ARKANSAS POWER & LIGHT COMPANY

May 25, 1989

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SUBJECT: Arkansas Nuclear One - Unit 1
Docket No. 50-313
License No. DPR-51
Licensee Event Report No. 50-313/89-004-00

Gentlemen:

In accordance with 10CFR50.73(a)(2)(ii), attached is the subject report concerning an inadequate design change process which resulted in the design temperature of the High Pressure Injection System piping being exceeded due to Reactor Coolant System backleakage through a failed-open check valve.

Very truly yours,

E. C. Ewing
General Manager,
Plant Support

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Approved OMB No. 3150-0104
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LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Arkansas Nuclear One, Unit One	0 5 0 0 0 3 1 3	1 OF 0 6

TITLE (4) Inadequate Design Change Process Results in the Design Temperature of the High Pressure Injection System Piping Being Exceeded Due to Reactor Coolant System Backleakage Through a Failed-Open Check Valve

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)
										0 5 0 0 0
0 1	2 0	8 9	8 9	0 0 4	0 0	0 5	2 5	8 9		0 5 0 0 0

OPERATING MODE (9): N

POWER LEVEL (10): 0 0 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)	__ Other (Specify in Abstract below and in Text, NRC Form 366A)
__ 20.405(a)(1)(iii)	__ 50.73(a)(2)(i)	__ 50.73(a)(2)(viii)(A)	
__ 20.405(a)(1)(iv)	X 50.73(a)(2)(ii)	__ 50.73(a)(2)(viii)(B)	
__ 20.405(a)(1)(v)	__ 50.73(a)(2)(iii)	__ 50.73(a)(2)(x)	

LICENSEE CONTACT FOR THIS LER (12)

Name	Telephone Number (Area Code)
Julie D. Jacks, Nuclear Safety and Licensing Specialist	5 0 1 9 6 4 - 3 1 0 0

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
B	B Q	V	V 0 8 5	Y					

SUPPLEMENT REPORT EXPECTED (14)	EXPECTED SUBMISSION DATE (15) Month / Day / Year
__ Yes (If yes, complete Expected Submission Date) X No	

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

Following a reactor trip on 1/20/89, High Pressure Injection (HPI) was used for additional Reactor Coolant System (RCS) makeup due to a slight RCS overcooling. When HPI was secured, an HPI line check valve (the single isolation between the RCS and HPI system) failed to reseat. Also during the trip, two of the four Reactor Coolant Pumps (RCPs) tripped due to a power supply failure to transfer to an offsite source. The RCS loops differential pressure created by the two-on/two-off RCPs along with the valve failure allowed reverse flow of reactor coolant into the HPI system. Subsequent analysis showed that some HPI piping components (e.g., fittings such as elbows) may have been overstressed as the HPI system design temperatures were lower than temperatures experienced. However, visual and non-destructive examinations revealed no damage from this event. The potentially overstressed components were replaced and redundant check valves were installed in each HPI line. Analyses of other systems showed no similar isolation designs. The event was caused by an inadequate design change process when a major system modification in 1979 installed HPI line cross-connects that created the condition of a single check valve providing isolation between the RCS and HPI system. Design change procedures currently in place are considered adequate to prevent the occurrence of a similar event.

A. Plant Status

At the time of this event, Arkansas Nuclear One - Unit One (ANO-1) was in Hot Shutdown just after a reactor trip from 100 percent full power due to a fault in the main generator exciter. The Reactor Coolant System (RCS) [AB] cold leg temperature (T_c) was approximately 545 degrees Fahrenheit. The details of the reactor trip event were reported in Licensee Event Report (LER) 50-313/89-002-00.

B. Event Description

On January 20, 1989, ANO-1 experienced a plant trip followed by off-normal equipment responses. Feedwater system anomalies caused an overfeeding of a steam generator which resulted in a slight RCS overcooling. Due to reactor coolant shrinkage from the overcooling, the control room Operators manually started a standby High Pressure Injection (HPI) [BQ] pump and initiated additional makeup flow into the RCS through two of the four HPI lines. The four HPI lines are used for flow injection into the four RCS cold legs downstream of the Reactor Coolant Pump (RCP) discharge. Also during the plant trip, two of the four RCPs tripped due to the failure of their power supply electrical bus to transfer immediately to an offsite source (i.e., the 'A' and 'C' RCPs tripped and the 'B' and 'D' RCPs continued to run).

When HPI flow was secured two and one-half minutes later, a check valve, MU-34B [BQ-V], in the 'B' HPI line failed to reseat. Because 'B' RCP continued to run after the plant trip, a pressure differential was developed between the 'B' HPI line containing the failed-open MU-34B check valve and the 'C' HPI line. These conditions allowed reactor coolant to backflow (i.e., backleakage) into the 'B' HPI line, through the failed-open check valve, into a penetration room outside the Containment Building, through the HPI 'BC' loop crossover line, and then back into the RCS through the 'C' HPI line. (See Figure 1 for a diagram of the flow path.) The RCS backleakage condition was discovered when an Operator was dispatched to investigate a smoke alarm caused by the melting of a piece of tape left on one of the affected HPI lines. Backleakage flow through the HPI system was stopped when the two idle RCPs were restarted.

