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Docket Number 50-346

NP-33-02-009-02
10 CFR 50.73

License Number NPF-3

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United States Nuclear Regulatory Commission
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Washington, D.C. 20555-0001

Ladies and Gentlemen:

LER 2002-009-02
Davis-Besse Nuclear Power Station, Unit No. 1
Date of Occurrence – November 29, 2002

Enclosed please find Revision 2 to Licensee Event Report (LER) 2002-009. LER 2002-009 was submitted voluntarily in accordance with NUREG-1022, Event Reporting Guidelines, Section 2.7 to provide written notification of the degradation of the High Pressure Injection thermal sleeves. Also in accordance with the guidance of NUREG-1022, revision bars have been added to the right margin to denote changes from the previous submittal of LER 2002-009 dated March 26, 2004. This revision provides an update to the inspection methods used during the current refueling outage and a revision to the schedule of future inspections.

Very truly yours,

Mark B. Bezilla

GMW

Attachment
Enclosure

cc: Regional Administrator, USNRC Region III
DB-1 Project Manager, USNRC
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 Compliance (419-321-8585) at Davis-Besse of any questions regarding this document or associated regulatory commitments.

COMMITMENTS	DUE DATE
Upon discovery of the cracks in both the 2-1 HPI thermal sleeve and the 2-2 HPI/MU thermal sleeve, the degraded thermal sleeves were removed and new thermal sleeves were installed.	Complete
Perform a visual inspection of the 2-1 and 2-2 thermal sleeves in the 14th refueling outage to confirm the thermal sleeves installed during the 13th refueling outage were not loose or demonstrated any indicators of a loose thermal sleeve.	Complete
The Augmented Inservice Inspection Program will be revised to include examination of the HPI/MU thermal sleeve at least once every other refueling outage, starting with the 16th refueling outage. This examination will be a VT-1 visual examination if the reactor is defueled. If the reactor is not defueled, a radiographic examination will be performed to verify the thermal sleeve weld buttons are in place and the thermal sleeve end at the weld buttons is in the required position, and an ultrasonic examination of the safe end and safe end to elbow welds will be performed to confirm no cracking has occurred in the nozzle welds.	Program will be revised prior to the start of the 15th Refueling Outage
DBNPS has initiated an Engineering Change Request (ECR 04-0106-00) and will determine the long-term action for thermal sleeve crack initiation.	Prior to the start of the 15th Refueling Outage
The inspection procedure (NA-QC-05560, "Visual Examination Procedure For VT-1, VT-3, and General Visual Inspections") was revised to include requirements of the Augmented VT-1 examination of the thermal sleeves and the acceptance criteria.	Complete

NRC FORM 366 (6-2004) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB NO. 3150-0104 EXPIRES 6/30/2007

Estimated burden per response to comply with this mandatory 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 and FOIA/Privacy Service Branch (T-5 F52), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to infocollects@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 an 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.

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

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4. TITLE

Degradation of the High Pressure Injection Thermal Sleeves

5. EVENT DATE			6. LER NUMBER			7. REPORT DATE			8. OTHER FACILITIES INVOLVED	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV NO.	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
11	29	2002	2002	- 009 -	02	05	17	2006		05000
									FACILITY NAME	DOCKET NUMBER
										05000

9. OPERATING MODE

D

10. POWER LEVEL

000

11. THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: *(Check all that apply)*

☐ 20.2201(b)	☐ 20.2203(a)(3)(i)	☐ 50.73(a)(2)(i)(C)	☐ 50.73(a)(2)(vii)
☐ 20.2201(d)	☐ 20.2203(a)(3)(ii)	☐ 50.73(a)(2)(ii)(A)	☐ 50.73(a)(2)(viii)(A)
☐ 20.2203(a)(1)	☐ 20.2203(a)(4)	☐ 50.73(a)(2)(ii)(B)	☐ 50.73(a)(2)(viii)(B)
☐ 20.2203(a)(2)(i)	☐ 50.36(c)(1)(i)(A)	☐ 50.73(a)(2)(iii)	☐ 50.73(a)(2)(ix)(A)
☐ 20.2203(a)(2)(ii)	☐ 50.36(c)(1)(ii)(A)	☐ 50.73(a)(2)(iv)(A)	☐ 50.73(a)(2)(x)
☐ 20.2203(a)(2)(iii)	☐ 50.36(c)(2)	☐ 50.73(a)(2)(v)(A)	☐ 73.71(a)(4)
☐ 20.2203(a)(2)(iv)	☐ 50.46(a)(3)(ii)	☐ 50.73(a)(2)(v)(B)	☐ 73.71(a)(5)
☐ 20.2203(a)(2)(v)	☐ 50.73(a)(2)(i)(A)	☐ 50.73(a)(2)(v)(C)	☒ OTHER
☐ 20.2203(a)(2)(vi)	☐ 50.73(a)(2)(i)(B)	☐ 50.73(a)(2)(v)(D)	Specify in Abstract below or in NRC Form 366A

