August 22, 2006

Mr. Jeffery Archie
Vice President, Nuclear Operations
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Virgil C. Summer Nuclear Station
Post Office Box 88
Jenkinsville, South Carolina 29065

SUBJECT: VIRGIL C. SUMMER NUCLEAR STATION — REVIEW OF RESPONSE TO GENERIC LETTER 96-06 CONCERNING WATERHAMMER AND TWO-PHASE FLOW (TAC NO. M96872)

Dear Mr. Archie:

The Nuclear Regulatory Commission (NRC) Generic Letter (GL) 96-06 (Reference 1) included a request for licensees to evaluate cooling water systems that serve containment air coolers to ensure that they are not vulnerable to waterhammer and two-phase flow conditions.

Subsequent to the issuance of GL 96-06, the Electric Power Research Institute (EPRI) developed an analytical methodology for evaluating the GL 96-06 waterhammer issue that was documented in EPRI Technical Report numbers 1003098 (Reference 2) and 1006456 (Reference 3).

The above reports were previously known as EPRI Report TR-113594, and were approved by the NRC staff in an evaluation dated April 3, 2002 (Reference 4). Section 3.3 of the NRC staff's safety evaluation requested that licensees who chose to use the EPRI methodology provide additional information to confirm that the EPRI methodology was properly applied, and that plant-specific risk considerations were consistent with the EPRI risk perspective; to justify any proposed exceptions to the EPRI methodology, and to provide any additional information that is required to address the GL 96-06 two-phase flow issue.

GL 96-06 referred licensees to the methodology discussed in NUREG/CR-5220, "Diagnosis of Condensate-Induced Waterhammer," for evaluating the effects of potential waterhammer events, and the EPRI methodology provided a somewhat less conservative approach that the NRC staff found to be acceptable for this limited-use application.

The South Carolina Electric and Gas Company (SCE&G, the licensee), provided it's response for the Virgil C. Summer Nuclear Station (VCSNS), addressing the waterhammer and two-phase flow aspects of GL 96-06 in letters dated October 30, 1996, January 28, 1997, October 30, 1998, May 6, 1999, and May 11, 2000.

The information that was submitted by the licensee was reviewed by Information Systems Laboratories, Inc. (ISL), under contract to the NRC. ISL's Letter Report No. 240-10, providing the results of ISL's review, was communicated to the licensee by NRC's letter dated March 28, 2001 (Reference 5).

As documented in their report, ISL reached the following conclusions concerning the licensee's response to GL 96-06:

(a) While the licensee's analysis of the column closure waterhammer pulse appeared to be conservative and consistent with the methodology presented in NUREG/CR-5220, the effect of the waterhammer pulse on piping and support structures was not evaluated.

(b) The licensee's conclusion that condensation induced waterhammer will not occur in horizontal pipes during fluid drain down because the Froude Number is near or above unity, it is not supported by experimental data.

(c) Based on the brevity of the two-phase flow condition and the absence of flow control valves or components in the affected piping, the licensee appropriately concluded that two-phase flow is not a concern.

Based on a review of the evaluation that was completed by ISL, the NRC staff was satisfied with the licensee's resolution of the two-phase flow element of GL 96-06, but considered the licensee's resolution of the waterhammer aspect to be incomplete for the reasons cited above in items (a) and (b).

The licensee's letter dated January 20, 2004, provided a status update on its efforts to address the GL 96-06 waterhammer issue; and the licensee's letter dated August 4, 2004, provided its response to the two open items that were referred to by the NRC staff in its March 28, 2001, letter. With respect to the first item, the licensee determined that two pipe supports related to reactor building cooling unit (RBCU) Train B appeared to be marginal, but operable, in accordance with the guidance provided in GL 91-18 (Reference 6). The licensee indicated that the two marginal pipe supports would be reinforced during refueling outage 15. With respect to the second item, the licensee indicated that based upon the EPRI methodology referred to above and approved by the NRC staff, the column-closure waterhammer bounds the condensation-induced waterhammer when certain criteria have been met. The licensee reasoned that since the VCSNS situation satisfied the EPRI criteria in this regard, the impact of the worst-case column-closure waterhammer is considered bounding and further analyses of condensation-induced waterhammer scenarios should not be necessary.

Based on a review of the information that was provided in the licensee's August 4, 2004, response, the NRC staff determined that additional information was required primarily to address the use of RELAP5 for evaluating waterhammer loads: 1) to identify any valves that are relied upon for preventing system drain-down and void formation; 2) to describe the measures that exist and ensure that excessive valve seat leakage will not occur over time; and 3) to discuss the methodology by which piping and support loads were determined, including a description of load combinations that were applied. The licensee's response was submitted on December 12, 2005.

