

UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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In the Matter of )

LONG ISLAND LIGHTING COMPANY )

(Shoreham Nuclear Power Station,  
Unit 1) )

Docket No. 50-322 (O.L.)

PREPARED DIRECT TESTIMONY OF  
GREGORY C. MINOR AND DALE G. BRIDENBAUGH  
ON BEHALF OF SUFFOLK COUNTY

REGARDING

SUFFOLK COUNTY CONTENTION 28(a)(i)

AND

SOC CONTENTION 7.A(1)

RESTART OF CORE SPRAY AND

LPCI SYSTEMS ON LOW LEVEL



May 4, 1982

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## SUMMARY OF TESTIMONY

Following the TMI-2 experience in which an operator turned off the coolant injection and the low water level subsequently resulted in core damage, BWRs were required to make changes to their ECCS logic to override a similar erroneous operation by the operators. This requirement is set forth in NUREG-0737, Item II.k.3.21.

LILCO has decided not to implement the NUREG-0737 change, and the NRC Staff has endorsed that position. The main reasons cited are trust in the operator and the complexity of the change. However, LILCO has provided no analyses to demonstrate that these "reasons" justify an exemption from NUREG-0737 or that Shoreham, without the Item II.k.3.21 fix, will meet the safety goals mandated by the Commission's Action Plan. There is no assurance LILCO has met the regulatory requirements of 10 CFR 50 Appendix K.

### Exhibits

1. BWR Owners' Group Evaluation of NUREG-0737 Item II.k.3.21 "Core Spray and Low Pressure Coolant Injection Systems Low Level Initiation"  
(Attachment 1 to SNPS-1 FSAR Section II.k.3.21)
2. Memo, Speis (NRC) to Lainas et al. (NRC),  
"Evaluation of BWR Owners' Group Generic Response to Item II.k.3.21 of NUREG-0737, "Core Spray and Low Pressure Coolant Injection Systems Low Water Initiation", April 14, 1982.

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DALE G. BRIDENBAUGH AND GREGORY C. MINOR  
REGARDING SUFFOLK COUNTY CONTENTION 28(a)(i) AND SOC CONTENTION 7.A(1)  
RESTART OF CORE SPRAY AND LPCI SYSTEMS ON LOW LEVEL

I. INTRODUCTION

This testimony was prepared by Dale G. Bridenbaugh and Gregory C. Minor.<sup>1/</sup> A statement of our qualifications and experience has been separately provided to the Board. The testimony addresses the concerns expressed in NUREG-0737, Item II.K.3.21, which states (in part):

"The core-spray and low pressure, coolant-injection (LPCI) system flow may be stopped by the operator. These systems will not restart automatically on loss of water level if an initiation signal is still present. The core spray and LPCI system logic should be modified so that these systems will restart, if required, to assure adequate core cooling."

LILCO has decided not to modify the systems at Shoreham to protect against this condition.

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<sup>1/</sup> The Contention was discussed jointly between the two authors. The first draft was prepared by G. C. Minor and subsequent revisions and editing were contributed by both authors. Accordingly, it is not possible to specify responsibility for particular portions.

that improper operator action does not cause core uncover or otherwise exacerbate an accident situation.

There is persuasive basis for the NUREG-0737 requirement that an automatic restart capability for LPCS or LPCI should be provided. In the TMI-2 accident, under the extreme pressures of coping with the events which occurred, reactor operators made serious errors in manually shutting off ECCS systems, thus permitting water level to decrease to an unsafe level. The NUREG-0737 requirement responds to this problem of operators making mistakes in the midst of coping with severe accident conditions by ensuring that key ECCS systems will restart automatically if conditions warrant such action. Indeed, the BWR Owners' Group has noted that unsafe conditions could occur if improper operator actions occurred. The Group noted three such circumstances:

1. Deliberate operator termination of multiple ECCS during the earlier phases of an incident when the systems have been automatically initiated. . . .
2. A second general circumstance during which errors and omissions could potentially lead to degraded core cooling conditions would be failure of the operator to adequately consider core cooling requirements during the long term period. . . .
3. During upset transients and small breaks, . . . it is highly desirable for the plant operators to intervene in this automatic process and assume manual reactor water level control. The key incentive is to prevent the water level from reaching Level 8 since in addition to the HPCS, both the feedwater system (if operating) and the RCIC will be tripped on high level. Consequently, it is probable that for the types of events described in Tables 2 and 4, the plant operators



will intervene fairly early and assume manual HPCS control.<sup>3/</sup>

Notwithstanding the benefits of ensuring automatic ECCS restart, LILCO has not proceeded to implement NUREG-0737, Item II.K.3.21. Instead, as part of the BWR Owners' Group, LILCO had GE prepare a generic response to the NUREG-0737 concern about manual shutoff of a needed ECCS function. The Owners' Group/LILCO conclusion was in two main parts:

1. General Electric and the BWR Owners' Group have reviewed the current CS and LPCI system and have concluded that overall BWR safety would not be enhanced by the type of control system modification suggested by the NRC.<sup>4/</sup>
2. Our evaluation of Item II.K.3.21 has considered the potential benefits of modifying the HPCS logic to extend automatic restart on Level 2 following manual termination. . . . It has been concluded that such HPCS changes are not required by plant safety considerations. However, the changes that would provide this capability appear to be relatively straightforward and may provide additional safety margin.<sup>5/</sup>

The NRC Staff evaluated the Owners' Group position and concluded that the position was acceptable, basically adopting the Owners' Group's words:

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<sup>3/</sup> BWR Owners' Group Evaluation of NUREG-0737, Item II.K.3.21 "Core Spray and Low Pressure Coolant Injection Systems Low Level Initiation," pp. 22-24.

<sup>4/</sup> Ibid. 3, p. 2.

<sup>5/</sup> Ibid. 3, p. 24.

We agree with the Owners' Group position that logic modifications for LPCI and core spray (except for HPCS) are unwarranted. The Owners' Group did propose a modification to the HPCS logic (applicable to BWR/5s and BWR/6s only; LaSalle will be the first operating BWR/5) which is simple and improves the safety function. The Owners' Group felt that the HPCS modification was beneficial but not required for safety. We agree with the Owners' Group assessment that the HPCS logic modification is beneficial and is a simple modification; therefore, it should be implemented. This position on the HPCS logic is consistent with the positions included in the SERS for near-term OLs.<sup>6/</sup>

However, the Staff review did not highlight the applicability of its conclusion, to Shoreham, nor did the Staff mention other ECCS modifications being considered for older BWRs. The Staff's SER for Shoreham similarly reflects no Shoreham-specific analyses to determine whether the NUREG-0737 changes would be appropriate for Shoreham.<sup>7/</sup>

III.B. NO ADEQUATE JUSTIFICATION HAS BEEN PROVIDED  
TO JUSTIFY FAILURE TO IMPLEMENT THE NUREG-  
0737 REQUIREMENT AT SHOREHAM

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The justifications for failing to institute the NUREG-0737 changes at Shoreham are not persuasive and provide no basis for exempting LILCO from compliance with the NUREG's requirements.

First, the Owners' Group recommendation concerning HPCS is completely inapplicable to Shoreham. Shoreham, a BWR-4, does not

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<sup>6/</sup> Memo: Spais (NRC) to Lainas (NRC) "Evaluation of BWR Owners' Group Generic Response to Item II.K.3.21 of NUREG-0737, "Core Spray and Low Pressure Coolant Injection Systems Low Level Initiation," April 14, 1982.

<sup>7/</sup> NUREG-0420, Supp. 1, Sept. 1981, pp. 22-84 and 22-85.

have an HPCS. Shoreham relies on a HPCI system with an RCIC as back-up for the high pressure/small LOCAs. Unfortunately, the Owners' Group position was silent on these systems, merely stating that:

There are some plant to plant variations in these systems but these variations are not important to the overall technical conclusions presented in this memorandum. Neither the High Pressure Coolant Injection system (HPCI) provided on some pre-BWR/5 reactors nor the Reactor Core Isolation Cooling system (RCIC) is discussed.<sup>8/</sup>

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<sup>8/</sup> Ibid. 3, p. 2. In addition, the technical specifications for Shoreham provide conditions for system unavailability which cannot be exceeded without jeopardizing the safety of the reactor. For example, it is permissible to have the HPCI out of operation for up to 14 days, based on the demonstrated operability of redundant and diversified low pressure core cooling systems. The low pressure ECCS at Shoreham are the LPCI and LPCS. LILCO Resp. to SC First Doc. Request, Request #3, Pre. Tech. Spec. GE STS (BWR 4), pp. B 3/4, 5-1, 5-2 (Doc. submitted to NRC Feb. 1, 1982). However, these are the same systems which II.K.R.21 is requiring to be automated, and the same systems that LILCO would like to be able to divert or shut off if the operator should decide to do so. The operability of the LPCS is assumed to be verified by surveillance testing during operation. However, operability cannot be assured unless operator action to shut off these systems can be overridden under the necessary circumstances. Many of these ECCS systems can be turned off by the operator if he perceives an improvement of the conditions which originally caused the system to actuate. If done improperly, this could lead to serious problems and even core damage. This is the issue brought up in NUREG-0737, Item II.K.3.21.

