93-340

ET-NRC-93-3979

Westinghouse Electric Corporation

Energy Systems

Nuclear and Advanced Technology Division

Box 355
Pittsburgh Pennsylvania 15230-0355

October 4, 1993

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

SUBJECT: Containment Spray Systems Issues

Per the request of Mr. W. Haass and Mr. M. Caruso please find attached for your information a copy of Westinghouse letter NSAL-93-016, Revision 1 dated October 4, 1993 entitled "Containment Spray Systems Issues".

If you have any questions regarding this letter, please contact Mr. H. A. Sepp of my staff at 412/374-5282.

Very truly yours,

N. J. Liparulo, Manager
Nuclear Safety and Regulatory Activities

/p
Attachment

Add: W. Haass Ltr Encl 1 1

150015

Y001 1/1

Westinghouse
Energy
Systems
Business
Unit

NUCLEAR SAFETY ADVISORY LETTER

THIS IS A NOTIFICATION OF A RECENTLY IDENTIFIED POTENTIAL SAFETY ISSUE PERTAINING TO BASIC COMPONENTS SUPPLIED BY WESTINGHOUSE. THIS INFORMATION IS BEING PROVIDED TO YOU SO THAT A REVIEW OF THIS ISSUE CAN BE CONDUCTED BY YOU TO DETERMINE IF ANY ACTION IS REQUIRED.

P.O. Box 355, Pittsburgh, PA 15230-0355

Subject: Containment Spray System Issues	**Number:** NSAL-93-016, Revision 1
Basic Component: Please See Enclosed Letter	**Date:** 10/4/93
Plants: Please See Enclosed List	

Substantial Safety Hazard or Failure to Comply Pursuant to 10CFR21.21(a)	Yes ☐	No ☐
Transfer of Information Pursuant to 10CFR21.21(b)	Yes ☒	
Advisory Information Pursuant to 10CFR21.21(c)(2)	Yes ☐	

SUMMARY

In Revision 0 of this letter, Westinghouse identified two potential safety issues. One issue is that a Small Break LOCA (SBLOCA) may have higher offsite dose consequences than a Large Break LOCA (LBLOCA), since the amount of rod burst may be higher during the SBLOCA than previously predicted. Also, the SBLOCA resulting in the highest peak clad temperature (PCT) is not expected in most plants to result in a containment pressure necessary to automatically actuate the CSS. If the CSS is not actuated (automatically or manually) during the SBLOCA, then the utility should assess whether the SBLOCA is more limiting than the LBLOCA for the purpose of meeting 10CFR100. Westinghouse has determined that it has insufficient information to determine whether this issue presents a substantial safety hazard for your plant. Therefore, pursuant to the requirements of 10CFR21.21(b), Westinghouse is transferring the enclosed information to you so that you can determine whether this issue presents a substantial safety hazard. To assist you in your evaluation, Westinghouse has developed a methodology which you may wish to use to determine the applicability of this issue to your plant. This method is discussed later in this NSAL letter.

The second issue involves the time in which the sump solution pH should be adjusted to an acceptable pH level during a SBLOCA. Since issuing Revision 0 of this letter, Westinghouse has performed a more extensive evaluation of the test data and past correspondence and has determined that the time in which the pH adjustment is made is acceptable as stated in the Westinghouse Standard Information Package (SIP). Westinghouse has clarified this evaluation in this NSAL letter. Therefore, Westinghouse has determined that there is no defect or failure to comply associated with the time requirement stated in the Westinghouse SIP.

Additional information, if required, may be obtained from the originator. Telephone 412-374-6460.

