LICENSEE EVENT REPORT (LER)

Form Rev 2.0

Facility Name (1)	Docket Number (2)	Page (3)
Byron, Unit 1	0 5 0 0 0 4 5 4	1 of 0 7

Title (4)

Loss of Shutdown Cooling During Reactor Cavity Level Lowering Evolution Due to Unexpected Flow Phenomenon

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 9	1 9	8 8	8 8	— 0 0 7 —	0 0	1 0	1 9	8 8	NONE	0 5 0 0 0
										0 5 0 0 0

OPERATING MODE (9)	6
POWER LEVEL (10)	0 0 0

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10CFR (Check one or more of the following) (11)

__ 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)	X Other (Specify in Abstract below and in Text) Voluntary
__ 20.405(a)(1)(iii)	__ 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	
Don Brindle, Operating Engineer	Ext. 2218	8 1 5	2 3 4 - 5 4 4 1

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

CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	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 fifteen single-space typewritten lines) (16)

On September 19, 1988, the reactor was fully depressurized in the Refueling Operational Mode at a temperature of approximately 95°F. Reactor cavity water level was approximately four inches. A reactor vessel stud hole protective insert had worked free and was floating on the water surface. At 1052 the 1B Residual Heat Removal (RHR) Pump was operated to lower reactor cavity water level to the vessel flange to permit insert replacement. Visual sighting of cavity water level was believed to be an accurate and timely indication for the evolution based on past experience. While completing the draining evolution, the 1A RHR Pump showed signs of cavitation and was stopped by a licensed reactor operator. Within two minutes of stopping the pump, the reactor vessel was gravity filled from the Refueling Water Storage Tank. Within 14 minutes, shutdown core cooling was restored using the 1B RHR Pump. This report is submitted voluntarily.

The 1A RHR Pump cavitation was caused by the entrainment of air to the pump's suction. It is believed that air was admitted by a vortex when reactor vessel water level lowered below the top of the reactor coolant hot legs. The cause of the excessive lowering of vessel water level was a failure to comprehend the fluid restriction created when the upper internals assembly is fully seated on the hold down spring.

Training sessions have been initiated describing this event with specific emphasis on reactor component features that contributed to this event. Procedure revisions have been initiated to provide better control and guidance.

(0118R/0012R)

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A. PLANT CONDITIONS PRIOR TO EVENT:

Event Date/Time 9/19/88 / 1100

Unit 1 MODE 6 - Refueling Rx Power 0% RCS [AB] Temperature/Pressure 95°F / 0 PSIG

B. DESCRIPTION OF EVENT:

On September 19, 1988, the Byron Unit 1 reactor was fully depressurized in the Refueling Operational Mode (Mode 6). Outlet temperature of the 1A Residual Heat Removal (RHR) [BP] Pump, which was indicative of reactor coolant temperature, indicated 95°F. The reactor vessel head had been removed and stored in its designated location in the Containment Building in preparation for a fuel shuffle. The reactor vessel upper internals assembly remained installed in the vessel. The reactor cavity was flooded to a level approximately four inches above the reactor vessel flange and the 1A RHR Pump was in operation to provide shutdown core cooling at a flow rate of 3200 gpm. Reactor coolant letdown to the Chemical and Volume Control System [CB] was in service via the RHR System. Reactor vessel water level was monitored by the installation of a tygon tube to a reactor coolant loop 1 hot leg connection. One reactor vessel stud hole protective insert had worked free and was floating on the water surface in the reactor cavity. To replace the protective insert, reactor cavity water level would have to be lowered to the vessel flange to permit personnel access to the area.

