Confidential Information Submitted Under 10 CFR 2.390

December 31, 2008

TVA-WBN-TS-08-04 10 CFR 50.90

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

Gentlemen:

In the Matter of	)	Docket No. 50-390
Tennessee Valley Authority (TVA)	)	

WATTS BAR NUCLEAR PLANT (WBN) UNIT 1 - RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION RE: WATTS BAR EMERGENCY CORE COOLING SYSTEM BORON REQUIREMENTS (TAC NO. MD9396)

The purpose of this letter is to respond to NRC's request for additional information (RAI) dated October 28, 2008.

This RAI is related to Tennessee Valley Authority (TVA) license amendment request dated August 1, 2008. The NRC's concerns identified in this RAI are related to the methodology used to evaluate potential boron precipitation, sump dilution, and subcriticality following a postulated large break loss of coolant accident for core designs with increased inventory of Tritium Producing Burnable Absorber Rods (TPBARs).

TVA's response to this RAI is given in Enclosures 1 and 2. Enclosure 1 is the Westinghouse proprietary response. Enclosure 2 is the Westinghouse non-proprietary response. Enclosure 3 is the Westinghouse authorization letter with accompanying affidavit, Proprietary Information Notice, and Copyright Notice. The affidavit sets forth the basis on which the information may be withheld from public disclosure by the Commission, and addresses with specificity the considerations listed in 10 CFR 2.390(b)(4) of the Commission's regulations, and TVA hereby requests that the Westinghouse proprietary information be withheld from public disclosure in accordance with the aforementioned regulation.

Correspondence with respect to the copyright or proprietary aspects of the items listed above or the supporting Westinghouse affidavit should be addressed to J. A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company, LLC, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

There are no regulatory commitments associated with this submittal. If you have any questions concerning this matter, please call me at (423) 365-1824 or Robert Clark at (423) 365-1818.

A002
D030
NRR

I declare under penalty of perjury that the foregoing is true and correct. Executed on this 31st day of December, 2008.

Sincerely,

Original signed by Christopher J. Riedl

C. J. Riedl (acting for M. K. Brandon
Manager, Site Licensing and
Industry Affairs)

Enclosures:

1. Response to NRC Request for Additional Information (proprietary)
2. Response to NRC Request for Additional Information (non-proprietary)
3. Westinghouse Affidavit, Proprietary Information Notice, Copyright Notice

cc: See Page 3

Enclosures
cc (Enclosures 1-3):

Mr. John G. Lamb, Senior Project Manager
U.S. Nuclear Regulatory Commission
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation
MS 0-8H1A
Washington, DC 20555-0001

cc (Enclosure 2):

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ENCLOSURE 2

Response to NRC Request for Additional Information (Non-Proprietary)

Question 1: Inclusion of Emergency Core Cooling System (ECCS) Boron Requirements in the Core Operating Limits Report (COLR)

Nuclear Regulatory Commission (NRC) Generic Letter (GL) 88-16, "Removal of Cycle-Specific Parameter Limits from Technical Specifications (TSs)" provides a means by which licensees may avoid cycle-specific revisions to the TSs by modifying the TSs to note that cycle-specific parameters shall be maintained in a COLR, which is provided to the NRC for information on a cycle-specific basis. To implement the GL 88-16 guidance, licensees are required to maintain, in their TSs, references to NRC-approved methodologies that are used to determine the parameter operating limits. If the methodology is plant-specific, a reference to the NRC safety evaluation approving the use of the methodology is alternatively required.

TVA proposes to implement the guidance contained in GL 88-16 to provide discreet levels of ECCS boron concentration requirements. Each level would be specified in the applicable Surveillance Requirement, and the specific level determined for the cycle would be specified in the COLR. To support this request, the licensee has proposed a COLR reference to WCAP-16932-P, Revision 1, as approved by the NRC staff's safety evaluation.

However, WCAP-16932-P describes the technical adequacy of an assumption crediting control rod insertion for certain postulated post-LOCA scenarios, in which trip reactivity is required for post-LOCA subcriticality. Hence, this proposed reference appears inappropriate, because it does not contain the methodology used to determine the cycle-specific ECCS boron concentration requirement.

Additionally, the NRC staff believes that a strong contingent of the cycle-to-cycle variability in required ECCS boron concentration is the inventory of TPBARs in the core. This belief is supported by, among other things, the fact that a previously approved request submitted by the Watts Bar licensee provided discreet levels of boron concentrations based solely on the TPBAR inventory.

In light of these considerations, please provide the following additional information:
Revise your proposed TS reference so that it accurately reflects a methodology document describing explicitly how the boron concentration level published in the COLR will be determined.

Explain what additional cycle-specific design considerations warrant your proposed boron concentration requirements' inclusion in the COLR as opposed to in the TSs. Why is this proposal inconsistent with your previous TS requirement?

Response:

At this time, the current ECCS minimum boron concentrations will be retained, i.e., the three discrete levels for the ECCS minimum boron concentrations will not be implemented. Instead, a revised License Amendment Request (LAR) will only seek approval for increasing the maximum allowed number of TPBARs from the current level of 400 TPBARs to 704 TPBARs. Thus, the new LAR is analogous to the LAR for Amendment 67, which increased the maximum TPBAR inventory from 240 to 400 TPBARs. Consequently, no changes to the references in the COLR will be required since no methodology changes are being implemented. The revised LAR will include an analysis of a representative core design with 704 TPBARs to demonstrate that subcriticality can be achieved for a typical design using the current ECCS boron concentrations.

It should be noted, however, that the required ECCS minimum boron concentrations are not solely or primarily a function of the number of TPBARs. For a given core design, the required ECCS boron concentrations (RWST and accumulators) are a function of the excess reactivity of that core design at post-LOCA conditions. In this context, the "excess reactivity" is the core reactivity controlled by the soluble boron in the reactor coolant. The number of TPBARs in the core design is just one factor that affects the core excess reactivity. Other factors, such as the design cycle energy, fuel enrichments, and the presence of other burnable absorbers, are also important. For example, it is possible for two core designs to have exactly the same TPBAR inventories but vastly different excess reactivity and ECCS boron requirements. Depending on the details of the core designs, a core with a cycle energy of 12 Effective Full Power Months (EFPM) could have much lower ECCS boron requirements than a core designed to operate for 24 EFPM, even though both designs have exactly the same TPBAR inventories.

The boron concentration required to keep the core subcritical at post-LOCA conditions for long term cooling will be determined using the same methodology approved as part of Amendment No. 67 in January of 2008. In this methodology, no control rod credit is assumed. The ECCS minimum boron concentrations and their resultant mixed mean sump boron concentration must be sufficient to ensure subcriticality. The available sump boron is a function of the RWST and accumulator minimum boron concentrations. Subcriticality margin is determined by comparing the critical boron concentration to the available sump boron concentration. If the available sump boron concentration is insufficient, the core design must be changed or the ECCS minimum boron concentrations must be increased, which would require a license amendment. Post-LOCA subcriticality is part of the Reload Safety Evaluation process and is evaluated for each core design. Additional details on the methodology are provided in the response to Question 3.

Question 2: Analytic Basis for ECCS Boron Concentration Requirements.

As required by 10 CFR 50.46, each pressurized light water nuclear power reactor must be provided with an ECCS that must be designed so that its calculated cooling performance following postulated loss-of-coolant accidents conforms to, among others, a requirement for long-term cooling. After any calculated successful initial operation of the ECCS, the calculated core temperature shall be maintained at an acceptably low value and decay heat shall be removed for the extended period of time required by the long-lived radioactivity remaining in the core.

As a part of this requirement, Westinghouse-evaluated ECCS designs are typically required to assist in maintaining a subcritical core configuration. As such, the ECCS is designed to contain sufficient boron to compensate for positive reactivity effects that could be associated with a postulated LOCA, for instance, reductions in average coolant temperature.
Please justify the technical adequacy of your proposed ECCS boron concentration requirements:

You state, "the negative worth of each absorber, including the reactor coolant system boron worth, decreases" (page E1-4 of submittal letter). Explain how your analysis accounts for the phenomena that contribute to the reduction of the boron worth.

Confirm that your analytic codes and methods are capable of accounting for the neutronic effects of boron concentration levels as high as 3800 parts per million (ppm).

Response:

The statement on page E1-4 of the application dated August 1, 2008, refers to the fact that core designs with larger burnable absorber inventories and higher fuel enrichments will tend to have smaller boron worths due the larger total neutron absorption cross section of the core and consequent competition for neutrons among the various neutron absorbers. This is an inherent characteristic of the core physics and is not limited to cores with TPBARs. Cores with larger inventories of conventional absorbers and/or higher fuel enrichments can and do experience the same effect.

