Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402-2801

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U. S. Nuclear Regulatory Commission
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Browns Ferry Nuclear Plant, Units 1, 2, and 3
Facility Operating License Nos. DPR-33, DPR-52, and DPR-68
NRC Docket Nos. 50-259, 50-260, and 50-296

Subject: **Response to Request for Additional Information for Regarding Generic Letter 2008-01, "Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems" (TAC Nos. MD7799, MD7800, and MD7801)**

References:

1. Letter from TVA to NRC, "Browns Ferry Nuclear Plant (BFN) Units 1, 2 and 3, Sequoyah Nuclear Plant (SQN) Units 1 and 2, and Watts Bar Nuclear Plant (WBN) Unit 1 – 9 Month Response to NRC Generic Letter (GL) 2008-01: Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems, dated January 11, 2008," dated October 11, 2008

2. Letter from NRC to TVA, "Browns Ferry Nuclear Plant, Units 1, 2 and 3 –Generic Letter 2008-01, 'Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems,' Request for Additional Information (TAC Nos MD7799, MD7800, and MD7801)'," dated August 24, 2009

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The Tennessee Valley Authority (TVA) response to NRC Generic Letter 2008-01 for Browns Ferry Nuclear Plant, Units 1, 2 and 3 was submitted to NRC by letter dated October 11, 2008 (Ref. 1). On August 24, 2009, the NRC requested that additional information be provided by September 25, 2009 regarding NRC Generic Letter 2008-01 (Ref. 2). This letter provides the TVA response to the subject NRC request for additional information.

There are no new regulatory commitments included in this submittal. If you have any questions concerning this information, please contact Dan Green at (423) 751-8423.

I declare under penalty of perjury that the foregoing is true and correct.
Executed on the 21st day of September 2009.

Respectfully,

R. M. Krich
Vice President
Nuclear Licensing

Enclosure: Response to Request for Additional Information Regarding NRC Generic Letter 2008-01

cc (Enclosure):

NRC Regional Administrator - Region II

NRC Senior Resident Inspector - Browns Ferry Nuclear Plant

ENCLOSURE

Tennessee Valley Authority
Browns Ferry Nuclear Plant, Units 1, 2, and 3
Docket Nos. 50-259, 50-260, and 50-296

Response to Request for Additional Information Regarding NRC Generic Letter 2008-01

Question 1.

Based on a review of the Tennessee Valley Authority's (TVA's) submittals dated May 9, June 6, July 11, October 11, 2008 and March 2, 2009, the following systems have been identified as emergency core cooling, decay heat removal (DHR), and/or containment spray systems (CSSs) (hereafter referred to as the subject systems), modes or components:

Emergency Core Cooling System (ECCS)
- High-pressure coolant injection (HPCI)
- Core Spray (CS)
- Low-pressure coolant injection (LPCI) – residual heat removal (RHR) in injection mode
- Automatic depressurization system (ADS)
- Suppression pool
- Condensate storage system (CST)

Decay Heat Removal System – RHR in shutdown cooling modes
Containment Spray System – Drywell and Torus Spray / Cooling modes of RHR

Address whether the listing of applicable subject systems, modes and components is complete.

Response 1.

The listing of systems in the above referenced submittals is complete. TVA's Generic Letter (GL) 2008-01 evaluation examined the following flow paths:

- The HPCI pump suction from the CST and from the Pressure Suppression Pool (PSP). The HPCI pump discharge to the reactor vessel (RV) and to the PSP through the minimum flow line.

- The Core Spray (CS) pump suction from the PSP. The CS pump discharge to the RV. The CS pump discharge to the PSP through its minimum flow line.

- The RHR (or LPCI) pump suction from the PSP and from the RV. The RHR pump discharge to the RV, to the PSP through its torus (i.e., the PSP) cooling line (which is also used during full flow testing of the pump) and its minimum flow line, to the Drywell and Torus Sprays.

The ADS is not within the scope of the GL 2008-01 evaluation.

Question 2.

The NRC staff reviewed the responses provided in letters dated May 9, 2008 and March 2, 2009. In a letter dated May 28, 2009 to the Nuclear Energy Institute, the NRC provided the criteria used to review the 9-month GL responses. It was indicated in Section 3.3.2 of the NRC's letter that "[c] overage of the subject systems provided by TSs [Technical Specifications] and TS Bases, such as TS Surveillance Requirements (SRs) and clarification of the meaning of "full of water" should be summarized, and any changes in TSs or TS Bases accomplished after January 11, 2008, should be described and justified. Areas not covered by TSs and TS Bases, such as not providing SRs for ECCS suction piping and not ensuring a void assessment at high points that are not equipped with a vent, should be identified and the process of ensuring adequate coverage should be identified."

Provide the above information and identify any supplementary actions, such as use of procedures and other processes, to address control of voids in the subject systems that are not covered by TS requirements

Response 2.

No changes to TS or TS Bases have been made as a result of the evaluation performed for GL 2008-01. Surveillance Requirements (SR) 3.5.1.1 and SR 3.5.2.2 require verification every 31 days that the HPCI pump, CS pump and RHR (or LPCI) pump discharge pipe is full of water. This SR is met by opening high point vents in these systems and verifying that a solid stream of water discharges from the vent prior to the vent valve being closed. With regard to the meaning of "full of water," the ECCS discharge pipe is maintained full by a continuous supply of water from a head tank or the CST so the SRs are simply verification that the continuous supply of water from the head tank is maintaining the discharge pipe "full of water."

The drawing review and survey of horizontal runs of discharge pipe performed for GL 2008-01 have verified that potential latent voids in the discharge pipe (voids that cannot be vented using existing vent locations and procedures) were verified to not exist or would not be of sufficient size to result in unacceptable system performance. Therefore, no changes to SR 3.5.1.1 and SR 3.5.2.2 or their bases is necessary.

TS and TS Bases do not contain a SR for verification that the ECCS pumps suction pipe is full of water. The GL 2008-01 evaluation for this suction pipe determined that due to its configuration (e.g., it self vents back to its suction source) and periodic full flow tests of the ECCS pumps (which dynamically sweep voids out of the suction pipe and portions of the discharge pipe), no additional controls are necessary.

TVA has made a commitment to evaluate adopting any TS changes produced by the nuclear industry Technical Specifications Task Force (TSTF) as a result of GL 2008-01. Should these TS changes require SRs with quantitative acceptance criteria, they will be considered; however, the GL 2008-01 evaluation has determined that the current design, operation, testing and SRs are adequate for ensuring these systems can perform their safety and operational functions. Other supplementary actions for the control of voids in the ECCS are provided as described in Responses 14.b and 14.c.

