GPU NUCLEAR

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January 20, 1997

6710-97-2028

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

Dear Sir:

Subject: Three Mile Island Nuclear Station, Unit 1 (TMI-1)
Operating License No. DPR-50
Docket No. 50-289
LER 96-002-00

The purpose of this letter is to transmit TMI-1 Licensee Event Report (LER) No. 96-002-00 regarding discovery of a condition outside the design basis with respect to accident procedures where a potential air entrainment of the ECCS pumps might have occurred during initiation of reactor building sump recirculation cooling following a loss of coolant accident. The root cause was a failure to recognize the effect of a lower reactor building pressure on ECCS flow rate. The abstract provides a brief description of the event.

The event did not adversely affect the health and safety of the public.

Sincerely,

J. Knubel

J. Knubel
Vice President and Director, TMI

MRK
Attachment

cc: Administrator, Region I
TMI Senior Resident Inspector
TMI Senior NRC Project Manager

IE22

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 MANAGEMENT AND BUDGET, WASHINGTON, DC 20503

LICENSEE EVENT REPORT (LER)

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

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TITLE (4)

POTENTIAL LOSS OF ECCS PUMP SUCTION IN THE ACCIDENT ANALYSIS DUE TO FAILURE TO RECOGNIZE THE EFFECT OF LOWER REACTOR BUILDING PRESSURE

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
12	21	96	96	-- 002 --	00	01	20	97	FACILITY NAME	DOCKET NUMBER

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

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)
M. R. KNIGHT, TMI REGULATORY AFFAIRS ENGINEER	(717) 948-9554

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)

YES (If yes, complete EXPECTED SUBMISSION DATE)	X	NO	EXPECTED SUBMISSION	MONTH	DAY	YEAR

ABSTRACT (Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines) (16)

At 0405 hours on December 21, 1996 while TMI-1 was operating at 100% power, it was discovered that an error in a 1992 calculation had resulted in a non-conservative setpoint used by operators in Abnormal Transient Procedures during Loss Of Coolant Accidents to initiate swapover of Emergency Core Cooling System (ECCS) Pump suction from the Borated Water Storage Tank to suction from the Reactor Building (RB) sump. It was discovered that use of this setpoint may result in air entrainment in the ECCS Pumps. This event is reportable in accordance with 10CFR50.73(a)(2)(ii)(B) as a condition in which the plant was found to be outside of its design basis. The root cause was personnel error. The calculation in 1992 failed to recognize that maximum cooling assumptions and an associated lower RB pressure should have been used in the evaluation of the transition from BWST to RB Sump suction. Procedures were changed and operators were trained to initiate swapover at a different setpoint to ensure that air entrainment will not occur at the ECCS pumps during postulated accident conditions. There were no immediate safety consequences associated with this event.

POTENTIAL LOSS OF ECCS PUMP SUCTION IN THE ACCIDENT ANALYSIS DUE TO FAILURE TO RECOGNIZE THE EFFECT OF LOWER REACTOR BUILDING PRESSURE

I. Background

Following a postulated Reactor Coolant System rupture, flow is initiated in the High Pressure Injection (HPI), Low Pressure Injection (LPI), and Core Flooding (CF) Systems from the Borated Water Storage Tank (BWST) and Core Flood Tanks (CFTs) to the Reactor Vessel (RV). Flow is also initiated by the Reactor Building (RB) Spray System to the RB spray headers from the BWST. Before the BWST inventory is completely exhausted, the suction valves from the RB sump (DH-V6A/B) must be opened and the suction valves from the BWST (DH-V5A/B) must be closed by the operator to provide suction from the RB Sump for both LPI and RB Spray Pumps.

Operator action to start suction from the RB sump is delayed to maximize the usable borated water inventory for core cooling and ECCS Pump Net Positive Suction Head (NPSH) while ensuring adequate BWST level is maintained to avoid air entrainment.

As part of the initial startup and test program, a BWST drawdown test was conducted. The test was begun with DHR Pumps [BP/P]* and RB Spray Pumps [BE/P] operating at design flow conditions of 9000 gpm. At five minutes from test termination, flow was estimated as 5005 gpm. The BWST [BP/T] was drawn down to a level of 3.58 ft. from the bottom of the tank. Test personnel stationed by the pumps observed no indications of vortexing or cavitation, nor did flow instrumentation reveal any of these effects. A BWST level of 40 in. was selected as the minimum level that should be maintained to avoid any concern with air entrainment. This level corresponds to the top of the outlet pipe.