Second, there is no evaluation of Shoreham-specific modifications to achieve the NUREG-0737 goals. Rather, the general discussion in the Owners' Group evaluation focuses on the multiple use of the RHR (in LPCI mode, Suppression Pool Cooling mode, etc.) and the complexity of the alterations necessary to change its mode of operation from one mode to another (e.g., from Suppression Pool Cooling to LPCI). It is on the basis of this complexity of logic modification that the fundamental decision was made to not modify the plant. The Owners' Group suggests that there would be new failure modes introduced and this would potentially result in a net reduction in safety. This is not substantiated in the Group's discussion.

In the Shoreham FSAR, LILCO cites the alleged complexity of necessary changes in addition to several other points, as justification for not modifying the ECCS logic.

The current system design is adequate and no design changes are required. This adequacy is based on several factors including the following:

1. Comprehensive nature of BWR operator training.
2. Emphasis on reactor water level control during training.
3. Emergency Procedure Guidelines.
4. Relatively long time available for operator action.

Any further automation would unnecessarily increase system complexity, reduce system reliability and restrict operator flexibility.<sup>9/</sup>

However, there are no analyses to support LILCO's statements on operator training, nor any indication that LILCO considered

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<sup>9/</sup> FSAR, p. II.K.3.21-1 and -2.

the questionable reliability of the vessel water level instruments under certain accident conditions (see Suffolk County testimony on Contention 7B). Similarly, there is no indication that LILCO has analyzed the Shoreham ECCS to verify that the reduced system reliability argument and length of time available for operator action are actually applicable to the Shoreham design.

Finally, it also appears that alternatives to modification of RHR and LPCS logic were not considered. For example, the possibility of adding auto restart for only LPCS on low water level was not specifically addressed, despite the facts that (a) comparable HPCS logic modifications were described as simple to implement for BWRs 5 and 6; and (b) despite the fact that other BWRs are considering whether modifications of LPCS are desirable.

#### IV. CONCLUSIONS

TMI-2 showed the danger of over-reliance on operators to make the correct decisions regarding manual operation of ECCS. NUREG-0737 included a requirement to analyze and implement an auto restart of LPCS/LPCI on BWRs. In evaluating the desirability of automating a restart of LPCS and LPCI, Shoreham has adopted a BWR Owners' Group position which is mainly focused on BWR 5s and 6s and is silent regarding modifications being considered for older BWRs (pre BWR 5). Thus, plants without LPCS should be considered separately and evaluated for various modifications including LPCS auto restart. Further, the reasons cited for rejecting the auto restart have not been justified for the Shoreham design. LILCO has, in effect, asked for a waiver from the requirements of II.K.3.21 but has not demonstrated adequate justification for deviation from the requirements. Until a plant-unique analysis



is conducted for the present ECCS, operator training, and equipment at Shoreham, there is no assurance that Shoreham will meet the requirements of 10 CFR 50, Appendix K and 10 CFR 50.46 under the worst case conditions of mis-operation of ECCS.



BWR OWNERS' GROUP EVALUATION OF

NUREG-0737 ITEM II.K.3.21

CORE SPRAY AND LOW PRESSURE COOLANT  
INJECTION SYSTEMS LOW LEVEL INITIATION

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CORE SPRAY AND LOW PRESSURE COOLANT  
INJECTION SYSTEMS LEVEL INITIATION

SUMMARY

The NRC has suggested certain modifications to the BWR Core Spray (CS) and Low Pressure Coolant Injection (LPCI) systems provided as part of the BWR ECCS network. These NRC suggestions center on control system logic modifications that would provide greater automatic system restart capability following manual termination of system operation. General Electric and the BWR Owners' Group have reviewed this issue on a generic basis and do not believe the NRC suggestions are required for plant safety considerations. This conclusion is based on the adequacy of the current ECCS logic design coupled with the potentially negative impact on overall safety of the proposed changes. For the low pressure ECCS these negative impacts include a significant escalation of control system complexity and restricted operator flexibility when dealing with anticipated events. Therefore, we conclude that no modifications be made to the low pressure ECCS with respect to automatic restart.

GE and the BWR Owners' Group have evaluated a modification to the HPCS system which would automate its restart on low level following its trip by the operator. This change would make the HPCS restart logic similar to the HPCI logic which already permits an auto restart on low level. We have concluded that this change, although not required for safety reasons, would lead to a net safety improvement which could be implemented without adverse impact on system performance.

This memorandum provides an overview discussion of GE's BWR ECCS design philosophy and presents the technical rationale for the GE/Owners' Group position on this issue.

## 1. INTRODUCTION

This memorandum has been prepared in response to Item II K.3.21 of NUREG-0737. In this Item, the NRC suggested certain modifications to the Core Spray (CS) and the Low Pressure Coolant Injection (LPCI) Emergency Core Cooling Systems (ECCS) that are provided as part of the BWR ECCS network. The NRC suggestions center on incorporating additional control system logic to provide automatic system restart from a low reactor water level signal following actions by the operators to terminate system operation. The NRC concern is that the reactor operators may terminate ECCS operation when a high reactor water level condition exists but may neglect to reinitiate the systems if a low level condition recurs.

General Electric and the BWR Owners' Group have reviewed the current CS and LPCI system for the plants identified in Appendix C and have concluded that overall BWR safety would not be enhanced by the type of control system modification suggested by the NRC. This memorandum describes the current CS and LPCI logic design and provides the technical rationale for the GE/Owners' Group position. This discussion is generic and includes the LPCI and both the low and high pressure core spray systems (LPCS/HPCS). There are some plant to plant variations in these systems but these variations are not important to the overall technical conclusions presented in this memorandum. Neither the High Pressure Coolant Injection system (HPCI) provided on some pre-BWR/5 reactors nor the Reactor Core Isolation Cooling (RCIC) system is discussed.

Section 2 of the memorandum describes the major elements of the GE ECCS design philosophy that are relevant to any discussion of providing expanded system automatic restart capability. A full understanding of the significance of CS and LPCI logic changes must be based on a recognition that these systems are part of the interdependent BWR ECCS network; any changes in one system must consider the possible interactive effects amongst the other systems making up the overall ECCS network. This must also include the potential impact on supporting systems such as the standby power supplies and the emergency service water system.

Furthermore, the LPCI system is a sub-system of the Residual Heat Removal (RHR) system which has other safety related functions such as suppression pool (containment) cooling and containment spray. Clearly, these other safety functions must not be compromised by any changes in the LPCI mode of operation.

Section 3.1 describes the sequence of events that would occur during several key reactor system transients. This information is for typical BWR transients and identifies system actions which occur automatically and also what operator actions are required. The intent of these generic event descriptions is to illustrate the adequacy of the current BWR ECCS design and to support the position that no modifications are required on the basis of any safety considerations.

Section 3.2 identifies the points in the transient events where inappropriate operator intervention and errors have the potential for leading to inadequate core cooling. These conditions are reviewed and it is concluded that in no case does the probability for error warrant any ECCS control logic change.

Furthermore, the safety margins incorporated in the BWR design provide considerable time between the point at which the operator should (but does not) take action and the time at which core cooling would be jeopardized. Typical BWR data is provided in Appendix B.

An important point of design philosophy is involved in the discussions presented in this memorandum. Control of BWR safety systems will always involve a combination of automatic and manual actions; the issue raised by this NUREG-0737 Item is simply where and how to define the boundary between these two control methods. The current GE ECCS designs are based on the approach that automatic system initiation is required during the short term phase of any incident but that longer term system control can and should depend upon the manual actions of the plant operating staff. Intuitively, it might appear that additional ECCS automation would be purely beneficial since this would supposedly provide added protection against operator errors and omissions. However, these perceived benefits of extended system automation must be measured against the very real penalties of increased system complexity, reduced system reliability and restricted operator flexibility for dealing with unanticipated events. These considerations are not amenable to precise quantification and control system design decisions must of necessity involve judgements as to relative importance of these competing influences. GE and the BWR Owners' Group believes the current BWR low pressure ECCS logic design has considered all of these factors and represents a balanced solution.

GE and the BWR Owners' believe that the current BWR 5/6 High Pressure Core Spray (HPCS) system is fully adequate and no design changes are required on a basis of any safety considerations. However, there are relatively straightforward HPCS design modifications that would automate the restart of HPCS on low level following its trip by the operator similar to the HPCI logic. This change which would enhance overall plant safety is described in Appendix A of this memorandum.