After reviewing the information that has been submitted to date, the NRC staff has determined that the licensee's evaluation of the GL 96-06 waterhammer issue is acceptable. In particular, the NRC staff agrees that the column-closure waterhammer is bounding for VCSNS consistent

with the criteria that was established by the EPRI methodology and referred to earlier; and the licensee has confirmed that the GL 96-06 risk perspective for VCSNS is consistent with the risk assessment that was completed as part of the justification for allowing use of the EPRI methodology.

While the NRC staff has not specifically reviewed and approved the licensee's application of RELAP5 for evaluating the impact of waterhammer events, the licensee indicated in its letter dated January 20, 2004, that the GL 96-06 RELAP5 analyses are more conservative than the EPRI methodology for single column-collapse scenarios. Additionally, numerous column-closure waterhammer tests simulating worst-case conditions for the VCSNS have been performed by the licensee (in conjunction with engineered safety feature surveillance testing) that support the conclusion that the licensee's use of RELAP5 for this particular application is conservative. Because the licensee plans to implement plant modifications that will (among other things) limit the extent of waterhammer to a single column-collapse scenario, the NRC staff considers the licensee's evaluation to be acceptable for this specific application.

In order to resolve the GL 96-06 waterhammer vulnerabilities that were identified at the VCSNS, the licensee's December 12, 2005, response indicated that the following plant modifications would be implemented during the fall of 2006:

(i) The RBCU service water system outlet gate valves will be replaced by fast closing butterfly valves. This will prevent the formation of the more significant void, leaving only one void to contend with.

(ii) Vacuum relief valves will be added downstream of the RBCU outlet valves, which will fill the remaining void with air and provide a cushion for column-closure waterhammer events that are expected to occur.

(iii) The opening logic of the RBCU outlet valves will be modified to have a 5-second delayed opening after starting the service water system booster pumps (SWBPs). This delayed valve opening will prevent the formation of additional voids on the upstream side of these valves when re-energizing the SWBPs.

The licensee also determined that two pipe supports related to RBCU Train B were considered to be marginal, but operable, for postulated waterhammer conditions, and indicated in its letter dated August 4, 2004, that the supports would be reinforced during refueling outage 15. Pending implementation of the planned modifications, the licensee identified specific administrative controls that would be established to minimize the potential frequency and impact of GL 96-06 waterhammer events such that containment integrity and safety system functions will not be impaired. The NRC staff considers the proposed interim actions and plant modifications to be acceptable for establishing design features that are appropriate for addressing the GL 96-06 waterhammer issue, though additional information is required to address single failure considerations as discussed in Question 2 of the attached request for additional information (RAI).

While the NRC staff agrees that the licensee has adequately evaluated the GL 96-06 waterhammer issue for the VCSNS, and that the interim measures that have been implemented

and plant modifications that are planned for the fall of 2006 are adequate for resolving the waterhammer concerns for the most part, additional explanation is required with respect to boundary valve leakage, single failure, technical specification requirements, and regulatory commitments that are being made. Therefore, in order for the NRC staff to complete its review, an acceptable response to the enclosed RAI is required.

Sincerely,

/RA/

Robert E. Martin, Senior Project Manager
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-395

Enclosure: 1. Request for Additional Information
2. List of References

cc: See next page

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REQUEST FOR ADDITIONAL INFORMATION

GENERIC LETTER 96-06, ASSURANCE OF EQUIPMENT OPERABILITY AND

CONTAINMENT INTEGRITY DURING DESIGN-BASIS ACCIDENT CONDITIONS

VIRGIL C. SUMMER NUCLEAR STATION

1. The licensee's December 12, 2005, response (pages 5 - 7 of the Attachment) discusses boundary valve leakage considerations. The worst-case scenario for the GL 96-06 waterhammer event is discussed on pages 15 and 16 of the Attachment. The licensee's analyses of the GL 96-06 waterhammer event scenarios are valid for the specific conditions that have been assumed. If excessive boundary valve leakage occurs, a void could form on the upstream side of the RBCUs that has not been evaluated by the licensee. The licensee's response dismisses this as an incredible occurrence due to the large volume of water that would have to drain from the RBCUs before a void could actually form. However, some containment fan coolers are designed such that the cooling water supply piping enters at the top in order to keep the water from gravity draining should a cooling water leak occur. The licensee has not established that the RBCUs at Summer will in fact gravity drain.

   Aside from the RBCU design consideration, back leakage through the SWBP discharge check valves could void the RBCU supply piping upstream of the RBCU supply check valves, resulting in a water column separation of about 63 feet in height (due to a loss of offsite power while cooling is being provided by the SWBPs). Also, because the industrial cooling (IC) cooling system is non-safety related, its integrity cannot be relied upon for loss-of-coolant accident (LOCA) mitigation and the IC system supply side check valves must be relied upon to prevent excessive back leakage and void formation. However, this is less of a concern than leakage through the SWBP discharge check valves because the IC system is a relatively clean, closed loop system.