The analysis accounts for this directly because the effect is inherently captured by the core model used to determine the critical boron concentration at post-LOCA conditions. The ANC-L core model explicitly models the fuel, the burnable absorbers, and the soluble boron with appropriate neutron absorption cross sections obtained from the PHOENIX-L lattice code. Use of these PHOENIX-L cross sections ensures that ANC-L will employ the correct neutron absorption cross sections and calculate the correct neutron spectrum and neutron absorption reaction rates. Thus, a core model with larger TPBAR inventories and higher fuel enrichments will inherently have larger core average absorption cross sections and a harder neutron spectrum (larger fast-to-thermal flux ratio). The effect of this is to reduce the soluble boron worth in the model. The worth of the soluble boron and the excess core reactivity determine the ppm concentration needed to ensure subcriticality. The core model is used to calculate this soluble boron concentration, which is then compared to the available boron concentration in the sump.

Critical boron concentrations at post-LOCA conditions will not approach 3800 ppm. Watts Bar cores will be limited to post-LOCA critical boron concentrations of less than ~2100 ppm since this will be the maximum mixed mean boron concentration in the sump for the long term subcriticality evaluation assuming the current ECCS minimum boron concentrations. The PHOENIX-P code, from which PHOENIX-L is derived, has been extensively benchmarked for a wide range of lattice parameters, including boron concentration. This benchmarking is documented in WCAP-11596-P-A, "Qualification of the PHOENIX-P/ANC Nuclear Design System for Pressurized Water Reactor Cores," which was approved by the staff in May of 1988.

Part of the PHOENIX-P benchmarking included analysis of the 101 Strawbridge and Barry criticals. These critical experiments covered a very wide range of lattice parameters, including boron concentrations ranging from 0 ppm to 3392 ppm and water-to-uranium ratios ranging from 1 to 12. Consequently, the critical experiments included a wide range of neutron spectrums. Figures 3-1 and 3-5 of the report show that PHOENIX-P exhibits no reactivity bias over the lattice parameter ranges considered for water-to-uranium ratio and boron concentration, respectively. The report concludes that the PHOENIX-P results for these criticals are in excellent agreement with the experimental data, with no significant bias or trends as a function of lattice parameters. The mean K_{eff} for the 101 criticals was [ ]^{a,c} with a standard deviation of [ ]^{a,c}, indicating that, on average, PHOENIX-P slightly over-predicted the reactivity for these experiments. Additional critical experiment results are also included in the report. The ANC core models use macroscopic group constants derived from PHOENIX-P, so that the PHOENIX-P reactivities are preserved in ANC.

Question 3: Critical Boron Requirements for a High Burnable Absorber Loading

The staff's initial review of the fuel system design required to support the requested TPBAR loading is documented in numerous letters and submittals between TVA and the NRC staff. The staff's review was governed, in part, by the guidance contained in Section 4.2 of the Standard Review Plan (SRP 4.2). SRP 4.2 directs the staff to review areas concerning reactivity control requirements and provisions. As such, the licensee submitted a description of changes in critical boron requirements to support operation with the requested number of TPBARs (Westinghouse Report NDP-00-0344, submitted to NRC on August 20, 2001). These boron requirements increased over those required for previous Watts Bar Cycle designs (see page 2-20 of NDP-00-0344).

While the NRC staff does not intend to repeat its review of the original request to operate a tritium production core, certain assumptions regarding the initial boric acid concentration could affect the required performance of the ECCS, immediate post-loss-of-coolant accident (post-LOCA) subcriticality, and the outcome of the long-term core cooling calculation.

Please explain how the core design computer codes determine the critical boron concentration for cycle reloads.

The staff reviewed Licensing Topical Report WCAP-11596-P-A describing the qualification of the PHOENIX-P/ANC code system. Most of the presented validation for critical boron concentration extended to slightly higher than 1000 ppm, with increased scatter at higher boron concentrations.

Does the current validation data set for the applicable version of PHOENIX/ANC include critical boron concentration measurements that extend to 2000 ppm or beyond?

Do available core follow statistics include reactors operating with heavy loadings of neutronic absorbers with low atomic numbers?

How does this compare to critical boron concentrations predicted for current core designs at similar Westinghouse 4-loop Pressure Water Reactors (PWRs)?

How is the core critical boron concentration incorporated into the post-LOCA long-term core cooling analysis?

Response:

The core design codes calculate critical boron through an iteration process in which the boron concentration is adjusted until the desired eigenvalue ($K_{eff} = 1.0$) is achieved. ANC models the effect of the boron in each core node. Fast and thermal microscopic absorption cross sections from PHOENIX-L are used in conjunction with the nodal boron-10 number density to obtain the required adjustments to the nodal fast and thermal macroscopic absorption cross sections. Three-dimensional core models are used in which the specific reactor conditions are modeled. For example, the pre-condition hot full power critical boron concentration is modeled by conservatively assuming peak xenon in the core. Peak xenon is achieved by decaying the iodine precursors in each node for a short period of time (about 7-8 hours). The critical boron is then calculated in ANC by iterating on the boron concentration until a critical eigenvalue is achieved. Similarly, at post-LOCA conditions, the cold fuel and moderator conditions are modeled by generating the appropriate cold cross sections using PHOENIX-L. The cold critical boron concentration is calculated using the same iteration process.

With respect to validation of the code system for high boron concentrations, WCAP-11596-P-A provides comparisons of predicted Hot Full Power (HFP) and Hot Zero Power (HZP) critical boron concentrations to measured values. The HFP critical boron concentrations are summarized in Table 4-10 of that report. This summary indicates that, for [ ]^{a,c} data points, the mean difference between measurement and prediction was only [ ]^{a,c} ppm with a standard deviation of only [ ]^{a,c} ppm. Table 4-1 summarizes the HZP critical boron comparisons and indicates a mean difference of [ ]^{a,c} ppm and a standard deviation of [ ]^{a,c} ppm. The maximum measured HZP critical boron concentration in these comparisons was [ ]^{a,c} ppm.

WCAP-16045-P-A, "Qualification of the Two-Dimensional Transport Code PARAGON," provides additional validation data for PHOENIX-P/ANC. The data in Table 1 below have been extracted from Table 4-2 of WCAP-16045-P-A. This table compares measured and predicted HZP critical boron concentrations for 22 different core designs, with measured boron concentrations ranging as high as [ ]^{a,c} ppm. As Table 1 shows, the mean difference between the measured and predicted boron concentrations was an over-prediction of [ ]^{a,c} ppm.

a,b,c

The core designs in the above table represent a range of spectral index values. The spectral index is the ratio of the average fast neutron flux to the thermal neutron flux and is representative of the degree of hardening of the thermal neutron spectrum (shift towards higher neutron energy). Table 2 below presents core average spectral index values for several of the above designs. Also provided are the core average spectral index values at post-LOCA conditions for core designs with 2304 and 928 TPBARs. The spectral index values for the measured cores bound the expected values at post-LOCA conditions. The last entry in Table 2 gives the spectral index for a PHOENIX-L unit assembly calculation that was performed as part of the initial benchmarking of PHOENIX-L versus MCNP (a Monte Carlo transport code for neutrons, photons, and electrons). The unit assembly calculation included 24 TPBARs and 104 integral fuel burnable absorber (IFBA) rods. In this benchmarking the PHOENIX-L eigenvalue (k_∞) was [ ]^{a,c} while the MCNP eigenvalue was [ ]^{a,c}. Thus, the PHOENIX-L and MCNP assembly reactivities agreed well with PHOENIX-L slightly over-predicting the assembly reactivity relative to MCNP. The spectral index value in this comparison is also larger than the expected spectral index value at post-LOCA conditions.

Table 2
Spectral Index (ϕ_1/ϕ_2) Values

Model	Conditions	Spectral Index
Plant B, Cycle 17	HZP	8.97
Plant B, Cycle 18	HZP	9.00
Plant I, Cycle 13	HZP	8.28
Plant I, Cycle 14	HZP	8.37
2304 TPBAR Core	Post-LOCA	8.48
928 TPBAR Core	Post-LOCA	8.36
PHOENIX-L Unit Assembly with 24 Lead Test Assembly TPBARs	HFP	9.05

Several of the cores in Table 1 had heavy burnable absorber loadings. For example, [ ]^{a,c} (More complete descriptions of these cores can be found in Table 4-1 of WCAP-16045-P-A.) Taken together, the data in Tables 1 and 2 and the qualification data contained in WCAP-11596-P-A demonstrate that the PHOENIX-L/ANC-L code system is capable of accurately modeling a wide range of lattices covering a wide range of spectral index values and burnable absorber loadings.

Watts Bar Unit 1 cores are designed to have HFP, equilibrium xenon critical boron concentrations of less than 1250 ppm. This boron concentration level is very representative of current Westinghouse core designs. This maximum HFP boron concentration level will be maintained in future core designs as well regardless of how many TPBARs are used. TPBARs have a large residual reactivity penalty because of the relatively small neutron absorption cross section of Li-6 (compared to B-10) and the resulting significant fraction of Li-6 remaining (about 50%) in the TPBARs at the conclusion of a typical 18 month cycle. When larger inventories of TPBARs are used, the feed region size and/or the feed fuel enrichment must increase to compensate for this reactivity penalty in order to achieve the same cycle energy. To limit the maximum HFP critical boron concentration to 1250 ppm or less, the core is designed with sufficient burnable absorbers (e.g., IFBAs) to control the excess core reactivity. Consequently, by design, cores with larger TPBAR inventories will not have larger excess reactivities at full power, and the use of additional TPBARs will not significantly increase HFP critical boron concentrations. At post-LOCA conditions, however, the critical boron concentrations for Watts Bar cores with significant inventories of TPBARs could be slightly larger than for typical cores because of the assumption of TPBAR failure for cold leg breaks and because of the slightly reduced worth of boron in cores with large inventories of thermal neutron absorbers.