## 2. GENERAL ELECTRIC ECCS DESIGN PHILOSOPHY

This section provides an overview discussion of the generic GE ECCS design philosophy and design practices as they govern ECCS initiation and operator control of these systems. ECCS control systems must satisfy multiple system design requirements and the information presented in this Section and Section 3 is intended to demonstrate that the current ECCS controls are based on a balanced consideration of these multiple requirements.



## 2.1 LOCA Signals

High drywell pressure\* and low reactor water level\*\* are the key accident related parameters that govern operation of the BWR ECC systems. The occurrence of either or both of these signals is taken as an indication that a Loss of Coolant Accident (LOCA) has occurred. This combination provides diversity of initiating signals but it is important to note that the control system hardware does not discriminate between signals generated by the drywell pressure sensors and those produced by the reactor water level instruments. Either or both of these sensed variables can produce a LOCA signal input to the control circuitry.\*\*\* The latter does not treat the signals separately and there is currently no way for the control hardware to recognize which parameter is indicating a LOCA condition exists.

This is a significant design feature because it means system logic reset cannot be accomplished until both of these LOCA signals have cleared: and an ECC system cannot be returned to its true standby mode until the logic circuits have been reset. With the current design, automatic restart of any ECC system will occur once it has been placed in the standby condition and an initiation signal recurs. As discussed below, there are in practice many BWR accident sequences where one or both of the ECCS initiation signals will persist for long periods of time. This characteristic complicates any scheme to provide the type of system restart proposed by the NRC.

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\* Typically 2 psig.

\*\* Actual setpoints are plant and system dependent. All setpoints are above the top of the active core.

\*\*\* Common LOCA logic is developed within each redundant ECCS division, so the core spray and LPCS controls receive the same signal at the same time.

The long term post-LOCA transient is good example of the significance of the combined drywell pressure and reactor water level LOCA signal input to the BWR ECCS. For all but the largest breaks, reflooding of the core will occur relatively soon after the ECCS have been automatically started by the high drywell pressure and/or low reactor water level signals. However, the high drywell pressure condition may persist for extended periods following the accident and the continued presence of this LOCA signal will prevent ECCS logic reset and thus prevent return of these systems to their standby mode. Control system modifications to provide automatic restart on low reactor water level would have to be based on logic that recognizes the possibility of a continuously present drywell pressure signal. The possibility for the drywell pressure signal not being present would also have to be included in the logic; longer term post-LOCA containment pressure conditions are sensitive to factors as break size, break location, type of ECCS equipment operating, etc. and pressures both above and below the 2 psig value could occur depending upon plant conditions.

In summary, the diversity of initiation signals is an important design philosophy that has had a major influence on the current BWR ECCS control system design. However, the BWR LOCA performance is such that one or more ECCS initiation signals can persist for extended periods of time. Any scheme to provide ECCS automatic restart capabilities would have to be complex in order to deal with this possibility. The added safety benefits of an automatic restart design must be balanced against the decreased reliability of the system brought about by the additional control system complexities required to implement the change.

Sections 2.3, 2.6 and 2.7 provide further discussion of this point.

## 2.2 Automatic System Initiation

Immediately following a LOCA that produces either high drywell pressure or low reactor water level, all BWR ECCS will automatically start. Injection of emergency cooling water into the reactor will occur when reactor pressure is within the design range of each particular system. This design feature would not be influenced by any plant modification to provide ECCS automatic restart capability.

Annunciators are set off by the initiating condition and are subsequently acknowledged by the plant operators. The audible alarm is silenced by the operator after he has acknowledged the conditions and determined his required action but the panel light persists until the originating condition disappears. Reoccurrence of the originating condition would cause a new audible alarm and alert the plant operators to the need to reactivate any secured pumps and restore reactor water level. These important control room annunciation/alarm features of the typical BWR together with the BWR reactor water level indicators will provide information that will ensure that the control room staff is continuously aware of the reactor water level condition and will undertake all the necessary safety actions in a timely manner.

## 2.3 Automatic System Termination

The low pressure emergency systems do not stop automatically in the event either the drywell pressure or the reactor water level signals return to non-LOCA conditions. See Paragraph 2.4 for high water level trip of the HPCS system.

In some plants, high-high containment system pressures will cause a portion of the LPCI system to automatically realign to the containment spray or wetwell spray mode of operation. (Some time delay is provided to allow reactor water level recovery). This design feature is intended to enhance the ability of the pressure suppression containment system to accommodate steam bypass of the drywell/wetwell vent system. Reoccurrence of the LPCI autostart signal would create conflicting simultaneous automatic signals which would have to be resolved by a priority logic and its attendant complications.

#### 2.4 System Termination on High Level

In general, flow from the High Pressure Core Spray (HPCS) system is terminated when a high reactor water level condition occurs (typically referred to as Level 8). The intent of this control feature is to prevent unnecessary flooding of the reactor vessel and steamlines. Termination of HPCS injection can occur either automatically or by operator action. In the event of the former, the HPCS system will restart automatically if and when reactor water level decreases from the high level trip point to the low level initiation setpoint.

Depending upon the circumstances involved, automatic restart may or may not occur following operator termination of the EPCS system. (See Section 2.5 for additional discussion.) It should be noted that the Reactor Core Isolation Cooling (RCIC) system is also available for high pressure reactor water makeup duty and can be considered a diverse backup for the HPCS. (See Note 1)

## 2.5 Operator Termination

The reactor operators can, at any time, stop any BWR ECCS system even if a LOCA signal is present. This manual override option is deliberate and is considered by General Electric to be an important safety feature of the BWR ECCS network. This feature provides the plant operators with flexibility for dealing with unforeseen but credible conditions requiring a particular system to be shut down. Examples would be equipment difficulties involving gross seal leakage, breaks in ECCS piping, failed ECCS pump motors, load shedding for other post-LOCA operations etc. General Electric strongly believes that any design changes which restrict this operator flexibility would not be beneficial and would not lead to improved plant safety. Because the reactor water level is directly measured in the BWR and the water level is a primary parameter in the operator guidelines, operator action is a highly reliable means of reinitiating low pressure ECCS if needed to assure adequate core cooling. It is believed the overall system reliability is higher if flexibility is included for operator action as compared to a system which cannot be overridden if a LOCA signal is present.

(NOTE 1: The BWR/6 HPCS control logic currently includes a high drywell pressure override of the high level flow termination signal, i.e., if a high drywell pressure signal is present, the HPCS system will not terminate on high level and will flood the reactor and main steamlines. General Electric believes overall plant safety would be improved if this override feature were removed and is currently reviewing such a change with the NRC staff.)

