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SUBJECT: Special rept:on 901108,indication of leak by observation of boron crystal accumulation on incore closure housing L2 during shutdown insp.Cause by equipment failure.Dye penetrant test performed on housings.W/910121 ltr.

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DUKE POWER

January 21, 1991

U. S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555

Subject: Oconee Nuclear Station
Docket No. 270
Special Report Concerning Reactor Coolant
System Pressure Boundary Leak on Incore
Instrumentation Closure Housing

Gentlemen:

This report is provided for information regarding reactor coolant system pressure boundary leak on incore instrumentation closure housing.

If you have any questions, please contact Rick Matheson at (803) 885-3119.

Very truly yours,

H B Barron

H. B. Barron
Station Manager

/ftr

Attachment

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NRC FORM 366 (6-89)

U.S. NUCLEAR REGULATORY COMMISSION

APPROVED OMB NO. 3150-0104
EXPIRES: 4/30/92

ESTIMATED BURDEN PER RESPONSE TO COMPLY WTH THIS INFORMATION COLLECTION REQUEST: 50.0 HRS. FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE RECORDS AND REPORTS MANAGEMENT BRANCH (P-530), U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC 20555, AND TO THE PAPERWORK REDUCTION PROJECT (3150-0104), OFFICE OF MANAGEMENT AND BUDGET, WASHINGTON, DC 20503.

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Oconee Nuclear Station, Unit 2	0 5 0 0 0 2 7 0	1 OF 1 1

TITLE (4) Reactor Coolant System Pressure Boundary Leak on Incore Instrumentation Closure Housing Due to Equipment Failure

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAMES	DOCKET NUMBER(S)
1 1	1 1	9 0	9 0	SPECIAL REPORT —	— 0 0	0 1	2 1	9 1		0 5 0 0 0
										0 5 0 0 0

OPERATING MODE (9): N

POWER LEVEL (10): - 0 -

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more of the following) (11)

20.402(b)	20.405(c)	50.73(a)(2)(iv)	73.71(b)
20.405(a)(1)(i)	50.36(c)(1)	50.73(a)(2)(v)	73.71(c)
20.405(a)(1)(ii)	50.36(c)(2)	50.73(a)(2)(vii)	X OTHER (Specify in Abstract below and in Text, NRC Form 366A)
20.405(a)(1)(iii)	50.73(a)(2)(i)	50.73(a)(2)(viii)(A)	50.72(b)(2)(i)
20.405(a)(1)(iv)	50.73(a)(2)(ii)	50.73(a)(2)(viii)(B)	
20.405(a)(1)(v)	50.73(a)(2)(iii)	50.73(a)(2)(x)	

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER	
	AREA CODE	
Henry R. Lowery, Chairman Oconee Safety Review Group	8 0 3	8 8 5 - 3 0 3 4

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

CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS

SUPPLEMENTAL REPORT EXPECTED (14)

☐ YES (If yes, complete EXPECTED SUBMISSION DATE) ☒ NO

EXPECTED SUBMISSION DATE (15): MONTH | DAY | YEAR

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

Operations Shift personnel had commenced a unit shutdown on 11/7/90, at 2136 hours in preparation for a Steam Generator Tube Leak outage. On November 8, 1990 at approximately 1900 hours, with Unit 2 at Hot Shutdown, an Operation's Staff Engineer discovered an indication of a leak by observation of boron crystal accumulation on Unit 2's Incore Closure Housing L2 during a routine shutdown inspection. There were no indications of water or steam. The leak was due to a crack in the Incore Closure Housing and a Work Request was generated to repair the problem. Maintenance removed the Incore Closure Housing. Further inspections discovered an indication on the L2 Incore pipe. This portion of pipe was also removed and the pipe was capped. Quality Assurance performed Dye Penetrant Tests on the remaining Incore Closure Housings and found one other similar defect which was repaired. The Root Cause of this event is Equipment failure.

