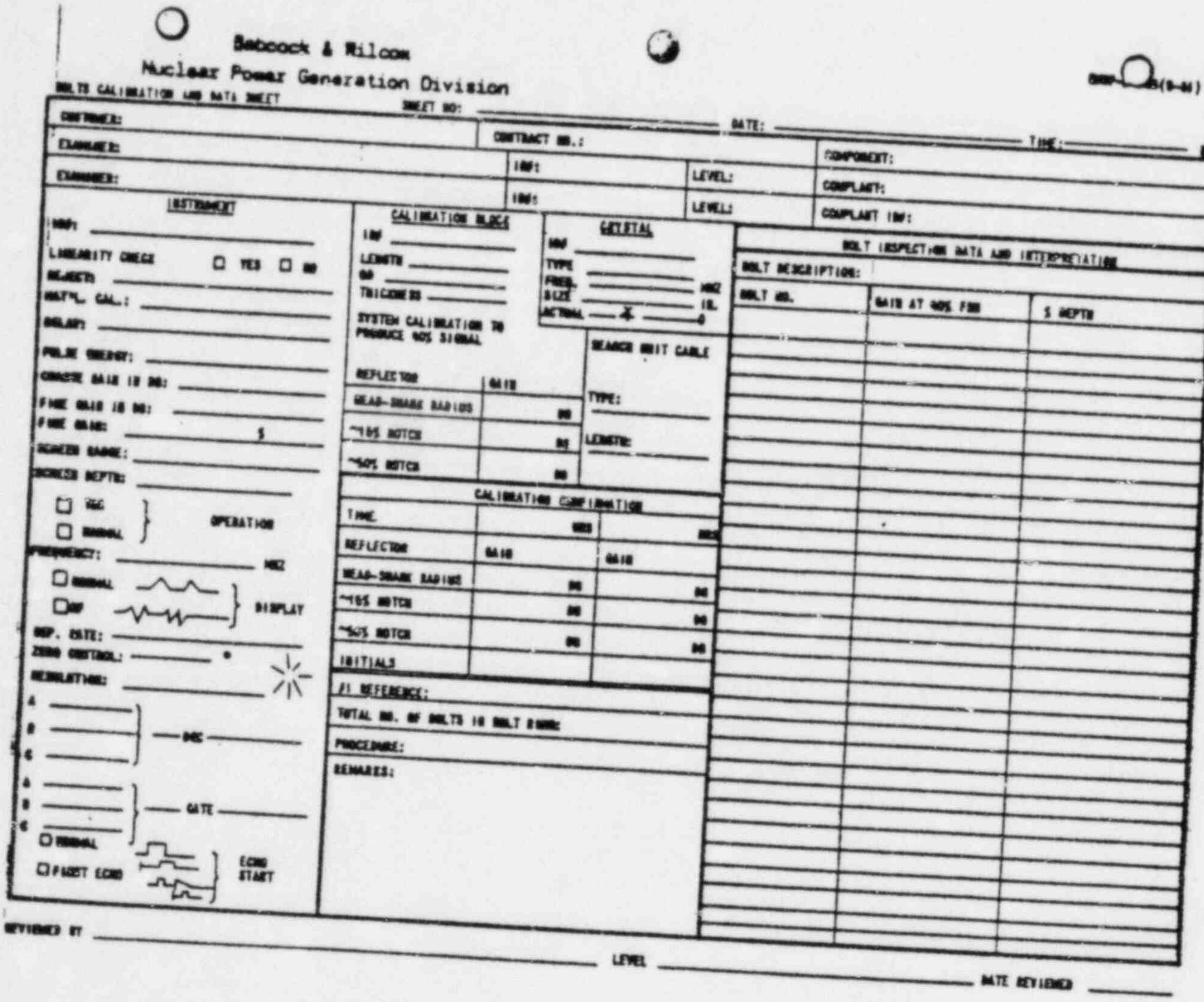


Note 1 - For flow distributor bolts and thermal shield bolts, the notch is cut approximately 1/16" below the flange.

Note 2 - For the upper restraint bolts and the core barrel bolts, the notch is cut approximately 1/8" below the flange.

Figure 2. Calibration Blocks.