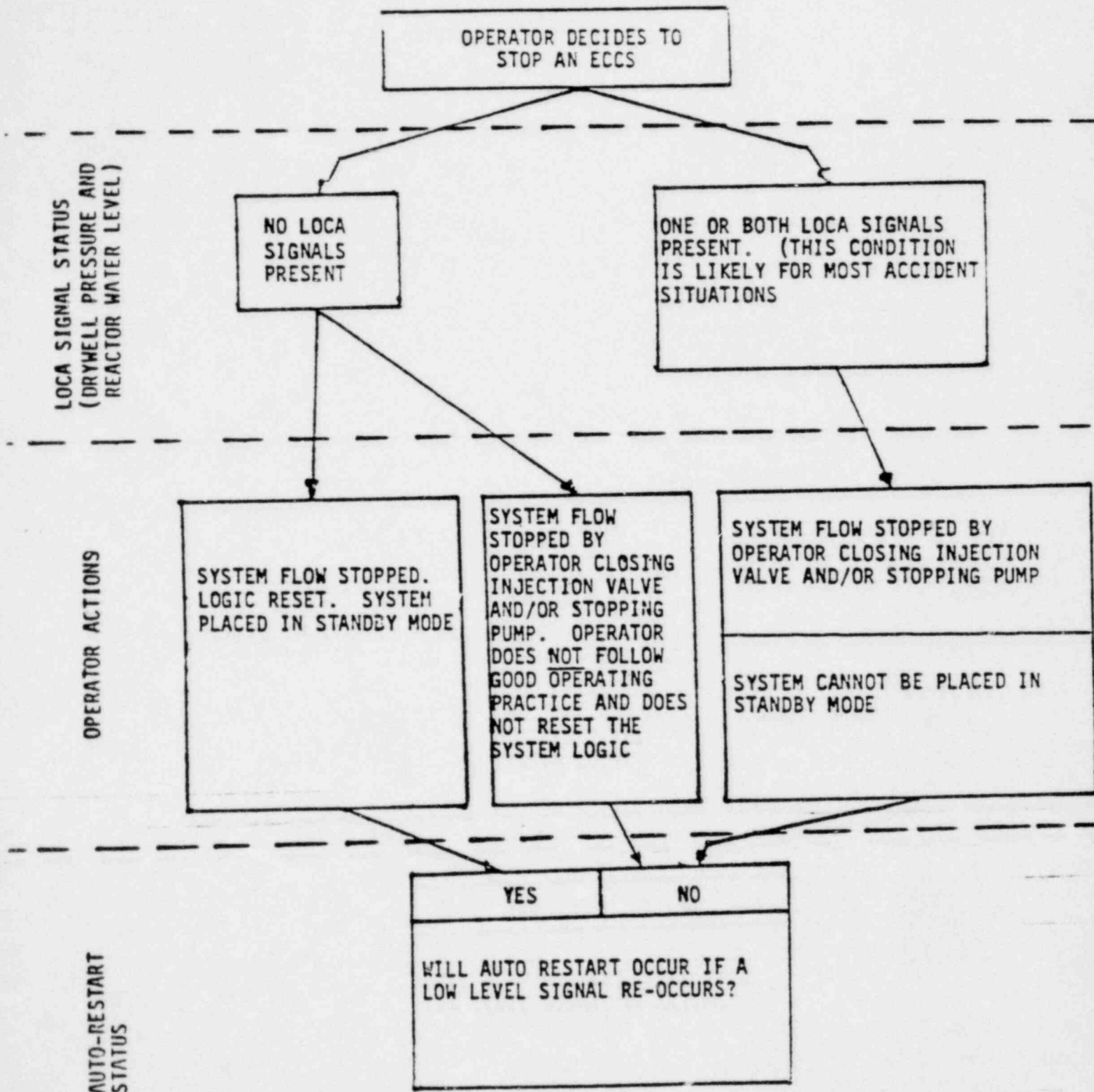


Depending upon the reactor condition, operator termination of a BWR ECCS can be achieved in several ways. Figure 1 is a schematic diagram which illustrates these options for typical low pressure systems. The schematic in Figure 2 illustrates the logic for the BWR/5 EPCS system. The key points to note are:

1. If properly secured and returned to the standby mode, all ECCS will automatically reinitiate if a LOCA signal re-occurs. Standby status can be achieved when all previous LOCA signals have cleared and the system logic has been reset. Correct operating procedure would be for the operator to attempt to return all ECCS to their standby mode any time a system is being secured; only when conditions such as the continued presence of a LOCA signal prevent this operation would a system be stopped and left in a non-standby mode.
2. If a LOCA signal persists, system flow can be terminated but the system cannot be returned to standby status. A typical ECCS system logic permits the operator to override the incoming automatic start logic (from the persistent LOCA signal) by use of either the "stop" position of the pump manual switch or the "close" position of the system injection valve. Momentary contact of either switch actuates logic elements which block the incoming automatic initiation signal. Once blocked, the automatic signal no longer controls pump or valve action and any subsequent system operation will be dependent upon manual operator actions.
3. An improperly secured system (eg: an injection valve closed but system not returned to standby mode) will not automatically restart if a LOCA signal reoccurs.



OPERATOR TERMINATION OF BWT  
EMERGENCY CORE COOLING SYSTEMS:  
A SCHEMATIC SHOWING TYPICAL OPTIONS



\*OPERATOR RESPONDING TO EITHER A MALFUNCTIONING SYSTEM OR A NEED TO INITIATE OTHER SAFETY RELATED FUNCTIONS (EG: ESTABLISH SUPPRESSION POOL COOLING)

FIGURE 1

A SCHEMATIC SHOWING BWR/5 HPCS TERMINATION ON HIGH REACTOR WATER LEVEL

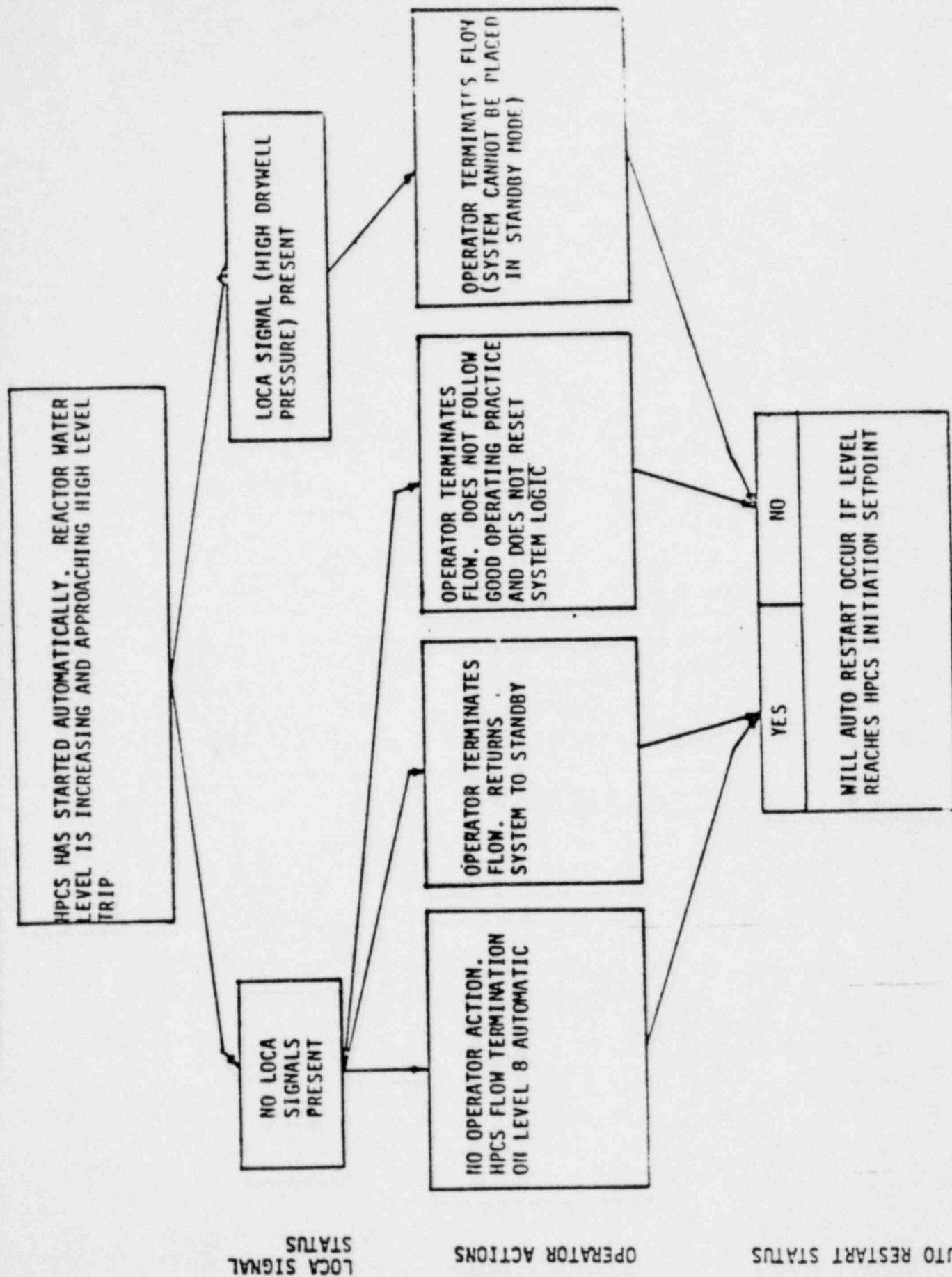


FIGURE 2

## 2.6 Long Term Control

BWR emergency system design is based on the assumption that long term control of the reactor will be completely dependent upon operator actions. This long standing design philosophy has been consistently applied to reactor control following both non-LOCA transient events (such as turbine trip) and also to the complete spectrum of credible loss of coolant accidents. A good example of this philosophy is the complete manual control of the multiple operations required to establish the long term post-LOCA containment cooling functions. Post-LOCA containment cooling is a key safety function since it prevents containment overpressurization and is thus required to support long term cooling of the core.

Providing purely manual control of the long term BWR transients is based on the thesis that the operator will ensure continued core cooling. This manual approach is considered superior to providing the very complex equipment and controls that would be necessary for comprehensive automatic ECCS restart capabilities during these transients.

As an indication of the potential complexity of the control systems that would be required, the following are some of the major long-term transient considerations that would have to be accounted for.

1. In many cases, the station standby power sources do not have sufficient capacity to permit all emergency systems to run simultaneously. The plant operators must establish priorities and make the necessary power assignment decisions. An example of this process would be the decision to shut down one or more of the multiple ECCS in order to provide power to the emergency service water pumps. This is clearly an appropriate action for the operators to take since the multiple ECCS will be providing redundant core cooling and the essential service water system must be activated if the containment cooling and pressure control functions are to be established.

