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U-603798
December 21, 2006

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555-001

Clinton Power Station, Unit 1
Facility Operating License No. NPF-62
NRC Docket No. 50-461

Subject: Submittal of Additional Documentation Presented at December 19, 2006 Regulatory Conference

References: (1) Letter from C. Pederson (NRC) to C. M. Crane (Exelon Generation Company, LLC), "NRC Inspection Report 05000461/2006011(DRS): Preliminary Greater Than Green Finding for Clinton Power Station," dated November 29, 2006

(2) Letter from P. Simpson (AmerGen Energy Company, LLC) to USNRC, "Submittal of Supporting Documentation for December 19, 2006 Regulatory Conference," dated December 12, 2006

In Reference (1), the Nuclear Regulatory Commission issued an inspection report with respect to the Reactor Core Isolation Cooling (RCIC) water storage tank at the AmerGen Energy Company, LLC (AmerGen) Clinton Power Station (CPS), Unit 1. This report concluded that the minimum water level to preclude vortex formation and subsequent air entrainment into the High Pressure Core Spray (HPCS) system pump suction line would not support that HPCS would be capable of performing its safety function. Using the Significance Determination Process (SDP), the NRC has preliminarily determined that this finding is "Greater than Green," based on a determination that the HPCS pump would fail due to significant air entrainment in the HPCS suction line when the water level in the RCIC water storage tank decreased prior to the transfer from the RCIC water storage tank to the suppression pool.

As a result, a Regulatory Conference between the NRC and AmerGen was held on December 19, 2006. During the Regulatory Conference, AmerGen presented information to support the NRC's efforts to reach a final determination of the above described finding's safety significance. The NRC summarized, at the conclusion of the Regulatory Conference, the additional information it would need as part of it's deliberations. The Attachments to this

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letter provide the requested information. Attachments 1 and 2 are the documents AmerGen anticipated submitting as described in Reference 2.

Attachment 1 provides a copy of Engineering Change (EC) Evaluation 363977, Revision 0. This EC includes the scale model test report and the results of an independent third party review, as well as, an overall summary of the issue and conclusions.

Attachment 2 provides a copy of EC Evaluation 363975, Revision 0. This EC contains the computer modeling and evaluation performed using the results of the scale model testing.

AmerGen has confirmed that valve 1E22-F002, "HPCS Suction Check Valve from RCIC Storage Tank," is included within the scope of the Inservice Testing Program. The closing function of the valve is confirmed by verifying proper operation of the HPCS system waterleg pump. The waterleg pump uses suppression pool water to keep the HPCS system filled and pressurized while in a standby condition. If valve 1E22-F002 was not seated while the HPCS system was in standby, suppression pool water would flow to the RCIC water storage tank resulting in an increasing tank water level. This has not been observed which provides confidence that 1E22-F002 would close when required and as described in Attachment 2.

During the Regulatory Conference, the results from recent scale model testing conducted at the Alden Research Laboratory were described. This testing was performed to further characterize the potential for vortexing and air entrainment in the HPCS suction piping. The scale model testing supports that vortex formation would not occur. However, air entrainment did occur due to localized draw down of the water level in the vicinity of the suction nozzle as the water level in the tank approached the top of the suction nozzle. Based upon the results of the testing and the subsequent evaluation, we have concluded that the HPCS pump performance would not have been adversely affected (i.e., no significant air entrainment will reach the HPCS pump suction) and that the HPCS system would have been able to perform its safety function.

Attachment 3 provides a document entitled, "SA-1578, Revision 3, 'Significance Determination Process (SDP) Evaluation for CPS HPCS RCIC Storage Tank Suction Vortexing.'" This version supersedes that previously provided in Reference 2. Revision 3 incorporates changes made to update the human reliability analysis in response to NRC comments made at the December 19, 2006 Regulatory Conference.

If you have any questions concerning this letter, please contact me at (217) 937-2800.

