George Thomas

SEP 12 1988

Donald Grace, Chairman
BWR Owners Group
GPU Nuclear
1 Upper Pond Rd
Building E
Parsippany, NJ 07054

Dear Mr. Grace:

SUBJECT: SAFETY EVALUATION OF "BWR OWNERS' GROUP - EMERGENCY PROCEDURE GUIDELINES, REVISION 4," NEDO-31331, MARCH 1987

The NRC staff has reviewed the General Electric Topical Report NEDO-31331, "Emergency Procedure Guidelines, Revision 4," March 1987 and has found the Emergency Procedure Guidelines to be generally acceptable for implementation. We believe that the BWR Emergency Procedure Guidelines (EPG) provide a basis for a significant improvement in current emergency operating procedures. The new hydrogen control guidelines for Mark I and Mark II plants and the detailed Guidance for determining the Primary Containment Pressure Limit (PCPL) are the major improvements. [Mark III Containment Hydrogen Control Guidelines are addressed separately under the Hydrogen Control Owners Group (HCOG) program.] The Safety Evaluation Report recommends a few changes to Appendix B of the guidelines. The recommended changes in Appendix B are described in the summary of the SER.

EPG-Rev 4 provides improved guidance on venting, but you should remain fully aware that the Commission is continuing to assess means for further minimizing the potential downside of venting. The Commission is currently considering a MARK I containment improvement program which could result in additional hardware changes. The purpose of these modifications would be to realize the full benefits of venting in reducing public risk. Those changes will be an integral part of the MARK I program.

As discussed in the Safety Evaluation Report (Enclosure 2), we find the actions specified in the Emergency Procedure Guidelines to be generally correct and appropriate and within the operators' capability. The combination of all emergency actions into four guidelines and six contingencies and the reductions in caution statements to seven greatly simplifies the emergency instructions. The continued use of symptoms, rather than events as bases for actions, should serve to minimize errors resulting from incorrect diagnosis of events and addresses the possibility of multiple failures and operator errors. We therefore find the guidelines acceptable for implementation.

We are sending a copy of this letter to the BWR licensees and applicants that will provide them with the Safety Evaluation Report. For those licensees who are now following Revision 1, Revision 2 or Revision 3 of the EPG and wish to revise their Emergency Operating Procedures to Revision 4 of the EPG, a suggested implementation program is given in Enclosure 1.

The SER closes all the open items carried from the previous revisions of the EPG. We consider the BWR EPG review as complete. However, each BWR licensee who wishes to use the Revision-4 of the EPG should assure that the EPGs will not impact its licensing bases. For example, if the hydrogen control guidelines are implemented as written, the containment atmosphere dilution (CAD) system may not be adequately addressed. That is, BWR plants that employ the CAD system as part of a hydrogen mitigation scheme would need to implement additional plant specific procedures consistent with its safety analysis or provide the staff with additional information to justify such deviations.

We expect that the BWR Owners will continue to improve the EPGs. Since the guidelines do not provide comprehensive severe accident mitigation strategies, we expect the Owners to upgrade the EPGs in parallel with resolution of severe accident issues.

The principal contact for this activity is George Thomas, Reactor Systems Branch, at 301-492-0892.

Sincerely,

/S/

Ashok C. Thadani, Assistant Director
for Systems
Division of Engineering & Systems Technology
Office of Nuclear Reactor Regulation

Enclosures:
1. Implementation Program
2. SER on Emergency Procedure Guidelines, Rev-4

cc w/enclosures:
R. Goranson, Northern States Power
P. Smith, GPU Nuclear
L. S. Gifford, GE
BWR Licensees

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DATE	9/6/88	9/9/88	9/9/88	9/12/88			

This report applies to the following plants:

Boston Edison Co.	Pilgrim 1
Carolina Power and Light	Brunswick 1 & 2
Cleveland Electric Illuminating Co.	Perry
Commonwealth Edison Company	LaSalle 1 & 2, Dresden 2-3, Quad Cities 1 & 2
Detroit Edison	Fermi-2
Georgia Power and Light	Hatch 1 & 2
GPU-Nuclear	Oyster Creek 1
Gulf States Utilities	River Bend, 1
Illinois Power Co.	Clinton
Iowa Electric Light and Power	Duane Arnold
Long Island Lighting	Shoreham
Nebraska Public Power District	Cooper
New York Power Authority	Fitzpatrick
Niagara Mohawk Power	Nine Mile Point 1 & 2
Northeast Utilities	Millstone 1
Northern States Power	Monticello
Pennsylvania Power and Light	Susquehanna 1 & 2
Philadelphia Electric Company	Peach Bottom 2 & 3, Limerick 1 & 2
Public Service Electric and Gas	Hope Creek
System Energy Resources, Inc.	Grand Gulf 1
Tennessee Valley Authority	Browns Ferry 1-3
Vermont Yankee	Vermont Yankee
Washington Public Power Supply Company	WNP-2 (Hanford 2)

ENCLOSURE 1

IMPLEMENTATION PROGRAM

Licensees who are now following Revision 1, Revision 2 or Revision 3 of the EPG should revise their EOPs to reflect the guidance in Revision 4 of the EPG as early as practical.

The staff suggests that implementation of the guidelines proceed in two steps; as follows:

(1) Preparation of Plant Specific Technical Guidelines (PSTG) that conform to the Emergency Procedure Guidelines referenced above and implementation of these guidelines as outlined in the following documents: Supplement 1 to NUREG-0737, transmitted by Generic Letter No. 82-33, dated December 17, 1982, NUREG-0899, "Guidelines for the Preparation of Emergency Operating Procedures" August 1982; and NUREG/CR-3632, "Methods for Implementing Revisions for Emergency Operating Procedures," May 1984.

(2) Preparation of supplements to the Plant-Specific Technical Guidelines which cover changes, new equipment, or new knowledge and incorporation of these supplements into plant-specific procedures.

Step (1) refers to the guidelines referenced above; Step (2) refers to guideline updates which will be generated as a matter of routine after the plant specific procedures have been put in place.

The staff notes that the guidelines are written for the procedure writers, not for control room operators. Therefore, preparation and implementation of plant specific procedures will require "human factors" input to assure that the procedures are logical, readable, easy to use, and consistent with plant conventions, labels and equipment. All emergency operating procedures and revisions should be developed in conformance with an acceptable plant-specific writer's guide, should be validated by appropriate methods, and should be included in plant training programs.

The staff is concerned about the continuing failure of licensees to properly implement the EPGs. Results from the NRC staff review of numerous plant PGPs and recent audits and inspections of the EOPs have identified a number of problems. Even though NRC Information Notice 86-64, Supplement 1 dated April 20, 1987 and 86-84 dated August 14, 1986 informed licensees of deficiencies uncovered by the staff in the licensee's implementation program, the deficiencies identified in the information notices continue to be identified.

The staff review of numerous plant procedure generation packages (PGP), recent audits and inspections of the EOPs have resulted in the following findings:

1. The EOPs for the most part accurately incorporated the generic guidelines and were technically correct.

2. Simulator exercise of the EOPs have shown that the operators were able to shutdown the plant safely.

3. Many plants had good labeling and component identification for the equipment used in the EOPs.

4. In many plants equipment (tools, jumper cables, etc.) were readily available and the operations personnel were familiar with the equipment location and use.

However, the staff is concerned about the continuing failure of licensees to properly implement the EPGs.

Specifically:

1. Inadequate evaluation and documentation of deviations from the NRC approved generic technical guidelines; and, in some cases, significant deviations without any evaluation.

2. Inadequate implementation of licensee specific EOP writer's guide.

3. Inadequate verification and validatation of plant specific EOPs.

4. Inadequate training and evaluatation of the operating staff in the use of the upgraded EOPs.

5. Failure to apply operational quality assurance controls to the EOP upgrade process to ensure meeting licensing commitments.

While the above findings do not necessarily represent the situation at any single plant, the frequency of their discovery across the plants visited raises concerns that the overall quality of EOPs may not meet the requirements of NUREG-0737, Supplement-1, and should be improved. To address these safety significant deficiencies, a high level of management oversight and effective management control should be provided to assure proper implementation of the EPGs.

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

BWR

EMERGENCY PROCEDURE GUIDELINES

REVISION 4

BWR 1 THROUGH 6

ENCLOSURE 2

SEPTEMBER 1988

9305050124

EPG, REVISION 4, SER

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1. INTRODUCTION

Following the accident at TMI-2, the BWR Owners' Group started developing symptomatic Emergency Procedure Guidelines (EPGs). Initially, operator guidance was developed only for SBLOCA. Later, the BWR Owners' Group developed symptomatic EPGs consistent with the requirements of item I.C.I of NUREG-0737. These guidelines addressed conditions beyond design basis accidents and included consideration of multiple failures. Revisions to the EPGs were made to incorporate new product lines (BWR/6) and to add guidelines for reactivity control, secondary containment control, hydrogen control, etc. Also, changes were made to reflect changes in equipment and new knowledge. The staff issued SERs for Revisions 2 and 3 on February 8, 1983 and November 28, 1983 respectively. At present, most BWR Owners are following Revision 2 or 3 of the EPG. During the period between 1983-1988, the staff met several times with the BWR Owners' Group to discuss Revision 4 of the EPG. The BWR Owners' Group submitted Revision 4 of the EPG in April 1987 for staff review. In letters (BWROG-8739, 8820), dated July 7, 1987 and May 16, 1988 the BWR Owners' Group responded to the staff's questions on Revision 4 of the EPG.

Revision 4 of the EPG is a significant improvement over earlier versions of the EPGs. Even though containment venting was approved in Revision 2, there were no detailed analyses to establish a venting pressure limit. In Revision 4, more detailed guidance is given to establish the containment vent initiation pressure. The improved guidance on containment venting will help to prevent and mitigate severe accidents.

There was no guidance for hydrogen control in Revision 3 of the EPG. Now, in Revision 4, hydrogen control is addressed for Mark I and Mark II containments. Mark III hydrogen control guidelines are addressed separately in the Hydrogen

Control Owners Group (HCOG) program. The hydrogen control guidelines included for the first time in Revision 4 will help to mitigate severe accidents.

ATWS guidelines were revised in Revision 4. Alternate control rod insertion steps were restructured and simplified and include actions not previously identified. In Revision 3, the Anticipated Transient Without Scram (ATWS) mitigation steps were event oriented rather than symptom oriented. The steps assumed the problems are electrical or pneumatic. The ATWS guidelines are symptom oriented in Revision 4. In the previous revision, RPV water level was allowed to decrease only to Top of the Active Fuel (TAF). It is difficult to control RPV water level exactly at TAF. Hence, the EPG was revised to give a range between TAF and minimum steam cooling RPV water level which is below the TAF. Thus, Revision 4 of the EPG gives improved guidance for coping with ATWS and this improved guideline will help to prevent and mitigate severe accidents.

In the revised EPG, the containment flooding contingency replaces the spray cooling contingency. This was done because of a lack of certainty that all the fuel bundles would get enough cooling by spray cooling alone. Revision 4 of the EPG is an improvement with respect to core cooling because containment flooding up to TAF will assure submergence of the core.

