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NP-33-03-002-01

Docket No. 50-346

License No. NPF-3

January 29, 2004

United States Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555

Ladies and Gentlemen:

LER 2003-002-01
Davis-Besse Nuclear Power Station, Unit No. 1
<u>Date of Occurrence – October 22, 2002</u>

Enclosed please find Revision 1 to Licensee Event Report 2003-002, which was submitted to provide written notification of an issue with the High Pressure Injection pumps. The issue concerns the potential for debris from the Containment Emergency Sump impacting the High Pressure Injection pumps following a design-basis accident whereby the pump internals may be damaged to the extent they would not be able to complete their intended safety function. This issue was identified as part of the Davis-Besse Return to Service Plan inspections. This LER is being submitted in accordance with 10CFR50.73(a)(2)(i)(B), 10CFR50.73(a)(2)(ii)(B), 10CFR50.73(a)(2)(v) and 10CFR50.73(a)(2)(vii). This Revision provides supplemental information regarding the apparent cause and the safety significance of this occurrence based on the evaluation performed on the High Pressure Injection pumps.

Very truly yours,

AWB/s

Attachment
Enclosure

cc: Regional Administrator, USNRC Region III
DB-1 NRC/NRR Senior Project Manager
DB-1 NRC Senior Resident Inspector
Utility Radiological Safety Board

IE22

COMMITMENT LIST

The following list identifies those actions committed to by the Davis-Besse Nuclear Power Station in this document. Any other actions discussed in the submittal represent intended or planned actions by Davis-Besse. They are described only as information and are not regulatory commitments. Please notify the Manager - Regulatory Affairs (419-321-8450) at Davis-Besse of any questions regarding this document or associated regulatory commitments.

COMMITMENTS	DUE DATE
To prevent debris that could plug the hydrostatic bearing orifices from entering the supply lines, self-flushing plates with approximately 0.050-inch diameter holes were installed on the water supply take-offs to the hydrostatic bearing.	Complete
The locations of the hydrostatic bearing supply take-offs were moved from the periphery of the pump fourth stage volute to a new location on the side of the fifth stage volute across from the impeller and adjacent to the discharge wear ring, which is closer to the shaft.	Complete
A new hydrostatic bearing design was installed that was based on a "figure 8" pocket configuration. Relief grooves were added to the hydrostatic bearing pockets to provide an "escape" path for the debris that gets into the bearing.	Complete
The parts with wear surfaces that are subject to debris that were not already hardfaced were replaced with hardfaced parts. These parts are wear rings, central volute bushing (rotating and stationary parts), and the hydrostatic bearing (rotating and stationary parts).	Complete
Replaced original cyclone separators with new model (with smallest clearance of 0.230-inches).	Complete

COMMITMENTS	DUE DATE
Scope of work was expanded to remove as much as possible of the remaining fibrous insulation from containment.	Complete
Evaluations were performed, in conjunction with the modifications performed on the containment emergency sump, which examined the Low Pressure Injection System, the High Pressure Injection System, the Containment Spray System, and the Boron Precipitation Control System.	Complete

NRC FORM 366 (7-2001)	U.S. NUCLEAR REGULATORY COMMISSION	APPROVED BY OMB NO. 3150-0104 EXPIRES 7-31-2004
LICENSEE EVENT REPORT (LER) (See reverse for required number of digits/characters for each block)		Estimated burden per response to comply with this mandatory information collection request: 50 hrs. Reported lessons learned are incorporated into the licensing process and fed back to industry. Send comments regarding burden estimate to the Records Management Branch (T-6 E6), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to bjs1@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202 (3150-0104), Office of Management and Budget, Washington, DC 20503. If a means used to impose information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

1. FACILITY NAME	2. DOCKET NUMBER	3. PAGE
Davis-Besse Unit Number 1	05000346	1 OF 7

4. TITLE
Potential Degradation of High Pressure Injection Pumps Due to Debris in Emergency Sump Fluid Post Accident

5. EVENT DATE			6. LER NUMBER			7. REPORT DATE			8. OTHER FACILITIES INVOLVED	
MO	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV NO	MO	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
10	22	2002	2003	002	01	1	29	04		05000
									FACILITY NAME	DOCKET NUMBER 05000

