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FACIL:50-305 Kewaunee Nuclear Power Plant, Wisconsin Public Servic 05000305
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RECIP.NAME RECIPIENT AFFILIATION

SUBJECT: LER 97-007-00:on 970606,design deficiency discovered in Kewaunee reactor vessel level indication sys.Caused by potential for non-conservative indicated level error.Interim operability determination prepared.W/970707 ltr.

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NRC-97-71

July 7, 1997

10 CFR 50.73

U. S. Nuclear Regulatory Commission
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Ladies/Gentlemen:

Docket 50-305
Operating License DPR-43
Kewaunee Nuclear Power Plant
Reportable Occurrence 97-007-00

In accordance with the requirements of 10 CFR 50.73, "Licensee Event Report System," the attached Licensee Event Report (LER) for reportable occurrence 97-007-00 is being submitted.

Sincerely,

M. L. Marchi
Manager - Nuclear Business Group

GIH

Attach.

IE22

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

NRC FORM 366 (4-95) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB NO. 3150-0104
EXPIRES 04/30/98

ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS MANDATORY INFORMATION COLLECTION REQUEST: 50.0 HRS. REPORTED LESSONS LEARNED ARE INCORPORATED INTO THE LICENSING PROCESS AND FED BACK TO INDUSTRY. FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE INFORMATION AND RECORDS MANAGEMENT BRANCH (T-6 F33), U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC 20555-0001, AND TO THE PAPERWORK REDUCTION PROJECT (3150-0104), OFFICE OF

LICENSEE EVENT REPORT (LER)

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

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
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TITLE (4)

Reactor Vessel Level Indication System Level Error Due To Design Deficiency

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 NAME	DOCKET NUMBER
									N/A	05000
06	06	97	97	-- 007 --	00	07	07	97	FACILITY NAME	DOCKET NUMBER 05000

OPERATING MODE (9)	N
POWER LEVEL (10)	000

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more) (11)

20.2201(b)	20.2203(a)(2)(v)	50.73(a)(2)(i)	50.73(a)(2)(viii)
20.2203(a)(1)	20.2203(a)(3)(i)	X 50.73(a)(2)(ii)	50.73(a)(2)(x)
20.2203(a)(2)(i)	20.2203(a)(3)(ii)	50.73(a)(2)(iii)	73.71
20.2203(a)(2)(ii)	20.2203(a)(4)	50.73(a)(2)(iv)	OTHER
20.2203(a)(2)(iii)	50.36(c)(1)	50.73(a)(2)(v)	Specify in Abstract below or in NRC Form 366A
20.2203(a)(2)(iv)	50.36(c)(2)	50.73(a)(2)(vii)	

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER (Include Area Code)
Gary I. Harrington	(414) 388-8559

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

SUPPLEMENTAL 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 15 single-spaced typewritten lines) (16)

On June 6, 1997, with the plant in refueling shutdown, a design deficiency was discovered in the Kewaunee reactor vessel level indication system (RVLIS). The deficiency was discovered while resolving a previously identified software error in the system. The deficiency results in the potential for a non-conservative indicated level error; indicated level may be as much as ten percent higher than actual level. This potential condition has existed since the system was installed in 1986.

Kewaunee is unable to determine if the level error actually exists without draining the reactor coolant system (RCS). Additionally, we are unable to assure that the condition will not occur during normal plant operation even if it could be proven that the condition was not created during RCS filling. The phenomenon which causes the potential for the level error and the inability to provide assurance that the condition will not occur during plant operation may be of generic interest.

An operability determination has been made assuming the condition occurs and the worst case level error exists. Administrative corrective actions have been implemented to address the potential offset in indicated level. The corrective actions will remain in place until the deficiency can be resolved during the next scheduled refueling shutdown in the fall of 1998.

DESCRIPTION OF EVENT

On June 6, 1997, while in Refueling Shutdown, a design deficiency was discovered in the Kewaunee reactor vessel level indication system (RVLIS). The deficiency results in the potential for a non-conservative indicated level [LI] error; the indicated level could be as much as ten percent higher than actual level. The maximum level error occurs when the reference chamber at the top of the RVLIS differential pressure transmitter reference leg fills with water and fails to drain as the reactor vessel [RPV] level falls below the reactor vessel head connection. The condition is caused by a combination of undersized tubing and the tubing orientation between the reference chamber and the reactor vessel.

The Kewaunee RVLIS design uses a differential pressure (DP) monitoring system as input to reactor vessel level indication. At the top of the reference leg of the DP transmitter [PDT] is a reference chamber. The chamber is approximately 17 inches higher than the top of the reactor vessel head tap. The chamber is connected to the reactor vessel with three eighths inch outside diameter stainless steel tubing at a "fuel recycling port" head penetration. The purpose of the reference chamber is to ensure a constant reference leg pressure by providing a volume of water sufficient to replace any volume of water lost from the reference leg during a transient. The mechanical portion of the system was designed by Fluor Engineers, Inc.