12. LICENSEE CONTACT FOR THIS LER

FACILITY NAME	TELEPHONE NUMBER *(Include Area Code)*
Gerald M. Wolf, Staff Engineer, Regulatory Compliance	(419) 321-8001

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

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

15. EXPECTED SUBMISSION DATE

MONTH	DAY	YEAR

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

On November 29, 2002, with the reactor defueled, during a borescope examination a crack was discovered on the 2-2 High Pressure Injection (HPI)/Makeup thermal sleeve. Inspection of the 2-1 HPI thermal sleeve on December 3, 2002 also revealed a cracked thermal sleeve. After discovery of the two cracks, the degraded thermal sleeves were replaced. The crack in either thermal sleeve did not affect the ability of the HPI system to perform its designed function nor did either crack provide a source of Reactor Coolant System pressure boundary leakage. The cause of the cracks appears to be high cyclic thermal fatigue. This event was determined to not meet the requirements of a reportable condition under 10 CFR 50.73. However, due to the industry interest in HPI thermal sleeve failure, this event is being reported voluntarily as a Licensee Event Report in accordance with the guidance provided in Section 2.7 of NUREG-1022, Revision 2, Event Reporting Guidelines.

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

DESCRIPTION OF OCCURRENCE:

On November, 29, 2002, with the reactor defueled, while performing a borescope examination it was discovered that the thermal sleeve [BQ-SLV] connected to the 2-2 High Pressure Injection (HPI)/Makeup (MU) nozzle was cracked. Inspection of the 2-1 HPI thermal sleeve on December 3, 2002, also revealed a cracked thermal sleeve. No cracking was observed during the inspection of the remaining two HPI thermal sleeves. The cracks on the thermal sleeves were axial cracks at the downstream end of the thermal sleeve.

The HPI system [BQ] is part of the Emergency Core Cooling System, which is designed to maintain core cooling in the event of a Loss of Coolant Accident. The HPI system is connected to the Reactor Coolant System (RCS) [AB] via four HPI nozzles [BQ-NZL], one per cold leg. The HPI nozzles on the RCS piping each contain a thermal sleeve designed to protect the nozzle from thermal stress by minimizing the thermal transient on the nozzle and RCS pipe when cold injection water flow is initiated through the hot nozzle. Of these four HPI lines to the RCS, two are connected with the Makeup and Purification System.

The Makeup and Purification System [CB] has many design functions, one of which is to control the RCS inventory during all phases of normal reactor operation. During normal operation the one operating makeup pump is connected to the RCS cold leg by the 2-2 HPI line and a minimum makeup flow is maintained through a manually set bypass around the makeup control valve. This bypass flow is provided to minimize thermal fatigue of the HPI/MU nozzle thermal sleeve by maintaining a minimum flow of makeup water.

BACKGROUND INFORMATION

During the 5th refueling outage at the Davis-Besse Nuclear Power Station (DBNPS), two pieces of the HPI/MU thermal sleeve were discovered in the reactor vessel when it was defueled during a refueling inspection (Refer to DBNPS LER 1988-015, Revision 1). The failure of the 2-1 HPI/MU thermal sleeve was concluded to be high cyclic thermal fatigue.