The discussion below details how the critical boron concentrations calculated by PHOENIX-L/ANC-L are used in the post-LOCA long term cooling subcriticality evaluation. The method described is the same as the current method reviewed and approved by the Staff as part of Amendment 67.

Post-LOCA subcriticality margin is determined by the core excess reactivity at post-LOCA (cold) conditions and by the sump boron concentration. The core excess reactivity, i.e., the reactivity controlled by the soluble boron in the moderator, is a function of several core design attributes, specifically, the cycle energy, the fuel design, the inventory of discrete and integral burnable absorbers, and the coolant conditions. Cores are designed such that the excess reactivity at normal operating conditions is controlled with soluble boron levels that permit limits on moderator temperature coefficient to be met. As discussed above, in Watts Bar Unit 1, HFP critical boron concentrations are typically less than ~1250 ppm near beginning of life.

Core reactivity at post-LOCA conditions increases relative to normal operation conditions due to several factors: (1) the decrease in fuel temperatures from full power to zero power (reduced negative Doppler feedback), (2) increased neutron moderation due to larger moderator densities (reduced negative moderator feedback), (3) axial neutron flux redistribution (flux shape shifts toward the top of the core where the fuel is more reactive), and (4) the assumption of no xenon or reduced xenon levels. These factors combine to make the post-LOCA condition significantly more reactive than normal operating conditions. Consequently, the cold critical boron concentrations at post-LOCA conditions are larger than the typical values at hot conditions. As part of the safety evaluation for each reload core design, analyses are performed to ensure that the cold critical boron concentration is less than the post-LOCA sump boron, thus ensuring subcriticality.

The sump boron concentration is calculated in a bounding fashion for several different times after event initiation and assumes the minimum RWST, accumulator, and containment ice boron concentrations permitted by the plant Technical Specifications. Also, the fluid masses assumed in the calculation are chosen in a conservative fashion, e.g., minimum RWST and accumulator fluid masses are assumed and a maximum reactor coolant system (RCS) fluid mass is assumed (since the RCS, due to its relatively low boron concentration, represents a dilution source). Since the RCS boron concentration varies with cycle burnup, the sump boron concentration is a function of RCS boron concentration. In the post-LOCA subcriticality methodology, the RCS boron employed is the HFP critical boron concentration assuming peak xenon at the burnup of interest. The conservative assumption of peak xenon has the effect of minimizing the RCS concentration which, in turn, conservatively reduces the sump boron concentration.

The sump boron concentration curves are maintained as key safety parameters in the reload safety evaluation process. Three sump boron curves are generated corresponding to three different times following the break: (1) at initiation of cold leg recirculation, (2) at hot leg switchover (HLSO), and (3) at 16 hours following the break. These sump boron curves account for a hypothetical unborated dilution source that would enter the containment at a maximum rate of 40 gpm and would be isolated within 16 hours after the break. Subcriticality evaluations are performed at hot leg switchover and at 16 hours after the break. The subcriticality evaluation at initiation of cold leg recirculation is non-limiting because the available sump boron concentration at that time is larger than the sump boron concentration assumed at HLSO. The current Watts

Bar Unit 1 ECCS minimum boron concentrations are given in Table 3 below. As discussed above, the RCS boron concentration is minimized through the assumption of peak xenon as the accident pre-condition. ANC is used to calculate the HFP, peak xenon critical boron concentration at the most reactive time in life. The sump boron, which is specified as a function of the RCS boron, can then be determined using the sump boron curves.

Table 3
Current RWST and Accumulator Boron Concentrations

Accumulator Minimum Boron Concentration (ppm)	Accumulator Maximum Boron Concentration (ppm)	RWST Minimum Boron Concentration (ppm)	RWST Maximum Boron Concentration (ppm)
3000	3300	3100	3300

The post-LOCA long term cooling subcriticality evaluation considers two scenarios: (1) the hot leg break scenario and (2) the cold leg break scenario.

In the hot leg break scenario, TPBAR failure is not expected due to the low temperatures of the fuel and TPBARs. Therefore, the assumptions for evaluating this scenario are as follows:

a. no TPBAR failures,

b. no xenon in the cold critical boron calculation,

c. no control rod insertion,

d. cold conditions,

e. a pre-condition of peak xenon to minimize the RCS boron concentration, and

f. most reactive time in life.

Because the TPBARs remain intact, the hot leg break scenario is less limiting that the cold leg break scenario.

In the cold leg break scenario, TPBAR failure is conservatively assumed to occur. In this scenario, control rod insertion is expected but not credited. The key assumptions are:

a. a pre-condition of peak xenon to minimize the RCS boron concentration,
b. cold conditions,

c. TPBAR failure for interior TPBARs with 50% Li-6 leaching and loss of 12 inches of $LiAlO_2$ pellets,

d. no control rod insertion,

e. sump dilution at the time of hot leg switchover,

f. a conservative xenon credit at the time of hot leg switchover (3 hours), and

g. most reactive time in life.

This scenario differs from the hot leg break scenario due to the assumption of TPBAR failure and the potential for sump dilution. At HLSO, the TPBAR failure assumptions are very conservative since leaching of the TPBARs is not instantaneous. The expected leaching rate is 3% per day; therefore, less than 0.5% of the lithium would have leached at the time of HLSO (3 hours), which is negligible. For the cold leg break, the limiting time is at hot leg switchover when the diluted sump water is conservatively assumed to displace the highly borated water in the reactor vessel without mixing. A long term subcriticality assessment with no xenon is also performed for this scenario, but it is never limiting due to the conservative assumptions in the HLSO assessment.

ANC is used to calculate the cold critical boron concentration at post-LOCA conditions using the above assumptions. The most reactive temperature in the range of 50 °F to 212 °F is evaluated. The moderator is assumed to be sub-cooled, and no credit is taken for the negative reactivity effect of voids. The fuel temperature is assumed to be equal to the moderator temperature, so that no credit is taken for decay heat and Doppler feedback. The resulting cold critical boron concentration is compared to the sump boron concentration. If the sump boron concentration is larger than the cold critical boron concentration, then the core is subcritical with the current minimum RWST and accumulator boron levels.

The above describes the long term cooling subcriticality evaluation beginning at the initiation of cold leg recirculation and ending at 16 hours after event initiation. Each reload cycle, a subcriticality evaluation is also performed for the reflood portion of the LOCA transient. This evaluation is similar to the above in that the expected boron concentration in the reactor vessel during reflood, which is a function of the RCS and accumulator boron concentrations, is confirmed to be sufficient to ensure subcriticality. Because of the large accumulator boron concentration employed in Watts Bar, this subcriticality assessment is non-limiting. For example, the current operating cycle, Cycle 9, had more than 300 ppm subcriticality margin at the time of reflood for the most reactive time in life. In this evaluation, the presence of xenon can be credited since reflood occurs within minutes of event initiation; therefore, essentially no xenon decay will have occurred. Control rod insertion is not credited. For cold leg breaks, this reflood evaluation is sufficient to confirm subcriticality from the time of reflood to hot leg switchover since the reactor vessel boron increases during this time due to boiling in the core. For hot leg breaks, the long term subcriticality assessment is more limiting than the reflood assessment since no xenon is assumed in the long term evaluation and the sump boron decreases with time (until 16 hours) following completion of reflood.
In summary, the cold leg break subcriticality assessment at HLSO is the most limiting subcriticality evaluation due the conservative assumptions employed (TPBAR failure, peak xenon RCS boron concentration, no mixing in the reactor vessel, etc.) Using the methodology described in Amendment 67 and above, subcriticality will be confirmed for each reload cycle as part of the reload safety evaluation.

<u>Question 4. Nuclear Safety Advisory Letter 07-7</u>

The NRC staff is aware that Westinghouse has recently issued a Nuclear Safety Advisory Letter concerning the capability of a PWR core to remain subcritical in the early stages following a large break LOCA based on the contribution of negative reactivity from core voiding during the blowdown, existing reactor coolant system boron concentration, and cold leg accumulator boron concentration. Confirm whether the proposed boron concentration levels account for the potential effects identified in that Nuclear Safety Advisory Letter.

Response:

Watts Bar Nuclear Plant Unit 1 was evaluated for the potential return to criticality as part of the NSAL-07-7 effort. The current technical specification cold leg accumulator boron was found to be adequate to assure the core remains subcritical at the beginning of reflood. Westinghouse has as part of the Reload Safety Evaluation development, a process to evaluate adequacy of cold leg accumulator (CLA) boron concentration to preclude a return to criticality at the beginning of reflood of a large break loss-of-coolant accident using NRC approved computer codes.

