VERMONT YANKEE
NUCLEAR POWER CORPORATION
185 OLD FERRY ROAD, PO BOX 7002, BRATTLEBORO, VT 05302-7002
(802) 257-5271

June 22, 2000
BVY 00-60

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

References:

(a) Letter, USNRC to VYNPC, "Request for Additional Information Regarding Generic Letter (GL) 96-06 at Vermont Yankee Nuclear Power Station (TAC No. M96880)," NVY 98-97, dated July 10, 1998.

(b) Letter, VYNPC to USNRC, "Response to NRC RAI Related to GL 96-06 Response," BVY 98-153, dated October 30, 1998.

(c) Letter, USNRC to VYNPC, "Request for Additional Information Regarding Generic Letter 96-06 Program at Vermont Yankee Nuclear Power Station (TAC No. M96880)," NVY 99-25, dated March 1, 1999.

(d) Letter, VYNPC to USNRC, "Response to Request for Additional Information Concerning GL 96-06," BVY 99-97, dated July 27, 1999.

(e) Letter, VYNPC to USNRC, "Response to Request for Additional Information Concerning GL 96-06," BVY 99-118, dated September 16, 1999.

(f) Letter, VYNPC to USNRC, "Update of Vermont Yankee's Plans to Address GL 96-06," BVY 99-136, dated October 29, 1999.

(g) Letter, VYNPC to USNRC, "Response to Request for Additional Information Concerning GL 96-06," BVY 00-35, dated March 29, 2000.

(h) Letter, USNRC to VYNPC, "Vermont Yankee Nuclear Power Station, Request for Additional Information Regarding Generic Letter (GL) 96-06," NVY 00-46, dated May 16, 2000.

Subject: **Vermont Yankee Nuclear Power Station**
License No. DPR-28 (Docket No. 50-271)
Response to Request for Additional Information Regarding GL 96-06

Generic Letter (GL) 96-06, "Assurance of Equipment Operability and Containment Integrity During Design-Basis Accident Conditions," dated September 30, 1996, included a request for licensees to evaluate cooling water systems that serve containment air coolers to assure that they are not vulnerable to waterhammer and two-phase flow conditions. By letters dated October 30, 1998, July 27, 1999, September 16, 1999, October 29, 1999 and March 29, 2000, Vermont Yankee (VY) provided responses and status to the Commission on this issue.

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On May 4, 2000, a telephone conference call was held with members of your Staff to discuss and clarify our previous submittals on this subject. Reference (h) summarized the additional information that we agreed to submit to assist in resolution of this issue. As we discussed in our telephone conference call, VY referenced the EPRI Interim Report, TR-113594, to establish the credentials of Altran Corporation in performing these type of analyses for our plant. You are aware of Altran Corporation's involvement in the EPRI program, however, VY is not participating, nor are we relying on the EPRI work. Altran has performed plant specific analysis for VY on this issue.

Attachment 1 to this letter provides supplemental information pertaining to our GL 96-06 response based upon questions discussed during our May 4, 2000 telecon.

Attachment 2 to this letter is a copy of our analysis for your review. This analysis is considered proprietary information by Altran Corporation. In accordance with 10CFR2.790(b)(1), an affidavit attesting to the proprietary nature of the information (report) is enclosed. Additionally, the analysis is current as of the date of this submittal and it is not VY's intent to maintain the docket current with regard to future revisions to this analysis.

If you have any questions concerning this submittal or desire additional information, please contact Mr. Jeffrey Meyer at (802) 258-4105.

Sincerely,

VERMONT YANKEE NUCLEAR POWER CORPORATION

Don M. Leach
Vice President, Engineering

Attachment

cc USNRC Region 1 Administrator
USNRC Project Manager – VYNPS
USNRC Resident Inspector – VYNPS
Vermont Department of Public Service w/o proprietary attachment

SUMMARY OF VERMONT YANKEE COMMITMENTS

BVY NO.: 00-60

The following table identifies commitments made in this document by Vermont Yankee. Any other actions discussed in the submittal represent intended or planned actions by Vermont Yankee. They are described to the NRC for the NRC's information and are not regulatory commitments. Please notify the Licensing Manager of any questions regarding this document or any associated commitments.