9. OPERATING MODE	D	11. THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check all that apply)							
10. POWER LEVEL	000		20.2201(b)		20.2203(a)(3)(ii)	X	50.73(a)(2)(ii)(B)		50.73(a)(2)(ix)(A)
			20.2201(d)		20.2203(a)(4)		50.73(a)(2)(iii)		50.73(a)(2)(x)
			20.2203(a)(1)		50.36(c)(1)(i)(A)		50.73(a)(2)(iv)(A)		73.71(a)(4)
			20.2203(a)(2)(i)		50.36(c)(1)(ii)(A)	X	50.73(a)(2)(v)(A)		73.71(a)(5)
			20.2203(a)(2)(ii)		50.36(c)(2)	X	50.73(a)(2)(v)(B)		OTHER Specify in Abstract below or in NRC Form 366A
			20.2203(a)(2)(iii)		50.46(a)(3)(ii)		50.73(a)(2)(v)(C)		
			20.2203(a)(2)(iv)		50.73(a)(2)(i)(A)		50.73(a)(2)(v)(D)		
			20.2203(a)(2)(v)	X	50.73(a)(2)(i)(B)	X	50.73(a)(2)(vii)		
			20.2203(a)(2)(vi)		50.73(a)(2)(i)(C)		50.73(a)(2)(viii)(A)		
			20.2203(a)(3)(i)		50.73(a)(2)(ii)(A)		50.73(a)(2)(viii)(B)		

12. LICENSEE CONTACT FOR THIS LER

NAME	TELEPHONE NUMBER (Include Area Code)
Aaron W. Bless, Associate Engineer - Licensing	(419) 321-8543

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

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX

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

16. ABSTRACT (Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines)

On October 22, 2002, with the reactor defueled, a potential deficiency was identified for the High Pressure Injection (HPI) pumps during the recirculation phase of postulated loss of coolant accidents (LOCA) and when HPI pump 2 is used for post-LOCA boron precipitation control. The HPI pumps may be damaged due to potential debris generated by certain postulated LOCAs and entrained in the pumped fluid. The HPI pumps may be subject to this debris after the pump suctions are switched over from the borated water storage tank to the discharge of the Low Pressure Injection Pumps, which are taking suction on the containment emergency sump.

The HPI pumps use a process-fluid lubricated hydrostatic radial bearing on the outboard end of the pump shaft. The hydrostatic bearing, an inter-stage bearing, and wear rings may be damaged by debris or particles in the pumped fluid. The HPI pumps were declared inoperable since the ability to maintain long-term core cooling while taking suction through the sump screens was in question. A non-emergency eight hour notification per 10 CFR 50.72 (b)(3)(ii)(B) was provided to the NRC as Event Number 39740 on April 7, 2003. Subsequently, this LER is being submitted in accordance with 10 CFR 50.73(a)(2)(ii)(B) as an unanalyzed condition that significantly degraded plant safety (in addition to other reporting criteria listed above). Following analyses, (HPI) pump modifications, qualification testing, and in-plant testing, HPI Trains 1 and 2 were declared operable on December 30, 2003.

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NARRATIVE *(If more space is required, use additional copies of NRC Form 366A)* (17)

DESCRIPTION OF OCCURRENCE:

As part of detailed system health reviews being conducted at the Davis-Besse Nuclear Power Station (DBNPS) to assure that plant systems can perform their safety functions, the High Pressure Injection (HPI) System was reviewed. On October 22, 2002, with the reactor defueled, a deficiency was identified whereby internal clearances of the HPI pumps [BQ-P] may not be sufficient to pass debris or particles contained in the fluid being drawn from the containment emergency sump during postulated loss of coolant accidents (LOCAs). As a part of the Emergency Core Cooling System (ECCS), the HPI pumps are required to provide cooling following a break or transient in the Reactor Coolant System (RCS) [AB] and are initially aligned to take suction from the Borated Water Storage Tank (BWST) [BP-TK]. In the event the BWST inventory becomes depleted, and HPI pump flow is still required, pump suction is switched to the containment emergency sump via the Low Pressure Injection (LPI) pumps [BP-P].

The HPI pumps, constructed by Babcock and Wilcox (B&W) Canada, Ltd. as part of the originally licensed plant design, were built from designs furnished by Pompe Guinard (Guinard Pumps, Annecy, France). The pumps are multi-stage horizontal centrifugal pumps. Per original equipment manufacturer records, DBNPS is the only domestic operational licensee supplied with these type pumps. The pump casing consists of a one-piece barrel or pressure case. On the driven end of the pump, an oil-lubricated bearing supports the shaft. The outboard end bearing is a process-fluid lubricated hydrostatic radial bearing within the pump casing. The shaft is also supported by a process-fluid lubricated inter-stage bushing and is sealed by a mechanical seal. The water to cool the HPI pump mechanical seal is passed through a cyclone separator and supplied via tubing from the first stage discharge of the pump. The cyclone separator is installed to reduce the amount of debris that reaches the mechanical seal.

