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RECIP.NAME RECIPIENT AFFILIATION

SUBJECT: LER 91-010-00:on 910918,determined that operating limit curve for letdown storage tank pressure versus level inadequate.Caused by design deficiency.Operating limit curve revised & addl instructions provided.W/911021 ltr.

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DUKE POWER

October 21, 1991

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

Subject: Oconee Nuclear Station
Docket Nos. 50-269, -270, -287
LER 269/91-10

Gentlemen:

Pursuant to 10 CFR 50.73 Sections (a)(1) and (d), attached is Licensee Event Report (LER) 269/91-10 concerning the High Pressure Injection System.

This report is being submitted in accordance with 10 CFR 50.73 (a)(2)(ii)(C). This event is considered to be of no significance with respect to the health and safety of the public.

Very truly yours,

H B Barron

H. B. Barron
Station Manager

RSM/ftr

Attachment

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IE22 1

LICENSEE EVENT REPORT (LER)

FACILITY NAME(1)	DOCKET NUMBER(2)	PAGE(3)
Oconee Nuclear Station, Unit 1	05000 269	1 OF 13

TITLE(4) High Pressure Injection System Technically Inoperable For Some Single Failure LOCA Scenarios Due to Design Deficiency

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)
									Oconee, Unit 2	05000 270
09	18	91	91	010	0	10	21	91	Oconee, Unit 3	05000 287

OPERATING MODE(9): N

POWER LEVEL(10): -0-

THIS REPORT IS SUBMITTED PURSUANT TO REQUIREMENTS OF 10CFR (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)		OTHER (Specify in Abstract below and in Text)
	20.405(a)(1)(iii)		50.73(a)(2)(i)		50.73(a)(2)(viii)(A)		
	20.405(a)(1)(iv)	X	50.73(a)(2)(ii)(c)		50.73(a)(2)(viii)(B)		50.72(b)(1)(ii)(c)
	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	803	885-3034

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

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS		CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	

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

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

On September 19, 1991, at 1225 hours, while reviewing an alarm setpoint change, Design Engineering determined that the operating limit curve for Letdown Storage Tank (LDST) Pressure versus Level was inadequate. Use of this curve could permit operation outside the design basis for the emergency injection function of the High Pressure Injection (HPI) system. It was determined that, under certain small break LOCA scenarios, a single failure could result in hydrogen gas from the LDST expanding into the suction piping of the HPI pumps, causing the pumps to be damaged. This deficiency has existed on all three Oconee units since initial startup. At the time of discovery, Unit 1 was shutdown for refueling and Units 2 and 3 were both at 100 % full power. Corrective actions were to revise the operating limit curve and to provide additional instructions for operator action. The root cause was Design Deficiency.

EVALUATION:

BACKGROUND

The High Pressure Injection (HPI) System [EIIS:BQ] controls the Reactor Coolant System (RCS) [EIIS:AB] inventory, provides the seal water for the Reactor Coolant Pumps [EIIS:P], and recirculates RCS letdown for water quality maintenance and reactor coolant boric acid concentration control. The HPI system uses the Letdown Storage Tank (LDST) as a surge tank and normal suction source for the HPI pumps. During operation, a hydrogen atmosphere is maintained in the LDST to promote oxygen scavenging. Guidance for establishing and maintaining this hydrogen pressure is given in OP/1, 2, 3/A/1104/02, "High Pressure Injection System," which includes a graph of permissible hydrogen pressure versus LDST level.

The HPI System is also a part of the Emergency Core Cooling System (ECCS) which mitigates the consequences of loss of coolant accidents (LOCA). The HPI System prevents uncovering of the core for smaller break sizes, where high RCS pressure is maintained, and delays the uncovering of the core for intermediate break sizes. The HPI System, during emergency operation, supplies borated water to the RCS from the Borated Water Storage Tank (BWST). The HPI System has three parallel HPI pumps that have the capability to take suction from the BWST and to discharge through two redundant flow paths into the RCS, utilizing four injection nozzles (two per flow path). The injection nozzles are located on each of the reactor inlet pipes downstream of the Reactor Coolant Pumps. (See Attachment 1)

