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SUBJECT: Arkansas Nuclear One - Unit 2
Docket No. 50-368
License No. NPF-6
Licensee Event Report 50-368/92-007-00

Gentlemen:

In accordance with 10CFR50.73(a)(2)(i)(B), enclosed is the subject report concerning High Pressure Safety Injection System flow.

Very truly yours,

James J. Fisicaro

James J. Fisicaro
Director, Licensing

JJF/TFS/mmg
Enclosure
cc: Regional Administrator
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NRC Form 366
(6-89)

U.S. Nuclear Regulatory Commission
Approved OMB No. 3150-0104
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LICENSEE EVENT REPORT (LER)

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TITLE (4) High Pressure Safety Injection Flow Rates Below Safety Analysis And Technical Specification Requirements Due To Incorrect Size Of Valve Discs Caused By Vendor Error

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 9	2 3	9 2	9 2	-- 0 0 7	-- 0 0	1 0	2 2	9 2		0 5 0 0 0

OPERATING MODE (9)		THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more of the following) (11)			
POWER LEVEL (10)	0 0 0	__ 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)	X 50.73(a)(2)(i)	__ 50.73(a)(2)(viii)(A)	
		__ 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)
Thomas F. Scott, Nuclear Safety and Licensing Specialist	5 0 1 9 6 4 - 5 0 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	

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)

On September 23, 1992, Arkansas Nuclear One Unit 2 discovered that the flow rates through High Pressure Safety Injection (HPSI) legs were unbalanced. They were also below the minimum value specified in Technical Specifications and less than the value assumed in the safety analysis. Flow rates were low in three legs of one HPSI loop and two legs of the other loop. The vendor for HPSI isolation valves made an error in fabrication drawings by incorrectly referencing an improper drawing for the valve disc plug. Parts with an incorrect dimension, manufactured from the drawing with the error and procured by ANO as identical replacements, were used to repair five valves between 1982 and 1989. After the condition was identified, the vendor reworked spare valve disc plugs to meet the proper flow area requirements. A successful flow balance test was completed following installation of the refurbished parts. An assessment of the safety significance of the condition with respect to safety-related functions of the HPSI System concluded that the degraded flow did not constitute a condition in which a significant reduction in safety occurred. Valves of this design are in use only in the HPSI System at ANO-2. The vendor has stated that this valve design is only applicable to ANO.

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

A. Plant Status

At the time this condition was discovered, Arkansas Nuclear One Unit 2 (ANO-2) was in refueling (Mode 6) with Reactor Coolant System (RCS) [AB] temperature 85 degrees and pressure 15 psia.

B. Event Description

On September 23, 1992, ANO-2 discovered that the flow rates through High Pressure Safety Injection (HPSI) [BQ] System legs were unbalanced. They were also below the minimum value specified in Technical Specifications (TS) and less than the value assumed in the safety analysis.

Three HPSI pumps are provided to inject borated water into the RCS via two headers if a break occurs in the RCS boundary. Each header supplies water to the four safety injection nozzles in the RCS cold legs. Each of the eight HPSI flow paths is isolated by a two inch, motor-operated globe valve.

Full flow HPSI testing was being performed to demonstrate full open stroke of HPSI check valves, to demonstrate the capability of cold leg injection motor-operated valves (MOVs) to open and close with maximum differential pressure as required by Generic Letter 89-10 (Safety-Related Motor-Operated Valve Testing and Surveillance), and to obtain HPSI pump data at full flow conditions as required by Generic Letter 89-04 (Guidance on Developing Acceptable Inservice Testing Programs). During the test, it was noticed that the flow rate indication from the #2 HPSI header was lower than anticipated. When the flow rates from indicators on each of the four HPSI lines were summed, they were 150 gpm greater than the indicated total flow rate. It was determined that this incorrect flow indication was caused by the orifice plate having been installed backwards. It was also noted that the flow rates in the four lines were unbalanced.

A Special Work Plan was developed to obtain additional data and balance the flow rates. Using "A" HPSI pump on loop #1, four injection valves were opened to obtain as-found flow rate indication, flow rate indication with the valves manually opened to their back seats, and flow rate indication after adjusting the valves for balanced flow. Results were: (All in gpm from Safety Parameter Display System [ID] indication)

INDICATOR	AS FOUND	BACK SEATED	BALANCED
2FI-5014-1	173	188	178
2FI-5034-1	150	149	173
2FI-5054-2	149	163	171
2FI-5074-2	269	258	170

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It was then verified that the pump was capable of producing sufficient flow by using an alternate flow path. Similar results were obtained when using "C" HPSI pump on loop #1. The "B" HPSI pump was aligned to loop #2 and the test repeated. Note that flow is through four different MOVs but the same flow indicators are used. Results were:

INDICATOR	AS FOUND	BACK SEATED	BALANCED
2FI-5014-1	139	140	[illegible]
2FI-5034-1	144	147	[illegible]
2FI-5054-2	237	245	[illegible]
2FI-5074-2	269	269	176

Technical Specification 4.5.2.h requires that the HPSI System be verified to be capable of supplying greater than or equal to 196 gpm via each of the four injection legs following completion of modifications that alter subsystem flow characteristics. Also, the safety analysis assumption (for the limiting case of Small Break Loss of Coolant Accidents) was that the sum of the flow rates of the three injection legs with the lowest flow would exceed 570 gpm. Since neither of these requirements were met, both HPSI trains were declared inoperable as Emergency Core Cooling System (ECCS) subsystems at 1100 on September 23, 1992.

C. Root Cause

During startup testing in 1977 prior to commercial operation, ANO-2 experienced two problems with the HPSI isolation valves. Three of the valves were modified by the vendor, Target Rock Corporation, to correct a low flow condition in the associated HPSI legs. This modification consisted of a 0.10 inch diameter tapered reduction to the bottom of the disc plug. Adequate flow balance was achieved following re-installation of the modified valve internals. In January of 1978 an event occurred in which damage to two of the HPSI valves resulted from two phase back-flow through the valves which induced destructive vibration. Target Rock modified the internals of all eight HPSI valves to prevent recurrence of this condition. The modification added guide vanes to the valve discs and reduced the diameter of the discs by 0.10 inch. In April of 1978 all HPSI valve discs were re-installed with guide vanes and disc plugs 0.10 inch smaller than the original design. Flow balance tests and flow rate tests were successfully completed prior to receipt of the ANO-2 operating license. This was the last testing of HPSI flow rate and balance prior to the September 1992 test.

The valve disc modification reducing the diameter of the first three valves was documented on Target Rock drawing SK-10621. The modification to add guide vanes was documented on Target Rock drawing SK-10655; however, SK-10655 incorrectly referred to the original part number (#100769) for the larger disc. Target Rock generated drawing 300885 to control all future manufacturing of the disc.

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The error made in SK-10655, reference to the original disc plug dimensions, was carried over into the new drawing. Drawing 300885 was released in March of 1982. ANO-2 subsequently ordered replacement parts by part number from the vendor assembly drawing. Target Rock manufactured replacement parts from the incorrect drawings. These drawings were Target Rock internal shop drawings considered proprietary and therefore not available to ANO at that time.

Between October 1982 and November 1989, spare disc assemblies were installed in five HPSI isolation valves. All five valves were in HPSI legs that were found to have a low flow rate during the September 1992 test. The HPSI system flow rate and balance tests were not performed following each maintenance activity because use of what was believed to be identical replacement parts was considered not to be a modification that changed flow characteristics.

To verify the difference in valve disc dimensions, a valve from a leg with adequate flow rate was opened up and examined. This valve was found to have the revised taper matching the correct Target Rock shop drawing SK-10621.

Replacement disc assemblies, procured from Target Rock and certified to be identical stock parts, were installed in five HPSI isolation valves (three in one loop and two in the other loop) during maintenance activities. The spare parts were correctly ordered by item number from the Target Rock assembly drawing. Once the parts were received at ANO, they were receipt inspected in accordance with ANO's approved Quality Assurance Manual. It has been determined that the root cause for the incorrect spare parts being in stock and being installed resulted from the vendor's internal shop drawing incorrectly referencing an earlier design detail. This earlier design detail has inadequate flow orifice area.

Based on ANO's review of this matter, improvements are being made to enhance the ANO testing program. These enhancements will ensure that periodic testing is accomplished beyond requirements to increase the probability that systems can perform their intended functions.

D. Corrective Actions

Target Rock Corporation reworked eight stock disc plugs previously manufactured per drawing 300885 and provided a Certificate of Conformance stating that the flow requirements were met by the refurbishment. The refurbished discs were installed in six of the eight HPSI valves.

A successful flow balance test of the HPSI System was completed following installation of the refurbished valve assemblies.

Target Rock Corporation has notified all appropriate individuals of the human error associated with this condition.

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The orifice plate for loop #2 total flow indication was returned to the correct orientation.

The vendor assembly drawing was revised by Target Rock on October 1, 1992. This revision has been reviewed and approved by ANO Design Engineering.

An investigation was completed to ensure that there were no problems of a similar nature associated with other MOVs manufactured by Target Rock in use at ANO. This included verification that flow through Low Pressure Safety Injection (LPSI) [BP] legs met safety analysis requirements.