In Revision 2 there were 26 cautions. In Revision 4 there are only 7. Each of the original 26 was reviewed to determine whether it was truly a caution. Some of them were not true cautions but included action statements. Many of them were incorporated into steps and others were deleted and will be part of the training process.

EPG-Rev 4 provides improved guidance on venting, but it should remain fully aware that the Commission is continuing to assess means for further minimizing the potential downside of venting. The Commission is currently considering a MARK I containment improvement program which could result in additional hardware changes. The purpose of these modifications would be to realize the full benefits of venting in reducing public risk. Those changes will be an integral part of the MARK I program.

Appendix A is a list of principal NRC staff contributors. Appendix B is a list of abbreviations. Appendix C is definition of variables.

2. OVERVIEW

The BWR Owners' Group, with the assistance of General Electric Company (GE) and consultants, has developed generic symptomatic emergency procedure guidelines (EPGs) Revision 4. The EPGs are generic to GEBWR 1 through 6 designs in that they address all major systems which may be used to respond to the emergency. The guidelines are written for plants as they are currently configured; no attempt has been made to propose system modifications. Because no specific plant includes all of the systems in these guidelines, the EPGs are applied to individual plants by deleting statements which are not applicable or by substituting equivalent systems where appropriate. For example, plants with no low pressure injection system will delete statements referring to LPCI, and plants with low pressure core flooding (LPCF) will substitute LPCF for LPCI.

Although considerable effort has been expended by the BWR Owners' Group and their consultants in the development of the EPGs and the EPGs have been critically examined by several members of the staff, operating experience will almost certainly reveal situations which are not covered by the EPGs. However, the procedures which will be developed from Revision 4 of the guidelines should be more comprehensive than those currently available. Also, because the operator using procedures based on the EPGs will be responding to symptoms rather than events, the consequence of an incorrect event diagnosis is minimal.

The entry conditions for the EPGs are symptomatic of both emergencies and events which may degrade into emergencies. The guidelines specify actions appropriate for both. Therefore, entry into procedures developed from these guidelines is not conclusive that an emergency has occurred. For example, a loss of drywell cooling while a plant is operating will result in a high drywell temperature and pressure with a resultant reactor scram and ECCS actuation but an emergency would not necessarily exist.

The EPGs are based upon maintaining core cooling and primary containment integrity. In all but few cases the EPGs emphasize core cooling. But in a few specific situations, when a decision between a possible loss of adequate core cooling and a loss of primary containment integrity must be made, the EPGs preferentially choose to maintain primary containment integrity in order to protect against the uncontrolled release of radioactivity to the general public from a degraded core condition. For example, step SP/L-3.3 of the containment control guidelines states that "if the primary containment water level cannot be maintained below the maximum Primary Containment Water Level Limit, terminate injection in the RPV from sources external to the primary containment irrespective of whether adequate core cooling is assured." The flooded containment immerses the core and provides long term cooling for the core. Thus this step is really a core protection measure as well as a containment protection measure.

The EPGs are functionally divided into four guidelines (RPV control guideline, primary containment control guideline, secondary containment control guideline, and radioactivity release control guideline) and six contingencies (Alternate Level control, Emergency RPV Depressurization, Steam Cooling, RPV Flooding, Level/Power Control and Primary Containment Flooding) and are designed to cover all emergency situations including Anticipated Transients Without Scram (ATWS). Therefore, small-break LOCA, large-break LOCA, transients with multiple failures or no failures, and inadequate core cooling are all addressed by the EPGs. The guidelines address operator errors by checking the effects of directed operator actions and providing guidance for those cases where previous operator actions were unsuccessful. The guidelines do address combustible gas control (Mark I and Mark II containments only), secondary containment control and radioactivity release control guidelines. The guidance provided for events with failure to scram is complicated and may result in core flow oscillations for ATWS events; however, core melt should be avoided if the ATWS guidance in the EPGs is followed.

The EPGs are organized to provide guidance for operator response to transients and accidents for the entire range of available systems. Guidance is provided for the use of all systems capable of performing a function. This "defense in depth" is discussed in evaluations of individual guidelines and contingencies.

The guidelines use a unique method to coordinate actions of different guidelines. This involves the evaluation of the necessity for an action in one guideline or contingency with the instructions for the action contained within another guideline or contingency. An example of this is emergency depressurization. Its need may result from containment control difficulties but its steps are found in the Emergency RPV Depressurization Contingency #2. This organization is necessary to ensure all the considerations associated with this action are addressed for all situations. This method of coordinating these functions is acceptable.

2.1 Summary of RPV Control

The purpose of the RPV control guideline is to restore and maintain the RPV water level within a satisfactory range, shut down the reactor and control RPV pressure, and cool the RPV to cold shut down conditions. The entry conditions are any of the following:

(1) RPV water level below low level scram setpoint,

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

(3) a condition which requires reactor scram and reactor power is above the Average Power Range Monitor (APRM) downscale trip or cannot be determined or

(4) RPV pressure above the scram pressure.

For events in which scram occurs, either automatically or manually, the operator verifies scram and proceeds to control RPV water level and pressure with whatever systems are available. The systems used to inject water are listed in an approximate order of preference and both safety and nonsafety systems are included. Alternate injection systems such as fire system are included as backup to the normal systems. Where possible, water level is maintained in the normal control range; where this is not possible, level is either controlled above the top of the active fuel or the operator attempts to verify sufficient injection to ensure adequate core cooling.

Both test and analysis have shown that maintaining the water level above the top of the active fuel is sufficient to assure adequate core cooling, provided the reactor is tripped. The EPGs are designed to give preference to covering the core with water to cool it. Further, test and analysis have shown that flooding to 2/3 core height with low pressure systems is adequate to maintain core cooling if the reactor is tripped but the core cannot be completely covered. The EPGs recognize this mode of cooling as an alternate to the preferred mode of cooling.

During Contingency #3 "Steam Cooling", if no injection systems are available to maintain inventory in the reactor vessel, the guidelines prescribe a combination of boiloff and depressurization to maintain core cooling while attempts are made to start inoperable systems to replenish inventory. Although this approach only delays the eventual heatup of the fuel, it is the best that can be done with no available injection.

2.2 Summary of ATWS Guidance

If scram does not occur when required, the EPGs call for several actions to be taken simultaneously. These include:

(1) Start boron injection with standby liquid control system (SLCS) or other systems if SLCS is not operable, and

(2) Initiation of Alternate Rod Insertion (ARI) if ARI has not initiated.

(3) Tripping of Reactor Recirculation Pumps.

(4) Manually insert control rods, reset scram, open breakers or remove fuses which deenergize scram solenoids, close scram air header supply valve and open scram air header vent valves, individually open scram test switches, and

(5) Lower water level until:

a. power below APRM downscale trip (3 percent is typical), or

b. containment heatup terminated, or

c. level reaches between the top of the active fuel and the minimum steam cooling RPV water level.

Although the lowering of the water level is effective in reducing power, it may result in core flow oscillations.

Lowering of the RPV water level to the minimum steam cooling RPV water level (below TAF) is contrary to normal operator response. The alternative leads to excessive suppression pool temperature and probable long term core melt for the most severe failure to scram events.

2.3 Dependence on Water Level Indication

Because many of the actions in the EPGs are keyed to reactor vessel water level, the EPGs contain cautions which alert the operator to conditions which cause the water level indications to be unreliable. These cautions are related to drywell temperature, indicated level and RPV pressure.

If the vessel water level cannot be determined, the EPGs instruct the operator to depressurize the vessel and flood the vessel until water pours out of the safety/relief valves. This guidance assures that the fuel remains covered with water so that the fuel is adequately cooled.

2.4 Summary of Containment Control

The containment control guideline is concerned with primary containment temperature, pressure, and water level. It is executed concurrently with the RPV control guidelines. The entry conditions are any of the following:

(1) Suppression pool temperature above the most limiting suppression pool temperature LCO,

(2) Drywell temperature above drywell temperature LCO,

(3) Containment temperature above its LCO (Mark III containments only),

(4) Drywell pressure above high pressure scram setpoint,

(5) Suppression pool water level above its maximum LCO,

(6) Suppression pool water level below its minimum LCO,

(7) Primary containment hydrogen concentration above high hydrogen alarm setpoint.

An element of the containment control guidelines which has received considerable attention is the guidance on containment venting, especially guidance on venting which may result in offsite radioactivity release rate. The BWR Owners Group has included guidance on venting since the early versions of the EPG's. The staff in its safety evaluation of Revision 2 to the BWR EPG's acknowledged the role of venting, to aid in the control of low probability severe accidents. However, the staff in its SER to Revision 2 of the BWR EPG's expressed concern over a lack of specific guidance in the EPG's for establishing the pressure at which venting was to be initiated, the primary containment pressure limit (PCPL). The staff's basic concern was (and remains) that venting even if it results in some radiological consequences should only be undertaken as an extreme means to prevent core melt or as a last resort measure to prevent the irreversible and unpredictable rupture of the containment which could otherwise lead to a larger release. The underlying strategy of containment venting is to prevent core melt and in extremely rare cases the choice of limiting potential release of radioactivity to avoid uncontrolled release.

Both the industry and the NRC have continued to investigate venting as a response to severe accidents. Revision 4 to the BWR EPG's incorporates the results of those continuing investigations.

First, the Owners Group has now identified a new definition of the PCPL. The Primary Containment Pressure Limit (PCPL) is defined to be the lowest of (1) the pressure capability of the containment or (2) the maximum containment pressure at which vent valves can be opened and closed to reject all decay heat from the containment or (3) the maximum containment pressure at which SRVs can be opened and will remain open or (4) the maximum containment pressure at which vent valves can be opened and closed to vent the RPV for primary containment flooding. The PCPL is a function of primary containment water level and temperature.

Second, the guidelines now direct the operator to vent, in spite of possible offsite releases, before reaching the PCPL; previously the guidelines directed the operator to vent if the pressure exceeded the PCPL. Thus the venting action is now somewhat anticipatory in order to assure continued operability of equipment and structural integrity of containment. Venting is used to maintain the containment pressure below the PCPL. Thus, once the pressure will remain below the PCPL without venting, venting should be terminated.

Finally, the guidelines previously instructed the operator to use containment sprays prior to venting even if use of containment sprays jeopardized the ability to restore or maintain adequate core cooling (e.g., by diverting the only available pump to containment spray rather than RPV injection). Revision 4 to the guidelines now reverses the order of these steps and directs the use of sprays, at the expense of RPV injection, only when venting is not successful. However, temporary use of an RHR pump in the containment spray mode is directed at an earlier point in the sequence of guidelines even with only one pump available provided continuous use in the low pressure coolant injection is not required.

