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SOUTHERN COMPANY
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December 2, 2002

Docket Nos.: 50-424
50-425

LCV-0897-H

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington D. C. 20555-0001

Ladies and Gentlemen:

Vogtle Electric Generating Plant – Units 1 and 2
Request for Additional Information Concerning GL 96-06, Assurance of Equipment Operability and Containment Integrity During Design-Basis Accident Conditions

Southern Nuclear Operating Company (SNC) previously responded by letter dated October 28, 1998, (Reference 5) to some of the items in the August 10, 1998, Request for Additional Information (RAI) made by the NRC regarding the Vogtle Electric Generating Plant (VEGP) response to Generic Letter (GL) 96-06. Other items were deferred pending completion of the EPRI Technical Basis Report (Reference 1) on the related waterhammer issues. In the intervening time period since the initial response to the RAI, additional work has been performed in analyzing the behavior of the VEGP nuclear service cooling water (NSCW) system in relation to the GL 96-06 waterhammer issues. This work has been in concert with the effort performed by EPRI at the industry level. A summary of the work performed, including updated conclusions, is provided in the attachment to this letter. Also, additional work has been performed in relation to the two-phase flow issue, and an updated summary is similarly provided. Following these summaries, responses are provided for those items that were deferred. Also, supplemental responses are provided for some of the previously answered items. This response is provided in accordance with the provisions of 10 CFR 50.54(f).

Mr. Jeffrey T. Gasser states he is Vice President of Southern Nuclear Operating Company and is authorized to execute this oath on behalf of Southern Nuclear Operating Company, and to the best of his knowledge and belief, the facts set forth in this letter are true.

A072

Please contact this office if there are any questions.

Sincerely,

Jeffrey T. Gasser

Sworn to and subscribed before me this 2nd day of December, 2002.

Notary Public

My commission expires: 11/10/06

JTG/BHW

Attachment

cc: Southern Nuclear Operating Company
Mr. G. R. Frederick
Mr. M. Sheibani
SNC Document Management – Vogtle

U.S. Nuclear Regulatory Commission
Mr. L. A. Reyes, Regional Administrator
Mr. F. Rinaldi, Project Manager, NRR
Mr. John Zeiler, Senior Resident Inspector, Vogtle

Attachment

Vogtle Electric Generating Plant – Units 1 and 2
Request for Additional Information Concerning GL 96-06, Assurance of Equipment Operability and Containment Integrity During Design-Basis Accident Conditions

Forward

Southern Nuclear Operating Company (SNC) previously responded by letter dated October 28, 1998, (Reference 5) to some of the items in the Request for Additional Information (RAI) made by the NRC regarding the VEGP response to Generic Letter (GL) 96-06. Other items were deferred pending completion of the EPRI Technical Basis Report (Reference 1) on the related waterhammer issues. In the intervening time period since the initial response to the RAI, additional work has been performed in analyzing the behavior of the VEGP nuclear service cooling water (NSCW) system in relation to the GL 96-06 waterhammer issues. This work has been in concert with the effort performed by EPRI at the industry level. A summary of the work performed, including updated conclusions, is provided below. Also, additional work has been performed in relation to the two-phase flow issue, and an updated summary is similarly provided. Following these summaries, responses are provided for those items that were deferred. Also, supplemental responses are provided for some of the previously answered items.

In accordance with Section 3.3 of the NRC SER (Appendix B to Reference 2), the following information is provided. The EPRI methodology provided in Reference 2, as clarified by the discussion under the heading "Comparison with EPRI Methodology" of this response, was properly applied in the waterhammer analyses. Also, VEGP-specific risk considerations, as clarified by the discussion under the heading "Risk Perspective" in this response, are consistent with the risk perspective that was provided in the EPRI letter dated February 1, 2002, (Appendix C to Reference 2).

Waterhammer Issues Update Summary

The approach originally taken by VEGP in response to GL 96-06 was to analyze the behavior of the NSCW system by making several simplifying but conservative assumptions. Principal among these was the assumption that the saturated steam temperature in the tubes of the containment air coolers instantaneously tracks the temperature of containment (to maximize draindown or voiding) until the pumps restart and then instantaneously is transformed to 95°F for system refill (to maximize the filling velocity). Thus, heat transfer calculations were not performed as part of the analysis.

