NMC
Committed to Nuclear Excellence

Kewaunee Nuclear Power Plant
Operated by Nuclear Management Company, LLC

March 10, 2004

NRC-04-032
10 CFR 50.73

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

KEWAUNEE NUCLEAR POWER PLANT
DOCKET 50-305
LICENSE No. DPR-43

REPORTABLE OCCURRENCE 2004-001-00

In accordance with the requirements of 10 CFR 50.73, "Licensee Event Report System," the attached Licensee Event Report (LER) for reportable occurrence 2004-001-00 is being submitted.

This letter contains no new commitments and no revisions to existing commitments.

Thomas Coutu
Site Vice-President, Kewaunee Nuclear Power Plant
Nuclear Management Company, LLC

cc: INPO Records Center
US NRC Senior Resident Inspector
US NRC, Region III

Attachment

IE22

N490 Highway 42 • Kewaunee, Wisconsin 54216-9511
Telephone: 920.388.2560

NRC FORM 366 (1-2001) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB NO. 3150-0104 EXPIRES 7-31-2004

Estimated burden per response to comply with this mandatory information collection request: 50 hours. 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.

LICENSEE EVENT REPORT (LER)

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

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Kewaunee Nuclear Power Plant	05000305	1 of 7

TITLE (4)

Blocked Lube Oil Coolers to Safety Injection Pumps Force Plant Shutdown

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MO	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV NO	MO	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
01	16	2004	2004	-- 001 --	00	03	10	2004	FACILITY NAME	DOCKET NUMBER

OPERATING MODE (9)	N
POWER LEVEL (10)	100

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

20.2201(b)		20.2203(a)(3)(ii)		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)		50.73(a)(2)(v)(A)	73.71(a)(5)
20.2203(a)(2)(ii)		50.36(c)(2)		50.73(a)(2)(v)(B)	OTHER
20.2203(a)(2)(iii)		50.46(a)(3)(ii)		50.73(a)(2)(v)(C)	Specify in Abstract below or in NRC Form 366A
20.2203(a)(2)(iv)	X	50.73(a)(2)(i)(A)	X	50.73(a)(2)(v)(D)	
20.2203(a)(2)(v)		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)	

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER (Include Area Code)
Gary Harrington	(920) 388-8559

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

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX
B	BQ	CLR	T193	Y					

SUPPLEMENTAL REPORT EXPECTED (14)				EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
X	YES (If yes, complete EXPECTED SUBMISSION DATE).		NO		June	30	2004

ABSTRACT

On 1/15/04, with the plant operating at 100% power, the discovery of significant biofouling (blockage by biological matter) of both trains of Safety Injection (SI) Pump lube oil coolers resulted in initiating a Technical Specifications (TS) forced shutdown of the Kewaunee Nuclear Power Plant (KNPP). KNPP was taken offline at approximately 0600 on Friday, 1/16/04. During maintenance and inspection activities on SI pump A on 1/15/04, the lube oil cooler was found to be biofouled. After the cooler was cleaned similar conditions were found in SI pump B. Visible flow was occurring in only 3 of the 20 tubes in the B cooler inlet pass. Even though the coolers were cleaned and operational, the decision was made to shut down the plant. Service water continuously flowed into the coolers through a 3/4-inch pipe into the top half of the inlet/outlet chamber. The small tube size, coupled with the size of the tubesheet surface between tubes, resulted in lakeweed accumulating against the tubesheet. The biofouling phenomenon existed on the top half of the inlet/outlet tubesheet and the bottom half of the return end tubesheet. Historical experience with the coolers demonstrates that the condition was not new. The biofouling occurred because the original design of the SI lube oil cooler was not sufficient given the SW flow velocity, tube size and system configuration. The lube oil coolers have been replaced with a different design. The root cause evaluation and past operability analyses are continuing. Once compete, they will provide a better understanding of the full scope of corrective action needs and the significance to this event. Upon completion of the analyses, a supplement to this event report will be provided. This event is considered a safety system functional failure.

