Enclosure 2

LETTER REPORT

Preliminary Review of Owners Group Severe Accident Management Guidelines

Idaho National Engineering Laboratory

D. A. Brownson
D. J. Hanson
S. C. Johnson
L. W. Ward

Pacific Northwest Laboratory

J. Bumgardner
J. S. Dukelow, Jr.
K. Erickson
G. Vargo

COMEX

G. W. Bethke

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SUMMARY

A preliminary review of the severe accident management guidelines (SAMGs) developed by the three pressurized water reactor vendor owners groups; Babcock & Wilcox (B&W), ABB-Combustion Engineering (CE), and Westinghouse (W) has been performed and the results are documented in this report. Personnel from the Idaho National Engineering Laboratory, Pacific Northwest Laboratory (PNL), and PNL's subcontractor COMEX conducted this review for the Nuclear Regulatory Commission's (NRC) Office of Reactor Research and Office of Nuclear Reactor Regulation. Information for the review came from (1) review of an initial CE SAMG by PNL and COMEX, which was presented on April 22, 1993, (2) the SAMG submittals from each owners group made in June and July 1993, and (3) additional information from a meeting with the owners group representatives on November 16 and 17, 1993.

The objective of our preliminary review was to examine the three SAMGs to determine whether applicable framework elements from the NRC SECY-89-012 letter on Accident Management Plans are adequately addressed, to identify possible conflicts between strategies and guidance in the SAMGs and the current emergency operating and emergency plan procedures, and to identify possible inconsistencies between the SAMG strategies and the current severe accident progression knowledge and understanding.

The SAMGs provided by the B&W, CE, and W owners groups are a major step forward in providing guidance to utilities for managing severe accidents. The owners groups obviously committed major resources in the development of these SAMGs. However, given the guidance provided by the Nuclear Management and Resources Council and the Electric Power Research Institute, the reviewers were surprised by the widely divergent approaches used by the three owners groups. Westinghouse took an entirely symptomatic approach to accident management whereas B&W and CE took a plant damage condition (PDC) determination approach. Where B&W chose to employ separate sets of accident management actions for each reactor coolant system and containment PDC, the CE approach was to link the reactor coolant system and containment in their PDCs and provide accident management actions for each combined condition.

All SAMG approaches were judged to be viable if numerous changes were made to the B&W owners group SAMGs, some changes to the CE owners group SAMGs, and a few changes to the W owners group SAMGs. Although all three owners group's SAMGs are believed to be workable, their large size could make their use difficult under severe accident conditions and pressures. In addition, the reviewers believe that some owners groups could realize a possible benefit by examining other owners group's approaches for resolving indicated problem areas in their SAMGs.

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LIST OF ACRONYMS AND ABBREVIATIONS

B&W	-	Babcock & Wilcox
CE	-	Combustion Engineering
CET	-	Core Exit Thermocouple
CH	-	Containment is challenged
CHLA	-	Candidate High Level Action
CO	-	Carbon Monoxide
CO_2	-	Carbon Dioxide
EOP	-	Emergency Operating Procedures
EPIP	-	Emergency Plan Implementation Procedures
EPRI	-	Electric Power Research Institute
EX	-	Core is ex-vessel
GSAG	-	Generic Severe Accident Guideline
GSAGTBD	-	Generic Severe Accident Guideline Technical Basis Document
H_2	-	Hydrogen
IPE	-	Individual Plant Examination
NRC	-	Nuclear Regulatory Commission
NUMARC	-	Nuclear Management and Resource Council
OX/BD	-	Core is heavily oxidized and/or badly damaged
PDC	-	Plant Damage Condition
PNL	-	Pacific Northwest Laboratory
PWR	-	Pressurized Water Reactor
RB	-	Reactor Building
RB UPC	-	Reactor Building Ultimate Pressure Capability
RCS	-	Reactor Coolant System
SAMG	-	Severe Accident Management Guidelines
TBD	-	Technical Basis Document
TSC	-	Technical Support Center
W	-	Westinghouse
W_{vapor}	-	Vapor generation flow rate

1. INTRODUCTION

A preliminary review of the severe accident management guidelines (SAMGs) developed by the three pressurized water reactor (PWR) vendor owners groups; Babcock & Wilcox (B&W), ABB-Combustion Engineering (CE), and Westinghouse (W) has been performed and the results are documented in this report. Personnel from the Idaho National Engineering Laboratory, Pacific Northwest Laboratory (PNL), and PNL's subcontractor COMEX conducted this review for the Nuclear Regulatory Commission's (NRC) Office of Reactor Research and Office of Nuclear Reactor Regulation. Information for the review came from (1) review of an initial CE SAMG by PNL and COMEX, which was presented on April 22, 1993, (2) the SAMG submittals from each owners group made in June and July 1993, and (3) additional information from a meeting with the owners group representatives on November 16 and 17, 1993.

The objective of our preliminary review was to examine the three SAMGs to determine whether applicable framework elements from Reference 1 are adequately addressed, to identify possible conflicts between strategies and guidance in the SAMGs and the current emergency operation procedures (EOPs) and emergency plan implementation procedures (EPIPs), and to identify possible inconsistencies between the SAMG strategies and the current severe accident progression knowledge and understanding.

