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Vol. 2

Developing and Assessing Accident Management Plans for Nuclear Power Plants

Evaluation of a Prototype Process

Prepared by
D. J. Hanson, S. P. Johnson, H. S. Blackman, M. A. Stewart

Idaho National Engineering Laboratory
EG&G Idaho, Inc.

Prepared for
U.S. Nuclear Regulatory Commission

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U.S. Nuclear Regulatory Commission
Washington, DC 20555
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ABSTRACT

This document is the second of a two-volume NUREG/CR that discusses development of accident management plans for nuclear power plants. The first volume (a) describes a four-phase approach for developing criteria that could be used for assessing the adequacy of accident management plans, (b) identifies the general attributes of accident management plans (Phase 1), (c) presents a prototype process for developing and implementing severe accident management plans (Phase 2), and (d) presents criteria that can be used to assess the adequacy of accident management plans. This volume (a) describes results from an evaluation of the capabilities of the prototype process to produce an accident management plan (Phase 3) and (b), based on these results and preliminary criteria included in NUREG/CR-5543, presents modifications to the criteria where appropriate.

FIN B5723—Accident Management Framework

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FIGURES

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EXECUTIVE SUMMARY

The Nuclear Regulatory Commission (NRC) and the Executive Director for Operations instructed the NRC staff to work with the nuclear utility industry to define the scope the content of accident management plans and to develop guidance for their development and implementation. Following these instructions, the Office of Nuclear Regulatory Research is conducting a research program (a) to establish the attributes of a severe accident management plan that will ensure effective response to credible severe accidents and (b) to recommend criteria that can be used to thoroughly assess these plans.

As participants in this research program we have developed an approach comprising four phases to identify the important attributes of a severe accident management plan and, using these attributes, to develop assessment criteria:

Phase 1. Identify the general attributes of an accident management plan

Phase 2. Integrate the general attributes into a prototype process that includes the steps necessary to develop and implement an accident management plan

Phase 3. Validate the capabilities of the prototype process through its application

Phase 4. Identify assessment criteria based on the important characteristics of the validated process.

Initial results from Phases 1 and 2 were documented in NUREG/CR-5543. Preliminary assessment criteria were also reported.

This report summarizes results from the performance of Phases 3 and 4 and is designated as Volume 2. The prototype process and preliminary criteria from NUREG/CR-5543 will be modified to reflect results from the process validation (Phase 3) and reissued as Volume 1 of this NUREG/CR.

The prototype process for developing accident management plans is shown in Figure ES-1. During Phase 3 an evaluation of this process was performed under conditions similar to those which would be found at a nuclear power plant to establish its capabilities to develop an initial accident management plan for that plant. The objectives of this evaluation are to determine whether: (1) the activities described for each step provide the products needed, and (2) the steps are integrated to provide the information necessary for a technically accurate and effective accident management plan.

Initial plans for assessing the capabilities of the prototype process included the participation of personnel from a nuclear utility. However, we were not able to obtain the agreements necessary for their participation, and consequently, it was not possible to obtain a complete set of plant hardware and operations information. To allow the evaluation to proceed, plants were identified for which necessary information was available. The Zion, Unit 1 plant was selected based on the availability of hardware and operational information and the knowledge that project personnel possessed on this and similar plants.

A team approach was used during Phase 3 to assess the prototype process because it is the most likely method that would be used for the development of an accident management plan at a nuclear power plant. Although it was not possible to exactly duplicate the knowledge and expertise of utility personnel, a team was selected from Idaho National Engineering Laboratory personnel with extensive nuclear experience. This team was composed of a mechanical engineer with thermal-hydraulic safety analysis, severe accident analysis, and accident management program development experience; an electrical engineer with PRA experience; a procedures and training expert with a broad background in human factors; and an operations expert with a PWR senior reactor operators license and knowledge of plant operations. All work used the team approach with some independent assignments given and then reported back to the team for integration.

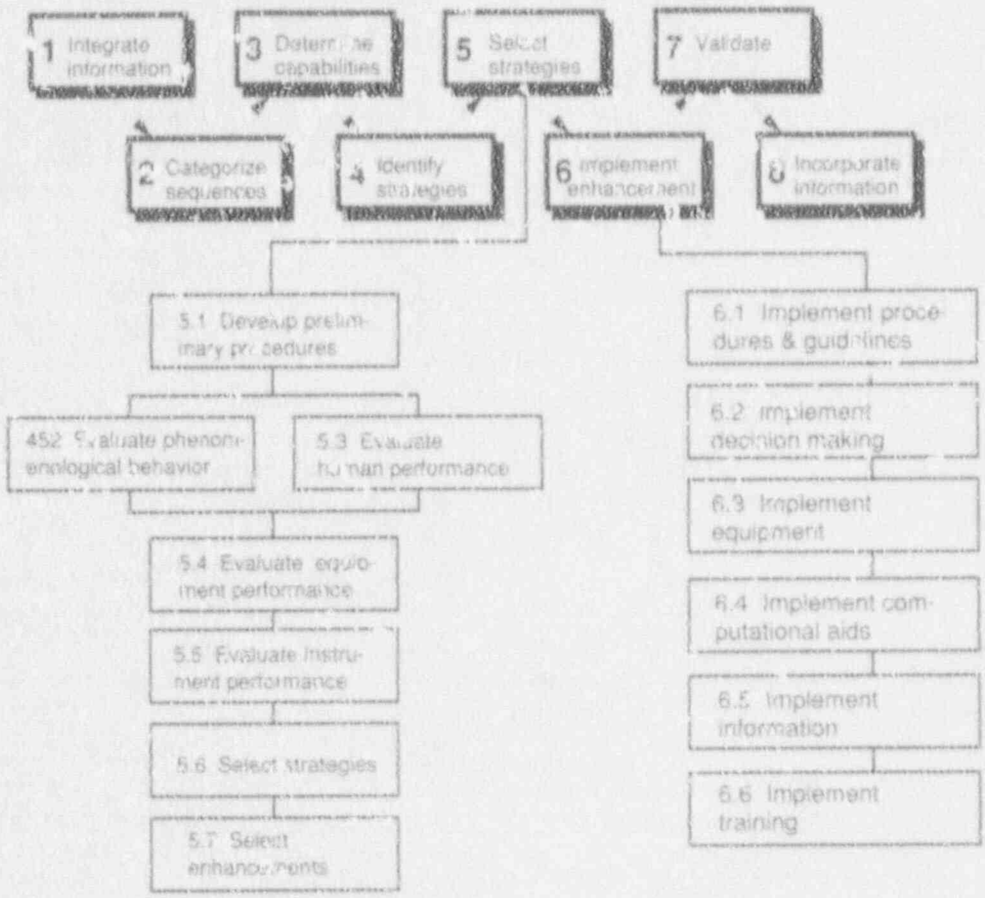


Figure SE-1. Process for developing an accident management plan.

The following are general results from the evaluation of the prototype process followed by results that are specific to individual process steps:

General Prototype Process Application Results

1. The lack of utility participation restricted our ability to adequately evaluate all steps of the prototype process using detailed plant hardware and operations information. As a consequence, evaluation of Steps 1 through 4 was completed and there was a partial evaluation of Step 5. It was not possible to perform an evaluation of Steps 6 through 8.

2. The general content of Steps 1 through 5 of the prototype process are adequately integrated. Some modifications to the individual steps were identified to correct shortcomings in the process and make it more efficient. Using these modifications Steps 1 through 5 will produce the results described in the prototype process.

3. The team approach was very effective in performing the steps of the prototype process because it helped generate synergism and creativity, especially when identifying plant capabilities and potential strategies. We expect that this approach would be even more effective in a setting where plant personnel with a higher level of plant knowledge and expertise were involved.