BACKGROUND

The Incore Instrumentation (INC)[EIIS:IQ] System provides on-line measurement of core power distribution and thermal conditions. The INC consists of self-powered neutron detectors and thermocouples which are inserted into the core from the bottom of the Reactor Vessel (RV)[EIIS:VSL] through the incore piping. The Incore Closure Housing and Incore piping are part of the Reactor Coolant System [EIIS:AB] pressure boundary. There are 52 incore strings within the 177 fuel assemblies.

The INC is inserted into the core through incore piping closure assemblies in the Incore Instrument Tank (see Attachment 1). The Incore Instrument Tank is the location of the pressure and electrical connections to the Incore Piping. From the Incore Instrument Tank, the Incore Piping completes two 90 degree turns and enters the bottom of the RV through the Incore Instrument Nozzles. These are the only penetrations into the RV below core level. From the bottom of the RV, the Incore piping extends up within the Lower Grid Assembly [EIIS:AC] and aligns the INC to the instrumentation tubes of 52 selected fuel assemblies.

EVENT DESCRIPTION

Operations shift personnel commenced a unit shutdown on 11/7/90, at approximately 2136 hours, in preparation for a Steam Generator [EIIS:HX] Tube Leak Outage. The Steam Generator tube leak had increased to approximately .09 gpm and a normal unit shutdown was performed. At approximately 1830 hours on 11/8/90, an Operations Staff Engineer (SE) began a hot shutdown tour inside the Reactor Building [EIIS:NH] to identify any problems that might exist so that they could be repaired during the ensuing outage. The SE had performed a similar tour during the unit's previous startup in October and did not observe any leakage or boron accumulation in the Incore Instrument Tank.

During the SE's tour, he discovered boron crystal accumulation near some Incore Instrument Housings. The SE determined the leak to be issuing from Incore Closure Housing locations F8 and L2. After completion of the tour, two Work Requests (WR), 30848C and 30849C, were prepared on 11/10/90 for "Inspection and Repair leak on Incore Detector." While performing WR 30848C, Instrument and Electrical (I&E) technicians determined that the cause of the leak on F8 was due to an improper seating of the fitting and sealant. Incore Closure Housing F8 was disassembled, the thread sealant was reapplied, the fitting reinstalled, and then torqued.

Upon I&E's attempt to repair L2, they discovered that the Incore Closure Housing had a crack just below the housing and above the weld (Attachment 2). I&E contacted Mechanical Maintenance (MM) upon the discovery of the crack. On 11/12/90, Quality Assurance performed a Dye Penetrant Test (PT) on the observed crack to determine the extent of the discrepancy. The PT revealed a second indication on the Incore Closure Housing. At the direction of a Mechanical Maintenance Engineer, the Maintenance technicians removed this second indication by grinding it out in accordance with WR 51271K on 11/13/90. PTs were performed on all the remaining 51 Incore Instrument housings and associated piping (pipe section between Incore Closure Housing and the pipe support collar). One other indication was observed, at location E7, and was buffed out in accordance with WR 54242I on 11/13/90.

On 11/12/90, Temporary Modification ONTM-820, WR 99361C, was prepared to cut off Incore Housing Assembly L2 and send it to Babcock and Wilcox (B&W) for destructive testing. It had been determined that Incore Instrument L2 was not safety related and could therefore be removed from service by cutting and the Incore pipe capped. B&W Nuclear Service Company reviewed Duke's proposed temporary modification and documented their concurrence in a letter dated 11/12/90. On 11/13/90 at 0940 hours, while the Reactor Coolant System was drained in preparation for the Steam Generator tube repair work, ONTM-820 was performed. Incore Closure Housing L2 was sent to the B&W Lynchburg Research Center for destructive testing. Another PT was performed to inspect for defects in the cap weld. While no defects were found in the cap weld, an additional indication was discovered on the Incore pipe between the cap weld and the support collar. At the direction of the Mechanical Maintenance Engineer, an attempt was made to grind out this indication. The grinding brought the piping below minimum wall thickness without removing the indication.

