AEOD TECHNICAL REVIEW REPORT*

UNIT: McGuire Nuclear Station, Unit 2
DOCKET NO.: 50-370
LICENSEE: Duke Power Company
NSSS/AE: Westinghouse/Licensee

TR REPORT NO. AEOD/T415
DATE: July 13, 1984
EVALUATOR/CONTACT: W. Lanning

SUBJECT: DESTRUCTION OF CHARGING PUMP

EVENT DATE: January 15, 1984

REFERENCES: Licensee Event Reports 84-04 and 84-02

SUMMARY

An event occurred at McGuire Unit 2 involving the losses of the residual heat removal (RHR) system and the chemical and volume control system. Operator error was the root cause for many of the important aspects of the event, including the destruction of the charging/safety injection pump. The loss of RHR was judged the most significant safety concern resulting from the event. The safety implications of contributing postulated events involving (1) the loss of reactor coolant without makeup, (2) loss of safety injection system, and (3) loss of reactor coolant pump seal flow were not considered to be of safety significance without other extenuating circumstances.

Since AEOD has evaluated previously the potential safety significance associated with the loss of RHR, no additional actions are required by AEOD. This event was suggested to be subject of a future Power Reactors Events article to increase operator awareness to alarms and procedures.

*This document supports ongoing AEOD and NRC activities and does not represent the position or requirements of the responsible NRC program office.

DISCUSSION

During Mode 5 with the reactor coolant temperature about 115°F, the reactor coolant system (RCS) was being filled and vented after an outage of about two weeks. Late night on January 15, 1984, a sequence of events (see table) occurred which resulted in the total losses of residual heat removal (RHR) and RCS letdown and makeup. RHR was restored (isolation valves were reopened) in about 49 minutes, but makeup was lost for about 21 hours. No mention was made in LER 84-04 (Enclosure) of any operator action to isolate letdown after RHR was restored and makeup flow was lost. Thus, the potential existed for removing reactor coolant for a long period of time without makeup. Since neither reference indicated loss of RHR pump suction, the operators obviously isolated letdown sometime during the event or the RHR pumps would have lost suction. Letdown must have been isolated soon after the loss of the charging pump because the RCS loops were not filled at the time of the event, e.g., depleted RCS inventory would have caused the RHR pump to lose suction quickly.

During the event, the suction to the charging pump from the volume control tank (VCT) in the chemical and volume control system (CVCS) was inadvertently isolated. After about 19 minutes of pump operation without flow, the centrifugal pump experienced significant damage (self-destruction). The other two charging pumps were inoperable due to maintenance. At McGuire, the centrifugal charging pumps are also the safety injection pumps. Thus, the safety injection system was also disabled, but it is not required to be operable in Mode 5.

The purpose of this technical report is to evaluate the safety significance of the McGuire event. Based on the review of the LERs, the following events appear to have potential safety significance:

(1) Loss of RHR cooling during shutdown;

(2) RCS inventory lost due to letdown without makeup;

(3) Loss of safety injection system while at power; and

(4) Loss of reactor coolant pump (RCP) seal flow while RCPs operate.

The loss of RHR cooling during shutdown is a potentially significant safety issue that has been evaluated by AEOD in case study report (draft to be issued July 1984) entitled, "Decay Heat Removal Problems at PWRs with Emphasis on Plants of Babcock and Wilcox Design". Thus, the reader is referred to this report for a detailed evaluation for the loss of RHR.

The loss of RCS inventory due to letdown flow without makeup flow during shutdown cooling can lead to the loss of RHR. With a loss of RCS inventory, the suction to the RHR pumps could uncover resulting in RHR pump cavitation and loss of RHR. This sequence leading to the loss of RHR was not identified during the AEOD study of decay heat removal problems based on operating experience, e.g., there were no reported events identifying excessive letdown as a cause for loss of RHR. Thus, the safety significance of this event is that it can cause a loss of RHR. Because of the available alarms to alert the operators to excessive letdown (McGuire operators received at least

18 alarms), this cause would not be expected to be a dominant contributor to the loss of RHR. At McGuire, the operators were negligent in acknowledging the numerous alarms and were responsible for the destruction of the charging pump--the major consequence of the event.