Question 3.

In Enclosure 1 to a letter dated October 11, 2008, TVA described its review of the BFN licensing basis as follows:

> This review determined that the licensing basis for the ECCS and DHR System is that voiding in these systems is maintained at a level that does not significantly affect their performance when mitigating design basis accidents (DBAs) or while maintaining safe shutdown (SSD). Therefore, to be in compliance with the licensing basis for BFN, voiding in these systems must be maintained at a level that does not significantly affect the performance of these systems when mitigating DBAs or maintaining SSD.

The gas concern covers all conditions where operability is necessary to maintain safe operation of the subject systems. As it is not limited to DBAs or maintaining SSD, address all conditions where operability of the subject systems is necessary to maintain safe operation during all modes including shutdown operation.

Response 3.

All the following modes of operation or system configurations were evaluated for GL 2008-01. The modes of operation of the ECCS and DHR system are:

- Normal shutdown cooling mode where the RHR (or DHR) pump takes suction from the RV and discharges through the RHR heat exchanger back to the RV,
- LPCI injection mode where the RHR (or DHR) pump takes suction from the PSP and discharges to the RV,
- The PSP cooling where the RHR pump takes suction from the PSP and discharges through the RHR heat exchanger back to the PSP,
- The Drywell cooling mode where the RHR pump takes suction from the PSP and discharges through the RHR heat exchanger to the drywell sprays,
- The Torus spray mode where the RHR pump takes suction from the PSP and discharges through the RHR heat exchanger to the torus sprays,
- The HPCI injection mode where the HPCI pump takes suction from the CST and discharges to the RV,
- The HPCI recirculation mode where the HPCI pump takes suction from the PSP and discharges to the RV, and

- The CS injection mode where the CS pump takes suction from the PSP and discharges to the RV.

Minimum flow lines associated with the systems were also included in the GL 2008-01 evaluation.

Question 4.

Provide the technical basis for not considering the potential for gas accumulation in suction piping or that voids cannot exist in the suction piping.

Response 4.

The water that fills the suction pipe is from the PSP or CST. Nitrogen inerting or cover or containment air is absorbed at the surface of the PSP or CST; therefore, the equilibrium concentration of these gases in the surface water is proportional to the pressure of gases at the surface of the water.

The suction piping is located below the surface of the water in the PSP or CST under all operating or DBA conditions; hence, the water in the suction pipe is at a higher pressure than the water at the surface of the PSP or CST. It can, therefore, contain a higher concentration of dissolved gases. This means that the water in the suction pipe will tend to absorb latent gas. The equilibrium concentration of gases in the water also increases as water temperature decreases; therefore, the absorption capability of the water increases if the water subsequently cools in the suction pipe.

If the water heats up in the suction pipe, the equilibrium concentration of the dissolved gases decreases, but this is offset due to the water in the suction pipe being at higher pressure than the water at the surface of the PSP or CST.

For example, the ratio of solubility constants of nitrogen in water at 65°F and in water at 95°F is 1.27, which means nitrogen (nitrogen is used in this example because all three units' containments are inerted with nitrogen) will not evolve from water that heats up from 65°F to 95°F provided the water pressure is a factor of 1.27 above containment pressure. The water level in the PSP is maintained at > 9.5 feet over the top of the PSP ring header, which supplies water to the RHR and CS pumps. The pressure at the centerline of the PSP ring header is a factor of 1.28 above containment pressure. This means that nitrogen will not form in the RHR pump and CS pump supply line from the CST if the water in this pipe heats up.

The HPCI pump suction pipe is aligned to the CST; thus, water in the suction pipe is at a higher pressure than the water in the RHR pump and CS pump suction pipe since there is a greater height of water above the suction intake. This means that nitrogen (or oxygen), for the temperature changes used in the example above, will not form in the HPCI pump supply line from the PSP if the water in this pipe heats up.

Note that the RHR and CS pump discharge pipe outside containment is also maintained at greater than atmospheric pressure due to their connections to a head tank. The HPCI pump discharge pipe outside the steam tunnel is maintained at greater than atmospheric pressure due to the > 17 feet of water in the vertical pipe from the torus room to the HPCI injection check valve in the steam tunnel. Therefore, the ECCS and DHR system suction and discharge pipe is not susceptible to gases coming out of solution and forming voids.

The conclusion that suction and discharge pipe is not susceptible to gas accumulation is also supported by evidence provided by Three Mile Island and Diablo Canyon Nuclear Plant representatives at the January 11, 2008 Nuclear Energy Institute (NEI) sponsored Gas Accumulation Workshop. These plants monitor ECCS suction pipe for voids using ultrasonic testing (UT) and both plants indicated that their monitoring always indicates the suction pipe to be full of water. The suction pipe configuration at these plants is similar to the Browns Ferry Nuclear Plant configuration in that the suction pipe is located below the water source.

Regardless of the above discussion on the evolution of gases from water, ultimately, the suction pipe configuration to all these pumps ensures that latent voids in their suction pipe will:

- Self-vent back to the PSP or CST,
- Be broken up into small bubbles prior to reaching the pump at horizontal to vertical elbows and vertical drops to the pumps in the suction flow path, and
- Be removed from the flow stream at dead leg connections upstream of the pump.

These factors ensure that pump operation will not be significantly affected. In addition, as discussed in Section 6.5 of the BWR Owners' Group Technical Report: ECCS Pumps Suction Void Fraction Study (Ref. 1), the suction and discharge pipe configuration for the RHR, CS and HPCI pumps prevents them from becoming air bound or losing their prime due to latent voids.

Successful, periodic, full flow pump tests ensure and demonstrate that latent voids in the suction pipe:

- from the PSP to the CS and RHR pumps, and
- from the CST to the HPCI pump

are maintained below a volume that challenges or degrades required pump operation.

Question 5.

On page E1-4 of Enclosure 1 to the October 11, 2008 submittal, TVA indicated that

> Pump discharge void volume acceptance criteria was based on maintaining pressure pulsations less than that which would cause a discharge pipe relief valve to lift or result in a hydraulic force that causes pipe stress to exceed allowable values. In order to meet these criteria, there must be no sudden changes in flow as the ECCS and DHR System

Pumps start and compresses voids in the discharge pipe. These criteria are usually met when the discharge pipe has been filled to the isolation valve as this prevents an abrupt stopping of flow.