An Equipment Attendant (EA) (non-licensed operator) was stationed in the Containment on the 426' operating deck to observe reactor cavity water level, because past experience indicated this was the most accurate indication of reactor vessel water level while lowering level only to the point at which maintenance could be performed at the vessel flange. The EA informed the Main Control Room Nuclear Station Operator (NSO) (licensed reactor operator) that he could not observe water level in the reactor vessel itself, because the upper internals assembly was still installed and obstructing his view. The NSO directed the EA to observe the level of the water surrounding the upper internals assembly, since level would only be lowered to the reactor vessel flange, which was in sight. At 0957 on September 19, 1988, the 1B RHR Pump was started to lower reactor cavity water level in accordance with "Pump Down of the Reactor Cavity to the Refueling Water Storage Tank Operating Procedure" (BOP RH-9). The EA observed lowering cavity water level and informed the NSO that level had lowered to the reactor vessel flange. At 1005 the NSO stopped the 1B RHR Pump. The EA checked reactor vessel water level as indicated by the tygon tube assembly attached to a reactor coolant hot leg. The level in the tygon tube had dropped approximately one foot from its level prior to the 1B RHR Pump run. At approximately 1030 the EA checked the tygon tube water level again and noted it had dropped another 5 inches. The NSO and other licensed operators on shift believed that the tygon tube level indicator was responding sluggishly and was not reflecting actual reactor vessel water level in real time. Visual sighting of vessel level was believed to be more accurate and timely and, therefore, was used.

A Mechanical Maintenance Foreman (non-licensed) entered Containment and requested further lowering of vessel water level, since he could still see water in the area of the reactor vessel flange stud holes. At 1052 the NSO started the 1B RHR Pump in accordance with BOP RH-9 while the Foreman observed cavity water level from the 426' operating deck level. When the Foreman was satisfied that the work area was clear of water, he told the NSO to stop the 1B RHR Pump. During this evolution the EA remained on the 426' operating deck but did not observe cavity water level to minimize his radiation exposure. A mechanic entered the reactor cavity, expeditiously installed a replacement reactor vessel stud hole protective insert, and exited the cavity.

B. DESCRIPTION OF EVENT: (Continued)

At about the time the Foreman recommended stopping the cavity water level decrease and while the NSO was monitoring RHR System instrumentation, the NSO observed that 1A RHR Pump motor amperage was fluctuating between 30 and 50 amps and that letdown flow rate was also fluctuating. At 1059 the NSO stopped the 1B RHR Pump and isolated letdown flow. At 1100 the NSO stopped the 1A RHR Pump because the motor amperage fluctuation had increased to between 20 and 60 amps. The NSO entered and complied with "Loss of RH During Refueling Unit 1 Abnormal Operating Procedure" (1BOA REFUEL-4). The 1A RHR Pump was declared inoperable and the action requirements for Technical Specification 3.9.8.2 were implemented. At 1102 the 1B RHR train was aligned to gravity fill the reactor cavity from the Refueling Water Storage Tank (RWST) in accordance with the "Filling the Reactor Cavity for Refueling Operating Procedure" (BOP RH-8). The gravity fill method provided a flow rate of approximately 1500 gpm. At 1108 the NSO started the 1B RHR Pump taking a suction from the RWST and discharging to the reactor coolant loop cold legs. At 1109 the NSO stopped the 1B RHR Pump, because the Foreman in Containment reported that reactor cavity water level was about six inches above the reactor vessel flange. The 1B RHR train was aligned to provide shutdown core cooling and at 1114 the 1B RHR Pump was started. Stable plant conditions were achieved and the licensed operators exited 1BOA REFUEL-4 at 1114. At 1153 a sample line valve from the 1A RHR Pump was opened about one-quarter turn and an air-water mixture was emitted for 20 to 40 seconds. At 1342 the NSO started the 1A RHR Pump for an operability test and all indications were that the pump started and operated normally. At 1346 the 1A RHR Pump was declared operable. At 1453 an Event Notification was telephoned to the NRC in accordance with 10CFR50.72 (b)(2)(iii), since Station management believed this article to apply at the time. Further investigation concluded that this event is not reportable pursuant to any 10CFR50.73 articles, but in view of the generic industry implications and subtlety of the event, this Licensee Event Report (LER) is submitted voluntarily.

C. CAUSE OF EVENT:

The 1A RHR Pump operating condition fluctuation was caused by the entrainment of air to the pump's suction, which caused a loss of net positive suction head. It is believed that the air was admitted by a vortex phenomenon caused when actual reactor vessel water level dropped below the elevation of the top of the reactor coolant hot legs and 1A RHR Pump flow rate was about 3200 gpm. Simultaneously reactor cavity water level remained above the reactor vessel flange. The 1B RHR Pump, which was being used to lower reactor vessel water level at the time, was operating at a lower flow rate (less than 1000 gpm) and never displayed abnormal operating symptoms during the event. The vortex phenomenon is known to be flow rate dependent and might also have disabled the 1B RHR Pump, if the level decrease had continued or if the 1B RHR Pump had been aligned to provide shutdown core cooling at a 3200 gpm flow rate.