SUBJECT: ULTRASONIC EXAMINATION OF UPPER RESTRAINT BLOCK BOLTS, FLOW DISTRIBUTOR BOLTS, CORE BARREL BOLTS & LOWER THERMAL SHIELD BOLTS	ISI-165, Rev. 1



Babcock & Wilcox
Nuclear Power Generation Division
BOLTS CALIBRATION AND DATA SHEET

SHEET NO: DATE: TIME:
CONTRACT NO.:
COMPONENT:
LEVEL:
LEVEL:
COUPLANT:
COUPLANT [illegible]:

INSTRUMENT
LINEARITY CHECK ☐ YES ☐ NO
MAT'L. CAL.:
PULSE ENERGY:
COARSE GAIN IN DB:
FINE GAIN IN DB:
FINE GAIN:
SCREEN RANGE:
SCREEN DEPTH:
OPERATION
FREQUENCY: MHZ
DISPLAY
REP. RATE:
ZERO CONTROL:
GATE
ECHO START

CALIBRATION BLOCK
LENGTH
THICKNESS
SYSTEM CALIBRATION TO PRODUCE 40% SIGNAL
REFLECTOR | GAIN
HEAD-SHANK RADIUS
~10% NOTCH
~50% NOTCH

CRYSTAL
TYPE
FREQ. MHZ
SIZE IN.
ACTUAL

SEARCH UNIT CABLE
TYPE:
LENGTH:

CALIBRATION CONFIRMATION
TIME
REFLECTOR | GAIN | GAIN
HEAD-SHANK RADIUS
~10% NOTCH
~50% NOTCH
INITIALS

TOTAL NO. OF BOLTS IN BOLT RING:
PROCEDURE:
REMARKS:

BOLT INSPECTION DATA AND INTERPRETATION
BOLT DESCRIPTION:
BOLT NO. | GAIN AT 40% FSH | % DEPTH

REVIEWED BY LEVEL DATE REVIEWED

Figure 3. Typical Calibration and Data Recording Sheet

PAGE NO. 5 OF 5

APPENDIX C

REACTOR VESSEL INTERNALS BOLTING
INSTALLATION TORQUE VS PRELOAD TEST DATA

Torque Test Data

Testing was conducted in 1972 and 1973 and later in 1981 in which prototypes of the 1" (lower thermal shield), 1-1/2" (upper thermal shield restraint), and 1-3/4" diameter (upper and lower core barrel) bolts were strain gaged to determine bolt load vs. applied torque. The main purpose of these tests was to establish the required torque to obtain the prescribed design bolt preload stress. Strain gages were applied to the smooth portion of the bolt shanks away from the areas of stress concentration. In all tests, neolube was applied to the threads and under-head bearing surface of the bolts, as was done on bolts installed in the reactor internals. Tables C-1, C-2 and C-3 present the pertinent data obtained for the 1-3/4" diameter, 1-1/2" diameter, and 1" diameter bolts, respectively.

A column in the attached tables labeled "Torque Sequence" describes the steps taken in installing a given bolt. Where two lines of values are shown, the step wise sequence was to torque from hand tight to a given value shown in the first line, then detension and retorque to the final value shown in the second line.

Table C-1

1-3/4" Diameter Upper and Lower Core Barrel Bolt

Stress/Torque Test Data

- o Smooth portion of four bolt shanks were instrumented with strain gages.
- o Neolube was applied uniformally to threads and bearing surface of head.
- o Bolts were torqued into the Rancho Seco reactor internals.

Torque Ft-lbs	Torque Sequence	Stress in KSI Bolt 1	Bolt 2	Bolt 3	Bolt 4	Comments
1000	0-2100 0-1750	12.2	10.9	8.5	7.0	
1000	0-2100 0-1750	--	--	11.4	8.2	Bolts 3&4 were relubricated and retorqued in same hole.
1750	0-2100 0-1750	19.1	18.9	16.9	13.8	
1750	0-2100 0-1750	--	--	20.1	15.2	
2000	0-3000	--	--	22.7	26.1	Under heads of bolts 3&4 were refinished.
2000	0-3000	--	--	--	24.7	Bolt 4 was relubricated & retorqued in different hole.
2400	0-3000	--	--	25.7	32.7	
3000	0-3000	--	--	31.7	40.8	

Table C-2
1" Diameter Lower Thermal Shield Bolt
Stress/Torque Test Data

- Smooth portion of bolt shanks were instrumented with strain gaps.
- Neolube was applied uniformally to the threads and bearing surface.
- Two bolts (Bolt Nos. 1&2) were torqued into the Rancho Seco reactor internals and two bolts were tested on a mock-up in the Lab.