The staff has considered the modifications to the BWR EPG's that deal with venting with offsite radioactivity release and judges those changes and the overall guidance to be appropriate. For most severe accident scenarios requiring venting, venting will release mostly steam. Even for those cases for which venting would release significant off-site doses, the choice is between a controlled release and a likely uncontrolled larger release. Therefore, containment venting is a dose reduction measure. This is not to imply that the staff views the overall issue of containment venting as static or having reached an optimal point of resolution. In conjunction with ongoing severe accident research and activities associated with the Mark I Containment Performance Program the staff is continuing to evaluate the merits of improving plant capability to optimize the benefits and reduce the risks associated with venting.

The staff and the industry have performed sufficient work in the area of containment venting that a number of observations can be made regarding the benefits and incremental risks associated with venting. With regard to the benefits, it is now apparent that venting serves both a prevention and mitigation role in severe accident management. Venting may be used as the mechanism to remove decay heat and if injection capability exists, core damage may be prevented. Venting under these conditions has been cited as a measure to significantly reduce the core damage frequency in the Peach Bottom risk analysis, especially core damage due to loss of decay heat removal capability. Venting as a mitigation measure to control pressure can provide for scrubbing of fission products through the suppression pool as opposed to the unpredictable nature of a release resulting from containment failure. However, there are downsides to a strategy which intentionally releases containment atmosphere to the reactor building or the environs. If the vent path is not capable of bearing the associated pressure and consequently ruptures upon initiation of venting, then the reactor building could become highly contaminated and operator access will be impractical. Thus, recovery of failed equipment may be prevented. Further, rupture of a vent line in the reactor building will unnecessarily threaten the functioning of safety equipment or instrumentation which was operating by exposing that equipment to a high temperature, steam, and radiation environment. It should also be noted that venting through a nonpressure bearing path may have habitability consequences for control room personnel.

Another potential negative associated with venting is the probability that venting will be performed for accidents in which subsequent recovery of other systems takes place and venting was not ultimately necessary. Especially since venting is now an anticipatory step it is possible that unnecessary venting could take place. The likelihood of this occurrence may be minimized by placing greater emphasis on the need for the operating crew or technical support staff to understand the accident in progress.

Additionally, while the BWR EPG's first direct the use of a vent path from the wetwell, thus benefitting from pool scrubbing, if wetwell venting capability does not exist, then venting from the drywell is directed. The benefits from drywell venting are less clear since release of fission products would occur earlier than if containment failure were allowed to occur or a higher venting setpoint were used.

Containment venting is also used for combustible gas control. Venting the primary containment irrespective of the offsite radioactivity release rate would only be considered to restore and maintain the primary containment hydrogen concentration below the deflagration concentration. Containment failure may follow if a deflagration were to occur. Venting the containment may be the only mechanism which remains to prevent an uncontrolled and unpredictable breach of the primary containment. The controlled release of radioactivity to the environment is preferable to containment failure whereby adequate core cooling might also be lost and radioactivity released with no control whatsoever.

The containment control guideline contains several limit curves such as a drywell spray initiation limit and Primary Containment Pressure limit. Beyond these limits, certain operator actions are required. Although the limits are conservative, they are derived from engineering analyses using best-estimate models. While the staff has not reviewed and approved the methods used to establish these limits, the staff does endorse definition and use of limit curves.

Consequently, these limits are not as conservative as the limits specified in a plant's technical specifications. This is not to imply that operation beyond the technical specifications is recommended in an emergency. Rather, such operation may be required under certain degraded conditions. The limits specified in the guidelines establish the boundaries within which continued safe operation of the plant can be assured. Therefore, conformance with the guidelines under degraded conditions does not ensure strict conformance with a plant's technical specifications or other licensing bases. The licensing specifications will already have been exceeded in order to get into such a situation in the first place and the safe recovery of the plant becomes the matter of paramount importance.

The staff's stated goal is to limit venting to a "last resort" action. The major staff concern has centered on the appropriate containment pressure for venting. As a result the venting pressure should be established to as high as reasonably achievable. If PCPL is less than the design pressure, the licensee must submit justification and the staff will evaluate on a case by case basis. Accordingly, a reasonable effort should be made by each licensee to increase the primary containment pressure limit as high as practical, e.g., perform adjustments to the pneumatic operating pressure of the SRVs, and consideration for improving vent valve operability.

2.5 Simultaneous Actions

Although the operator could be using several procedures simultaneously, the simulator demonstrations of procedures for several plants that were based on the guidelines have demonstrated that containment parameters do not change rapidly enough to be beyond the operator's capability to respond.

2.6 Nature of Guidelines

The BWR Owners' Group should complete the development of the guidelines and maintain the guidelines after development is complete. Maintenance would include incorporation of operating experience and new knowledge into the guidelines and modification of the guidelines to account for new equipment. The actions specified in the EPGs are generally correct and appropriate and within the operator's capability. The combination of all emergency actions into four guidelines and six contingencies and only seven cautions greatly simplifies the emergency instructions. In addition, the continued use of symptoms rather than events as bases for actions eliminates errors resulting from incorrect diagnosis of events and addresses multiple failures and operator errors. A more detailed discussion of individual guidelines and contingencies follows.

3. RPV CONTROL GUIDELINE

The purpose of the RPV control guideline is to restore and maintain RPV water level within a satisfactory range, shut down the reactor, control pressure, and cool the RPV to cold shut down conditions. The entry conditions are any of the following:

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

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

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

(4) RPV pressure above the scram pressure.

The first step in this guideline is to initiate reactor scram if it has not been initiated. The RPV control guideline then branches into three segments (level control, pressure control, and power control) which are executed concurrently.

3.1 Level Control

At first the operator initiates containment isolation, ECCS and Emergency Diesel generator, if not initiated. Isolation actions terminate loss of reactor coolant inventory and simplify RPV water level control. Initiation of ECCS aligns sources of make-up water and starts ECCS pumps for injecting water into the RPV. Emergency Diesel Generator initiation assures power supply to the ECCS pumps. Level control attempts to control reactor water level between the low level scram set point and high level trip set point. The following systems, designated as preferred injection systems, are used initially for RPV level control:

Condensate/Feedwater
CRD, HPCI
RCIC (with suction from condensate storage tank defeating low RP pressure isolation interlocks and high suppression pool water level

suction transfer logic if necessary) HPCS, RHR, LPCS (Vortex and NPSH limits are specified for pump protection.)

If water level cannot be maintained above the low level scram set point, then level control attempts to maintain the water level above the Top of the Active Fuel (TAF). If the preferred injection systems are not available, alternate injection systems such as fire system or RHR service water crosstie are used. If level can be maintained above TAF and the Automatic Depressurization System (ADS) timer has initiated, then the operator is instructed to reset the ADS timer. Plants which don't have ADS inhibit switch require frequent resetting of the ADS timer to prevent ADS actuation.

Three of the six contingencies are called from level control. The conditions under which these are called are as follows:

(1) Boron injection required, enter level/power control Contingency #5.

(2) Reactor pressure vessel (RPV) water level cannot be determined, enter RPV flooding Contingency #4.

(3) If RPV water level cannot be maintained above the top of the active fuel, enter the alternate level Contingency #1.

Each of the contingencies will be discussed separately in Section 7. For a typical recovery from plant transients there will be no need to call upon any of the contingencies; the steps in the level control portion of the RPV control guidelines are simple and they are adequate to assure that the core is covered with water.

3.2 Pressure Control

The RPV pressure control section of the RPV control guideline controls pressure such that safety relief valve (SRV) cycling is minimized and suppression pool heat capacity and load limits are not exceeded. The steps of the RPV pressure control guidelines are adequate for normal recovery from plant transients and cooldown to shut down cooling.

SRV cycling is terminated by manual opening of SRVs to reduce RPV pressure to substantially below the lowest SRV lifting set point. This also may be achieved by Isolation Condenser or Low Low Set Control Logic of the SRVs.

If the main turbine bypass valves cannot be used to control RPV pressure, additional systems such as RCIC, HPCI, main steam line drains, steam jet air ejectors, reactor feed pump turbines, RHR steam condensing mode, etc., are used.

RPV depressurization and cooldown may not proceed until at least one of the four conditions that follow are satisfied.

(1) All control rods are inserted to or beyond maximum subcritical banked withdrawal position.

(2) It has been determined that the reactor will remain shut down under all conditions without boron injection.

(3) Cold shut down boron weight of boron have been added.

(4) The reactor is shut down and no boron has been injected into the RPV.

SRVs are used to depressurize the RPV. Once the RPV pressure reduces to below the high pressure interlock of the RHR shutdown cooling system, RHR system is put into service. Then normal reactor shut down procedures are used. Once reactor shut down is achieved either by control rod insertion alone or by injection of the cold shut down boron weight of boron into the RPV, an exit from the RPV pressure control is permitted.

3.3 Power Control

The reactor power control section of the the RPV guideline verifies that rods are inserted, and the reactor is shut down. The operator is then directed to the scram procedure. The remainder of the power control section deals with those steps (other than water level control) to bring the reactor to a shut down condition if the rods did not fully insert or if the reactor power is above the APRM downscale trip or cannot be determined. The reactor power control section includes such steps as place the reactor mode switch in shut down (provides another scram signal), trip the recirculation pumps, initiate ARI, inject boron before the suppression pool temperature reaches the boron injection initiation temperature (typically 110°F) and insert control rods by various means. If these steps do not work, then Contingency #5, level/power control, is used to control power by other means.

One step in the reactor power control section takes a considerable length of time. Step RC/Q-6 states: If boron cannot be injected with SLCS, inject boron into the RPV by one or more of the following alternate methods:

- CRD
- HPCS
- RWCU
- Feedwater
- HPCI
- RCIC
- Hydro pump.

Because the time required to add boron to the water source for these systems is large the efficacy of this step is questionable. However, the probability of needing step RC/Q-6 is quite low. This step is a "last ditch" effort with a low probability of success. Our review has concluded that at least it is not detrimental to safety to try this approach despite the low probability of success.

During boron injection automatic initiation of ADS is prevented by operator action. ADS initiation may result in the injection of large amounts of relatively cold, unborated water from low pressure ECCS systems. With the reactor either critical or shut down on boron, the positive reactivity addition due to boron dilution and temperature reduction effected through the injection of cold water may result in a reactor power excursion large enough to cause substantial core damage. Defeating ADS is therefore appropriate when boron injection is required.

4. PRIMARY CONTAINMENT CONTROL GUIDELINE

The primary containment control guideline is executed concurrently with the RPV control guideline. Its purpose is to maintain primary containment integrity, and protect primary containment equipment. Entry conditions are any of the following:

(1) Suppression pool temperature above the most limiting suppression pool temperature limiting condition for operation (LCO),

(2) Drywell temperature above drywell temperature LCO or maximum normal operating temperature, whichever is higher,

(3) Containment temperature above its LCO (Mark III containments only),

(4) Drywell pressure above high pressure scram setpoint,

(5) Suppression pool water level above its maximum LCO,

(6) Suppression pool water level below its minimum LCO,

(7) Primary containment hydrogen concentration above high hydrogen alarm setpoint [Mark I and II containment only].