<u>Question 5. Selection of Pipe Breaks for Post-LOCA Subcriticality</u>

For the scenarios used to evaluate post-LOCA subcriticality, a cold leg accumulator line break and a pressurizer surge line break are assumed. The post-LOCA subcriticality analyses do not appear to account for reactor coolant pipe breaks. Please explain.

Response:

The subcriticality analysis for Watts Bar considers the whole range of break sizes up to and including a double ended guillotine rupture of the main coolant loop piping. The only analysis that restricted itself to branch line breaks (accumulator line and pressurizer surge line) was that done for the structural analysis demonstrating control rod insertability, which has been withdrawn from the licensing amendment request. See the response to RAI number 3 for additional information on the subcriticality calculation.

<u>Question 6. Staff Confirmatory Calculation of Post-LOCA Long-Term Core Cooling</u>

Due to the high ECCS boric acid concentration requirements, the NRC staff intends to perform confirmatory analysis regarding the long term core cooling capability.

1. Please provide the following information for the WBN Unit 1 Nuclear Steam Supply System (NSSS):

    a. Volume of the lower plenum, core and upper plenum below the bottom elevation of the hot leg, each identified separately. Also, provide heights of these regions.

    b. Loop friction and geometry pressure losses from the core exit through the steam generators to the inlet nozzle of the reactor vessel. Also, provide the locked rotor Reactor Coolant Pump (RCP) k-factor. Please provide the mass flow rates, flow areas, k-factors, and coolant temperatures for the pressure losses provided (upper plenum, hot legs, Steam Generators (SGs), suction legs, RCPs, and discharge legs). Please include the reduced SG flow areas due to plugged tubes. Please also provide the loss from each of the intact cold legs through the annulus to a single broken cold leg.

    c. Capacity and boron concentration of the RWST.

   d. Capacity of the condensate storage tank.

   e. Boric acid concentration vs. time for the limiting large break.

   f. Flushing flow rate at the time of switch to simultaneous injection

   g. High Pressure Safety Injection runout flow rate.

2. What is the sump temperature vs. time following recirculation and how does this impact precipitation? Is the boric acid concentration in the vessel below the precipitation limit based on the minimum sump temperature at the time the switch to simultaneous injection is performed? Please explain.

3. Please provide the following elevation data:

   a. bottom elevation of the suction leg horizontal leg piping

   b. top elevation of the cold leg at the RCP discharge

   c. top elevation of the core (also, height of core)

   d. bottom elevation of the downcomer

Response:

On December 5, 2008, a conference call was held between the TVA staff and NRC staff, where TVA staff informed the NRC that the TPBAR inventory in the Watts Bar Unit 1 core would be reduced from the proposed 2304 rods to a value of approximately 700 rods and that the boron levels would be kept at or below previously approved values. TVA stated that this information would be documented in a supplement to the original application dated August 1, 2008.

Based on the above information, the NRC issued a letter dated December 19, 2008 stating that they no longer need to perform a confirmatory calculation regarding boron precipitability for long term core cooling and that the NRC staff has withdrawn question number 6 from the RAI letter dated October 28, 2008.

Question 7. Boric Acid Concentration Calculation of Post-LOCA Long-Term Core Cooling

The NRC staff is aware that a boric acid concentration calculation has been performed that more closely aligns to the NRC staff's current expectations and acceptance criteria regarding the precipitability of boric acid in the long-term phase following a LOCA. Please provide a summary of this calculation.

Response:

A post-LOCA (loss-of-coolant accident) long term cooling confirmatory reanalysis has been performed. There are two aspects to a long term cooling analysis: the potential for boric acid precipitation and maintaining long term decay heat removal. This confirmatory analysis demonstrates continued compliance with 10CFR50.46 Paragraph (b), Item (4) and

10CFR50.46, Paragraph (b), Item (5) in light of the issues identified by the NRC staff in Reference 3.

The injection and sump recirculation ECCS modes are described in the Updated Final Safety Analysis Report (FSAR), Section 6.3. Boric acid precipitation during long term cooling is addressed in Updated FSAR Section 6.3.2.2. Operator actions to prevent boric acid precipitation are described in the Updated FSAR Section 6.3.2.17 and the Updated FSAR, Section 15.2.13.2. The switchover from injection mode to cold leg recirculation mode and the switchover from to cold leg recirculation mode to hot leg recirculation mode are described in the Updated FSAR Table 6.3-3 and Table 6.3-3a.

Input Parameters, Assumptions, and Acceptance Criteria

The major inputs to the boric acid precipitation calculation include core power assumptions and assumptions for boron concentrations and water volume/masses for significant contributors to the containment sump. The input parameters used in the WBN TPBAR RAI boric acid precipitation calculations are given in Table 1.

The boric acid precipitation calculation model is based on the following assumptions:

- *The boric acid concentration in the core region is computed over time with consideration of the effect of core voiding on liquid mixing volume. Voiding is calculated using the Modified Yeh Correlation described in Reference 1.*

- *The core mixing volume used in the calculations is shown to be conservative with respect to the potential negative effects of loop pressure drop on core mixing volume.*

- *The boric acid concentration limit is the experimentally determined boric acid solubility limit as reported in Reference 2 and summarized in Table 2 and Figure 1. For large breaks and large small breaks, the effect of containment or RCS pressure above atmospheric pressure is not credited and the boric acid solubility limit at 212°F is assumed. For large small breaks where RCS depressurization is not complete or for even smaller small breaks where the RCS might be at elevated pressures at hot leg switchover time, the solubility limit associated with the saturation temperature of water at the associated elevated pressure is credited.*

- *The liquid mixing volume used in the calculation includes 50% of the lower plenum volume.*

- *For SBLOCA scenarios, the analysis does not assume a specific start time for cooldown/depressurization in the emergency procedures, nor does it assume depressurization to some minimum pressure at hot leg switchover time. WBN is designed so that high pressure SI provides hot leg recirculation flow. As such it is not necessary to depressurize the RCS to get effective core dilution flow. For the purpose of defining expected scenarios, it is expected that operators will begin cooldown/depressurization within 1 hour of the initiation of the event.*

- *The effect of containment sump pH additives on increasing the boric acid solubility limit is not credited.*

- *The decay heat generation rate for both boric acid accumulation and decay heat removal is based on the 1971 American Nuclear Society Standard for an infinite operating time with 20% uncertainty. The assumed core power includes a multiplier to address instrument uncertainty as identified by Section 1.A of IOCFR50, Appendix K.*

- *The boric acid concentration of the make-up safety injection water during recirculation is a calculated sump mixed mean boron concentration. The calculation of the sump mixed mean boron concentration assumes maximum mass and maximum boron concentrations for significant boron sources, and minimum mass and maximum boron concentrations for significant dilution sources.*

- *ECCS flow and enthalpy changes that may occur during the switchover from injection mode to sump recirculation are not part of the long term cooling analysis scope and were instead considered in the Small Break LOCA Analysis.*

The above methodology meets NRC stated requirements in Reference 3 and is consistent with the interim methodology reported in Reference 4.

Compliance with the acceptance criteria for the Long Term Cooling Analysis is a demonstration of the ability to keep the core cool after a LOCA. There were no specific acceptance criteria for the results of the calculations that determine an appropriate hot leg switchover time. However, the FSAR, the Tech Specs, and the Emergency Operating Procedures (EOPs) must be consistent with the maximum time to establish simultaneous hot leg and cold leg injection.

ECCS recirculation flows are evaluated by comparing minimum safety injection pump flows to the flows necessary to dilute the core, and the flows necessary to replace core boil off, thus keeping the core quenched.

Table 1 - WBN Post-LOCA Long Term Cooling Analysis Input Parameters	
Parameter	**AOR Value**
Analyzed Core Power (MWt)	3459
Analyzed Core Power Uncertainty (percent)	0.6
Decay Heat Standard	1971 ANS, Infinite Operation, plus 20% (10 CFR50 Appendix K)
H_3BO_3 Solubility Limit (weight percent)	See Table 2
RWST Boron Concentration, Maximum (ppm)	3800
Accumulator Boron Concentration, Maximum (ppm)	3800
RWST Volume, Maximum (gallons)	380,000
Ice Mass, Minimum (lbm)	1,750,000
Ice Boron* Concentration (ppm)	2,000
Approximate Total Sump Liquid Mass (lbm)	5,688,838

*Boron is in the form of Sodium Tetraborate ($Na_2B_4O_7$).