It concluded that, in an otherwise full pipe system, voids due to unfavorable pipe slope and bow in nominally horizontal pipe or trapped due to flow obstructions (e.g., orifice plates) are gradually compressed and do not result in an unacceptable pressure transient during pump start.

Provide the meaning of "these criteria are usually met." Address what is meant by "sudden changes in flow."

Response 5.

The meaning of "these criteria..." is referring to the state of fill of the discharge pipe that prevents an unacceptable hydraulic transient when the ECCS or DHR system pump is started. The meaning of "... are usually met" is that the state of fill of the discharge pipe could not meet this criteria and still not result in an unacceptable hydraulic transient; however, additional evaluation would be required under these circumstances. When the state of fill of the discharge pipe meets these criteria, no additional evaluation is required. The drawing review and survey data taken for the GL 2008-01 evaluation verified that after being filled and vented, the discharge pipe met these qualitative criteria so quantitative analysis was not required.

The meaning of "sudden changes in flow" is the qualitative description of a transient hydraulic requirement. In order to maintain bulk flow conditions in a piping system (and thus prevent large hydraulic forces), the disturbance time must be much greater than the propagation time. The propagation time, is at most, the time it takes a pressure wave to travel the length of the discharge pipe. Based on the pipe lengths for the RHR, CS, and HPCI pumps, the propagation times are very small, thus bulk flow conditions are maintained during a pump start transient. For example, the length of the HPCI discharge pipe is < 400 feet; therefore, the propagation time is (400 feet)/(4800 feet/second) = 0.08 seconds.

Question 6.

On page E1-4 of Enclosure 1 to the October 11, 2008 submittal, TVA indicated that an analysis of ECCS piping downstream of the injection valves was completed and, with the exception of HPCI piping, air in this piping will have no adverse consequences related to accident conditions and, even if small voids did exist, the pressure transient would not be greater than the normal injection pressure. The configuration of the HPCI pipe was stated to allow all voids upstream of the discharge isolation valve to be swept to the condensate storage tank during periodic pump tests. The discharge pressure of the HPCI pump is greater than the primary system pressure and BFN concluded that flow through the discharge pipe to the reactor vessel does not stop during a DBA. It concluded that pressure transients due to voids in the HPCI discharge pipe will be mild. Simply slowing the flow can cause a pressure pulse. For example, there will be an increase in kinetic energy associated with the increased flow rate that results from initial void compression followed by later transfer of kinetic energy into potential energy that manifests itself as a pressure increase as the void compression rate decreases. The energy transfer may result in a pressure pulse.

Provide the basis for concluding that it is necessary for the flow to stop to cause a pressure pulse.

Response 6.

The words on page E1-4 of Enclosure 1 to the October 11, 2008 submittal (Ref. 2) were not intended to mean that a pressure pulse will only occur in the HPCI pump discharge pipe if flow stops. However, the pressure pulse will be mild because the HPCI pump discharge pressure is greater than the normal operating pressure in the RV, thus the flow may slow down, but it will not abruptly stop during the HPCI pump start. This conclusion is supported by HPCI flow data for an injection to the RV at operating conditions, which occurred on Unit 3 in April, 2002 and on Unit 1 in June, 2007. In addition, the HPCI pump discharge pressure increases above RV pressure and HPCI flow rate changes gradually during the pump start.

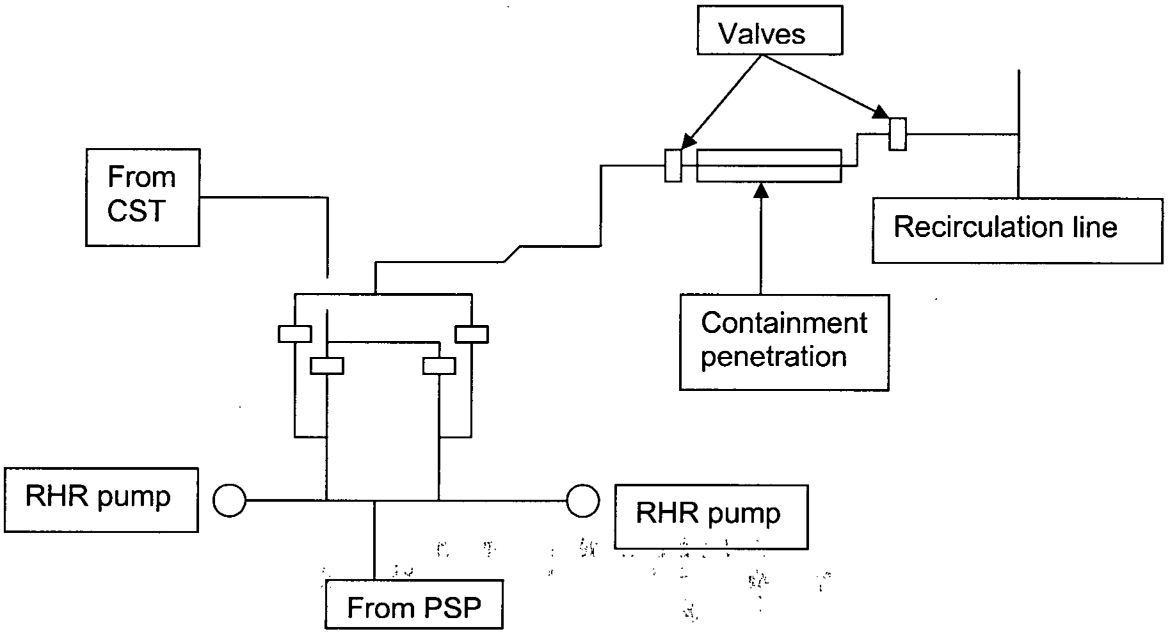
Question 7.

On page E1-4 of Enclosure 1 to the October 11, 2008 submittal, TVA indicated that a portion of the DHR system suction pipe from the primary system is located inside containment and, at the time of the July 11 2008 submittal, the survey of this pipe was deferred until the next refueling outage for each unit. Further, TVA stated that the configuration of this pipe and its distance from the DHR system pump suction would prevent it from containing a void large enough to cause a loss of the DHR system pumps when they take suction from the primary system. BFN also stated that the DHR system pumps have not become gas bound with their suctions aligned to the primary system for shutdown cooling and, therefore, this pipe is no longer required to be surveyed in upcoming refueling outages.

Provide the maximum void volume that could be held up in the DHR system pipes. Given the operating experience indicating that licensees are continuing to discover subject system voids that potentially jeopardize operability where a problem was not previously identified, how does historically not having pumps become gas bound justify a conclusion that there will not be a void problem?