The suction lines from the LDST to the HPI pumps are normally isolated from the BWST supply lines by check valves [EIIS:V] (HP-101 and HP-102) and motor operated valves (HP-24 and HP-25). In the event of an Engineered Safeguards [EIIS:JE] actuation, the motor operated valves will open, and the pressure due to elevation head in the BWST will overcome the pressure due to LDST level and hydrogen pressure, opening check valves HP-101 and HP-102, closing HP-97 (LDST outlet header check valve), and providing flow from the BWST to the HPI pumps. As BWST level drops, the available pressure from the LDST could exceed the available pressure from the BWST, allowing flow from the LDST as a check valve opens. If allowed to continue, the hydrogen gas in the LDST could expand, filling the suction piping, until HPI pump suction could be lost, resulting in damage to one or more pumps. Therefore, the required total system flow might not be met and core damage could result. The procedural operating limit curve for LDST hydrogen pressure and volume is intended to assure that LDST pressure does not exceed available BWST pressure, even as BWST level is drawn down during a LOCA.

Technical Specification 3.3.1 requires three HPI pumps and two HPI flow paths to be operable when RCS temperature is greater than 350 degrees with fuel in the core. This is based on considerations of potential small breaks at the Reactor Coolant Pump discharge piping for which two HPI trains (two pumps and two flow paths) are required to assure adequate core cooling.

EVENT DESCRIPTION

On April 16, 1991, an event occurred during which the pressure in the Letdown Storage Tank (LDST) for Oconee Unit 2 exceeded the procedural maximum limit. One of the design bases for the High Pressure Injection (HPI) system was that the hydrogen in the LDST could not be allowed to expand into the HPI pump suction piping following a LOCA. The pressure versus level curve contained in the Operating Procedures was intended to limit the amount of gas in the tank in order to assure system operability following an accident. Therefore, the event resulted in the HPI system being declared technically inoperable for approximately 20 minutes. That event was reported as LER 270/91-03.

During the review of that event, it was observed that the setpoint for a control room alarm for high LDST pressure exceeded the highest pressure in the normal operating range. Therefore, one corrective action from that event was to lower the alarm setpoint.

On August 20, 1991 a setpoint change request was initiated by Operations Technical Support. Design Engineering (DE) was notified of the change request and began their review. The DE review of the setpoint change included verification of the suitability of the setpoint. Previously, in December, 1990, a Design Basis Document (DBD) was issued for the HPI system. While reviewing the draft of that DBD, the basis of the pressure versus level curve (see Figure 1) contained in the Operating Procedures had been questioned but this item was carried as a open item for future resolution. Therefore, DE decided to document the basis of the pressure versus level curve as part of the setpoint verification.

During this review, the assigned engineer utilized a 1990 draft Limit and Precautions document prepared by Babcock & Wilcox (B&W) for the B&W Owners Group. This document includes a copy of a 1971 curve and states that it is based on calculations which, for certain scenarios, require the operator to isolate the LDST within 6.5 minutes by closure of HP-23, the LDST outlet header isolation valve. HP-23 is considered non-safety related and does not have safety related controls or power. In event of failure of HP-23, the only alternative was to vent the LDST into another non-safety related support system. DE did not consider it appropriate to continue to take credit for non-safety related equipment and operator action within this short time period in order to prevent loss of the HPI system should this scenario occur.

Therefore, DE began their own calculations to determine if the existing curve was adequate to prevent hydrogen gas expansion into the HPI piping under all required accident scenarios. One part of these calculations accounted for pressure drops due to flow in addition to static head due to level differences. The results indicated that the existing curves had not included the effects of losses due to flow. On September 18, 1991, DE initiated a Problem Investigation Report and began discussions with station Compliance and Operations personnel.

Operations personnel noted that their procedures did not call for isolation of HP-23. They did not understand that the operating curves were based on that action. Operations wished to avoid any requirement to close HP-23. After receiving input from the station, DE continued their evaluation of the situation.

On September 19, 1991, at 1225 hours, it was concluded that the current procedure limits were adequate for most scenarios, but a scenario existed where a single failure might result in total failure of the HPI system. This scenario assumes a small break LOCA with a concurrent single failure of either HP-24 or HP-25, the two Borated Water Storage Tank (BWST) to HPI suction isolation valves. This failure would cause all of the required HPI injection flow to pass through one suction supply line, which would lead to higher pressure losses and therefore lower pressure in the suction supply header, resulting in entrainment of hydrogen from the LDST and eventual pump damage.