Both the 2-1 (the normal makeup line at the time) and 2-2 thermal sleeves were replaced in the 5th refueling outage. A branched type linear indication on the 2-2 HPI thermal sleeve was located approximately in the same area of the failure on 2-1 HPI/MU thermal sleeve. However, subsequent visual and liquid penetrant examinations performed on the 2-2 HPI thermal sleeve showed no cracking. The broken thermal sleeve on HPI line 2-1 allowed makeup water to impinge on the mouth of the HPI nozzle. Both a liquid dye penetrant inspection and a manual ultrasonic examination were performed on the HPI nozzle which revealed minor flaws in the cladding. These minor flaws were evaluated and found to not extend into the base metal and determined to be acceptable for continued service in the unrepaired condition with the continued use of this nozzle as the normal makeup flow path. However, a modification was completed in the 6th refueling outage that installed new piping to re-route normal makeup flow through a different HPI nozzle (2-2 HPI line) to eliminate any possibility of cold makeup flow effects upon the thermal sleeve in nozzle 2-1 or the nozzle itself.

Visual inspections of the 2-2 HPI/MU thermal sleeve were performed during the 10th (April 24, 1996) and 12th (May 8, 2000) refueling outages. No cracks were identified in these two inspections. The other 3 HPI thermal sleeves were not inspected due to no identified cracks on 2-2 HPI/MU thermal sleeve.

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DESCRIPTION OF OCCURRENCE (continued):

CURRENT DISCOVERY

The inspection of the 2-2 HPI/MU thermal sleeve was scheduled to be conducted after the reactor was defueled in the 14th refueling outage. However, an opportunity during the 13th refueling outage existed with the reactor defueled, therefore the inservice examination was performed. On November 29, 2002, it was discovered that the 2-2 HPI/MU thermal sleeve, which was modified for normal makeup flow during the 6th refueling outage, was cracked. Inspection of the 2-1 HPI thermal sleeve on December 3, 2002, also revealed a cracked thermal sleeve. No cracking was observed during the inspection of the remaining two HPI thermal sleeves. Both the 2-1 and 2-2 HPI thermal sleeves have been used for normal makeup flow, one cycle (cycle 6) for 2-1 and seven cycles (cycles 7-13) for 2-2.

There have been several problems discovered at Babcock and Wilcox plants (and throughout the industry) associated with the HPI and HPI/MU thermal sleeves as stated in Framatome ANP, "Interim BWOG Report on HPI/MU Nozzle Cracking" Document Identifier 51-5000239-01. The industry has been made aware of problems due to thermal cyclic fatigue in thermal sleeves and other components through the issuance of operating experience and correspondence from the Nuclear Regulatory Commission (NRC) and the industry. One such example is NRC Information Notice 82-30: "Loss of Thermal Sleeves in Reactor Coolant System Piping at Certain Westinghouse PWR Power Plants", which was written to "provide further notification regarding the continuance of thermal sleeve failures in both pressurized and boiling water reactor (PWR and BWR) plants."

The visual borescopic inspections performed on the 2-1 and 2-2 thermal sleeves identified axial cracks at the downstream end of each of the thermal sleeves. Neither crack exhibited any loss of material from the thermal sleeve based on these visual inspections, therefore the thermal sleeves provided thermal protection to the RCS piping. The crack in either thermal sleeve does not render the HPI system incapable of performing its designed safety function, therefore this event has been determined not to meet any of the reporting requirements under 10 CFR 50.72 or 10 CFR 50.73. However, due to the interest of the industry in thermal sleeve and thermal nozzle problems, this event is being reported voluntarily as a Licensee Event Report in accordance with the guidance provided in Section 2.7 of NUREG-1022, Revision 2, Event Reporting Guidelines.

APPARENT CAUSE OF OCCURRENCE:

The cracking of the 2-2 and 2-1 HPI thermal sleeves appears to have been caused by high cyclic thermal fatigue. The thermal mixing of hot reactor coolant and the relatively low amount of cool makeup flow may have generated cyclic thermal stresses in the sleeve. Cyclic thermal stresses may have also been caused by changes in normal makeup flow. In addition to the thermal cyclic stresses which were present in each of the thermal sleeves, a contributor to the cracking could have been flow induced vibration from the RCS flow in the RCS cold leg. The end of the thermal sleeve extends into the cold leg approximately 2 inches and the flow through the cold leg could provide additional stress to an already weakening thermal sleeve which has seen thermal cyclic stress.