The expertise of the personnel who performed these reviews was varied and included:

- Reactor Operations
- Reactor Operator Examiners
- Severe Accident Phenomena
- Instrumentation
- Human Factors
- Emergency Operating Procedure Reviewers
- Emergency Planning
- Emergency Drills

Although each vendor owners group refers to its set of guidelines by different names, this report will generically refer to them as SAMGs. Similarly, the documents providing the technical basis for the SAMGs will be generically referred to as Technical Basis Documents (TBDs).

Section 2 of this report discusses the review criteria used to evaluate the owners group SAMGs. Comments about areas that were determined to need improvement are presented in Section 3 and comments about areas that would benefit from suggested improvements are presented in Section 4. Section 5 and 6 present the report conclusions and references, respectively. Appendices A through C contain information used to develop review criteria.

2. REVIEW CRITERIA

The following criteria were used in the review of the owners group SAMGs. Criteria were developed from NRC guidance on severe accident management, References 2 and 3, generally accepted operating practices, and findings from plant reviews of EOPs and emergency plans. Reference 2 is found in its entirety in Appendix B and pertinent pages from Reference 3 are found in Appendix C.

- The following accident management framework elements outlined in SECY-89-012 (Reference 1) should be addressed and should be used to develop and implement accident management plans for use in the control room or the technical support center.

  - Accident management strategies
  - Instrumentation
  - Guidance and computational aids
  - Decision making

  (recognizing that training will be addressed by the Institute for Nuclear Power Operations).

- The SAMGs should generally meet the intent of the criteria for accident management plans outlined in NUREG/CR-6009 for the following:

  - Information needed to understand plant capabilities
  - Adequacy of the proposed set of severe accident strategies
  - Development and implementation of procedures and guidance
  - Identification of available and alternate systems and equipment
  - Identification of available and alternate instrumentation
  - Guidance on validation and verification
  - Description of how new information will be incorporated

- There should be minimal conflicts between the SAMGs and the current EOPs.

- The strategies described should be consistent with the current knowledge and understanding of severe accident progression and phenomenological behavior.

- An adequate method for identifying and prioritizing strategies should be provided.

- Calculation aids should be adequately described and should be easy to use.

- SAMGs should incorporate lessons learned from EOP reviews, emergency plan reviews, and plant drills.

Based on the findings from the application of these criteria, comments have been grouped into seven different areas. These areas were chosen to categorize and coordinate similar comments. Criteria for which there were no comments are not discussed in any of the areas.

1. General Adequacy

This area includes comments related to validation and verification of the SAMGs and incorporation of relevant new information into the SAMGs.

2. Transition

This area includes comments on implementing severe accident guidance and minimizing conflicts during the transition from EOPs to the SAMGs and during the transfer of decision-making authority from the control room to the technical support center (TSC).

3. PDC Determination and CHLA Prioritization

This area includes comments on the accurate and timely identification of a plant damage condition (PDC) and the prioritization method for choosing candidate high level actions (CHLAs). They both are related to strategy identification and prioritization.

4. Strategies

This area includes comments related to the adequacy of the proposed set of severe accident strategies and whether these strategies are consistent with the current knowledge and understanding of severe accident progression and phenomenological behavior.

5. Equipment and Instrumentation

Comments on the identification of available and alternative systems and equipment and on the identification of instrumentation capabilities and their availability and alternatives are included in this area.

6. Calculation Aids

This area contains comments on the usefulness and adequacy of the calculation aids considering their objective, inputs, assumptions, and possible limitations.

7. Implementation Instructions

This area includes comments related to the guidance provided by the owners groups to the utilities for the development and implementation of plant specific accident management plans and the development of detailed procedures for carrying out the CHLAs. Lessons learned from EOP reviews, emergency plan reviews, and plant drills played an important role in developing these comments.

Comments generated in each of the seven evaluation areas were placed in two rating categories: (1) areas needing improvement; and (2) areas that would benefit from suggested improvements. The criteria for determining whether an area needed improvement were:

- The guidance is insufficient to ensure proper implementation of the SAMGs by individual utilities.
- Strategies for significant actions are lacking.
- If the guidelines are followed, the plant condition could be further degraded.

The criteria for determining whether an area would benefit from suggested improvements were:

- The suggested improvements are similar to "Improvement Items" in NRC inspection reports.
- The improvement would increase the quality of the area (based on reviewer experience).
- The problem with an area is not perceived to be a critical flaw.

3. NEEDED SAMG MODIFICATIONS

The following sections identify comments on those areas needing improvement in the owners group's SAMGs and provide details on why the reviewers believe these areas need improvement. References are provided for some of these areas to further support this rating. Table 1 summarizes the number of areas needing improvement for each of the owners group's SAMGs in each of the seven evaluation areas.

Table 1. Number of needed improvements for owners group's severe accident management guidelines.

