January 28, 2000

Mr. W. Glenn Warren, Chairman
Boiling Water Reactor Owners Group
c/o Southern Nuclear
42 Inverness Center Parkway
P.O. Box 1295
Birmingham, Alabama 35242

SUBJECT: BOILING WATER REACTOR OWNERS GROUP (BWROG) EMERGENCY PROCEDURE AND SEVERE ACCIDENT GUIDELINES

Dear Mr. Warren:

The purpose of this letter is to document our understanding regarding closeout of the Nuclear Regulatory Commission's (NRC) comments on the BWROG Emergency Procedures and Severe Accident Guidelines (EP/SAG).

Over the last three years, the NRC has considered the improvement in reactor safety achieved through the development and implementation of the BWROG EP/SAG. The staff and industry gained insights into the EP/SAG through several information exchanges (NRC letters dated July 20, 1998, and April 2, 1997, and BWROG responses dated July 15, 1999, and January 9, 1998), as well as a severe accident management demonstration visit at one BWR plant in 1998. These activities also served to identify a number of areas for further enhancement of the severe accident guidelines.

In the July 15, 1999, letter, the BWROG identified a number of modifications to the severe accident guidelines and/or supporting technical bases to address staff concerns, and committed to incorporate the modifications in a future update (Revision 2) of the EP/SAG scheduled for year 2000. Several additional changes being considered by the BWROG were brought to our attention in subsequent discussions with BWROG representatives. It is our understanding that these modifications are being pursued as part of the ongoing activities of the BWROG Emergency Procedure Committee and tracked as formal EP/SAG issues as follows:

– Further guidance regarding core cooling at 2/3 core height and its impact on the decision to flood containment (Issue 9816).

– Further guidance on the significance of drywell flooding in preventing liner melt-through (Issue 9910).

– Refinements in the strategy for containment flood-up following reactor vessel breach to delay the need for containment venting (Issue 9812).

– Relaxations in the drywell spray initiation limits to permit expanded use of drywell spray in severe accidents (Issue 9919).

– Further guidance to emphasize the need to evaluate radiological consequences associated with containment venting, including venting to facilitate flooding (Issue 9907).

– Further guidance to specify the priority of wetwell over drywell venting (Issue 9908).

We consider the planned changes and approach acceptable for bringing these matters to closure.

Based on an NRC contractor review, three areas were identified where further enhancements to the guidelines would be beneficial (two of which relate to issues identified above). These involve the containment venting philosophy, the strategy for inhibiting ADS, and the restrictions imposed by the drywell spray initiation limit. A summary discussion of these items is provided as an enclosure to this letter for consideration by the BWROG and member utilities.

We recognize that plant-specific guidance may vary from the generic SAG as a result of plant-specific features, and that the responsibility for implementation details rests with the individual utilities. In areas where plant-specific features impact the approach to severe accident mitigation, utilities may deviate as necessary from the generic guidelines to develop the plant-specific guidance in a manner most appropriate for their plant(s). Furthermore, as noted in the safety evaluation regarding Revision 4 of the EPGs, licensees should assure that the plant-specific procedures relevant to design basis events do not impact the plant licensing basis.

This completes the NRC's comments on the BWROG EP/SAG (Revision 1). We request that the BWROG provide a copy of EP/SAG, Revision 2, to the NRC for information, when it is issued.

If you have any questions regarding this response, please contact the NRC project manager, Robert M. Pulsifer, at (301) 415-3016.

Sincerely,

/***RA/***

Stuart A. Richards, Director
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 691

Enclosure: Comments

cc w/encl: See next page

Further guidance to emphasize the need to evaluate radiological consequences associated with containment venting, including venting to facilitate flooding (Issue 9907).

Further guidance to specify the priority of wetwell over drywell venting (Issue 9908).

We consider the planned changes and approach acceptable for bringing these matters to closure.