Originator: J. W. Fasnacht, Strategic Licensing Issues

H. A. Sepp, Manager, Strategic Licensing Issues

t:\0007.wpf:1b-100193

PLANT APPLICABILITY LIST

D.C. Cook 1
D.C. Cook 2
J.M. Farley 1
J.M. Farley 2
Byron 1
Byron 2
Braidwood 1
Braidwood 2
V.C. Summer 1
Zion 1
Zion 2
H.B. Robinson 2
Shearon Harris
Haddam Neck
W.B. McGuire 1
W.B. McGuire 2
Catawba 1
Catawba 2
Beaver Valley 1
Beaver Valley 2
Turkey Point 3
Turkey Point 4
Vogtle 1
Vogtle 2
Indian Point 2
Indian Point 3
Seabrook 1
Millstone 3
Prairie Island 1
Prairie Island 2
Diablo Canyon 1
Diablo Canyon 2
Trojan
Salem 1
Salem 2
R.E. Ginna
Wolf Creek
Callaway 1
Comanche Peak 1
Comanche Peak 2
South Texas 1
South Texas 2
Sequoyah 1
Sequoyah 2
Surry 1
Surry 2
North Anna 1
North Anna 2
Watts Bar 1
Watts Bar 2
Point Beach 1
Point Beach 2
Kewaunee
Maanshan 1
Maanshan 2
Napot Point
Fort Calhoun 1

CONTAINMENT SPRAY SYSTEM ISSUES

ISSUE DESCRIPTION

Issue 1: SBLOCA Radiological Consequence Analysis

This issue involves assumptions that were made in the Radiological Consequence analyses performed under 10CFR100. These assumptions may not bound the most limiting release scenario, and thus, there may be more limiting release scenarios which have not been analyzed.

Specifically, 10CFR100 requires each licensee to evaluate the radiological consequences associated with a fission product release that is ". . . based upon a major accident . . . that would result in potential hazards not exceeded by those from any accident considered credible." Currently, it is assumed that the most limiting accident for the fission product release is a Large Break LOCA (LBLOCA) with core melt. During a LBLOCA with core melt, the amount of fuel damage is maximized, but credit is taken for the Containment Spray System (CSS) removal of iodines from the containment vapor space. During a credible Small Break LOCA (SBLOCA), the amount of fuel damage is lower than for a LBLOCA, but since containment pressure is not expected to reach the setpoint at which CSS is actuated, credit for automatic CSS operation cannot be assumed. Recently, it has been determined that the amount of fuel damage during a SBLOCA can be much higher than the small amount previously assumed. Therefore, the SBLOCA may have higher off site radiological consequences than a LBLOCA used in the radiological analysis for the plant licensing basis.

Issue 2: Long-term Sump pH Control During a SBLOCA

The second issue involves the pH requirements of the long-term sump solution following a SBLOCA. In general, the pH of the sump solution should be raised into the range of 7 to 9.5 in order to maximize the retention of iodine in solution and minimize the potential for chloride induced stress corrosion cracking of stainless steel components. Many plants rely on the CSS to deliver an alkaline chemical (usually sodium hydroxide) to the containment sump for long-term pH control. During a SBLOCA, the CSS may not automatically actuate, and the operator may need to take action to add a sufficient quantity of an alkaline chemical to adjust the sump pH.

In Revision 0 of this letter, Westinghouse indicated that the recommended time limit, as stated in the Westinghouse SIP as 48 hours, may not be adequate to preclude chloride induced stress corrosion cracking. The information presented in this letter (Revision 1) indicates that the 48 hour requirement is adequate to preclude stress corrosion cracking. However, this requirement may not be adequate to assure the retention of iodine in the sump solution. As a result, the technical evaluation for Issue 1 has been modified to assume that no iodine is retained in the sump solution.

TECHNICAL EVALUATION

Issue 1: <u>SBLOCA Radiological Consequence Analysis</u>

Westinghouse has performed an evaluation to assess whether a SBLOCA, with higher fuel damage than previously assumed and without CSS actuation, has higher off site dose consequences than a LBLOCA used in the licensing basis for offsite doses. This evaluation is designed to assist you in determining whether this issue is a substantial safety hazard. It is believed that if plants apply the evaluation results and make the appropriate adjustment for plant specific design features, then the plants should be able to show that this issue is not a substantial safety hazard. However, it should be noted that some of the conditions and assumptions may not be applicable to your plant's design basis. Therefore, you should carefully review the analysis conditions and assumptions to assess the applicability to your plant specific licensing basis.

The following discussion is provided to identify a "representative" analysis that you may wish to use to assess this issue. The purpose of the analysis is to calculate the off site dose consequences associated with a "representative" SBLOCA. The following are some of the inputs and assumptions used for the analysis.