The containment control guideline has six sections which are executed concurrently, these are:

SP/T - suppression pool temperature,
DW/T - drywell temperature,

CN/T - containment temperature,
PC/P - primary containment pressure,
SP/L - suppression pool level, and
PC/H - hydrogen and oxygen concentrations.

° SP/T

The purpose of the SP/T section is to monitor and control suppression pool temperature. The operator is instructed to operate pool cooling when the pool temperature equals or exceeds its LCO and to scram the reactor before the pool temperature reaches the boron injection initiation temperature or the suppression pool temperature limit whichever is lower. Also, the operator is instructed to control RPV pressure to maintain the pool temperature below the heat capacity temperature limit (to assure stable condensation of discharge from SRVs). If suppression pool temperature and RPV pressure cannot be restored and maintained below the heat capacity temperature limit, then emergency RPV depressurization is required.

° DW/T

The purpose of the DW/T section is to monitor and control drywell temperature. The operator is instructed to operate available drywell cooling before the drywell temperature exceeds its LCO or maximum normal operating temperature, whichever is higher. When the drywell temperature cannot be maintained below this threshold temperature, isolation interlocks may need to be disabled to operate all available cooling. Also, a caution is highlighted to the operators that high drywell temperature has a direct effect on the RPV water level indication.

Before drywell temperature reaches maximum ADS qualification temperature or drywell design temperature, whichever is lower, but only if suppression water level is sufficiently below the drywell-wetwell vacuum breakers and drywell pressure and temperature are below the drywell spray initiation limit, recirculation pumps and drywell cooling fans are shut down if dictated by plant specific considerations and drywell sprays are initiated (if adequate core cooling is assured). The drywell spray initiation limit is defined to preclude containment failure (i.e. below the drywell-wetwell differential pressure capability) and potential oxygen ingress caused by condensation of steam in the drywell when sprays are initiated. This limit applies only to Mark I and Mark II containments.

If the drywell temperature cannot be maintained below the ADS qualification temperature or drywell design temperature, then emergency depressurization and reactor scram is required. This step is necessary because the high drywell temperature may cause the ADS to become inoperable and the capability to rapidly depressurize, if needed, would be lost. The staff concludes that a manual scram should be initiated early in this sequence, such as before drywell temperature reaches maximum ADS qualification temperature consistent with initiation of drywell sprays.

° CN/T

The CN/T section of the primary containment control guideline applies to Mark III containments only and is very similar to the DW/T section for Mark I and Mark II containments. The operator uses available containment cooling when the containment temperature exceeds its temperature LCO. Also, a caution is highlighted to the operators on the direct effect of high containment temperature on the RPV water level indication. Before containment temperature reaches the containment design value, but only if suppression chamber pressure is above the Mark III containment spray initiation pressure limit, the operator initiates suppression pool sprays (if adequate core cooling is assured). If the containment temperature cannot be maintained below the design temperature, emergency RPV depressurization and reactor scram is required.

° PC/P

The PC/P section of the primary containment control guideline monitors and controls primary containment pressure.

In this section, the BWR EPGs call for emergency containment venting as one of the last steps in a sequence of procedural steps involving operator actions designed to reduce containment pressure. In the SER for the BWR EPGs Revision 2, the staff established an interim limit of twice the containment design pressure for venting with the understanding that more precise analyses may be used to establish a venting pressure limit. These analyses, in general, could consider ADS valve operability, containment integrity structural tests, purge valve operability, and leaktightness of gaskets and seals.

The rationale for containment venting in Revision 2 and Revision 3 to the EPGs was to maintain suppression pool integrity and not vent unless catastrophic containment failure was imminent; then, to vent regardless of the activity in the containment. The idea was that a controlled release was better than an uncontrolled, unisolatable release. The major debate has centered on the appropriate containment pressure for venting with the concerns being rupture pressure and limit for operability of ADS valves and isolation valves used for venting.

Even though the staff established an interim limit of twice the containment design pressure, the actual containment vent pressure adopted by most of the licensees is a lower limit. The availability of ADS valves to depressurize the RPV and to control containment pressure was the controlling factor in deciding the vent pressure. In most plants, the ADS valves are designed to operate only at a lower containment pressure than the containment structural limit. Therefore, many plants have decided to vent the containment at the containment design pressure or lower. Use of ADS valves for RPV depressurization is essential to prevent a reactor core melt and ultimately containment failure.

If venting is done through a path which passes through the pool, then the benefit of pool scrubbing is achieved. Thus, the suppression pool vent path is given first priority for containment venting. There may be one or more vent paths of different sizes predetermined for containment venting. In general, the vent paths should be used in order of increasing size. These priorities mean that large vent paths are opened only if necessary and, if possible, releases are routed through the suppression pool before release directly to the atmosphere.

Equipment qualification is another concern associated with containment venting. There should be assurance that the isolation valves used for containment venting are capable of opening and reclosing at the containment venting pressure. The containment venting pressure will be decided on the following criteria:

a. Containment structure capability.

b. Vent valve operability.

c. SRV operability.

d. RPV vent valve operability.

As part of the Revision 4 EPGs, the BWROG has submitted more detailed criteria for determining the venting pressure, i.e., Primary Containment Pressure Limit. The Primary Containment Pressure Limit (PCPL) is defined to be the lesser of either (1) the pressure capability of the containment or (2) the maximum containment pressure at which containment and RPV vent valves can be opened and closed or (3) the maximum containment pressure at which SRVs can be opened and will remain open. The PCPL is a function of primary containment water level and pressure, and the limit is used to preclude containment failure and core damage. PCPL is a plant specific limit and is expected to vary from plant to plant. In previous versions, containment venting was done only when the suppression chamber pressure exceeds the PCPL. In Revision 4 venting is allowed before suppression chamber reaches the PCPL. As a result, containment venting is expected at an earlier stage as the event progresses. This ensures containment integrity is maintained for most severe accidents which may come later.

The staff's stated goal is to limit containment venting to a "last resort" action. The major staff concern has centered on the appropriate containment pressure for venting. As a result, the venting pressure should be established to as high as reasonably achievable. If PCPL is less than the design pressure, the licensee must submit justification and the staff will evaluate on a case by case basis. Accordingly, a reasonable effort should be made by each licensee to increase the primary containment pressure limit as high as practical, e.g., perform adjustments to the pneumatic operating pressure of the SRVs, and consider improving vent valve operability. Also, containment venting is used in combustible gas control, which is addressed later in this evaluation.

In Revision 4, the PCPL section entails five key steps. Normally, monitoring and control of primary containment pressure below the high drywell pressure scram setpoint is achieved by operating the following systems as required:

- Containment pressure control systems.

- Standby gas treatment system (SBGT) and drywell purge.

These actions should be sufficient for most situations. The following steps are for progressively degraded situations.

Before suppression chamber pressure reaches the suppression chamber spray initiation pressure (Mark I and II containments), or if the suppression chamber pressure is above the Mark III spray initiation pressure limit, suppression pool sprays should be initiated. The purpose of the Mark I and II suppression chamber spray initiation pressure limit is to reduce pressure before the drywell spray is needed (drywell sprays may damage electrical equipment). The Mark III containment spray initiation pressure limit has already been discussed in the CN/T section. For Mark I and II designs, the pool water level limit is checked to assure that the sprays can condense steam in the airspace; if the nozzles are submerged, the spray is not effective. It should be noted that spray activation in these early steps are contingent on adequate cooling being satisfied. If more systems, including RHR, are available for core cooling, the RHR system is used for spray as necessary.

For Mark I and II containments, when suppression chamber pressure exceeds the suppression chamber spray initiation pressure, this step calls for activation of the drywell spray, taking cognizance of the drywell spray initiation pressure limit which was discussed in the DW/T section.

If suppression chamber pressure cannot be maintained below the pressure suppression pressure curve, the third step instructs the operator that emergency depressurization is required. The pressure suppression pressure curve serves to limit pressure in order to assure the pressure suppression function of the containment is maintained while the RPV is at elevated pressure.

The fourth step in the PC/P section states that "Before suppression chamber pressure reaches the Primary Containment Pressure Limit then, irrespective of the offsite radioactivity release rate, vent the primary containment, defeating isolation interlocks if necessary, to reduce and maintain pressure below the limit as follows:

- If the suppression pool water level is below the elevation of the bottom of the suppression chamber vent, vent the suppression chamber.

- If the suppression chamber cannot be vented, vent the drywell."

While this step is drastic, it is necessary to attempt to control increasing containment pressure. A controlled release through the containment vent paths is preferable to a potential uncontrolled release to the environment and possible loss of the suppression pool. It should be noted, venting should be minimized to reduce releases while maintaining the containment pressure below PCPL.

The next step is worded identically to the previous step with the exception that this step directs venting the primary containment irrespective of adequate core cooling, and when suppression chamber pressure exceeds the Primary Containment Pressure Limit. This action applies to a few plants which use a specified pathway for venting that may threaten continued adequate core cooling.

When the suppression chamber pressure cannot be maintained below the primary containment pressure limit then, irrespective of whether adequate core cooling is assured, the final step requires:

- If suppression pool water level is below elevation of suppression pool spray nozzles, initiate suppression pool sprays.

- If suppression chamber is sufficiently below the drywell-wetwell vacuum breakers and the drywell pressure is below the drywell spray initiation pressure limit, initiate drywell sprays.

This step elects to preserve containment integrity and scrub fission products over core cooling. This is acceptable since it recognizes the value of preserving the last barrier to release of radioactivity and it recognizes that if containment integrity is lost, then core cooling may ultimately fail for such overpressurization events due to loss of heat sink.

- SP/L

Section SP/L of the primary containment control guideline monitors and controls suppression pool water level. The first step merely maintains the water level between the high level and low level LCOs; this should be adequate for most events.

The second step applies when the suppression pool water is below the minimum pool water level LCO. A heat capacity level limit is provided which is based on absorbing energy from a RPV blowdown, and states that if suppression pool water level limit cannot be maintained above that limit, emergency RPV depressurization is required. Also, the following substep is to be performed concurrently, if the suppression pool level cannot be maintained above the top of the HPCI exhaust, secure HPCI irrespective of whether adequate core cooling is assured. This step would preclude pressurization of the suppression chamber.

The third step of the SP/L section has several substeps based on progressive increases in containment water level above the maximum suppression pool water level LCO and should be performed concurrently. The first substep instructs the operator to maintain suppression pool water below the SRV Tail Pipe Level Limit. This limit is defined to be the highest suppression pool water level at which opening of a SRV will not result in exceeding the capability of the SRV tail pipe, tail pipe supports, quencher and quencher supports, thus precluding potential SRV system damage and containment failure. If suppression pool level cannot be contained below this limit, a reactor scram should be initiated. Then, if adequate core cooling is assured, terminate injection into the RPV from sources external to the primary containment except for boron injection systems and CRD.

For the second substep, if the suppression pool water level is not sufficiently below the drywell-wetwell vacuum breakers, terminate the drywell spray and similarly as described in the first substep terminate external water sources.