COMMITMENT	COMMITTED DATE OR "OUTAGE"
None	N/A

Attachment 1

Vermont Yankee Nuclear Power Station

Response to Request for Additional Information Regarding Generic Letter 96-06

Attachment 1

Supplemental Information for the Vermont Yankee Submittal for Generic Letter 96-06

References:

(1) Altran Technical Report 99251-TR-001, Rev. 0, "Drywell Cooler Response to a Simultaneous LOCA & LOOP Event."
(2) Altran Technical Report 99251-TR-002, Rev. 0, "Analysis of the RBCCW Piping for LOCA/SLB and LOOP Conditions."
(3) NUREG/CR-6519, "Screening Reactor Steam/Water Piping Systems for Water Hammer," 1997.
(4) E.B. Wylie, V.L. Streeter, "Fluid Transients in Systems," Prentice Hall, 1993.
(5) Kreith, "Principles of Heat Transfer," International Textbook Company, 1965.

The Reference (1) and (2) technical reports address the effects on the Reactor Building Closed Cooling Water (RBCCW) system of a Loss of Offsite Power (LOOP) concurrent with a Loss of Coolant Accident (LOCA) or Steam Line Break (SLB) event. The 99251-TR-001 report provides an analysis of the RBCCW system thermodynamic response and evaluation of predicted waterhammer loads, and the 99251-TR-002 report provides a qualification of the piping system and supports under these loading conditions.

The RBCCW system at Vermont Yankee (VY) is a closed loop system supplied by two non-safety related RBCCW pumps. Pump suction head is maintained by a head tank. Inside the Drywell, the system consists of a header feeding four Drywell coolers (RRUs), two Recirculation pumps, and a sump cooler. The only safety related function of the RBCCW system in the Drywell is to maintain containment integrity.

The analyses documented in the referenced technical reports determined that two types of waterhammer can potentially affect the RBCCW system. The first is a condensation induced waterhammer (CIWH) which may occur under a combined LOOP/SLB when the Drywell heats the RBCCW water through the RRUs and introduces hot steam voids. If these voids progress into the sub-cooled water in the header pipe, rapid condensation can lead to CIWH events. The CIWH may occur during the voiding phase of the event, or during the refill phase before all the voids are closed. However, the CIWH events are expected to have minimal impact on the system. A second waterhammer that may occur is brought about by the final closure of the steam voids when the system refills. This event is referred to as column closure waterhammer (CCWH) or column rejoin waterhammer, and is primarily driven by the velocity of the refilling water from the RBCCW pumps.

Two issues are addressed in this letter: 1) the evaluation of condensation induced waterhammer and 2) the evaluation of column closure waterhammer. Each of these items is addressed below:

Condensation Induced Waterhammer

Condensation induced waterhammer events during the voiding phase of the transient were determined to be bounded by the column closure waterhammer when the system refilled. Three factors contribute to this conclusion. These include the effects of non-condensable gas, sub-cooling margin, and piping geometry/waterhammer impulse.

Non-condensables

Non-condensable gas will exist in the steam void and in the water. This will reduce sonic velocities and the magnitude of the CIWH impact. NUREG/CR-6519 (Ref. 3) indicates that a sonic velocity of 2000 ft/sec was common in CIWH tests performed at MIT, and two phase mixtures at low pressure could be as low as 30 ft/sec. These low sonic velocities in water streams with very small amounts of gas or steam are also supported by Reference (4). Waterhammers occurring in these conditions will be very small. Released non-condensable gas in the water will also "soften" the water column impact by spreading out the rise time. For the purpose of pipe structural loading, which is based on the differential pressure across a pipe segment, the longer rise time will greatly reduce piping and support loads. The CCWH which bounds the expected CIWH loads and was used in the structural qualification, featured a very conservative 2 millisecond (ms) rise time.

