August 29, 2000

MEMORANDUM TO: Stephen Dembek, Chief, Section 2
Project Directorate IV
Division of licensing Project Management
Office of Nuclear Reactor Regulation

FROM: Robert M. Pulsifer, Project Manager, Section 2 ***/RA/***
Project Directorate I
Division of licensing Project Management
Office of Nuclear Reactor Regulation

SUBJECT: BOILING WATER REACTOR OWNERS' GROUP, DRAFT APPENDIX R FIRE PROTECTION COMMITTEE SUPPLEMENTAL INFORMATION

The enclosed draft supplemental information was transmitted by e-mail on August 25, 2000 by the Boiling Water Reactor Owners' Group (BWROG) to the NRC staff. Review of the supplemental information would allow the staff to be prepared for a conference call requested by the BWROG on the above subject. This memorandum and the enclosure do not represent an NRC staff position.

Project No. 691

Enclosure: Draft BWROG letter, "BWR Owners' Group Appendix R Fire Protection Committee Use of Safety Relief Valves and Low Pressure Systems as Redundant Safe Shutdown Paths, GE Report No. GE-NE-T43-00002-00-03-R01, August 1999

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BWROG-000xx NRC Project 691
Xxxxxx xx, 2000

US Nuclear Regulatory Commission
Document Control Desk
Mail Stop 8 D1
Washington, DC 20555–0001
Attn: John N. Hannon,
Plant Systems Branch Chief

SUBJECT: ***BWR Owners' Group Appendix R Fire Protection Committee Use of Safety Relief Valves and Low Pressure Systems as Redundant Safe Shutdown Paths, GE Report No. GE-NE-T43-00002-00-03-R01, August 1999***

References: BWROG-00073, James M. Kenny to John N. Hannon, BWR Owners' Group Appendix R Fire Protection Committee Use of Safety Relief Valves and Low Pressure Systems as Redundant Safe Shutdown Paths, GE Report No. GE-NE-T43-00002-00-03-R01, August 1999, July 20, 2000

Please find enclosed the supplemental information requested by the NRC Staff regarding the capability of the BWR to maintain hot shutdown. As described in the Reference submittal, the EPG's direct the operator to proceed to cold shutdown because this is the safest condition for the unit when in a degraded condition, such as may result from a fire. As noted on page 5 of the subject submittal, the Part 50 Statement of Considerations acknowledges that "cold shutdown is the ultimate safe shutdown goal." As such, the BWROG does not endorse a concept that would suggest that a plant remain in a hot shutdown condition when the ability to proceed directly to cold shutdown is available.

As described in the Reference, when using SRVs and Low Pressure Systems for achieving safe shutdown, the equipment required for cold shutdown is the same equipment used to achieve hot shutdown. Therefore, the ability to expeditiously proceed directly to cold shutdown will be available.

As requested by the NRC Staff, we have provided a supplemental discussion, to that provided in Attachment 1 to the Reference, describing the design/functional capability of the BWR in maintaining hot shutdown should such a condition ever be required in response to fire damage. This supplemental information is provided as Revision 1 to Attachment 1 (Reference). Please refer to the Attachment 1 Revision 1 attached to this letter.

The BWROG believes that the information provided with this letter resolves all of the remaining open issues between the BWROG and the Staff related to this subject. Based on this response, we expect that the NRC will be able to issue an SER on the subject BWROG Report endorsing the use of Safety Relief Valves and Low Pressure Systems as acceptable Safe Shutdown Paths. This acceptance would allow the use of Safety Relief Valves and Low Pressure Systems as Redundant Post-Fire Safe Shutdown paths meeting the requirements of Appendix R Section III.G.1 and 2 (and the equivalent sections of NUREG-0800, C.5.b.1 and C.5.b.2). It would also allow the use of Safety Relief Valves and Low Pressure Systems as Alternative Safe Shutdown Paths meeting the requirements of Appendix R Section III.G.3 (and the equivalent sections of NUREG-0800, C.5.b.3). Alternative shutdown is used in those areas where separation of redundant safe shutdown trains cannot be accomplished in accordance with the requirements of Appendix R Section III.G.2.

If you have any questions about the information provided here or if you would like a meeting to discuss this response, please contact Tom Gorman (PPL) at (610) 774-7762, or Kathy Sedney (GE) at (408) 925-5232.