After consulting with Design Engineering, Revision 1 to ONTM-820 was developed and the following was performed on 11/14/90:

1) Cut the support collar to the incore pipe weld.

2) Pull incore pipe up far enough to PT the affected section of incore pipe.

3) Weld support collar to incore piping.

4) Cut incore piping a minimum of 1/2" below lowest indication without cutting incore wire.

5) Cut and restrain incore wire.

6) Weld cap onto incore pipe.

The cap weld and collar weld received a PT and no other indications were observed. The portion of the incore pipe that was removed was also sent to B&W for destructive testing on the defect. B&W Nuclear Service Company also provided concurrence for Revision 1 in a letter dated 11/15/90 after an engineering analysis. On 11/17/90, the Incore Instrument Tank, Closure Housings, and Incore Pipe were inspected upon startup, with the Reactor Coolant System pressure between 2200 and 2210 psi, and no leaks were observed.

CONCLUSIONS

It is concluded that Incore Closure Housing L2 started leaking sometime after the previous Unit Startup (end of October 1990) and before the time of the hot shutdown tour performed during a unit shutdown for a Steam Generator Tube Leak Outage on November 8, 1990.

Both the Incore Closure Housing L2 and the removed portion of the Incore Piping were sent to the B&W Lynchburg Research Center for destructive testing. Dye Penetrant Tests performed at the Research Center on the Incore Closure Housing indicated one through-wall crack with several other cracks approximately 180 degrees away.

A visual inspection of the Incore Pipe stub performed by the research center indicated a number of cracks. The pipe stub has been sent to an independent testing facility for dye penetrant and destructive testing.

The major conclusions of the B&W analysis of the Incore Pipe stub and the Incore Housing are as follows:

1) Incore Closure Housing L2 and Incore Pipe failed primarily due to mechanical fatigue.

2) Fatigue striation spacings indicated high-cycle, low-amplitude loading.

3) The source of the loading is not known, but could have been caused by multi-mode vibrations.

4) The Incore Closure Housing material exhibited a relatively high non-metallic inclusion content, which may have reduced the fatigue life of the component.

5) Bulk chemistry for both the Incore Closure Housing and the Incore Pipe was within the limits for Type 304L stainless steel as stated in ASME Specification SA-182.

A review of LERs over the past 24 months reveals that this event is nonrecurring. There was equipment failure involved in this event, therefore it is NPRDS reportable. The radiation releases resulting from this event were contained in the Reactor Building. The radiation exposure resulting from planned work activities to repair the component and the test of other similar components was not excessive. There were no personnel injuries as a result of this event. The health and safety of the public were not compromised as a result of this event since the quantity of leakage was not significant and all the leakage was contained in the Reactor Building.

CORRECTIVE ACTIONS

Immediate

1) Staff Engineer wrote Work Requests upon discovery of the leaks.

Subsequent

1) Mechanical Maintenance directed Quality Assurance to perform Dye Penetrant Tests on all Incore Closure Housings and Incore piping within the Incore Instrument Tank.

2) Temporary Modification ONTM-820 was implemented which removed portions of L2 on which indications had been observed and capped the remaining portion of piping to maintain the pressure boundary.

3) Incore Closure Housing L2 and the Incore piping portion of L2 that was removed were sent to B&W for destructive testing.

4) All accessible Incore piping was visually inspected for leakage at hot shutdown conditions during the unit startup.

Planned

1) Conduct tests and monitoring as required to determine the root cause of the failure. Future actions will be determined based on the monitoring and testing.

SAFETY ANALYSIS

A broken Incore pipe will provide a single-ended flow path from the Reactor Coolant System (RCS). The force exerted on the associated incore instrumentation by the RCS water is reasonably expected to cause the instrumentation to be expelled from the broken line. The resulting flow path is estimated to have a maximum flow area of 0.002 square feet. Because each incore monitor is individually sealed in the Incore Instrument Tank, the only possible flow path is through the broken line between the RCS and the break location.