Finally, if the water level reaches the Maximum Primary Containment Water Level Limit, the operator is instructed to terminate injection into RPV from sources external to the primary containment irrespective of whether adequate core cooling is assured.

° PC/H

The PC/H section of the primary containment control guideline monitors and controls primary containment hydrogen and oxygen concentrations. This section applies to Mark I and II containments only. The actions for controlling hydrogen/oxygen concentrations depend on a determination of hydrogen/oxygen concentrations in the suppression chamber and drywell, as indicated by monitors and analyzers which obtain gas samples from the affected regions.

The hydrogen control guideline entails five major steps. The principal overriding instruction during the execution of these procedures consists of the following components:

(a) If drywell or suppression chamber hydrogen concentration cannot be determined to be below 6 percent and drywell or suppression chamber oxygen concentration cannot be determined to be below 5 percent, emergency RPV depressurization is required;

(b) Secure and prevent operation of hydrogen mixing system and recombiners;

(c) Vent/purge the primary containment, irrespective of the offsite radioactivity release rate.

The intent of this override is to reduce the potential of hydrogen combustion (i.e., a deflagration). The approach is to remove the primary containment atmosphere out of the flammability region. It should be noted that if concentrations cannot be determined, the levels are assumed to be in excess of those required to support combustion and correspondingly the operator actions are the same as if hydrogen reaches 6 percent volume concentration and oxygen reaches 5 percent volume concentration. Also, the hydrogen mixing system and recombiners are secured to eliminate potential ignition sources. The key concern is that a deflagration may result in a peak primary containment pressure high enough to rupture the drywell-to-wetwell boundary, thereby defeating the pressure suppression function of the containment.

Containment venting is also used for combustible gas control. Venting the primary containment irrespective of the offsite radioactivity release rate would only be considered to restore and maintain the primary containment hydrogen concentration below the deflagration concentrations. Containment failure may follow if a deflagration were to occur. Venting the containment may be the only mechanism which remains to prevent an uncontrolled and unpredictable breach of the primary containment. The controlled release of radioactivity to the environment is preferable to containment failure whereby, adequate core cooling might also be lost and radioactivity released with no control. This concept of venting is similar to the above PC/P evaluation.

The first step of the PC/H section requires venting/purging of the suppression chamber or drywell, whenever either of the respective regions reaches the minimum detectable hydrogen concentration provided that the offsite radioactivity release rate is expected to remain below the offsite release rate LCO.

The staff had requested the BWROG to provide additional clarification on the need for this step, since it would appear that a minimum detectable hydrogen concentration condition and the offsite radioactivity release rate below the LCO to be an unlikely combination. This comment was predicated on hydrogen generation from the zirconimum (cladding) metal water reaction being the dominate contributor. Further, the staff believes that venting may not be necessary based solely upon hydrogen concentrations above the minimum detectable level and below flammability levels. The staff believes that use of recombiners is valuable and should be utilized where appropriate.

The Owners Group has indicated that while such a combination is unlikely, it is mechanistically possible, since dissolved hydrogen is present in the reactor coolant during normal operation. As such, if the intent of this step is to remedy a hydrogen problem during normal operation, then there should be sufficient safeguards to preclude this action from being implemented during a genuine emergency situation. In particular, if conditions are met as described above, the current procedure instructs the operator to vent/purge by defeating isolation interlocks, when actual isolation signals are present.

In the staff's view, the BWROG should provide additional clarification to reduce the perceived level of operator flexibility through Appendix B to the EPG. Therefore, the staff finds that operators should have detailed guidance when conditions dictate removal of hydrogen during normal reactor operation.

The next two steps, performed concurrently, involve actions in which drywell and suppression chamber hydrogen/oxygen concentration are monitored and controlled. The staff notes that use of air-CAD (Containment Atmosphere Dilution System) as described in the EPGs may adversely affect the potential for significant combustion in the containment. For example, with measured oxygen concentration marginally above 5 percent, actuation of air-CAD would significantly increase oxygen concentration and thereby increasing the likelihood of combustion.

Also, it is indicated in Appendix B that the CAD system should not be used to repressurize the containment. This approach is contrary to some BWR's licensing bases which requires containment repressurization during a postulated hydrogen generation event. Therefore, BWR plants that employ the

CAD system as part of a hydrogen mitigation scheme would need to implement additional plant specific procedures consistent with its safety analysis or provide the staff with additional information to justify such deviations.

In PC/H-2, when drywell hydrogen concentration reaches the minimum hydrogen concentration for recombiner operation or minimum detectable hydrogen concentration, whichever is higher, but below maximum hydrogen concentration for recombiner operation or 6 percent or drywell oxygen concentration is below maximum oxygen concentration for recombiner operation or 5 percent, whichever is lower, hydrogen recombiners should be placed in service taking suction directly from the drywell, and the drywell hydrogen mixing system should be initiated.

When the drywell reaches the hydrogen/oxygen concentration limit described above, the recombiner taking suction from the drywell should be secured, and this procedure is continued at step 4.

Step PC/H-3 is identical to PC/H-2 except it is applied to the suppression chamber, and correspondingly the recombiner suction is taken from the suppression chamber. The drywell hydrogen mixing system is not called to function.

If no hydrogen recombiner can be placed in service directly on the suppression chamber, but only if either drywell hydrogen or oxygen concentration is below the maximum limit, then suction should be taken indirectly from the suppression chamber by way of the drywell.

Similarly to PC/H-2, when the suppression chamber reaches the hydrogen/oxygen concentration limits, recombiners taking suction directly on the suppression chamber should be secured.

When flammability conditions have been reached, the initial actions within step PC/H-4 are common to the override instructions described earlier in this section. The following substeps are to be performed:

If suppression pool water level is below spray nozzles, initiate suppression pool sprays, provided adequate core cooling is assured.

If suppression pool water level is below the elevation of the bottom of the suppression chamber vent, vent the suppression chamber. If the water is above the bottom of the vent or if the suppression chamber cannot be vented, vent the drywell.

If the suppression chamber or drywell can be vented, initiate and maximize the drywell purge flow. The purpose of this substep is to force hydrogen from the containment. Also, the containment is de-inerted to reach this step, purging can be achieved with either air or nitrogen sources.

If the suppression pool water level is sufficiently below the drywell-wetwell vacuum breakers, and the drywell temperature and pressure are within the drywell spray initiation limit, initiate drywell sprays provided adequate core cooling is assured.

In the fifth and final step, when the drywell or suppression chamber hydrogen concentration cannot be restored and maintained below 6 percent and drywell or suppression chamber oxygen concentration cannot be restored and maintained below 5 percent, then irrespective of whether adequate core cooling is assured, initiate suppression chamber and then drywell sprays as conditioned in the fourth step. The use of the sprays is to mitigate the consequences of a deflagration, if it were to occur, and preclude loss of the containment function.

5. SECONDARY CONTAINMENT CONTROL GUIDELINE

The purpose of the Secondary Containment Control guideline is to preserve the integrity of the secondary containment, limit radioactivity release to and from the secondary containment, and protect the equipment in the secondary containment from an adverse environment. Entry conditions into these guidelines are any of the following:

1. Differential pressure at or above 0 in. of water.

2. An area temperature above the maximum normal operating temperature.

3. A HVAC cooler differential temperature above the maximum normal operating differential temperature.

4. A HVAC exhaust radiation level above the maximum normal operating radiation level.

5. An area radiation level above the maximum normal operating radiation level.

6. A floor drain sump water level above the maximum normal operating water level.

7. An area water level above the maximum normal operating water level.

The secondary containment control guideline has three sections which are executed concurrently; these are:

SC/T - secondary containment temperature
SC/R - secondary containment radiation level
SC/L - secondary containment water level.

All three sections of the secondary containment guideline are straightforward and contain the following three steps:

1. If any area parameter (temperature, radiation or water level) exceeds or cannot be restored to its maximum normal operating limit, isolate all systems that are discharging into the area except systems required to shut down the reactor, assure adequate core cooling, or suppress a fire.

The next two steps should be performed concurrently:

2. If a primary system is discharging into an area, then, before any area parameter reaches its maximum safe operating limit, enter procedure

developed from the RPV Control Guideline and execute it concurrently with this procedure. When an area parameter exceeds its maximum safe operating limit in more than one area, emergency RPV depressurization is required.

3. When an area exceeds its maximum safe operating limit in more than one area, the reactor should be shut down.

In addition to the three steps mentioned above, the section for SC/T contains instructions to operate the area coolers and HVAC if the radiation level is below a certain value. Also, in the section for SC/L, the initial step requires the operation of available sump pumps to restore the area water level to normal operating limits.

The guideline also contains a table entitled "Operating Values of Secondary Containment Parameters." This table is utilized to define the specific areas of the secondary containment and associated action levels for parameter referenced in the entry conditions.

6. RADIOACTIVITY RELEASE CONTROL GUIDELINES

A new section, PC/H, dealing with the monitoring and control of hydrogen and oxygen concentrations has been added to the Primary Containment Control Guidelines. Operator Action PC/H-1 instructs the operator to vent and purge the containment "when the drywell or suppression chamber hydrogen concentration reaches 0.5 percent (or the minimum detectable hydrogen concentration), but only if the offsite radioactivity release rate is expected to remain below the offsite release rate LCO..." The reason for venting and purging the containment is to prevent further increases in hydrogen concentration which will directly threaten containment integrity. Since hydrogen concentrations near the minimum detectable are not containment threatening, purging is permitted only if it can be done within the limits prescribed for normal (nonemergency) plant operation. If, during these operations, the offsite radioactivity release rate reaches the offsite release rate LCO, then the operator must isolate the primary containment vent and purge. It prevents the offsite radioactivity release rate from reaching the offsite release rate LCO.

Operator Action PC/H-4 instructs the operator to depressurize the reactor pressure vessel (RPV) and vent and purge the primary containment, in spite of the offsite radioactivity release rate, when the drywell or suppression chamber hydrogen concentration reaches 6 percent and the drywell or suppression chamber oxygen concentration is above 5 percent. This operator action is acceptable since the occurrence of a hydrogen or oxygen detonation in the drywell or suppression chamber when the RPV is pressurized could result in either severe core damage or in loss of primary containment integrity and an uncontrolled release of radioactivity much greater than might occur from a controlled purging and venting of the primary containment.

A new operator action, SC/R-3, has been added to the section on monitoring and controlling secondary containment radiation levels under the Secondary Containment Control Guideline. This action instructs the operator to commence an orderly reactor shut down when an area radiation level exceeds its maximum safe operating radiation level in more than one area. This action is to be executed concurrently with operator action SC/R-2, which directs the operator to either scram or depressurize the RPV depending on the area radiation level in an area. Whereas operator action SC/R-2 pertains to a radiation level increase caused by the discharging of a primary system into secondary containment, operator action SC/R-3 is to be performed in spite of the source of the high secondary containment radiation level. The operator action SC/R-3 is acceptable since it is prudent to commence reactor shut down as a first step when maximum safe operating radiation levels are exceeded in more than one area in the secondary containment.