The cause of the excessive lowering of reactor vessel water level was a failure to comprehend, on the part of all personnel involved in the reactor cavity draining evolution, the fluid flow restriction created when the reactor vessel upper internals assembly is seated fully on the hold down spring during cavity draining evolutions. The personnel involved incorrectly assumed that observation of reactor cavity water level was sufficient to ensure adequate reactor vessel water level, because previous operating experience had proven this to be the case. Refer to Figure 1 for the following discussion. When reactor cavity water level is above the top of the upper internals, then cavity water level indicates that the vessel is water filled since cavity level is hydraulically coupled to the vessel via numerous penetrations in the top of the upper

C. CAUSE OF EVENT: (Continued)

internals assembly. However, the design of the upper internals assembly (top hat design) precluded adequate hydraulic coupling of reactor vessel water level and reactor cavity water level, when cavity water level was below the top of the upper internals assembly and the upper internals are fully seated on the hold down spring. In this condition with cavity water level below the top of the upper internals, hydraulic coupling with reactor vessel level occurred via bypass flow holes in the lower internals flange to the vessel downcomer region (cold leg side of core barrel). When the 1B RHR pump was used to lower cavity water level, it actually took suction from a reactor coolant hot leg, which was hydraulically coupled to the upper internals outlet plenum. This acted to lower water level in the reactor vessel beneath the upper internals by direct coolant removal. The cavity water level dropped at a slower rate due to restricted flow through the bypass flow holes in the flange. Therefore cavity water level was held artificially high by the limited capacity of the bypass flow holes, while the actual reactor vessel water level beneath the upper internals assembly lowered according to 1B RHR pump flow rate. As the maintenance personnel in Containment observed cavity water level, the actual, concealed reactor vessel water level dropped to a level where vortexing to the 1A RHR Pump suction occurred.

The flow restriction phenomenon had not been observed previously at Byron and would not be expected to occur during a routine refueling outage. Typical refueling activities involve the flooding of the reactor cavity and removal of the upper internals assembly. Following the fuel shuffle, the upper internals assembly is lowered into the reactor vessel and its weight is supported by the newly installed fuel assembly top nozzle springs. The support offered by the fuel assemblies is sufficient to permit a gap between the hold down spring and the bottom of the upper internals assembly flange. During reactor cavity draining this gap around the circumference of the flange permits reactor vessel water level and the reactor cavity water level to lower in unison. In contrast, during this event the upper internals assembly had not been lifted since the previous refueling in early 1987. During the fuel cycle the fuel assembly top nozzle springs were compressed and had lost some resilience, therefore, the upper internals assembly flange remained fully seated on the hold down spring. When reactor cavity draining was necessitated due to equipment problems, sufficient flow paths did not exist between the reactor cavity and the volume beneath the upper internals assembly. Therefore, the reactor cavity water level remained substantially higher than reactor vessel water level. Support of the upper intervals assembly by the fuel assembly top nozzle springs was confirmed at Byron on October 6, 1988, when the assembly was lowered into the reactor vessel following the fuel shuffle. The post shuffle elevation of the upper internals assembly flange was three-quarters of an inch higher than it was when the assembly was removed from the reactor vessel.

Equipment deficiencies existed that contributed to the operators' reliance upon direct visual observation of cavity water level in lieu of vessel water level indicators. The tygon tube level had responded sluggishly, which is believed to have been caused by the partial kinking of the tube at several locations where the tube negotiated corners. The tube kinks restricted air flow induced by liquid level variations within the tube. The restriction delayed accurate level indication until pressure could be equalized across the tube kinks. Also, a level instrument (1LI-RY046) designed to provide reactor vessel water level indication in the Main Control Room was not in service at the time. This instrument's approximate range covers elevations from the bottom of the hot leg to just above the reactor vessel flange. The instrument was removed from service as a planned part of the outage to permit installation of a modification designed to add another range of indication among other improvements.