Respectfully,

Patrick R. Simpson

Patrick R. Simpson
Regulatory Assurance Manager
AmerGen Energy Company, LLC

Attachments: (1) Engineering Change Evaluation 363977 Revision 0

(2) Engineering Change Evaluation 363975 Revision 0

(3) SA-1578, Revision 3, "Significance Determination Process (SDP) Evaluation for CPS HPCS RCIC Storage Tank Suction Vortexing"

cc: Regional Administrator, USNRC, Region III
NRC Resident Inspector, Clinton Power Station
A. M. Stone, USNRC, Region III

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ATTACHMENT 1

Engineering Change Evaluation 363977 Revision 0

Reason For Evaluation
This EC evaluates the analysis demonstrating High Pressure Core Spray (HPCS) functionality during the suction transfer from the (Reactor Core Isolation Cooling (RCIC) tank to the suppression pool. It accepts the corporate performed EC 363975 as applicable to Clinton. It accepts the Alden Lab test report and resolves the MPR comments. It contains a summary of the issue and time line.

History of Issue
High Pressure Core Spray is a safety related, seismic I, emergency core cooling system. It functions to supply water to the reactor vessel over the full range of reactor pressure. It has two suction paths. The system is normally lined up to the RCIC tank. When the tank reaches a low level the suction valves automatically re-align the suction from the tank to the suppression pool.

In December of 2005 an NRC inspection found that the CPS calculation for the vortexing allowance in the HPCS suction from the RCIC tank was inadequate. The analysis inappropriately extrapolated to determine a void entrainment into the suction piping. A RELAP calculation was performed in December 2005 following the inspection (IP-M-0384 rev 1B) to demonstrate that that the HPCS system would have functioned as designed. This analysis was not intended as a design basis analysis, but as an evaluation of past capability of the system. The December 2005 RELAP analysis also extrapolated published industry data. The calculation was also not accepted by the NRC because the basis for the air void input lacked hard data for Clinton's flow condition and geometry. It has been asserted that excess air would be drawn into the suction piping and the air would prevent the HPCS system from performing its design function. Ideally, no air should be allowed to reach the HPCS pump.

The HPCS suction was subsequently modified in August 2006 by adding a downturned elbow in EC 359252. Calculation IP-M-0761 evaluates the modified suction for correct vortex margin. During the time between the identification of the issue and the modification correcting it, the HPCS suction was maintained aligned to the suppression pool.

Alden Laboratory Test Report
The test report is included as an attachment to this EC, Reference 1. The intent of the test was to determine Clinton specific data on the RCIC tank outlet behavior as the tank level approaches the outlet pipe. A scale model was built as described in the test report. The model was prepared based on design documents transmitted to Alden. CPS personnel and an independent third party, MPR Associates, reviewed this scaling. CPS, MPR, and Nuclear Reactor Regulation (NRR) personnel witnessed the testing. No surface air vortex was observed. As the tank level approached the outlet, a localized surface depression formed and when the depression reached the level of the outlet pipe the air entrainment suddenly began. A direct measurement of the entrained air could not be performed due to the quantity. A value of 24% air was used in the RELAP analysis as justified there. The test was run at 3 different flow rates as described in the test. A scaled value of 5500 gpm is representative of pump runout. A scaled value of 3000 gpm is more

representative of flows at a higher reactor pressure seen following a scram. A third flow value of 4250 gpm was also run to show that the data was consistent. Statistical analysis and uncertainty were performed in the RELAP analysis.
The MPR review letter is an attachment to this EC, Reference 2.

MPR letter, DRN 0065-0036-01, had 4 recommendations, which have been resolved either by the change incorporated into the Alden report or into the RELAP analysis.

1. Confirm the geometry of the other nozzles and obstructions in the tank do not affect the results. Alden added a further explanation in section 3.0.
2. Perform a statistical analysis of the data to determine the uncertainty. This was performed with the RELAP analysis.
3. Don't use the middle flow data point without additional runs to provide assurance of the validity of the results. This point was not used in the RELAP analysis.
4. Correct typos. Corrected in the Alden report.

Corporate EC 363975

The onset of entrained air begins before the tank level reaches the point where the suction valve from the suppression pool begins to open in the 5500 gpm case. Therefore, it was necessary to calculate the movement of the air entrainment through the pipe concurrent with the subsequent instrumentation signal to open the suction valve from the suppression pool and the hydraulic transient of the suction valve opening. Reference 3, EC 363975, performed this analysis with RELAP5. The intent of that analysis is to determine how much air reaches the HPCS pump suction. The high flow case of 5500 gpm pump flow was evaluated. This flow rate is bounding over the lower rates tested of 3000 gpm and 4250 gpm. The air entrainment on the 3000 gpm tests began after the tank low level setpoint allowable value was reached.