Table 2 - Boric Acid Solution Solubility Limit			
Temperature, °C (°F)	**Solubility g H_3BO_3/100 g of Solution in H_2O**	**Temperature, °C (°F)**	**Solubility g H_3BO_3/100 g of Solution in H_2O**
P = 1 Atmosphere		75 (167)	17.41
0 (32)	2.70	80 (176)	19.06
5 (41)	3.14	85 (185)	21.01
10 (50)	3.51	90 (194)	23.27
15 (59)	4.17	95 (203)	25.22
20 (68)	4.65	100 (212)	27.53
25 (77)	5.43	103.3 (217.9)	29.27
30 (86)	6.34	P = P_{SAT}	
35 (95)	7.19	107.8 (226.0)	31.47
40 (104)	8.17	117.1 (242.8)	36.69
45 (113)	9.32	126.7 (260.1)	42.34
50 (122)	10.23	136.3 (277.3)	48.81
55 (131)	11.54	143.3 (289.9)	54.79
60 (140)	12.97	151.5 (304.7)	62.22
65 (149)	14.42	159.4 (318.9)	70.67
70 (158)	15.75	171 (339.8) = Congruent Melting of H_3BO_3	

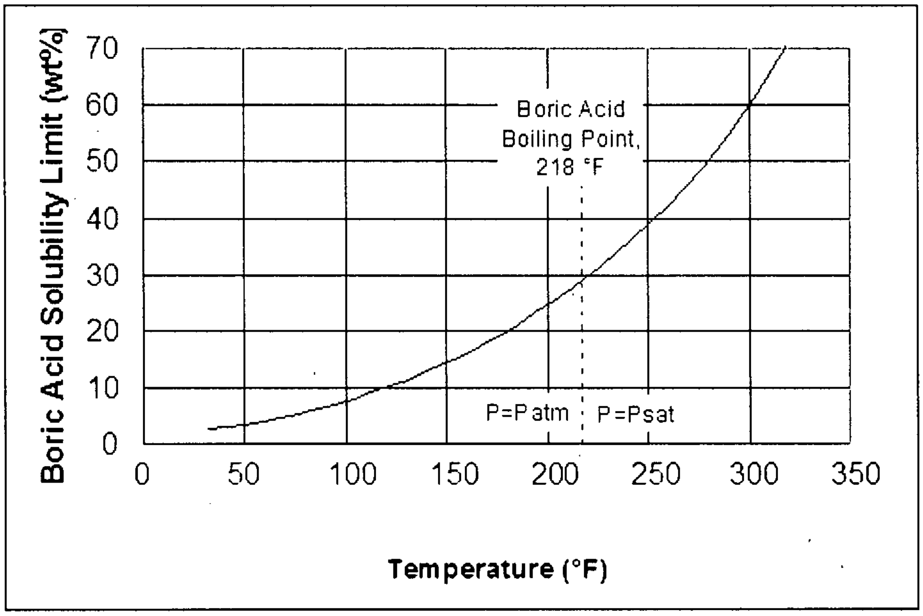

Figure 1 - Boric Acid Solubility Limit

Description of Analyses and Evaluations

There are two aspects to a long term cooling analysis: the potential for boric acid precipitation and decay heat removal. The purpose of the boric acid precipitation analysis is to demonstrate that the maximum boric acid concentration in the core remains below the solubility limit, thereby preventing the precipitation of boric acid in the core. If boric acid were to precipitate in the core region, the precipitate might prevent water from remaining in contact with the fuel cladding and, consequently, result in the core temperature not being maintained at an acceptably low value. The boric acid precipitation analysis determines the appropriate time for switching some or all ECCS recirculation flow to the hot leg and verifies that there is sufficient dilution flow through the core to prevent the continued concentration of the boric acid solution.

Prior to sump recirculation, core cooling is addressed by the Large Break LOCA analysis that demonstrates core reflood and stable and sustained quench and by the SBLOCA analysis that demonstrates core recovery. After a SBLOCA, RCS system refill, depressurization and entry into shutdown cooling, or depressurization and indefinite sump recirculation will occur. With the switch to sump recirculation, long term cooling is addressed by demonstrating that the core remains covered with two-phase mixture in the long term, thereby ensuring that the core temperature is maintained at an acceptably low value. Paragraph (b)(5) of 10CFR50.46 is satisfied when the fuel in the core is quenched, the switch from injection to recirculation phases is complete, and the recirculation flow is large enough to match the boil-off rate. Prior to hot leg recirculation, the ECCS recirculation flow must be sufficient to remove decay heat. ECCS pump availability and specific flow path alignments may reduce ECCS recirculation flow as compared to the flows available during the injection phase. After the switch to hot leg recirculation, core flow sufficient to dilute the core or prevent boric acid buildup, by definition, exceeds core boil-off and therefore provides core cooling.

The Long Term Cooling Analysis described here supports the Post-LOCA Boric Acid Precipitation Control Plan presented in Table 3. The flowchart in Figure 2 shows the applicability of the calculations to the specific post-LOCA scenarios.

Large Break LOCA

Large breaks (double-ended guillotine down to approximately 1.0 ft^2) will rapidly depressurize to very near containment pressure with no operator action. The 14.7 psia boric acid precipitation calculation models this scenario and calculates the boric acid build-up for the limiting condition of a cold leg break. Dilution and core cooling flows are confirmed for 14.7 psia RCS backpressure. After hot leg switchover, the hot leg injected flow will provide immediate core dilution for a cold leg break. If the break is in the hot leg, injected ECCS flow to the cold leg is sufficient to prevent the buildup of boric acid in the core after switchover to hot leg recirculation.

Large breaks that lead to rapid RWST drain down represent the limiting case for recirculation flow requirements. For plants that see ECCS flow reductions during recirculation (such as Watts Bar Unit 1 where low head pump flow provides suction to the high head and charging and a portion of its flow may be diverted to containment spray), ECCS flow during sump recirculation is evaluated.

Large Small Break LOCA

Large small breaks (approximately 0.2 - 1.0 ft^2) will depressurize to relatively low pressures (before the potential for boric acid precipitation) with no operator action. The 120 psia boric acid precipitation calculation models this scenario and calculates the boric acid build-up for the limiting condition of a cold leg break. The 120 psia calculations consider less core voiding, a lower h_{fg}, and do not credit SI subcooling to reduce core boil-off. After hot leg switchover, as with large breaks, the hot leg injected flow will provide core dilution for cold leg breaks and cold leg injected flow will prevent buildup of boric acid in the core for hot leg breaks. Dilution and decay heat removal flows are confirmed as adequate at 120 psia RCS backpressure. Core dilution flow will provide effective core cooling.

Small Break LOCA

For small breaks (approximately 0.005 - 0.2 ft^2), emergency procedures will instruct operators to take action to depressurize and cool down the RCS. It is expected that this process will begin within 1 hour after the event. Depressurization to 120 psia (the threshold for boric acid precipitation concerns) may occur before or after hot leg switchover time. In either case, the boric acid buildup at hot leg switchover time is conservatively represented by that calculated for the 120 psia RCS backpressure scenario since this calculation takes no credit for SI subcooling, nor any beneficial effects of the operator action (such as reduced net core boil-off due to condensation in and resultant reflux from the steam generators). If 120 psia is reached before hot leg switchover time, the core dilution flow after hot leg switchover, which is confirmed as adequate for 120 psia backpressure, will provide effective core dilution. If at hot leg switchover time, the 120 psia has not been reached, boric acid precipitation will not occur so long as the RCS remains above this pressure since water and boric acid are miscible at the saturation temperature for these pressures. Even if the RCS pressure is above 120 psia at 12 hours after the LOCA with no core dilution flow, the total boric acid in the core will be well below the saturation limit at the corresponding saturation temperature. Furthermore, if after 12 hours with no dilution flow and the RCS depressurized at the maximum cooldown rate allowed by procedure, the core will be diluted prior to reaching the boric acid precipitation point. If subcooled core conditions are reached either before or after hot leg switchover, boric acid precipitation is not a concern since there will be no net boiling in the core. If subcooled core entry conditions are not reached, the operators will continue to depressurize the RCS under controlled conditions. Sump recirculation will continue, decay heat in the core will decrease, and core dilution flow will prevent the buildup of boric acid. Eventually, subcooled core conditions will be reached, the system will be put into shutdown cooling or it will remain in indefinite recirculation cooling. It is important to note that WBN is designed so that high pressure SI provides hot leg recirculation flow. As such, it is not necessary to depressurize the RCS to get effective core dilution flow.

Very Small Break LOCA

For very small breaks (less than approximately 0.005 ft^2), emergency procedures will instruct operators to take action to depressurize the RCS. Because the break is small, subcooled conditions will be reached prior to depressurization to 120 psia (the threshold for boric acid precipitation concerns). Natural circulation, if lost, will be quickly restored. While in natural circulation, boric acid precipitation is not a concern because the core region will not be stagnant. When subcooled conditions occur, net core boiling will cease and boric acid will not accumulate. Eventually, the RCS will be depressurized under controlled conditions to shutdown cooling entry conditions or continued natural circulation and sump recirculation will keep the boric acid from accumulating in the core.