Various SBLOCA analyses have been performed from a whole spectrum of break sizes and break locations. These analyses have examined the consequences of breaks on the RCS loops and the Core Flood Tank discharge lines. Breaks on the Incore pipes have not been analyzed. However, the consequences of a break on an Incore pipe can be determined from a cold leg break analysis with the same break size.

The analyzed spectrum of SBLOCAs have determined that a cold leg break at the discharge of a Reactor Coolant Pump (RCP) will lead to the most severe system response. A break size below 0.005 feet square will result in the RCS depressurizing without interruption of single-phase flow in the RCS loops. The RCS pressure will drop below 1600 psig, actuating injection flow from the High Pressure Injection (HPI) System. The RCS pressure will eventually stabilize at a pressure at which the energy removal through the break and the Steam Generators match or exceed the decay heat level. The HPI flow will be able to replace any coolant that is lost through the break. The core will not uncover, and fuel cladding temperature will remain within a few degrees of the RCS temperature. Then the cladding temperature will remain far below the 10CFR50.46 acceptance criterion of 2200 degrees Fahrenheit. In addition, breaks smaller than 0.005 feet square allow a near-normal cooldown and depressurization of the RCS.

A break of this size on an Incore pipe will not lead to any worse consequences than seen with the same size break on a RCS cold leg. The same inventory conditions (single-phase water) will exist throughout a SBLOCA event for a 0.002 feet square break at either location. By applying the same conservative initial conditions and boundary conditions used in the cold leg break analysis, the only differences between a SBLOCA at the RCP discharge and a SBLOCA on the Incore pipe are seen to be:

a) The amount of HPI flow available to the RCS.

b) The break geometry

c) The location of the flow diversion relative to the core

d) The amount of the leakage flow that reaches the RB sump

With an Incore pipe break, all of the HPI injection flow will reach the RCS. This in contrast with a cold leg break, for which it is assumed that a portion of the HPI flow is immediately lost out the break and is not available for RCS makeup. In this manner, the Incore pipe break is less severe or less limiting than the cold leg break.

The flow path through a ruptured Incore pipe will produce greater frictional pressure losses than for a cold leg break. The flow path length for a cold leg break is relatively short, being the thickness of the pipe. RCS inventory escaping through a ruptured Incore pipe must pass through the intact portion of the tube inside the RCS, through the reactor vessel lower head wall, and through whatever portion of the Incore pipe lies between the reactor vessel and the break location. However, the additional static head resulting from the differences in the break locations will tend to offset the higher frictional pressure drop to some degree. Thus, for the same RCS fluid conditions at the break location, the leakage flows are expected to be comparable for the two locations, with the cold leg break producing higher flows.

The fact that an Incore pipe break diverts water from the lower reactor vessel is expected to have no worse of an effect on flow through the core than from a cold leg break. In both cases the break will divert RCS flow upstream of the core inlet. As previously mentioned, the flow rates for the two break location are expected to be comparable for equivalent RCS conditions. Seeing that adequate core cooling has been established for this size cold leg break, it is reasonable to expect that the same is true for an Incore pipe break.

The difference in break locations affects the amount of borated leakage flow that reaches the Reactor Building Emergency Sump (RBES), impacting the availability of the sump as a long-term source of RCS makeup. During a LOCA event, part of the break flow will flash to steam, while the remainder accumulates in the Reactor Building (RB) as borated liquid. The steam is eventually condensed by the RB Cooling Units (RBCUs), or by the RB Spray System and reaches the RB sump as unborated water. With a cold leg break, the borated liquid will eventually end up in the RBES.

An Incore pipe rupture in the Incore Instrument Tank will provide a direct leakage path to the RB atmosphere. The leakage appearing as borated liquid will reach the RBES via the monitor tank drains. The portion that flashes to steam will exit through the open top of the tank. By the time the Borated Water Storage Tank (BWST) is nearly depleted, enough borated water will be in the RBES to provide the HPI System or Low Pressure Injection (LPI) System with a long-term source for RCS makeup.