During the 1996/1997 extended refueling outage, modifications to the RVLIS software were made to address a previously identified error (reference LER 97-003-00). During post-modification testing, the indicated level and actual reactor vessel level did not agree.

The post-modification testing was performed while draining the reactor coolant system (RCS) [AB]. The level error was corrected by venting the top of the RVLIS reference chamber.

The investigation into the level error revealed that the reference chamber was full at the start of RCS draining. Opening the chamber vent confirmed that the chamber was not draining back to the reactor vessel when level was lowered. It was subsequently determined that the three eighths inch tubing connecting the reference chamber to the reactor vessel head has a vertical run of approximately 0.7 feet. The small diameter tubing and the vertical orientation prevents the reference chamber and tubing from draining back to the reactor vessel.

Although the tubing and its orientation result in failure of the reference chamber to drain, it is the elevation of water trapped in the tubing and chamber combined that establish the degree of level offset. As long as the pressure internal to the reference chamber is at or below the RCS pressure, water will not drain from the vertical run of tubing.

There are a number of ways in which water can be introduced to the tubing which can result in the phenomenon. It can be introduced by any number of combinations of vent valve [VTV] operations during RCS filling or when the RCS is full. This can be overcome by ensuring a level in the chamber is established while RCS level is below the head tap prior to filling the RCS. Another manner in which water can be introduced is by "vacuum filling" the RCS subsequent to an outage. During "vacuum filling," if the process is successful, the chamber and interconnecting tubing is evacuated. Under this condition, the voided volume

will be replaced with water. This condition can be overcome by isolating the chamber at a location close to the reactor head between the head and any vertical run of tubing after a level has been established in the chamber and prior to drawing a vacuum on the RCS.

Following repairs of the steam generator tubes this outage, Kewaunee performed "vacuum filling" of the RCS. Whether the process actually resulted in a filled reference chamber is indeterminate. During the process Kewaunee did not isolate the reference chamber.

Regardless of any efforts to ensure proper conditions are established in the RVLIS reference leg connections while filling the RCS, there is another mechanism whereby the chamber and connecting tubing may become filled. Subsequent to establishing proper conditions, as RCS pressure is increased, the air in the tubing and reference chamber will be compressed. This results in water being introduced into the tubing and possibly the chamber. Normally it would be expected that a subsequent decrease in RCS pressure would result in the water being displaced back to the RCS. However, during extended operation under pressure, it is postulated that some or all of the compressed air will go into solution. This theory also assumes that the air entrained in the water will not come out of solution after the RCS is depressurized. Given this theory, the condition of having water trapped in the tubing is likely. The degree of resulting level offset would be dependent upon how much air went into solution and how much returned after the RCS depressurized.

Analysis shows that the phenomena of having water trapped in the tubing and reference chamber causes the indicated level to be higher than actual level in the reactor vessel. The degree of error when the reference chamber is filled, which is the maximum error, is equal

to the elevation difference between the chamber and the interconnecting tubing penetration at the reactor vessel. For Kewaunee's design this is approximately 17 inches, which is about ten percent of the monitored span. The phenomenon is caused by the water column suspended in the tubing applying a negative force on the column of water in the reference leg. The value of the level error is constant from zero to 100 percent of the monitored span.

In addition to the level indication being offset, the condition also impacts a second feature of the Kewaunee RVLIS; RVLIS also provides indication of percent void fraction in the reactor vessel. While reactor vessel level is measured with the reactor coolant pumps [P] off, void fraction is measured with either of the reactor coolant pumps operating.

Void fraction is measured as a comparison of the density between the fluid in the reference leg and the fluid in the reactor vessel. The impact of the suspended column of water in the tubing is less significant on void fraction. However, it is not a constant offset as with reactor vessel level.

Void fraction measures the magnitude of voiding as it occurs in the reactor vessel. Under subcooled up to saturated water conditions, void fraction equals zero. At 100 percent saturated vapor in the core void fraction equals 100 percent. The effect caused by water trapped in the reference chamber is an error in void fraction from one to seven percent as voids develop. The effect is linear as void formation goes from zero to 100 percent.

CAUSE OF THE EVENT

The condition found is primarily attributed to a design deficiency. The tubing size and its vertical orientation prevent water from draining back to the reactor vessel. Why this design was selected is not specifically known. It appears that the individuals involved in the development of the design failed to recognize the potential of the phenomenon described. The likely reason for selecting small diameter tubing is to preclude a loss of reactor coolant beyond the capacity of a charging pump should a line rupture occur.