INPUTS AND ASSUMPTIONS

1. It is assumed that 100% of the fuel rods burst and that the rod bursts occur at time zero. This assumption is selected to bound all possible rod burst occurrences. This assumption is made even though it has been shown that the actual rod burst percentage is likely to be lower, depending upon plant specific design. Plant design factors which would lower the amount of rod burst include, but are not limited to: peak clad temperature during SBLOCA, fuel design features, and precision used in the rod burst calculation.

2. The break size is small enough so that the CSS is not automatically actuated. Please note that the potential use of the CSS to mitigate the off site dose consequences of the SBLOCA is discussed in the Recommendations section of this letter. However, if the plant decides to initiate the CSS during a SBLOCA, then the plant must assure that the initiation of the CSS is considered in the 10CFR50.46 analysis. (See "Recommendations" for details.)

3. The offsite thyroid dose acceptance criterion is specified in 10CFR100 as 300 rem. This criterion is selected even though a lower dose acceptance criterion has been recommended by ANSI/ANS-51.1-1983 which states that the appropriate acceptance criteria for a SBLOCA should be 25% of the 10CFR100 guidelines, or 75 rem. It should be noted that ANSI/ANS-51.1 has not been incorporated into the radiological licensing basis of most plants and the NRC Standard Review Plan does not identify any dose acceptance criteria specifically for the SBLOCA.

4. The amount of activity accumulated in the fuel clad gap is assumed to be 2% of the iodines and 2% of the noble gases accumulated in the core at the end of core life. This assumption differs from the assumption of a 10% gap fraction recommended by the NRC in Regulatory Guide 1.77 for the rod ejection accident. It is believed that the 2% is a bounding and conservative value and that the 10% value is excessively conservative, since the total core is being considered in the analysis. The selection of a two percent gap fraction is based on the results of analysis of Westinghouse fuel using the ANSI/ANS 5.4-1982 model for determination of the fraction of fission products in the fuel/clad gap. The analysis showed that for the short-lived iodines and noble gases (i.e., those with half-lives of less than one year) the maximum gap fraction for I-131, which is the nuclide of greatest concern for the determination of thyroid doses, was less than two percent and the gap fractions for the other nuclides were lower than that for I-131. Additionally, in Section 3.1.5 of NUREG/CR-5009 it is stated that 95 to 99 percent of the fuel rods will have an I-131 gap faction of 0.9 percent or less. Assuming that 95 percent of the fuel rods have a gap fraction of 0.9 percent and that the remaining five percent have a gap fraction of ten percent (consistent with Regulatory Guide 1.77), the core average gap fraction is 1.4 percent. This conservatively assumes that none of the fuel rods have a gap fraction of less than 0.9 percent.

5. Consistent with the guidance provided in Regulatory Guide 1.77, it is assumed that 100% of the iodine activity released from the fuel reaches the containment atmosphere and 100% of the activity is retained in the reactor coolant system.

   This assumption is different than the one provided in Revision 0 to this letter. Recall that the assumption in Revision 0 to this letter was that 50% of the iodine activity released from the fuel reaches the containment atmosphere and 50% is retained in the Reactor Coolant System (RCS). The assumption in Revision 0 is based on the supporting assumption that the iodine in the RCS is retained in the sump fluid after the RCS spills. The iodine retention is believed to occur since the sump pH would be adjusted to a pH > 7 within the 8 hour time specified for Issue #2 in Revision 0.

   The guidance for Issue #2 has been revised in this letter (Revision 1) to indicate that the time for sump pH adjustment during a SBLOCA can be extended to 48 hours, as stated in the Westinghouse SIP. Since the time for pH adjustment may be as high as 48 hours, the iodine may not be retained in the sump. Therefore, it is conservative to assume that the iodine is not retained in the sump solution and is available for release into the containment atmosphere.

6. Credit is taken for the deposition removal of airborne iodine on the containment surfaces. Although this deposition removal process is recognized by the NRC in Section 6.5.2 of the Standard Review Plan, it is not part of the licensing basis for most plants. The removal of airborne iodine from the containment atmosphere is accomplished by deposition onto containment surfaces by using a removal coefficient of 2 hr^{-1}. Based on eight specific plant analyses, this value is less than would be expected.