EC 363975 was reviewed against the CPS configuration. The RELAP5 analysis is realistic analysis with some conservatism. It concluded that approximately 1% air reaches the pump suction.

The evaluation used a 1E22F015 stroke time of 21 seconds. The 21 second time is appropriate as it bounds all the valve stroke surveillance test times.

Air entrainment input was from the test results with uncertainties applied. The quantity of air used was 24%. This is justified in the RELAP EC, reference 3, based on the flow regime seen, the tank level draw down rate and the similarity with a video of 24% known air injection.

The low tank level suction transfer was initiated at the setpoint allowable value. This is conservative being below the nominal trip setpoint.

The CPS NPSH calculation was reviewed for the potential affects of the air in the suction piping. There is abundant margin. Calculation 01HP08 determines a NPSH equal to 39.5 ft at a suction water elevation of 724'. The RELAP analysis determines the final drawdown elevation is 723.5'. The required NPSH is 5 ft. Therefore, there is 34 ft of margin. This pump was designed to handle high temperature water from the suppression pool. The abundant margin is created because of the relatively cool tank water at atmospheric pressure.

Summary of the sequence of events.
The model testing showed that the air entrainment for 5500 gpm began at an average of 4.5 inches above the top of the tank exit pipe internal diameter. With the uncertainty applied this was 6 inches above the top of the tank exit pipe internal diameter. This will be assigned time zero for this discussion (t=128.879 sec in RELAP5). The tank level continues to decrease, but at slower rate than before because some of the flow that is exiting is now air. At about 14 sec (6.0" – 3.8" = 2.2 sec at 6.299 seconds per inch yields 13.858 sec) the tank level reaches the nominal trip setpoint for the low tank level signal, but the RELAP model does not begin the 1E22F015 opening stroke until the tank level reaches the trip allowable value at approximately 17 seconds (t=145.7 sec in RELAP5). At 15 seconds into the event (t=143.6 sec in RELAP5), the initial air entrainment has traveled down the pipe from the RCIC tank to the Tee where it joins the larger pipe from the suppression pool. When the 1E22F015 valve begins to open, flow begins from the suppression pool to the pump suction. This flow increases as the valve opens more. The flow from the RCIC tank begins to slow down because a larger fraction of the pump flow is coming from the suppression pool. When the flow in the pipe from the RCIC tank slows the air begins to rise and collect along the top of the pipe rather than being completely entrained. At about 18 to 24 seconds (t=147 to 153 sec in RELAP5), the largest air void fraction reaches the Tee that joins the pipe from the suppression pool. At 24 seconds the suppression pool valve 1E22F015 is about 35% open. Some air is swept in to the bulk flow traveling to the pump, but it is diluted with the suppression pool suction path flow. The maximum air void fraction reaching the suction of the pump is 1.06% at about 24.4 seconds (t= 153.3 sec in RELAP5). At about 33 seconds (t=162.3 sec in RELAP5) the flow from the RCIC tank pipe is stopped. The water level in this line is below the level of the suppression pool and the water tries to back fill the pipe to the RCIC tank. This is prevented by the check valve 1E22F002. Any back leakage through the check valve is small compared the capacity of the 20" line carrying 5500 gpm to the pump. At 38 seconds (t=166.7 sec in RELAP5), the 1E22F015 valve is full open. This would start the isolation valve 1E22F001 closing. The 1E22F001 is not modeled because the flow would be back toward the RCIC tank and is blocked by the check valve.

It should be noted that the bulk velocity of 9.67 ft/sec and pipe length of 285 ft would predict that the air entrainment would arrive at the Tee about 29 sec after the air enter the suction line. RELAP determined this transient time at 15 sec implying that the air travels much faster than the bulk flow. The 1E22F015 opens at this time and immediately and quickly reverses the air void transient. This is shown on Figure 7 of

Reference 3 that the air void transient turns around when 1E22F015 is only a few seconds open.