In the intervening time period since the initial response, VEGP personnel have followed and participated in the efforts of the industry as coordinated by EPRI. Furthermore, the VEGP methodology has been reviewed and compared to the methodology recommended by EPRI in Reference 2. One of the central elements in the EPRI approach is to perform

a plant-specific draindown (or voiding) analysis based on the heat transfer characteristics of the containment air coolers coupled with system hydraulics. This approach has the advantage of lending better realism to the analysis which, in turn, allows better focus on the issues of importance.

In view of the above, VEGP has elected to re-perform the GL 96-06 waterhammer analyses (a specific analysis for each train/unit) to include heat transfer considerations and to utilize the EPRI recommended methodology provided in Section 2.2 of Reference 2. The revised analyses also eliminate some identified configuration inconsistencies in the original analyses and revise some of the original hydraulic assumptions. Furthermore, the revised analyses consider valve stroke tolerances and examine single failures in conjunction with the waterhammer event.

It should be noted that the NSCW system has been qualified for waterhammer resulting from loss of offsite power (LOSP) only events. This was done through special testing performed during the pre-operational test period. Section 3.4 of Reference 2 indicates that LOSP only waterhammers will bound LOSP/LOCA or LOSP/MSLB waterhammers for plants that void during LOSP conditions and that have the same pump and system line-up during these events. Even though the VEGP NSCW system meets the above criteria, there is potential that worst case conditions can result in LOSP/LOCA waterhammer that is not bounded by LOSP only waterhammer. This is because the NSCW system design includes a "slow fill" feature that refills the system at a reduced rate for a certain time period following power restoration, thereby mitigating the waterhammer. In the event of a LOSP/LOCA, the steam pressure tends to increase draindown volume and reduce the refill rate, thereby extending the time necessary to refill the system. If the needed refill time extends past the "slow fill window," then final void closure can potentially occur at a higher refill rate than that for which the system was qualified by testing. Therefore, the revised analyses place emphasis on examination of conditions that can lead to this possibility.

Brief descriptions of the methodology and results for the revised analyses are provided below.

Draindown Methodology

A design basis LOCA has been shown to be bounding and is used in the analyses since this provides greater heat input to the cooling water in the containment coolers than a MSLB. The NSCW temperature prior to the event is assumed to be at its highest allowable value. Heat transfer rates from the containment atmosphere to the containment air coolers and auxiliary containment air cooler are calculated as a function of time along with the resulting NSCW temperatures. The corresponding NSCW saturation pressures are utilized along with piping resistances and elevation differences to calculate the extent of draindown (voiding) from the coolers and associated piping.

In the original analyses, it was believed that steam pressure in the auxiliary containment air cooler, if operating, would prevent draindown of the containment air coolers. Upon

further review and consideration of system hydraulic resistances, this is no longer believed to be the case and the revised analyses model simultaneous draining from the auxiliary containment air cooler and the containment air coolers.

Draindown is calculated for two separate cases based on the initial positions of the valves at the NSCW cooling tower. That is, draindown is calculated for both the spray mode (spray valve open and bypass valve closed) and also for the bypass mode (bypass valve open and spray valve closed).

Draindown Results

The tower bypass mode of operation results in the greatest volume of water being drained/boiled from the system. In this case, water is evacuated from the top coils and mostly from the middle coils of all four containment air coolers.

The piping arrangement at the auxiliary containment air cooler limits the drainage from the cooler itself to a relatively small amount. However, significant drainage occurs from the associated outlet piping (return line). Also, some drainage can occur from the associated inlet piping (supply line).

Refill and Column Closure Waterhammer Methodology

The results of the draindown analyses were used in developing the initial conditions for the refill transients. As was done in the original analyses, the Bechtel HSTA computer code was used in analyzing the refill transients. This computer code utilizes the method of characteristics to obtain solutions to the liquid velocity and pressure head at known grid locations. These flow variables were then used by HSTA to generate the dynamic forcing functions (force time histories) on specified pipe run segments. The Bechtel ME101 computer code was used, as necessary, to calculate pipe stresses and support loads based on the HSTA-generated forcing functions.