D. SAFETY ANALYSIS:

The actual progression of this event did not present danger to plant personnel or the public. At all times radiation levels in the containment remained normal and maintenance personnel radiation exposures were as predicted by Health Physics Technicians. Although shutdown core cooling flow provided by the RHR system was unavailable, within two minutes the NSO established a gravity fill of 80°F borated water from the RWST to the reactor vessel and within fourteen minutes shutdown core cooling flow from RHR was reestablished. The NSO properly preserved the operability of the 1B RHR Pump until the plant condition was stabilized and it was safe to operate the 1B RHR Pump. The 1B RHR Pump could have been, and was briefly, used to provide cooling water from the RWST to the reactor core during this event. While the 1B RHR Pump operated to lower reactor vessel level from 0957 to 1005 and again from 1052 to 1059, the 1B RHR Pump discharge temperature indicated approximately 90°F. While gravity filling the reactor vessel via the B RHR Train from the RWST, pump discharge temperature indicated approximately 80°F. When the 1B RHR Pump was started in a shutdown core cooling alignment at 1114, pump discharge temperature rose to approximately 107°F within one minute and decreased to less than 100°F in the next two minutes. Within ten minutes pump discharge temperature had stabilized at approximately 95°F. It is believed that temperature stratification of the water in the reactor vessel caused this temperature response. The cold RWST water was added at the bottom of the core while the hottest water was located in the upper internals outlet plenum, from which the 1B RHR Pump took a suction. When the temperature transient passed, an average coolant temperature increase of approximately 5°F was indicated by the B RHR Train instrumentation.

The safety significance of this event rests in what could have happened. The low reactor vessel water level could have resulted in air ingestion by the 1B RHR Pump in addition to the actual air ingestion by the 1A RHR Pump. Reactor vessel water level could still have been restored by the gravity fill method from the RWST. The RHR Pumps could have been vented and restored to operable status. This postulated scenario and sequence of required actions would have delayed the restoration of shutdown core cooling.

An analysis was performed by Westinghouse to estimate the lowest reactor vessel water level attained during this event. Based upon studies performed in the "Loss of RHRS Cooling While RCS is Partially Filled Topical Report" (WCAP 11916), an RHR Pump operating at a flow rate of 3200 gpm would cavitate, as indicated by motor amperage fluctuation, when reactor vessel water level lowers to approximately one-inch below the centerline of the reactor coolant hot leg. Therefore, the best estimate of the lowest reactor vessel water level achieved during this event is a level of approximately one-inch below the hot leg centerline.

E. CORRECTIVE ACTIONS:

1. An Operating Department Order was issued on September 19, 1988, to prohibit any cavity/vessel draining operations below the top of the upper internals until this event has been resolved to the satisfaction of Operating Department management.

2. raining sessions have been completed with Operating Department shift personnel describing this event with specific emphasis on the reactor vessel component construction features that contributed to this event.

E. CORRECTIVE ACTIONS: (Continued)

3. Operating procedure revisions have been initiated to provide licensed operators with better control of reactor cavity drain rate and to provide more guidance and cautions. Completion of the procedure revisions is tracked by Action Item Record (AIR) 454-225-88-0203.