BREAK SIZE	SCENARIO	ANALYSIS
DEG – 1.0 FT^2	Large Breaks Large breaks will rapidly depressurize to near containment pressure.	Large Breaks Represented by 14.7 psia boric acid build-up calculation. Dilution flows confirmed for 14.7 psia RCS backpressure
1.0 FT^2 – 0.2 FT^2	Large Small Breaks Large small breaks will depressurize to below 120 psia without operator action.	Large Small Breaks Represented by 120 psia boric acid build-up calculation. Dilution flows are confirmed at 120 psia RCS backpressure.
0.2 FT^2 – 0.005 FT^2	Small Breaks Emergency procedures will instruct operators to take action to depressurize RCS. Eventually the system will be put into SDC or it will remain in indefinite recirculation cooling.	Small Breaks Credit operator action to depressurize the RCS. If the 120 psia is reached before HLSO time, the 120 psia boric acid buildup calculation applies. If 120 psia is not reached before HLSO time, credit higher boric acid solubility limit. If core subcooling conditions are reached, boric acid precipitation is not a concern since there will be no net boiling in the core.
0.005 FT^2 – 0.001 FT^2	Very Small Breaks Emergency procedures will instruct operators to take action to depressurize RCS. Subcooled conditions will be reached prior to depressurization to 120 psia (the threshold for boric acid precipitation concerns). Eventually the RCS will be depressurized under controlled conditions to shutdown cooling entry conditions.	Very Small Breaks Natural circulation, if lost, will be quickly restored. While in natural circulation, boric acid precipitation is not a concern because the core region will not be stagnant. Eventually, RCS will be filled and depressurized under controlled conditions to SDC entry conditions.
0.001 FT^2	Charging Flow Makeup Capacity	

Table 3 - Post-LOCA Boric Acid Precipitation Control (BAPC) Plan

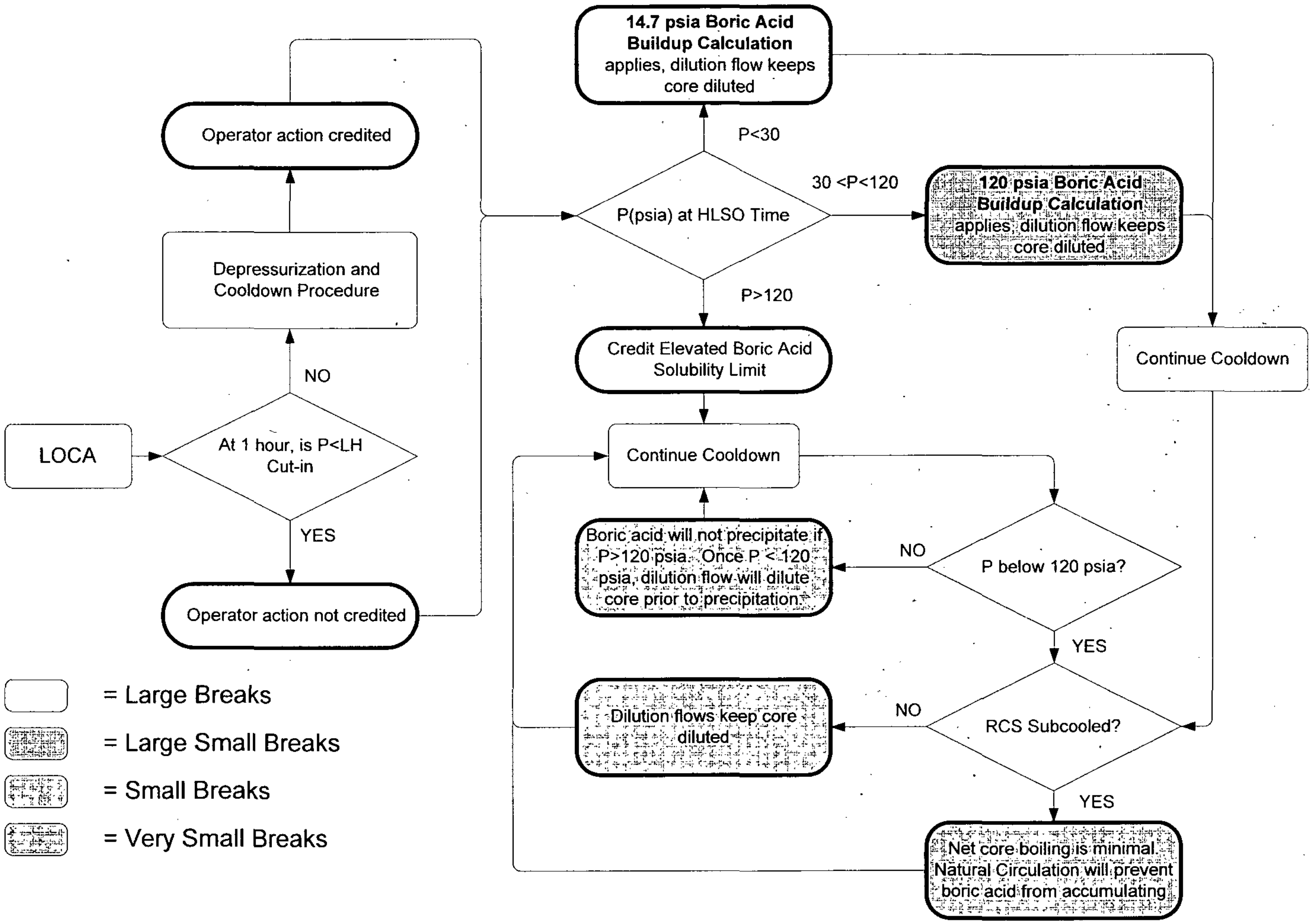

Figure 2 - Post-LOCA Boric Acid Precipitation Control Plan

Results

To address large break LOCAs, post-LOCA boric acid precipitation control calculations for 14.7 psia demonstrate that a 3 hour HLSO time to establish simultaneous hot leg and cold leg recirculation will prevent the precipitation of boric acid in the reactor vessel. Figure 3 shows the buildup of boric acid versus time and the boric acid solubility limit used for this scenario. Although the boric acid buildup calculations for this scenario apply to RCS pressures of up to 30 psia, the boric acid solubility above the atmospheric boiling point of a saturated boric acid and water solution is not credited. Figure 3 also shows the dilution effect of the hot leg injected flow after simultaneous hot leg and cold leg recirculation is established.

To address small break LOCAs, post-LOCA boric acid precipitation control calculations for 120 psia were performed. These calculations show that there is considerable margin to the boric acid solubility limit at the designated switchover time for this scenario. The 120 psia calculations consider less core voiding, a lower h_{fg}, and do not credit SI subcooling to reduce core boil-off. Since the boric acid buildup calculations for this scenario apply to RCS pressures of 30 to 120 psia, the boric acid solubility for the saturation temperature of water at 30 psia was credited. Figure 4 shows the buildup of boric acid versus time and the solubility limit appropriate for this scenario. Figure 4 also shows the dilution effect of the hot leg injected flow after simultaneous hot leg and cold leg is established.

In the unlikely event that the RCS pressure remains above a saturation pressure of 120 psia (and corresponding saturation temperature) at hot leg switchover time, boric acid precipitation will not occur since the total boric acid in the core will be well below the saturation limit at the elevated pressure saturation temperature. In order to demonstrate the effectiveness of hot leg dilution flow for this scenario, calculations were performed for a hypothetical condition where there would be no hot leg dilution flow for 12 hours. Figure 5 shows the boric acid concentration in the core with the RCS at 120 psia for 12 hours assuming no SG heat removal, no dilution flow, and no benefit of reduced steaming due to SI subcooling. At 12 hours, the boric acid concentration is still below the boric acid solubility limit at the saturation temperature at 120 psia. Figure 5 also shows that if hot leg flow is established at 12 hours and the RCS is at saturation and is then cooled (with corresponding depressurization) at a cooldown rate of 100°F/hr, boric acid precipitation will not occur. The resulting hot leg dilution flow maintains the boric acid concentration in the core well below the solubility limit, even as the solubility limit is reduced due to the RCS cooldown. For WBN, hot leg dilution flow is provided by the SI pumps which would, in fact provide dilution flow at RCS pressures well above 120 psia.

Calculations were performed to support an early switchover to hot leg or simultaneous injection. Two aspects of early switchover were considered: the hot leg entrainment threshold and core cooling. If switchover occurs too early, injected SI in the hot legs might be carried around the loops and might not be available for core cooling and dilution. Entrainment threshold calculations similar to those reported in Reference 5 demonstrated that significant hot leg entrainment would not occur after 63 minutes. Calculations showed that either hot leg or cold leg flows are sufficient to provide core cooling flow at 3 hours after the LOCA.

Assessments were made of the effect of loop pressure drop and downcomer boiling on the core mixing volume by performing calculations similar to those reported to the NRC in Reference 5 and Reference 6. In all cases, the core region mixing volume assumed in the boric acid buildup calculation was found to be conservatively small in relation to the collapsed liquid volume that would be based on loop pressure drop and available downcomer head.

The effect of the refilling of the pump suction leg loop seals was also assessed by performing calculations similar to those reported to the NRC in References 5 and 6. While the simultaneous complete closure of all four loop seals would depress the core mixture to slightly below that associated with the core mixing volume, the expected duration of the depression would be brief. Brief core mixture level depressions would have the benefit of promoting mixing between the core region and lower plenum by cycling liquid back and forth between the core region, lower plenum, and downcomer.

An assessment was made of the effect of boric acid plate-out in the SGs by performing calculations similar to those reported to the NRC in Reference 6. These calculations show that, with 10% entrainment for 1.5 hour, the total boric acid mass entrained would deposit a coating of approximately 0.003 inch over 10 feet of SG tubes. This coating would not significantly increase loop resistance or depress the core mixture level.