The inadventent closure of the suction valve to the charging pump resulted in the damage to the pump. At McGuire and other PWRs, the charging pump is also a safety injection pump. Assuming the same sequence of events occurred at power, the safety injection system would not be available. The loss of this safety system in combination with a small break loss of coolant accident is a safety concern. However, even more alarms are available to the operators to alert them to the loss of charging flow (discussed below) and to protect the safety injection system. The loss of the safety injection system was evaluated by AEOD (AEOD/E317) and the issue is being addressed as part of generic issue A-17 entitled, "System Interaction in Nuclear Power Plants."

The charging pump provides RCP cooling when the RCPs are operating. In this event, the RCPs were not operational. Without RCP seal cooling, there is the potential for seal degradation and a small break loss of coolant event when the RCPs are operating. Thus, the loss of the charging pumps could initiate an event that would require the same pumps (in the safety injection mode) to mitigate the event. In addition to the VCT alarms indicating excessive letdown, there are alarms indicating insufficient RCP seal flow to alert the operators to take corrective action. Although it is probable that the operators could fail to recognize the numerous alarms as evidence by the McGuire event, the operators are more likely to be responsive to alarms involving the RCPs. Thus, without gross operator error, the sequences leading to failed RCP seals and loss of safety injection do not appear likely. In addition there does not appear to be numerous events involving the loss of the charging pumps due to operators failing to recognize and acknowledge repeated alarms related to the charging/makeup system.

The loss of suction due to the closed suction valve is similar to a sequence involving the failure of the VCT instrumentation causing all letdown flow to be diverted to a holdup tank. Eventually, the inventory in the VCT will be depleted which can lead to the damage of the charging pump without operator action. Operator actions and automatic actions were judged to be adequate to protect the core for this sequence. If the sequence of events at McGuire had occurred at power, the normal letdown to the CVCS would automatically isolate on low pressurizer level. The operators could then trip the charging pumps before damage to the pumps would be expected.

CONCLUSIONS

The destruction of the charging/safety injection pump at McGuire resulted from the failure of the operators to verify an operable flow path and subsequently, the lack of operator attention and timely actions to alarms indicating abnormal conditions in the CVCS. The loss of the pump is judged not to be a significant safety concern without other extenuating circumstances. The most significant safety concern was the loss of RHR which occurred in conjunction with, but not as a result of the loss of the charging pump.

AEOD has evaluated previously the safety aspects of loss of RHR in a separate study. Thus, no additional AEOD or other NRC office actions are necessary with regard to this issue. IE has issued a Notice of Violation concerning the lack of personnel action during the event.

The McGuire event provides evidence that operators can fail to protect safety equipment, even with numerous alarms available. Credit for operator actions was a primary consideration by the NRC staff in concluding that a failure of the VCT instrumentation did not represent a safety concern. In view of the McGuire event, it may be prudent for NRR to focus more emphasis on system interactions related to potential loss of the safety injection system. AEOD should review the progress of the generic issue and determine if the issue is properly addressing the loss of the safety injection systems due to a failure in the CVCS.

Because of the gross operator errors and lack of attention to alarms by operators, this event should be included in Power Reactor Events to increase operator awareness. The economic penalty for the operator errors in this event was estimated to be about $60,000.

TABLE

SEQUENCE OF EVENTS

January 8, 1984

CVCS pump B removed for maintenance.

January 15, 1984

Filling and venting operation, RCS loops not filled, RCS temperature about 115°F.

2207 Loss of RHR - Isolation valve closed inadvertently.
Operators stopped RHR pump 2A and CVCS pump 2A.

Loss of letdown from RCS via RHR to CVCS.
Alternate letdown path established via normal letdown path.