Any scheme to automatically restart the ECCS in a vessel injection mode would have to recognize and account for these other essential post-LOCA activities as well as recognize unavailable or failed systems and equipment.

2. For many plants, operator action is required to ensure adequate ECCS pump Net Positive Suction Head (NPSH) during events involving elevated suppression pool temperatures. In most cases, automatic ECCS system initiation does not involve any system flow control. Consequently the system will operate at the maximum flow rate as vessel pressure reaches drywell pressure. This operating mode is usually referred to as the run out condition and it involves the most severe NPSH requirement at the pump suction. NPSH conditions can (in some cases) lead to pump cavitation as the suppression pool water temperature increases. These undesirable NPSH situations are avoided by the plant operator manually adjusting the system flow rate to design values. Again, this aspect of design would have to be accounted for in any scheme to provide auto-reinitiation capability.
3. Many BWR transient and accident events involve significant release of reactor system energy to the suppression pool which increases the pool temperature and containment pressure. Control of these temperature/pressure conditions is achieved by manually placing the LPCI/RHR system in the suppression pool cooling mode. This LPCI/RHR mode, in conjunction with emergency service water system operation, permits rejection of the excess suppression pool energy to the station ultimate heat sink. Much of the equipment used for this cooling function is also used for the LPCI ECCS mode of the RHR system. Any scheme to provide automatic initiation of the ECCS system would either have to bypass the LPCI system after it has been assigned to the suppression pool cooling function or automatically realign the equipment to the LPCI mode.

Consideration of the second option provides a good example of the many practical difficulties associated with retroactive modification of BWR ECCS systems. Automatic realignment of the LER system from the suppression pool cooling mode to the LPCI mode would have to recognize the "as-built" characteristics of the hardware involved. For example, the typical RHR pool return line valve is a 12 - 18 inch valve which would require 90 seconds to close whereas the LPCI injection line is a 12 - 24 inch valve which would open in 24 seconds. This represents a 3:1 valve closure period mismatch and any simultaneous signal to realign the RHR system would result in a significant period of time during which the RHR pump would be supplying flow to both flow paths. The RHR pumps are not designed for the excess duty associated with this mode of operation: inadequate pump NPSH, pump motor overloading and auxiliary power source overloading are potential problems that would have to be addressed. Clearly, these types of hardware problems are not insurmountable but would have to be addressed as part of any retroactive ECCS modification program.\* The intent of this discussion of potential difficulties is not to suggest that retroactive ECCS system logic changes are impossible but rather to highlight the non-trivial hardware changes that may accompany any control system logic redefinitions.

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\* Additional logic to avoid the valve timing mismatch requires additional LPCI valve permissives and so adds to the probability of failure.



## 2.7 BWR Geometry Considerations That Impact System Logic

The BWR core and internal configuration are such that certain design basis break locations and sizes do not permit complete post-LOCA reflooding of the core. For jet pump plants, very large ruptures in the external recirculation system pipe allow the ECCS to reflood the reactor vessel only to the elevation of the jet pump suction plane. This elevation is at approximately 2/3 of the core height. However, the actual water level inside the shroud is considerably higher due to the existence of voids. For non-jet pump plants large recirculation line breaks do not permit full reflooding of the core. Adequate core cooling is achieved under these conditions for either reactor type but the reactor water level can never be restored to the ECCS initiation level.

This characteristic complicates any scheme to provide automatic reinitiation of the ECC systems on low water level. For large breaks in jet pump plants, inadequate core cooling would probably have to be defined so as to be based on the 2/3 core height level. This revised definition would have to be in addition to the current initiation level which is conservatively identified as a water elevation above the core. It is not clear what comparable alternative signal could be used in the case in the non-jet pump plants. However, it is believed that the minimal need for (and benefits of) providing automatic ECCS reinitiation for large BWR recirculation line breaks does not justify the penalties associated with the significantly more complicated control system that would be required. In summary, the current ECCS logic is well suited to the BWR geometry characteristics and no changes are required on the basis of the inadequacies in the current design.



### 3. TYPICAL EVENTS INVOLVING ECCS INITIATION

#### 3.1 Event Description

Typically analyzed BWR LOCA and non-LOCA events are discussed in this Section of the memorandum; the events have been treated generically. In each case the emphasis is placed on interactions between the LOCA signal and the actions the plant operator can or must take to ensure safe plant conditions. The event descriptions are based on current ECCS control system logic.

The following events have been selected as representative BWR transients:

1. A design basis recirculation line break which will not permit reflooding of the core above the 2/3 core elevation. This accident is included as a base case to illustrate the reasons for the existing system logic.
2. A small break not involving significant loss of reactor water inventory. This accident will lead to high drywell pressure but not a low reactor water level ECCS initiation signal.
3. An intermediate size loss of coolant accident that involves some core uncover but with a subsequent reflooding of the reactor by the ECCS.
4. An upset transient that produces a momentary reactor water reduction and thus HPCS initiation on low water level but no high drywell pressure LOCA signal.

Tables 1 through 4 show the major sequence of events for these four transients.

TYPICAL BWR TRANSIENTSCASE 1: DESIGN BASIS RECIRCULATION LINE BREAKSEQUENCE OF EVENTS

- Break occurs
- High drywell pressure signal                      These signals will persist
- Low reactor water level signal                      indefinitely and cannot be reset.
- All ECCS start and inject water into the vessel automatically
- Core heat-up terminated, all ECCS running, core flooded to 2/3 height. In some cases, part of the LPCI flow may automatically be diverted to containment or wetwell spray.

END OF SHORT TERM BLOWDOWN PHASE OF ACCIDENT

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- Multiple operator actions to establish long term post-LOCA core and containment cooling. Actions include some ECCS termination, standby power reassignments, emergency service water startup, actuation of suppression pool cooling, pump throttling to assure adequate NPSH, elimination of unnecessary ECCS pump operation so as to minimize pump heat input to the suppression pool etc.

## TYPICAL BWR TRANSIENTS

### CASE 2: SMALL BREAK NOT INVOLVING SIGNIFICANT LOSS OF REACTOR INVENTORY (BWR 5/6)

#### SEQUENCE OF EVENTS

- Break occurs
  - High drywell pressure signal - signal will persist indefinitely
  - No low reactor water level
  - All ECCS start automatically (low pressure systems will not inject because of high reactor pressure)
  - HPCS Injection
  - HPCS flow terminates automatically on high level (Level 8) (assuming deletion of high drywell pressure inhibit for BWR/6)
  - HPCS auto restarts on initial level (Level 2)
  - Continuous automatic reactor water level control
- OPTION 1      OPTION 2
- Operator observes increasing reactor water level and terminates HPCS by stopping pump or closing injection valve. This action precludes subsequent automatic initiation on low level
  - Subsequent HPCS restart requires operator action. Because of persistent high drywell pressure, system logic cannot be reset and system returned to standby

#### END OF SHORT TERM PHASE OF EVENT

- Core cooling dependent upon operator actions
- Multiple operator actions to initiate orderly shutdown of reactor. Depending upon equipment availability, heat rejection will be to main condenser, suppression pool, or normal shutdown path. Considerations will be to establish core and containment cooling, assure adequate power supply distribution, start emergency service water pumps, throttle pumps to assure adequate NPSH, etc.

## TYPICAL BWR TRANSIENTS

### CASE 3: INTERMEDIATE LOSS OF COOLANT ACCIDENT

#### SEQUENCE OF EVENTS

- Break occurs
- High drywell pressure signal. (This signal will persist indefinitely)
- Low reactor water level signal. (Level will be recovered at some point in the accident)
- All ECC systems start automatically
- Core uncover/heatup transient terminated. All ECCS running, reactor vessel flooded. In some cases, part of the LPCI flow may be automatically diverted to containment spray.

#### END OF SHORT TERM PHASE OF ACCIDENT

Core  
cooling  
dependent  
upon  
operator  
actions

- } - Multiple operator actions essentially same as those identified in Table 1 for the Design Basis Accident (DBA)

# TYPICAL BWR TRANSIENTS

## CASE 4: UPSET TRANSIENT (BWR 5/6)

### SEQUENCE OF EVENTS

- Upset event
  - Low reactor water level signal occurs (either due to loss of feedwater or because of momentary level reduction due to void collapse). High drywell pressure does not occur.
  - High pressure system starts and injects
  - Reactor water level increasing
  - HPCS flow terminates automatically on high level
  - HPCS auto restarts when initiation level reached
  - Continuous automatic reactor level control
- OPTION 1      OPTION 2
- HPCS flow terminated by operator. Logic cleared, system returned to standby mode
  - HPCS auto restart if initiation level reached
  - Repeat of cycle. Continuous automatic reactor level control

### END OF SHORT TERM PHASE OF EVENT

- Multiple operator actions essentially the same as those identified in Table 2



be summarized as follows:

Is it possible that the plant operators could stop an ECC system at a time and in a manner that would, unless the system is manually restarted, lead to inadequate core cooling? If this is the case, and since there is a remote chance the operator may not restart the system, restart should be made automatic.