Evaluation Area	Number of Needed Improvements		
	B&W	CE	W
General Adequacy	2	2	1
Transition	2	1	0
PDC Determination and CHLA Prioritization	3	0	0
Strategies	3	2	0
Equipment and Instrumentation	2	2	0
Calculation Aids	1	1	0
Implementation Instructions	2	1	1
TOTAL	15	9	2

3.1 General Adequacy

The following two comments identify areas needing improvement for the SAMGs general adequacy:

1. A description of the B&W and CE owners group's validation and verification activities for their SAMGs needs to be provided to ensure that all parts of the guidelines work together to provide the desired level of accident management capability and to provide the utilities with confidence that they are receiving workable guidance. In addition, these owners groups need to provide guidance to the utilities on the validation and verification of their plant specific accident management plans. This requirement is discussed in Reference 2, Section 5.3.6, page 4 and Reference 3, Section 4.3, Item 1, page 61.

2. All owners groups need to describe how new information from the individual plant examinations (IPE), the owners groups, and the NRC will be periodically evaluated and incorporated into the SAMGs. The SAMGs need to be treated as a living document, requiring corrections and modifications as new information becomes available. The evaluation and incorporation of new information should occur at the owners group level to ensure that all utilities are aware of impacts and modifications to SAMGs. Otherwise there is the potential that new information will not be evaluated by individual utilities. This requirement is discussed in Reference 2, Section 5.2, fourth bullet, page 2 and Reference 3, Section 4.3, Item 2, page 61.

3.2 Transition

The following three areas were identified as needing improvement in the SAMGs transition from EOPs to SAMGs and the transition of decision-making authority from the control room to the TSC:

1. The CE owners group does not provide concise SAMG entry conditions. The decision to enter the SAMGs is left to the discretion of the emergency site director based on tracking a number of plant parameters. There could be delays in the entry to the SAMGs due to emergency site director's high work load and possibility of indecision. To avoid delay in implementing necessary actions, entry into SAMGs needs to be based on set points for measured parameter(s), such as core exit thermocouple (CET) temperature, reactor vessel level indicator system, etc.

2. The B&W SAMGs need to provide guidance to the control room operators on their role or actions if severe core damage conditions occur prior to the staffing and activation of the TSC. At the time entry into the SAMGs is made, the EOPs are closed. No guidance is provided to control room personnel as to what activities they should be performing while awaiting direction from the TSC. Control room personnel could be instructed to continue EOP actions initiated prior to entry into the SAMGs, monitor key plant parameters and report trends to the TSC, or both.

3. There is inadequate guidance in the B&W SAMGs to the control room after decision-making responsibilities have been transferred to the TSC. Additional guidance needs to be provided to ensure that control room personnel have a clear description of their role, which will foster operator trust, cooperation, and response. Because the control room operators must be an integral part of implementing any actions specified by the TSC, the operators must be provided some form of guidance once EOPs are dropped. This requirement is discussed in Reference 3, Section 4.2, Item 5, page 60.

3.3 PDC Determination and CHLA Prioritization

The following three areas were identified as needing improvement in the determination of the PDC and CHLA prioritization:

1. The PDC determination criteria of the B&W SAMGs is embedded in the PDC sections. This requires a simultaneous review of all PDC sections to determine the correct PDC, which could be a prolonged process unless the TSC staff has extensive training on the PDC states. Quick PDC determination is needed to prevent excessive delays in implementing effective CHLA actions. It would be simpler if the criteria needed to determine PDC was added as the initial step in the SAMGs. This requirement is discussed in Reference 2, Section 5.3.1, second paragraph, item 1, page 5.

2. The B&W CHLAs are pre-prioritized for SAMG implementation. However, there is no quantitative information at the beginning of the CHLA to allow the TSC to determine whether this CHLA needs to be entered. For example, if the reactor building (RB) pressure is less than 80% reactor building ultimate pressure capability (RB UPC), containment venting may not be a high priority. Although the B&W owners groups states that all CHLAs will be open concurrently for a given PDC, quantitative CHLA entry conditions will allow the TSC to focus on more urgent actions. This requirement is discussed in Reference 2, Section 5.3.1, second paragraph, item 2, page 5.

3. The B&W SAMGs state that successful CHLA actions are to be continued without quantitatively defining the success criteria. In addition, the SAMGs do not instruct that CHLA actions are to be terminated if certain adverse conditions result. Quantitative criteria for the continuation or termination of CHLA actions needs to be added to the CHLAs. This requirement is discussed in Reference 2, Section 5.3.1, second paragraph, item 3, page 5.

3.4 Strategies

The following three areas were identified as needing improvement in the determination of PDCs and CHLA prioritization:

1. The B&W and CE CHLA sets are judged to be incomplete based on IPE results for a range of PWRs. B&W needs to incorporate strategies for containment hydrogen control, auxiliary building spray, and containment vacuum mitigation or provide a discussion in their TBD explaining the basis for their absence. Although the B&W owners group claims that hydrogen control and use of recombiners is addressed in the typical facilities emergency plans, based on the reviewer's familiarity with all U.S. operating reactor's emergency plans, hydrogen control is not covered in the emergency plans. Hydrogen control may be covered in EOPs, but these are closed in the B&W SAMGs. CE needs to incorporate a strategy for containment vacuum mitigation or provide a discussion in their TBD explaining the basis for its absence.