Based on an NRC contractor review, three areas were identified where further enhancements to the guidelines would be beneficial (two of which relate to issues identified above). These involve the containment venting philosophy, the strategy for inhibiting ADS, and the restrictions imposed by the drywell spray initiation limit. A summary discussion of these items is provided as an enclosure to this letter for consideration by the BWROG and member utilities.

We recognize that plant-specific guidance may vary from the generic SAG as a result of plant-specific features, and that the responsibility for implementation details rests with the individual utilities. In areas where plant-specific features impact the approach to severe accident mitigation, utilities may deviate as necessary from the generic guidelines to develop the plant-specific guidance in a manner most appropriate for their plant(s). Furthermore, as noted in the safety evaluation regarding Revision 4 of the EPGs, licensees should assure that the plant-specific procedures relevant to design basis events do not impact the plant licensing basis.

This completes the NRC's comments on the BWROG EP/SAG (Revision 1). We request that the BWROG provide a copy of EP/SAG, Revision 2, to the NRC for information, when it is issued.

If you have any questions regarding this response, please contact the NRC project manager, Robert M. Pulsifer, at (301) 415-3016.

Sincerely,
/***RA/***
Stuart A. Richards, Director
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 691

Enclosure: Comments

cc w/encl: See next page

DISTRIBUTION:
File Center RPalla
PUBLIC GThomas
PDIV-2 R/F

DOCUMENT NAME: G:\PDIV-2\BWROG\BWROG-EG-SAG.WPD

To receive a copy of this document, indicate **"C"** in the box

OFFICE	PDI-1/PM	C	PDIV-2/LA	C	SPSB		PDIV-2/SC		PDIV/D	N
NAME	RPulsifer:lcc		EPeyton		RBarrett		SDembek		SRichards	
DATE	01/27/00		01/24/00		01/06/00		01/27/00		01/28/00	

OFFICIAL RECORD COPY

cc:
Mr. James M. Kenny
BWR Owners' Group Vice Chairman
PP&L, Inc.
Mail Code GENA6-1
Allentown, PA 18101-1179

Mr. Thomas J. Rausch
RRG Chairman
Commonwealth Edison Company
Nuclear Fuel Services
1400 Opus Place, 4th Floor
Downers Grove, IL 60515-5701

Mr. Drew B. Fetters
PECO Energy
Nuclear Group Headquarters
MC 61A-3
965 Chesterbrook Blvd.
Wayne, PA 19087-5691

Mr. H. Lewis Sumner
Southern Nuclear Company
40 Inverness Parkway
PO Box 1295
Birmingham, GA 35201

Mr. Carl D. Terry
Vice President, Nuclear Engineering
Niagara Mohawk Power Corporation
Nine Mile Point - Station
OPS Bldg/2nd Floor
PO Box 63
Lycoming, NY 13093

Mr. George T. Jones
PP& L, Inc.
MC GENA6-1
Two North Ninth Street
Allentown, PA 18101

Mr. John Kelly
New York Power Authority
14th Floor Mail Stop 14K
Centroplex Building
123 Main Street
White Plains, NY 10601

Mr. Thomas G. Hurst
GE Nuclear Energy
M/C 182
175 Curtner Avenue
San Jose, CA 95125

Mr. Thomas A. Green
GE Nuclear Energy
M/C 182
175 Curtner Avenue
San Jose, CA 95125

COMMENTS ON BWROG EMERGENCY PROCEDURE AND SEVERE ACCIDENT GUIDELINES FOR BWROG/UTILITY CONSIDERATION

CONTAINMENT VENTING PHILOSOPHY

Description of Concern

Instructions that the primary containment vents should be opened "irrespective of the offsite radioactivity release rate" appear at several locations within the severe accident guidelines (SAG). Under certain circumstances, it may indeed be preferable to accept an early and controlled release of fission products in lieu of a later (and certain) uncontrolled release from a ruptured containment. However, there may be instances where early vent opening may not be well-founded for specific plants. Furthermore, literal interpretation of the phrase "irrespective of the offsite radioactivity release rate" might be interpreted by control room operators as direction to open vents without regard to consequences, and can lead to unintended consequences.