Response 7.

The acceptability of voids in the horizontal RHR pump supply pipe from the RV located inside containment was not based on quantitative acceptance criteria (i.e., a maximum void volume). Rather, the GL 2008-01 evaluation based the acceptability of voids in this pipe on the suction pipe configuration. Specifically, there is < 18 feet of horizontal pipe inside the drywell and < 14 feet of horizontal pipe inside the containment penetration. These horizontal pipes are located > 45 feet above the pump suction with 5 horizontal to vertical pipe elbows in the suction flow path. Voids are trapped and split apart at these horizontal to vertical elbows and only small bubbles that do not affect pump operation travel towards the pump. In addition, > 11 feet above the RHR pump suction, the supply pipe from the RV connects to a vertical pipe through the branch of a horizontal to vertical tee. Any voids in the flow stream from the RV supply to the RHR pump are stripped out of the flow stream at this location and remain trapped in a dead leg of the RHR pump supply from the CST. This pipe configuration is illustrated in the below figure, which is not to scale and has been rotated several times for clarity.



The 18 feet section of horizontal pipe in containment was surveyed during the Unit 1 and 2 refueling outages. The Unit 1 and 2 pipes were found to be level to within 0.2 inches resulting in a maximum potential latent void volume of < 0.1 cubic feet. As previously committed to in Reference 1, the Unit 3 pipe segment will be surveyed at the next Unit 3 refueling outage.

<u>Question 8.</u>

On page E1-7 of Enclosure 1 to the October 11, 2008 submittal, TVA indicated that the survey of the ECCS and DHR system discharge pipe identified some locations that could contain a void due to unfavorable pipe slope or pipe bow. However, it also stated that voids at these locations are either swept to the pressure suppression chamber or CST during periodic pump tests or are well below the size that would result in significant pressure pulsations. For example, the largest possible void in the CS pump discharge pipe that is not swept during periodic pump tests was stated to have a maximum cross section of 7 percent of the pipe flow area. TVA also stated that portions of the pipe segments were inspected by ultrasonic testing (UT) and no voiding was identified.

Question 8a.

Provide the basis for concluding that there are no voids in the pipe segments that were not inspected by UT;

Response 8.a.

The GL 2008-01 evaluation surveyed ECCS and DHR system pipe and used this survey data, pipe drawings and the location of system vents to determine potential latent void locations in these systems.

Potential latent void locations in the ECCS and DHR system suction pipe that are swept during periodic testing of the ECCS and DHR system pumps did not receive additional evaluation. This is because the periodic pump tests not only remove any voids that may accumulate at these locations, but also demonstrate that any voids contained at these locations do not adversely impact pump operation or degrade pump performance. In addition, successful consecutive periodic pump tests provide proof that latent voids in the suction pipe do not grow to the point that degradation or failure of the pumps would occur in the interval between the tests. The cumulative history of successful pump tests indicates that latent voids do not result in pump damage.

Potential latent void locations in the ECCS and DHR system discharge pipe that are swept during periodic testing of the ECCS and DHR system pumps did not receive additional evaluation. This is because the periodic pump tests remove any voids that may accumulate at these locations. In addition, the response to question 4 explains why these locations would not accumulate voids between pump tests.

Potential latent void locations in the ECCS and DHR system discharge pipe that are not swept during periodic testing of the ECCS and DHR system pumps were evaluated to determine the maximum cross sectional area that a potential latent void could occupy. Potential latent void locations that could result in a void occupying more than 20% of the pipe cross sectional flow area were examined by UT to ensure a potential void exceeding 20% of the pipe cross sectional flow area is not present. As noted in the October 11, 2008 submittal (Ref. 2), only one potential latent void location was found that exceeds this criterion (the Unit 3 HPCI discharge pipe discussed in Question 9 with associated responses); although more than just this one location was examined by UT. The results of the UT examinations performed on the HPCI discharge piping did not identify any voids.

Based on the above logic, the GL 2008-01 evaluation concluded that potential latent void locations that were not examined by UT either do not contain a void or do not contain a void that could result in system performance less than needed for the system to meet safety and operational requirements.

Question 8.b.

Provide the basis for the statement that 7 percent of the pipe flow area is the maximum cross section;

Response 8.b.

The CS pump discharge pipe at the potential latent void location is 14 inch schedule (Sch.) Standard (STD) and due to unfavorable pipe slope or bow, the top 1.9 inches of the pipe cannot be vented. The ratio of the area of a 1.9 inch high circular segment to the total flow area of the pipe is < 9%. It should be noted that in the October 11, 2008 submittal, this void was reported as occupying a maximum 7% of the pipe cross sectional flow area. The discrepancy (9% versus 7%) is due to the way the void height in this segment is calculated. In the October 11, 2008 submittal, the maximum void cross section was determined based on the average void height over a 5 foot section of pipe; this average void height is < 1.9 inches. The above calculation of void cross section is based on the maximum (point location) void height. Regardless of which void height is used, the potential latent void at this location is well below the acceptance criteria of 20% of pipe cross sectional flow area (see Response 8.d).

Question 8.c.

Address what the item b) maximum cross section translates to in terms of void volume;

Response 8.c.

The potential latent void volume is < 0.85 cubic feet.

Question 8.d.

Provide the criteria that form the basis that the voids are well below the size that would result in significant pressure pulsations, and,

Response 8.d.

The 20% maximum cross sectional flow area criteria is from the Diablo Canyon Nuclear Plant presentation at the July 28, 2008 NEI sponsored Gas Intrusion Workshop. Specifically, void cross sectional area should not exceed 20% of the pipe flow area to maintain bubbly flow when the pump starts so that voids are gradually compressed, preventing a water hammer or severe pressure pulse. The 20% maximum cross sectional area or pipe void fraction is a lower bound for the transition from bubbly flow to slug flow in horizontal pipe (also see NUREG/CR-5535-V1, RELAP5/MOD3 Code Manual (Ref. 3)).

Question 8.e.

Provide the Froude numbers associated with dynamic venting of the discharge pipes.

Response 8.e.

The HPCI pump discharge pipe that is dynamically vented during pump tests is 14 inch Sch. 100 or smaller. The HPCI pump flow rate during the pump test is > 5000 gpm so the Froude number (Fr) is > 2.4.