The simple response to this position is that the current BWR ECCS design does indeed permit the plant operators to terminate system operation in a way that would eventually jeopardize cooling of the core assuming the operator ignores the water level instrumentation and procedures. However, a review of the particular circumstances that would have to be involved leads to the conclusion that this is not necessarily an unacceptable situation which must be immediately remedied by providing additional ECCS automation. To support this position, the typical generic events described in Table 1 through 4 have been subjected to the following questions.

- What operator actions are required?
- What deleterious operator actions are possible?
- Could the deleterious operator actions lead to degraded core cooling?
- Is an ECCS logic design change required to protect against the possible operator errors?

Table 5 summarizes the response to these questions for the four typical generic BWR transients described in Section 3.1.

A review of Table 5 shows that the current ECCS control logic coupled with reasonable operator actions provides adequate core cooling throughout the four typical events presented. However; there are three general circumstances where it is possible (but not probable) for operator errors to produce conditions that could potentially lead to degraded core cooling. These conditions are:

automatically initiated. In general, automatic restart will not occur because the initiating signals (high drywell pressure and low water level) will still be present and will preclude the system logic reset. The ECCS logic design which permits operator intervention is based on a legitimate assumption that the operators are not likely to prematurely terminate ECCS flow and jeopardize the core cooling process. In actual practice, one of their highest priority activities will be to assess the situation to assure all emergency systems have started correctly and attempt to start any that may not have. The alternative to providing this operator flexibility would be to design the system so that any termination attempt by the operators would be overridden. This is not considered good design practice since it provides no flexibility for the operator to deal with unanticipated situations in which overall plant safety may be increased if a malfunctioning ECCS system can be shut down. An example of the latter would be to secure a system that has gross seal leakage that could potentially flood an ECCS compartment and deplete pool water.

2. A second general circumstance during which errors and omissions could potentially lead to degraded core cooling conditions would be a failure of the operators to adequately consider core cooling requirements during the long term period. During this longer term phase, the plant operators are manually setting up the auxiliary systems to support eventual termination of the incident. In the event of degraded core cooling, automatic ECCS initiation is unlikely to occur because the systems will not be in a true standby mode. Consequently, adequate core cooling is dependent upon correct operator actions.

occurrence of high fuel clad temperatures. (See Appendix B) The operator must take manual control of all systems during this period and it is not considered credible that he would provide inadequate cooling to the core. As discussed in Table 5, the alternative would be to provide the complex logic necessary to automatically restart certain ECCS. This would involve a major escalation of control system logic complexity and the benefits of added protection against unlikely operator error do not appear to compare favorably with the penalties of increased control system complexity, decreased system reliability and the loss of operator flexibility in dealing with unanticipated events.

3. During upset transients and small breaks, the highest reactor operator priority with respect to control of water level will be to avoid overfilling the vessel and flooding the main steam lines. These events will initiate the HPCS and the control logic is capable of automatically maintaining the reactor water level within the HPCS level control range (i.e. between the high level trip elevation and the low level system initiation setpoint). However, it is highly desirable for the plant operators to intervene in this automatic process and assume manual reactor water level control. The key incentive is to prevent the water level from reaching Level 8 since in addition to the HPCS, both the feedwater system (if operating) and the RCIC will be tripped on high level. Consequently, it is probable that for the types of events described in Tables 2 and 4, the plant operators will intervene fairly early and assume manual HPCS control. Under normal circumstances, good operating practice will result in the system being returned to a standby condition anytime system operation is terminated. Automatic restart on low reactor water level will then occur.

control will be required. Inadequate core cooling as a result of the operator failing to reinitiate the EPCS system would not occur because eventually the ADS initiation level would be reached. This would result in reactor blowdown and core flooding by the low pressure ECCS. However, the availability of level data coupled with operator training that has stressed the central importance of adequate water level will ensure appropriate and timely operator control of the EPCS during transients and small break accidents.

This conclusion is further reinforced when it is remembered that during a transient event, at least one half hour of zero reactor makeup flow conditions can be permitted to exist before clad temperatures approaching 2200 F will occur. (See Appendix B)

NOTE: The High Pressure Core Spray (HPCS) system currently restarts automatically if the Level 2 initiation signal reoccurs and the system is in the fully automatic mode or the system had previously been returned to standby conditions. Our evaluation of Item II.K.3.21 has considered the potential benefits of modifying the HPCS logic to extend automatic restart on Level 2 following manual termination. (See 2.4 and 2.5) This logic is already included in the HPCI system design. It has been concluded that such HPCS changes are not required by plant safety considerations. However, the changes that would provide this capability appear to be relatively straightforward and may provide additional safety margin. The recommended changes are described in Appendix A.

EVENT	CONDITION	REQUIRED OPERATOR ACTIONS	POSSIBLE DELETERIOUS OPERATORS ACTIONS (A)	COULD (A) LEAD TO DEGRADED CORE COOLING	IS A DESIGN CHANGE REQUIRED TO PROTECT AGAINST (A)	COMMENTS
1, CTA	Short term blowdown phase of accident	None	Operator could conceivably intervene and terminate flow. Systems would not automatically restart. (Logic cannot be cleared because initiation signals are present)	Yes, if sufficient systems were stopped	No. Water level maintenance is emphasized during operator training and reinforced by the Emergency Procedure Guidelines	Operator would face multiple conditions that a loss of cooling accident had occurred. It is credible that there would be sufficient ECCS to cause degraded core cooling. Preventing override is not a design goal. See Section 2.5
1, CTA	Long term post-LOCA core and containment cooling	Multiple actions required. See Table 1	Core cooling could be interrupted by operator actions which violate guidelines and procedures. Automatic system restart would not occur because high drywell and low water level signals are continuously present and preclude logic reset	Yes, if sufficient systems are stopped	No. It is reasonable to assume the operator will follow procedures and accomplish all long term core and containment cooling functions satisfactorily. Extended time periods are available. Water level does not recover above 2/3 core height; however up to 20 minutes is available before zero ECCS flow would cause excessive fuel heat-up. See Appendix B	Redesign of the ECCS control to provide automatic restart of certain ECCS would require complication of control system. This expanded logic would recognize and account for multiple considerations listed in Table 1 and Section 2.6 (pool cooling function, 11 by power sources, pump motor water requirements etc.). Benefits of added protection operator error do not balance penalties of increased system complexity (and therefore cost) and loss of operability in dealing with events
2, Small Break	HPCS has started automatically and is injecting into the reactor vessel	None, other than to monitor the situation especially reactor water level. System will automatically terminate flow on high level and restart at low level initiation value	Premature termination of HPCS flow. System cannot be returned to standby mode because LOCA signal present and will not permit logic reset	No, remainder of ECCS network would automatically provide cooling. It is probable the operator would manually re-initiate HPCS flow. RCIC is a backup	No. Low water level is annunciated and alarmed in the control room; there is a considerable period of time before zero makeup flow would cause fuel heat-up; operator training and the Emergency Procedure Guidelines emphasize level control	Probability of operator terminating HPCS flow and allowing the level to reach the ADS setpoint is very low. Even if this occurred, cooling is maintained
2, Small Break	Same as above	Same as above	As above but further compounded by operator securing the low pressure systems. None of the systems can be returned to the full standby mode and would not restart automatically	Yes, but not considered a credible situation. Operator would continue operator water level with HPCS and RCIC	No. (See above)	Probability of this series of multiple operator errors is above