The potential consequences of venting a boiling water reactor primary containment "irrespective of the offsite radioactivity release rate" under severe accident conditions are both obvious and severe. Drywell venting would almost certainly be called for if the SAG are entered for any accident sequence (risk-important or otherwise) as a result of the central goal of these guidelines, which is to flood the containment to an elevation equivalent to the top of the core. The associated compression of the drywell atmosphere requires that venting be initiated, either to permit flooding by low-pressure pumps, or to avoid undesirably high containment pressure.

The generic SAG also call for venting as a means to preclude hydrogen combustion, with the decision to vent to be based on the concentrations of hydrogen and oxygen within the wetwell or drywell. Severe accident progression typically involves a period of extended core uncovery, followed by hydrogen generation and fission product release, with significant hydrogen generation and the onset of fission product release occurring in the same general time period. Accordingly, venting might be initiated at low containment pressure, just prior to or coincident with significant entry of fission products into the containment.

It can be concluded that containment venting will be called for if the SAG are entered. What is in question is the plant-specific procedural guidance with respect to the preparatory steps taken, and the authorization required before the vents are opened.

Considerations for Boiling Water Reactor Owners Group (BWROG) and Individual Utilities

In their July 15, 1999, response, the BWROG "agrees that deliberate containment venting should remain a last resort action" and "agrees that a decision to vent the primary containment should always weigh the potential benefits against the expected radiological consequences and believes that effective controls on venting are already in place at all plants." The response further states that "Appendix B will be revised to emphasize that the radiological consequences of venting should also be evaluated and to clarify that venting to facilitate flooding is appropriate only if it is expected that the resulting increase in flow will preclude degradation to a less desirable plant condition." In view of the general agreement that venting must be a deliberate

action taken only after consequences are weighed, we believe that alternative wording reflecting the actual considerations or decision process governing venting is more appropriate than the phrase "irrespective of the offsite radioactivity release rate."

The BWROG has committed to more clearly specify in Appendix B that the suppression chamber vent is the preferred path and that the drywell path should only be used when the suppression chamber vent cannot or should not be used. As stated in our previous correspondence on this topic, we consider it incumbent upon individual utilities to ensure that proper advantage is taken of the benefits of pressure suppression pool scrubbing by venting from the wetwell whenever feasible, and to assure that the plant-specific instructions and training regarding venting includes appropriate emphasis on the use of wetwell vent paths before other vent paths are utilized.

Our review also noted two areas where additional guidance and/or controls could further reduce the risk associated with venting: (1) guidance aimed at assuring that the vents, if opened early, can be closed when fission products appear, and (2) clearly established responsibilities within the licensee's management organization for authorizing containment venting under accident conditions. These aspects of containment venting could be addressed by the BWROG and individual licensees, respectively.

ADS INHIBIT

Description of Concern

EP/SAG direct the operators to inhibit the automatic initiation of the automatic depressurization system (ADS) in non-anticipated transient without scram (ATWS) sequences with loss of high pressure injection, even when low-pressure pumps are running and available for injection. With automatic initiation inhibited and a sustained loss of injection, it is necessary for the operators to keep track of the continuing decrease in reactor vessel water level. Subsequently, at the appropriate time, they must manually actuate the ADS (or employ other manual means) to effect vessel depressurization so that the low pressure pumps can inject in time to prevent core damage.

Operator error probabilities for failure to manually depressurize the vessel under such circumstances have been found to vary widely in the BWR individual plant examinations (IPEs) and in some cases, to significantly increase the calculated core damage probability. Risk perspectives of inhibiting ADS are documented in NUREG-1560. Section 3.2 of this report, "Boiling Water Reactor Perspectives," identifies failure to depressurize as a dominant contributor to core damage frequency for accident sequences classified as transient with loss of injection. A "failure to depressurize influenced by operator action to inhibit the automatic depressurization system (ADS)" is cited as important for most BWR 3/4 and 5/6 plants.