The containment emergency sump originally incorporated screens with 1/4 inch square openings to prevent debris or particles (greater than approximately 5/16 inches diagonally) from entering the system and blocking flow. These screens have been replaced with a design utilizing 3/16 inch round openings during the current outage (Refer to DBNPS LER 2002-005 for further details). The pump internal openings that provide lubricating flow to the hydrostatic bearing are smaller than the screen openings (original and new screen). Debris from the containment emergency sump could potentially block the pump internal openings, which could result in damage of the hydrostatic bearing. In addition to the potential to clog the hydrostatic bearing, the original cyclone separators installed in the HPI system have internal clearances that are smaller than the openings in the containment emergency sump. Clogging of the cyclone separators could starve the mechanical seal of cooling water and possibly increase leakage. The HPI pumps were declared inoperable since the ability to maintain long-term core cooling while taking suction through the original sump screens was in question.

Investigation into this issue initially considered that debris introduced to the HPI pump via the containment emergency sump would be reduced in size after passage through the LPI Pump and the first four stages of the HPI Pump.

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DESCRIPTION OF OCCURRENCE (continued):

Lubricating water, in the form of process fluid, was provided to the hydrostatic bearing via two radial ports in the fourth stage volute of the pump and enters the bearing through five ports. The fluid, after flowing past the bearing surface, is returned to the suction of the third stage of the pump. If the debris or particles were of sufficient size and hardness, they could potentially damage the bearing shaft sleeve. Initial investigation also theorized that debris or particles of size and structural strength capable of blocking internal lubricating ports would be too dense to be transported to the sump. Documentation provided in 1975 by the nuclear steam system supplier addressed the acceptability of the pump design to function when provided with fluid supplied from the containment emergency sump. It was noted that "... particles which could deteriorate the pump are in the range of 0.004 in. to 0.015 in. These particles can pass through the mechanical seals and wear rings. However, if the mechanical seals failed from these particles, it will not prevent the pump from performing its intended function of supplying fluid to the system at the required pressures. The only other possible effect would be increased wear on the wear rings, which could result in a minor loss of efficiency (approximately 5% if the wear ring clearance is doubled) and a slight decrease in discharge pressure. Again, this will not prevent the HPI pump from performing its intended function." The effect of these particles on the hydrostatic bearing was not addressed.

Communications with the current vendor for the HPI pumps identified clearances of various rotating parts and noted that debris that is small enough to pass through the bearing may cause localized erosion of mating material surfaces, but would not lead to imminent failure of the bearing. The pump vendor also noted larger debris could block flow to the hydrostatic bearing, resulting in bearing damage.

On March 4, 2003, review of a spare hydrostatic bearing assembly revealed the existence of a threaded plug with an approximately 0.11 inch diameter hole in each of the five feed holes (approximately 0.315 inch in diameter) to the bearing that was not documented in the vendor manual. Since these openings are smaller than the sump screen openings, they may become clogged with debris. It was also identified that the radial clearances on the impeller wear rings could be eroded by the debris, resulting in a reduction in pump efficiency, capacity, and stability (pump vibration).

Thus, although not quantified, a range of debris or particles was recognized that could possibly result in degradation of the HPI pumps.

APPARENT CAUSE OF OCCURRENCE:

The apparent cause of the HPI pump debris tolerance issues is that the original HPI pump specification did not fully consider debris entrained in the water. The concern with the original design and capability of the HPI pumps to tolerate debris are related to errors that occurred during the design and construction of the facility in the latter 1960s and early 1970s. When the plant design was developed, the design of the HPI pump and the use of a hydrostatic bearing was apparently not adequately evaluated for the

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APPARENT CAUSE OF OCCURRENCE (continued):

potential impact of post-LOCA debris that was smaller than the containment emergency sump screen openings.

A contributing cause was determined to be that the nuclear steam supply system supplier failed to consider effects of debris on internal components within the HPI pumps when questioned in the mid-1970's. The HPI pump configuration includes a "piggyback" arrangement to receive containment sump inventory through discharge from the LPI pumps. Subsequently, the nuclear steam supply system supplier reviewed the impact of debris in the water in the size range between 0.004 to 0.015 inches and concluded that the debris would not affect the capability of the HPI pump to successfully continue operation.