Specific Prototype Process Application Results

1. The method for categorization of sequences described in Step 2 was not effective because it defined an excessively large number of sequence categories. We concluded that cate-

gories of severe accident behavior based on events that occur during severe accidents provide more insight into possible accident management actions than categories that are defined through sequence categorization or sequence binning. Three alternate methods of developing categories were examined.

The first method used the events directly from the event trees to act as severe accident management evaluation categories. The categories in this approach would be easy to identify and would produce a reasonable number of categories. The second method used the structure of the safety objective trees described in NUREG/CR-5543 to define important events. Mechanisms that can cause challenges to plant safety functions were selected to define the assessment categories. Examples of categories based on mechanisms are: Inadequate RCS Inventory, Inadequate Containment Heat Removal, Core Concrete Interaction, Failure to Isolate Containment, and Interfacing System Loss-of-coolant Accidents. In the third method, we transcribed the severe accident sequences for Zion, Unit 1 onto the safety objective trees and found that the mechanisms contained all of the events associated with these sequences.

We conclude that all methods could be successful in categorizing sequences but we preferred the method that transcribed events to the safety objective tree mechanisms because it was easy to relate the assessment categories to both plant safety functions and to possible strategies, through the safety objective tree structure. This is the method used in the application of the prototype process.

2. Identification of plant capabilities was determined to be a very important step in developing an accident management plan. We found it was difficult to separate the identification of plant capabilities and the identification of how these capabilities could be used to improve accident management for the plant. The method described for the prototype process was determined to be inefficient. A more structured approach was developed using a question-answer format which proved to be effective in identifying plant and personnel capabilities and how they could be used to prevent or mitigate conditions affecting the sequence categories. The questions developed are general and could be applied directly or easily modified for identification of capabilities for other nuclear power plants.

3. About thirty-five strategies with the potential to improve severe accident management were identified using a process similar to that described in Step 4 of the prototype process. Results from the question-answer format used to identify plant capabilities were used to guide the identification of potential strategies and to help determine how they should be structured.

4. Development of preliminary procedures in Substep 5.1 was successful in determining the personnel, hardware, and instrumentation involved in potential strategies. Although there was not enough information to thoroughly assess Step 5 of the prototype process, Evaluate and Select Strategies and Identify Enhancements, our judgement is that the process described for evaluation and ranking would be effective.

The objective of Phase 4 is to finalize a set of criteria that can be used to assess: (1) the adequacy of methods suggested for developing severe accident management plans, and (2) the adequacy of proposed or implemented severe accident management plans. The preliminary set of criteria were reviewed by the team after completion of the process assessment. Criteria for Steps 1 through 4 and Substep 5.1 were reviewed individually to determine whether they were compatible with the results from the prototype process evaluation. Modifications to criteria for these steps were made and new criteria were added to account for changes in the process. It was not possible to update the criteria associated with Substeps 5.2 through 5.7 and Steps 6 through 8 because they were not evaluated during the validations effort (Phase 3). The preliminary criteria developed for these steps during Phase 2 are judged to be adequate for evaluation of accident management plans. A discussion of the criteria for all evaluation steps is presented in Volume 1 of this NUREG/CR.

ACKNOWLEDGEMENTS

We express appreciation to Donald E. Solberg, NRC Project Manager, and to those within the NRC who have offered ideas and suggestions for improving this work. We thank Orville R. Meyer for his contributions during the early stages of the work and William R. Nelson for his beneficial comments on the draft report.

ACRONYM LIST

AFW	auxiliary feedwater
BWST	borated water storage tank
CCI	core-concrete interaction
CST	condensate storage tank
DCH	direct containment heating
EOP	Emergency Operating Procedure
EPIP	Emergency Plans Implementation Procedure
IPE	individual plant examination
ISLOCA	interfacing system loss-of-coolant accident
IVSW	isolation valve seal water
MDAF	motor driven auxiliary feedwater
NRC	Nuclear Regulatory Commission
PORV	power-operated relief valve
PRA	probabilistic risk assessment
PWR	pressurized water reactor
RCP	reactor coolant pump
RCS	reactor coolant system
RES	Office of Nuclear Regulatory Research
RHR	residual heat removal
RTD	resistance temperature detector
RVLMS	reactor vessel level monitoring system
SCET	simplified containment event tree
SGTR	steam generator tube rupture
SI	safety injection
SRV	safety relief valve
SW	service water
TSC	technical support center
VCT	volume control tank

Developing and Assessing Accident Management Plans for Nuclear Power Plants: Evaluation of a Prototype Process

1. INTRODUCTION

The Nuclear Regulatory Commission (NRC) instructed the NRC staff to "Work with NUMARC [Nuclear Management and Resources Council] to define the scope and content of an acceptable accident management program and to develop a plan for incorporating plant-specific actions into such a program (Chilk 1989)." In response to these instructions, the Office of Nuclear Regulatory Research (RES) is conducting a research program to (1) establish those attributes of a plant severe accident management plan necessary to ensure effective response to credible severe accidents and (2) recommend criteria that can be used to assess the adequacy of accident management plans and their implementation.

As participants in this research program, we developed a four-phased approach to identify the important attributes of a severe accident management plan and, based on these attributes, to produce assessment criteria. Our approach is shown in Figure 1. The rectangles in the figure represent the information sources used; the circles represent the four phases or objectives that must be accomplished. The objectives are as follows:

Phase 1. Identify the general attributes that an implemented accident management plan should include, based on the stated accident management objectives and other pertinent information, for example, the NRC accident management framework elements.

Phase 2. Integrate the general attributes into a prototype process that includes the steps necessary to develop and implement an effective accident management plan.

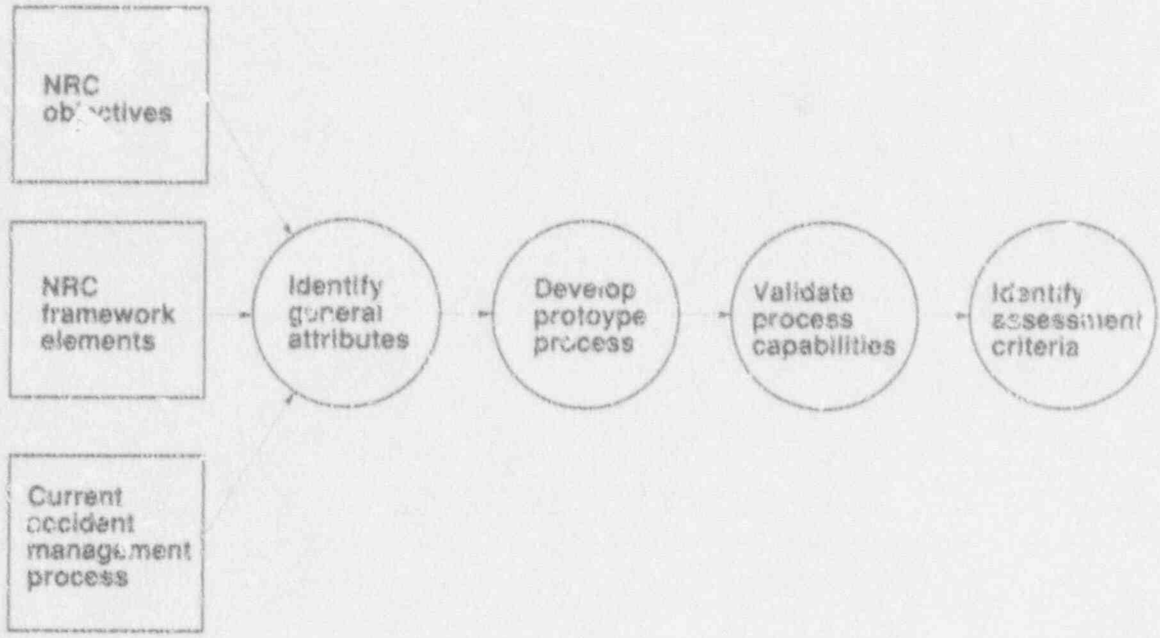


Figure 1. Approach for developing criteria for an accident management plan.