2. More specific CHLA cross references and guidance for performing concurrent actions need to be made by the B&W and CE owners groups. For example, the need to depressurize the reactor

coolant system (RCS) before injecting should be based on the shut-off head of available/alternative injection sources.

3. Some B&W strategies appear to be questionable in that they may result in either a delay in implementing more urgent actions or they may have adverse consequences that are not discussed. Questionable strategies need to be eliminated, corrected, or a discussion of possible adverse consequences should be included. Taken individually, modifications to these strategies may not be considered necessary, but considered collectively, there is sufficient concern to warrant needed correction.

   a. ADDING NITROGEN TO CORE FLOOD TANKS TO INCREASE INJECTION FLOW RATES

   GSAG, III.A (OX/BD)-6 suggests adding nitrogen to core flood tanks, but does not provide guidance (e.g., applicable only at pressures > ? 600 psig) or cautions (e.g., manual isolation should be implemented when core flood tanks are empty to avoid injection of nitrogen into RCS). This strategy is not discussed in the Technical Basis Document.

   b. STOPPING CONTAINMENT SPRAY ON RB PRESSURE INCREASE

   GSAGTBD, III.G (EX)-17 states, "If RB pressure reaches 80% of the RB UPC, then spray flow should be terminated". It is unlikely that spray will cause a significant pressure increase and there is no discussion of the spray conditions that would cause a pressure increase. In addition, the strategy says nothing about commencing venting while continuing to spray to reduce the reactor building pressure. Stopping spray entirely would likely accelerate the reactor building pressure increase and result in an earlier reactor building failure.

   c. LIMITING RCS INJECTION TO W_{vapor}

   GSAG, III.A (OX/BD)-5 and -6 (3.2) limits RCS injection to W_{vapor} (for unborated or high enthalpy sources) except in the case of an anticipated transient without scram or a large break loss-of-coolant accident. In addition, GSAGTBD, III.C-2 states that injection at a rate equal to W_{vapor} will re-flood the core. The calculation of W_{vapor} uses only energy addition from decay heat. If stored energy and energy from metal-water reaction is accounted for, the time required to cool the core would be very long. A lengthy reflood time would likely result in extensive core damage and the formation of debris beds may make core cooling much more difficult. Limiting injection to W_{vap} should not be recommended unless cautions are included to indicate that extensive core damage is possible at this flow rate.

   d. STEAMING VIA ATMOSPHERIC DUMP VALVES WHEN TURBINE BYPASS VALVES ARE AVAILABLE

   GSAG, III.A (OX/BD)-18 (3.6.3) does not differentiate between steaming via the atmospheric dump valves and the turbine bypass

valves if the condenser is available as a heat sink. Additional fission product scrubbing may be available by steaming through the condenser. The use and prioritization of the turbine bypass valves should be considered and discussed.

e. ADDITION OF RADIOACTIVE STEAM TO CONTAINMENT TO SCRUB FISSION PRODUCTS

GSAG, III.A (OX/BD)-23 (3.12.1) "Bump RCPs [reactor coolant pumps]" states that "addition of steam to the RB is expected to remove FPs [fission products] from the RB atmosphere". This is misleading, as it suggests that adding more radioactive steam (which was the original source of the RB fission products) will somehow scrub those very same fission products. This statement should be discussed further or it should be eliminated.

f. ADDITION OF RADIOACTIVE STEAM TO CONTAINMENT FOR HYDROGEN INERTING

GSAGTBD, III.I (CH)-15 (version dated 12/1/93) states that "if the partial pressure of steam in the RB can be maintained > ~53%, combustion of H_2 can be prevented". The top of page 16 suggests several strategies for keeping RB steam concentration high. This section of the TBD fails to acknowledge that containment will eventually de-inert through losses to ambient, and that the hydrogen must be dealt with either through venting or recombiners.

g. MONITORING FOR CO AND CO2 IN CONTAINMENT

GSAG, III.B (EX)-1 lists the presence of CO and CO_2 as symptoms of the EX PDC during core-concrete interaction but fails to recognize that these gases are not normally monitored and fails to provide guidance as to whether these monitoring capabilities should be developed. The implementation of these capabilities would likely be difficult and extensive time to sample and evaluate samples would likely be required in order to make judgement of PDC. The reviewers consider the development of such capabilities a second order concern for the implementation of the SAMGs.

h. LIMITING RCS INJECTION ON POWER OPERATED RELIEF VALVE CAPACITY VERSUS RCS PRESSURE

GSAGTBD, III.F (OX/BD)-20 (version dated 12/1/93) discusses limiting injection flow to 80% of the power operated relief valve/safety relief valve design flow. This approach does not account for the likely case where there are other escape paths for the injected water, e.g., a leak or break. It would be more prudent to throttle or control injection based on an observed RCS pressure, thus taking into account flow through all escape paths.

i. TERMINATING RCS INJECTION AT 80% RB UPC VERSUS LIMITING AND REDUCING CONTAINMENT PRESSURE (E.G., VIA VENTING)

GSAGTBD, III.F (OX/BD)-22 (version dated 12/1/93) provides this guidance. The TBD does not discuss the more prudent course of reducing (versus terminating) injection and performing the necessary alignments to vent the RB.