Sincerely,

Original signed by JM Kenny

James M. Kenny, Chairman
BWR Owners' Group

Attachment

cc: JA Gray, BWROG Vice Chairman
BWROG Primary Representatives
BWROG Appendix R Committee
FA Emerson, NEI
TG Hurst, GE
GB Stramback, GE
KK Sedney, GE

Introduction:

In a memorandum from Robert M. Pulsifer, Project Manager, Project Directorate 1, Section 2 to Stuart A. Richards, Director, Project Directorate IV & Decommissioning, dated May 24, 2000, documenting the results of an April 25, 2000 meeting between the NRC staff and the BWROG, the following action was requested of the BWROG:

> *The BWROG will provide the staff with a step-by-step narrative discussion of how plant-specific operating procedures (derived from BWR EPG Rev. 4) can be used to achieve and maintain hot shutdown conditions using the SRV/LPS (rather than HPCI, RCIC, or condensate/feedwater or other possible shutdown systems) after a reactor scram which occurs with a 100 percent power history, to the extent that latent and decay heat would be of sufficient magnitude to permit continuation of this mode of plant operation.*
>
> *[Such a plant-specific operating procedure would be needed to meet the hot shutdown capability of Appendix R, Section III.G.1.a, and the intent of Appendix R as stated in the Statement of Considerations in Federal Register, Section Q, Associated Circuits, November 19, 1980 (45 FR 76609). As described in Appendix R, Section III.G.1.b, cold shutdown capability may not be available for up to 72 hours due to potential fire damage to shutdown cooling components. Therefore, the NRC staff and the BWROG agreed that hot shutdown capability is required in Appendix R, Section III.G.1.a.]*

BWROG Response to Requested Action:

Currently, most BWRs are using the BWR Owners' Group Emergency Procedures and Severe Accident Guidelines (EPG/SAG). The differences between EPG Revision 4 and EPG/SAG relative to this issue are not significant; therefore, the information provided below reflects the content of EPG Revision 4.

The entry conditions for the EPGs are symptomatic of both emergencies and events that may degrade into emergencies. The guidelines specify actions appropriate for both. As such, use of Emergency Operating Procedures developed from these EPGs is an appropriate response to a fire event should the plant symptoms dictate such a response.

The EPGs are organized to provide guidance for operator response to a full range of transients and accidents using all available systems. Since the EPGs provide guidance for the use of all systems capable of performing a function, some simplifying assumptions must be made in order to describe how these procedures could be used to maintain hot shutdown using SRV/LPS. For purposes of this response, it will be assumed that all other systems with the capability to perform the same functions as SRV/LPS are, at some point in the fire scenario, damaged by the fire. Therefore, in the narrative that follows, the following assumptions are made relative to the extent of fire damage.

(1) The reactor is successfully scrammed. This occurs either because the fire causes an automatic scram or because the operator's ability to control the unit is degraded and the operator decides to manually scram the unit.

(2) The MSIVs are closed.

(3) Automatic functions are unavailable due to fire damage.

(4) One loop of RHR, with a heat exchanger, is available.

(5) A sufficient number of SRVs is available to control reactor pressure and to rapidly depressurize the reactor, if required.

(6) Necessary support systems, such as service water systems and electrical distribution systems, are available to assure the proper operation of the systems described above.

(7) All other systems capable of performing RPV inventory control (HPCI, RCIC, HPCS, Condensate/Feedwater, CRD, etc.) are, at some point, lost due to the fire damage.

For the fire event described above, the RPV Control Guideline of Revision 4 to the EPGs would apply. The purpose of the RPV Control Guideline is to restore and maintain RPV level within a satisfactory range, shut down the reactor, control reactor pressure and, ultimately, cool the RPV to cold shutdown conditions. The entry conditions are any of the following:

(1) Reactor pressure vessel (RPV) water level below the low level scram setpoint,

(2) Drywell pressure above the high drywell pressure scram setpoint,

(3) A condition which requires reactor scram and the reactor power is above the APRM downscale trip or cannot be determined, or

(4) RPV pressure above the high pressure scram setpoint.

The initial conditions of a reactor scram and MSIV closure described above would result in an increase in reactor pressure and a decrease in reactor level. These conditions would result in an entry condition into The RPV Control Guideline. Upon entry into the RPV Control Guideline, the operator is instructed to enter and execute the three segments of the procedure (level control, pressure control and power control) concurrently.

The Power Control segment of the RPV Control Guideline verifies that the reactor is shutdown and the control rods are inserted. Through this step, hot shutdown is achieved. Hot shutdown is maintained as long as the reactor remains sub-critical with all control rods but one fully inserted. The requirements of Appendix R Section III.G.1.a to achieve and maintain hot shutdown are satisfied by this step. For the scenario being postulated, once a scram has been achieved, the remaining challenge to the reactor is limited to reactor vessel inventory loss due to boil-off.

The RPV Pressure Control segment of the RPV Control Guideline controls pressure such that safety relief valve cycling is minimized and suppression pool limits are not exceeded. SRVs are used to depressurize the RPV. Once the RPV pressure is reduced to below the pressure interlock of the RHR shutdown cooling system, the RHR system is put into service. Once RHR shutdown cooling is in service, (either normal shutdown cooling or the alternate shutdown cooling mode) normal reactor shutdown procedures are used.