Phase 3. Validate the process through an application that uses information that would be available at a nuclear power plant.

This application is intended to identify problems with the process and to develop improvements to correct them.

Phase 4. Identify criteria, based on the important characteristics of the validated process, that can be used to assess the adequacy of accident management plans and their implementation.

We provided initial results from Phases 1 and 2 in April, 1991, and documented the results in NUREG/CR-5543 (Hanson 1991). Preliminary assessment criteria were also developed and reported, based on the Phase 2 prototype process.

This report, Volume 2, summarizes the results from the validation process (Phase 3) and presents criteria that can be used to assess the adequacy of accident management plans (Step 4). To accomplish Phase 3, we evaluated the prototype process by applying it to a nuclear power plant using the information that should be available at a plant. Based on the results from Phase 3 and the preliminary criteria produced in Phase 2, final criteria were developed (Phase 4) to assess accident management plans. NUREG/CR-5543 will be modified to reflect results of the process assessment and reissued as Volume 1 of this NUREG/CR.

2. Approach

This Section provides a description of the prototype process and the approach used to evaluate this process.

2.1 The Eight-Step Prototype Process

An approach for identifying the important attributes of an accident management plan and for developing assessment criteria is described in NUREG/CR-5543 and is illustrated in Figure 1. Phases 1 and 2 of this four-phase approach were completed earlier and are also reported in NUREG/CR-5543. During Phase 2, an eight-step prototype process (see Figure 2) was produced that is intended to be used to develop accident management plans. The following is a brief description of these steps:

Step 1. Assemble and integrate existing information needed to understand plant capabilities and limitations during severe accidents.

Step 2. Categorize the severe accident sequences identified by the Individual Plant Examinations (IPEs) or Probabilistic Risk Assessments (PRAs) into groups that have similar accident characteristics and challenges to safety functions. These categories will guide the remaining steps in determining what plant capabilities exist to enhance accident management and what accident management strategies would be beneficial.

Step 3. Identify plant-specific accident management capabilities having the potential to be effective for the accident sequence categories identified

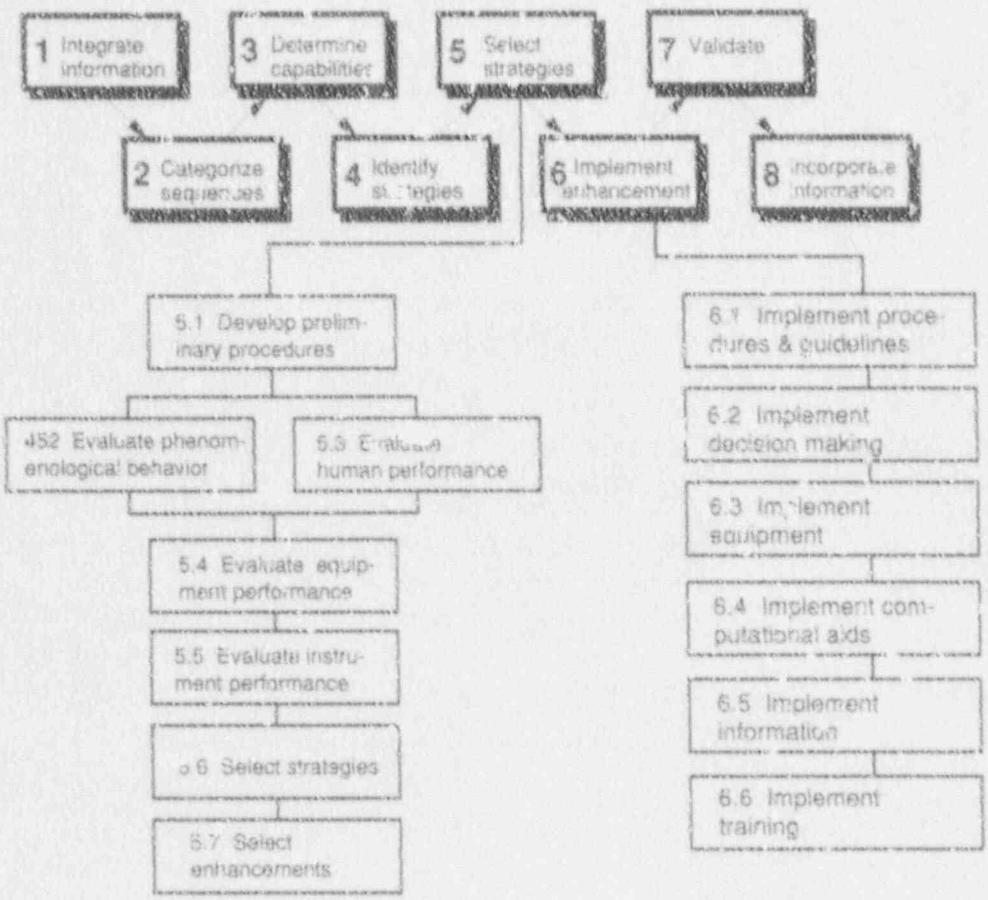


Figure 2. Process for developing an accident management plan.

in Step 2. These capabilities will be used in Steps 4 and 5 to identify and evaluate strategies.

Step 4. Identify strategies that have the potential to prevent or mitigate the consequences of the categorized sequences identified in Step 2.

Step 5. Evaluate the potential strategies identified in Step 4 and select those that would be most effective. The results of these evaluations can then be used to select strategies that will be effective in addressing the sequence categories. Once strategies have been selected, identify the accident management enhancements necessary for implementation of all selected strategies. Enhancements are those changes in the plant hardware and operations necessary to implement the selected strategies.

Step 6. Use the information developed in the four previous steps to implement the accident management enhancements. Although each plant may have a unique process for implementation, there are only a limited number of methods that can be used to implement accident management enhancements. These methods include changes in one or more of the following areas: (a) procedures and guidance, (b) delineation of decision-making responsibility and authority, (c) equipment and engineered systems, (d) computational aids, (e) instrumentation, (f) training programs.

Step 7. Validate the implemented accident management plan, including the strategies, procedures, guidance, computational aids, engineered methods, decision-making structure, and training. The methods are similar to the validation tasks identified in NUREG-0899 for implementation of the symptom-based emergency operating procedures.

Step 8. Identify and incorporate new severe accident information in the implemented accident management plan. This is accomplished by (a) identifying new severe-accident information that has not been considered in the implemented accident management plan, (b) determining how this new information influences the implemented accident management plan, and (c) identifying needed improvements, if any.

The two final phases of the process have intended to evaluate the capabilities of this eight step process (Phase 3) and to identify final assessment criteria (Phase 4). The following is a brief description of the approach used in accomplishing these final two phases.

2.2 Phase 3 Validate Process Capabilities

The objective of this phase of the program was to evaluate the prototype process by applying it to a nuclear power plant to determine whether (a) the activities described for each step provide the products specified, and (b) the steps are integrated to provide the information needed to develop a technically accurate and useful accident management plan.

In the early planning stages of this program, we recognized that it was important to apply the process under conditions typical of those found at a nuclear power plant. Consequently, our desire was to establish a cooperative effort with a nuclear utility to evaluate the prototype process. This arrangement would allow us to draw on their plant hardware and operations knowledge to (a) provide the detailed plant information we needed and (b) evaluate the suitability of the prototype process for application in a utility environment. However, we were not able to obtain the agreements necessary for participation of a utility in any of our work. As a result, the amount of detailed information on plant hardware and operations available during Phase 3 was restricted to what was publicly available and readily accessible. The lack of detail in this information limited our ability to evaluate all steps in the prototype process. Evaluation was completed for Steps 1 through 4 with a partial assessment of Step 5. No evaluation was possible for Steps 6 through 8.