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TABLE 5

EVENT	CONDITION	REQUIRED OPERATOR ACTIONS	POSSIBLE DELETERIOUS OPERATORS ACTIONS (A)	COULD (A) LEAD TO DEGRADED CORE COOLING	IS A DESIGN CHANGE REQUIRED TO PROTECT AGAINST (A)	REMARKS
2, Small Break	Long term actions to initiate orderly shut-down to cold conditions	Multiple actions required. See Table 2	Core cooling could be interrupted by operator actions which violate guidelines and procedures. Automatic system restart would not occur because the continuously present high drywell pressure prevents logic reset	Yes, if sufficient operator error are made	No. It is reasonable to assume the operator will follow procedures and accomplish all long term core and containment cooling functions satisfactorily. Extended time periods are available. (See Appendix B)	See comments on Event term post
3, Intermediate Break	Short term blowdown phase of the accident	Same discussion and conclusions as for the DBA. No design changes required.				
3, Intermediate Break	Long term post accident core and containment cooling					
4, Upset Transient	Short term responses. Reactor water level rising	None other than to monitor the situation especially water level. HPCS is capable of automatic stopping and starting within its level control range	HPCS system flow terminated and system returned to standby mode. (Requires no initiation signal present)	No, system will automatically restart on low level	No	If the plant operator action or if he correct terminates HPCS flow, will respond automatically low reactor water level
4, Upset Transient	Short term response. Reactor water level rising	As above	HPCS system flow terminated by simple pump stoppage or injection valve closure. System not returned to standby mode	Adequate core cooling will eventually require operator action. HPCS will not auto restart and ADS initiation will require manual action	No. An unlikely operator error is involved. Also, RCIC system would be available as a backup. See comment on Item 2. Extended time periods available. See Appendix B	
4, Upset Transient	Long term post incident recovery	Same comments and conclusions as other long term transients i.e. adequate core cooling dependent upon operator action. Situation acceptable				

the current BWR ECCS control logic as well as the BWR ECCS design modifications suggested by the NRC in NUREG-0737 Item II.K.3.21 have been reviewed. This review has included a consideration of all aspects of EPCS, LPCS and LPCI system operation which would be influenced by any expanded automatic restart capability. It is concluded that the current system design is adequate and no design changes are required. This conclusion is based on a combination of factors that include: the comprehensive nature of BWR operator training, the emphasis placed in this training on reactor water level control, the Emergency Procedure Guidelines, the relatively long time the operator has to correct errors and the extent to which low reactor water level conditions are displayed and alarmed in the control room. The most important consideration is that the benefits of providing enhanced automatic ECCS reinitiation do not justify the associated penalties of increased system complexity, reduced system reliability, restricted operator flexibility and the other undesirable effects discussed in this memorandum.

In summary, General Electric and the BWR Owners' Group believe the current BWR low pressure ECCS design, when coupled with rigorous and continuous operating staff training programs, represents the optimum approach to BWR safety. No modification of existing LPCI and low pressure core spray system need to be undertaken. Modification of the HPCS system to automate restart on low level following manual trip, although not required for safety considerations, will lead to a net improvement in overall ECCS performance.

### High Pressure Core Spray (HPCS) System Modification:

'GE and the BWR Owners' Group have reviewed the current HPCS system and have concluded that no system design changes are required. However, some additional safety margin may be added to the BWR design by making a relatively straightforward modification to the HPCS control logic to provide automatic restart of the system following manual termination of pump operation. The purpose of this Appendix is to conceptually describe this potential HPCS design change.

### Summary

Auto restart of HPCS after manual stop can be provided if a logic system can be developed which:

- (1) Restarts the HPCS pump on Level 2,
- (2) Blocks high drywell pressure restart,
- (3) Self clears if both auto signals disappear, and
- (4) Still allows injection valve closure or pump stop if absolutely essential for protection of the public.

Any such design should adhere to the applicable portions of IEEE 279-1971.

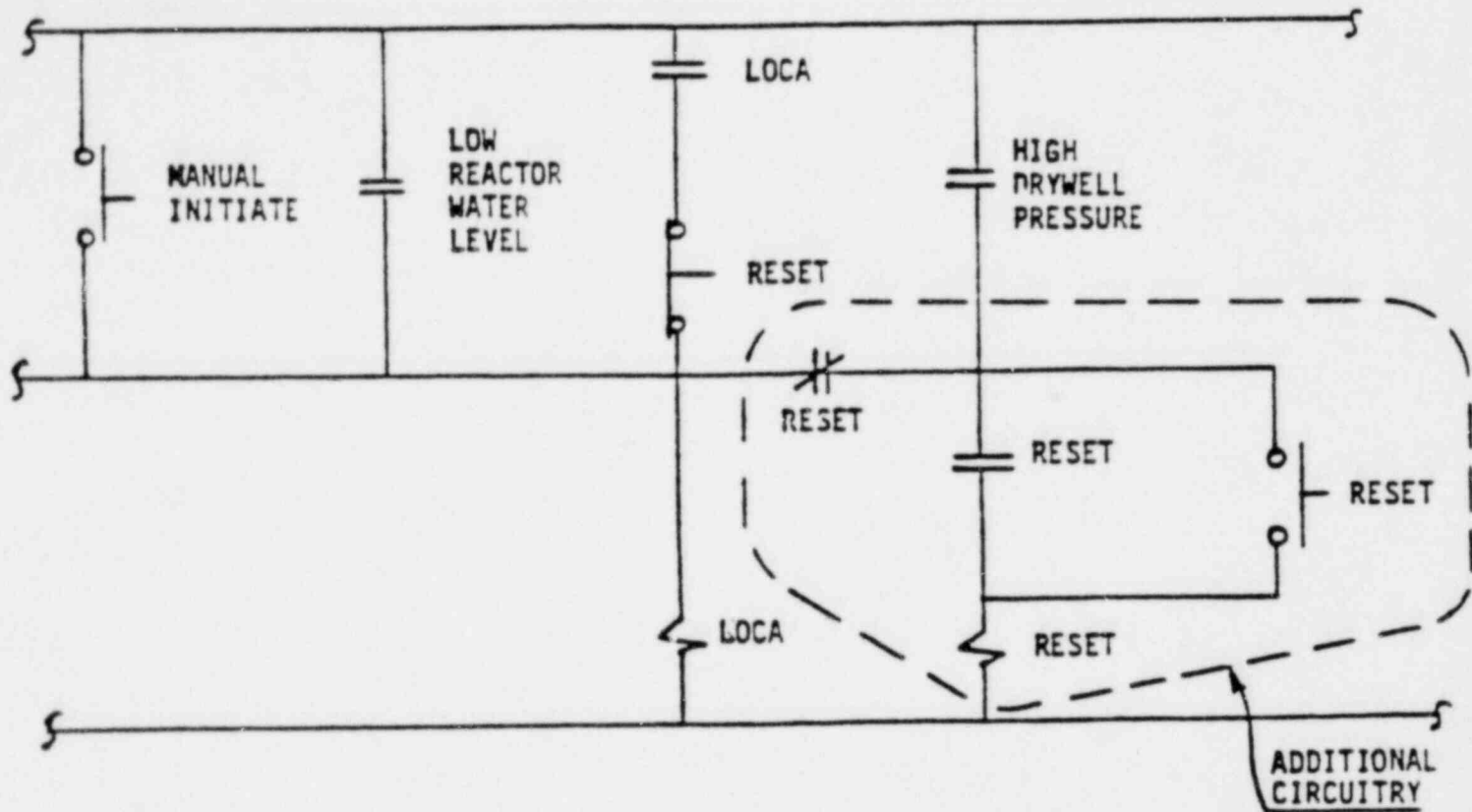
reactor water level. Each parameter has four sensors and analogic trip units or four switches set up in a one-out-of-two-twice logic scheme. The above logic is assembled and the output fed to an OR gate along with the system level manual initiation signal. The output of the OR gate is a LOCA initiation signal which is sealed in. A reset switch permits release of the seal in. The assembled initiation signals are not sealed in so that they self-clear when the abnormal condition disappears.

#### Proposed Modification

The feature being considered will reset the auto initiation signal, on level and block the continuing auto initiation signal based on high drywell pressure. This will allow auto EPCS restart on low level after operator stop of the pump. It does block auto restart on high drywell pressure unless drywell pressure decreases below the setpoint and again increases above the setpoint. A decrease in drywell pressure below trip level will remove all reset features and return EPCS logic to the original status. The EPCS pump is not stopped automatically by any reset. Pump stop still requires operator action.

System isolation must still be possible with or without this modification.

# HPCS INITIATE CIRCUITS



CONCEPTUAL DESIGN  
HPCS INITIATION CIRCUIT  
USING RELAY LOGIC  
(SOLID STATE LOGIC IS EQUALLY ADAPTABLE)



As discussed in the body of this memorandum, General Electric and the Owners' Group believe the current ECCS control logic is fully adequate. This position is based on a combination of factors one of which is the period of time available between the time at which the operator should (but does not) start an idle ECCS system and the time at which inadequate core cooling may begin. As discussed below this can be a fairly long time period and the purpose of this Appendix is to demonstrate this safety margin that is built into the BWR.

Assuming that after operator termination of a system, there is no source of reactor water level makeup at all and further assuming the core is initially at saturation temperature conditions, the following table summarizes the time between pump flow termination and the occurrence of 2200°F fuel clad temperatures.

<u>Case</u>	<u>Time to Reach 2200°F</u>
1. Isolated - no break	
Boil off from Level I (Typically only a few feet above the top of the core)	30 minutes
2. Isolated - large recirculation system break	
Boil off from top of jet pump	15 to 20 minutes

process results in decreasing reactor water level leading eventually to core uncover. This case is representative of transients involving no reactor system break. It should be noted that Level 1 is a very low reactor level (one or two feet above the top of the active core) and the allowable period of zero reactor water make up is considerably extended if it is assumed to start with a higher reactor water level condition.