A new operator action has been added in Revision 4 to the Radioactivity Release Control Guideline. This action states that if the turbine building HVAC is shut down (or isolated due to high radiation) while executing the operator actions in this guideline (i.e., limiting radioactivity release into areas outside the primary and secondary containments), restart the turbine building HVAC, defeating isolation interlocks if necessary. The reason why the turbine building ventilation should remain operational during an offsite radioactivity release is that continued personnel access to the turbine building may be essential for responding to emergencies or transients which may degrade into emergencies. In addition, with the turbine building HVAC not operating, a radioactivity release inside the turbine building would eventually lead to an unmonitored ground level release. Operation of the turbine building HVAC would assure that any radioactivity release inside the turbine building would be discharged through a monitored release point. For these reasons, this additional operator action is acceptable.

7. CONTINGENCIES

7.1 Contingency #1, Alternate Level Control

This contingency is entered from the level control portion of the RPV Control Guideline when the operator determines that water level cannot be maintained above the top of the active fuel; however, the water level may still be above the top of active fuel. Once water level is increased, control is returned to the RPV Control Guideline. If while executing this contingency boron injection is required, RPV water level cannot be determined, or RPV flooding is required, control switches to the appropriate contingency. If RPV water level drops below the ADS initiation set point during this contingency, the operator prevents automatic initiation of ADS in order to maintain flexibility in coping with the event.

The first step in this contingency is to initiate core cooling using the isolation condenser and to line up pumps for injection from two or more of the ECCS subsystems or a condensate system. In the initial level control, NPSH and vortex limits are not violated. But in alternate level control all the pumps are operated irrespective of NPSH and vortex limits. The undesirable consequences of uncovering the core outweigh the risk of equipment damage that could result if NPSH and vortex limits are exceeded. If less than two of the normal injection subsystems can be lined up, the operator is instructed to line up as many of the following alternate injection subsystems as possible.

- RHR service water crosstie
- Fire system
- Interconnections with other units
- ECCS keep-full systems

- SLC (test tank)
- SLC (boron tank).

The operator then monitors RPV pressure and water level.

There are two criteria to be considered: 1) Is water level increasing or decreasing, and 2) Is RPV pressure high or low. If while executing one of the steps indicated, the RPV water level trend reverses the operator enters the RPV control guideline.

- RPV Water Level Decreasing, RPV Pressure High

Although alternate injection subsystem pumps are started, injection into the RPV will occur only when the RPV is depressurized to below the shutoff head of one of the operating alternate injection subsystems. All alternate injection subsystem pumps are started to maximize injection flowrate. If the RPV level drops to the top of The Active Fuel (TAF), all systems including steam driven systems such as HPCI and RCIC are used. If at least one source of injection into the RPV is available, emergency RPV depressurization is performed to maximize the injection flowrate from operating sources of injection. The action to depressurize the RPV remains appropriate even if a steam driven pump is the only source of injection to the RPV. If HPCI is in operation, the steam demand of the HPCI turbine alone will depressurize the RPV, irrespective of the emergency RPV depressurization. If RCIC is in operation the operator bypasses low RPV pressure automatic isolation.

When RPV water drops to the TAF, if no injection system, injection subsystem or alternate injection subsystem is lined up with at least one pump running, steam cooling is required (Contingency #3). Steam cooling is only a temporary measure to gain time to start an injection system. Steam cooling is effective in removing decay heat when RPV water level has decreased well into the core region.

- RPV Water Level Decreasing, RPV Pressure Low

All available injection systems and subsystems are operated as necessary irrespective of NPSH and vortex limits of the pumps. If the RPV water level has dropped to the TAF the operator initiates emergency depressurization. Emergency depressurization is not initiated until RPV water level has dropped to TAF because adequate core cooling exists so long as RPV water level remains above TAF. The time required for the RPV water level to decrease to TAF can best be used to line up and start pumps, attempting to reestablish injection and reverse the decreasing RPV water level trend. If RPV depressurization does not result in reversing the decreasing RPV water level trend, then alternate injection subsystems such as fire system or RHR service water crosstie, are initiated. As a matter of last resort, when all attempts to submerge the core through RPV injection prove unsuccessful, submergence of the core is achieved through primary containment flooding. Operator actions transfer to Contingency #6, "Primary Containment Flooding," for this purpose.

7.2 Contingency #2, Emergency RPV Depressurization

Emergency RPV Depressurization is identified as being required at several steps in the Containment Control Guideline, in Contingency #1, and at two steps in Contingency #5. Whenever Emergency RPV Depressurization is required, pressure control switches to Contingency #2.

Whether boron injection is not required or boron injection is required with all injection into the RPV except from boron injection systems and CRD and RCIC blocked, several steps are taken which quickly depressurize the reactor pressure vessel. If an isolation condenser is available, it is initiated. If suppression pool water level is above top of the SRV discharge device, the operator opens all ADS valves. If any ADS valve cannot be opened, the operator opens other SRVs until the same number of SRVs used for ADS (typically 7) are open. This step should depressurize the RPV to pressures within the range of low head pumps within three to five minutes.

Further, if fewer than the minimum number of SRVs required for emergency depressurization (typically 4) are open and RPV pressure is at least the minimum SRV re-opening pressure (typically 50 psig) above suppression chamber pressure, the operator rapidly depressurizes the RPV using one or more of the following systems (used in order which will minimize radioactive release to the environment):

- Main condenser,
- RHR (steam condensing mode),
- Other steam driven equipment,
- Main steam line drains,
- HPCI steam line,
- RCIC steam line,
- Head vent,
- Isolation condenser tube side vent.

For a typical BWR/4, the reactor can be depressurized quickly with as few as three SRVs. If only one SRV is available, it will still depressurize the RPV but the time to depressurize will be much longer (on the order of 20 to 30 minutes). Therefore, additional vent paths will be needed. The main condenser, if available, is very effective; most of the other systems listed are low capacity but in combination may be helpful.

If RPV flooding is required, the operator switches to procedures developed from Contingency #4, RPV Flooding, once the reactor pressure vessel is depressurized.

When any of the following conditions are established, control of RPV pressure is transferred to the RPV pressure control section of the RPV control guideline:

- The reactor is and will remain shut down under all conditions when no control rod is withdrawn beyond the maximum subcritical banked withdrawal position.

- The reactor will remain shut down under all conditions without boron.

- The cold shut down boron weight of boron has been injected into the RPV.

- The reactor is presently shut down on control rod insertion alone.

7.3 Contingency #3, Steam Cooling

Steam cooling is called out in Contingency #1 if while attempting to restore RPV water level, if all four of the following occur:

(1) RPV water level is decreasing

(2) RPV pressure is high

(3) No system, injection subsystem, or alternate injection subsystem is lined up with at least one pump running,

(4) RPV water level drops to the top of the active fuel.

Stated simply, steam cooling is used when there are no systems injecting into the vessel except for level/power control. This contingency provides cooling for an interim period while the plant staff attempts to start an injection system, and as soon as a system is injecting, the operator returns to the level restoration contingency.

For steam cooling, the water level is allowed to decrease to the level that corresponds to a maximum fuel cladding temperature of 1800F. SRVs are then opened to obtain steam cooling.

During contingency #5, "level/power control," RPV injection may be in progress to keep the RPV level between Minimum Steam Cooling Water Level and high level trip set point. During this scenario the uncovered portion of the core is cooled by steam. The covered portion of the reactor core will generate sufficient steam to preclude any cladding temperature in the uncovered portion of the core from exceeding 1500°F.

7.4 Contingency #4, RPV Flooding

Reactor pressure vessel flooding is required when RPV water level cannot be determined, irrespective of whether the reactor is shut down. If the reactor is not shut down, the core is adequately cooled by a combination of submergence and steam cooling.

The flooding procedure depressurizes the RPV and slowly fills the vessel using any of a number of specified makeup water systems. If the water level cannot be determined, the flooding may be verified by monitoring the response of RPV pressure. SRVs provide a return path for flow to the suppression pool.

Three separate flooding methods are used in Contingency #4. If flooding is necessary when all control rods are not fully inserted, Step C4-1 is followed. If flooding is required because RPV water level cannot be determined, Step C4-3 is used. If water level can be determined and all rods are fully inserted, Step C4-4 is used.

For Step C4-1, all injection into the RPV except from boron injection systems and CRD, is blocked to avoid large power excursions due to cold water addition from ECC system, and boron dilution. The action in step C4-1.1 to terminate and prevent injection allows RPV depressurization to proceed safely under ATWS conditions. Injection from boron injection systems and CRD is not terminated because operation of these systems may be needed to establish and maintain reactor shut down.

Steam lines (Mainsteam, RCIC, etc.) connected to the RPV are isolated before initiating the action to flood the RPV to preclude thermal shock. Steam lines, main turbine, RCIC turbine, etc., may not be designed for the weight of the water. Isolation is performed, however, only if the SRVs depressurize the RPV during the flooding evolution. The loss of main condenser as a heat sink is acceptable because, in an ATWS situation, steam lines have to be closed to prevent boron diversion from the RPV.

Once RPV pressure is below the minimum alternate RPV flooding pressure, injection is commenced irrespective of pump NPSH and vortex limits and is slowly increased to maintain pressure above the minimum alternate RPV flooding pressure. The systems preferred are those that inject outside the shroud. This will reduce the possibility of large power excursions. If RPV pressure cannot be maintained above the minimum alternate RPV flooding pressure, other systems injecting inside the shroud are used. If RPV flooding is not possible, primary containment flooding actions are taken by Contingency #6.

If the reactor is shut down and will remain shut down the following procedures are used. If the rods are fully inserted and water level cannot be determined, step 4-3.1 instructs the operator to commence injection into the RPV with a number of systems after isolation of steam lines. All pumps are operated irrespective of NPSH and Vortex requirements. HPCS and feedwater pumps high level trips are bypassed as necessary. RPV depressurization is explicitly called for prior to flood. Injection flow is increased until at least the minimum number of SRVs required (typically 4) are open and RPV pressure is not decreasing and is at least above the RPV flooding pressure (typically 72 psig). Pressure above the RPV flooding pressure will assure water level is increasing or if the vessel is full, water is flowing through the SRVs. Once water is flowing through the SRVs, the water level is known to definitely be above the top of the active fuel.

Flooding of the RPV should refill level instrument reference columns which may have been depleted due to flashing or boiloff. Once the RPV is filled, injection is terminated so that the water level may drop and the operator can determine if level indication has been restored. If level indication is not restored within the maximum core uncovery time limit, flooding is resumed.

Once RPV water level can be determined, RPV level and pressure control is entered.

7.5 Contingency #5, Level/Power Control

Contingency #5 is entered from Guideline RC/L or Contingencies #1, and 4 if boron injection is required following a failure to scram. The objective of Contingency #5 is to minimize heatup of the suppression pool during boron injection. If a reactor isolation does not accompany a failure to scram, it is unlikely that Contingency #5 will be entered. Steam will simply be discharged to the condenser and no containment heatup will occur. If the reactor isolation does occur, relief valves will discharge steam to the suppression pool at a rate equivalent to the reactor power level. Unless power is reduced, the suppression pool heatup during the boron injection will be excessive. Tripping the recirculation pumps to reduce power to natural circulation levels is not sufficient. Therefore, the operator decreases power by reducing the core flow by lowering the water level and thus reducing the natural circulation driving head.