Alternate sources of detailed plant hardware and operations information had to be identified because utility participation was not possible. A wide range of plants were reviewed to determine whether the following types of information were publicly available: (a) a recent probabilistic risk assessment (PRA), (b) a readily available Final

Safety Analysis Report, (c) detailed drawings of the plant layout and hardware, and (d) a set of plant operating procedures. We found that an integrated set of detailed plant information is difficult to obtain for most nuclear power plants. Therefore, a plant was selected based on the amount of information that was readily available in each of these four areas and the knowledge that project personnel possessed on the plants. Zion Unit 1 was selected as the reference plant.

We chose to assess the prototype process using a team approach because we believe that it is the method that would be most likely used at a nuclear power plant to develop an accident management plan. The composition of a team and the way the team applies the process are important because they can influence the results obtained. Although it was not possible to exactly duplicate the knowledge and experience of utility personnel, our team was selected from personnel with extensive nuclear experience. Our team was composed of a mechanical engineer with thermal-hydraulic safety analysis, severe accident analysis, and accident management program development experience; an electrical engineer with PRA experience; a procedures and training expert with a broad background in human factors; and an operations expert with a PWR senior reactor operator's license and knowledge of plant operations. Most activities were performed as a group to ensure that a range of perspectives was considered. Some independent assignments were performed and the individuals reported back to the team for integration of their contribution. One obstacle for team members was the lack of adequate resources to draw upon when information was not available. Resources to supply the following detailed information would have been very beneficial: additional details for the PRA event trees and fault trees; details on plant hardware capabilities, limitations, location and operation; utility organization; decision-making authority and responsibility; plant operations; training practices and procedures; and emergency planning.

Availability of typical plant information and expertise restricted this assessment to the first five steps out of the eight steps that comprise the prototype process.

2.3 Phase 4 Identify Assessment Criteria

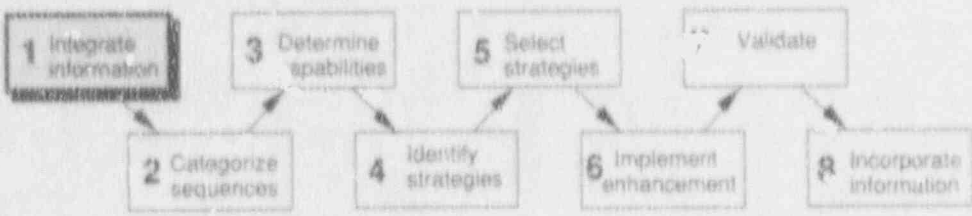
The objective of Phase 4 is to produce a set of criteria that can be used to assess (a) the adequacy of methods suggested for developing severe accident management plans, and (b) the adequacy of proposed or implemented severe accident management plans. After an evaluation of the prototype process was completed, each of the preliminary criterion was reviewed and discussed to determine whether (a) it was still applicable, (b) it should be revised to recognize changes identified during the process evaluation, and (c) additional criteria were needed.

The preliminary criteria for process Steps 1 through 4 and Substep 5.1 were modified to reflect lessons learned during the process evaluation. Since an evaluation of Substeps 5.2 through 5.7 and Steps 6 through 8 was not performed, these preliminary criteria were not revised.

3. VALIDATION RESULTS FOR EACH STEP

This section describes the results from evaluating the approach presented in Section 2 for each process step. The steps are presented in the sequence of Figure 2, highlighted with icons.

Step 1. Assemble and Integrate Information



Information for Zion Unit 1 was assembled to familiarize the team members with the characteristics, capabilities, and limitations of the plant hardware and personnel that would be involved in accident management. Table 1 lists the information obtained, reviewed, and used in later steps. Some information was not sufficiently complete to represent the information available at a plant. For example, in the area of probabilistic risk assessment, there are computer models of the accident progression event trees, but the team members were not sufficiently familiar with them to obtain information that would help in evaluating the process. Most information describing the severe accident progression beyond core damage was from simplified containment event trees (Sattison and Hall 1990) developed to assess containment performance issues. Consequently, the PRA information we had available was not as detailed as information we would expect available at a plant. As indicated in Table 2, some plant operating procedures used for the assessment were also not complete. Table 2 lists information identified during the evaluation that would have

Table 1. Sources of information available for process validation.

Plant and Related Information

- Piping and Instrumentation Diagrams
- Westinghouse Emergency Procedure Guidelines
- Normal Operating Procedures (Partial)
- Abnormal Operating Procedures (Partial)
- Emergency Operating Procedures
- Final Safety Analysis Report
- Regulatory Guidelines

IPE/PRA Results

- NUREG 1150
- NUREG/CR-4550 Vol. 7 Rev. 1 (Zion Internal Events)
- NUREG/CR-5575 (Zion Simplified Containment Event Trees)

Additional Severe Accident Information

- NUREG/CR-4550 Vol. 3, Rev. 1 (Surry Internal Events)
- NUREG/CR-4551 Vol. 3, Rev. 1. (Surry Containment Analysis)
- NUREG/CR-4624 Vol. 5
- IDCOR (Industry Degraded Core Rulemaking Safety Program) Results

Table 2. Unavailable sources of information that would have improved process assessment.

Plant and Related Information

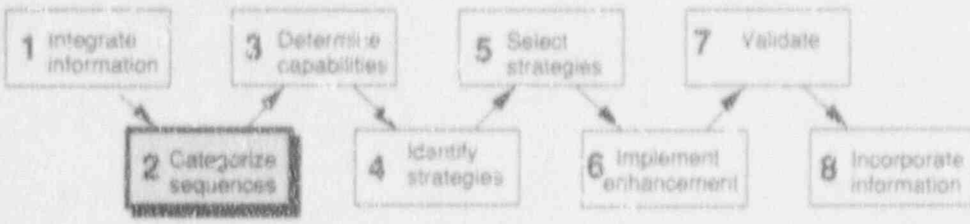
- Administrative procedures
- Emergency plan implementation procedures (EPIPs)
- Training material
- All normal and abnormal operating procedures
- INPO significant event reports

IPE/PRA Results

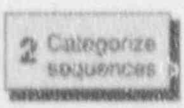
- PRA event tree and fault tree computer models added substantially to the quality of the information we developed.

The prototype process recommends that the plant information be placed in a database. We established a library of the information collected but did not evaluate the use of a database because the information set was not complete and we were not in a plant setting. A complete database evaluation would also require information on the skills, knowledge, and abilities of the accident management team members, which was not available.

Step 2. Categorize Severe Accident Sequences



Three substeps were defined in the prototype process for categorizing sequences. The first substep defines the sequence categories based on the possible severe accidents identified for the plant. Severe accident sequences are then selected and assigned to the appropriate categories. In the final substep, typical sequences are identified for each category so they can be used in later process steps to evaluate accident management capabilities and enhancements. A description of the assessment and results from these substeps follows.