This conclusion, which applied to all three Oconee units, was reached while Unit 1 was at cold shutdown for a refueling outage, and Units 2 and 3 were operating at 100 % Full Power.

As immediate corrective action DE provided new curves for use in the affected operating procedures. The new curves are slightly more restrictive so as to provide an additional safety margin to assure that hydrogen gas in the LDST will not expand into the HPI pump suction piping for any scenarios which do not involve single failure of a valve in the path from the BWST. Additionally, new instructions were provided to the operators for an alternative mitigating action if the single failure scenario does occur. Under the new guidance, operators will have at least thirty minutes to realign the HPI and Low Pressure Injection (LPI) [EIIS:BP] systems into "Piggyback" mode if a failure of either HP-24 or 25 is observed after an accident. The flow path would then be from the BWST through the LPI pumps to the HPI pump suction. This path would allow the LPI pumps to supply enough additional head pressure to assure that the hydrogen could not expand into the suction piping. This information was provided verbally to the Operations personnel on shift at the time. Procedure changes to incorporate the revised curves were approved later in the day of September 19, 1991.

Another version of the curve is currently under review. This curve would further restrict the operating range so that operator action would not be required even in the event of single failure. However, at this time it is not certain that operation within its limits would still provide adequate oxygen scavenging during normal operation.

A search of master file documents revealed a draft procedure dated March 24, 1970, which provided a LDST pressure versus level curve and operating guidance. According to an enclosure taken from B&W documentation, the calculations established two limiting curves to

prevent gas entrainment into the pump suction assuming the BWST had been drained (following the accident) and no operator action was needed to vent or isolate the LDST. Case 1 assumed a LDST level at the bottom instrument tap and Case 2 assumed a LDST level at the physical bottom of the tank. Case 1 was more restrictive.

A Duke Power curve was drawn and included in station operating procedures on 9/30/71. It is virtually equal to the B&W 1970 Case 1 curve for levels less than 55 inches and more conservative at higher levels. Subsequently the curve was redrawn several times as part of general procedure upgrades. No procedure change documentation mentions any intentional changes to the curves, but there are minor differences between the various versions. The 1978 version was less conservative than the 1971 version, especially between 25 to 75 inches, which includes the normal operating range.

CONCLUSIONS

The root cause of this event is Design Deficiency, (Functional Design Deficiency, Mechanical) because the potential for hydrogen entrainment leading to pump damage was recognized, operational guidance was provided, but was based upon inappropriate operator response times and operation of equipment which does not have sufficient provision for single failure. Design Criterion 14 (FSAR 3.1.14) requires automatic actuation of core protection systems. Design Criteria 38 and 41 (FSAR 3.1.38 and 3.1.41) require that the Emergency Core Cooling Systems function assuming a failure of a single active component.

The operational curve was provided by Babcock and Wilcox (B&W), the Nuclear Steam Supply System vendor, in the early 1970's, but it is not certain if documentation of the basis was also provided at that time. The documentation found to date still does not adequately document if any consideration was included for dynamic flow losses.

Also, it is noted that "appropriate operator response time" has been open to interpretation and has evolved over the years. The current interpretation at Oconee assumes ten minutes for problem recognition and diagnosis prior to initiation of any manual corrective actions.

It is also noted that, even if the 6.5 minute operator response time had been acceptable, Operations procedures did not contain adequate instructions to perform those actions. This indicates a historical Design Deficiency, deficient documentation because, in the past, design basis documentation was not maintained in a reasonably accessible manner. Station personnel were unable to recognize that the Letdown Storage Tank (LDST) pressure curve was based on prompt operator action. This generic problem was recognized several years ago which resulted in the creation of the Design Basis Documentation (DBD) project. The DBD project is not yet complete, but is being worked on system by system, therefore the appropriate corrective action for this cause is already in progress. While this problem was not

specifically discovered during the creation of the DBD for the HPI system, the operating curve had been identified as an action item for further evaluation.