j. NOT FEEDING STEAM GENERATORS IF MAIN FEEDWATER NOZZLES ARE COVERED

GSAGTBD, III.F (OX/BD)-40 states "if the level in the SGs [steam generators] is high enough to cover the MFW [main feedwater] nozzles, then no condensation will take place and this method will be ineffective". This section is not clear on what "condensation" (primary or secondary?) is being considered. Supplying main feedwater will condense steam on the RCS side of the steam generator tubes for a wide range of RCS pressures and will wet the tubes to decrease the chances of creep failure.

k. BELIEF THAT WATER CAN FLOOD OUTSIDE OF REACTOR VESSEL LOWER HEAD VIA SMALL HOLES IN MIRROR INSULATION

GSAGTBD, III.F (OX/BD)-65 through -68 (3.13.2.2.1) discusses flooding the reactor pressure vessel cavity via relatively small holes in cavity walls and wetting the outer reactor vessel wall through small gaps in the mirror insulation. The strategy fails to acknowledge that backpressure within the mirror insulation created by flashing would slow or preclude further water from contacting the outer reactor vessel wall. The figure on page 68 showing the entrapment of vapor in the elevation difference between the reactor vessel skirt and the reactor vessel cavity penetrations does not include effects within the mirror insulation. In fact, the mirror insulation is altogether absent from this diagram. The possible backpressure effects within the mirror insulation need to be discussed.

l. BELIEF THAT EX-CORE STEAM GENERATION DURING RB SPRAY WILL OVERWHELM CONDENSATION FROM REST OF SPRAY AND THAT SOLUTION IS TO LIMIT SPRAY FLOW

GSAGTBD, III.G (EX)-15 (CHLA-1) states, "if RB pressure is high, then it may be desirable to limit spray flow rate, thus limiting steam generation rate". This concept seems to ignore the steam condensing benefits of the higher (excess) RB spray flows. If spray is not adequate to control the RB pressure, venting may be the only alternative. Failure to remove heat through the spray system would only allow additional energy to remain in the containment. Guidance should be provided in this section to consider containment venting if RB pressure is high.

m. DEPRESSURIZING THE RCS VIA POWER OPERATED RELIEF VALVES AND HIGH POINT LOOP VENTS WHEN RB IS CHALLENGED

GSAG, III.D (CH)-1 (3.13.1) under a challenged containment condition, depressurization via discharge paths which are internal to containment is recommended. Since high pressure is

the primary symptom of the CH PDC, depressurizing the RCS into the RB seems to defy conventional logic.

n. HINTS AT CLASSIC BOILING WATER REACTOR LEVEL-POWER CONTROL FOR PWRs, BUT NO DETAILS

GSAG, III.A (OX/BD)-7 hints at a strategy similar to the boiling water reactor "Level-Power Control Strategy", but the technique is not formalized with guidance on reactor vessel level, power, pressure, etc. This technique could not be found (and was not discussed) in the related GSAGTBD. Since adequate reactivity control through level manipulation is difficult at best, cautions should be provided and direction given that extensive analysis would be required to use level to control power.

3.5 Equipment and Instrumentation

The following two areas were identified as needing improvement in the identification and prioritization of necessary equipment and instrumentation:

1. A generic prioritization of equipment for repair and recovery and guidance for plant specific concerns for equipment operability during severe accidents is needed in the B&W and CE SAMGs. Equipment availability is key to CHLA prioritization and the development of TSC direction and guidance. Better guidance in the SAMG will ensure that utilities benefit from creative ideas on the use of equipment. This requirement is discussed in Reference 2, Section 5.3.1, third paragraph, page 3.

2. The plant instrumentation is the only means that plant personnel have to understand plant conditions and the effectiveness of CHLA actions. Since the instrumentation behavior may be altered by severe accident conditions, the reliability and accuracy of instrumentation under severe accident conditions needs to be discussed in the B&W and CE SAMGs (e.g., adverse containment conditions). Alternative instrumentation also needs to be identified and its use in PDC determination and CHLA prioritization discussed. This will help utility personnel understand how plant conditions may be determined if their primary instruments fail. This requirement is discussed in Reference 2, Section 5.3.4, page 3 and Reference 3, Section 4.2, Item 4, pages 59 and 60.

3.6 Calculation Aids

The following area was identified as needing improvement in the calculation aids:

1. Key inputs, assumptions and limitations for each calculation aid need to be clearly identified in the B&W and CE SAMGs so the applicability and limitation of the aid to the plant conditions can be determined (e.g., uniform mixing of hydrogen in containment assumed for hydrogen concentration calculation aid). The applicability of example graphs in the SAMGs should be

discussed. The identification is necessary to ensure that utilities understand the limitations of the aids so they will not be misused or misinterpreted.