Substep 2.1 Define Sequence Categories

The objective of this substep is to condense the relatively large number of severe accident sequences into categories that can be used to conveniently identify plant capabilities and aid in selecting and evaluating strategies. To accomplish this objective, the prototype process proposes the following functional approach to establish sequence categories by following the progression of challenges to the plant safety functions. Figures 3, 4, and 5 are the PWR safety objective trees that show the safety functions, challenges, and mechanisms used in the following example. In NUREG/CR-5543, a hypothetical example is given of a severe accident sequence involving the loss of all feedwater compounded by the loss of injection and the loss of containment cooling for a PWR with a large dry containment. The prototype process uses the sequence of mechanisms resulting in challenges to the safety functions to define the sequence category. For this example, the mechanisms identified in Volume 1 were inadequate secondary inventory, inadequate reactor coolant system (RCS) inventory, non-coolable relocation, insufficient containment energy removal, and aerosol dispersion. Other sequences with the same progression of challenges and mechanisms would be placed in this category, unless there was a significant difference in one or more of the following: timing of key events; major differences in key RCS or containment conditions; the unavailability of support systems, for example, electrical power, instrument air, or service water; or the existence of adverse environments, for example, radiation fields or flooding. Significant differences in any of these areas could warrant establishing additional categories. The discussion presented in Volume 1 estimates that this method of categorization would result in about twenty to thirty sequence categories, depending on the severe accident sequences identified for the plant.

We assessed the proposed method of establishing sequence categories using the severe accident sequences from the Zion Level 1 PRA (Sattison and Hall 1990) and the Zion simplified containment event trees (SCETs) (Kelley 1990). A detailed examination of the Level 1 event trees was not performed because they are based on the prevention of core damage, whereas this accident management evaluation is directed toward the mitigation of severe accidents.

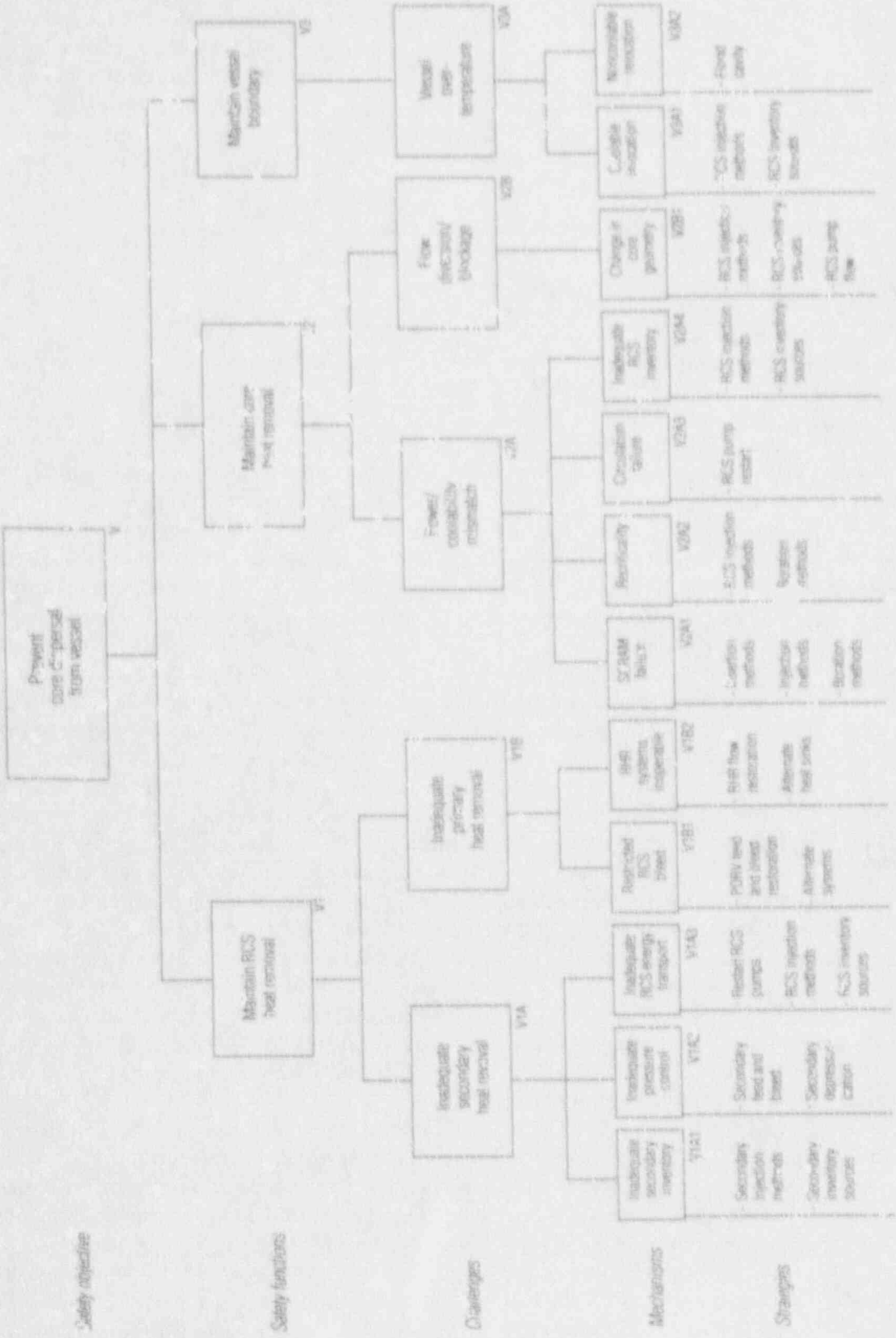


Figure 3. Safety objective tree: prevent core dispersal from vessel.