2236 Loss of makeup - Valve (2NV-141A) from VCT to makeup pump inadvertently closed.

2255 RHR isolation valves opened.
RHR pump 2A restarted.
RCS temperature increased about 20°F due to loss of RHR.
Procedures call for re-establishing letdown from RHR to CVCS.

2258 CVCS pump 2A started.
Operators failed to verify flowpath.

2301 Low CVCS pump discharge pressure alarm.

2302-2314 18 high VCT pressure and/or high VCT level alarms.

2315 Fire warning alarms for zone 83 (CVCS pump area)
CVCS pump discharge flow zero.

2317 Operators stop CVCS pump 2A.
CVCS pump self-destructed.

2326 Suction valve to CVCS pump from VCT discovered closed.

January 16, 1984

2045 CVCS pump 2B restored to operable status.

January 20, 1984

CVCS pump 2A returned to service.

NRC Form 366
(9-83)

U.S. NUCLEAR REGULATORY COMMISSION
APPROVED OMB NO. 3150-0104
EXPIRES: 8/31/85

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
McGuire Nuclear Station, Unit 2	0 5 0 0 0 3 7 0	1 OF 0 3

TITLE (4)
Chemical and volume control pump 2A damaged after running with the suction isolated

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 1	1 5	8 4	8 4	— 0 0 4	— 0 0	0 2	2 9	8 4		0 5 0 0 0
										0 5 0 0 0

OPERATING MODE (9)	5
POWER LEVEL (10)	0 0 0

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

20.402(b)	20.405(a)	50.73(a)(2)(iv)	73.71(b)
20.405(a)(1)(i)	50.36(a)(1)	X 50.73(a)(2)(v)	73.71(c)
20.405(a)(1)(ii)	50.36(a)(2)	50.73(a)(2)(vii)	OTHER (Specify in Abstract below and in Text, NRC Form 366A)
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
Phillip B. Nardoci, Licensing Engineer	AREA CODE 7 0 4 — 3 7 3 - 7 4 3 2

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
A	C B	P	P 0 2 5	Y					

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)

Chemical and Volume Control (NV) Pump 2A was declared inoperable at 2317 on January 15 after the pump was started and run for approximately 19 minutes without suction. The Volume Control Tank Outlet Isolation Valve inadvertently closed prior to starting the pump, causing destruction of the pump. During this time, NV Pump 2B was inoperable for maintenance. With both NV pumps inoperable, the limiting conditions of Technical Specifications 3.1.2.1 and 3.1.2.3 were not met. However, the Action Statements were met since no operation involving core alterations or positive reactivity changes were conducted. Unit 2 was in Mode 5 at the time of this incident.

This event is attributed to Personnel Error due to the operators' failure to verify a suction path prior to operating NV Pump 2A. Also, error is noted for their subsequent failure to identify the loss of suction to the pump during operation despite control board indications and numerous indirect Operator Aid Computer (OAC) Alarms.

NV Pump 2A was repaired. Appropriate personnel will be counseled with emphasis placed on verification of flow paths prior to starting any pump, and giving OAC alarms proper attention.

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McGuire Nuclear Station, Unit 2	0 5 0 0 0 3 7 0	8 4	— 0 0 4	— 0 0	0 2 OF 0 3

TEXT (If more space is required, use additional NRC Form 366A's) (17)

Chemical and Volume Control (NV) [EIIS:CB] Pump 2B [EIIS:P] was removed from service for maintenance on January 8. On January 15 at 2207, valves [EIIS:V] 2ND-1B and 2ND-2A, Reactor Coolant Loop 3 discharge valves to the residual heat removal system (ND) [EISS:BP] isolation, closed inadvertently after their supply breakers were energized with the effect that decay heat removal from the core was lost (REF. LER 370/84-02). ND Pump 2A and NV Pump 2A were stopped immediately. Since letdown through valve 2NV-121A, Residual Heat Removal Letdown to NV, had been lost from ND, an alternate letdown flow path was established (by opening 5 NV valves). During these valve manipulations valve 2NV-141A, volume control tank outlet isolation valve, inadvertently closed (at 2236). Although the valve position indication is provided on the main control board and valve closure is monitored by an audible alarm and light, the valve closure went unnoticed by the Contorl Operators. They did not recall receiving or acknowledging this alarm, but it was verified to be operable after the incident. It should be noted that during this time there were numerous other activities requiring the Control Operators' attention.