4. Tygon tube level indicator deficiencies have been corrected by removing the kinks from the tube.

5. The modification to the vessel level instrument that provides control room indication will be completed as scheduled.

F. PREVIOUS OCCURRENCES:

LER NUMBER	TITLE
NONE	

G. COMPONENT FAILURE DATA:

a) MANUFACTURER	NOMENCLATURE	MODEL NUMBER	MFG PART NUMBER
Not Applicable			

LICENSEE EVENT REPORT (LER) TEXT CONTINUATION

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

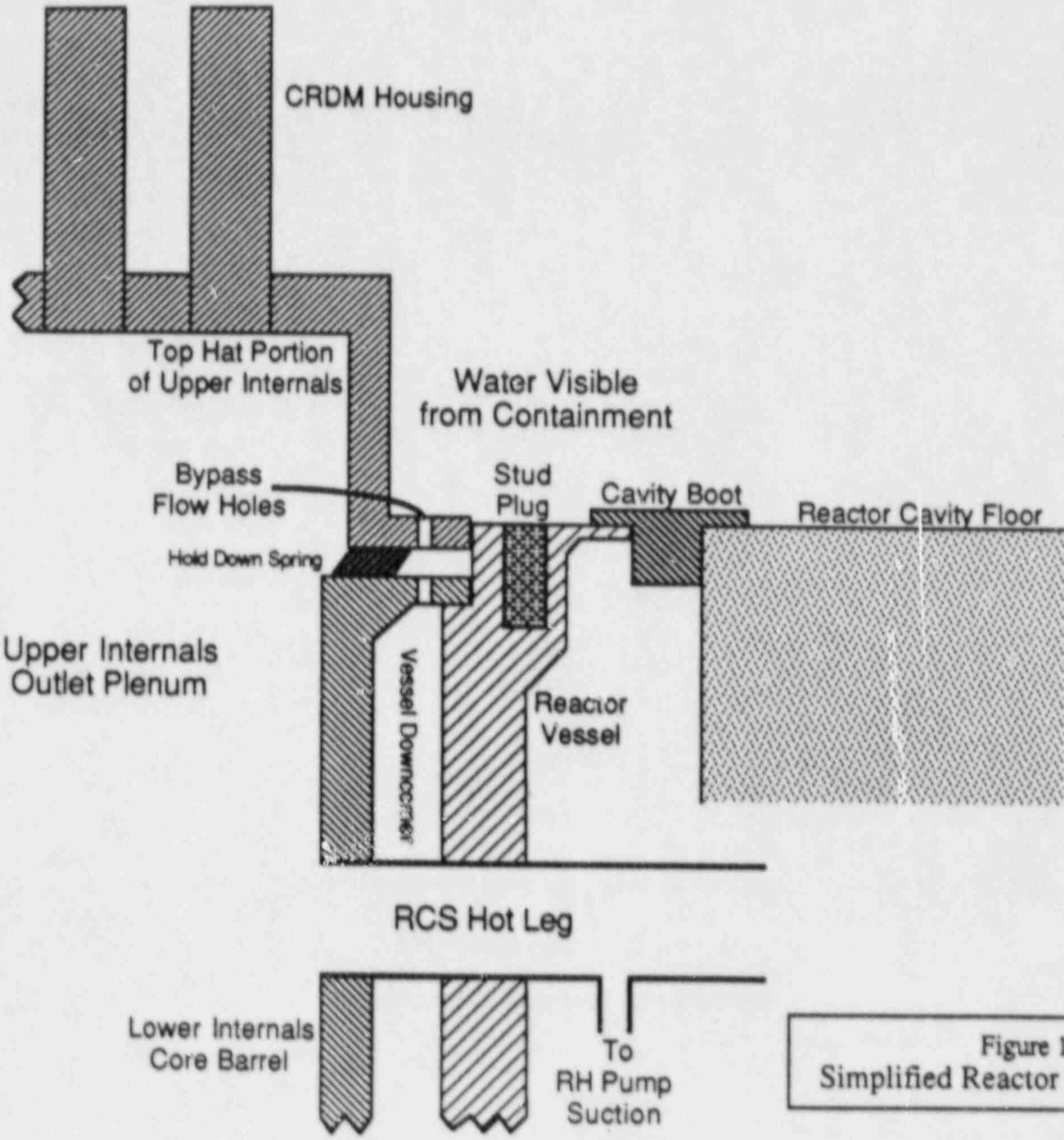

Figure 1
Simplified Reactor Construction

(0118R/0012R)

Commonwealth Edison
Byron Nuclear Station
4450 North German Church Road
Byron, Illinois 61010

October 19, 1988

U. S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555

Dear Sir:

The enclosed Licensee Event Report from Byron Generating Station is being transmitted to you as a voluntary report.

This report is number 88-007; Docket No. 50-454.

Sincerely,

T.P. Joyce
for R. Pleniewicz
Station Manager
Byron Nuclear Power Station

Enclosure: Licensee Event Report No. 88-007-00

cc: A. Bert Davis, NRC Region III Administrator
P. Brochman, NRC Senior Resident Inspector
INPO Record Center
CECo Distribution List

Ltr: BYRON 88-1081 (1921M/0206M)

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