The Level Control segment of this EPG will instruct the operator to maintain level above the low level scram setpoint. If level cannot be maintained above the low level scram setpoint, then the level control segment of this EPG will instruct the operator to maintain level above the top of active fuel (TAF).

To maintain level, the Level Control segment will instruct the operator to inject with Condensate/Feedwater, CRD, HPCI, RCIC, HPCS, RHR or Core Spray. Based on the assumptions described above, RHR would eventually be the only available source of injection not damaged by the fire. The RHR system, however, is a low pressure system and injection using RHR is not possible until reactor pressure reaches approximately 300 psia.

In a controlled depressurization of the reactor that reduces reactor pressure at a rate of less than 100^{o} F/hr, the Technical Specification Limit[1], it will take approximately 1 hour and 20 minutes[2] to reach the reactor pressure at which RHR injection is possible. Depending on the timing of the fire damage to the other sources of injection, however, reactor level may reach TAF, due to boil off, prior to reactor pressure reaching the level where RHR can inject. The following examples provide information on the typical times to reach TAF in a BWR given fire damage to various systems:

(1) If the fire damage stops all high pressure injection at the same time that the reactor is scrammed and the MSIVs are closed, reactor level will reach TAF in approximately 25 minutes.

(2) If the fire damages all high pressure injection capability, except feedwater in a plant with a steam driven feedwater system, at the same time as (1) above, and feedwater operates (i.e. coasts down) until it is tripped by the

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[1] For BWRs, this cooldown rate is an "operating limit", not a "safety limit". Cooldown in excess of 100^{o} F/hr will not have adverse consequences on the integrity of the RPV or attached piping. The possibility of an ADS blowdown is included in the design basis of the Reactor Coolant System.

[2] **Basis**: Reactor $\text{Pressure}_{\text{init.}}$ = 1050 psia corresponding to 550^{o} F; Reactor $\text{Pressure}_{\text{RHR inject.}}$ = 300psia corresponding to 417^{o} F; $\{550^{o}\text{ F} - 417^{o}\text{ F}\}/\ 100^{o}$ F/hr. = 1.33 hr.

high water level trip, then reactor level will reach TAF in approximately 35 minutes.

(3) If the fire damage is identical to that described in (2) above except that CRD is not damaged and is maximized by the operator after 10 minutes, then reactor level will reach TAF in approximately 1 hour.

It is evident from these cases, that the specific fire damage and the timing of this damage will have an effect on whether or not rapid depressurization of the reactor will be required. These cases also reflect analyses performed using decay heat values indicative of a full power operating history.

In each of the three cases described above, reactor level would reach TAF prior to reactor pressure reaching the level at which RHR could inject. Based on reactor level reaching TAF, the RPV Level Control section of the RPV Control Guideline would instruct the operator to rapidly depressurize the reactor at a rate greater than 100^{o} F/hr. to allow injection using the available low pressure system.

In any case, during the time it takes for the reactor to depressurize to the reactor pressure at which low pressure systems can inject, the EPGs instruct the operator to line up and start any pumps with the ability to inject into the reactor at any pressure. During this time, the EPGs also expect that operators will take actions to attempt to re-establish injection and to reverse the RPV level trend. Since adequate core cooling is assured as long as RPV level remains above TAF, the EPGs instruct the operator to delay rapid depressurization until reactor level reaches TAF to provide the operator with the maximum amount of time for taking other corrective actions. [Note: At least one BWR does not inhibit ADS, but rather allows ADS to automatically depressurize the reactor when level reaches –129″. In this case, however, due to the timers installed in the ADS automatic logic, the actual depressurization does not occur until approximately the same level as when the operator performs this function manually.] If other systems could be restored or if the fire damage evolves over a longer period of time (i.e. 1.5 hours), rapid depressurization would not be required. For the scenario being postulated here, none of these other options are assumed to become available.

Throughout this entire process, the reactor remains in hot shutdown and adequate core cooling exists. If reactor level reaches TAF, the EPGs instruct the operator to rapidly depressurize the reactor. After rapidly depressurizing the reactor, the reactor can remain in hot shutdown for an extended period of time unless decay heat is removed by using either RHR in the shutdown cooling or alternate shutdown cooling mode. Cold shutdown would be achieved and maintained by using RHR in the shutdown cooling or the alternate shutdown cooling mode. RHR is placed in the alternate shutdown cooling mode by directing injection flow through the open SRVs into the suppression pool where decay heat is removed by RHR suction being directed through the RHR heat exchanger. At this point the requirements of Appendix R Section III.G.1.b to achieve cold shutdown will be satisfied.