Since credit is assumed for deposition as a time dependent process, no credit is taken for the instantaneous plateout of iodine that is identified in TID-14844, "Calculations of Distance Factors for Power and Test Reactor Sites," dated 3/23/62. (Most plants, in their LBLOCA dose analysis, have taken credit for instantaneous plateout of half the iodine released to the containment atmosphere.)

7. The design basis containment leak rate is assumed to be 0.1% per day.

8. The core power level is assumed to be 3565 MWt.

9. The assumed atmospheric dispersion factors are provided below. It is believed that these factors bound most of the operating plants.

	Time	Dispersion Factor
Site Boundary	(0-2 hours)	1.0E-03 sec/m^3
Low Population Zone	(0-8 hours)	1.5E-04 sec/m^3
	(8-24 hours)	1.0E-04 sec/m^3
	(24-96 hours)	5.0E-05 sec/m^3
	(96-720 hours)	2.0E-05 sec/m^3

RESULTS

Using the inputs and assumptions listed above, the following results are obtained.

	Containment Leakage	Secondary Side Releases	Total
Site Boundary	41.3 rem	3.3 rem	44.6 rem[(1)]
Low Population Zone			
(0-8 hr)	9.2 rem	4.7 rem	
(8-24 hr)	2.2 rem	—	
(24-96 hr)	2.3 rem	—	
(96-720 hr)	2.5 rem	—	
	16.2 rem	4.7 rem	20.9 rem[(1)]

[(1)]The doses for the sample analysis are twice the values stated in Revision 0 of this letter. Assumption #5 identifies the analysis changes that resulted in the doubling of the doses.

The total dose at the site boundary is 44.6 rem. The total dose at the low population zone boundary is 20.9 rem. These doses are well below the 10CFR100 guideline of 300 rem and are bounded by the LBLOCA doses that would be determined for this representative plant.

USE OF RESULTS TO ASSESS APPLICABILITY OF THE ISSUE TO PLANT SPECIFIC PARAMETERS

The first concern in the determination of the applicability of the sample SBLOCA dose analysis is whether the assumptions used are ones that are consistent with the plant licensing basis. Also, since most plants have no defined licensing basis for the SBLOCA dose analysis, the assumptions should be ones for which the licensee is willing to take credit. There are only a few operating plants which have a time-dependent deposition removal model (assumption #6) in their licensing basis analysis for the LBLOCA; however, there is no apparent reason why this approach could not be used for the SBLOCA analysis for all plants. Relative to the assumption of a two percent gap fraction (assumption #4), there are a number of older plants that use calculated gap fractions that are near this value (with different values determined for each nuclide, some of which are far below the two percent value). Most plants have a ten percent gap fraction in their licensing basis, and the use of the two percent value would be a departure from past practice. The use of the two percent gap fraction is still conservative for an event involving the total core.

After verifying and selecting the appropriate assumptions, the site specific doses can be estimated using the following equation.

$$(PSD) = \left[\frac{(PSCLR)}{.1\%^{(a)}}\right]\left[\frac{PSCPL}{3565MWt^{(b)}}\right]\left[\sum_{t=1}^{n} (AD)_t \frac{(PSADF)_t}{(AADF)_t}\right]$$

Definition of Variables

PSD = Plant Specific Dose (Site boundary or low population zone, depending on which is more limiting)

PSCLR = Plant Specific Containment Leak Rate Percent

PSCPL = Plant Specific Core Power Level (MWt)

$(AD)_t$ = Analysis Dose (rem)

$(PSADF)_t$ = Plant Specific Atmospheric Dispersion Factor (sec/m^3)

$(AADF)_t$ = Analysis Atmospheric Dispersion Factor (sec/m^3), see page 3

n = number of time intervals. For a Site Boundary Dose, n = 1 for the time interval (0-2 hours). For the Low Population Zone, n = 4 for the four time intervals (0-8 hr), (8-24 hr), (24-96 hr) and (96-720 hr)

Notes for Equation

(a) See assumption #7, page 3.