LICENSEE EVENT REPORT (LER)
TEXT CONTINUATION

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Kewaunee Nuclear Power Plant	05000305	2004	-- 001 --	00	2 of 7

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

DESCRIPTION

On 1/15/04, with the plant operating at 100% power, the discovery of significant biofouling (blockage by biological matter) of both trains of Safety Injection (SI)[BQ] Pump [P] lube oil (LO) coolers [CLR] resulted in initiating a Technical Specifications (TS) forced shutdown of the Kewaunee Nuclear Power Plant (KNPP). KNPP was taken offline at approximately 0600 on Friday, 1/16/04. This event was initially reported on 1/16/04, at 0020 according to 10CFR50.72(b)(2)(i), TS Required Shutdown, 10CFR50.72 (b)(3)(ii)(B), Unanalyzed Condition, and 10CFR50.72(b)(3)(v)(D), Accident Mitigation.

During maintenance and inspection activities on SI pump A on 1/15/04, the lube oil cooler was found to be biofouled. After the cooler was cleaned very similar conditions were found in SI pump B. In fact, visible flow was only occurring in 3 of the 20 tubes in the B cooler inlet pass. Even though the coolers involved were cleaned and operational, Nuclear Management Company (NMC) decided to shut down the plant.

Service water (SW)[BI] flow through the coolers before and after cleaning was measured at approximately four and six gallons per minute, pre and post-cleaning respectively. Previous surveillances were considered acceptable based on visible flow through a sight glass [FG]. However, recent analysis produced a family of curves taking into account all parameters necessary to remove pump heat. These curves include service water flow, heat exchanger [HX] surface area, and lake temperature. Based on these findings, safety injection pumps A and B were declared inoperable. A review of operating experience from Lake Michigan plants indicated that coolers with 3/8-inch tubes could become substantially blocked within 24 hours of cleaning. Although partial blockage tended to increase velocity through the remaining tubes, the surface area available for heat exchange was reduced, potentially affecting the cooler's ability to remove the design basis heat load. The event also showed that low service water velocity can contribute to the buildup of debris in the coolers. The safety injection pump lube oil coolers are operated with continuous, low-velocity flow; consequently, they were more susceptible to debris accumulation.

The SI pump LO cooler was a two-pass heat exchanger. It was approximately 18 inches long and contained 20 3/8-inch diameter tubes for each pass. Tubes were contained in a tubesheet at each end; each end also had a hemispherical chamber. The inlet/outlet chamber contained a horizontal divider plate with an inlet nozzle on the top half and an outlet nozzle on the bottom. The opposite end, the return chamber, did not have a divider plate. Service water flowed continuously into the cooler through a 3/4-inch pipe into the top half of the inlet/outlet chamber and continued through the 20 tubes on the top half of the cooler. Flow exited the top tubes, entered the return end chamber and continued into the bottom 20 tubes for the second pass. The service water then exited the second pass tubes into the outlet chamber and outlet nozzle [NZL].

The small tube size of the LO coolers, coupled with the size of the tubesheet surface between tubes, resulted in lake weed becoming trapped against the tubesheet. This biofouling condition existed on the top half of the inlet/outlet tubesheet and the bottom half of the return end tubesheet.

The historical experience with the SI LO coolers demonstrated that this event was not a new phenomenon with the coolers. However, new performance criteria were being applied to the clean and inspect activity to ensure heat removal capability of the heat exchanger. Considering KNPP and industry

operating experience (OE), it was concluded that the design of the SI lube oil cooler may not have been sufficient given the low SW flow velocity, tube size and system configuration. The remaining safety related components in the SW System have not demonstrated similar fouling and have velocity characteristics that support this conclusion.

CAUSE OF THE EVENT

The root cause of the LO cooler becoming plugged was a potentially inadequate LO cooler design for the conditions and foreign materials that Lake Michigan could introduce into SW system. The most significant contributing factors were the low flow velocities at the cooler and the tube sheet limiting dimensions.