An additional, non-causal deficiency was observed and identified as Management Deficiency, (Procedure Control, deficient procedure review and maintenance) because unintentional "minor," but non-conservative, changes occurred in curves during procedure reissues without detection and correction. The best guidance found related to accuracy of graphs is a statement in Operations Management Procedures 4-1, Enclosure 5.6, Operations OP Verification Checklist, which states "Are data on graphs and tables appropriate, correct, and legible." The Nuclear Production Department Procedure Development Guide, used by all groups other than Operations, addresses only the appearance of graphs. Existing guidance on generation of graphs and curves for use in procedures does not address how the necessary data points are generated and controlled. It also does not address how to verify the new curves are correct.

This event is considered recurring. Several Licensee Events Reports have addressed design deficiencies directly related to the design of the High Pressure Injection System. Others have affected other Engineered Safeguards systems. These are listed on Attachment 2. In general, these other deficiencies also occurred during original design of the system and resulted in the affected system being technically inoperable for certain accident scenarios. Since the deficiency in this event has existed since initial startup, no corrective action from previous events could have prevented it. Several of these deficiencies have been discovered through reviews related to the DBD project.

One additional event, documented as voluntary LER 270/89-007, occurred where Oconee Unit 2 was shutdown because it was thought to be operating in an unanalyzed condition due high tilt and imbalance following a dropped rod [EIIS:ROD]. That event also involved Duke Design not having adequate documentation of a vendor analysis. The DBD project is expected to improve the level of documentation of analyses available to Duke Power, but it is recognized that some vendor information will not be readily available.

There were no NPRDS equipment failures, personnel injuries, contamination, over-exposures, or releases of radioactive materials associated with this event.

CORRECTIVE ACTIONS

Immediate

1. Operations personnel were provided verbal guidance for maintaining Letdown Storage Tank (LDST) pressure within the new limits, and for immediate corrective actions to be taken in the event the applicable accident scenario were to occur.

Subsequent

1. The operating procedure was revised to incorporate the new LDST Pressure Versus Level curve prepared by Design Engineering.

2. Revised Emergency Procedure to include requirement to immediately line up in Piggyback if a single failure of HP-24 or HP-25 occurred during/after a small break LOCA.

Planned

1. Evaluate revision of operating procedure for another, more restrictive, curve which would not require any operator action.

2. Establish Station Directive guidance related to preparation and review of safety significant curves used in station procedures to better assure accuracy. Existing curves will be reviewed when changed or when the procedure is reissued.

SAFETY ANALYSIS

The suction lines from the Letdown Storage Tank (LDST) to the High Pressure Injection (HPI) pumps are normally isolated from the Borated Water Storage Tank (BWST) supply lines by check valves and motor operated valves. In the event of an Engineered Safeguards actuation, the motor operated valves will open, and the pressure due to elevation head in the BWST will overcome the pressure due to LDST level and hydrogen pressure, opening the check valves and providing flow from the BWST to the HPI pumps. As BWST level is drawn down, some of the inventory in the LDST will also be used, but normal letdown flow will be isolated. Therefore, the LDST water level will drop and the hydrogen gas will expand. Procedural limits on the LDST hydrogen pressure and volume are intended to assure that the hydrogen cannot expand enough to enter the HPI pump suction.

Because of the potential for a single failure of one HPI pump suction supply isolation valve, Design Engineering performed an Operability Evaluation which determined that the HPI system had been technically inoperable. The significance was that, had an accident occurred with a concurrent single failure, the hydrogen gas in the LDST would expand as level dropped and could enter the HPI pump suction, cause gas binding and severe pump damage. Due to the system lineup, this potential scenario could lead to damage to all three HPI pumps which would correspond to loss of system function. The probability of such an event actually occurring is low. It is further reduced by the fact that the actual LDST pressure is routinely less than the maximum pressure permitted by the operating curve and would frequently be within the limit of the new curve.

In the event that this scenario did actually occur, the Babcock and Wilcox, (B&W) 1990 draft Limits and Precautions Document states that the necessary operator response time could be as short as 6.5 minutes. Possible actions would be 1) to isolate the LDST by closing HP-23, the LDST outlet block valve, 2) to make-up to the LDST to maintain minimum level, or 3) to vent the LDST gas volume to the Gaseous Waste Disposal System. However, these activities all depend upon operation of components/systems which are not safety related, are not supplied from emergency power sources, and/or do not have full redundancy. Therefore, while it is probable that some appropriate operator action would have been attempted, if needed, it is possible that HPI system function would have been lost.