II. Related History:

The BWST level to initiate RB sump recirculation had been established at 6 ft. 4 in. to provide conservative margin to potential air entrainment while transferring sufficient BWST inventory to the RB to meet the ECCS Pump NPSH requirements. A detailed review of ECCS pump performance, potential air entrainment, recirculation NPSH requirements, RB sump pH, RB pressure and temperature, offsite dose considerations, boron concentration effect on reactivity controls, and changes to operating procedures was completed. It was determined that the switchover would meet the requirements for the RB conditions and ECCS flow rates associated with the FSAR Loss of Coolant Accident (LOCA) analysis.

Recently, GPUN completed a series of RB pressure and temperature calculations as part of a GPU Nuclear self assessment on the ECCS function of the DHR system. The purpose of these calculations was to maximize ECCS and containment heat

removal effectiveness. Increased effectiveness results in lower core clad temperature, and lower RB pressures and temperatures. These have traditionally been seen as more favorable post accident conditions and therefore have not been considered limiting accident scenarios. These calculations were being done to evaluate NPSH margin when on RB sump recirculation.

III. Plant Operating Conditions before Event:

On December 21, 1996, TMI-1 was operating at 100% power with T_{ave} at 579 °F and Reactor Coolant System (RCS) Pressure at 2155 psig.

IV. Status of Structures, Components, or Systems that were Inoperable at the Start of the Event and Contributed to the Event:

None.

V. Event Description:

On December 20, 1996, the Plant Review Group (PRG) met to evaluate three potentially non-conservative assumptions that had been identified during an NRC Engineering Design Inspection which was ongoing. The assumptions had been used in a 1992 calculation which reevaluated the adequacy of the nominal low-low level setpoint for initiation of switchover from the BWST to the RB sump. The three concerns were:

1. The calculation used a nominal low-low level alarm setpoint of 6 ft. 4 in. (6.33 ft.) to establish when the alarm would enunciate. The calculation did not consider instrument error. When considering the instrument drift and calibration error, the BWST low-low level alarm may be received when the tank level is as low as 4.86 ft.

2. The calculation used a total operator response time of 71 seconds based on a LBLOCA scenario simulator training exercise conducted on August 3, 1992. Unknown to the originator of the calculation, the plant computer point for BWST level used for the estimate had a scan time of 60 seconds which resulted in the operator response time being underestimated by approximately 25 seconds.

3. The third concern involved the RB pressure during the switchover to RB recirculation. The calculation had used an RB pressure which was calculated assuming minimum Emergency Safeguards (ES) equipment available. The recent (December 1996) calculations were performed by GPU Nuclear to establish the worst case combination of RB pressure and sump liquid temperature for use in NPSH calculations for the DHR and RB Spray Pumps.

These calculations maximized cooling which provided the minimum RB pressure conditions. Lower RB pressures are more limiting with regard to the air entrainment analysis because lower RB pressure results in a more rapid drawdown of the BWST.

Although it was recognized that these calculations included some simplifying assumptions that would result in lower calculated pressures than those which might actually occur, the deviation from the RB pressure value used in the existing drawdown analysis needed to be evaluated.

The PRG initially assembled to evaluate the potential effect of these concerns on ECCS air entrainment on the morning of December 20, 1996. The PRG reviewed the above information and noted the following:

1. The failure to consider instrument error would not be significant assuming that actual practice in calibrating instrumentation is to leave the instrument very close to the middle of the allowable tolerance band. The PRG requested Maintenance to perform a calibration check on the instrument and report the current "as-found" condition to the PRG.

2. Concerning the operator response time assumptions, although the original calculation had not accounted for the scan time error in the data analysis, more recent training experience at the simulator indicates that operator response time for beginning the switchover sequence was less than the value used in the calculation. It was therefore concluded that the original assumption of 24 sec. is reasonable and conservative.

3. The RB pressure calculations which were recently performed in order to maximize cooling and therefore minimize pressure assumed an initial pressure of -1 psig (13.7 psia) a river water temperature of 40 °F and a BWST temperature of 40 °F. The minimum RB pressure was calculated to be 13.4 psia using the assumptions adopted for the maximum cooling calculations. For current actual conditions, an assumed river water temperature of 35 °F and a BWST temperature of 60 °F would be conservative at this point in time. It was expected that further review would identify other conservatisms and would result in a higher final RB pressure.

4. The lower fluid velocity at the end point of the switchover evolution would be expected to provide "self-venting" of the suction piping which would minimize the potential for air entrainment.