In the original analyses, single failures were accounted for by noting that the NSCW system design includes two independent trains. A single failure in one train during the waterhammer event does not lead to a disabling of the safety-related cooling capability of the other train. However, in the revised analyses, single failures are examined from the standpoint of accentuating the effect of a waterhammer event on the pressure boundary of the train under consideration, consistent with the Reference 2 methodology. This is to ensure that containment integrity is not compromised, even though functionality of the train may not be required.

Various scenarios were modeled in the refill analyses to account for possible operating modes and single failures. Where the effects were not obvious beforehand, specific HSTA runs were made to determine the worst case. Runs were also made as part of a sensitivity analysis to determine the worst case effects of tolerances when applied to the timing and settings of various automatic valves.

For the auxiliary containment air cooler, adjustments were made to account for the effect of air/steam cushioning on the HSTA-calculated void closure velocities. Adjustments were also made to account for the rise time of the pressure pulse. These adjustments were made following the basic guidance of the Reference 2 methodology and were based on the data provided in Reference 2.

For the containment air coolers, no adjustments were made to account for air/steam cushioning or rise time on the piping forcing functions. This is because, as described below, the results from the revised analyses remain bounded by the original analyses without having to take credit for these effects.

Refill and Column Closure Waterhammer Results

For the containment air cooler piping loops, final void closure was predicted to occur inside the tubes of the coolers for all the cases that were run, except for a single failure case in which the tower valve fails open. All of the various scenarios and HSTA runs performed in the revised analyses result in forcing functions (force time histories) that are bounded by the original analyses. Therefore, the structural evaluations previously performed for the containment air cooler piping loops bound the revised analyses. These structural evaluations take into account the design changes made to the piping and supports discussed in RAI Item No. 16.

In the revised analyses, the application of single failure scenarios leads to worst case forcing functions for the auxiliary containment air cooler piping loop that are not bounded by the original analyses. The worst case was found to be common failure of the inlet and outlet isolation valves for the auxiliary containment air cooler to automatically close as designed. Normally, the valves will begin closing after power is restored following LOCA/LOSP and will be fully closed shortly after pump start. This normally precludes final void closure and associated waterhammer from originating in this loop since the piping outside the boundary of the isolation valves is water solid when the pumps start and remains so. However, if the valves fail to close, void closure and waterhammer will occur. Two main void closure locations are predicted by the HSTA code. The first closure impact occurs upstream of the cooler and starts the water moving through the cooler tubes. The second and largest impact occurs in piping downstream of the cooler when water backfilling through the return line impacts the forward moving water from the cooler. This impact was calculated to have an uncushioned velocity of about 26.5 ft/sec or less and a cushioned velocity of about 22 ft/sec or less.

Structural evaluations of piping and supports have been initiated for the postulated waterhammer events described above that originate in the auxiliary containment air cooler piping loops. Final documentation of these evaluations has not yet been completed due to the significant effort involved. However, engineering assessments have been made to verify that the pressure boundary integrity of the auxiliary containment air cooler piping will be maintained following the waterhammer events. Therefore, containment integrity will be maintained. The affected piping does not have a safety-related cooling function. It should be noted that the scenario being evaluated represents a

very low probability event, i.e. a particular type of single failure in combination with simultaneous occurrence of LOSP and LOCA.

Design Changes

Following completion of the formal structural evaluations described above, SNC will evaluate the necessity for any additional design changes beyond those that have already been implemented. If additional changes are deemed necessary, they will be tentatively planned for implementation by completion of the twelfth refueling outage for Unit 1 (Spring 2005) and the tenth refueling outage for Unit 2 (Spring 2004).

Comparison with EPRI Methodology

The revised VEGP analyses follow the basic guidance outlined in Sections 2.2 and 7.3 of Reference 2. The HSTA computer code is used as a tool in implementing the hydraulic portions of the EPRI methodology. The use of a transient computer code is especially beneficial at VEGP due to complexities in the automatic, slow fill feature of the NSCW system (valve timing and setting tolerances, etc.). The use of the HSTA code allows many of the hand calculations shown in the example problem in Section 7.4 of Reference 2 to be performed by computer. The methodology steps outlined in Section 7.3 of Reference 2 are discussed below as applied to VEGP. These discussions give particular emphasis to differences between the VEGP analyses and the example problem in section 7.4. As previously stated, air/steam cushioning and rise time effects are only credited for void closures that occur in the auxiliary containment cooler piping loops.