If a loss of the HPI System were to occur, the Emergency Operating Procedure would instruct the operators to depressurize the Reactor Coolant System (RCS) using steam generator cooling. This depressurization would allow injection from the core flood tanks (at about 600 psig) and eventually the Low Pressure Injection System. If inadequate core cooling conditions are indicated by superheated core exit thermocouple temperatures, the operators would also open the pressurizer power operated relief valve (PORV) and the reactor vessel and hot leg high point vents to further depressurize the RCS. Although this approach may result in enough Emergency Core Cooling System (ECCS) injection to prevent core damage, the effectiveness of these processes for all small break LOCA scenarios has not been demonstrated.

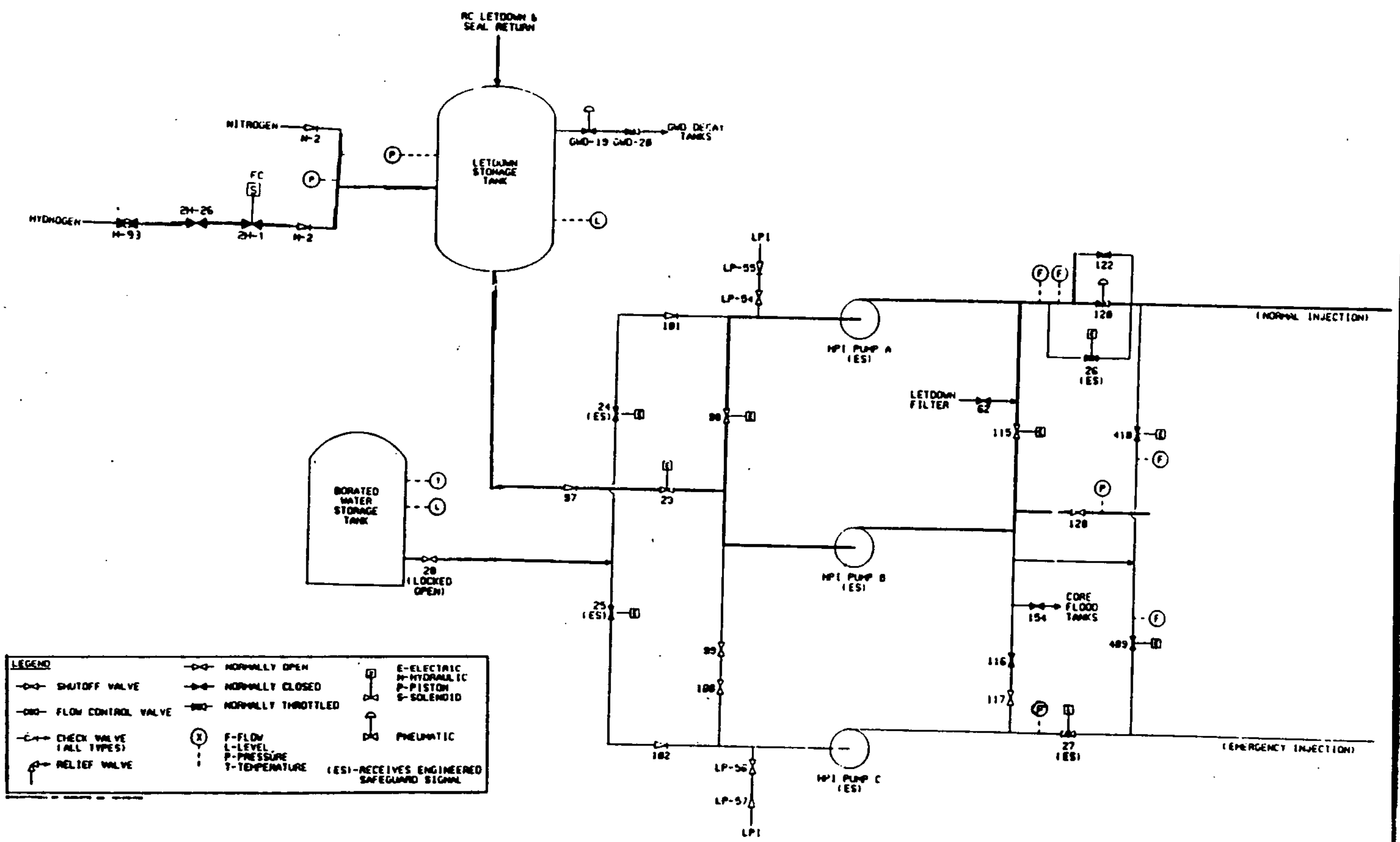
The analysis for a Maximum Hypothetical Accident (MHA) as described in the Final Safety Analysis Report assumes that some core damage occurs. That analysis shows that 10CFR100 limits would still be met.