In their July 15, 1999, response, the BWROG indicated that there is no risk-informed justification which clearly requires the use of automatic versus manual ADS, and that the decision for use of a manual versus automatic ADS should be made on a plant-specific basis.

Considerations for BWROG and Individual Utilities

It is recommended that the strategy to prevent automatic initiation of ADS in non-ATWS accident sequences be carefully considered in view of the IPE insights indicating that this strategy may be a major contributor to core damage frequency.

In a January 9, 1998, BWROG response to a request for additional information on the EP/SAG, the BWROG indicated that the symptom-oriented nature of the guidelines precludes automatic operation of ADS for the following reasons: (1) the conditions assumed in the design of the ADS system actuation logic may not exist when the action specified in the EOP is performed, (2) ADS actuation may complicate efforts to control reactor pressure vessel (RPV) water level, (3) if only steam driven systems are available for injection, ADS actuation may directly lead to loss of adequate core cooling and subsequent core damage, and (4) the operating crew can draw on much more information than is available to the ADS logic and can better judge, based on instructions contained in the EPG/SAG, when to depressurize the RPV. One of the primary benefits of having a procedural override of the installed ADS logic is apparently to defer actuation of ADS as long as possible in hope of avoiding the severe thermal transient to the reactor vessel that accompanies any rapid depressurization. However, to obtain this delay it is necessary to complicate the EPGs and to introduce the possibility of core damage due to operator error as cited in NUREG-1560. In the final analysis, the advantage of such a delay will only be realized if high pressure injection is restored during the delay so that use of the ADS is avoided entirely.

As a result of our review, we continue to believe that this tradeoff should be carefully evaluated, considering the delay in depressurization gained through the ADS inhibit strategy (the time in which water level falls from the point at which the valves would open automatically to the manual initiation setpoint), the aforementioned operational considerations associated with automatic actuation of ADS, and the potential for human error associated with inhibiting ADS. Consistency with the plant's licensing basis with respect to small-break loss-of-coolant accident (LOCA), for which the ADS is an important design feature for accident mitigation, would be an additional consideration at the plant-specific level. The time between valve opening in the automatic mode and manual opening in accordance with the generic guidelines is plant-specific, but with the water level falling at a rate of about five inches per minute, this is expected to be no more than about five or ten minutes. In view of this small advantage, licensees may with adequate justification chose to simplify their plant-specific procedures by eliminating the ADS override provision of the generic guidelines.

DRYWELL SPRAY INITIATION LIMIT

Description of Concern

For most Mark I containment plants, accident sequences that lead to release of molten core debris from the reactor vessel bottom head have a high likelihood of early containment failure as a result of direct contact of core debris with the drywell shell. An NRC-sponsored study (NUREG/CR-6025) has shown that the presence of water on the drywell floor prior to vessel failure can prevent such a failure. The SAG are developed in a manner to take advantage of the use of drywell sprays to: reduce temperature and pressure, scrub fission product aerosols from the atmosphere, introduce water over the drywell floor in anticipation of a breach of the

reactor vessel bottom head, and submerge any core debris that is subsequently released from the vessel. In accordance with the SAG, water would be provided to the drywell floor before vessel failure by carrying out the Containment and Radioactivity Release Control Severe Accident Guideline (Step PC/R), which requires drywell spray in response to high containment radiation levels, provided the drywell pressure and temperature are within the drywell spray initiation limit (DWSIL).

The manner in which the DWSIL is calculated has the potential to preclude the use of sprays when needed in severe accidents. Specifically, in establishing the DWSIL, assumptions that the spray temperature is 32°F, that the drywell atmosphere humidity is zero, and that there is no flow into the drywell through the vacuum breakers, produce a limit curve that appears unrealistic and overly restrictive. As a result, use of drywell sprays is expected to be prohibited in most sequences unless a BWR facility chooses to use more realistic assumptions in developing the DWSIL, or employs a different approach to protect against rapid evaporative cooling.