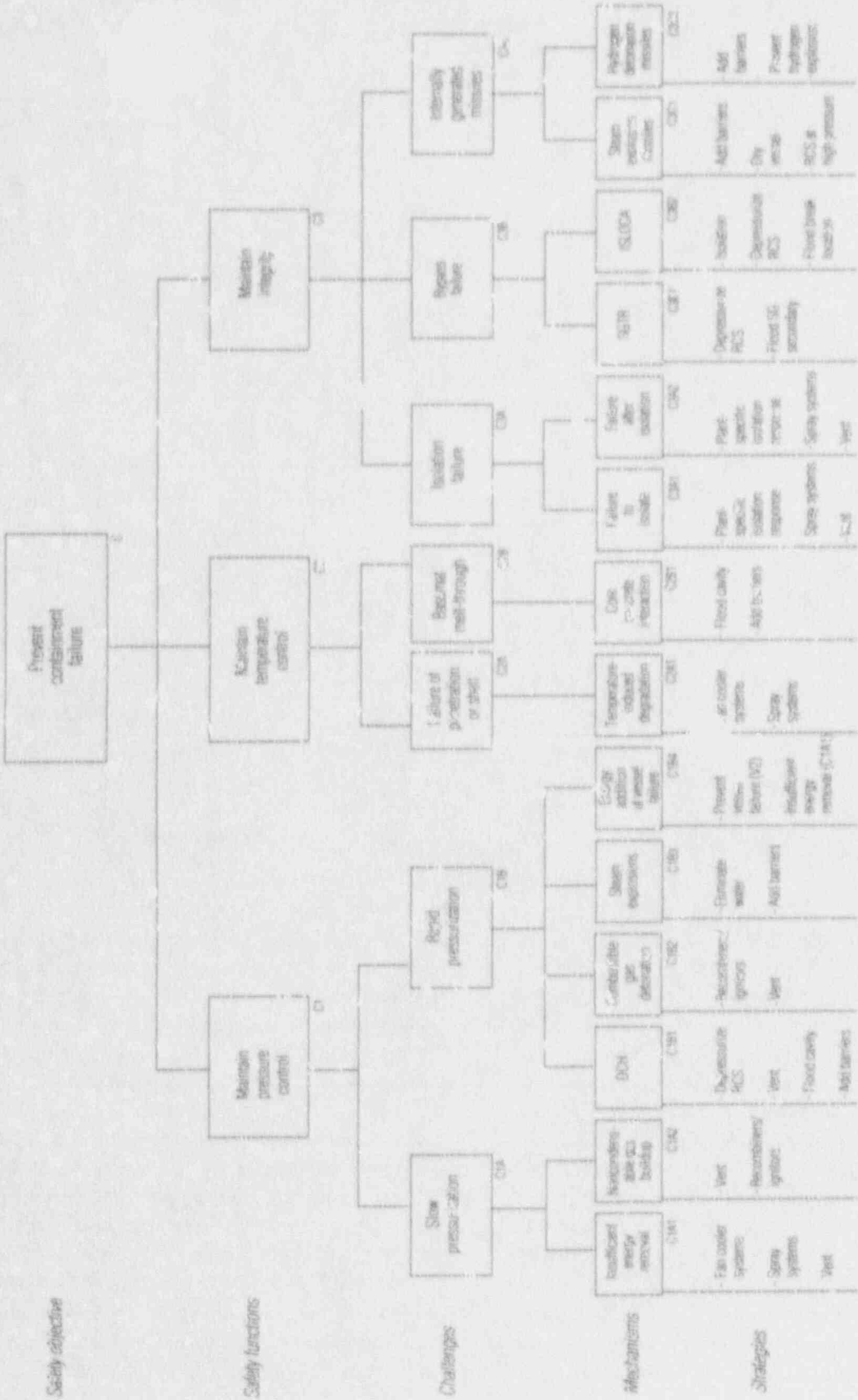


Figure 4. Safety objective tree: prevent containment failure.

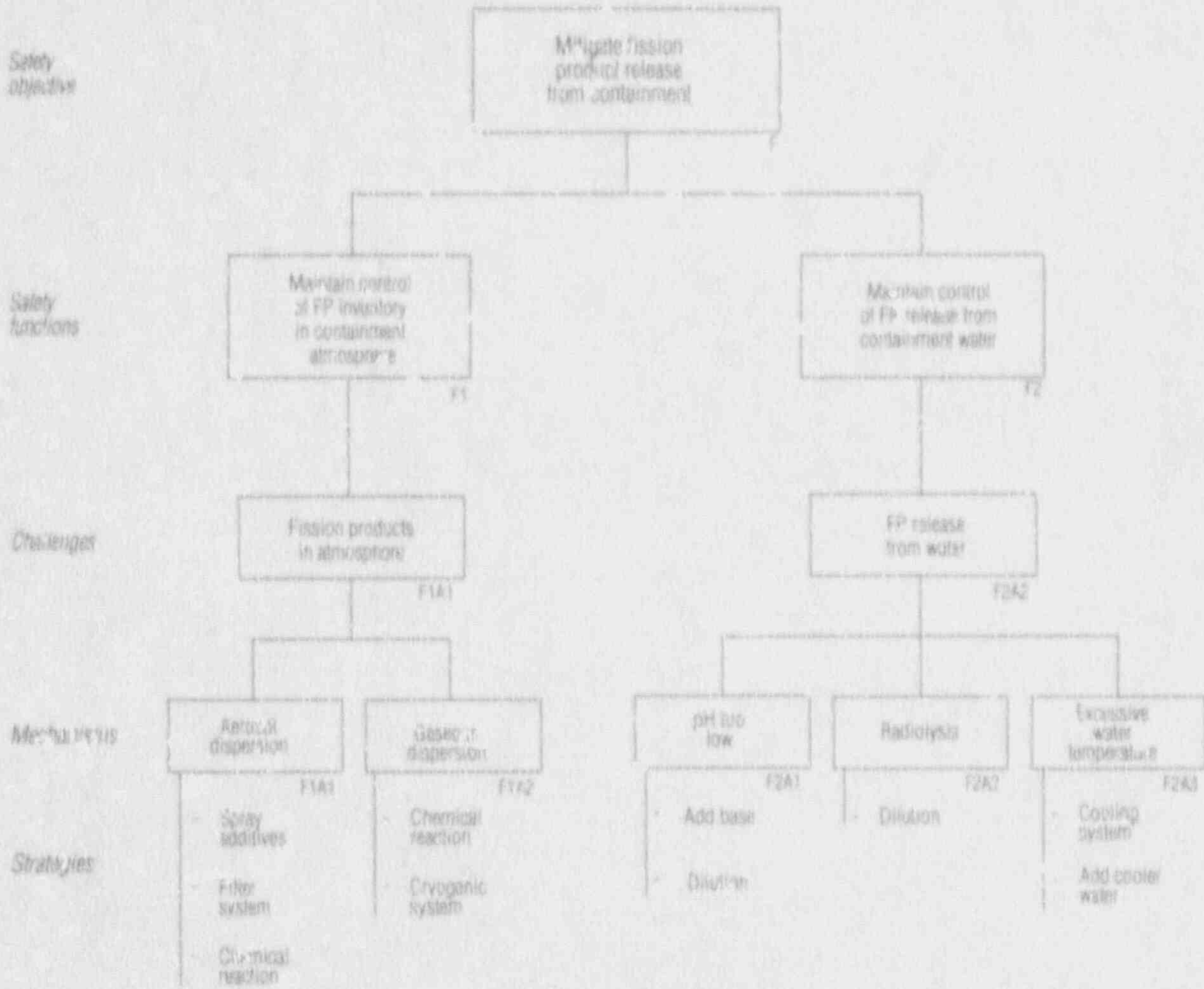


Figure 5. Safety objective tree: mitigate fission product release from containment.

Zion SCETs are available for each of the dominant plant damage states: (a) loss-of-coolant accidents, (b) station blackout, (c) transients including anticipated transient without scram, and (d) containment bypass. Each of the Zion SCETs were examined to determine what sequence categories would be defined. We charted event tree sequences onto the safety objective trees by indicating the mechanisms, challenges, and safety functions affected. As an example, Figure 6 is a portion of the simplified containment event tree for the station blackout transient initiator. The sequence to be charted is highlighted, uppermost sequence on the tree. Events that occur during this sequence are Preexisting Containment Leak, Steam Generator Tube Rupture, Vessel Breach, Early Containment Heat Removal, High Pressure Melt Ejection, and Core Concrete Interaction. These events have a close correspondence with the mechanisms on the safety objective trees. In addition, events on the Level 1 event trees indicate that the Inadequate Secondary Inventory, Inadequate RCS Inventory, and Non-coolable Relocation mechanisms would also be important.

Mechanisms on the safety objective trees were marked with a diagonal slash to indicate that there is an event that shows they occur during the sequence being evaluated (see Figures 7 and 8 as examples). The containment Failure to Isolate mechanism (Figure 8) is marked with a slash because the Preexisting Containment Failure event would indicate this mechanism has occurred. However, the containment Insufficient Energy