The actual amount of time that it will take to reach cold shutdown is a function of many variables such as, operating history, the extent of fire damage and the timing of the fire damage. In any case, including those cases where high pressure systems are available, the actual time will be dictated by reactor thermal hydraulics and physics. The amount of time that hot shutdown can be maintained, in the event that proceeding to cold shutdown is restricted for some reason, is similar for cases using high pressure systems and low pressure systems.

In the case of the scenario postulated above, however, the time to reach cold shutdown is not critical since the equipment required to maintain the plant in a safe and stable hot shutdown condition is also adequate for maintaining the plant in a safe and stable cold shutdown condition.

As described above, the EPG's direct the operator to proceed to cold shutdown since this is the safest condition for the unit when in a degraded condition. As noted on page 5 of the BWROG submittal on the Use of SRVs and Low Pressure Systems as Redundant Safe Shutdown Paths, Report No. GE-NE-T43-00002-00-03-R01, the Part 50 Statement of Considerations acknowledges that "cold shutdown is the ultimate safe shutdown goal". As such, the BWROG does not endorse a concept that would suggest that a plant remain in a hot shutdown condition when the ability to proceed directly to cold shutdown is available. The 72 hour time frame described in Appendix R Section III.G.1.b for making repairs to cold shutdown equipment is interpreted by the BWROG to be an upper bound limit on the amount of time given to make any cold shutdown repairs. It is our belief that this limit was instituted in an effort to limit the types and number of repairs that could be made to equipment required for cold shutdown. We do not believe that there was any intent with this requirement that hot shutdown should be maintained for this period of time particularly when the ability to proceed to cold shutdown is available.

The EPGs and site procedures are designed to provide appropriate guidance for responding to emergencies and events that may degrade into emergencies based on the available equipment. Plant operations personnel are instructed to follow these procedures, and will control plant conditions within the parameters prescribed by these procedures. With respect to the timing requirements associated with repairs postulated to be required in response to an Appendix R fire event, the time lines are selected based on assuring safe and stable plant conditions. These repairs are not arbitrarily assigned a 72 hour completion time. When considering the feasibility of repairs in the Post-Fire Safe Shutdown analysis, repair completion times must be consistent with the plant's anticipated response to the shutdown transient. The expectation is that any postulated repairs would be completed in a time frame consistent with that dictated by assuring stable plant conditions and that the plant operator would expeditiously proceed to the safest plant condition given the equipment available.

After depressurizing the reactor and restoring reactor coolant level, the operator would proceed to cold shutdown using either shutdown cooling or alternate shutdown cooling. As described above, for this shutdown methodology, the equipment required for cold shutdown is the same equipment used to achieve hot shutdown. Therefore, the ability to expeditiously proceed directly to cold shutdown will be available.

From a BWR design/functional capability perspective, however, if it is assumed that entering shutdown cooling is prevented because of fire damage to equipment required to make the transition to cold shutdown, hot shutdown can be maintained for an extended period of time while repairs are made to the cold shutdown equipment. As described above, the ability to maintain hot shutdown for an extended period of time using any of the systems designed into the BWR is dependent upon the core power history. The discussion that follows is based on the decay heat load at the end of a full power operating cycle.

The typical core heat load for a BWR at the end of an operating cycle contains a sufficient amount of decay heat to be capable of raising the temperature of the reactor coolant to the boiling point for a very long period of time beyond shutdown. For a typical BWR 4, the decay heat at 72 hours after shutdown has been calculated to be approximately 48 million BTUs/Hr. Even if the total loss of shutdown cooling occurs after reactor cool down has taken place, the amount of decay heat available at 72 hours has been determined to be capable of raising the reactor coolant temperature from an initial temperature of 90^{0}F to above 200^{0}F in less than 2 hours. In the event of a total loss of shutdown cooling, the available decay heat will increase the reactor coolant temperature to 212^{0} F. Once the reactor coolant temperature rises to 212^{0} F, the unit will again be in hot shutdown. As the reactor coolant continues to boil, the reactor pressure will increase and reactor level will decrease. Reactor pressure can be regulated with the SRVs by either cycling or keeping open the SRVs. Reactor pressure can be maintained below the shutoff head for the available low pressure system. The available low pressure system can then be used to periodically inject coolant into the reactor to maintain reactor level. Depending on the amount of coolant injected, the reactor coolant temperature could momentarily drop below 200^{o}F. Based on the available decay heat, however, the temperature will quickly rise to 212^{o}F.

In this manner, hot shutdown can be maintained as long as there is sufficient decay heat available to continue to raise the temperature of the reactor coolant to 212^{o}F. Therefore, when using SRVs and LPS as redundant safe shutdown paths, for the hypothetical scenario described above, it would be expected that hot shutdown could be maintained for a period of 72 hours or greater while cold shutdown repairs are performed.