Initial visual inspections of the affected HPI piping and piping supports found no obvious heat damage to the system. However, subsequent Engineering review of the event determined that the HPI system piping was not designed for RCS fluid temperatures. A preliminary thermal stress piping analysis was performed using conservative assumptions, such as rigid piping supports instead of flexible supports; an assumed fluid temperature of 545 degrees (the RCS T_c during the event) throughout the affected backleakage flowpath; and an assumed flowrate of 105 gpm based on the check valve failing completely open. The analysis identified several high stress points: those areas where the calculated stresses on pipe, pipe components (e.g., fittings such as elbows), and pipe supports exceeded ASME code allowables. Based on this conservative analysis, the HPI system piping was considered to have been potentially overstressed by the backleakage.

Design reviews were initiated to determine if the potential existed for other safety-related systems to be subjected to fluids at temperatures higher than design temperatures by a failed-open valve. Results of these reviews identified no other single valve failures which could lead to a high temperature/low temperature concern; hence, adequate safety margins existed in the current designs of the systems evaluated.

Design reviews were also initiated to determine if the operating temperatures for certain safety-related systems, considering the potential modes of operation (i.e., normal, emergency, or test conditions), were bounded by appropriate design temperatures. During this review, discrepancies were discovered between the design temperatures and the possible operating temperatures of the HPI system when in the "piggyback" mode of operation (DHR/LPI pump discharge aligned to HPI pump suction). These findings were evaluated and determined to be reportable and are discussed in LER 50-313/89-006-00. Additionally, during this review, discrepencies were found between the design temperatures and possible operating temperatures of the Decay Heat Removal/Low Pressure Injection (DHR/LPI) [BP] system. Other discrepencies were also found in the analysis assumptions for the weights of four valves associated with the DHR/LPI injection piping (i.e., two valves in the Core Flood Tank (CFT) outlet line and two DHR/LPI check valves). These findings were evaluated and determined to be reportable and are discussed in LER 50-313/88-026-00.

During subsequent detailed system walkdowns to prepare and implement modifications to the HPI system which were necessitated by the check valve failure and the resultant design reviews and analysis, other HPI piping was discovered which may have been subjected to potential overstress conditions. The HPI check valve MU-34B and a nearby vent stack were found to have encountered interference with structural steel as a result of contact during system piping thermal expansion. Also, a spring can, MU-454, on the HPI loop 'AD' crossconnect line was found with its travel stops still installed, preventing the support from carrying its design load. These findings were evaluated and determined to be reportable and are discussed in LER 50-313/89-019-00.

C. Safety Significance

Three conditions are necessary for RCS backflow to occur: a motive force to open the HPI check valve (i.e., HPI initiation), failure of the check valve to reseat, and a differential pressure to cause reverse flow through the HPI piping and the crossover line (such as occurs with an unbalanced RCS loop flow due to an idle RCP). If subjected to the maximum possible RCS fluid flow and temperatures, operability of the HPI system could have been compromised.

The capability of the HPI system to perform its principal function of injection of borated water for accident mitigation was evaluated given the possibility of RCS backflow into a crossover line. In general, the accident analyses which credit HPI for accident mitigation were not impacted initially as HPI flow must be secured in at least one train before RCS backflow can occur; this happens only when Operators have verified that HPI flow for that train is not necessary. However, the possibility that RCS backflow through the HPI system piping located outside the Containment Building could have resulted in exceeding the design temperatures of the piping and might have induced piping failure is considered safety significant.

D. Root Cause

In 1979 the HPI system was modified to add crossover lines between the 'B' and 'C' HPI lines and the 'A' and 'D' HPI lines. This modification was made after identification of an RCS break location (i.e., in the RCP discharge piping) which was found to be the most limiting for a small break LOCA. This modification created the potential for an RCS backflow event with the failure of a single check valve and unbalanced RCP operations. However, the potential for such an occurrence was apparently not recognized.

E. Basis for Reportability

The failure of check valve MU-34B subjected the HPI piping to temperatures higher than the design temperatures for which it was analyzed. This may have overstressed several components in the system and resulted in the plant being in an unanalyzed condition that significantly compromised plant safety. Accordingly, this event is reportable under 10CFR50.73(a)(2)(ii)(A).

This condition is also considered to have been outside the design basis of the plant as the HPI system's operability was impacted by a single failure. Accordingly, this event is also reportable under 10CFR50.73(a)(2)(ii)(B).