RPV water level may have to be reduced to a level below the automatic initiation of ADS. ADS actuation imposes a severe thermal transient on the RPV and complicates the level control required in this contingency. If ADS is actuated, low pressure ECCS systems will inject unborated cold water to RPV and will quickly dilute the boron and may start a power transient. Hence the operator is instructed to prevent automatic initiation of ADS.

If MSIVs are closed due to low RPV water level, the interlocks are bypassed to open the MSIVs. (Other interlocks such as isolation on high radiation are not bypassed). The use of main condenser will reduce the heat load on the suppression pool.

The operator lowers RPV water level by terminating and preventing all injection into the RPV except from boron injection systems and CRD until either:

(1) Reactor power drops below the APRM downscale trip, or

(2) RPV water level reaches the top of active fuel, or

(3) All SRVs remain closed and drywell pressure remains below the high drywell pressure scram setpoint.

This minimizes the suppression pool heatup but also reduces the flow below that required to mix the boron with the water in the vessel.

The operator will try to keep the RPV level above TAF. When the water level is deliberately lowered during an ATWS, power instabilities may produce noticeable oscillations in RPV water level and make it difficult to maintain water level exactly at TAF. Hence the low end of the RPV water level range is now changed to the minimum steam cooling RPV water level (MSCWL). The operator may reduce the RPV level to the minimum steam cooling RPV water level depending upon power oscillations. The widened RPV water level control range provides operational flexibility while still assuring adequate core cooling. The following systems, which inject outside of the core shroud are used for RPV level control: Consensate/feedwater, CRD and RCIC. LPCI and HPCI are used only if they can be lined up to inject outside the shroud. If RPV water level cannot be maintained above MSCWL, RPV is depressurized to make use of the low pressure systems.

Injection to RPV is terminated while depressurizing to prevent uncontrolled injection of large amounts of cold water. The following systems: SLCS, CRD and RCIC are allowed to run, since they are low capacity systems. The RPV is depressurized below the minimum alternate RPV flooding pressure. Then injection into the RPV is reestablished to maintain adequate core cooling. If systems that inject outside the shroud are not available, systems which inject inside the shroud are used as a last resort.

If flow is decreased sufficiently to reduce reactor power to the desired level, boron mixing efficiency is so low that the boron stagnates in the lower plenum. Once the required amount of boron has been injected, core flow must be increased to rapidly distribute the boron throughout the core. This is accomplished by raising RPV water level until natural circulation flow is reestablished (recirculation pumps cannot be used because of the low RPV water level interlock designed to prevent cavitation). Test data indicate that sufficient boron mixing will occur as the water level increases.

After the boron injection, the RPV level is kept between scram setpoint or TAF and high level trip point, if possible. If the RPV level is above TAF and if the vessel is depressurized, the reactor will be taken into cold shut down using the normal shut down procedures. If the RPV level is still below TAF, RPV will be depressurized and the same steps discussed above will be repeated. If the RPV level cannot be maintained above MSCWL, the containment is flooded using Contingency #6. Adequate core cooling is assured by core submergence through primary containment flooding.

The steps outlined in Contingency #5 to reduce power by dropping the water level to the minimum steam cooling RPV water level which is below the top of the active fuel are contrary to normal operator response and have the potential to produce some cladding failure as a result of flow chugging in the core. However, the alternative leads to excessive suppression pool temperature and probable long term core melt for the most severe failure to scram events. Therefore the procedure outlined in Contingency #5 is acceptable for the current designs of BWR systems.

7.6 Contingency #6 Primary Containment Flooding

Containment flooding is required when:

(1) from Contingency #1, Alternate level control, when RPV water level can not be restored and maintained above TAF.

(2) from Contingency #4, RPV flooding, when the minimum alternate RPV flooding pressure cannot be established and

(3) from Contingency #5 level/power control, when RPV water level cannot be restored and maintained above the minimum steam cooling RPV water level.

During Contingency #6, Suppression Pool Level Control is exited if the operator is using that procedure. Suppression pool make-up system is initiated. It rapidly adds a large quantity of water to the primary containment. All available systems that take suction from external sources other than the primary containment are started to fill up the containment. The following systems are used mainly to flood the containment.

- HPCS with suction from the CST
- LPCS with suction from the CST if possible
- Condensate/feedwater
- CRD
- RCIC with suction from CST
- LPCI with suction from sources external to containment
- RHR Service water cross-tie
- Fire system
- ECCS keep-fill systems

When primary containment water level reaches the elevation of the bottom of the lowest recirculation piping, RPV is vented to get rid of the steam and noncondensibles. If the RPV is not vented properly, the core will not be fully submerged when the containment water level reaches the TAF. The following valves or lines are used for RPV venting: Flood vent valves, MSIVs, mainsteam line drains, HPCI steam line, RCIC steam line, isolation condenser tube side vents, RHR. RPV is vented to the containment or to outside atmosphere. Venting is done irrespective of off-site radioactivity. Venting is discontinued when RPV water level reaches TAF.

The primary containment water level is maintained between TAF and the maximum primary containment water level. If maximum containment water level limit is exceeded, the structural integrity of the primary containment is no longer assured. Injection into the RPV from sources outside the primary containment is terminated, irrespective of Adequate Core Cooling (ACC). The integrity of the primary containment is given priority over ACC.

8. CONCLUSIONS

We have reviewed the BWR Emergency Procedure Guidelines and find them to be acceptable. The Owners' Group also submitted Appendix B, the support document which gives the basis for different steps in the EPG. The Owners' Group should revise the following areas in Appendix B for additional clarification and better understanding of the steps:

(1) The Emergency Operating Procedures (EOPs) are entered when the entry conditions are satisfied. If different parameters like reactor level, reactor pressure etc., which are used for entry conditions cannot be determined, then the operator is also supposed to enter the EOP. This approach is not explained in Appendix B.

(2) The first step of the PC/H section requires venting/purging of the suppression chamber or drywell, whenever either of the respective regions reaches the minimum detectable hydrogen concentration provided that the offsite radioactivity release rate is expected to remain below the offsite release rate LCO.

The staff had requested the BWROG to provide additional clarification on the need for this step, since it would appear that a minimum detectable hydrogen concentration condition and the offsite radioactivity release rate below the LCO to be an unlikely combination. This comment was predicated on hydrogen generation from the zirconimum (cladding) metal water reaction being the dominate contributor.

In response, the Owners Group had indicated that while such a combination is unlikely, it is mechanically possible, since dissolved hydrogen is present in the reactor coolant during normal operation. As such, if the intent of this step is to remedy a hydrogen problem during normal operation, then there should be sufficient safeguards to preclude this action from being implemented during a genuine emergency situation. In particular, if conditions are met as described above, the current procedure instructs the operator to vent/purge by defeating isolation interlocks, whether actual isolation signals are present.

In the staff's view, the BWROG should provide additional clarification to reduce the perceived level of operator flexibility (e.g., through Appendix B to the EPGs). Therefore, the staff finds that operators should have guidance when conditions dictate removal of hydrogen during normal reactor operation.

3. Also, it is indicated in Appendix B that the CAD system should not be used to repressurize the containment. This approach is contrary to some BWR's licensing bases which requires containment repressurization during a postulated hydrogen generation event. Therefore, BWR plants that employ the CAD system as part of a hydrogen mitigation scheme would need to implement additional plant specific procedures consistent with its safety analysis or provide the staff with additional information to justify such deviations.

We find the guidelines to be acceptable. Implementation of procedures based on the guidelines may proceed before these concerns are corrected. However, each BWR licensee should verify if the EPGs are consistent wiht its licensing based analysis. That is, BWR plants should implement appropriate plant specific procedures consistent with its safety analysis or provide the staff with additional information to remedy such deviations.

The BWR Owners should complete the development of the guidelines and maintain the guidelines after development is complete. The development of the guidelines may be considered complete after comprehensive severe accident guidelines are submitted to NRC. Maintenance would include incorporation of operating experience and new knowledge into the guidelines and modification of the guidelines to account for new equipment.

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APPENDIX-A

This Safety Evaluation Report is a product of the NRC Staff. The NRC staff members listed below were principal contributors to this report.

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EPG ABBREVIATIONS

ADS	-	Automatic Depressurization System
APRM	-	Average Power Range Monitor
ARI	-	Alternate Rod Insertion
ATWS	-	Anticipated Transient Without Scram
CRD	-	Control Rod Drive
ECCS	-	Emergency Core Cooling System
HPCI	-	High Pressure Coolant Injection
HPCS	-	High Pressure Core Spray
HSBW	-	Hot Shutdown Boron Weight
HVAC	-	Heating Ventilating and Air Conditioning
IC	-	Isolating Condenser
LCO	-	Limiting Condition for Operation
LPCI	-	Low Pressure Coolant Injection
LPCS	-	Low Pressure Core Spray
MSCWL	-	Minimum Steam Cooling Water Level
MSIV	-	Main Steamline Isolation Valves
NPSH	-	Net Positive Suction Head
RCIC	-	Reactor Core Isolation Cooling
RHR	-	Residual Heat Removal
RPS	-	Reactor Protection System
RPV	-	Reactor Pressure Vessel
RSCS	-	Rod Sequence Control System
RWCU	-	Reactor Water Cleanup
RWM	-	Rod Worth Minimizer
SBGT	-	Standby Gas Treatment
SBLOCA	-	Small Break Loss of Coolant Accident
SLC	-	Standby Liquid Control
SPMS	-	Suppression Pool Makeup System
SRV	-	Safety Relief Valve
TAF	-	Top of Active Fuel

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APPENDIX-C

Definitions

1. BORON INJECTION INITIATION TEMPERATURE

The Boron Injection Initiation Temperature is defined to be the greater of either (1) the suppression pool temperature at which a reactor scram is required by plant Technical Specifications or (2) the highest suppression pool temperature at which initiation of boron injection will result in injection of the Hot Shutdown Boron Weight before suppression pool temperature exceeds the Heat Capacity Temperature Limit. The Boron Injection Initiation Temperature is a function of reactor power, and it is utilized in establishing the conditions before which boron injection must be initiated if RPV depressurization with the reactor at power is to be precluded.

2. COLD SHUTDOWN BORON WEIGHT

The Cold Shutdown Boron Weight is defined to be the least weight of soluble boron which, if injected into the RPV and mixed uniformly, will maintain the reactor shut down under all conditions. This Weight is utilized to assure the reactor will remain shut down irrespective of control rod position or RPV water temperature.