5. No credit had been taken for the time that it would take for entrained gas to travel from the BWST to the BWST isolation valves [BP/ISV]. This was discussed as additional conservative margin in the evaluation.

These factors were considered in GPU Nuclear's determination of current operability while calculations were initiated to provide the additional information needed to accurately assess the combined effect on the BWST drawdown analysis.

Based on the above, GPU Nuclear initiated a computer calculation which uses a BWST drawdown model with the assumptions as stated above. It was expected that this would show results to support a conclusion that the ECCS systems were operable under the actual conditions at that time. With this expectation, it was agreed that, in the interim, the systems were considered operable, and action was initiated to promptly complete more detailed evaluations of the conservatism included in the model. It was expected that a proper set of conservative assumptions would support a conclusion of operability for future conditions, also.

The PRG reconvened the afternoon of December 20, 1996 when this requested information became available. At the beginning of this portion of the meeting, revised calculations had been received from Engineering for the expected RB pressure at the time of post-LBLOCA recirculation. The result showed an RB pressure of about 14.7 psia at the time of switchover from the BWST to the sump. Engineering was asked to provide an additional BWST drawdown computer run for the BWST switchover based on this final RB pressure of 14.7 psia, rather than 13.4 psia.

While the above BWST drawdown calculation was in progress, information was received regarding the results of the instrument calibration check. The check showed that the "as-found" setpoint was presently 6 ft. 3 in., which was only 1 in. below the nominal setpoint of 6 ft. 4 in.

The drawdown calculation using the more typical, yet conservative input values for BWST temperature, initial RB pressure and river water temperature was completed and faxed to the PRG at about 1730 on December 20, 1996. The calculation used the worst case instrument error assumptions (alarm received at 4.86 ft.) for receipt of the low-low level alarm (4.86 ft.), maintained the conservative stroke times for the valves and used the operator response times of the original calculation. This calculation showed some reduction in the drawdown rate with decreasing flow rates as the BWST level dropped resulting in a final calculated BWST level of approximately 2.3 ft. This BWST level was less than the desired minimum of 40 in. Reviewing the overall results, it was estimated that analysis using the additional 1.4 ft. of inventory associated with the 6.25 ft. as-found alarm value would likely result in a final level above 40 in., if all other factors remained the same.

While this calculation was being set up and run, the PRG considered possible procedural enhancements which could provide additional margin to the time available for the operator to switch over to the RB sump. These included:

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

1. When the 9.5 ft. BWST low level alarm point is reached, instructing the operators to switch High Pressure Injection (HPI) suction from the BWST to the discharge of the DHR pumps (piggy-back mode), rather than at the 6.33 ft. low-low alarm point. This would reduce the BWST drawdown rate.

2. Providing an early notification to operators at the 9.5 ft. low level BWST alarm point to prepare to open suction valves (DH-V6A and DH-V6B) from the RB sump as soon as the low-low level alarm is received, in order to minimize the operator response time.

3. Emphasize the existing procedure instructions for turning off the RB Spray pumps if RB pressure decreases below 4 psig. This would reduce flow from the BWST, allowing more time for the switchover transition.

These instructions would provide additional margin, regardless of the outcome of the current operability concern. Therefore, the PRG decided to initiate Temporary Change Notices (TCNs) to Abnormal Transient Procedures (ATPs) 1210-7, "Large Break LOCA Cooldown," and 1210-10, "Abnormal Transients Rules, Guides and Graphs," and Alarm Response Procedure E-2-4, "BWST LEVEL LO," to implement these changes. These TCNs were approved and put in place in the Control Room at about 2100 hours on December 20, 1996.

During this time, computer runs were being attempted, but problems were occurring which prevented completion. Changes were made to decrease the time steps in the calculation, which then allowed the computer runs to proceed, although increasing the elapsed time for each set of calculations.

The drawdown calculation using a 6.25 ft. alarm level was completed at approximately 2230 hours on December 20, 1996. This calculation indicated a higher final BWST level, but still below the 40 in. The question was raised as to why the calculation indicated an increase in drawdown rate at essentially the same BWST level below the top of the nozzle compared to previous calculations. Engineering explained that the RELAP5 model uses a perfect mixing assumption for air and water in a node and that the model should not be used below a certain level in the BWST. The calculation now indicated the minimum level criteria used for air entrainment was reached about 40 sec. before switchover was complete.