The current alignment of normal makeup flow is through the HPI 2-2 line, however the 2-1 HPI thermal sleeve that was installed during the 5th refueling outage was exposed to one single fuel cycle of operation as the normal makeup flow path during the 6th fuel cycle. Visual testing was performed during the 6th refueling outage with no indications of thermal stress fatigue; therefore no further tests

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APPARENT CAUSE OF OCCURRENCE (continued):

were conducted at that time. The thermal cyclic stress from the one cycle of operation as the normal makeup flow path could provide enough thermal cyclic stress in the sleeve along with flow induced vibration from the RCS cold leg flow for seven cycles to cause the crack identified on the 2-1 thermal sleeve. A vendor with thermal hydraulic analysis experience was consulted and it is believed that cracks could initiate as early as in their first cycle of service as a makeup flow path.

The thermal sleeves that were discovered to have cracked this outage (HPI lines 2-2 and 2-1) were of a newer design than the sleeve that failed in 1988, however the thermal sleeves maintained the same temperature gradients and maintained the same flow characteristics at the discharge end and were expected to respond similarly to fluctuating temperature fields. A corrective action that was initiated due to the 1988 failure of the 2-1 HPI/Makeup thermal sleeve was to increase the minimum bypass flow. The bypass flow was increased in 1988 to approximately 11 - 15 gallons per minute (gpm) to preclude thermal stratification of flow within the sleeve and to minimize the effects of high cycle mixing at the thermal sleeve end. In 2001 Framatome ANP released "Interim BWOG Report on HPI/MU Nozzle Cracking," Document Identifier 51-5000239-01 which recommends approximately 50 gpm flow through the thermal sleeve for a typical 1.5-inch inner diameter (ID) thermal sleeve. Framatome ANP states in this report that this would prevent the mixing zone of warm and cool fluid in the thermal sleeve, thereby reducing thermal cycling in the sleeve itself. It appears that the previous increase in flow through the thermal sleeve was not sufficient based on new and updated calculations (Framatome ANP Report 51-5000239-01, "Interim BWOG Report on HPI/MU Nozzle Cracking").

Two additional contributing causes identified in the evaluation of the thermal sleeve degradation were 1) low frequency of inspection on the HPI/MU nozzle documented in the Augmented Inservice Inspection program and 2) the quality of inspections. The inspections prior to the 13th refueling outage of the thermal sleeve were performed without established criteria for quality of visual image. The visual examinations performed were not qualified examinations (i.e., the examinations included no criteria to ensure a minimum level of acuity).

ANALYSIS OF OCCURRENCE:

The thermal sleeves installed in the HPI nozzles are to limit stresses from thermal shock to acceptable values in the HPI injection connection to the reactor coolant inlet piping. The thermal sleeves in the 2-1 and 2-2 HPI line were visually examined and found to have axial cracks at the downstream end of the thermal sleeve. Based on borescopic visual inspections performed on the thermal sleeve, and ultrasonic examinations of the safe end to nozzle weld, the thermal sleeve was still providing relief of thermal shock to the HPI nozzle connection to the RCS cold leg, however it was in a degraded condition. The pressure boundary showed no crack indications or indications of leakage.

The two nozzles with cracked thermal sleeves had both previously been used as the primary makeup flow path. Both are a changed design from the originally installed thermal sleeve. The two HPI nozzles that have never been used for makeup (and their thermal sleeves) have had no failures or relevant indications over the life of the plant and are original design thermal sleeves.

ANALYSIS OF OCCURRENCE: (Continued)

While cracks in the thermal sleeve are an undesired condition, the cracks found in the 2-1 and 2-2 thermal sleeves did not render the HPI system incapable of performing its designed safety function. And as stated above the HPI pressure boundary safe end welds showed no crack indications nor indications of leakage. Therefore because the cracking of the thermal sleeves did not render the HPI system inoperable nor did the condition actually degrade the pressure boundary to cause pressure boundary leakage, this event has been determined to not meet any of the requirements for reportability under 10 CFR 50.72 or 10 CFR 50.73.

However, due to the interest of the industry in thermal sleeve and thermal nozzle problems, this event is being reported voluntarily as a Licensee Event Report in accordance with the guidance provided in Section 2.7 of NUREG-1022, Revision 2, Event Reporting Guidelines.

CORRECTIVE ACTIONS:

Upon discovery of the cracks in both the 2-1 HPI thermal sleeve and the 2-2 HPI/MU thermal sleeve, the degraded thermal sleeves were removed and new thermal sleeves were installed. The original sleeve material (prior to 1988) was ASTM A336 Class F8M for both the 2-1 and 2-2 HPI thermal sleeves. Thermal sleeve material for the 1-1 and 1-2 HPI thermal sleeves is currently still ASTM Class F8M. No cracking was observed during the inspection of the 1-1 and 1-2 HPI thermal sleeves. The replacement sleeve material, both in 1988 and 2002, is ASTM SA336 Class F316. There were no indications of leakage on the adjacent RCS cold leg piping.