Following evaluations that determined the piping may have been overstressed, this event was reported to the NRC Operation Center on January 29, 1989, at 1056 hours in accordance with 10CFR50.72(b)(2)(i): an event, found while the reactor is shutdown, that, had it been found while the reactor was in operation, would have resulted in the plant being in an unanalyzed condition that significantly compromises plant safety.

F. Corrective Actions

In addition to the preliminary thermal stress analysis of the HPI system, a program of visual inspections and non-destructive examinations (NDE) was completed to identify any system degradations caused by thermal stresses. This program consisted of three parts:

- The affected piping in the 'BC' loop was inspected for general degradation caused by thermal movement of pipe into interferences, walls, penetrations, etc.

- A sample of welds in straight pipe runs was examined by liquid dye penetrant testing, including each of the four lines inside containment and both HPI crossover lines.

- All high stress areas or components identified by the thermal stress analysis were examined by dye penetrant testing and also by volumetric examinations to the extent possible given the system configuration.

No damage, deformations, cracks, or other piping degradation attributed to the backflow event were found.

Pipe support loads from the thermal stress analysis were compared to design pipe support loads to identify supports which might have experienced loads beyond their design capacity. These pipe supports were subjected to an extensive inspection. No damage, deformation, unacceptable welds or cracks, or other pipe support degradation was found.

The piping penetrations through the containment wall were also evaluated by analysis and inspection. No damage, deformations, cracking, or other degradation was found.

The MU-34 check valves (MU-34A, B, C, and D) were disassembled and inspected. Based on the findings, the cause of the failure of MU-34B to close was determined to be excessive wear in the hanger bushing connection and binding of the disc anti-rotation pins. Excessive wear allowed the hanger bracket bushings to disengage and wedge on the outer surface of the bracket stop. This wedging action caused the hanger yoke ears to bend (spring) outward and further promote potential binding. The hanger bracket bushings on the check valves were modified to prevent binding during closing of the valve disc, and the anti-rotation pins were also modified to prevent binding.

Although the 'AD' HPI loop was not affected by this event, a review of past transients showed four possible events where RCS backflow could have occurred and not been detected. A preliminary thermal stress analysis was performed for the 'AD' HPI loop. As a result, piping, pipe supports, penetrations, and other identified potential high stress locations were subjected to visual and NDE inspections as were performed on the 'BC' HPI loop. Based on these inspections and the fact that MU-34A and MU-34D did not have the same degree of wear as MU-34B, the 'AD' HPI loop was determined not to have been potentially overstressed and was considered acceptable for continued operations.

Piping components in the 'BC' HPI loop which were identified by analysis as having been potentially overstressed were replaced. Additionally, two elbows near MU-34B which were affected by the MU-34B and vent stack interferences with structural steel were also replaced. The vent stack near MU-34B was angled to provide adequate clearance for thermal expansion.

Modifications were performed on the HPI system to preclude a recurrence of this event. An additional check valve was installed inside the Containment Building in each HPI line upstream of the existing MU-34 valves. Vents and drains were also installed as necessary to permit testing of the check valves for backleakage. In the piping penetration rooms outside the Containment Building, local temperature indicators have been installed to indicate if gross backleakage is occurring. Temperature tape has also been placed on each line which will serve to record the highest temperature to which the piping has been subjected.

Several procedure changes have been made as a result of this event and the subsequent analyses and system modifications. An HPI check valve backleakage test procedure has been written and will be performed each refueling outage. Operation's logs have been revised to add readings of the local temperature indicators and temperature tape; these will be taken once per shift. Procedural guidance is given concerning actions to be taken if the temperature readings are outside certain specifications, including referring the Operator to a new abnormal operating procedure for an HPI line high temperature. The shutdown procedure and the startup procedure have both been revised to require logging HPI line temperature whenever unbalanced RCP operation occurs.

The design change process has been improved several times since the modification to the HPI system was completed in 1979. In 1987, AP&L implemented a comprehensive program aimed at improving the quality, depth, and documentation of reviews conducted under 10CFR50.59 for plant design changes and procedure changes. The design change procedures in place at the present time require detailed documented reviews of design basis documents for each design change and are considered adequate to prevent the occurrence of a similar event.

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TEXT (If more space is required, use additional NRC Form 366A's) (17)

G. Additional Information

A similar design error due to an inadequate design change process (and also associated with the modification of the HPI system in 1979 as detailed in this LER) resulted in a postulated HPI line break scenario not enveloped by the Small Break Loss of Coolant Accident Safety Analysis. This is reported in LER 50-313/89-007-00.

Energy Industry Identification System (EIIS) codes are identified in the text as brackets [XX].

NRC Form 366A
(9-83)

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LICENSEE EVENT REPORT (LER) TEXT CONTINUATION

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TEXT (If more space is required, use additional NRC Form 366A's) (17)

Figure 1

RCS Backleage into HPI System