Other ANO-2 Technical Specification surveillances required to be performed following system modification were reviewed to verify performance of the test during the most recent refueling outage.

The procedure for HPSI flow testing has been revised to provide confirmation of flow balance and capacity required by Technical Specification 4.5.2.h each refueling outage.

As an enhancement to minimize the potential for similar events, ANO event-driven Technical Specification surveillances required to be performed following system modification are being compared to revised standard Technical Specification requirements to determine if testing on a periodic basis should be performed. Appropriate procedure changes will be implemented prior to the next refueling outage for each unit.

E. Safety Significance

The ANO-2 HPSI system, part of the Emergency Core Cooling System (ECCS), provides short term and long term emergency core cooling following a Loss of Coolant Accident (LOCA). It is also credited with injecting borated water for reactivity control following a Main Steam Line Break (MSLB).

In addition to these safety related functions, HPSI also provides other functions of varying regulatory importance or significance (i.e. RCS inventory control following Safety Injection Actuation System (SIAS) [JE] initiation, backup coolant inventory during a Loss of Shutdown Cooling [BP] event, alternate boration path in Modes 5 and 6, and once-through cooling via the ECCS vents). However, each of these issues is not significantly impacted by the degraded flow conditions encountered since 1) success is not linked to any significant fraction of available flow and 2) flow for these events was not significantly degraded (i.e. less than 6 percent). As a result, the more detailed assessment of the safety significance of this condition will be focused on the Design Basis Accidents (DBA) for which HPSI safety related functions are credited, the MSLB and LOCA.

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In the MSLB event, HPSI is credited with providing borated water for additional shutdown margin to limit recriticality and return to power. Since the MSLB analyses do not assume loss of ECCS injection out through a break, the full "as-found" flows from all four injection legs can be credited. The minimum of these is 95 percent of the original which, assuming that this degradation was valid over the entire range of HPSI pressure, means that the total borated water and associated reactivity control would be approximately 95 percent of that assumed in the original analyses. Safety Analysis Report (SAR) Figure 15.1.14-50 indicates that the reactivity excursion experienced in a limiting MSLB is dominated by the moderator effects once the steam generator blowdown and resulting cooldown are complete. ECCS contribution to control of the reactivity excursion is second order at best and crediting only 95 percent of the ECCS reactivity control would have an insignificant impact on consequences (i.e. on post-trip return to power). In no case would peak post-trip power be affected, since reactivity control due to HPSI delivery is zero or insignificant at the time of peak (i.e. transient maximum post-trip power). The significance of the degraded HPSI flow condition is also minimized by the unrealistic analysis assumption of no moisture carryover. A large MSLB, such as the limiting case depicted in this SAR figure, will carry over an appreciable amount of moisture from the steam generator that will then be unavailable for cooling down the RCS. The resulting reduction in cooldown will then translate into less reactivity addition, less critical reactor conditions, and a lower return to power. Though not currently credited in the MSLB analyses, charging [CB] pumps would be automatically actuated by the Engineered Safety Features Actuation System (ESFAS) [JE] and would provide flow from the Refueling Water Tank (RWT) or Boric Acid Makeup tanks at 44 gpm each. The flow from one charging pump is sufficient to offset the as-found reduced total HPSI flow for long-term reactivity control.

For the LOCA event, HPSI is credited in the ECCS analyses for short and long term core cooling and, in separate analyses, with providing borated water for shutdown margin considerations. The reactivity control function is of most importance in the Large Break LOCA (LBLOCA) event since control rod insertion is not explicitly assumed. However, the analysis of the LBLOCA post accident core reactivity is not sensitive to the HPSI flow rate and the degraded flow condition. The ECCS analyses for this event should be addressed in two parts, Small Break (SBLOCA) and LBLOCA since the ECCS demands and functions differ between the two categories.

For the LBLOCA, existing analysis is based on significant delivered ECCS flow from HPSI, Low Pressure Safety Injection (LPSI), and Safety Injection Tanks (SITs). The critical consideration for LBLOCA analysis is time of core uncovery and time to reflood. Existing LBLOCA analyses conservatively bounded the as-found degraded flow condition by virtue of significant available total LPSI and HPSI flow (i.e. safety analysis assumptions take credit for less flow than is available even given the reduced HPSI flow). Therefore, the degraded flow condition does not impact the current LBLOCA analysis.