Sub-cooling

A sub-cooling margin of 36°F (Ref. 3) is typically required for rapid steam condensation. In a draining open loop system, the draining fluid is principally driven by gravity forces and the steam void will expand to follow the draining fluid into subcooled pipe. In the VY closed loop system, gravity forces on the fluid will resist the expansion of the steam void. As the steam void pushes through the individual RRU piping and to the header, the condensation process will consume steam and heat the piping and surrounding fluid. This is likely to produce steam voids surrounded by hot water at a similar temperature. CIWH is therefore unlikely during the draining and refilling stages of the transient.

Geometry/Impulse

The mass of the column of water and volume of the steam void into which it can expand are limited by the geometry of the VY RBCCW system. The physics of CIWH are based on the system pressure driving a mass of water into a rapidly condensing steam void. One measure of the energy of the pressure pulse is defined by the impulse, which is the product of the pulse magnitude and duration (Pressure x Time). With a limited water slug size and acceleration length, the impulse of the CIWH is much less than the impulse of the CCWH used to qualify the system. For example, the CCWH pressure pulse magnitude and duration for which the structural qualification was performed were 267 psig and 167 ms, respectively, with an impulse of 44.5 psi-sec (267 psi x .167 sec = 44.5 psi-sec). To achieve the same impulse, a CIWH would require a 35′ column of water to be accelerated for 35 feet under a constant driving pressure of 60 psi. The lengths of pipe and amount of steam generated by the VY system do not support CIWH of this magnitude.

<u>Column Closure Waterhammer</u>

Column closure waterhammers were calculated using a method of characteristics approach based on the published model by Dr. E. B. Wylie (Reference 4). This method considers the dynamic behavior of the water column which is accelerated by the restarted RBCCW pumps and the pressurization of steam and non-condensable gas in the voided piping to determine the column closure waterhammer pressure pulse. Significant conservatisms in the model are discussed below. These include the effects of non-condensable gas release, sonic velocity, and heat transfer.

Non-Condensable Gas Release

In the CCWH analysis, credit was taken for the cushioning effects of non-condensable gas which is liberated from the RBCCW system fluid during the boiling/void formation process. A very conservative model was used to estimate non-condensable gas release. No credit was taken for oxygen in the system, since some of the oxygen may be scavenged by corrosion inhibitors and the pipe wall. Therefore, only the remaining nitrogen was assumed to be liberated. The amount of nitrogen that was credited as being present in the void corresponded to the amount of gas in the steam that could be condensed during the event, leaving behind the non-condensable gas. This model is therefore independent of the steam creation process, and this model conservatively does not credit nitrogen liberated by heating the water. Only the nitrogen "left behind" by the condensation process was credited in the void. If credit had been taken for release of non-condensables during the boiling process the amount of gas may have been a factor of ten greater. The additional gas would have significantly reduced the waterhammer pulse predictions. The gas release model was therefore very conservative.

Sonic Velocity

The sonic velocity in water was defined in the model, and this value directly affects the prediction of waterhammer pressure. The Joukowski equation provides waterhammer pressure pulse (ΔP) as a function of water density (ρ), sonic velocity (C), and velocity change (ΔV) and a constant, usually taken as ½ for water on water column closure (Reference 4):

$$\Delta P = \tfrac{1}{2}\rho C \Delta V$$

It can be seen that a decrease in sonic velocity will linearly affect waterhammer pressure pulse magnitude. As stated previously, values as low as 2000 ft/sec are common when non-condensables and pipe flexibility are taken into account. In the VY model, a very conservative value of 4500 ft/sec was used.