Initial Velocity: Applicable portions of the entire NSCW system are modeled in the HSTA code, including pump curves and pertinent flow coefficients. The HSTA code is not only capable of solving the flow balance equations, but is a transient code capable of accounting for inertia effects and tracking the location of voided sections of piping. Therefore, HSTA is well suited to directly calculate the initial velocity. Justification is provided in the VEGP analyses for application of the EPRI methodology (use of air/steam cushioning charts) to initial velocities that are in excess of 20 ft/sec.

Accelerating Column and Void Lengths: Estimates are made of the initial water and void column lengths for use in selecting the appropriate air/steam cushioning charts from Appendix A of Reference 2.

Mass of Gas: This is calculated per the EPRI methodology.

Cushioned Velocity: This is calculated per the EPRI methodology (air/steam cushioning charts in Appendix A of Reference 2). However, the cushioned velocity is not used by the HSTA code in calculating peak waterhammer head. Since the cushioned velocity and head are not directly calculated by HSTA, cushioning effects are credited by making an equivalent adjustment when calculating the structural loading on the piping system.

Sonic Velocity: The sonic velocity is manually calculated per Section 5.2 of the EPRI User's Manual for solid water (without air bubbles) and used as an input to the HSTA code.

Peak Pulse with No Clipping: The peak waterhammer pressure pulse is calculated by the HSTA code based on the uncushioned velocity and the sonic velocity. The peak pressure (or head) is calculated as a solution to the fundamental continuity and momentum equations, which is equivalent to using the Joukowski equation. The HSTA code does not calculate rise time attributable to air/steam cushioning; therefore, there is no clipping of the pressure pulse. The HSTA code tracks the propagation of the pressure pulse through the affected piping and calculates forcing functions (force time histories) on the various piping segments. The forcing functions are manually adjusted for air/steam cushioning effects based on the EPRI suggested reductions provided in Appendix A to Reference 2.

Rise Time: As stated above, rise time due to air/steam cushioning is not calculated in the HSTA computations (the steam is assumed to condense at the same rate as the reduction in steam volume and air is not assumed to be in the vapor void in the HSTA computations). The pressure increase at the column collapse location is therefore instantaneous. Rise time effects are credited by making equivalent adjustments when calculating the structural loading on the piping system. These adjustments are consistent with the linear increase in pressure during rise time as per the EPRI methodology. For conservatism, only one half of the EPRI suggested rise time is credited in the VEGP analyses.

Transmission Coefficients: The HSTA code is capable of directly solving the fundamental continuity and momentum equations at flow area change locations in the piping, which is equivalent to using the transmission and reflection coefficients described in Section 5.3.6 of Reference 2.

Duration: The HSTA code is capable of tracking reflections from the initial pressure pulse and calculating the pressure pulse accordingly. Therefore, the pressure pulse duration is inherently calculated by the computer code. As previously stated, rise time due to air/steam cushioning is not computed by the HSTA code and, therefore, does not add to the duration. The effect of any actual increase in duration due to the short rise times in the VEGP analyses is more than offset by other conservatisms in the analyses such as using only one half the EPRI recommended rise time and no credit for clipping.

Peak Pressure Clipping: Clipping is not credited in the VEGP analyses. In reality, the location of void collapse in relation to system boundaries is expected to lead to pressure clipping, making the analysis conservative.

Pressure Pulse Shape: The HSTA code generates a pressure pulse that is essentially a square wave. However, as stated previously, rise time adjustments are applied to the structural loading of the piping in a manner consistent with the linear increase in pressure during rise time as per the EPRI methodology.

Flow Area Attenuation: See the discussion for "Transmission Coefficients." The HSTA code inherently calculates the attenuation/amplification of the pressure pulse as it travels through the system. For the containment air coolers, attenuation calculations are also manually performed at the coil/header interface to account for HSTA modeling of the coils as equivalent pipe. Fluid structure interaction (FSI) effects are conservatively ignored in the VEGP analyses, as suggested by the EPRI methodology.