Therefore, while it is not expected that the situation would actually result in pump damage, damage is assumed in the low probability event that a small break LOCA occurred simultaneously with single failure of one HPI suction valve from the BWST. The assumed loss of system function is still bounded by FSAR analysis. Therefore, the health and safety of the public was not affected by this event.

FACILITY NAME(1)	DOCKET NUMBER(2)	LER NUMBER(6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE(3)		
Oconee Nuclear Station, Unit 1	05000 269	91	010	0	9	OF	13

Attachment 1

High Pressure Injection System



Attachment 2

Recurring Design Deficiencies

LER Number	Title/Problem
269/88-06	Inadequate Design Analysis of the High Pressure Injection System in the Emergency Core Cooling System Sump Recirculation Mode. (Found that Design (B&W) did not calculate/verify required HPI pump NPSH in "Piggyback" mode.)
269/90-04	Unanticipated System Interaction During Undervoltage Condition in the 230KV Switchyard Results in Failure to Comply With Technical Specifications. (Relay setpoints were not coordinated, resulting in a situation where, after a unit trip, the backup power breakers could not close in due to an undervoltage condition, but emergency power would not be initiated. If this occurred, the HPI system (and other Engineered Safeguards systems) could be without power.)
269/90-05	Design Deficiency/Unanticipated Interaction of Systems Results in the Potential Closure of the Startup Transformer "E" Breaker on to a Degraded (Low Voltage) Switchyard. (Protective relay setpoint would permit selection of an under voltage power source, leading to Engineered Safeguards equipment failure.)
269/90-10	Potential Failure of Engineered Safeguards System by Improper Valve Failure Mode Due to Design Deficiency, Deficient Documentation. (During construction, air operated valves were changed to fail closed with out adequate documentation and in conflict with the FSAR. This made the Penetration Room Ventilation System, an Engineered Safeguards system, technically inoperable.)

Attachment 2

Page 2

Recurring Design Deficiencies

LER Number	Title/Problem
269/90-12	Potential Overload Condition May Result in Inadequate On-Site Emergency Power Source During a LOCA/LOOP Event Due to Design Deficiency. (Two diverse potential single failures would allow an operating Keowee Hydro unit to become overloaded, potentially causing random loss of Engineered Safeguards equipment due to overcurrent protection.)
269/90-15	Unit Operation in an Unanalyzed Condition Due to Design Deficiency, Design Oversight. (Identified a different location for worst case small break. This affected operational requirements for HPI system.)
269/91-01	Potential Single Failure During LOCA/LOOP Event May Result in the Loss of Emergency Power Due to Design Deficiency. (A single failure mechanism was postulated which would allow the two Keowee Hydro units (emergency power generators) to close in out of synchronization, resulting in assumed damage and loss of both units. If this occurred, the HPI system (and other Engineered Safeguards systems) could be without power.)
269/91-03	Technical Inoperability of Oconee Backup Electrical Power Sources Results From Deficiently Designed Circuit Breaker Arrangement of Keowee Hydro Auxiliary Loads. (Breaker co-ordination problem would allow a fault in a non-safety circuit to potentially shut down one emergency power generator. A common mode failure could cause both generators to be lost due to this problem. If this occurred, the HPI system (and other Engineered Safeguards systems) could be without power.)

Attachment 2

Page 3

Recurring Design Deficiencies

LER Number	Title/Problem
269/91-07	Breaker Coordination Problem Due to Design Deficiency Results in Technical Inoperability of Safety Related Equipment. (Failure of non-safety related equipment could cause loss of power to safety-related equipment, including HP-25.)