If an Incore pipe rupture occurs in the reactor vessel cavity, the leakage appearing as borated liquid will collect in the cavity, while the steam escapes into the remainder of the RB via the cavity vents. As the accident progresses, the water level in the reactor vessel cavity will continue to rise. Once the cavity has filled to the level of the reactor nozzles, the borated liquid will begin to overflow onto the RB basement. Any further break leakage will then reach the RBES. The minimum required volume of water in the BWST is more than sufficient to:

a) Makeup for RCS shrinkage during the cooldown to cold shutdown,

b) Fill the reactor vessel cavity to the spill-over elevation, and

c) Provide enough borated water in the RBES and on the RB basement floor to allow the HPI System or the LPI System to be used in the recirculation mode,

before the BWST was depleted. Therefore, long-term make-up to the RCS would be ensured following a rupture of an Incore pipe within the reactor vessel cavity.

In the event of a sudden rupture in the vicinity of the pipe-to-pipe Incore Closure Housing weld in the Incore Instrument Tank, the following potential consequences have also been considered;

1) Loss of function to all or a portion of the Incore Instrumentation as a result of jet impingement effects, projectile impact (Incore Closure Housing or Incore Instrument), or electrical nonfunction due to saturated steam environment.

2) Structural failure of one or more additional Incore Closure Housings due to jet impingement, projectile impact after initial failure.

3) Loss of function to nearby safety related equipment due to jet impingement, projectile impact, or steam discharge.

Following is a discussion of the likelihood that the above consequences could pose a real safety concern in terms of operation and safe shutdown of the plant.

1) It is possible any number of Incore Instruments could lose function because of impingement effects, impact from failed Incore Closure Housing, or intense exposure to saturated steam. However, since the Incore Instrumentation is a non-safety related system, loss of function is not a concern in terms of safe shutdown of the plant in the event of a LOCA.

2) A structural failure near the tapered end of the Incore Closure Housing is assumed to cause instantaneous pipe separation. The result is a horizontal jet plume which impinges on nearby housings as it propagates. As the flange moves away from the incore pipe/guide tube the plume dissipates and the jet flow is axial to the pipe. The housing and cable support assembly may become a missile. Due to the short duration of the jet impingement plume, it is unlikely that failure of adjacent Incore Closure Housings would occur.