The Augmented Inservice Inspection program was revised to perform visual inspections of all 4 HPI thermal sleeves following Revision 0 of this Licensee Event Report. However, after completion of the evaluation on the thermal sleeve issue, it was determined that observations and operating histories define that the HPI/MU nozzle thermal sleeve cracking is related to the inservice nozzle for normal makeup flow and is not related to HPI function. Therefore, performance of the examination on all 4 HPI thermal sleeves was determined to be not required.

Revision 1 of this Licensee Event Report stated the Augmented Inservice Inspection Program had been updated to schedule a radiographic and ultrasonic examination of the 2-1 and 2-2 thermal sleeves in the 14th refueling outage. This inspection was intended to confirm the thermal sleeves installed during the 13th refueling outage were not loose or demonstrated any indicators of a loose thermal sleeve. The radiographic examination was to verify the thermal sleeve weld buttons were in place and the thermal sleeve end at the weld buttons was in position. The ultrasonic examination was to confirm no cracking occurred in the nozzle welds, since thermal fatigue cracking could occur if the thermal sleeve was not intact. These radiographic and ultrasonic examinations were selected because access for visual examination was not expected to be available during the 14th refueling outage as the reactor was not planned for complete defueling. Defueling is required to obtain the deep drain conditions required to provide access for visual examination of the thermal sleeves.

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CORRECTIVE ACTIONS (continued):

After Revision 1 of this Licensee Event Report was submitted, a complete defueling of the reactor was scheduled for the 14th refueling outage, which permitted a visual examination of the thermal sleeves. Visual examination is the preferred technique as it permits complete examination of the thermal sleeve, while radiographic examination is limited to only the button area of the thermal sleeve. The thermal sleeve cracks identified during the 13th refueling outage were discovered via visual examination of the end of the thermal sleeve, which is not accessible for radiographic examination. VT-1 visual examinations of the 2-1 and 2-2 thermal sleeves during the 14th refueling outage were completed on March 25, 2006, and no cracks of the thermal sleeves were observed.

The Augmented Inservice Inspection Program will be revised to include examination of the HPI/MU thermal sleeve at least once every other refueling outage, starting with the 16th refueling outage. This examination will be a VT-1 visual examination if the reactor is defueled. If the reactor is not defueled, a radiographic examination will be performed to verify the thermal sleeve weld buttons are in place and the thermal sleeve end at the weld buttons is in the required position, and an ultrasonic examination of the safe end and safe end to elbow welds will be performed to confirm no cracking has occurred in the nozzle welds.

The minimum makeup flow during normal operation of the makeup system through to the HPI line used to minimize thermal fatigue of the HPI/MU thermal sleeve is lower than the 50 gpm recommended by the 2001 Framatome ANP document. Initial reviews indicated that the DBNPS design is not capable of the 50 gpm flow rate based on the demineralizer as the limiting component. DBNPS has initiated an Engineering Change Request (ECR 04-0106-00) and will determine the long-term action for thermal sleeve crack initiation.

Improved remote inspection equipment (due to the availability of higher resolution video equipment) and inspection procedure changes occurred prior to the discoveries of the cracks in the two thermal sleeves. The inspection procedure (NA-QC-05560, "Visual Examination Procedure For VT-1, VT-3, And General Visual Inspections") was revised to include requirements of the Augmented VT-1 examination of the thermal sleeves and the acceptance criteria. These changes have resulted in lower threshold of detection (reduction in the size of defect that can be detected). The ability to use inspection and inspection driven replacement is directly linked to the threshold of detection.

FAILURE DATA:

Davis-Besse has issued a previous LER (LER 1988-015, Revision 1) on loose parts discovered in the reactor vessel which investigations revealed that thermal cyclic fatigue resulted in loss of material from the HPI/MU thermal sleeve. Previous corrective action to increase the flow through the thermal sleeve is believed to not have been sufficient due to greater flow (approximately 50 gpm for 1.5 inch ID thermal sleeves) recommendations by Framatome ANP in 2001.

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

NP-33-02-009-02 Condition Reports 2002-09739 and 2002-09928