The CS pump discharge pipe that is dynamically vented by the flow from one pump during periodic testing is 12 inch Sch. STD. The flow rate through this pipe during pump testing is > 3000 gpm so the Fr is > 1.4. The CS pump discharge pipe that is dynamically vented by the flow from two pumps during periodic testing is 14 inch Sch. STD. The flow rate through this pipe during the pump test is > 6250 gpm so the Fr > 2.4.

The RHR pump discharge pipe that is dynamically vented by the flow from one pump during periodic testing is 20 inch Sch. Extra Strong (XS) or smaller. The flow rate through this pipe during pump testing is > 9000 gpm so the Fr is > 1.3. The RHR pump discharge pipe that is dynamically vented by the flow from two pumps during periodic testing is 24 inch Sch. XS. The flow rate through this pipe during the pump test is > 12000 gpm so the Fr > 1.1.

Question 9:

On page E1-7 of Enclosure 1 to the October 11, 2008 submittal, TVA indicated that there is one pipe segment in the Unit 3 HPCI system that, due to unfavorable pipe slope, could contain a void whose maximum cross section exceeds 20 percent of the pipe flow area. However, it also stated that the average void cross section in this pipe segment could not exceed 20 percent of the pipe flow area.

Question 9.a.

Provide the maximum HPCI pipe cross sectional area that can be voided;

Response 9.a.

The unfavorable slope at this location is 4.7 inches. This is 14 inch Sch. 100 pipe so the maximum cross sectional area that can be voided is < 36% of the pipe flow area.

Question 9.b.

Provide the maximum volume of the void that could accumulate in this pipe;

Response 9.b.

The maximum void volume that could accumulate at this location is < 19 cubic feet.

Question 9.c.

Provide the acceptance criteria for this void location and how they were determined; and,

Response 9.c.

The potential void at this location did not meet the discharge pipe acceptance criteria of (see Response 8.d): the void maximum cross sectional area was less than 20% of pipe flow area. Therefore, additional evaluation of the potential void at this location was performed and it was determined to be acceptable. The basis for this conclusion is that:

- This discharge pipe void will be compressed to greater than the pressure in the RV during the HPCI pump startup transient and then flow into the RV so there will be no sudden changes in discharge pipe velocity (see Response 4). Thus, bulk flow conditions are maintained and the HPCI discharge pipe will not be subject to large acoustic forces (see Response 5).

- The HPCI pump discharge does not contain a discharge check valve so the mini-flow connection to the PSP acts as a water hammer arrestor preventing the propagation of pressure waves to the HPCI suction pipe.

- HPCI is a high pressure system. The discharge pipe is rated at a higher pressure than the normal RV operating pressure. The discharge pipe has no relief valve that could potentially open during HPCI pump start, which prevents a loss of ECCS fluid from a hydraulic transient. The overpressure protection of the HPCI discharge pipe is provided by the RV relief valves; however, due to the large steam space in the RV, a HPCI pump start cannot cause a hydraulic transient that would cause these RV relief valves to open.

Question 9.d.

Address whether TVA intends to correct the condition so that a void cannot accumulate in this location or to add a vent to eliminate a void if it should occur.

Response 9.d.

The GL 2008-01 evaluation of the potential void at this location determined that it is acceptable (see Response 9.c, above). Therefore, no corrective actions are required. However, this location has been identified as an intermediate high point in the HPCI discharge pipe and the fill and vent procedure requires a UT examination at this location when it is refilled after being drained.

Question 10.

On page E1-7 of Enclosure 1 to the October 11, 2008 submittal, TVA indicated that as some pipe segments in the discharge pipe were identified that have unfavorable pipe slope or pipe bow, the operating procedures are being revised to require UT inspection or dynamic venting of some of these locations should this pipe be drained. Address which locations are not being addressed and why that is acceptable.

Response 10.

The potential void locations in the ECCS and DHR system discharge pipes that are not required to be dynamically vented or examined by UT after being refilled are those locations that either cannot be dynamically vented or that contain a potential void with cross sectional area < 20% of the pipe cross sectional area due to configuration. As discussed in Response 5, some configuration precludes a severe hydraulic transient. In these pipe segments, the discharge pipe is full from the pump to the isolation valve and latent voids in nominally horizontal pipe are small enough (i.e., < 20% of pipe cross sectional area) that bubbly flow is maintained during pump start.

In addition, potential void locations in the ECCS and DHR system discharge pipe that is downstream of the injection check valves are not required to be dynamically vented or examined by UT after being refilled as voids in these locations will be at RV pressure and will be not be subject to further compression when flow is initiated. Thus they will be swept to the RV with the injection flow and not cause a hydraulic transient.

Question 11.

On page E1-7 of Enclosure 1 to the October 11, 2008 submittal, TVA indicated that there is a short length of HPCI discharge pipe in the steam tunnel that was not surveyed. The survey of this pipe was identified as being deferred until the next refueling outage for each unit. Further it was indicated that due to the configuration of this pipe, it cannot contain a void that exceeds acceptance criteria. Therefore, TVA intends to no longer survey this pipe in upcoming refueling outages.

Question 11.a.

Address whether the short length of the HPCI discharge pipe discussed will be surveyed in the next outage;

Response 11.a.

The GL 2008-01 evaluation determined that this short length of HPCI pump discharge pipe was not required to be surveyed. This determination was based on its short pipe segment length. The horizontal pipe is < 3 ft in length and the HPCI discharge pipe vent is located on the top of this pipe segment. This pipe received a visual inspection during the last Unit 1 refueling outage and Unit 2 refueling outage and was found to be level. A similar visual inspection is planned during the next Unit 3 refueling outage.

Question 11.b.

Provide the volume of void that could be contained in the steam tunnel piping that was not surveyed;

Response 11.b.

Other than the short horizontal pipe segment described in Response 11.a, above, the remainder of the pipe upstream of the HPCI injection check valve is vertical. Therefore, once the pipe in the steam tunnel has been filled and vented no significant void can be present in this pipe. For this instance, even if this pipe segment were only half full, the void volume would be < 1.5 cubic feet.

Question 11.c.

Provide the acceptance criteria and how they were determined; and,

Response 11.c.

The acceptance criteria for this pipe segment is that it is a short length of pipe (< 3 ft.) and that it was found to be horizontal. This acceptance criteria is consistent with the guidance given in Section 3.4.6 of the May 28, 2009 letter from NRC to the NEI (Ref. 4), as to which horizontal pipe segments should be surveyed (i.e., those over 10 feet in length).

Question 11.d.

Provide a justification for not surveying this pipe given that there may be other voids in the discharge pipe that may interact to exceed allowable criteria.

Response 11.d.