ANALYSIS OF THE EVENT

This event is being reported under 10 CFR 50.73(a)(2)(ii), "a condition found while shutdown that resulted in a condition not covered by the plant's operating and emergency procedures." This event is also being reported to provide information to the industry which may be of generic interest. It appears that any facility using a similar RVLIS design may be susceptible to the same phenomena. The significance of the condition will vary depending upon the span of level that is monitored and the elevation differences between the reference chamber and the top of the reactor vessel for each facility using a similar RVLIS design..

At Kewaunee the significance of the level error is minimal. The Kewaunee RVLIS instruments are used in determining the status of reactor vessel inventory during emergency events. Kewaunee Integrated Plant Emergency Operating Procedures (IPEOPs) provide guidance to Operations' personnel at three distinct reactor vessel levels when the reactor

coolant pumps are off; 100, 30 and zero percent level. When indicated level is higher than actual level at 100 and zero percent, there is no impact on operator guidance provided by the IPEOPs. At 30 percent there is a potential that the level error may give the operator a false sense of security of the magnitude of void development.

With the RVLIS operating properly (i.e., no level error), at 100 percent indicated level, the actual reactor vessel level can be between 100 and 109 percent of the span monitored by the DP transmitter. This is due to the elevation difference between the top of the reference leg (reference chamber) and the reactor vessel head penetration. The software program for Kewaunee's instrumentation is set such that the indicated output is 100 percent at levels 100 percent and greater. The nine percent difference accounts for approximately 15 inches. Also, 100 percent level is actually at the RVLIS head penetration and the penetration is approximately 1.25 feet higher than the inside diameter of the head. Therefore, the 17 inches from the error caused by the suspended water column would have no impact on operator actions nor would it be identifiable by control room indication.

The 100 percent level guidance provided by the IPEOPs informs the operator that voiding is beginning to occur in the reactor vessel. This information is provided for the operator to make a determination whether or not to continue RCS cooldown under natural circulation with void formation. Due to elevation differences between the reference chamber, the RVLIS penetration elevation and the vessel head, the net effect of the level error with regard to operator guidance is of no consequence.

Kewaunee's RVLIS indication at zero percent is at the bottom of the RCS hot leg piping. The IPEOP guidance at zero percent level is provided for the operator to determine whether or not to stop safety injection flow. According to the IPEOPs, the operator is to verify the core is not uncovered by confirming a RVLIS level greater than zero percent. The bottom of the hot leg is two to three feet above the top of the core. It is an additional foot above the active fuel. Therefore, even with the 17 inch error, the operator can confirm the core remains covered at zero percent indication.

The operator guidance provided by the IPEOPs at 30 percent is to ensure the magnitude of voiding in the reactor vessel has not progressed to the point of potentially interrupting natural circulation flow and to ensure margin exists to preclude entering inadequate core cooling (ICC) conditions. The top of the RCS hot leg is approximately 17 percent vessel level, a 13 percent margin from the IPEOP guidance. According to the IPEOP Setpoint Document, 30 percent was selected based upon the top of the hot leg plus 6.5 percent channel inaccuracy. Therefore, with the maximum level error, the potential exists that void formation could grow to the point where natural circulation cooldown could be challenged. With regard to ICC, the ten percent level offset is of no significant impact. The entry level into the ICC mitigation procedure is based on core exit thermocouple (CET) temperature. The CETs are well below the bottom of the hot leg and would remain covered with the maximum offset in indication. Due to the potential for void formation interrupting natural circulation flow, administrative corrective actions have been implemented to eliminate the concern.

IPEOP guidance for void fraction directs the operator to monitor any increasing or decreasing trends in voids when a reactor coolant pump is operating. The ability to monitor trends is not impacted by the level error in the RVLIS.

CORRECTIVE ACTIONS

Kewaunee has taken the following corrective actions:

1) An interim operability determination has been prepared which allows plant operation through the next operating cycle. This determination was presented to the Plant Operations Review Committee on 6/6/97 for concurrence. The determination concluded that the RVLIS, with administrative changes to operator guidance at 30 percent level, is capable of satisfying its intended functions of providing indication of void formation in the reactor vessel over its required span.

2) The IPEOPs have been revised. The IPEOP guidance at 30 percent was changed to 40 percent to account for the ten percent level error. Additionally, a memo was sent to the operating shifts and the training department informing them of the error potential and the changes made to the IPEOPs.

3) An "INPO Nuclear Network" message was sent to inform the industry of the potential condition identified with the Kewaunee design. The message also indicated that an LER would be submitted.

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

The final resolution to the design deficiency has yet to be determined. It is unclear at this time what the most effective corrective action is to preclude the conditions which can cause the level error. Kewaunee will have final corrective measures completed during the next scheduled refueling outage in the Fall of 1998.

ADDITIONAL INFORMATION

None

SIMILAR EVENTS

LER 97-003-00