   On the discharge side of the RBCUs, the RBCU outlet isolation valves must also be relied upon to prevent excessive seat leakage in order to prevent voiding in the piping between the RBCUs and the RBCU discharge isolation valves. Again, the integrity of the IC system cannot be relied upon for LOCA mitigation.

   Given these considerations, it is the NRC staff's view that the RBCU boundary isolation valves must be credited for maintaining the water column in the upstream and (to some extent) in the downstream RBCU piping. This view is also consistent with the analysis that was performed by Sargent and Lundy and submitted by SCG&E in a letter dated May 11, 2000. Therefore, in order for the licensee's GL 96-06 waterhammer evaluation to remain valid over time, assurance must be established that the RBCU boundary valves will not leak excessively as the plant ages. This can be accomplished by explicitly crediting the technical specification (TS) surveillance testing that is referred to

on page 17 of the Attachment, and by revising the TS Bases accordingly. Alternatively, other programs for confirming that excessive RBCU boundary valve leakage does not exist can be credited, such as by performing periodic valve seat leakage testing. Please discuss measures that will be taken to confirm that excessive RBCU boundary valve seat leakage does not exist over time, and confirm that the Final Safety Analysis Report and the inservice testing program for Summer will be revised to properly reflect the importance of the closing function of the RBCU boundary valves for preventing water column separation and voiding in the RBCU cooling water supply and outlet piping.

2. As discussed in the December 12, 2005, response (page 2 of the Attachment), the RBCU cooling water outlet isolation valves are relied upon for preventing the formation of the second void that forms between the RBCUs and their cooling water outlet isolation valves during certain waterhammer event scenarios. Explain how postulated single failures associated with the RBCU cooling water outlet isolation valves were resolved in order to assure elimination of this second void.

3. The December 12, 2005, response (page 16 of the Attachment) indicates that modifications will be made to: (i) add vacuum breakers to vent the RBCU cooling water piping downstream of the RBCU cooling water outlet isolation valves, (ii) replace the RBCU cooling water outlet isolation gate valves with fast closing butterfly valves, and (iii) delay the opening of the RBCU cooling water outlet isolation valves for five seconds after the SWBP is started. While page 11 of the Attachment to the December 12 response indicates that existing TS requirements are adequate, more detailed information is required to explain: (i) what specific TS requirements apply to these new features, (ii) how existing TS Surveillance Requirements will assure that these features function in accordance with the acceptance criteria that have been established for demonstrating operability, (iii) how the existing TS allowed outage times will be applied, and (iv) where in the TS Bases operability considerations that pertain to these features are discussed.

4. The December 12, 2005, response (page 12 of the Attachment) establishes a regulatory commitment to complete the planned modifications during Refuel 16. Because the Summer plant will continue to operate for some months before the planned modifications are fully implemented, a more extensive regulatory commitment is required to include implementation of the interim actions (licensee's first and second phases) that are referred to in the December 12 response on page 15 of the Attachment. Clarification that the regulatory commitment applies to all of the modifications that are referred to in the December 12 response on page 16 of the Attachment is also required. Finally, please confirm that the necessary reinforcements have been made to the two marginal pipe supports associated with RBCU Train B (referred to in the August 4, 2004, response).

References:

1. NRC Generic Letter 96-06, "Assurance of Equipment Operability and Containment Integrity During Design-Basis Accident Conditions," September 30, 1996, (Agencywide Documents Access and Management System (ADAMS) No. ML031110021).

2. EPRI report number 1003098, “Generic Letter 96-06 Waterhammer Issues Resolution, Technical Basis Report - Proprietary,” April 2002, (ADAMS Nos. ML021750063 and ML021750141).

3. EPRI report number 1006456, “Generic Letter 96-06 Waterhammer issues Resolution, user’s Manual - Proprietary,” April 2002 (ADAMS No. ML021750025).

4. Letter, J. Hannon, NRC, ‘NRC Acceptance of EPRI Report TR-113594, Resolution of Generic Letter 96-06 Waterhammer Issues, Volumes 1 and 2,” April 3, 2002 (ADAMS No. ML020940132).

5. Letter, K. Cotton, NRC, “V. C. Summer Nuclear Power Station - Review of the Licensee’s Response to GL 96-06 Concerning Waterhammer and Two-Phase Flow,” March 28, 2001 (ADAMS No. ML010870511).

6. NRC Generic Letter 91-18, “Information to Licensees Regarding Two NRC Inspection Manual Sections on Resolution of Degraded and Nonconforming Conditions and on Operability,” November 7, 1991 (ADAMS No. ML031140549).

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