Case 2 is representative of a large recirculation line break in a jet pump plant. For this case, it was assumed that there was no water outside the shroud and that the collapsed water level inside the shroud is at the top of the jet pump. The swollen water level is actually somewhat higher.

The heat up times given in this Appendix are minimum estimates of typical BWR values. Times would be longer if the events started with less than maximum expected core decay power and/or if the ECCS flow is terminated later in the transient. Availability of other makeup systems such as the control rod drive flow could significantly extend the time before core heat up would occur.

The above information clearly demonstrates that there is a significant period of time available for the operator to recognize that he has inadvertently permitted the reactor water level to decrease and for him to take the necessary corrective action.

NUREG-0737 II.K.3.21

This report applies to the following plants, whose Owners participated in the report's development.

Boston Edison	Pilgrim 1
Carolina Power & Light	Brunswick 1 & 2
Commonwealth Edison	LaSalle 1 & 2, Dresden 1-3
	Quad Cities 1,2
Georgia Power	Hatch 1 & 2
Iowa Electric Light & Power	Duane Arnold
Niagara Mohawk Power	Nine Mile Point 1 & 2
Nebraska Public Power District	Cooper
Northeast Utilities	Millstone 1
Northern States Power	Monticello
Pacific Gas & Electric	Humboldt Bay 3
Philadelphia Electric	Peach Bottom 2 & 3; Limerick 1 & 2
Power Authority of the State of New York	Fitzpatrick
Tennessee Valley Authority	Browns Ferry 1-3, Hartsville 1-4,
	Phipps Bend 1 & 2
Detroit Edison	Enrico Fermi 2
Long Island Lighting	Shoreham
Mississippi Power & Light	Grand Gulf 1 & 2
Pennsylvania Power & Light	Susquehanna 1 & 2
Washington Public Power Supply System	Hanford 2
Cleveland Electric Illuminating	Perry 1 & 2
Houston Lighting & Power	Allens Creek
Illinois Power	Clinton Station 1 & 2
Public Service of Oklahoma	Black Fox 1 & 2
Vermont Yankee Nuclear Power	Vermont Yankee

APR 14 1982

MEMORANDUM FOR: Gus Lainas, Assistant Director for Safety Assessment, DL  
Thomas Novak, Assistant Director for Operating Reactors, DL  
Robert Tedesco, Assistant Director for Licensing, DL

FROM: Themis P. Speis, Assistant Director for Reactor Safety, DSI

SUBJECT: EVALUATION OF BWR OWNERS' GROUP GENERIC RESPONSE TO  
ITEM II.K.3.21 OF NUREG-0737, "CORE SPRAY AND LOW PRESSURE  
COOLANT INJECTION SYSTEMS LOW LEVEL INITIATION"

Plant Name: Multiplant Item F-50, See Attached List  
Responsible Branch: --OR Branch #2  
Project Manager: V. Rooney  
DSI Branch Involved: RSB  
Requested Completion Date: March 31, 1982  
Status: Complete

Enclosed is our evaluation of the BWR-Owners' Group response to NUREG-0737 Item II.K.3.21. This evaluation is applicable to operating plants, OL applications and CP applications. This item has been evaluated independently on near-term OL applications with SERs completed; however, the plant specific evaluations were contingent upon completion of this generic evaluation. Therefore, the final SERs should be updated to reference this evaluation.

We agree with the Owners' Group position that logic modifications for LPCI and core spray (except for HPCS) are unwarranted. The Owners' Group did propose a modification to the HPCS logic (applicable to BWR/5s and BWR/6s only; LaSalle will be the first operating BWR/5) which is simple and improves the safety function. The Owners' Group felt that the HPCS modification was beneficial but not required for safety. We agree with the Owners' Group assessment that the HPCS logic modification is beneficial and is a simple modification; therefore, it should be implemented. This position on the HPCS logic is consistent with the positions included in the SERs for near-term OLs.

If you have any questions concerning this item, please contact Wayne Hodges on extension 27579.

Original Signed By  
Themis P. Speis

Themis P. Speis, Assistant Director  
for Reactor Safety  
Division of Systems Integration

Enclosures:  
As stated

\*SEE PREVIOUS CONCURRENCE SHEETS

OFFICE	cc: See Next Page	RSB:DSI	RSB:DSI	ADRS:DSI
NAME		WHodges:cs*	BSheron*	TSpeis*
DATE	CONTACT: W. Hodges, x27579	4/12/82*	4/13/82*	4/13/82*

This SER applies to the following plants:

Boston Edison	Pilgrim 1
Carolina Power & Light	Brunswick 1 & 2
Commonwealth Edison	LaSalle 1 & 2, Dresden 1-3
	Quad Cities 1,2
Georgia Power	Hatch 1 & 2
Iowa Electric Light & Power	Deane Arnold
Niagara Mohawk Power	Nine Mile Point 1 & 2
Nebraska Public Power District	Cooper
Northeast Utilities	Millstone 1
Northern States Power	Monticello
Pacific Gas & Electric	Eumboldt Bay 3
Philadelphia Electric	Peach Bottom 2 & 3; Limerick 1 & 2
Power Authority of the State of New York	Fitzpatrick
Tennessee Valley Authority	Browns Ferry 1-3, Eartsville 1-4, Phipps Bend 1 & 2
	Enrico Fermi 2
Detroit Edison	Shoreham
Long Island Lighting	Grand Gulf 1 & 2
Mississippi Power & Light	Susquehanna 1 & 2
Pennsylvania Power & Light	Hanford 2
Washington Public Power Supply System	Perry 1 & 2
Cleveland Electric Illuminating	Allens Creek
Houston Lighting & Power	Clinton Station 1 & 2
Illinois Power	Black Fox 1 & 2
Public Service of Oklahoma	Vermont Yankee
Vermont Yankee Nuclear Power	



Requirement as Stated in NUREG-0737

The core-spray and low-pressure, coolant-injection (HPCI) system flow may be stopped by the operator. These systems will not restart automatically on loss of water level if an initiation signal is still present. The core spray and LPCI system logic should be modified so that these systems will restart, if required, to assure adequate core cooling. Because this design modification affects several core-cooling modes under accident conditions, a preliminary design should be submitted for staff review and approval prior to making the actual modification.

Evaluation of Owners' Group Position

The intent of this requirement was to assure adequate water delivery to the core if an operator should manually terminate LPCI or core spray and subsequently fail to restart a system, if required. The BWR Owners' Group response to this position is given in a letter report to Darrell G. Eisenhut (NRC) from D. B. Waters (BWR Owners' Group), BWROG-80-12, December 29, 1980.

The essence of the Owners' Group position is that automation of the restart of LPCI and core spray (or low pressure core spray) will result in a net decrease in safety because of the complexity of the logic required. Also automation of the restart of HPCS would result in a net increase in safety, but is not required from safety considerations.

With regard to automatic restart of the HPCS after manual termination, we have reviewed the logic modification proposed in Appendix A to the reference Owners' Group submittal and we feel that the modification should be made on all BWRs with HPCS systems. The modification is simple and straightforward and results in a safety improvement at little cost.

We concur with the Owners' Group that logic modifications to the LPCI and core spray systems (other than HPCS) are not warranted. The reasons we concur that no modifications are warranted are outlined in the paragraphs below.

High drywell pressure and low reactor water level are the key accident related parameters that govern operation of the BWR ECC systems. The occurrence of either or both of these signals is taken as an indication that a Loss of Coolant Accident (LOCA) has occurred. This combination provides diversity of initiating signals but the control system hardware does not discriminate between signals generated by the drywell pressure sensors and those produced by the reactor water level instruments. There are many accident sequences for which one or both of the ECCS initiation signals will persist for long periods of time.

With the present logic, the reactor operators can, at any time, stop any BWR ECCS system even if a LOCA signal is present. This provides the plant operators with flexibility for dealing with unforeseen but credible conditions requiring a particular system to be shut down. Examples would be equipment difficulties involving gross seal leakage, breaks in ECCS piping, failed ECCS pump motors and load shedding for other post LOCA operations. This flexibility would still be needed for the automated system but the automation would increase the complexity of the required logic.

Many BWR transient and accident events involve significant release of reactor system energy to the suppression pool which increases the pool temperature and containment pressure. Control of these temperature/pressure conditions is achieved by manually placing the LPCI/RHR system in the suppression pool cooling mode. This LPCI/RHR mode, in conjunction with emergency service water system operation, permits rejection of the excess suppression pool energy to the station ultimate heat sink. Much of the equipment used for this cooling function is also used for the LPCI ECCS mode of the RHR system. Any scheme to provide automatic restart of the ECCS system would either have to bypass the LPCI system after it has been assigned to the suppression pool cooling function or automatically realign the equipment to the LPCI mode.