Loss of drywell coolers alone, which generally occurs concurrent with or shortly after the onset of most risk-dominant BWR accident sequences, will result in an early loss of spray initiation capability. Within a few minutes of losing drywell coolers, heat transfer from the reactor vessel will produce a high drywell temperature-low drywell pressure combination that will typically fall within the spray exclusion zone of the plant-specific DWSIL curve as derived from the current assumptions. Such a limitation on the use of drywell sprays can be revealed by overlaying the expected containment temperature-pressure pairs following loss of drywell coolers (with the reactor vessel pressurized) on the DWSIL curve. The drywell atmosphere condition may remain in the exclusion zone throughout the period of core degradation culminating in bottom head failure. Containment conditions that preclude the initiation of sprays per the DWSIL may also be reached late in less likely design-basis LOCA accident sequences.

The importance of drywell sprays in severe accident mitigation, as determined by the BWR utilities while performing their IPEs, is summarized in NUREG-1560. In addition to recognizing the contribution of sprays in preventing early containment failure, the "Late Failure Perspectives" section of this report includes the observation that: "In all the IPEs, containment sprays are found to be of great benefit for preventing or mitigating late containment failure." However, concern over unnecessarily restrictive drywell spray limitations was expressed in several of the IPEs. Specifically, important plant improvements reflected in Table 4.2 of NUREG-1560 include "less restrictive drywell spray initiation criteria" for early containment failure, and "ensuring that the drywell floor is flooded" for late containment failure.

Considerations for BWROG and Individual Utilities

The threat to containment integrity posed by spray initiation derives from the potential for rapid, evaporative cooling of the drywell atmosphere to result in unacceptable reverse pressure loads across the drywell shell. This threat is temporary, however, and limited to the evaporative cooling period when spray water first enters the drywell and saturates the atmosphere, and before drywell-wetwell vacuum breakers would be effective in reducing this pressure differential. As the spray droplets evaporate, the relative humidity of the atmosphere increases and the threat diminishes. Based on our review, we believe it is feasible to simplify the SAG

and improve the availability of drywell sprays under accident conditions by eliminating or reducing unnecessary constraints on spray initiation within the SAG.

Since the reverse pressure transient is dependent on the initial flow of spray water into the drywell, a limitation on use of sprays does not appear necessary for plants that have the ability to throttle sprays. In this case, alternative guidance specifying that sprays be initiated at a flow rate below some predetermined value and maintained at this rate for a certain duration before increasing the flow to rated capacity could achieve the objective of protecting the drywell structure without unduly restricting the use of sprays. The reduced flow rate and flow duration would be developed by the BWROG or individual licensees. For plants that cannot throttle sprays, it may be possible to demonstrate that a flow profile (flow rate versus time) sufficient to saturate the atmosphere while producing an evaporative cooling rate too small to threaten containment integrity is obtained during the period of reduced flow during the opening of the spray valves. For example, the water mass introduced by a few seconds of spray at a reduced rate of 1000 gpm may be sufficient to saturate the drywell atmosphere in any Mark I or II containment without adverse pressure impact.

If the BWROG or individual licensee chooses to maintain limitations on spray initiation under certain conditions, the major assumptions in developing the DWSIL curve could be revisited, and more realistic assumptions could be adopted, with the objective of assuring that drywell spray initiation will not be precluded by the loss of drywell coolers or by the temperature-pressure conditions expected to occur in risk significant BWR sequences. This could include more realistic assumptions for initial spray water temperature and drywell relative humidity. Restrictions on the use of drywell sprays might also be lifted if the drywell vents are open, which is a time when maximum benefit can be obtained from drywell sprays in reducing fission product release.