Condensation Induced Waterhammer Considerations

Based on the characteristics of the containment atmosphere following a design basis LOCA, the NSCW temperature in the tubes of the containment air coolers and auxiliary containment air coolers is limited to about 250°F. The corresponding saturation pressure is about 30 psia or about 15 psig. Using the guidance in Section 4.2 of Reference 2, it is concluded that any condensation induced waterhammers (CIWH) that may occur are limited in magnitude such that they are not a threat to pressure boundary integrity. The effects of any CIWH will be less than the effects of column closure waterhammer (CCWH). The VEGP NSCW system has been shown to be capable of withstanding CCWH by qualification testing for LOSP conditions and by analysis for conditions of LOSP/LOCA. Therefore, an explicit calculation of CIWH was not performed.

Risk Perspective

Appendix C to Reference 2 includes an EPRI letter to the NRC dated February 1, 2002. This letter provides a discussion of risk considerations for occurrences of LOCA or MSLB in combination with loss of offsite power, and the likelihood of a resulting unacceptable event. A brief discussion of the VEGP-specific risk considerations compared to the generic EPRI risk considerations is provided as follows.

The EPRI letter gives a probability on the order of $1.5 \cdot 10^{-5}$/year for the combined LOCA/MSLB and LOSP event. The VEGP-specific estimate for the combined event is $1.8 \cdot 10^{-5}$/year. From an overall risk perspective, the VEGP estimate is considered to be essentially the same as the EPRI value. The difference in numerical value between the VEGP and EPRI estimates is attributable to a MSLB mean frequency of occurrence of $1 \cdot 10^{-3}$/year used in the EPRI report versus a slightly higher value of $1.25 \cdot 10^{-3}$/year used in the VEGP estimate.

It should be noted that the LOSP dependent probability value ($1.4 \cdot 10^{-2}$/demand) used in the VEGP estimate is based on NUREG/CR-6538, consistent with the EPRI letter. Although a VEGP-specific LOSP dependent probability value has not been developed, based on limited VEGP experience data collected (no LOSP events out of 38 reactor trips and no LOSP events out of 1 SI/ECCS actuation), it is expected that it would be slightly less than $1.4 \cdot 10^{-2}$/demand.

Two-Phase Flow Issue Update Summary

The VEGP response to GL 96-06 addressed two-phase flow from the same perspective as that applied to the waterhammer issue, i.e. MSLB or LOCA coincident with LOSP. This event results in steam generation during the period when the NSCW pumps are not running and the containment air coolers are draining; hence, both steam and water phases are present in the NSCW system. However, the GL 96-06 response did not discuss the possibility of two-phase flow occurring during MSLB/LOCA with offsite power available and the NSCW pumps operating. Therefore, this possibility is addressed in this update summary.

The VEGP Design Bases for the NSCW system include the requirement of no boiling (flashing) in the containment air coolers or in the return piping from the containment during accident conditions. This requirement assumes that two pumps are operating in the train under consideration. VEGP calculations have been performed to confirm that the requirement is met. A description of the most recent analysis is provided below.

Two-Phase Flow Assumptions and Methodology

The analysis considers conditions that minimize the NSCW flow and pressure at the coolers and maximize the outlet temperature. The NSCW pumps are assumed to be degraded 7% to allow for possible wear. The ESF chiller control valve is assumed to be full open which diverts as much flow as possible around the containment air coolers. The containment auxiliary air cooler and reactor cavity cooler are designed to automatically isolate from the NSCW system under safety injection (SI) conditions and, therefore, are assumed to do so. Similarly, NSCW blowdown flow is designed to isolate under SI conditions and is assumed to do so. The cooling tower sprays are assumed to be in service because, if not, the temperature of the water returning to the cooling tower will cause an automatic switchover from bypass mode to spray mode. Two NSCW pumps are assumed to be operating in accordance with system design and operating procedures. Cooling tower basin level is assumed to be slightly above the tech spec minimum level for normal operation. Since the peak NSCW outlet temperature from the containment air coolers occurs at around 100 seconds following event initiation, there is no appreciable drop in basin level due to evaporation.

The NSCW outlet temperature from the containment air coolers used in the two-phase flow analysis is the peak temperature calculated for post-LOCA conditions assuming single train operation and clean tubes. This temperature is calculated based on containment conditions that are more adverse than the current containment pressure/temperature analysis. Thus, the NSCW temperature used in the two-phase flow analysis is conservative. The outlet temperature is calculated assuming that the NSCW basin temperature is 90°F, which is the tech spec maximum allowable temperature for normal operation.