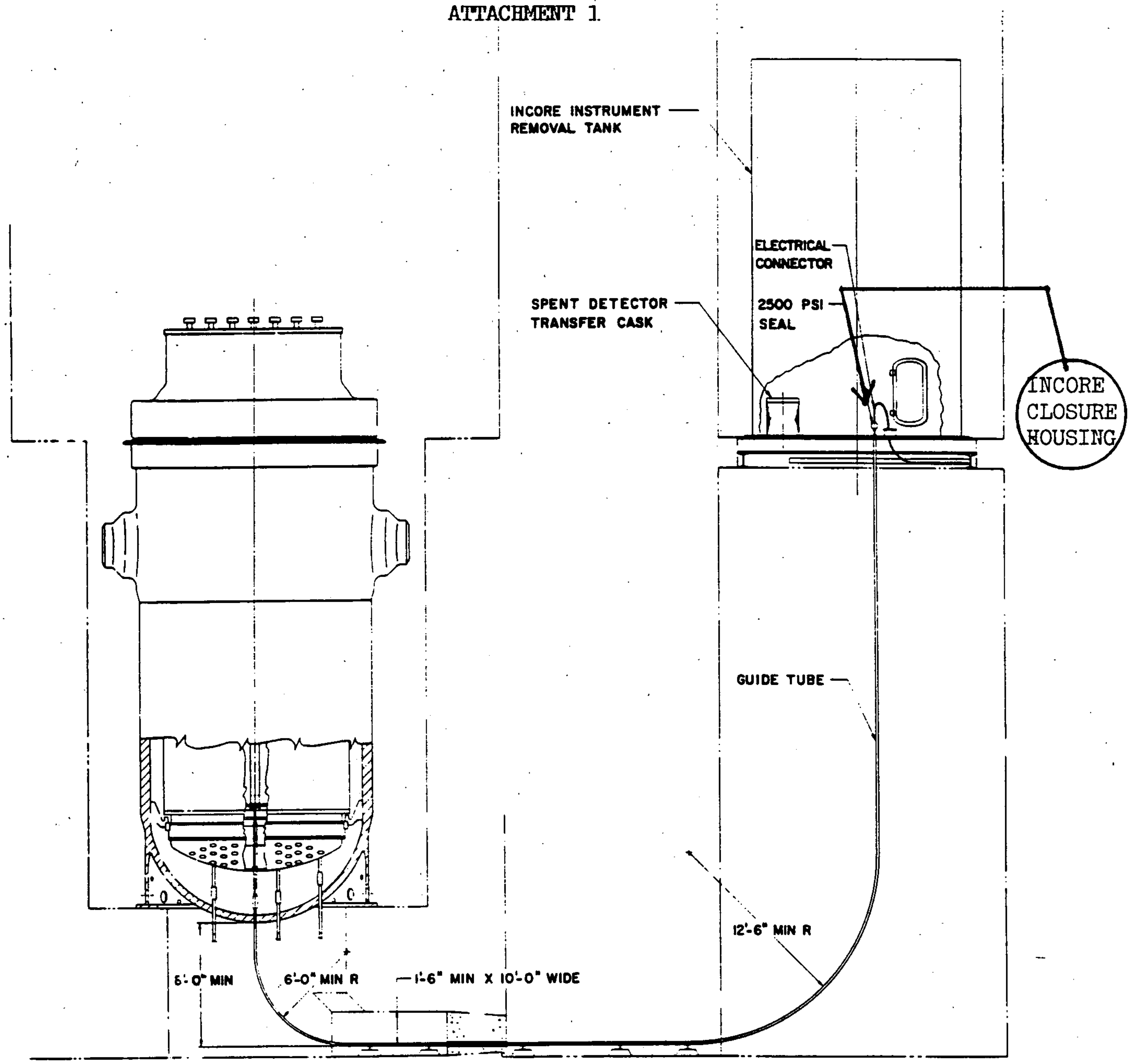
   As to the severed Incore Closure Housing, the likely trajectory is vertical and would be propelled up through the Incore Instrument Tank. If the Incore Closure Housing trajectory were to occur at an angle resulting in an impact with a nearby Incore Closure Housing, failure of the assembly, although unlikely due to the short duration of the impact, cannot be ruled out. However, failure of a third Incore Closure Housing is inconceivable. Therefore, maintenance of core inventory with 2 Incore Closure Housing failures, is not expected to be a problem.

3) All 52 Incore Closure Housings are mounted on the steel plate floor of the Incore Instrument Tank. The tank is open at the top. There is no safety related equipment located in the tank along with the Incore Closure Housings. Missile shields are above the tank in case of a projectile resulting from the severed Incore Closure Housing.