As discussed in Response 11.b, the short length of this horizontal pipe that is level based on visual inspection means that it cannot contain a significant void. As discussed in the Response 9.c, voids in the HPCI pump discharge will be gradually compressed and flow to the RV during HPCI injection without causing a hydraulic transient.

Question 12.

On page E1-7 of Enclosure 1 to the October 11, 2008 submittal, TVA indicated that voids in pipe downstream of the HPCI injection isolation valves do not adversely affect system performance and the survey of this pipe was deferred until the next refueling outage for each unit. Therefore, TVA does not intend to survey this pipe in upcoming refueling outages.

Address why the pipe will no longer be surveyed and provide a basis for the conclusion that the identified voids do not adversely affect system performance.

Response 12.

The pipe discussed on page E1-7 of the October 11, 2008 submittal enclosure is not the pipe downstream of the HPCI pump injection isolation valve that has been the topic of discussion in Questions 9 and 11. This is the HPCI pump discharge pipe downstream of HPCI injection isolation check valve. This pipe segment connects to the main feedwater line. Voids downstream of the HPCI injection check valve are at approximately RV pressure so they are not subject to further compression during HPCI injection. That is, they are swept to the RV during HPCI injection without being subject to further compression. As a result, no discharge pipe pressure transients are caused by voids in the HPCI discharge pipe downstream of the HPCI injection check valve (see Response 10). This is the basis for the conclusion that voids in this pipe do not adversely affect system performance.

Question 13.

Provide the basis for the conclusion that the survey of the ECCS and DHR system pipe did not identify the need for additional vent capability. Although no voids were detected during this survey, address what precludes void formation in the future.

Response 13.

The GL 2008-01 evaluation did not identify the need for additional vent capability because of the following.

- The RHR (or LPCI) pump and CS pump suction pipe from the PSP and the HPCI pump suction pipe from the CST are dynamically vented during periodic pump tests. The HPCI pump suction pipe from the PSP was surveyed and potential latent voids in this pipe total < 1 cubic feet. Any voids that accumulate in excess of this amount will, due to pipe configuration, self vent to the PSP or CST. The suction pipe configuration for all pumps has no designed intermediate high points (i.e., an inverted U in the pipe) and no vent valves. This piping was designed to self vent to the PSP or CST.
- The ECCS discharge pipe that is not dynamically vented during periodic pump tests was surveyed and the potential void cross sectional area met acceptance criteria.
- As discussed in Response 7, the DHR suction pipe from the RV, while not dynamically vented, was evaluated and it was determined that voids in this pipe would not be transported to the pump suction.

As discussed in Response 4, there are no sources of gas in the pipe of these systems.

Question 14.

Consistent with Section 3.3.5 [3.5] of the NRC's May 28, 2009 letter, provide a summary of those procedures which:

Question 14.a.

Describe the TS surveillances for the subject systems;

Response 14.a.

The description of the Browns Ferry Nuclear Plant procedures for TS Surveillances associated with managing gas accumulation for the Core Spray, RHR and HPCI systems is as follows.

Procedures Credited for Static Venting:

1,2,3-SR-3.5.1.1(CS I), CS System Venting Loop I
These procedures are performed once per 31 days in Modes 1 though 5. The procedures require venting of the Core Spray loop 1 highpoint piping immediately upstream of the injection valve. Gas releases are timed using a stopwatch. A Problem Evaluation Report (PER) is currently required to be initiated if a gas release is detected. Gas releases are currently trended by the system engineer through the PER process.

1,2,3-SR-3.5.1.1(CS II), CS System Venting Loop II
These procedures are performed once per 31 days in Modes 1 though 5. The procedures require venting of the Core Spray loop 2 highpoint piping immediately upstream of the injection valve. Gas releases are timed using a stopwatch. A PER is currently required to be initiated if a gas release is detected. Gas releases are currently trended by the system engineer through the PER process.

1,2,3-SR-3.5.1.1(RHR I), RHR System Venting Loop I
These procedures are performed once per 31 days in Modes 1 though 5. The procedures require venting of the A and C RHR pumps, the A and C RHR heat exchangers, portions of the unit to unit cross tie piping, the piping immediately upstream of the loop I LPCI injection valve, and a portion of the RHR containment spray header. Gas releases are timed using a stopwatch. A PER is currently initiated if a gas release is detected. Gas releases are currently trended by the system engineer through the PER process. In accordance with procedure, Unit 1 currently performs UT on the Loop I LPCI injection piping instead of venting due to a degraded condition as described in the March 2, 2009 submittal (Ref. 5).

1,2,3-SR-3.5.1.1(RHR II), RHR System Venting Loop II
These procedures are performed once per 31 days in Modes 1 though 5. The procedures require venting of the B and D RHR pumps, the B and D RHR heat exchangers, portions of the unit to unit cross tie piping, the piping immediately upstream of the loop II LPCI injection valve, and a portion of the RHR containment spray header. Gas releases are timed using a stopwatch. A PER is currently initiated if a gas release is detected. Gas releases are currently trended by the system engineer through the PER process. In accordance with procedure, Unit 1 currently performs UT on the Loop II LPCI injection piping instead of venting due to a degraded condition as described in the March 2, 2009 (Ref. 5).

1,2,3-SR-3.5.1.1(HPCI), Maintenance Of Filled HPCI Discharge Piping
These procedures are performed once per 31 days in Modes 1 though 3. The procedures require venting of the HPCI discharge piping highpoint immediately upstream of the injection check valve. Gas releases are timed using a stopwatch.

A PER is currently initiated if a gas release is detected. Gas releases are currently trended by the system engineer through the PER process.

Procedures Credited for Dynamic Venting:

1,2,3-SR-3.5.1.6(CS I) and 1,2,3-SR-3.5.1.6(CS II)
These procedures are the Quarterly Core Spray Flow Rate tests that are performed once per 92 days. These procedures also flush the Core Spray suction piping from the torus and the discharge piping to the torus.

1,2,3-SR-3.5.1.6(CS I-COMP) and 1,2,3-SR-3.5.1.6(CS II-COMP)
These procedures are the Core Spray Comprehensive Pump Tests that are performed at least once per 24 months. These procedures also flush the Core Spray suction piping from the torus and the discharge piping to the torus.

1,2,3-SR-3.5.1.6 (RHR I) and 1,2,3-SR-3.5.1.6 (RHR II)
These procedures are the Quarterly RHR System Rated Flow Tests that are performed once per 92 days in Modes 1 through 5. These procedures also flush the RHR suction piping from the torus and the discharge piping to the torus including the RHR heat exchangers.