3.7 Implementation Instructions

1. There is no guidance from all three owners group SAMGs for developing CHLA implementation procedures. Guidance needs to be developed as to how CHLA actions need to be translated into procedures for use by the control room (e.g., valve alignments, bypasses, and interlock defeats by jumpering). Guidance needs to be developed to ensure utilities identify special use hardware for manufacture and pre-staging (e.g., jumper cables, spool pieces, and blank flanges). Identification of the need for procedures and equipment is necessary to ensure the timely and accurate implementation of the CHLA actions. This is necessary, because all utilities do not have the same expertise and knowledge which may cause procedures to be incorporated incorrectly or omitted altogether. The reviewer's experience with annual emergency plan exercises indicates that TSCs at utilities with methods for producing procedures "on-the-fly" never get to the point of being able to accomplish mitigation actions because of a lack of detailed procedures, tools, and parts. This requirement is discussed in Reference 2, Section 5.3.1, third paragraph, page 3 and Reference 3, Section 4.2, Items 2 and 3, pages 58 and 59.

2. No specific details on containment vent paths are provided in the B&W SAMGs. When evaluating the use of containment venting, no guidance is provided for determining the order of preference for available vent pathways. Some PWRs have already installed Post-Accident Containment Vent systems which should be a high preference followed by other creative line-ups.

4. SUGGESTED SAMG MODIFICATIONS

The following sections identify comments on those areas that would benefit from suggested improvements in the owners group's SAMGs. Details have been provided as to why the reviewer's believe these areas will benefit from recommended improvements and, where possible, references are provided. Table 2 summarizes the number of comments for suggested improvements for each of the owners group's SAMGs in each of the seven evaluation areas.

Table 2. Number of suggested improvements for owners group's severe accident management guidelines.

Evaluation Area	Number of Suggested Improvements		
	B&W	CE	W
General Adequacy	1	1	0
Procedural Transition	3	4	0
PDC Determination and CHLA Prioritization	1	3	0
Strategies	10	11	2
Equipment and Instrumentation	2	3	3
Calculational Aids	0	1	0
Implementation Instructions	3	3	1
TOTAL	20	26	6

4.1 General Adequacy

The following comment is suggested to improve the general adequacy of the SAMGs:

1. To increase the clarity of the CHLA actions, it is recommended that the B&W and CE SAMGs provide definitions of the following terms either in the SAMGs or through a reference to the EOPs:
   - Inadequate Core Cooling
   - Primary to Secondary Coupling
   - Recent changes
   - Rapid changes

These terms are subject to a broad range of interpretation that could lead to confusion and/or a delay in taking necessary actions for severe accident mitigation.

4.2 Transition

Five comments were compiled for suggested improvements to the transition from the EOPs to the SAMGs and the transfer of decision-making authority from the control room to the TSC.

1. The entry point for the B&W owners group SAMGs is defined as a fuel cladding temperature of 1800°F, which must be correlated to a CET temperature reading based on RCS pressure. However, no guidance is provided on possible errors in the CETs resulting from differences in water level and the lag time between the fuel rod temperatures and thermocouple temperatures. Additional guidance on CET interpretation would benefit the utilities.

2. The CE owners group should provide additional guidance to the control room operators on their role or actions when severe core damage conditions occur prior to the staffing and activation of the TSC. Although the EOPs are to remain open after entry into the SAMGs is determined to be necessary, there are no provisions for the control room operators to continue or initiate additional actions recommended by the EOPs if the TSC is not operational.

3. It is recommended that the B&W and CE owners groups identify those steps within the EOPs where severe accident conditions may potentially be entered. Cautions should be added to these steps to alert control room operators that entrance into SAMGs may be imminent. Such cautions could prepare the control room for the transfer of decision-making authority to the TSC and alert the TSC to prepare to initiate SAMG actions.

4. Specific control room guidance is recommended for the CE owners group SAMGs during the transition from EOPs to the SAMGs, and after the SAMGs are implemented to enhance coordination between the control room and the TSC. Additional guidance could help ensure that control room personnel know their role. This will foster operator trust, cooperation, and response. However, even with additional guidance, unilateral use of the EOPs by the control room may cause friction.

5. In the CE SAMGs it is stated consideration of "current EAL [emergency activation level]" is one of two factors likely to be used by the emergency site director to determine if a severe accident is in progress and to initiate the SAMGs. However, no specific guidance is provided as to how the EAL is to be used in the decision-making process. Also, it does not appear that the B&W owners group discusses the interface between the SAMGs and the emergency plans, e.g., EPIPs. Both owners groups need to provide specific guidance to interface the SAMGs with a plant's emergency plans and EPIPs. This requirement is discussed in

Reference 2, Section 5.2, first paragraph, second bullet, page 2.

4.3 PDC Determination and CHLA Prioritization

The following three comments were compiled as suggested improvements to the determination of a PDC and the prioritization of the CHLAs.

1. Although quantitative information is used by the CE owners group in PDC determination, the time taken to determine RCS and RB conditions may delay implementation of necessary actions. If possible, guidance should be improved to allow quicker PDC determination to allow more rapid implementation of mitigative actions.

2. It may be difficult to distinguish between BD and EX PDCs and time spent doing so may delay implementation of necessary actions. Because not all of the fuel would be expected to melt and relocate, the initial action should be same for either PDC - inject water into the RCS. Creative means of injecting water would be needed in either PDC. The B&W and CE owners groups should consider eliminating the EX PDC.