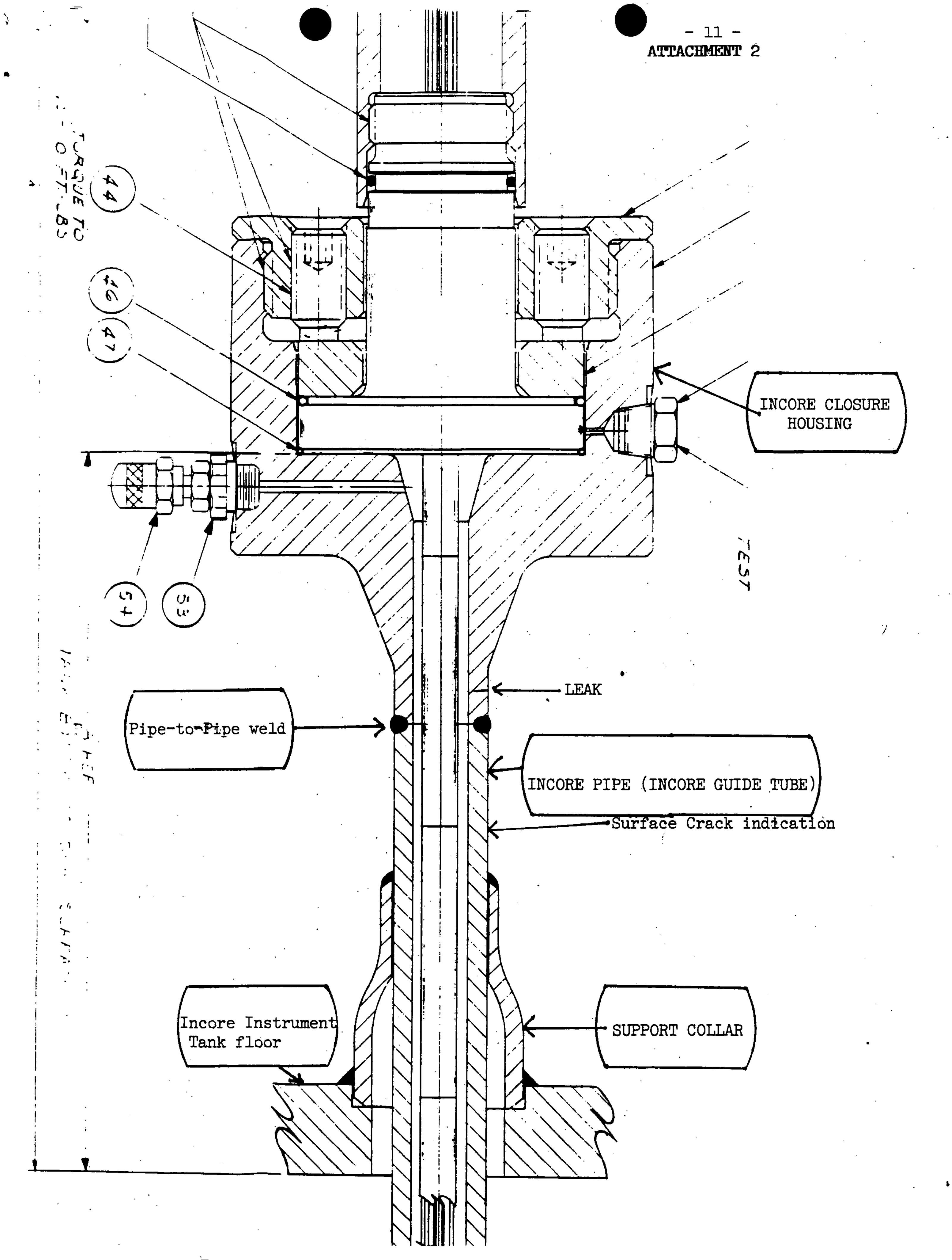
By comparing the differences between an Incore pipe SBLOCA and a cold leg break of the same area, at the RCP discharge, the analyzed cold leg break possesses the more limiting boundary conditions of the two cases. So, the consequences of an Incore pipe SBLOCA would be less severe or less limiting than a cold leg break. Therefore, the core will remain covered, and no fuel damage will occur subsequent to a rupture of an Incore pipe. In both cases, long-term RCS makeup can be provided from the RBES.

Since Incore pipe SBLOCA's consequences are bounded by the more limiting boundary conditions of an analyzed cold leg break and the fact that the crack on the Incore Instrument closure housing was discovered while it was still small, the health and safety of the public was not jeopardized as a result of this event.

ATTACHMENT 1



INCORE MONITORING CHANNEL
OCONEE NUCLEAR STATION
Figure 7.6-11


44
46
47
54
53
INCORE CLOSURE HOUSING
TEST
LEAK
Pipe-to-Pipe weld
INCORE PIPE (INCORE GUIDE TUBE)
Surface Crack indication
Incore Instrument Tank floor
SUPPORT COLLAR