WOLF CREEK
NUCLEAR OPERATING CORPORATION

October 20, 2015

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Vice President Engineering

ET 15-0025

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

References:
1) NRC Generic Letter 96-06, "Assurance of Equipment Operability and Containment Integrity During Design-Basis Accident Conditions," dated September 30, 1996

2) Letter dated July 9, 2001, from J. Donohew, USNRC, to O. L. Maynard, WCNOC, "Closeout of Responses to Generic Letter 96-06 Concerning Waterhammer and Two-Phase Flow for Wolf Creek Generating Station (TAC No. M96887)"

3) Letter dated July 5, 2012, from D. A. Powers, USNRC, to M. W. Sunseri, WCNOC, "Wolf Creek Generating Station – NRC Problem Identification and Resolution Inspection Report 05000482/2012007 and Notice of Violation"

4) Letter dated May 8, 2014, from A. C. Heflin, WCNOC, to USNRC, "Change to an Essential Service Water System Water Hammer Mitigation Commitment"

Subject: Docket No. 50-482: Supplemental Information Related to Generic Letter 96-06

Gentlemen:

Reference 1 was issued identifying Nuclear Regulatory Commission (NRC) concerns with equipment reliability and containment integrity during design basis accident conditions. Reference 1 requested that all addressees submit information relative to these issues and required that all addressees submit written responses to the NRC relative to actions taken to address these issues. Reference 2 contained the NRC's safety evaluation of Wolf Creek Nuclear Operating Corporation's (WCNOC) responses to Reference 1 and concluded that WCNOC provided the required evaluations and has adequately addressed the issues raised in Reference 1 regarding the potential for condensate induced water hammer and two-phase flow.

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Subsequently, in Reference 3 the NRC issued Notice of Violation (NOV) EA-12-135 for the failure to perform an adequate evaluation after a water hammer event on August 19, 2009, to determine the cause of previous water hammer events and of internal corrosion in the Essential Service Water (ESW) system, and did not take corrective action to preclude repetition of additional water hammer events. In Reference 4, WCNOC committed to mitigate the adverse effects of column closure water hammer in the ESW system to within acceptable design parameters.

In the spring of 2015, during Refueling Outage 20, modifications were completed on the ESW system and containment air coolers at Wolf Creek Generating Station (WCGS). This letter voluntarily provides the results of completed analysis addressing condensate induced water hammer and two-phase flow in support of these modifications that serve to supplement the information previously provided to the NRC relative to Reference 1.

This letter contains no commitments. If you have any questions concerning this matter, please contact me at (620) 364-4156, or Cynthia R. Hafenstine (620) 364-4204.

Sincerely,

Jaime H. McCoy

JHM/rlt

Attachment

cc: M. L. Dapas (NRC), w/a
C. F. Lyon (NRC), w/a
N. H. Taylor (NRC), w/a
Senior Resident Inspector (NRC), w/a

**Supplemental Information Related to Generic Letter 96-06 Addressing Condensate Induced Water Hammer and Two-Phase Flow**

## BACKGROUND

On September 30, 1996, the Nuclear Regulatory Commission (NRC) issued Generic Letter (GL) 96-06, "Assurance of Equipment Operability and Containment Integrity During Design-basis Accident Conditions," (Reference 1). GL 96-06 requested that all addressees submit information relative to these issues and required that all addressees submit written responses to the NRC relative to actions taken to address these issues. The NRC issued its safety evaluation of Wolf Creek Nuclear Operating Corporation's (WCNOC) responses to GL 96-06 on July 9, 2001 (Reference 2) and concluded that WCNOC provided the required evaluations and has adequately addressed the issues raised in GL 96-06 regarding the potential for condensate induced water hammer (CIWH) and two-phase flow.

Subsequently, on July 5, 2012 the NRC issued Notice of Violation (NOV) EA-12-135 (Reference 3) for the failure to perform an adequate evaluation after a water hammer event on August 19, 2009, to determine the cause of previous water hammer events and of internal corrosion in the Essential Service Water (ESW) system, and did not take corrective action to preclude repetition of additional water hammer events. In a letter dated May 8, 2014, WCNOC committed to mitigate the adverse effects of column closure water hammer (CCWH) in the ESW system to within acceptable design parameters (Reference 4).

In the spring of 2015, during Refueling Outage 20 (RF20), modifications were completed on the ESW system at Wolf Creek Generating Station (WCGS). The modifications consist of adding a loop seal with vacuum breakers to the ESW system discharge and check valves installed on the service water supply to the containment air coolers. These modifications greatly reduce susceptibility to CCWH in the ESW system. In addition, the cooling coil design of one of the four containment air coolers has been modified such that the original coil material of 90-10 copper-nickel alloy has been replaced with stainless steel (AL6-XN) to significantly reduce tube degradation. The other three containment air coolers are planned to be similarly modified during subsequent refueling outages. To help ensure tube integrity until their replacements with stainless steel are complete, the cooling coils of these three containment air coolers were replaced with the same copper-nickel alloy during RF20 to reset their susceptibility to tube degradation. The result of these modifications changes the boundary conditions of the containment air coolers such that the coolers may be vulnerable to CIWH or two-phase flow conditions as outlined in GL 96-06.

This attachment provides the results of the completed analysis in support of these modifications that serve to supplement information provided to the NRC related to the issues identified in GL 96-06.

## GL 96-06

The following issues were identified in GL 96-06:

1. CIWH in the containment air cooler cooling water system following Loss of Coolant Accidents (LOCAs) and Main Steam Line Breaks (MSLB).