3. It is suggested that the CE owners group incorporate measurable or quantitative success criteria to determine completion of the CHLAs. The use of vague success criteria such as "acceptable water level has been restored" should be eliminated and replaced with a measurable level so that mitigative actions are not terminated prematurely and to prevent delays in the implementation of other mitigative actions.

4.4 Strategies

Twelve comments on areas that would benefit from suggested improvements have been identified for the SAMG strategies. These comments are as follows:

1. The prevention of containment failure to prevent fission product release should be given a high priority by the B&W and CE owners groups. Containment conditions, even if not challenged, should not be a "LESS IMMEDIATE" concern as stated in the B&W SAMGs. Containment pressure should be constantly monitored to prevent containment challenge and provide adequate time for implementing mitigation strategies.

2. It is recommended that the B&W and W owners groups include guidance to the utilities to develop discussions on how the actions suggested in each CHLA compliment or conflict with current EOPs. This could facilitate better understanding by the control room operators as to why the TSC is instructing that certain actions are to be taken, thereby fostering control room trust and cooperation.

3. Because multiple CHLAs could be in use at the same time, the B&W and CE owners groups need to provide guidance on how accident

management personnel maintain their place within each CHLA. This guidance could be to simply recommend that the utilities use existing place keeping methods they currently use in their EOPs.

4. It is not clear how IPE guidance was used to identify and develop the strategies or other parts of the SAMGs by the B&W owners group. A description of how the IPEs were used should be provided. The CE owners group could provide additional detail on how the IPEs were used to identify and develop or eliminate SAMG strategies (e.g. containment vacuum). This information ensures that all relevant information was considered in the development of the SAMGs.

5. It is recommended that the CHLAs of all owners groups indicate that the adequacy of net pump section head be considered for all pumping systems whenever their use is discussed. The B&W owners group references this as a concern for the reactor coolant pumps, but neglects this concern for other pumping systems. W identifies this concern for most of its pumping systems, but omits it occasionally.

6. The CE owners group over emphasizes the concern about the boron content of injection sources when trying to reflood the core in order to prevent recriticality. This concern could delay core injection and allow the core to degrade further. Although recriticality is a concern, it is a second order concern and should not prevent or delay the initiation of core injection.

7. Although both the B&W and CE owners groups discuss the concerns of adding water to a hot/dry steam generator in their TBDs, it is suggested that they add cautions discussing these effects in their CHLAs. Adding these cautions within the CHLAs will make it less likely that the undesirable effects of adding water to a hot/dry steam generator will be overlooked under the pressures and time constraints of a severe accident situation.

8. It is suggested that the B&W owners group consider the scrubbing of fission products through a failed steam generator and discuss the benefits of such an action. Isolation of a failed steam generator and then depressurizing the RCS to reach injection sources could result in containment venting to prevent a challenge to the containment integrity. Containment venting could lead to higher population doses than would have resulted if the failed steam generator had been allowed to remain in service. Although the CE owners group recommends the scrubbing of fission products through a failed steam generator, the benefits of such an action should be discussed in greater detail.

9. Although the CE owners group provides actions on hydrogen control, it is suggested that a discussion or caution should be included to indicate that long-term ambient losses from the containment will de-inert the containment.

10. The B&W and CE owners groups over emphasize concerns about the negative effects caused by the pH of sump water. These concerns are that the pH of sump water may result in hydrogen generation (primarily from oxidation of aluminum and zinc surfaces in containment), may cause piping corrosion, and may result in iodine resuspension. Because sump water is used only after all other water sources have been determined to be unavailable, the pH of this water is a second order concern. Over emphasis of these concerns should be eliminated since they may cause delay in creative use of water sources and distract staff from more urgent actions.

11. Because the habitability of plant areas could be degraded during a severe accident, the B&W and CE owners groups should address access to plant areas during all strategies. Guidance should be provided to the utilities to consider plant habitability and access before CHLA actions are implemented.

12. The B&W owners group states in their TBD that steam explosions as the core relocates into the containment are not a problem. There is currently insufficient information available to suggest that this is not a problem. At a minimum, it should be acknowledged that steam explosions may be a potential problem. The CHLA strategies will probably not change as a result of this acknowledgement, but it is something that utilities should be aware of. In the CE SAMGs, the CHLA for RCS depressurization calls for depressurization to containment pressure as low as possible, but does not caution for the possibility of steam explosions at pressures < 75 psi as stated in their TBD. CE should provide this caution in their RCS depressurization CHLA.

4.5 Equipment and Instrumentation

The following four comments suggest improvements to the SAMGs discussions about equipment and instrumentation availability and reliability:

1. The B&W, CE, and W SAMGs should provide additional details concerning subsystem support for equipment operability when considering the status of available equipment. Equipment availability is key to CHLA prioritization and TSC direction and guidance in the SAMG will ensure that utilities benefit from creative ideas on the use of equipment. This requirement is discussed in Reference 2, Section 5.3.1, third paragraph, page 3.

2. The W owners group provides information on instrument reliability in their TBD. It would be useful, however, if they would provide guidance to the utilities on using this information for CHLA prioritization and TSC direction.