1,2,3-SR-3.5.1.6 (RHR I-COMP) and 1,2,3-SR-3.5.1.6 (RHR II-COMP)
These procedures are the RHR Comprehensive Pump Tests that are performed once per 24 months. These procedures also flush the RHR suction piping from the torus and the discharge piping to the torus including the RHR heat exchangers.

1,2,3-SR-3.5.1.7, HPCI Main And Booster Pump Set Developed Head And Flow Rate Test At Rated Reactor Pressure
These procedures are performed once per 92 days. These procedures also flush the HPCI suction piping from the CST and the discharge piping to the torus.

1,2,3-SR-3.5.1.7(COMP), HPCI Comprehensive Pump Test
These procedures are performed once per 24 months. These procedures also flush the HPCI suction piping from the CST and the discharge piping to the torus.

1,2,3-SR-3.5.1.8, HPCI Main And Booster Pump Set Developed Head And Flow Rate Test At 150 psig Reactor Pressure
These procedures are performed once per 24 months using 150 psig steam pressure. These procedures also flush the HPCI suction piping from the CST and the discharge piping to the torus.

Question 14.b.

Describe the fill and vent operations used for the subject systems;

Response 14.b.

The description of the Browns Ferry Nuclear Plant procedures for fill and vent operations for the Core Spray, RHR and HPCI Systems is as follows.

1,2,3-OI-75 are the Core Spray Operating Instructions. These Operating Instructions contain sections to fill and vent Loop I and Loop II piping separately. The filling and venting steps include opening suction and discharge piping vents up to the injection valves. A UT is performed at the system highpoint after the fill is performed. This is immediately upstream of the injection valve. The Operating Instructions also include steps to fill piping downstream of the injection valve if access to the drywell is allowed. The Operating Instructions have a note to perform a dynamic vent by running the Core Spray pumps if the piping upstream of the injection valve has been drained.

1,2,3-OI-74 are the RHR Operating Instructions. These Operating Instructions contain sections to fill and vent Loop I and Loop II piping. The filling and venting steps include opening suction and discharge piping vents up to the injection valves. A UT is performed at the LPCI injection highpoint and the RHR Containment Spray highpoint after the fill is performed. This is immediately upstream of the injection valves. The Operating Instructions also include, or are being revised to include, steps to fill piping downstream of the injection valve if access to the drywell is allowed. The revisions to the Operating Instructions are expected to be complete by September 30, 2009. The Operating Instructions have a note to perform a dynamic vent by running the RHR pumps if the piping upstream of the injection valve has been drained.

1,2,3-OI-73 are the HPCI Operating Instructions. These Operating Instructions contain sections to fill and vent HPCI piping. The filling and venting steps include opening suction and discharge piping vents up to the injection valve. A UT is performed at the discharge piping highpoint after the fill is performed. This is immediately upstream of the injection check valve. Unit 3 Operating Instruction has the additional requirement to perform a UT inspection on some adversely sloped discharge piping. The Operating Instructions have a note to perform a dynamic vent by running the HPCI pump if the piping upstream of the injection valve has been drained.

Question 14.c.

Describe the design engineering process related to gas accumulation; and,

Response 14.c.

NPG Standard Programs and Processes procedure SPP-9.3, Plant Modifications and Engineering Change Control, was revised to include the following question in the Technical Evaluation "Does the change affect the system configuration, system control, or system operation in such a manner that the change introduces or increases the potential for gas accumulation to occur such that it adversely affects the ability of the system to perform its design function(s)? If YES, additional review is required to eliminate unacceptable gas accumulation. Ref. GL 2008-01." At Browns Ferry Nuclear Plant, Technical Evaluations are required to be performed for modifications to the plant in accordance with standard procedure SPP-9.3.

Question 14.d.

Describe the ECCS and related system operations.

Response 14.d.

A summary description of the Browns Ferry Nuclear Plant ECCS subsystems included in the Generic Letter 2008-01 evaluation is as follows.

- The HPCI System consists of a steam driven turbine pump unit, piping, and valves to provide steam to the turbine, as well as piping and valves to transfer water from the suction source to the core via the feedwater system line, where the coolant is distributed within the RV through the feedwater sparger. Suction piping for the system is provided from the CST and the suppression pool. Pump suction for HPCI is normally aligned to the CST source to minimize injection of suppression pool water into the RV. However, if the CST water supply is low, or if the suppression pool level is high, an automatic transfer to the suppression pool water source ensures a water supply for continuous operation of the HPCI System. With HPCI taking suction from the condensate storage tank and injecting to the reactor vessel, there is sufficient inventory in the tank such that the high suppression pool level suction transfer will occur before a low condensate header level would be created. The steam supply to the HPCI turbine is piped from a main steam line upstream of the associated inboard main steam isolation valve.

- The CS System is composed of two independent subsystems. Each subsystem consists of two 50% capacity motor driven pumps, a spray sparger above the core, and piping and valves to transfer water from the suppression pool to the sparger. The CS System is designed to provide cooling to the reactor core when reactor pressure is low. Upon receipt of an initiation signal, the CS pumps in both subsystems are automatically started. When the RV pressure drops sufficiently, CS System flow to the RV begins. A full flow test line is provided to route water from and to the suppression pool to allow testing of the CS System without spraying water in the RV.

- LPCI is an independent operating mode of the RHR System. There are two LPCI subsystems, each consisting of two motor driven pumps and piping and valves to transfer water from the suppression pool to the RV via the corresponding recirculation loop. The two LPCI pumps and associated motor operated valves in each LPCI subsystem are powered from separate 4 kV shutdown boards. Both pumps in a LPCI subsystem inject water into the reactor vessel through a common inboard injection valve and depend on the closure of the recirculation pump discharge valve following a LPCI injection signal.

A more detailed description of the Browns Ferry Nuclear Plant ECCS is provided in UFSAR Chapter 6, Emergency Core Cooling System.

A description of the associated ECCS operating procedures is provided in Responses 14.a and 14.b above.

Question 15.

Following the walkdowns described in the March 2, 2009 submittal, the RHR and CS system operating instructions 1-OI-74 and 1-OI-75, respectively, that address fill and vent operations, were revised to address venting of piping downstream of the injection valves. However, on Page E-5 Item 4 of the submittal lists the procedures changes as applying to all piping and adds UT inspection to dynamic venting. Clarify the extent of those procedure changes or "enhancements" identified in the submittal.

Response 15.