3. DRYWELL SPRAY INITIATION LIMIT

The Drywell Spray Initiation Limit is defined to be the highest drywell temperature at which initiation of drywell sprays will not result in an evaporative cooling pressure drop to below either (1) the drywell-below-wetwell differential pressure capability or (2) the high drywell pressure scram setpoint. This temperature is a function of drywell pressure, and the Limit is utilized to preclude containment failure or de-inertion following initiation of drywell sprays.

4. HEAT CAPACITY LEVEL LIMIT

The Heat Capacity Level Limit is defined to be the higher of either (1) the elevation of the Mark I/II downcomer openings or (2) two feet above the elevation of the top of the Mark III horizontal vents or (3) the lowest suppression pool water level at which initiation of RPV depressurization will not result in exceeding the Heat Capacity Temperature Limit. This water level is a function of the margin to the Heat Capacity Temperature Limit, and the Level Limit is utilized in conjunction with the Temperature Limit to preclude failure of the containment or equipment necessary for the safe shut down of the plant and to preclude loss of the pressure suppression function of the containment.

5. HEAT CAPACITY TEMPERATURE LIMIT

The Heat Capacity Temperature Limit is defined to be the highest suppression pool temperature at which initiation of RPV depressurization will not result in exceeding either (1) the suppression chamber design temperature or (2) the Primary Containment Pressure Limit before the rate of energy transfer from the RPV to the containment is within the capacity of the containment vent. This temperature is a function of RPV pressure, and the Limit is utilized to preclude failure of the containment or equipment necessary for the safe shut down of the plant.

6. HOT SHUTDOWN BORON WEIGHT

The Hot Shutdown Boron Weight is defined to be the least weight of soluble boron which, if injected into the RPV and mixed uniformly, will maintain the reactor shut down under hot standby conditions. This Weight is utilized to assure the reactor will be shut down irrespective of control rod position when RPV water level is raised to uniformly mix the injected boron.

7. MARK III CONTAINMENT SPRAY INITIATION PRESSURE LIMIT

The Mark III Containment Spray Initiation Pressure Limit is defined to be the greater of either (1) the high drywell pressure scram setpoint or (2) the lowest containment pressure at which initiation of containment sprays will not result in an evaporative cooling pressure drop to below atmospheric pressure. This Limit is utilized to preclude containment failure following initiation of containment sprays.

8. MAXIMUM CORE UNCOVERY TIME LIMIT

The Maximum Core Uncovery Time Limit is defined to be the greatest amount of time the reactor core can remain completely uncovered and uncooled without resulting in a peak clad temperature in excess of 1500°F. This amount of time is a function of the time after reactor shut down, and the Limit is utilized to preclude fuel damage during recovery from the RPV flooding evolution.

9. MAXIMUM PRIMARY CONTAINMENT WATER LEVEL LIMIT

The Maximum Primary Containment Water Level Limit is defined to be the lesser of either (1) the elevation of the highest containment vent capable of rejecting all decay heat or (2) the highest containment water level which will not result in exceeding the pressure capability of the containment. The water level is a function of suppression chamber pressure and temperature, and the Limit is utilized to preclude containment failure.

10. MAXIMUM RUN TEMPERATURE

The Maximum Run Temperature is defined to be the lowest RPV water level instrument run temperature at which the instrument will indicate RPV water level at the bottom of the instrument scale when RPV water level is actually at the elevation of the instrument variable leg tap. This Temperature is utilized in establishing the conditions under which an RPV water level instrument may be used to determine RPV water level. Separate Temperatures are provided for each RPV water level instrument.

11. MAXIMUM SAFE OPERATING RADIATION LEVEL

The Maximum Safe Operating Radiation Level is defined to be the highest radiation level at which neither (1) equipment necessary for the safe shut down of the plant will fail nor (2) personnel access necessary for the safe shut down of the plant will be precluded. This Radiation Level is utilized in establishing the conditions under which RPV depressurization is required. Separate Radiation Levels are provided for each secondary containment area.

12. MAXIMUM SAFE OPERATING TEMPERATURE

The Maximum Safe Operating Temperature is defined to be the highest temperature at which neither (1) equipment necessary for the safe shut down of the plant will fail nor (2) personnel access necessary for the safe shut down of the plant will be precluded. This Temperature is utilized in establishing the conditions under which RPV depressurization is required. Separate Temperatures are provided for each secondary containment area.

13. MAXIMUM SAFE OPERATING WATER LEVEL

The Maximum Safe Operating Water Level is defined to be the highest water level at which neither (1) equipment necessary for the safe shut down of the plant will fail nor (2) personnel access necessary for the safe shut down of the plant will be precluded. This Water Level is utilized in establishing the conditions under which RPV depressurization is required. Separate Water Levels are provided for each secondary containment area.

14. MAXIMUM SUBCRITICAL BANKED WITHDRAWAL POSITION

The Maximum Subcritical Banked Withdrawal Position is defined to be the lowest control rod position to which all controls rods may be withdrawn in bank and the reactors will nonetheless remain shut down under all conditions. This Position is utilized to assure the reactor will remain shut down irrespective of RPV water temperature.

15. MINIMUM ALTERNATE RPV FLOODING PRESSURE

The Minimum Alternate RPV Flooding Pressure is defined to be the lowest RPV pressure at which steam flow through open SRVs is sufficient to preclude any clad temperature from exceeding 1500°F even if the reactor core is not completely covered. This Pressure is a function of the number of open SRVs, and it is utilized to preclude fuel damage during the RPV flooding evolution when the reactor may not be shut down.

16. MINIMUM CORE FLOODING INTERVAL

The Minimum Core Flooding Interval is defined to be the greatest amount of time required to flood the RPV to the top of the active fuel with RPV pressure at the Minimum RPV Flooding Pressure and at least the Minimum Number of SRVs Required for Emergency Depressurization open. This Interval is a function of the number of SRVs which are actually open, and it is utilized to assure the reactor core has been covered before recovery from the RPV flooding evolution is initiated.

17. MINIMUM INDICATED LEVEL

The Minimum Indicated Level is defined to be the highest RPV water level instrument indication which results from off-calibration instrument run temperature conditions when RPV water level is actually at the elevation of the instrument variable leg tap. This level is utilized in establishing the conditions under which an RPV water level instrument may be used to determine RPV water level. Separate levels are provided for each RPV water level instrument.

18. MINIMUM NUMBER OF SRVs REQUIRED FOR EMERGENCY DEPRESSURIZATION

The Minimum Number of SRVs Required for Emergency Depressurization is defined to be the greater of either (1) the least number of SRVs which, if opened, will remove all decay heat from the core at a pressure sufficiently low that the ECCS with the lowest head will be capable of making up the SRV steam flow or (2) the least number of SRVs which correspond to a Minimum Alternate RPV Flooding Pressure sufficiently low that the ECCS with the lowest head will be capable of making up the SRV steam flow at the corresponding Minimum Alternate RPV Flooding Pressure. This Number is utilized to assure the RPV will depressurize and remain depressurized when emergency depressurization is required.

19. MINIMUM RPV FLOODING PRESSURE

The Minimum RPV Flooding Pressure is defined to be the greater of either (1) the Minimum SRV Re-opening Pressure or (2) the lowest differential pressure between the RPV and the suppression chamber at which steam flow through the Minimum Number of SRVs Required for Emergency Depressurization is sufficient to remove all decay heat from the core. This Pressure is utilized to assure sufficient liquid injection into the RPV to maintain SRVs open and to flood the RPV to the elevation of the main steam lines during the RPV flooding evolution when the reactor is shut down.

20. MINIMUM SRV RE-OPENING PRESSURE

The Minimum SRV Re-opening Pressure is defined to be the lowest RPV pressure at which an SRV will fully open and remain fully opened when its control switch is placed in the OPEN position. This Pressure is utilized to preclude SRV cycling during the RPV flooding evolution.

21. MINIMUM STEAM COOLING RPV WATER LEVEL

The Minimum Steam Cooling RPV Water Level is defined to be the lowest RPV water level at which the covered portion of the reactor core will generate sufficient steam to preclude any clad temperature in the uncovered portion of the core from exceeding 1500°F. This Water Level is utilized to preclude fuel damage when RPV water level is lowered to below the top of the active fuel.

22. MINIMUM ZERO-INJECTION RPV WATER LEVEL

The Minimum Zero-Injection RPV Water Level is defined to be the lowest RPV water level at which the covered portion of the reactor core will generate sufficient steam to preclude any clad temperature in the uncovered portion of the core from exceeding 1800°F. This Water Level is utilized to preclude significant fuel damage and hydrogen generation for as long as possible.

23. NPSH LIMIT

The NPSH (Net Positive Suction Head) Limit is defined to be the highest suppression pool temperature which provides adequate net positive suction head for an ECCS pump taking suction on the pool. This temperature is a function of ECCS pump flow and suppression chamber overpressure (airspace pressure plus hydrostatic head over the ECCS suction), and the Limit is utilized to preclude ECCS damage due to cavitation. Separate limits are provided for each ECCS, as appropriate.

24. PRESSURE SUPPRESSION PRESSURE

The Pressure Suppression Pressure is defined to be the lesser of either (1) the highest suppression chamber pressure which can occur without steam in the suppression chamber airspace or (2) the highest suppression chamber pressure at which initiation of RPV depressurization will not result in exceeding the Primary Containment Pressure Limit before RPV pressure drops to the Minimum RPV Flooding Pressure or (3) the highest suppression chamber pressure which can be maintained without exceeding the suppression pool boundary design load if SRVs are opened. This Pressure is a function of primary containment water level, and it is utilized to assure the pressure suppression function of the containment is maintained while the RPV is at pressure.

25. PRIMARY CONTAINMENT PRESSURE LIMIT

The Primary Containment Pressure Limit is defined to be the lesser of either (1) the pressure capability of the containment or (2) the maximum containment pressure at which vent valves can be opened and closed to reject all decay heat from the containment or (3) the maximum containment pressure at which SRVs can be opened and will remain opened or (4) the maximum containment pressure at which vent valves can be opened and closed to vent the RPV. This pressure is a function of primary containment water level and temperature, and the Limit is utilized to preclude containment failure and core damage.

26. SRV TAIL PIPE LEVEL LIMIT

The SRV Tail Pipe Level Limit is defined to be the highest suppression pool water level at which opening an SRV will not result in exceeding the capability of the SRV tail pipe, tail pipe supports, quencher, or quencher supports. This water level is a function of RPV pressure, and the Limit is utilized to preclude SRV system damage and containment failure.

27. SUPPRESSION CHAMBER SPRAY INITIATION PRESSURE

The Suppression Chamber Spray Initiation Pressure is defined to be the lowest suppression chamber pressure which can occur when 95 percent of the noncondensibles in the drywell have been transferred to the suppression chamber. This Pressure is utilized to preclude chugging.

28. VORTEX LIMIT

The Vortex Limit is defined to be the lowest suppression pool water level above which air entrainment is not expected to occur in an ECCS taking suction on the pool. This suppression pool water level is a function of ECCS flow, and the Limit is utilized to preclude ECCS damage due to air entrainment. Separate limits are provided for each ECCS suction or suction header, as appropriate.