The SBLOCA analysis is considered the limiting DBA for ANO-2 with respect to the impact of degraded HPSI flow. The currently approved ANO-2 evaluation model (EM) analysis identifies the limiting break size as the 0.1 ft^2 break. This break is on the threshold of break sizes which are sensitive to HPSI flow (i.e. larger breaks would be dominated by SIT injection). The fidelity of the approved EM for ANO-2 is limited for breaks smaller than 0.1 ft^2 (which are sensitive to HPSI flow reductions), therefore, the safety significance of the as-found HPSI flow degradation was assessed through a combination of best-estimate analyses and qualitative bounding assessments.

First, qualitative arguments have been developed to show ANO-2 is bounded by other Asea Brown Boveri-Combustion Engineering (ABB-CE) SBLOCA analyses. In addition, ABB-CE has recently provided information which supports the bounding nature of the Waterford SBLOCA analysis with respect to the ANO-2 design. The Waterford model is based on a newer version of the ABB-CE evaluation model and has a more detailed break spectrum analysis below 0.1 ft^2. A Waterford model also exists using the new ABB-CE Realistic Evaluation Model (REM) for which the Combustion Engineering Owners Group (CEOG) is presently responding to NRC questions. The REM was developed by the CEOG using the new 10CFR50.46 criteria.

In this model the HPSI flow was reduced by 20 percent and no charging pump flow was credited. (The degraded flow condition for ANO-2 reflects approximately 19 percent flow reduction at the limiting break size.) The results from the Waterford-3 analysis indicate that the limiting break size has not changed, but with the HPSI flow reduction of 20 percent, the PCT is only 1590 degrees including uncertainties. From this it can be seen that the present evaluation models are very conservative and an ANO-2 analysis using the REM with the as-found HPSI flow is expected to result in Peak Clad Temperatures (PCTs) less than the Waterford analysis which are well within the 2200 degree limit. In addition to the above, additional extensive analyses have been performed as documented in EPRI report TR-100675 using RELAP5/MOD2 to demonstrate for a 2700 MWt CE plant that reduction in HPSI flow rates of 15 percent are quite feasible. Based on the above analyses, previous qualitative assessments, and NRC and industry acknowledged significant conservatisms in the Appendix K evaluation models (reference NUREG-1230), Entergy Operations concludes that the ANO-2 as-found HPSI flow imbalance would not have produced unacceptable SBLOCA results.

Finally, as mentioned previously, following a LOCA the HPSI pumps are used for long-term core cooling by recirculating the sump water into the RCS which is boiled off by decay heat. The as-found flows were more than adequate to satisfy this requirement since recirculation (RWT depletion) is not considered to occur before approximately 30 minutes after reactor trip and the design flow for the HPSI pumps is based upon conservative decay heat levels 20 minutes after trip. Based upon widely accepted best estimate decay heat curves, the decay heat level at the time of recirculation start is actually low enough that the as-found delivered flows (lowest 3 of the 4 injection legs) are more than adequate to satisfy the design function.

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In summary, the limiting events and conditions that dictate the design requirements of the HPSI system were reviewed for the impact of the degraded flow condition and the inaccurate flow indication. Based upon qualitative evaluations of the margins available in the analysis of the limiting events and by comparison to similar Nuclear Steam Supply System (NSSS) designs and analyses, it has been concluded that the degraded flow and indication did not constitute a condition in which an actual significant reduction in safety occurred. The evidence presented above indicates that, had one of the design basis events occurred during the time that the degraded conditions existed, the HPSI safety functions would have been accomplished as required; therefore, actual safety significance is considered low.

F. Basis For Reportability

Technical Specification 4.5.2.h requires that the HPSI System flow rate meet or exceed 196 gpm in each of four injection legs following a modification that alters subsystem flow characteristics. Since installation of valve discs of improper dimensions which were assumed to be identical stock parts resulted in flow rates less than 196 gpm, this condition constitutes an operation prohibited by Technical Specifications reportable per 10CFR50.73(a)(2)(i)(B).

The condition was reported at 1341 on September 23, 1992, in accordance with 10CFR50.72(b)(2)(i) as 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 compromised plant safety. Since the conclusion of the Safety Significance evaluation provided above is that the condition did not significantly compromise plant safety, this reporting criterion and other potential reporting criteria from 10CFR50.73 were determined not to be applicable.

The valve vendor, Target Rock Corporation, provided an evaluation concluding that the condition was not reportable in accordance with 10CFR21. Based upon the conclusion provided in the Safety Significance above that the deviation did not result in a substantial safety hazard, reporting per 10CFR21 is not applicable.

G. Additional Information

There have been no previous similar conditions reported as Licensee Event Reports by ANO.

The HPSI isolation valves are model 71J-002 manufactured by Target Rock Corporation, manufacturer code T020. The eight valves installed in the ANO-2 HPSI System are the only valves with the particular disc design.

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