The response to Item 8, Page E1-8, in the October 11, 2008 submittal enclosure (Ref. 2) stated that the ECCS and DHR System operating procedures provided adequate instructions for filling and venting. However, as enhancements to minimize voiding, actions were identified to revise the procedures to ensure that the LPCI lines are vented at the optimum high point (Page E1-12, Table 1, Item 3). In this same section and page of the submittal enclosure, based on nuclear industry operating experience reviews, additional enhancement actions were in progress to revise the ECCS and DHR operating procedures to require the UT inspection or dynamic venting of locations that could contain a significant void if the pipe were drained (Page E1-12, Table 1, Item 4).

During the Fall 2008 Unit 1 refueling outage, the normally inaccessible piping walkdowns were performed and additional enhancements to procedures were identified. As discussed on Page E-2 of the March 2, 2009 submittal enclosure (Ref. 5), the piping downstream of the RHR and CS injection valves was found to be elevated above any existing vent locations (i.e., void formations may be possible) and the piping was found to contain venting configurations that were not presently used.

The October 11, 2008 submittal (Ref. 2) addressed the potential for air void downstream of the injection piping on Pages E-2 and E-3 and concluded that voids in this particular section of piping were inconsequential. Therefore, the extent and intent of the procedure change described in the March 2, 2009 submittal (Ref. 5) was to provide an opportunity, prior to primary containment (drywell) closeout (if the lines had been drained) for personnel to confirm that the normally inaccessible piping downstream of the injection valves is as full as practicable. Like the previous procedure changes, this change added an additional barrier to prevent inadequate filling of a safety system and was completed prior to issuance of the submittal. Thus, Item 4 was not changed in the March 2, 2009 submittal (Ref. 5) other than to provide a status as "complete." A new action item for this last enhancement was not added to Table 1 as it was thoroughly discussed in and completed prior to the submittal.

To complete the discussion of procedure changes addressed in the March 2, 2009 submittal enclosure (Ref. 5), as described on Page E-3, the Unit 1 LPCI line venting was not practical and the corrective action (Page E1-12, Table 1, Item 3) for Unit 1 was revised to require procedure revisions to use UT examinations instead of LPCI injection valve bonnet venting.

Note that, contrary to Question 15 above, Item 4 does not list the procedure changes as applying to all piping but only to locations that could contain a significant void should this pipe be drained. Further, for these locations, Item 4 states that the Operating Instructions (OIs) are being revised to require UT inspection or dynamic venting, not both activities.

Question 16.

On page E1-10 Enclosure 1 to the October 11, 2008 submittal, TVA stated that the ECCS and DHR system operating procedures are being revised to require UT inspection or dynamic venting of locations that could contain a significant void should the discharge piping be drained. Provide a quantitative definition of "significant void."

Response 16.

The GL 2008-01 evaluation did not establish a quantitative definition of "significant void." The designation "significant void" is assigned to any potential void locations in the discharge pipe that are dynamically vented during periodic full flow pump tests. That is, if any discharge pipe can be dynamically vented by a full flow pump test then it is assumed to contain a "significant void" after being drained and is required to be dynamically vented (see Response 8.a). In addition, the void location identified in Question 9 is also assumed to contain a "significant void" after being drained and then is required to be examined by UT.

Question 17.

Training was not identified in the GL but is considered to be a necessary part of applying procedures and other activities when addressing the issues identified in the GL. Provide a brief discussion on training including what training is currently provided, to whom, on what frequency, and whether additional changes to the training program are intended to be made.

Response 17.

Browns Ferry Nuclear Plant operator training material is based on procedural requirements. As a part of maintaining accurate training material, procedure revisions are reviewed to determine potential impact on the operator training materials. In addition to lesson plans, the Required Reading Program is also used to ensure the operators maintain an accurate picture of procedural requirements. The procedures revised due to GL 2008-01 (Ref. 6) were screened and appropriate actions taken. In this particular case, the procedure revisions were described in the Required Reading Program. To date, required reading for Licensed and Non-Licensed Operators in quarterly Cycles 1, 3, and 4 of fiscal year 2009 have contained information derived from procedure revisions associated with GL 2008-01 (Ref. 6).

Question 18.

On page E1-10 Enclosure 1 to the October 11, 2008 submittal, TVA stated BFN states that "procedures ... are being revised to require that, for an extended gas release in the ECCS and DHR System, a report is entered into the Corrective Action Program." Define "an extended gas release." Provide the justification for not entering the Corrective Action Program every time a void is identified during operation.

Response 18.

The venting procedures used to meet the requirements of TS SR 3.5.1.1 and SR 3.5.2.2 currently require that any gas release during venting is entered into the Corrective Action Program (CAP). Analyses are being performed to establish a time that bubbles may be observed in the flow stream from the vent locations due to voids in the vent piping only (i.e., voids in the vent pipe from its connection to the ECCS and DHR system discharge pipe to the end of the vent pipe). As discussed in Responses 2 and 4, the ECCS and DHR system discharge pipe is expected to be full of water at all times so any bubbles discharged subsequent to the purging of the vent pipe would indicate a condition requiring further evaluation. As a result, after the analyses are completed and associated venting procedures revised, a PER would be generated any time the volume of gas detected during venting is indicative of gas accumulation in the associated system(s).

References

1. BWR Owners' Group Technical Report: ECCS Pumps Suction Void Fraction Study, Revision 0, GE Hitachi Nuclear Energy Report No. 0000-0087-5676-R0, dated August 2008.

2. Letter from TVA to NRC, "Browns Ferry Nuclear Plant (BFN) Units 1, 2 and 3, Sequoyah Nuclear Plant (SQN) Units 1 and 2, and Watts Bar Nuclear Plant (WBN) Unit 1 – 9 Month Response to NRC Generic Letter (GL) 2008-01: Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems, dated January 11, 2008," dated October 11, 2008.

3. NUREG/CR-5535, RELAP5/MOD3 Code Manual, Volume 1, dated August 1995.

4. Letter from NRC to the Nuclear Energy Institute (NEI), "Preliminary Assessment of Responses to Generic Letter 2008-01, 'Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems,' and Future Nuclear Regulatory Commission Staff Review Plans," dated May 28, 2009.

5. Letter from TVA to NRC, Browns Ferry Nuclear Plant (BFN) Unit 1 – Nine-Month Supplemental (Post-Outage) Response to Nuclear Regulatory Commission (NRC) Generic Letter (GL) 2008-01, dated March 2, 2009.

6. Generic Letter 2008-01, Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems, dated January 11, 2008.