An assessment was made concerning the potential for boric acid precipitation at the hot leg injection point or at colder regions of the vessel. A simplified demonstration calculation showed that the mixing of injected SI with the highly borated solution in the reactor vessel would not initiate boric acid precipitation at the injection point. This calculation ignored temperature and boric acid gradients and assumed effective mixing with no differentiation between different mixing mechanisms such as diffusion (thermal or molecular) and density-driven convection within the vessel. The assessment also concluded that the heating of the injected water as it travels to the core region (either from the downcomer or hot leg) and the expected density-driven mixing mechanisms in the vessel would make it unlikely that significant temperature or boric acid gradients would exist. These conclusions were consistent with those reported to the NRC in Reference 6.

In summary, the WBN TPBAR Post LOCA boric acid precipitation calculations used conservative methodology to establish a 3 hour HLSO time to realign the ECCS to provide SI flow to the hot legs. SI flow to the hot leg will provide effective core dilution thus precluding boric acid precipitation in the reactor vessel. This realignment addresses the requirements of 10CFR50.46 (b) (4) coolable geometry and 10CFR50.46 (b) (5) long term cooling. ECCS flows during sump recirculation were shown to be sufficient to remove decay heat after a LOCA for TPBAR plant conditions, provided the ECCS realignment to provide SI flow to the hot legs occurs no sooner than 3 hours following the event. This addresses the requirements of 10CFR50.46(b)(5) long term cooling.

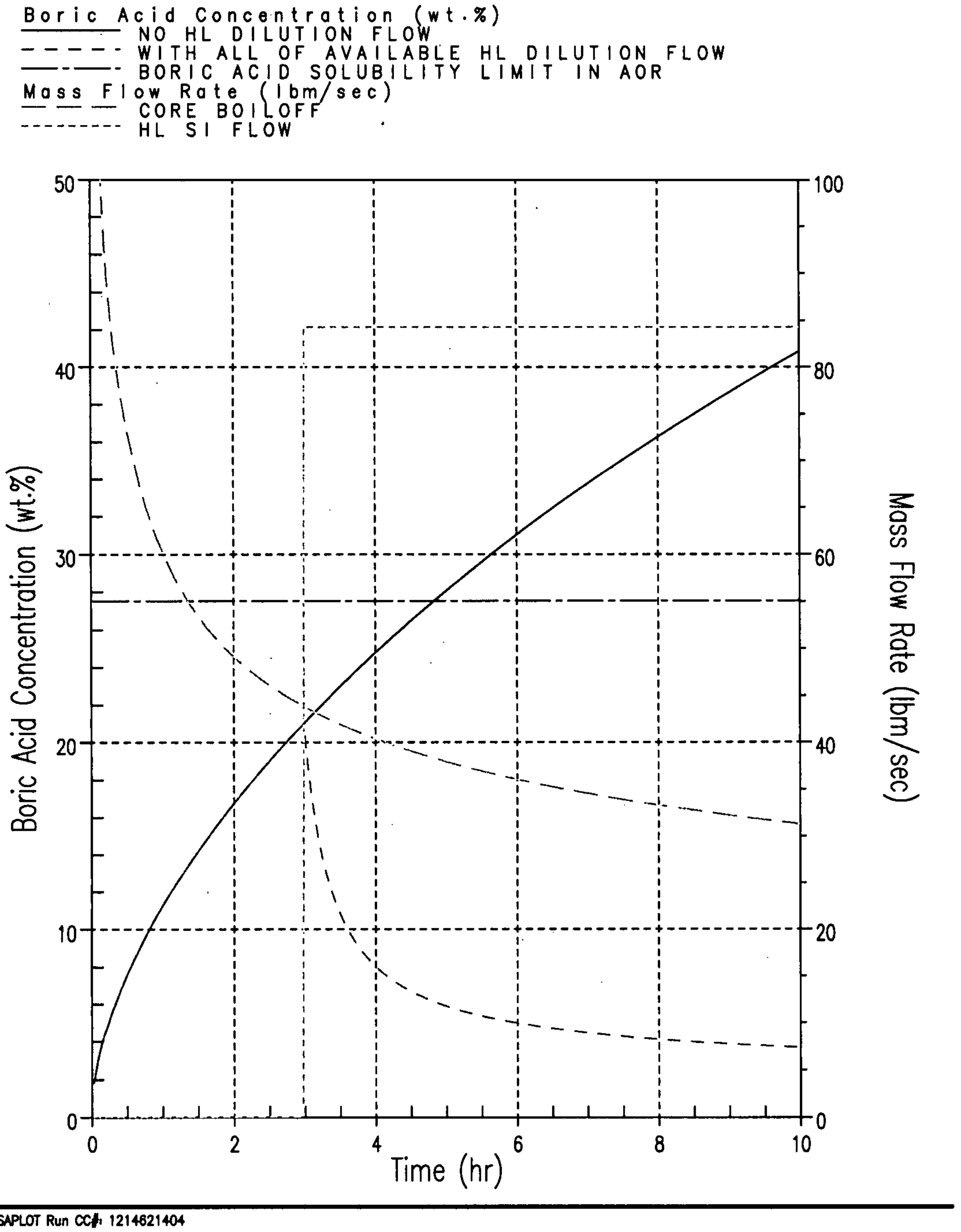

Figure 3 – Boil-off, SI, and Core Dilution Rate at a 3 Hour HLSO Time at 14.7 psia

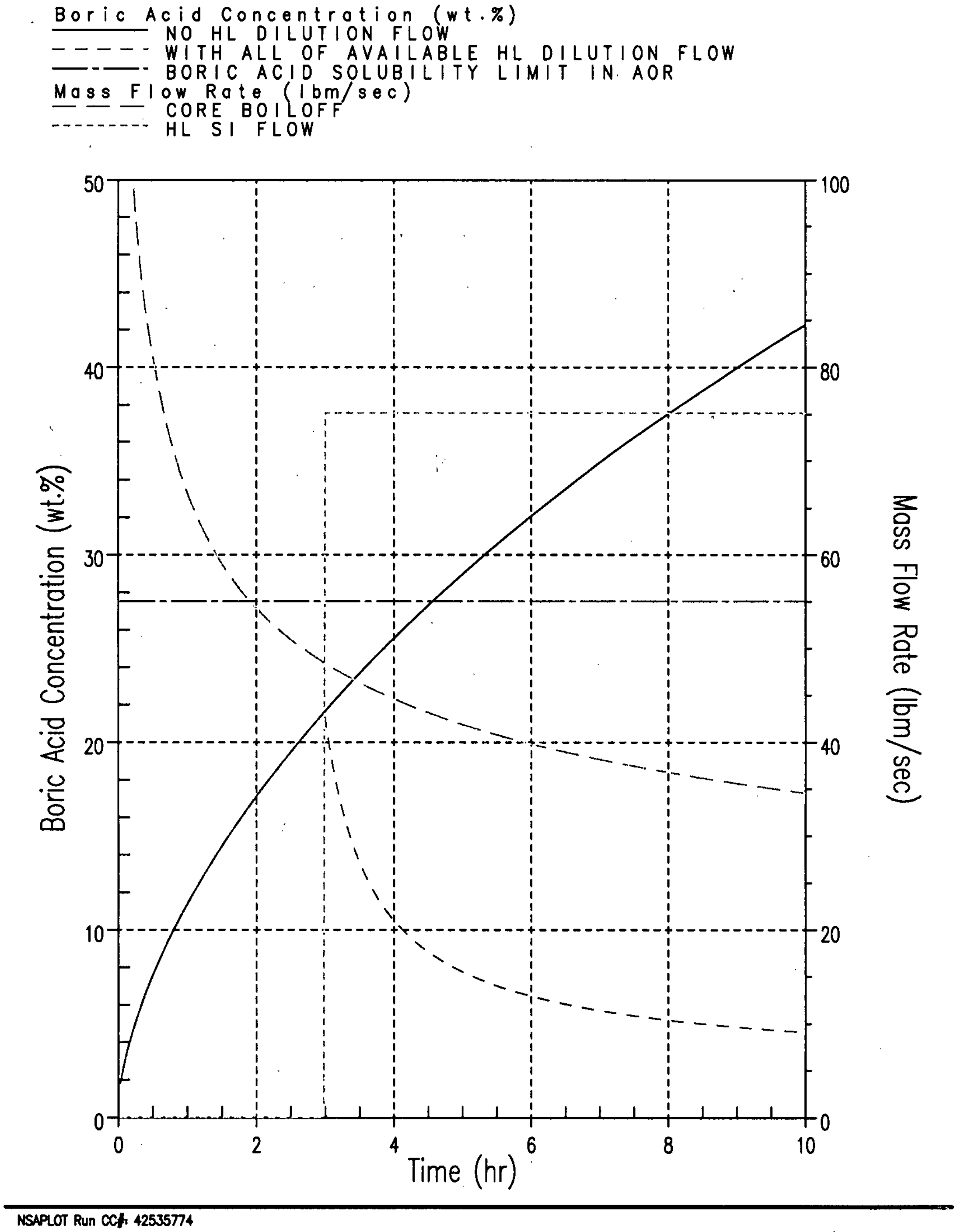

Figure 4 – Boil-off, SI, and Core Dilution Rate at a 3 Hour HLSO Time at 120 psia