Based on the above assumptions, the basic methodology used in the two-phase flow analysis is to calculate the NSCW pressure at critical locations in the containment air

coolers and associated outlet piping. This pressure is then compared to the vapor pressure associated with the peak NSCW fluid temperature. The locations examined include the high point at the containment air cooler outlets (lowest pressure experienced by the coolers), the vena contracta locations at the discharge from flow restricting and flow measuring orifices, and the farthermost downstream piping location prior to mixing with cooler NSCW return flow from other loads.

NSCW pressures in the regions of interest are calculated using computer models of the NSCW system based on the previously described configuration assumptions. "Pipe-Flo" software is used for this purpose. The computer generated pressures are manually adjusted as necessary to predict pressures at the exact locations described above.

Two-phase Flow Results

The results of the analysis indicate that the pressures at the lowest pressure locations exceed the vapor pressure of the NSCW fluid by a reasonable margin. Therefore, boiling or flashing in the containment air coolers and associated outlet piping does not occur and two-phase flow does not exist. Consequently, the assumption of single phase flow for heat transfer and pressure drop calculations is appropriate.

References

1. EPRI Report No. 1003098, Generic Letter 96-06 Waterhammer Issues Resolution, Technical Basis Report – Proprietary, April 2002.

2. EPRI Report No. 1006456, Generic Letter 96-06 Waterhammer Issues Resolution, User's Manual – Proprietary, April 2002.

3. Georgia Power Company letter to NRC, LCV-0897A, VEGP 120-Day Response to Generic Letter 96-06, January 27, 1997.

4. NRC letter to SNC, Request for Additional Information Concerning Generic Letter (GL) 96-06, VEGP Units 1 and 2, August 10, 1998.

5. SNC letter to NRC, Response to Request for Additional Information Concerning GL 96-06, VEGP Units 1 and 2, October 28, 1998.

6. NRC letter to SNC, VEGP Units 1 and 2 RE: EPRI Report TR-113594, "Resolution of Generic Letter 96-06 Waterhammer Issues," Volumes 1 and 2, May 2, 2002.

Response to Specific Items

1. NRC Request

Provide a detailed description of the "worst case" scenarios for waterhammer and two-phase flow, taking into consideration the complete range of event possibilities, system configurations, and parameters. For example, all waterhammer types and water slug scenarios should be considered, as well as temperatures, pressures, flow rates, load combinations, and potential component failures. To the extent that the possibility for waterhammer and two-phase flow to occur is eliminated, describe the minimum margin to boiling that will exist.

SNC Response

In the revised waterhammer analyses, the methodology from Reference 2 was followed in regard to worst case considerations.

The two-phase flow analysis previously described in the Two-Phase Flow Issue Update Summary reflects the worst case scenario by selecting conditions that minimize NSCW flow and pressure at the containment air coolers while maximizing the outlet temperature. The analysis indicates that the lowest pressures in the coolers and associated outlet piping remain about 10 psi or more above the vapor pressure of the cooling water when at its maximum temperature.

2. NRC Request

If a methodology other than that discussed in NUREG/CR-5220, "Diagnosis of Condensation-Induced Waterhammer," was used in evaluating the effects of waterhammer, describe this alternate methodology in detail. Also, explain why this methodology is applicable and gives conservative results (typically accomplished through rigorous plant-specific modeling, testing, and analysis).

SNC Response

The revised waterhammer analyses follow the basic methodology recommended and described in Reference 2. Additional discussion is provided in the Waterhammer Issues Update Summary under the heading of Comparison with EPRI Methodology.

3. NRC Request

Identify any computer codes that were used in the waterhammer and two-phase flow analyses and describe the methods used to validate and bench mark the codes for the specific application and loading conditions involved.

SNC Response

A response has been previously provided to this request via Reference 5. However, the previous response is supplemented as follows.

As described in the Two-Phase Flow Issue Update Summary, NSCW system computer models are used to predict pressures in the regions of interest for use in the two-phase flow analysis. "Pipe-Flo" software, developed by Engineered Software, Inc., is used for this purpose. This commercially available software is widely used and has been qualified for nuclear safety-related applications at VEGP. Pipe-Flo calculates the balanced flow rates and pressures within fluid piping systems. Head loss calculations are performed using the Darcy-Weisbach formula. The software is well suited for cooling water system applications such as the NSCW system. The version of Pipe-Flo used in the VEGP analysis was tested via a software testing documentation package which includes comparison of calculated results with hand calculations to ensure the software provides accurate results.