ANALYSIS OF OCCURRENCE:

The HPI pumps are automatically started upon receipt of a Safety Features Actuation System (SFAS) [JE] signal with suction aligned to BWST to provide flow to the RCS. Depending on the size of the postulated break, HPI Pump suction may be switched over from the BWST to the LPI Pump discharge in order to maintain flow from the containment emergency sump to the RCS. While the LPI pumps are utilized to mitigate the largest of RCS piping breaks, the HPI pumps are utilized on smaller breaks. Additionally, HPI pump 2 is utilized to control boron concentration post-LOCA that may result from boiling heat transfer within the core.

Technical Specification 3.5.2 requires that two independent ECCS subsystems be operable during Modes 1, 2, and 3. Each subsystem includes one Operable HPI pump with an Operable flow path initially from the BWST with suction transferred to the containment emergency sump during the recirculation phase of operation. This condition is being reported under 10 CFR 50.73 (a)(2)(i)(B) as operation or condition prohibited by the plant's technical specifications since the condition existed for a time longer than permitted by the DBNPS Technical Specifications.

This condition is also being reported under 10 CFR 50.73 (a)(2)(v) as a condition that could have prevented the fulfillment of the safety function of a system needed to maintain the reactor in a safe shutdown condition and remove residual heat. Likewise, this condition is being reported under 10 CFR 50.73(a)(2)(vii)(B) as a single condition that caused two independent trains to become inoperable in a single system designed to remove residual heat, and under 10 CFR 50.73 (a)(2)(ii)(B) as a condition that resulted in the nuclear power plant being in an unanalyzed condition that significantly degraded plant safety. A non-emergency eight hour notification per 10 CFR 50.72 (b)(3)(ii)(B) was provided to the NRC as Event Number 39740 on April 7, 2003.

On December 5, 2003, FENOC replied to NRC Inspection Report 2003-021, "Preliminary Significance Determination for a Greater Than Green Finding - Davis-Besse High Pressure Injection Pump Design Issue." This response (Serial Letter Number 1-1339) was submitted to provide the NRC additional

NARRATIVE *(If more space is required, use additional copies of NRC Form 366A)* (17)

ANALYSIS OF OCCURRENCE (continued):

information to facilitate a more refined risk analysis. As stated in the response, a containment debris transport study was combined with an evaluation of the HPI pump in response to this limited debris. It was determined that High Pressure Recirculation (HPR) is viable to support plant cool-down during a reactor coolant pump seal LOCA and Makeup/HPI cooling for a limited period of time. The Makeup and Purification System provides feed and bleed capability via the BWST to maintain core cooling in the event of a loss of all secondary side cooling. Additionally, the lack of activation of containment spray for these types of events provides a significant amount of time for Makeup/HPI cooling before depleting the BWST. This additional time allows for reduction in the decay heat source such that the mission time of HPI recirculation for these events can be limited to 24 hours or less. After 24 hours low pressure recirculation is able to be placed in operation and provide adequate core cooling. The increase in core damage frequency including fire and seismic was determined to be approximately 3 E-6/year. The total increase in core damage probability for the period the condition existed was approximately 4.69 E-5.

These events were selected based on their contribution to core damage frequency and the more limited debris generation and transport that was expected. For events other than Makeup/HPI cooling or reactor coolant pump seal LOCAs, the debris generated was not quantified; consequently, it was assumed that HPI recirculation would fail when demanded.

CORRECTIVE ACTIONS:

Programs currently in place at Davis-Besse will help to prevent occurrence of this type of issue in the future. Policy NOPL-CC-0001, "Engineering Principles and Expectations," documents the fundamental principles and expectations for technical and engineering work at FENOC. Also, detailed design reviews are required to be completed as part of the Engineering Change process. The design review process utilized today is more stringent and rigorous than the design reviews that were done during original plant construction. This process provides adequate rigor to ensure the type of concerns that have been identified with the HPI pumps from original construction will not occur today.

Following the discovery of the HPI pump design issue, Corrective Actions were taken to ensure debris does not result in the loss of the HPI function when operating with suction aligned to the emergency sump. Modifications to the HPI Pump internals include (but are not limited to) installation of self-flushing strainers, change in locations of hydrostatic bearing take-offs supply, hydrostatic bearing pad design change, and hardfacing of close clearance parts.

Installation of Self-Flushing Strainers
To prevent debris that could plug the hydrostatic bearing orifices from entering the supply lines, self-flushing plates with approximately 0.050-inch diameter holes (over 400 holes in each strainer) were installed on the water supply take-offs to the hydrostatic bearing.