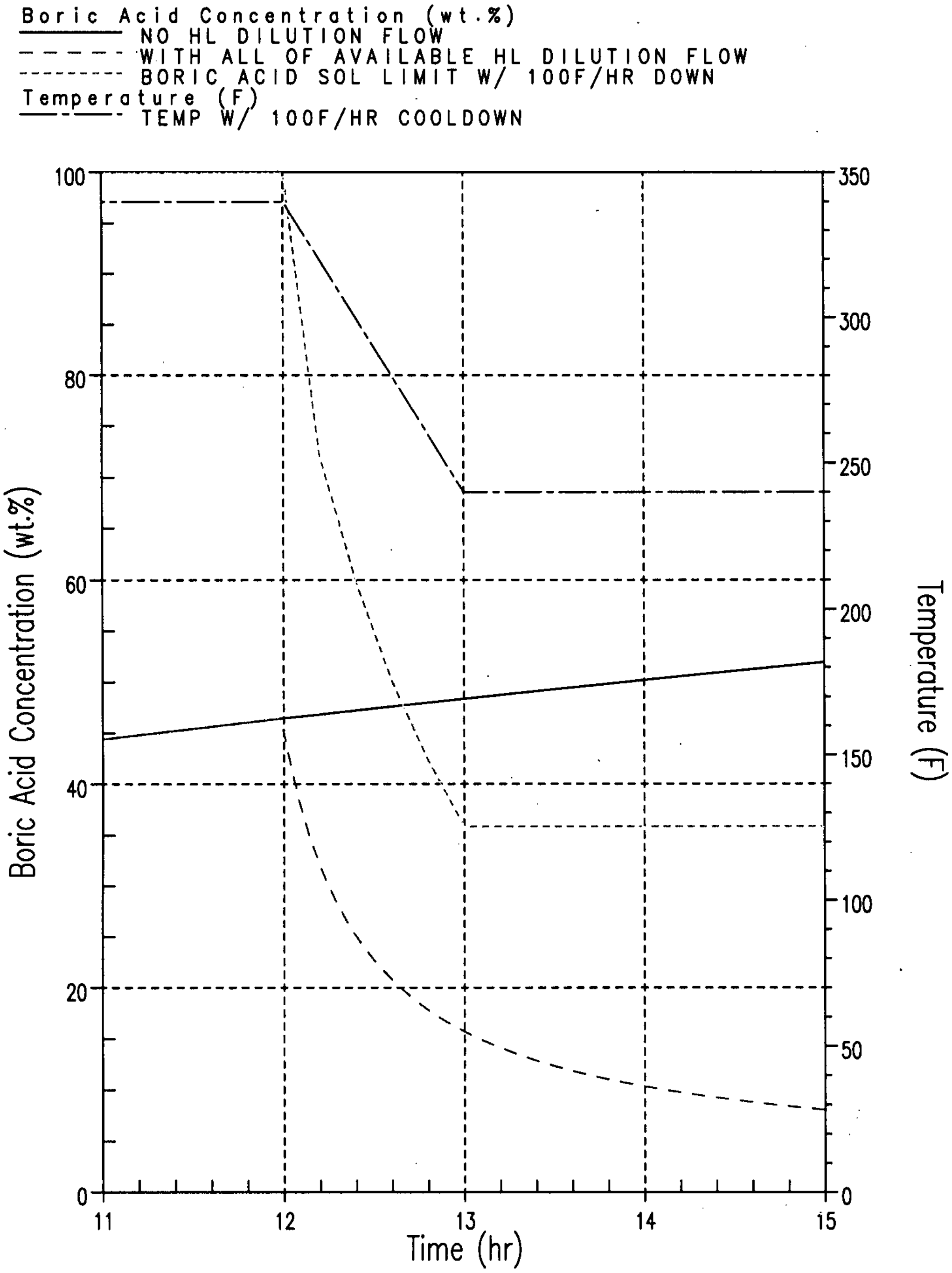

Figure 5 - Demonstration of Core Dilution at 12 hours

References

1. H. C. Yeh, "Modification of Void Fraction Calculation," Proceedings of the Fourth International Topical Meeting on Nuclear Thermal-Hydraulics, Operations and Safety, Volume 1, Taipei, Taiwan, June 6, 1988.

2. P. Cohen, 1980 (Originally published in 1969), Water Coolant Technology of Power Reactors, Chapter 6, "Chemical Shim Control and pH Effect," ANS-USEC Monograph.

3. Letter dated August 1, 2005 from R. A. Gramm, U. S. Nuclear Regulatory Commission to J. A. Gresham, Westinghouse Electric Company, "Suspension of NRC Approval for Use of Westinghouse Topical Report CENPD-254-P, 'Post LOCA Long Term Cooling Model' Due to Discovery of Non-conservative Modeling Assumptions During Calculations Audit."

4. Letter dated October 3, 2006 from Sean E. Peters, Project Manager, Special Projects Branch, Division of Policy and Rulemaking, Office of Nuclear Reactor Regulation, NRC to Stacey L. Rosenberg, Chief, Special Projects Branch, Division of Policy and Rulemaking, Office of Nuclear Reactor Regulation, NRC, "Summary Of August 23, 2006 Meeting With The Pressurized Water Reactor Owners Group (PWROG) To Discuss The Status Of Program To Establish Consistent Criteria For Post Loss-Of-Coolant (LOCA) Calculations."

5. Letter L-05-112, FirstEnergy Nuclear Operating Company to USNRC, "Responses to a Request for Additional Information in Support of License Amendment Request Nos. 302 and 173", July 8, 2005.

6. Letter L-05-169, FirstEnergy Nuclear Operating Company to USNRC, "Responses to a Request for Additional Information (RAI dated September 30, 2005) in Support of License Amendment Request Nos. 302 and 173", November 21, 2005.

Westinghouse Non-Proprietary Class 3
Confidential Information Submitted Under 10 CFR 2.390

ENCLOSURE 3

Westinghouse Affidavit
Proprietary Information Notice
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WAT-D-11704
Our ref: CAW-08-2511

December 30, 2008

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: Watts Bar Nuclear Plant (WBN) Unit 1 – Response to Request for Additional Information Re: Watts Bar Emergency Core Cooling System Boron Requirements (TAC No. MD9396) (Proprietary)

The proprietary information for which withholding is being requested in the above-referenced report is further identified in Affidavit CAW-08-2511 signed by the owner of the proprietary information, Westinghouse Electric Company LLC. The affidavit, which accompanies this letter, sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b)(4) of 10 CFR Section 2.390 of the Commission's regulations.

Accordingly, this letter authorizes the utilization of the accompanying affidavit by TVA Nuclear.

Correspondence with respect to the proprietary aspects of the application for withholding or the Westinghouse affidavit should reference this letter, CAW-08-2511 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

JA Gresham

J. A. Gresham, Manager
Regulatory Compliance and Plant Licensing

Enclosures

cc: G. Bacuta (NRC OWFN 12E-1)

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared J. A. Gresham, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse), and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

J A Gresham

J. A. Gresham, Manager
Regulatory Compliance & Plant Licensing

Sworn to and subscribed before
me this 30th day of December 2008

Margaret L Gonano
Notary Public

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Margaret L. Gonano, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Jan. 3, 2010
Member, Pennsylvania Association of Notaries

(1) I am Manager, Regulatory Compliance & Plant Licensing, in Nuclear Services, Westinghouse Electric Company LLC (Westinghouse), and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rule making proceedings, and am authorized to apply for its withholding on behalf of Westinghouse.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 of the Commission's regulations and in conjunction with the Westinghouse "Application for Withholding" accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission 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 and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information that is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390, it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked as "Watts Bar Nuclear Plant (WBN) Unit 1 – Response to Request for Additional Information Re: Watts Bar Emergency Core Cooling System Boron Requirements (TAC No. MD9396) Proprietary," being transmitted by TVA Nuclear letter and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted for use by Westinghouse for Watts Bar Unit 1 is expected to be applicable for other licensee submittals in response to certain NRC requirements for justification for increasing the number of Tritium Producing Burnable Absorber Rods (TPBARs).

This information is part of that which will enable Westinghouse to:

(a) Support an increase in the number of TPBARs from the current Technical Specification value.

(b) Provide customer specific calculations.

(c) Provide licensing support for customer submittals.

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to sell the use of similar information to its customers for purposes of meeting NRC requirements for licensing documentation associated with demonstrating the use of TPBARs.

(b) Westinghouse can sell support and defense of the technology to its customer in the licensing process.

(c) The information requested to be withheld reveals the distinguishing aspects of a methodology which was developed by Westinghouse.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar information and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended.

Further the deponent sayeth not.

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and/or non-proprietary versions of documents furnished to the NRC in connection with requests for generic and/or plant-specific review and approval.

In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).