Time line in seconds

- 0 Tank level @ 6", air entrainment starts
- 14 Nominal trip setting reached
- 15 RELAP calculates the air begins to reach the Tee to the 20" line
- 17 Allowable value trip setting reached, 1E22F015 starts to open
- 18 to 24 largest air void fraction reaches the Tee joining the flow
- 24.4 RELAP calculates the max air void to the HPCS pump at 1.06%
- 33 Flow from the RCIC tank has stopped
- 38 1E22F015 is full open,

Conclusions:
The results are acceptable to show that the HPCS would have functioned. The low air (<2%) entrainment at the pump would not adversely impact the pump performance. The analysis is not intended to be a design calculation. It was not intended to show operability as it uses measured plant inputs for voiding, suction transfer setpoints, and 1E22F015 valve stroke times, etc. An operability calculation uses bounding analysis limits.

References /Attachments:
Reference 1 /Attachment A is the Alden test report.
Reference 2/ Attachment B is the third party reviewer (MPR) comments on the test report. DRN 0065-0036-01
Reference 3 is the RELAP evaluation, cross referenced in passport EC 363975.
Reference 4: Calculation IP-M-0384, rev 1B

Reference 5: Calculation 01HP08
Reference 6: Clinton Nuclear Power Station UFSAR, Rev. 11
Reference 7 SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION SUPPORTING AMENDMENT NO. 73 TO FACILITY OPERATING LICENSE NO. NPF-62, ILLINOIS POWER COMPANY, ET AL, CLINTON POWER STATION, UNIT 1, DOCKET NO. 50-461, April 9, 1993.
Reference 8."OPL-4 and 5 Approval," Clinton Letter ELPU-0226 to Erik Stromqvist (GE) from Dale A. Spencer (CPS), dated January 22, 2001.
Reference 9. GE-NE-A22-00110-27-02, Revision 1, "Project Task Report, Clinton Power station Extended Power Uprate Task T0407: ECCS-LOCA SAFER/GESTR," September 2001.

CNS Vortex Final Report.pdf

ITPR HPCS Vortex 0065-0036-01.pdf

DAR Review
Design Attribute Review

"Engineering Technical Evaluations" procedure CC-AA-101, Rev. 6, step 4.2.5 requires a Design Attribute Review (DAR) per CC-AA-102, Rev. 13. The CC-AA-102, Attachment 1 DAR was included in the passport panel as required. To summarize the results, since this EC is a backward looking EC Evaluation of past functionality, and is not a configuration change in the past, or future, the DAR shows no impacts.

Regulatory Assurance performed an impact assessment because of the nature of the evaluation. No impacts were identified.

The following was used to answer "not applicable" to DAR item 4.1.31: DETERMINE impact on nuclear fuel, core components, core design, reactivity management, criticality control and accountability of nuclear materials as well as transient and / or accident analysis. A 2% volumetric air void would briefly reduce the HPCS flow rate to the reactor core at the time of switchover. Air intrusion into the HPCS suction line up to 2% for a period of 20 seconds will not degrade the HPCS function. Running at 5500 GPM pulling suction from 125,000 Gallons (Ref. 7) in the RCIC tank would require 22.7 minutes, well past the short term 10 minute LOCA PCT period. HPCS is required for long term cooling at a flow rate of 4900 GPM to the nozzles per Ref. 6 UFSAR Table 6.3-2.D. The runout flow rate of 5500 GPM would lose a maximum of 2% or 110 GPM due to air voiding for 20 seconds. HPCS leakage is bounded by 110 GPM at 4900 GPM defined in Ref. 8 and 9. Adjusted for the increased flow rate: (5500/4900)*110 GPM = 123.5 GPM. The remaining 5390 GPM, minus 123.5 GPM leakage results in 5266.5 GPM will exceed the minimum required 4900 GPM to the HPCS spray nozzles to assure long term cooling if Low Pressure Core Spray is not available. Even with the brief 2% volumetric rate air intrusion for 20 seconds, there is no impact on HPCS system functions credited in the design basis LOCA analysis. There is no impact on the DAR for Item 4.1.31.