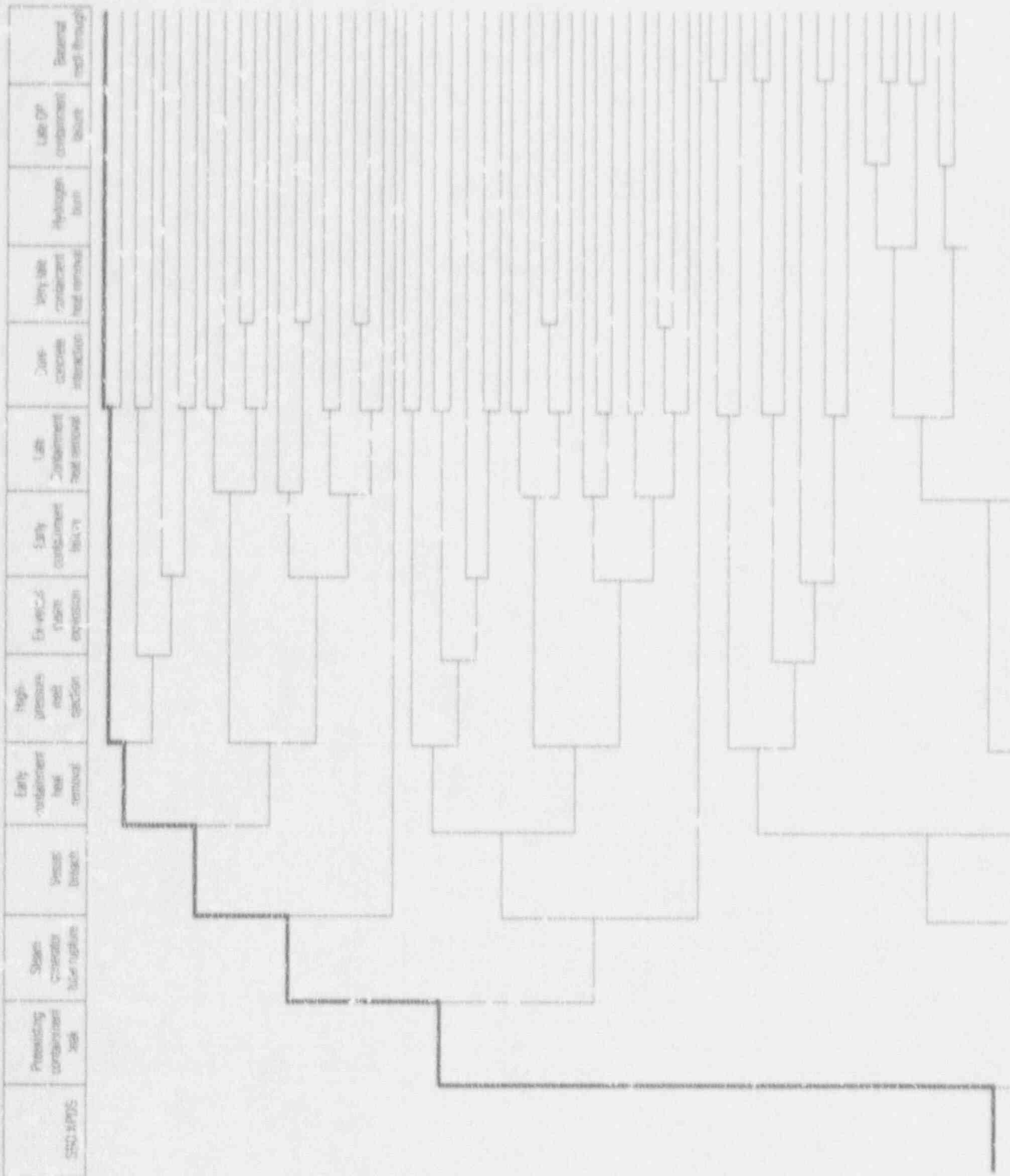


Figure 6 Simplified containment event trees for Zion, Unit 1.

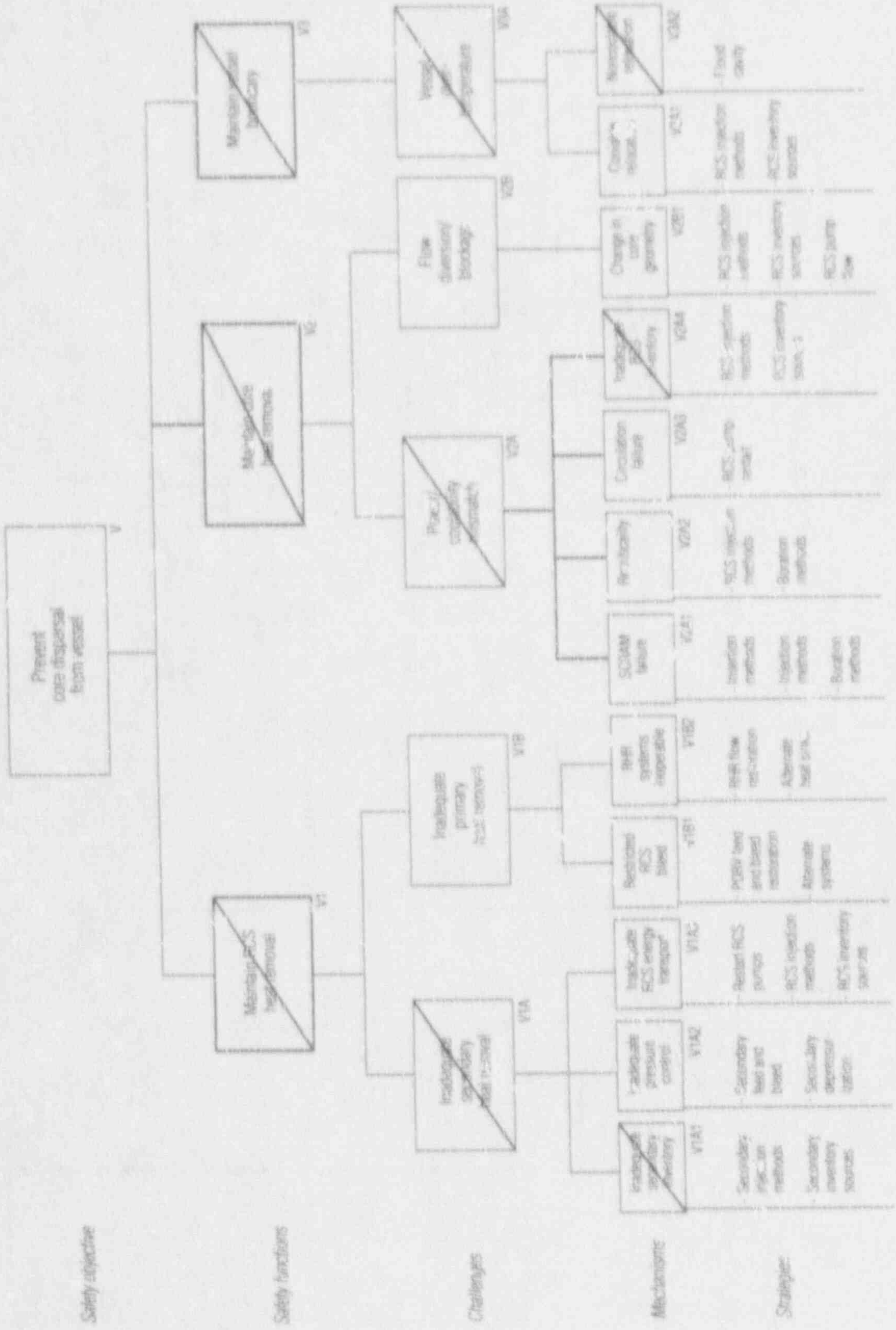


Figure 7. Sequence markings on prevent core dispersal from vessel safety objective tree.