4. NRC Request

Describe and justify all assumptions and input parameters (including those used in any computer codes) that were used in the waterhammer and two-phase flow analyses, and provide justification for omitting any effects that may be relevant to the analyses (e.g., fluid structure interaction, flow induced vibration, erosion). Confirm that these assumptions and input parameters are consistent with the existing design and licensing basis of the plant. Any exceptions should be explained and justified.

SNC Response

For the revised waterhammer analyses, assumptions and input parameters are consistent with the Reference 2 methodology and with the existing VEGP design and licensing basis.

For the two-phase flow analysis, assumptions and input parameters are described in the Two-Phase Flow Issue Update Summary and are consistent with the existing VEGP design and licensing basis.

5. NRC Request

Explain why voiding in the CACs is limited to the 2 top coils (i.e., is this an assumption or is it based on heat transfer considerations).

SNC Response

A response has been previously provided to this request via Reference 5. However, the previous response is supplemented as follows.

As described in the Waterhammer Issues Update Summary under the headings of Draindown Methodology and Draindown Results, the revised analyses include heat transfer considerations to calculate the draindown volumes. For the tower bypass mode of operation, water is predicted to drain from the top coils and mostly from the middle coils of all four containment air coolers in each train. Based on this result, the refill portions of the transient analyses are modeled to begin with the top two coils voided.

6. NRC Request

The January 27, 1997, response indicated that additional analyses would be completed to determine if modifications or system operational changes would be required to reduce waterhammer stresses. Describe the additional analyses that were completed and conclusions that were reached.

SNC Response

A response has been previously provided to this request via Reference 5. However, the previous response is supplemented as follows.

The original VEGP waterhammer analyses have been revised as described in the Waterhammer Issues Update Summary.

7. NRC Request

Explain and justify all uses of "engineering judgement" that were credited in the waterhammer and two-phase flow analyses.

SNC Response

The revised waterhammer analyses follow the basic methodology recommended and described in Reference 2. Additional discussion is provided in the Waterhammer Issues Update Summary under the heading of Comparison with EPRI Methodology.

For the two-phase flow analysis, engineering judgement is not explicitly credited. However, engineering judgement is implicitly used to conclude that the margins in the results along with the conservatism in the methodology and assumptions outweigh uncertainties in the calculation process used to estimate pressures.

8. NRC Request

Discuss specific system operating parameters and other operating restrictions that must be maintained to assure that the waterhammer and two-phase flow analyses remain valid, and explain why it would not be appropriate to establish Technical Specification requirements to acknowledge the importance of these parameters and operating restrictions. Also, describe and justify use of any non-safety related instrumentation and controls for maintaining these parameters.

SNC Response

A response has been previously provided to this request via Reference 5.

9. NRC Request

Implementing measures to minimize or eliminate waterhammer and two-phase flow conditions may be a viable approach for addressing these issues. However, all scenarios must be considered to assure that the vulnerability to waterhammer and two-phase flow has been eliminated. Confirm that all scenarios have been considered, including those where the affected containment penetrations are not isolated (if this is a possibility), such that the measures that have been established (or will be established) are adequate to address the waterhammer and two-phase flow concerns during (and following) all applicable accident scenarios.

SNC Response

No new measures have been implemented at VEGP to minimize or eliminate the type of waterhammer events described in GL 96-06. Rather, the events have been analyzed and structural design changes have been implemented or will be implemented that improve the capability of the NSCW system to withstand the events.

As described in the Two-Phase Flow Issue Update Summary, two-phase flow does not occur in the containment air coolers or associated outlet piping. Therefore, there is no need to implement new measures.

10. NRC Request

Confirm that the waterhammer and two-phase flow analyses included a complete failure modes and effects analysis (FMEA) for all components (including electrical and pneumatic failures) that could impact performance of the cooling water system and confirm that the FMEA is documented and available for review, or explain why a complete and fully documented FMEA was not performed.

SNC Response

A response has been previously provided to this request via Reference 5. However, the previous response is supplemented as follows.