Hand calculations adjusting the level for conservative assumptions in the selection of valve stroke time, RB Spray flow rates, and the transit time from the BWST nozzle to the BWST isolation valves concluded that the actual switchover could be completed before reaching 40 in. BWST level. However, calculations using the more sophisticated computer code were needed to confirm some of the simplifying assumptions.

Computer runs were initiated which incorporated the operator action as specified in procedure ATP 1210-10 to secure RB Spray when RB pressure is less than 4 psig. This would result in reducing the flow from the BWST to RB spray by (2 x 1500) gpm, or 3000 gpm. Although a calculation of RB pressure versus time was not readily available, this assumption was judged valid. Either the pressure would be above 4 psig, which would significantly reduce the direct flow to the RB sump (RB pressure being calculated low is the basis for the increased drawdown rate that raised the concern), or operator action to secure the RB spray would be triggered by dropping below 4 psig.

The drawdown calculation with the results from securing RB spray at 4 psig (actual code assumption was reduction to 400 gpm RB spray flow due to concerns with using 0 gpm as an input) was completed and faxed to the PRG at about 2345 hours on December 20, 1996. This calculation provided additional BWST level, but still resulted in final BWST levels below 40 in. Many questions were explored as to the validity of this code run, but the eventual conclusion was that the decrease in RB spray flow was being offset by an increase in direct flow to the sump. The PRG discussed the calculation assumptions and actual plant data in detail. The sensitivity of the computer code to the input parameters was also discussed, as well as some deviations between the code and hand calculation estimates. Following these discussions, it was decided that another run should be made using actual valve stroke times, reduced operator response times, as-found low-low alarm setpoint, 2 psig RB pressure, essentially no RB spray flow following 4 psig, and transitioning HPI pumps [BQ/P] to piggy-back mode at the BWST low level alarm point. The 2 psig assumption was estimated due to the reduced cooling and condensing by securing RB spray flow at 4 psig.

During these computer runs, the PRG recognized that the significance of opening the sump recirculation valves with a low RB pressure is to decrease the elapsed time for BWST level to draw down since flow from the BWST would also go directly to the RB sump through the DH recirculation valves. Therefore it was decided to explore a new approach rather than the approach taken in the previously approved TCN's. The new approach would be to instruct the operators to begin opening the RB sump recirculation valves (DH-6A/B) on receipt of the low level BWST alarm at 9.5 ft., and then close the BWST isolation valves (DH-V5A/B) on receipt of the low-low level alarm at 6.33 ft.

This approach would provide significant additional time for the DH-V6A/B valves to open before the contents of the BWST are completely transferred to the sump. Since DH-V5A/B close in about 15 sec., flow from the BWST would be secured very shortly after the low-low level alarm, assuring that vortexing and air entrainment would not occur.

The drawdown calculation with the input changes that included the 2 psig RB pressure was completed and faxed to the PRG at about 0330 hours on December 21, 1996. These results did show that the switchover to the RB sump would be complete about 5 sec. after reaching the 40 in. minimum level criterion. Flow rates at the 40 in. level were calculated to be about 5,300 gpm, with subsequent reduction below the 3,000 gpm self-venting flow rate three sec. later. Including the earlier estimate of at least 10 sec. transit time from the BWST to the DH-V5A/B isolation valves, there would be no air entrainment reaching the ECCS pumps for the assumptions used in this last run. The PRG considered this information and the various assumptions and confirmatory calculations that would be necessary to support the conclusion of operability from this computer run. It was determined that little, if any, margin would exist, and that any nonconservative deviations might invalidate a conclusion of operability. It was also recognized that some of the changes proposed during the PRG meeting were better overall approaches to the BWST switchover. These factors combined with the potential length of time needed to conduct the analyses and evaluations for follow-up led the PRG to conclude that an appropriate course of action was to declare the ECCS pumps inoperable.

Accordingly, the PRG concluded that the ECCS systems were inoperable and that Technical Specification 3.0.1 should be entered, which allows one hour to initiate a plant shutdown to place the plant in a condition in which the Limiting Conditions for Operation (LCO's) no longer apply.

The PRG also concluded that this condition is reportable in accordance with 10 CFR 50.72 (b)(1)(ii) within one hour, as a condition in which the plant is outside its design basis; and a Licensee Event Report (LER) is required in accordance with 10 CFR 50.73 (a)(2)(ii)(B).

These conclusions were reached at 0405 hours on December 21, 1996. Following this meeting, the NRC was notified via the ENS telephone line at 0445 hours.