2. Two phase flow in the containment air cooler cooling water system during LOCAs and MSLBs.

3. Potential overpressurization of isolated water filled sections of piping, with emphasis on the containment penetrations.

This letter addresses Issues 1 and 2 identified in GL 96-06. The ESW and containment air cooler modifications had no effect on previous responses to GL 96-06 by WCNOC related to potential overpressurization of isolated water filled sections of piping.

## ANALYSIS

To address the results of the modifications with respect to GL 96-06, a new analysis was performed using the new parameters for the containment air coolers. The analysis performed is documented in calculation EF-M-078, "Evaluation of Wolf Creek Essential Service Water System (ESW) Modifications during LOOP/LOCA Conditions" (Reference 5). This calculation evaluates the behavior of the modified ESW system under a Loss of Offsite Power (LOOP) condition concurrent with a LOCA. This condition was evaluated previously which addressed the effects of LOOP/LOCA as part of the response to GL 96-06. The implemented modifications dramatically alter the boundary conditions affecting LOOP/LOCA, eliminating free drain down of the ESW system and forcing the cooler coils to generate steam against the backpressure provided by the modifications. Calculation EF-M-078 quantifies that the behavior, along with the void closure response on start of the ESW pumps, is consistent with the methodology accepted for resolution of GL 96-06 issues. This methodology is detailed in Electric Power Research Institute (EPRI) Technical Report "Generic Letter 96-06 Waterhammer Issues Resolution" (Reference 6).

The analytical approach applied consists of the following:

1) A detailed RELAP5 thermal hydraulic model of the containment air coolers and the discharge piping was developed to assess the extent of steam void generation in the cooler coils and growth of steam voiding in the discharge piping. The coil condensing heat transfer is examined in detail to determine the effects of the fins on the condensation coefficients determined in the containment analysis. The containment temperature boundary condition is applied and then the heat transfer and void generation problems are evaluated. The key output of this step is to provide the extent of voiding and void pressure expected for each containment air cooler configuration.

2) Evaluate the void creation predicted in Step 1) and evaluate the potential for CIWH during the void generation process. This evaluation applies the screening criteria provided in NUREG/CR-6519, "Screening Reactor Steam/Water Piping Systems for Water Hammer," September 1997 (Reference 7) to assess potential for CIWH in the discharge piping. The principal criteria of interest here are the lengths of voided horizontal runs and the fluid boundary conditions adjacent to the voided sections.

3) Evaluate the void closure transients using the approved EPRI methodology detailed in Reference 6. This methodology provides an assessment of the rate of void closure along with an approach to generate resulting piping loads, and accounts for the effects of dissolved air released in the steam voids and the effects of void pressure.

A thermal hydraulic evaluation has been performed using the approved EPRI methodology as described in Reference 6. The column closure pressure response has been computed for each containment air cooler drain piping geometry, ensuring that applicable limits of the Rigid Body Model method were observed. The following conclusions are determined by the analysis:

1) The modifications have a positive impact on the drain down behavior. There is no column separation created due to draining.
2) Void generation occurs in the containment air coolers, but is opposed by the static head supplied by the loop seal. This results in significantly smaller voids than previous evaluations. The voids have to pressurize to grow, which is in direct contrast to the rapid draining and reducing pressure behaviors considered previously.

3) The column closure pressures limiting case was a cushioned water hammer pressure rise of 126 psi for the 'B' containment air cooler drain piping. The 'B' containment air cooler drain piping is limiting since its run length prevented the pressure clipping observed in the other three containment air cooler drain piping.

4) CIWH has been evaluated consistent with the guidance of Reference 6 and any CIWH event is expected to be bounded by the column closure events evaluated.

5) Future replacement of containment air cooler coils with stainless steel (AL6-XN) tubes has been evaluated and shown to be bounded by the evaluations performed in this calculation.

## CONCLUSION

During RF20, WCNOC completed modifications on the ESW system to deal with CCWH. These modifications changed the hydraulic performance of the system, such that other aspects of the issues raised in GL 96-06 needed to be considered. WCNOC performed an analysis on the system with the modifications to determine the hydraulic performance during events which could lead to the situations described in GL 96-06. Based on this analysis, the issues identified in GL 96-06 have been adequately addressed.

## REFERENCES

1. NRC Generic Letter 96-06, "Assurance of Equipment Operability and Containment Integrity During Design-Basis Accident Conditions," September 30, 1996.

2. Letter dated July 9, 2001, from J. Donohew, USNRC, to O. L. Maynard, WCNOC, "Closeout of Responses to Generic Letter 96-06 Concerning Waterhammer and Two-Phase Flow for Wolf Creek Generating Station (TAC No. M96887)"

3. Letter dated July 5, 2012, from D. A. Powers, USNRC, to M. W. Sunseri, WCNOC, "Wolf Creek Generating Station – NRC Problem Identification and Resolution Inspection Report 05000482/2012007 and Notice of Violation"

4. Letter dated May 8, 2014, from A. C. Heflin, WCNOC, to USNRC, "Change to an Essential Service Water System Water Hammer Mitigation Commitment"

5. WCNOC Calculation EF-M-078, Revision 0, "Evaluation of Wolf Creek Essential Service Water System (ESW) Modifications during LOOP/LOCA Conditions," April 2015.

6. EPRI Technical Report "Generic Letter 96-06 Waterhammer Issues Resolution," User's Manual Proprietary, Final Report, April 2002.

7. NUREG/CR-6519, "Screening Reactor Steam/Water Piping Systems for Water Hammer," September 1997.