LICENSEE EVENT REPORT (LER) TEXT CONTINUATION

FACILITY NAME(1)	DOCKET NUMBER(2)	LER NUMBER(6)			PAGE(3)		
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER			
Oconee Nuclear Station, Unit 1	05000 269	91	010	0	13	OF	13

Figure 1

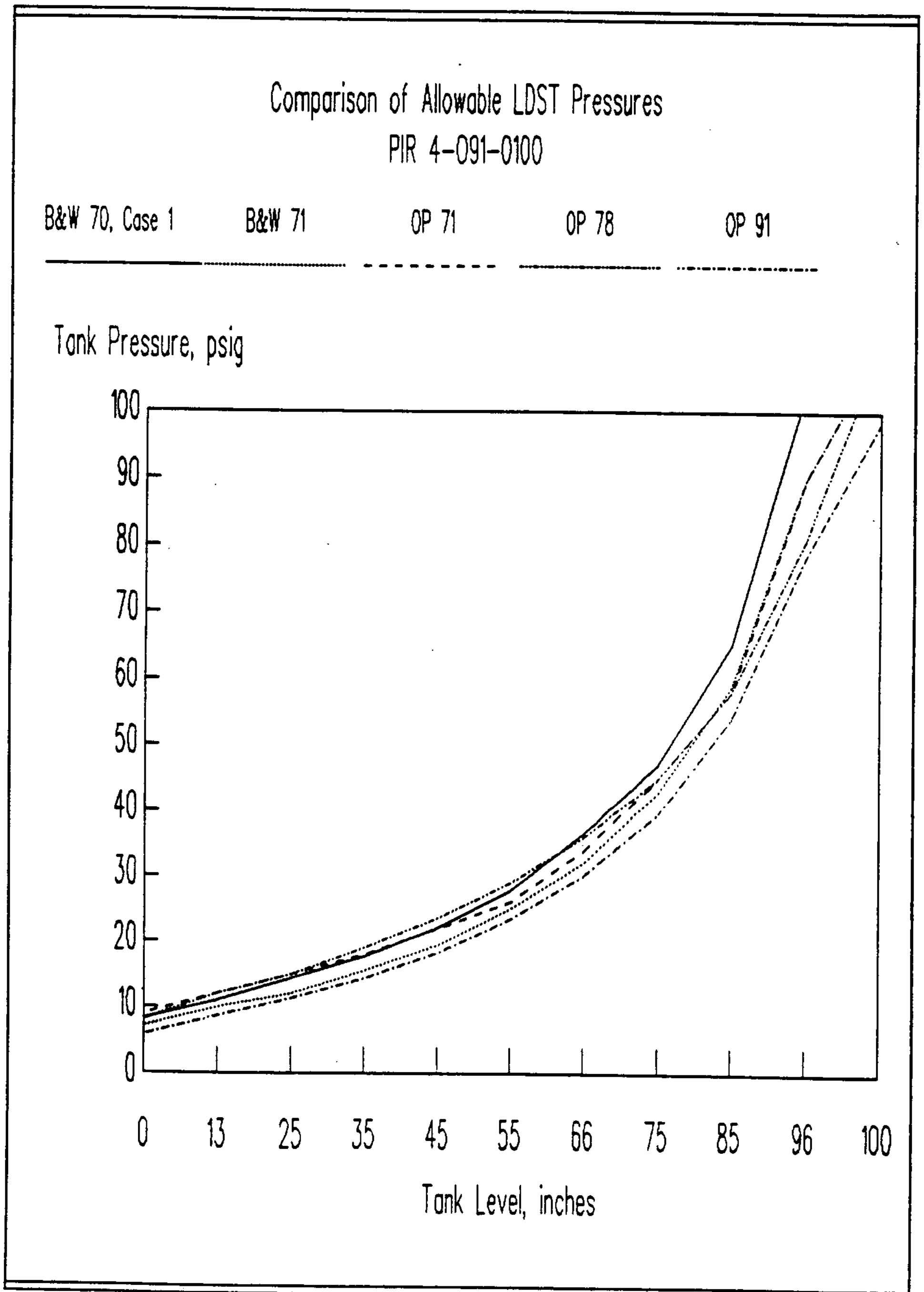


Figure 1 LDST Pressure vs Level