(b) See assumption #8, page 3.

The resultant value will provide a determination of whether the doses are greater than the licensing basis LBLOCA doses.

Issue 2: <u>Long-term Sump pH Control During a SBLOCA</u>

Many plants rely on a CSS to deliver an alkaline chemical to the containment sump for long-term pH control during an accident. During a SBLOCA, the CSS may not automatically actuate and the operator may take action to add a sufficient quantity of an alkaline chemical to adjust the sump pH within acceptable limits. In the past, the Westinghouse Standard Information Package (SIP) has indicated that the sump pH be adjusted to a pH of 8 within 48 hours of the accident. The pH adjustment is needed to mitigate stress corrosion cracking of the stainless steel components which are part of the emergency core cooling system (ECCS) and to maximize the retention of iodine in the sump solution.

Westinghouse has re-evaluated this recommendation in light of test data. It had been determined (in Revision 0 of this letter) that based upon a <u>conservative</u> interpretation of the test data, the SIP should be changed to recommend that the sump pH be adjusted to a pH greater than 7 as soon as possible, but within 8 hours of a LOCA.

Since issuing NSAL-93-016, Revision 0 on August 6, 1993, several plants have requested Westinghouse to consider performing a more detailed evaluation of this issue to show that it does not present a substantial safety hazard. Based on further evaluation, Westinghouse has made the following interpretations of the test data.

In Revision 0 of this letter, Westinghouse indicated that the sump pH be adjusted to a pH greater than 7 as soon as possible, but within 8 hours of a LOCA. As previously mentioned, the statement was based on a conservative interpretation of the test data. The test was conducted by exposing various stainless steel coupons to a representative LOCA environment without the appropriate pH adjustment. The test data indicates that no coupon cracking was observed at 8 hours into the test and indicates that at 72 hours, cracking was observed in some of the coupons. There are no observations between 8 and 72 hours. Therefore, based on a direct and limited interpretation of the test data, Westinghouse recommended that the time for pH adjustment occur within 8 hours of a LOCA to preclude chloride induced stress corrosion cracking of stainless steel components.

Westinghouse has further evaluated the test data by considering primarily two additional factors. One is a sump temperature profile for a representative SBLOCA. The other is the general conditions under which cracking will occur for stainless steel components. As a result of this evaluation, Westinghouse has determined that chloride induced stress corrosion cracking of stainless steel ECCS components should not occur during a representative SBLOCA before 48 hours. Therefore, implementation of the 48 hour requirement provided in the Westinghouse SIP is still acceptable and should be sufficient to preclude chloride induced stress corrosion cracking of stainless steel ECCS components. It is believed that the time period (8 hours or 48 hours) starts when the ECCS is placed on recirculation. However, it would be more conservative, for the purpose of mitigating stress corrosion cracking, to start the time period from the beginning of the accident.

It should be noted that extending the time requirement to 48 hours impacts the dose analysis provided for Issue #1 in Revision 0 of this letter. The impact is discussed in Assumption #5 of the Technical Evaluation for this letter. The dose analysis results for Issue #1 have been modified to incorporate the information in Assumption #5. Please see page 3 of this letter for more details.

SAFETY SIGNIFICANCE

Issue 1: SBLOCA Radiological Consequence Analysis

Utilities should be able to use the information presented in the Technical Evaluation to show that this issue is not a substantial safety hazard. It is believed that by using the sample analysis provided in the technical evaluation, the utilities should be able to show that the SBLOCA would result in doses below the guidelines of 10CFR100.

Although the analysis presented in the technical evaluation is conservative and is appropriate for the determination of whether there is a substantial safety hazard, it does not constitute a licensing basis analysis. Most plants have not included any determination of the SBLOCA doses in their licensing basis because of the prior determination that there would be little or no rod burst. With the potential for a significant fraction of fuel rod burst, the licensing basis evaluation assuming minimal or no fuel rod burst may no longer be appropriate.

Westinghouse has determined that it has insufficient information to determine whether this issue presents a substantial safety hazard for your plant. Therefore, pursuant to the requirements of 10CFR21.21(b), Westinghouse is transferring this information to the licensees so that they can determine whether this issue presents a substantial safety hazard for their plants.