Valves 2ND-1B and 2ND-2A were opened manually. ND Pump 2A was started at 2255 and NV Pump 2A was started at 2258. Since NV Pump 2A had been stopped only 50 minutes previously the Control Operator did not suspect any problems with the suction path. After the pump was started at 2258, pump discharge pressure and discharge header flow indication appeared normal. At 2301 the NV Pump 2A discharge pressure went low appearing as an information point (non-alarm) on the Operator Aid Computer (OAC) alarm typer. Between 2302 and 2314, several High Volume Control Tank (VCT) Level computer alarms appeared along with High VCT Pressure computer points. Due to numerous other alarms appearing on the OAC during this time, these high VCT level and pressure alarms were not immediately acted upon.

At 2315 Fire Warning for Zone 83, NV Pump Room 2A, was received in the Control Room due to smoke caused by the pump overheating. The Control Operator then noticed the NV Pump 2A charging flow was indicating zero and immediately stopped the pump at 2317. At 2326, 2NV-141A was discovered closed and was subsequently reopened.

During this time, NV Pump 2B was inoperable for maintenance. With both NV pumps inoperable, the limiting conditions of Technical Specifications 3.1.2.1 and 3.1.2.3 were not met. However, the Action Statements were met since no operation involving core alterations or positive reactivity changes were conducted. Unit 2 was in Mode 5 at the time of this incident.

This event is attributed to Personnel Error due to the operators' failure to verify a suction path prior to operating NV Pump 2A in accordance with good operating practice. Also, error is noted for their subsequent failure to identify the loss of suction to the pump during operation despite control board indications and numerous indirect Operator Aid Computer Alarms.

Troubleshooting of the control circuit for valve 2NV-141A found it functioning properly. Investigation determined that the only means to close valve 2NV-141A was the close pushbutton on the control board. The possibility of inadvertant closure of 2NV-141A by this pushbutton is unlikely, but it is possible. The close pushbutton for 2NV-141A is located approximately 7" below the switches for the 5 NV valves which were manipulated to establish the alternate letdown flow path.

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		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
McGuire Nuclear Station, Unit 2	0 5 0 0 0 3 7 0	8 4	— 0 0 4	— 0 0	0 3 OF 0 3

TEXT (If more space is required, use additional NRC Form 366A's) (17)

NV Pump 2A had been started and run for approximately 19 minutes without suction, causing destruction of the pump. NV pump 2B was declared operable January 16 (at 2045) after completion of maintenance work. NV Pump 2A was disassembled, a new rotating assembly (pacific dresser) installed, and returned to service on January 20, 1984. Digital points on OAC for NV Pump 2A and 2B Low Discharge Pressure were changed from information points (non-alarm) to alarm points.

This report will be covered with all Operations personnel in crew meetings. Emphasis will be placed on verification of flow paths prior to starting any pump. Emphasis will also be placed on giving OAC alarms proper attention.

With the reactor coolant system [EIIS:AB] below 200°F, one operable Boron Injection System is acceptable without single failure consideration. This is based on the stable reactivity condition of the reactor and the additional restrictions prohibiting core alterations and positive reactivity changes in the event the single Boron Injection System becomes inoperable.

From January 15 at 2317 until January 16 at 2045, both CCPs were inoperable. During this time, no operations involving core alterations or positive reactivity changes were made. Therefore, the health and safety of the public were unaffected.