Concurrent with these actions, TCNs were initiated to change TMI procedures to instruct the operators to open DH-V6A/B at the 9.5 ft. level and to close the DH-V5A/B valves at the 6.33 ft. level. These revised instructions provide ample margin to assure completion of switchover before the BWST level reaches 40 in. The TCNs were approved and placed in the Control Room at 0501 hours on December 21, 1996. The Technical Specifications shutdown time clock was also terminated at 0501 hours since the revised instructions provided in the TCNs restored operability to the ECCS.

VI. Component Data

The affected components were the Decay Heat Removal, Makeup and Purification, and Reactor Building Spray pumps.

VII. Identification of Root Cause

The root cause was personnel error. When performing the calculation in 1992, it was not recognized that the lower RB pressure associated with the best case conditions for Large Break LOCA assumptions should be used in the BWST drawdown evaluation.

A contributing factor is the regulatory and industry focus placed on restricting the availability of mitigating action or equipment for the evaluation of most accident analyses. Using minimal mitigation equipment typically results in conditions that are more conservative when evaluating dose consequences, core clad temperature and Reactor Building environmental effects. However, this emphasis may lead to the incorrect assumption that taking credit for redundant or diverse mitigation actions will always provide more acceptable results.

VIII. Automatic or Manually Initiated Safety System Response:

No safety system responses occurred or were required to occur.

IX. Assessment of the Safety Consequences and Implications of the Event:

It is a significant nuclear safety concern that the ECCS Pumps have an adequate supply of water through all design basis accident scenarios. This assessment was significant because it involved a problem with the common suction source for the ECCS Pumps.

There were no immediate safety consequences associated with this event in that the circumstances did not occur which may have resulted in air entrainment at the ECCS Pump suction. Conservative actions were taken to provide additional margin to prevent air entrainment at the suction of the ECCS Pumps during the BWST to RB Sump switchover process.

X. Previous Events of a Similar Nature:

There have been no previous LERs at TMI-1 related to the failure to consider the effects of reduced RB pressure on air entrainment from the BWST.

XI. Corrective Actions:

A. Immediate Correction Action:

Temporary procedure changes were implemented to instruct the operators to open the RB sump recirculation valves (DH-V6A/B) at the 9.5 ft. level and to close the BWST isolation valves (DH-V5A/B) at the 6.33 ft. level.

Management briefed the on-shift crew using written material to ensure that control room personnel were aware of the air entrainment concern and the specific procedural changes being implemented to address the concern.

A BWST drawdown analysis has been completed which models the revised operator action specified in the procedure changes which demonstrate the completion of switchover to Reactor Building Sump recirculation leaving an approximately 1.5 ft margin of BWST level above the 40 in. minimum BWST level where air entrainment is assumed to occur.

B. Additional Actions Taken:

Subsequent oncoming shifts were briefed by plant management using the written material as an adjunct part of shift turnover. The procedural changes were also reviewed as required by the shift turnover process.

A real time checkout of the revised procedural steps was conducted at the TMI-1 simulator which verified that the operator actions can be performed well within the time frame required, and are consistent with the other activities being conducted in response to the accident sequences.

Changes were made to highlight the overhead annunciator alarm panel [IB/PL] for the BWST 9.5 ft. low level alarm as previously provided at the BWST 6.33 ft. low-low level alarm panel.

C. Actions Planned to Prevent Recurrence:

1. Permanent procedure changes will be implemented that incorporate the Temporary Change Notices issued as part of the Immediate Corrective Action.

2. More formal documentation of the BWST drawdown calculation will be completed using the Large Break LOCA minimum RB pressure and the revised operator actions. This will include formal documentation of the RB pressure effect to ensure that future evaluations will recognize the need to

consider the associated changes in drawdown flowrate.

3. Revision to the Licensed Operator and Shift Technical Advisor (STA) training programs will be made and incorporated in future operator training and simulator exercises.

4. Changes which have been initiated to revise the demarcation of the Control Room BWST level indicator to make the low level and low-low level more easily discernible by the Operators will be completed.

XII. Conclusions:

Based on the above, GPU Nuclear concludes that the revised procedural guidance for the transition from BWST to RB Sump suction provides adequate margin to ensure that air entrainment will not occur at the ECCS pumps during design basis accident conditions.

* The Energy Industry Identification System (EIIS), System Identification (SI) and Component Function Identification (CFI) Codes are included in brackets, "[SI/CFI]." where applicable, as required by 10 CFR 50.73 (b)(2)(ii)(F).