Heat Transfer

The temperature of the water at the steam/water interface would be approximately the same as the steam void temperature. This is due to contact between water and steam during the transient, passage of the water through the RRUs as the system refills, and heating from the hot pipes, through which the water is flowing. When the pumps restart, negligible condensation would occur, the water column upstream and downstream of the void would move at nearly the same velocity, and the void would be pushed downstream. Eventually some cooler piping would be encountered and, as the steam was consumed by condensation, the columns would close. The impulse associated with this closure would be relatively small because the void can travel downstream into the proximity of reflection surfaces. If more heat transfer occurred during the closure process then more steam would be consumed, the void pressure would be lowered, the closure velocity increased, and therefore an increase in the column closure waterhammer magnitude would result.

For conservatism, more heat transfer was therefore imposed. A conservative approach was taken where the CCWH was forced to occur sooner by reducing the water temperature to 20°F below the temperature of the steam. This conservatively reduced steam void pressure, increased the waterhammer closure velocity and therefore increased the waterhammer pressure magnitude. In addition, the impulse was conservatively large because the distance to free/reflective surfaces was increased.

A heat transfer coefficient between the water column and the steam in the void is necessary to define the behavior of the steam at this interface. Typical condensation coefficients are 1000 to 20,000 BTU/hrft^{2}F per Kreith (Ref. 5). To account for a potentially irregular condensing surface, the heat transfer coefficient was increased by more than a factor of three beyond the upper bound in Kreith and the condensing surface area was assumed to be the upstream and downstream water flow areas.

Based on the conservative air release, sonic velocity, and heat transfer methods the MOC modeling technique is conservative and appropriate for the VY analysis.

Attachment 2

Vermont Yankee Nuclear Power Station

Response to Request for Additional Information Regarding Generic Letter 96-06

(Proprietary Information)

AFFIDAVIT OF MOHSEN A. EISSA

1. I am Senior Vice President, Altran Corporation (Altran), and as such have the responsibility of reviewing the proprietary information sought to be withheld from public disclosure in connection with the nuclear plant analysis, and am authorized to apply for its withholding on behalf of Altran.

2. I am making this affidavit in conformance with the provisions of 10 CFR 2.790 of the regulations of the Nuclear Regulatory Commission (NRC) and in conjunction with Altran's application for withholding, which accompanies this affidavit.

3. Pursuant to the provisions of Paragraph (b)(4) of 10 CFR 2.790, the following is furnished for consideration by the NRC in determining whether the information sought to be withheld from public disclosure should be withheld.

   (i) The information sought to be withheld from public disclosure is owned by Altran and has been held in confidence by Altran and its consultants.

   (ii) The information is of a type that would customarily be held in confidence by Altran. The information consists of analysis methodology details, analysis results, testing results, supporting data, and aspects of development programs relative to a method of analysis that provides a competitive advantage to Altran.

   (iii) The information was transmitted to the NRC in confidence and under the provisions of 10 CFR 2.790, it is to be received in confidence by the NRC.

   (iv) The information sought to be protected is not available in public to the best of our knowledge and belief.

   (v) The proprietary information sought to be withheld in the submittal is Altran Technical Report 99251-TR-001, Rev. 1, "RBCCW Response to a Simultaneous LOCA/SLB & LOOP Event."

   This information enables Altran to support BWR and PWR plants with analyses in response to USNRC Generic Letter 96-06.

   (vi) The proprietary information sought to be withheld from the public disclosure has substantial commercial value to Altran.

      (a) Altran intends to sell the information to nuclear utilities for the purpose of supporting the operation and licensing of nuclear power plants.

      (b) The subject information could only be duplicated by competitors at similar expense to that incurred by Altran.

4. Public disclosure of this information is likely to cause harm to Altran because it would allow competitors in the nuclear industry to benefit from the results of a significant development program without requiring a commensurate expense or allowing Altran to recoup a portion of its expenditures or benefit from the sale of the information.

Mohsen A. Eissa, being duly sworn, on his oath deposes and says that he is the person who subscribed his name to the foregoing statement and that the matters and facts set forth in the statement are true.

Mohsen A. Eissa, Sr. Vice President

Sworn to and subscribed before me this 6th day of June, 2000. Witness my hand and official seal.

Josette M. Rispettoso
Notary Public

My commission expires 6/18/04