CORRECTIVE ACTIONS (continued):

Change in Locations of Hydrostatic Bearing Take-Offs Supply
The locations of the hydrostatic bearing supply take-offs were moved from the periphery of the pump fourth stage volute to a new location on the side of the fifth stage volute across from the impeller and adjacent to the discharge wear ring, which is closer to the shaft (reducing the concentration and size of debris at the take-offs). The take-off was moved to the fifth stage to increase the available differential pressure to compensate for the decreased pressure near the wear ring and to overcome increased pressure drop through the strainer, tubing, and hydrostatic bearing. At the location of the take-off port under the impeller, the circumferential flow velocity is essentially constant over all pump flow rates. The high velocity keeps the surface of the strainer clear of debris to prevent plugging.

Hydrostatic Bearing Pad Design Change
A new hydrostatic bearing design was installed that was based on a "figure 8" pocket configuration. Relief grooves were added to the hydrostatic bearing pockets to provide an "escape" path for the debris that gets into the bearing (debris larger than the bearing clearance but smaller than the strainer holes or openings). These features are to ensure reliable operation with debris-laden fluid while maintaining comparable stiffness and support to the original bearing during clean water operation.

Hardfacing of Close Clearance Parts
The parts with wear surfaces that are subject to debris that were not already hardfaced were replaced with hardfaced parts. These parts are wear rings, central volute bushing (rotating and stationary parts), and the hydrostatic bearing (rotating and stationary parts). The hardfacing will wear at a slower rate than the original materials, reducing localized erosion of mating material surfaces.

In addition to the internal modifications that were performed, external modifications were completed to address debris issues and the operation of the HPI pumps. These external modifications include (but are not limited to) cyclone separator replacement and reduction in fibrous insulation from containment.

Cyclone Separator Replacement
The mechanical seal on each of the HPI pumps is supplied by cooling water that is passed through a cyclone separator to reduce debris. The model of cyclone separator originally installed on the HPI pumps has been installed since initial construction. The originally installed cyclone separators had a smallest clearance of 0.13-inches which is less than the original screen size (and recently modified size of 0.1875-inches) opening for the Emergency Sump. The result could be clogging of the cyclone separators and potential isolation of the cooling water to the HPI pump mechanical seals. Therefore, replacement of the original cyclone separators with a new model (with smallest clearance of 0.230-inches) will allow sump water debris to pass without plugging the orifices in the cyclone separator. Debris testing was

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CORRECTIVE ACTIONS (continued):

performed on the new model cyclone separator which determined that the new model cyclone separators will continue to provide cooling water flow to the mechanical seals of the ECCS pumps following a LOCA.

Reduction in Fibrous Insulation in Containment

Because of testing conducted on modifications to the HPI pump hydrostatic bearing supply lines, the scope of work was expanded to remove as much as possible of the remaining fibrous insulation from containment. Removal of in-containment sources of fiber to protect the HPI pumps hydrostatic bearings will also benefit the ECCS pump's cyclone separators by reducing the amount of fiber that could find its way into the cyclone separators. The effort to remove as much as possible of the remaining fibrous material will also be beneficial because, as documented in LER 2002-005-02, fibrous insulation represents a potential source to clog the containment emergency sump screen if the insulation is damaged and dislodged from piping by the effects of a postulated high-energy pipe break.

The above modifications were initiated to address concerns identified with the HPI System identified during the 13th Refueling Outage. Following the HPI pump modifications, analyses, qualification testing, and in-plant testing, HPI Trains 1 and 2 were declared operable on December 30, 2003.

Evaluations were performed, in conjunction with the modifications performed on the containment emergency sump, which examined the Low Pressure Injection System, the High Pressure Injection System, the Containment Spray System, and the Boron Precipitation Control System. The purpose of the evaluations was to evaluate the impact of debris (less than or equal to 3/16 inch) that could pass through the screen and affect ECCS system components which are required post LOCA for emergency sump re-circulation. The evaluations examined the piping, valves, coolers, flow elements and orifices, pumps and instrumentation for each system, as applicable. The results determined that the debris issue does not render the subject equipment listed above incapable of fulfilling their specified safety functions in the event of a design-basis accident.

PREVIOUS SIMILAR EVENTS:

There have been no LERs in the previous two years involving similar deficiencies associated potential damage of hydrostatic bearings or other pump internals due to debris entrained in the pumped fluid.

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

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CR 2002-08492,
CR 2003-01736