Torque Ft-lbs	Torque Sequence	Bolt Stress in KSI Bolt 1	Bolt 2	Bolt 3	Bolt 4	Comments
	0-450					
350	0-350	30.8	35.8	37.9	37.6	
	0-450					Bolts 3&4 were relubricated and retorqued in same hole.
350	0-350	--	--	36.4	37.7	

Table C-3

1-1/2" Diameter Upper Thermal Shield Restraint Bolt

Stress/Torque Tests Data

- o Smooth portion of bolt shanks were instrumented with strain gages.
- o Neolube was applied uniformally to threads and bearing surface of head.
- o Three bolts were torqued into a special fixture that simulated the reactor internals.

Torque	Torque Sequence	Bolt Stress in KSI Bolt 1	Bolt 2	Bolt 3
	0-1100			
700	0-1200	16.1	15.5	16.4
	0-1100			
800	0-1200	18.7	17.1	19.4
1100	0-1100	24.2	25.3	25.4

Appendix D

NRC Question on Installation Torque
and Prestress

During the NRC meeting the staff requested that copies of slides on prestress and installation torque be provided for the UCB and LCB bolts at the affected 177 FA plants. These slides were not included in the meeting handouts. Table D-1 and D-2 provide the requested information. Table D-2 was developed to evaluate the peak normal operating stress in the region under the head. The peak stress is determined from total normal operating and prestress loads and is obtained by multiplying the total stress by the exhibited proper stress concentration factor to account for the diameter change at the head to shank transition. In addition, the question was raised why the three Oconee plants used different installation torques and, therefore, have different prestress values for the UCB and LCB bolts. Examination of records that indicate after the preparation of specification and procedure for Oconee 1 bolt installation, increased attention was placed on the design margins for joint integrity under faulted condition loads. The increased torque was apparently specified for Oconee 2 and 3 to increase those margins to ensure the joint was maintained closed during faulted condition loadings.

The NRC also asked what steps will be taken for replacement bolts to insure that the torque actually applied in the field provides the prestress set by Engineering specification.

Torque vs load tests will be provided on several production line bolts to correlate prestress with applied torque. UT calibration will then be made to provide a method of field determination of actual prestress.

Installation in the field will be by calibrated hydraulic torque wrench with the installation torque values recorded. This data will then be verified by UT examination after torquing. Incorrectly torqued bolts will be detensioned and retorqued to the proper value then rechecked by UT.

Information provided in Tables D-1 and D-2 is based on specific documentation of field procedures or installation records where available. B&W and the listed utilities are continuing to review records to ensure that the information is accurate. Until that work is complete the data reported in these two tables is subject to change. However, the changes are expected to be within the ranges shown and should not effect conclusions drawn from this data.

Table D-1

PRELIMINARY STRESS LEVEL COMPARISON

BOLTING RING	PLANT	NOMINAL PRELOAD STRESS (KSI)	NOMINAL OPERATING STRESS (KSI)	TOTAL STRESS (KSI)	PEAK STRESS (KSI)
UPPER CORE BARREL	OCONEE 1	10	5	15	34.5
	OCONEE 2	29.5	5	34.5	79.5
	OTHER PLANTS	36.5	5	41.5	95.5
LOWER CORE BARREL	OCONEE 1	10	8	18	41.5
	OCONEE 2			27	62
	RANCHO SECO	19	8	27	62
	ANO-1				
	OCONEE 3	28	8	36	83
	CR-3				
	DB-1				
	MIDLAND 1 & 2				
UPPER THERMAL SHIELD	OCONEE 1	17	3	20	40
	CR-3	20	3	23	46
	OTHER PLANTS	31.5	3	34.5	69
FLOW DISTRIBUTOR	ALL PLANTS	33	2	35	70
LOWER THERMAL SHIELD (INITIAL INSTALLATION)	ALL PLANTS	33	32	65	137
SURVEILLANCE HOLDER TUBE	CR-3	45	3	48	101
	DB-1				

YIELD STRESS OF A-286 VARIES FROM 100 TO 134 KSI. PRELOAD STRESS VALUES BASED ON NEOLUBE.

Table D-2

Installation Torque for

Upper and Lower Core Barrel Bolts

Plant	Torque-Ft-lbs UCB Bolts	LCB Bolts
Oconee 1	950	950
Oconee 2	2000-3000*	1750
Oconee 3	3000	2400
ANO-1	3000	1750
Crystal River 3	3000	2400
Rancho Seco	3000	1750
Davis Besse 1	3000	2400
Midland 1 & 2	3000	2400

*Documentation as to correct value presently under investigation.