In addition to the design application deficiency, a review of historical data and industry performance information related to heat exchanger fouling revealed a number of previous opportunities to identify and correct the conditions that led to the plant shutdown. The following is a summation of some of the issues identified by the root cause evaluation team:

The Nuclear Regulatory Commission (NRC) issued Generic Letter 89-13 requesting plants to conduct performance testing on heat exchangers cooled by service water to verify heat transfer capability. Alternate approaches such as "inspect and clean" were considered acceptable for small, accessible components such as lube oil coolers. KNPP elected to implement this requirement for the SI pump LO coolers by establishing a recurring preventive maintenance action item that would be performed annually consistent with the NRC directive that inspections be conducted at every refueling outage. However, a comprehensive program document with assigned program owner that described the program was not established. There was also no specific acceptance criterion for biofouling established.

Initial inspection of the two SI pump LO coolers was performed during the spring 1992 refueling outage. The coolers were found to be approximately 50% fouled with "green plant matter" and Incident Report (IR) 92-045 was established to address the issue. One of the corrective action recommendations from the IR was to determine maximum temperature differences between the service water and the lube oil to establish criteria to clean the coolers. On 12/5/94, the Plant Operations Review Committee (PORC) approved canceling this IR corrective action. Consequently the PORC may have contributed to plant overconfidence that the issue was not of major concern.

The first inspection also set the tone for future acceptances of the biofouling conditions, specifically:

- Since the coolers had never, in the life of the plant (approximately 17 years), been previously inspected, biofouling was not unexpected.
- Annual inspection was probably excessive and future inspections would show that the frequency could be reduced.
- The SI pumps were operable based on the lube oil temperature measurements, which were on the order of 120 degrees F during surveillance testing.
- No specific acceptance criteria for biofouling were identified.

- Visible flow though the sight glass was considered acceptable flow.

The LO coolers were inspected and cleaned on roughly an annual basis between 1992 and 2000. Fouling was present to varying degrees. Since no acceptance criterion was specified in the work orders, no corrective action reports were issued.

In 1997, as a result of radiography performed on the service water piping, flow to the LO coolers and SI pump stuffing boxes was measured to confirm that nodules seen on the radiographs were not significantly impeding flow. The flow measurements revealed that the 14 gallons per minute (gpm) minimum flow required by the vendor drawing (10 gpm to the cooler and 2 gpm to each stuffing box) was not being met. Kewaunee Assessment Process (KAP) 97-0783 was initiated to evaluate the condition. A calculation included in the KAP 97-0783 evaluation concluded that the cooler required heat load removal capacity would be met with as low as 1.5 gpm flow through the cooler. The calculation assumed that all tubes would be open when calculating minimum required flow that the pipe must be able to pass.

C11423 was the calculation that had established the minimum flow requirements for the SI LO coolers to be 1.5 gpm. In late 2003 a review of calculation C11423 was performed. The calc was reviewed as a precautionary measure to Radiograph Testing (RT) of the SW piping to the LO coolers. Unacceptable RT results would require installation of ultrasonic flow measuring devices (UFMs) to quantify minimum flow to the SI LO coolers. This in-turn questioned the minimum flow required and drove the calculation improvement and established the new performance criteria for cooler plugging. The calculation concluded the following:

- The required service water flow rates vary based on service water inlet temperature and degree of tube blockage.
- Three gpm is sufficient, even for the maximum analyzed service water temperature of 80 degrees F if the cooler has less than half of the tubes blocked per pass.
- If more than half of the tubes per pass are blocked, the cooler may not be able to remove the required heat.

The calculation was approved on 1/12/04 and all the pieces were in place that resulted in the decision, once both LO coolers were found to be substantially blocked, to declare the SI pumps inoperable and force a shutdown of the plant.

ANALYSIS OF THE EVENT

This event is reportable under 10CFR50.73(a)(2)(vii), "The completion of any nuclear plant shutdown required by the plant's Technical Specifications," 10CFR50.73(a)(2)(v)(D), "Any event or condition that could have prevented the fulfillment of the safety function of structures or systems that are needed to: Mitigate the consequences or an accident," and 10 CFR 50.73(a)(2)(vii)(D), "Any event where a single

cause or condition caused at least one independent train or channel in multiple systems or two independent trains or channels to become inoperable in a single system designed to: Mitigate the consequences of an accident."