Issue 2: Long-term Sump pH Control During a SBLOCA

The safety significance is that during a SBLOCA, the operator may need to place the plant ECCS on cold leg recirculation to maintain core cooling. As a result, the ECCS components must be able to perform their intended design functions. To help assure that these components are able to perform their intended design functions, it is necessary to assure that the sump pH is properly adjusted to mitigate stress corrosion cracking of the stainless steel parts of these components. Utilities should be able to use the information presented in the Technical Evaluation to determine if the plant specific EOPs are adequate to ensure that the sump pH is adjusted within the proper time frame for a SBLOCA.

NRC AWARENESS/REPORTABILITY CONSIDERATION

Westinghouse has been requested by the NRC to provide a copy of this letter (NSAL-93-016, Revision 1) to the NRC. In response, Westinghouse will formally transmit this letter to the NRC Document Control Desk, effective the date of this letter.

RECOMMENDATIONS

Issue 1: SBLOCA Radiological Consequence Analysis

In making the 10CFR21 assessment, you may wish to consider the following:

Each plant should consider using the methodology in the "Technical Evaluation" to show that this issue is not a substantial safety hazard. The methodology is presented in a manner that should enable plants to apply plant specific features to show that increased rod burst during a design basis SBLOCA does not result in a major reduction in the degree of protection provided to the public health and safety. Each plant should carefully review the applicability of the assumptions and inputs in the "Technical Evaluation" to the plant specific design features and adjust the inputs and assumptions as required to match these features.

However, if a plant does not wish to use the methodology or obtained unacceptable results, then the plant may wish to consider the option using the CSS during the SBLOCA if high radiation levels, indicative of substantial fuel damage, are detected inside containment. The CSS is highly effective in removing airborne iodine from the containment atmosphere. Use of the CSS in the appropriate manner should demonstrate that this issue does not present a substantial safety hazard.

Also, it should be noted that the use of the CSS during a SBLOCA may impact the plant specific analysis performed pursuant to 10CFR50.46. While early initiation of spray during a small break LOCA would reduce offsite dose, if the initiation is too early, switchover of the ECCS to cold leg recirculation could occur during the core uncovery period of the accident. This may result in a period of reduced SI flows leading to higher calculated Peak Cladding Temperatures (PCT) for the SBLOCA event. Therefore, if the plant EOPs are to be modified to require the operator to start the CSS in the event of an SBLOCA, this action should be restricted to occur no earlier than 30 minutes into the transient, as measured from the "S" signal time. In this manner, the rapid drain down of the RWST by the CSS should not occur prior to the onset of core recovery for the SBLOCA event, and the PCT should not be affected.

Issue 2: <u>Long-term Sump pH Control During a SBLOCA</u>

Each plant should review the plant specific design features and operating procedures to assure that the sump pH is adjusted to a pH > 7 within 48 hours following the initiation of recirculation during a SBLOCA. This adjustment will help to mitigate the potential stress corrosion cracking of ECCS components. One way to perform this adjustment is to actuate the CSS during the SBLOCA, if the CSS is used to deliver an alkaline chemical for sump pH adjustment. However, it should be noted that the use of the CSS during a SBLOCA may impact the plant specific analysis performed pursuant to 10CFR50.46. While early initiation of spray during a small break LOCA would inject chemicals to raise the sump pH, if the initiation is too early, switchover of the ECCS to cold leg recirculation could occur during the core uncovery period of the accident. This would result in a period of reduced SI flows leading to higher calculated Peak Cladding Temperatures (PCT) for the SBLOCA event. Therefore, if the plant EOPs are to be modified to require the operator to start the CSS in the event of an SBLOCA, this action should be restricted to occur no earlier than 30 minutes into the transient, as measured from the "S" signal time. In this manner, the rapid drain down of the RWST by the CSS should not occur prior to the onset of core recovery for the SBLOCA event, and the PCT should not be affected. Alternatively, you may wish to consider the use of an alternate pH adjusting system such as TSP (Trisodium Phosphate) passive basket system to adjust the sump pH within acceptable limits, following the accident.