3. Because traditional injection sources may be unavailable during the course of a severe accident, alternative and creative actions such as system cross-ties need to be discussed. Although some discussion of these actions are included in the CE

SAMGs, it is suggested that more such actions be discussed for supplying injection sources.

4. A discussion of the data sampling frequency of each parameter used to select the PDCs should be included by all owners groups to provide guidance to the utilities on utilizing their data collection processes. The CE owners group discusses a data sampling rate of every 15 minutes. However, this sampling rate may not be adequate for the timely determination of a PDC and may critically delay the implementation of necessary actions. All owners groups need to identify what sampling rate they consider optimal for the accurate and timely determination of PDCs and recommend that utilities consider modifying their current data gathering protocol and practices when relying on manual methods.

4.6 Calculation Aids

The following comment is a suggested improvement on the usefulness of the calculation aids.

1. Many of the calculation aids provided in the CE SAMGs are lengthy and cumbersome. Their use could delay implementation of necessary actions. For example, the calculation aid to determine the hydrogen concentration in containment involves the calculation of the hydrogen released from fuel rod cladding oxidation during boildown and recovery, from core-concrete interactions, from the corrosion of aluminum and zinc metals in the containment, and from radiolysis. The time required to obtain the information needed to determine each of these hydrogen release levels could consume a lengthy time period.

4.7 Implementation Instructions

Four suggested improvements have been identified for improving SAMG guidance to the utilities for implementing plant specific accident management plans. These comments are as follows:

1. The B&W and CE owners groups should provide a writers guide or provide equivalent guidance to the utilities of the construction of the plant specific SAMGs. Because similar guidance had to be provided during the writing of EOPs, this guidance could simply recommend that the utilities use their EOP writers guide.

2. The B&W owners group should provide guidance to the utilities for reviewing data sources that support decision-making in the TSC. The reliability of the data sources is necessary to allow accurate prioritization and selection of CHLA actions.

3. The B&W and CE owners groups should provide a method for tracking water inventories of tanks, including alternatives, and identification of makeup sources. These should be tied to the water requirements of the CHLAs.

4. When evaluating the use of containment venting, CE and W should provide additional guidance for determining the order of preference for available vent pathways. Some PWRs have already installed Post-Accident Containment Vent systems that should be identified as having a high preference followed by other creative line-ups.

5.0 OBSERVATIONS

The SAMGs provided by the B&W, CE, and W Owners Groups are a major step forward in providing guidance to utilities for managing severe accidents. The owners groups obviously committed major resources in the development of these SAMGs. However, given the guidance provided by the Nuclear Management and Resource Council (NUMARC) and the Electric Power Research Institute (EPRI), the reviewers were surprised by the widely divergent approaches used by the three owners groups. Westinghouse took an entirely symptomatic approach to accident management whereas B&W and CE took a PDC determination approach. Where B&W chose to employ separate CHLAs for each RCS and containment PDC, the CE approach was to link RCS and containment PDCs and provide CHLAs for each combined condition.

All SAMG approaches were judged to be viable if numerous changes were made to the B&W owners group SAMGs, some changes to the CE owners group SAMGs, and a few changes to the W owners group SAMGs. The two areas needing improvement for all three owners group's SAMGs are (1) the need for additional detailed guidance for implementation of the SAMGs at the utilities and (2) the need for additional guidance on incorporating new information from IPE Results, Owners Group Studies, and NRC Reports. Although all three owners group's SAMGs are believed to be workable, their large size could make their use difficult under severe accident conditions and pressures. In addition, the reviewers believe that some owners groups could realize a possible benefit by examining other owners group's approaches for resolving indicated problem areas in their SAMGs.

Other areas needing improvement in the B&W owners groups are (1) the guidance for the transition from the EOPs to the SAMGs, (2) the guidance for the transfer of decision-making authority from the control room to the TSC, (3) the method for identifying PDCs, (4) the completeness of the CHLAs, (5) the technical basis for some CHLAs, (6) the guidance on the evaluation and use of plant equipment, (7) the discussion of instrumentation capabilities and the guidance on its use, (8) the guidance on SAMG validation and verification, and (9) the SAMG implementation instructions. Overall, the reviewers believe that the B&W owners groups lack the necessary detail to ensure that utilities are receiving a complete and workable set of SAMGs.

Other areas needing improvement in the CE owners groups are (1) the guidance for the transition from the EOPs to the SAMGs, (2) the guidance for the transfer of decision-making authority from the control room to the TSC, (3) the guidance for entering some CHLAs, (4) the guidance for CHLA success criteria and effectiveness evaluation, (5) the ease-of-use of some calculation aids, (6) the discussion of instrumentation capabilities and the guidance on its use, and (7) the guidance on SAMG validation and verification.

Besides the two areas discussed above as needing improvement, no additional areas were determined to need improvement for the W SAMGs.

Comments from which the needed and suggested improvements were derived as well as comments on SAMG details not relating to those found in

Sections 3 and 4 can be found in Appendix D for the B&W SAMGs, Appendix E for the CE SAMGs, and Appendix F for the W SAMGs. Some of these comments include typographical errors and potential mistakes or misstatements in the SAMG's text.

6. REFERENCES

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