As described in the Waterhammer Issues Update Summary, the revised waterhammer analyses examine single failures from the standpoint of accentuating the effect of a waterhammer event on the pressure boundary of the train under consideration. The Reference 2 methodology provides the basic guidance for performing this failure analysis. The failure analysis is incorporated into the overall GL 96-06 waterhammer analyses.

11. NRC Request

Describe the uncertainties that exist in the waterhammer and two-phase flow analyses, including uncertainties and shortcomings associated with the use of any computer codes, and explain how these uncertainties were accounted for in the analyses to assure conservative results.

SNC Response

The revised waterhammer analyses follow the basic guidance set forth in Reference 2. Additional discussion is provided in the Waterhammer Issues Update Summary under the heading of Comparison with EPRI Methodology.

For the two-phase flow analysis described in the Two-Phase Flow Issue Update Summary, there is some uncertainty in the calculation of fluid pressures and also in the calculation of NSCW fluid temperature at the outlet of the containment air cooler. However, these uncertainties are offset by the conservatism in the analysis and the margins in the results. The containment air cooler outlet temperature is calculated assuming containment pressure/temperature conditions that are more adverse than the current containment analysis. NSCW basin temperature is assumed to be 90°F, which is the highest temperature allowed by tech specs. The NSCW pumps are assumed to be 7% degraded. The ESF chiller control valve is assumed to be full open. The analysis indicates margins of about 10 psi or more above the vapor pressure of the cooling water. Taken in the aggregate, the uncertainties are judged to be satisfactorily accounted for in the analysis.

12. NRC Request

The waterhammer and two-phase flow analyses assume that there is no back flow through the containment supply check valves Describe measures that exist that assure that these valves will remain leak-tight over the life of the plant.

SNC Response

A response has been previously provided to this request via Reference 5. However, the previous response is supplemented as follows.

The check valves in the NSCW supply lines to the containment cooling units are disassembled for cleaning and inspection every 15 years. This maintenance is performed to provide assurance that the check valves can accomplish their design function.

13. NRC Request

The response seems to indicate that two-phase flow due to fluid conditions in concert with the pressure drop associated with various system components was not considered. Confirm that the potential for two-phase flow throughout the affected system was evaluated and that two-phase flow conditions do not exist for any of the applicable accident scenarios. If it is determined that two-phase flow does exist, then heat transfer, structural, and system integrity concerns must be addressed. For example, the following two-phase flow effects would be relevant:

- *the effects of void fraction on flow balance and heat transfer;*
- *the consequences of steam formation, transport, and accumulation;*
- *cavitation, resonance, and fatigue effects; and*
- *erosion considerations.*

Licensees may find NUREG/CR-6031, "Cavitation Guide for Control Valves," helpful in addressing some aspects of the two-phase flow analyses.

SNC Response

As described in the Two-Phase Flow Issue Update Summary, the potential for two-phase flow was evaluated. It was found that two-phase flow does not occur in the containment air coolers or associated outlet piping during conditions that maximize the NSCW fluid temperature and minimize the fluid pressure. Therefore, two-phase flow conditions do not exist for any of the applicable accident scenarios.

14. NRC Request

The waterhammer analysis was based on analyses of the NSCW system associated with Unit 1, Train A. Confirm that the analyses that were completed are bounding for the other NSCW trains for both of the Vogtle units.

SNC Response

A response has been previously provided to this request via Reference 5. However, the previous response is supplemented as follows.

The revised waterhammer analyses include a specific analysis for each of the two trains in each of the two units, i.e., Unit 1 Train A, Unit 1 Train B, Unit 2 Train A, and Unit 2 Train B. Similarly, the structural evaluations are performed specific to each train and unit.

15. NRC Request

Provide a simplified diagram of the affected system, showing major components, active components, relative elevations, lengths of piping runs, and the location of any orifices and flow restrictions.

SNC Response

A response has been previously provided to this request via letter Reference 5.

16. NRC Request

Describe in detail any plant modifications or procedure changes that have been made or are planned to be made to resolve the waterhammer and two-phase flow issues, including schedules for completion.

SNC Response

A response has been previously provided to this request via Reference 5. However, the previous response is supplemented as follows.

Additional discussion is provided in the Waterhammer Issues Update Summary under the heading of Design Changes.