This event required a unit shutdown in accordance with the Kewaunee Technical Specifications due to both trains of Safety Injection being declared inoperable. At the time, the SI LO coolers failed to meet the performance criteria based on the number of blocked tubes versus service water temperature. A full loss of heat removal capability did not occur based on as-found measured flow and known flow through 3 of 20 tubes. The full extent of the safety significance remains under evaluation at this time. There had been no instances reported nor evidence found to support that the coolers were ever completely blocked at anytime.

Weekly updates on "past operability" evaluation efforts are provided to NRC Region III as the plant staff progresses further into reanalyzing the SI pump and LO cooler heat removal design requirements. When the safety significance evaluation of the event is completed, a supplemental report will be submitted.

CORRECTIVE ACTIONS

An extensive extent of condition review was performed to determine potential effects of plugging on the remainder of the components cooled by the SW system. This included:

- Comparing the internal dimensions of tubes in all the plant safety related heat exchangers and coolers and assessing the flow velocities based on available flow test data. Some non-safety related plant heat exchangers were also reviewed.
- Visually inspecting a number of safety and non-safety related plant heat exchangers and area fan coil coolers.
- Re-examining heat exchanger performance data for signs of degradation.
- Measuring the internal clearances of the rotating SW strainers to ensure bypass potential for lake debris did not exist.

Based upon review of plant data, industry OE, and prior evaluations at KNPP and Point Beach Nuclear Plant (PBNP), NMC concluded that SW cooled safety related heat exchangers with tube sizes of 1/2-inch and greater are not susceptible to similar lakeweed fouling. As described above, the SI lube oil cooler was a two-pass exchanger with twenty (20) 3/8-inch tubes in each pass. At the design flow rate of 6 gallons per minute (GPM), the tube flow velocity was approximately 1.2 feet per second (FPS). NUREG/CR-5210 guidance to minimize silting and biofouling, recommends maintaining flow velocity above 3 FPS. The design of the heat exchanger did not meet this criterion. In addition to the low velocity in the heat exchanger, industry and KNPP operating experience indicate that 3/8-inch tubes and smaller have a higher occurrence of fouling. This was due to a number of factors including flow velocity and distance between the tubes (spacing on the tube sheet). Of the safety related components normally supplied with SW, the SI LO cooler is the only safety-related cooler with 3/8-inch tubes, with the next

smaller size being 1/2-inch tubes in the Turbine [TRB] Driven Auxiliary Feedwater (TDAFW)[BA] pump LO cooler.

The SI LO coolers were replaced with a different design under DCR 3518. The new coolers are of a single tube coil design with an internal tube dimension of 3/4-inch. The larger tube size and expected flows are consistent with recommended flow velocities to preclude biofouling similar to what caused this event.

A past operability evaluation is in progress. This effort is being undertaken to determine the safety significance of the cooler plugging. As noted earlier, weekly NRC Region III updates are being conducted on the status of the past operability review.

The root cause evaluation is also still in progress. Due to the nature of the event and the scope of the root cause evaluation, the full extent of corrective actions needs are not fully understood. As can be seen from the Cause of Event section of this report, there were previous opportunities to take corrective actions from previous findings of plugging in the LO coolers. It also appears that corrective actions taken as the LO coolers were found with biofouling from previous events were not appropriate or were the result of a lack of comprehensive understanding of the conditions that were being found. To date the RCE efforts have signified a potential need for corrective measures in the following areas:

- Managing emergent issues.
- Establishing appropriate equipment performance acceptance criteria.
- Program management.
- Program staffing.
- Prioritization

Considering there are additional actions required by NMC staff to fully understand the causes of this event beyond replacing the LO coolers, and the fact that the past operability determination continues in order to further understand the safety significance of the condition that was found, a supplemental event report will be submitted.

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
Kewaunee Nuclear Power Plant	05000305	2004	-- 001 --	00	7 of 7

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

SIMILAR EVENTS

None.

EQUIPMENT INFORMATION

SI Pumps

- Bingham-Willamette Co. (now Sulzer Bingham Co.), Model 4x6x9, Type CP, 11 stage, 3600 RPM pumps.

Old Lube Oil Coolers

- Thermxchanger, Inc, Type BF 2-Pass Liquid Cooler.