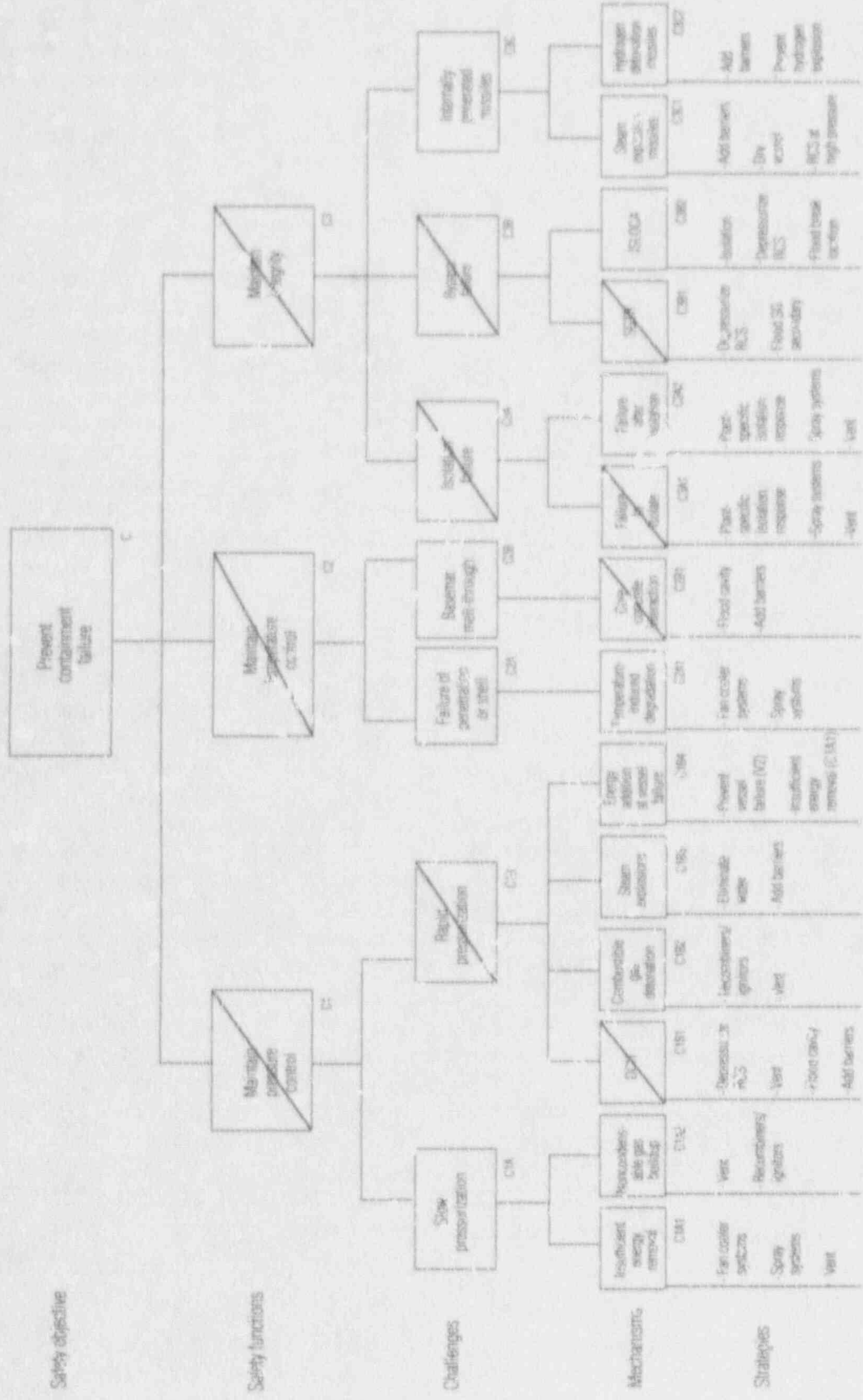


Figure 8. Sequence markings on prevent containment failure safety objective tree.

Removal mechanism is not shown with a slash because Early Containment Heat Removal is shown on Figure 6 to be active for this sequence. The challenges that are caused by these mechanisms and the safety functions that are being challenged were also marked with a slash to highlight which safety functions would require accident management actions. Based on the proposed sequence categorization method, this sequence would be given the following designators: Inadequate Secondary Inventory, Inadequate RCS Inventory, Noncoolable Relocation, Direct Containment Heating (DCH), Core Concrete Interaction, Failure to Isolate, and Steam Generator Tube Rupture. Examination of the remaining 62 sequences displayed in Figure 6 show that no two sequences would have the same designator. Although sequences on event trees for other plant damage states may have similar designators, the number of sequence categories would still remain very large using this categorization method. We concluded, therefore, that this method of categorizing sequences would not meet our objective to significantly condense the severe accident sequence information.

Since the PRA has the sequences categorized into plant damage states and accident progression bins, they were considered as a potential sequence categorization method for accident management. Although this method produced a relatively small number of categories, they are very broad and therefore make it difficult to develop insights into what safety functions are being challenged, what strategies might be effective, or what instrumentation should be monitored to help identify the challenges to safety functions or the effectiveness of preventive or mitigative strategies.

Two alternative methods were identified that categorize severe accident behavior into a form that satisfies the objective of this substep. For the first method, we concluded that the events on the event trees can be used as categories because all sequences comprised a series of these events. This method would produce a reasonable number of categories and could be used to identify and evaluate possible accident management strategies that could prevent or mitigate the effects of each event. We chose to call these categories assessment categories, rather than sequence categories, because they allow assessment of the current accident management conditions and future accident management improvements for all sequences included in a particular event. The second method uses the mechanism from the safety objective trees as assessment categories. We reasoned that the mechanisms represent unique identifiers of challenges to plant safety functions and that strategies with the potential to prevent or mitigate challenges to safety functions can be related directly to these mechanisms. There is also good correspondence between the events on the event trees and the mechanisms on the safety objective trees. To better understand the relationship between the events from the event trees and the mechanisms from the safety objective trees, we charted the events associated with the sequences from the simplified containment event trees onto the safety objective trees in the same way, as shown in Figures 7 and 8.

To help identify relationships between individual assessment categories (events charted as mechanisms) in the sequences, a hyper-text tool was used to track the relationship among the mechanisms because more than one mechanism (or event) could be causing challenges to plant safety functions for a PRA sequence. An understanding of the relationship among assessment categories may be important, since strategies that may be beneficial for one assessment category must be checked to ensure that they do not cause negative effects for related assessment categories. The hyper-text tool tallied the co-occurrence of the mechanisms causing challenges to the safety functions for the assessment categories. For example, for the steam generator tube rupture assessment category, we found that failure to isolate containment co-occurred 27 times, and direct containment heating co-occurred 39 times. It is intended that this information be used in later steps to assess the potential negative effects of proposed strategies and provide insights into how strategies might be combined to maximize benefits.

The mechanisms that would represent the assessment categories are listed in Table 3. This

Table 3. Assessment categories based on Safety Objective Tree Mechanisms ("+" relates to Level 1 events from Zion; "•" corresponds with events on simplified containment event trees from Zion)

Prevent Core Dispersal from Vessel Safety Objective Tree

+ Inadequate Secondary Inventory
+ Inadequate Secondary Pressure Control
Inadequate RCS Energy Transport
+ Restricted RCS Bleed
+ (RHR) Systems Inoperable
+ SCRAM Failure
Recriticality
RCS Circulation Failure
+ Inadequate RCS Inventory
Change in Core geometry
Coolable Relocation
• Noncoolable Core Relocation

Prevent Containment Failure Safety Objective Tree

• Insufficient Containment Energy Removal (late and very late recovery)
• Noncondensible Gas Buildup
• Direct Containment Heating
• Combustible Gas Detonation
• Steam Explosions
Energy Addition at Vessel Failure
• Temperature-induced Degradation
• Core Concrete Interaction
• Failure to Isolate
Failure After Isolation
• Steam Generator Tube Rupture (SGTR)
• Interfacing System Loss-of-coolant Accident (ISLOCA)
Steam Explosion Missiles
Hydrogen Generated Missiles

list includes assessment categories appropriate for prevention and mitigation of severe accidents. Categories based on the Mitigate Fission Product Release from Containment safety objective tree are not listed because there were no events from the event trees that had corresponding mechanisms on this tree, and there was no apparent advantage for considering them separately.

We concluded that both methods of defining severe accident assessment categories could be used in the later steps of the prototype process. However, we prefer using assessment categories based on the safety objective tree mechanisms because the trees show the relationship between the plant safety objectives, the assessment categories (mechanisms), and potential and final strategies. Understanding these relationships should assist in identifying plant accident management capabilities and assessing potential accident management strategies. Based on these observations, the individual mechanisms on the safety objective trees were selected for use as assessment categories for the remainder of the steps in the prototype process.

Substep 2.2. Select Sequences to Categorize

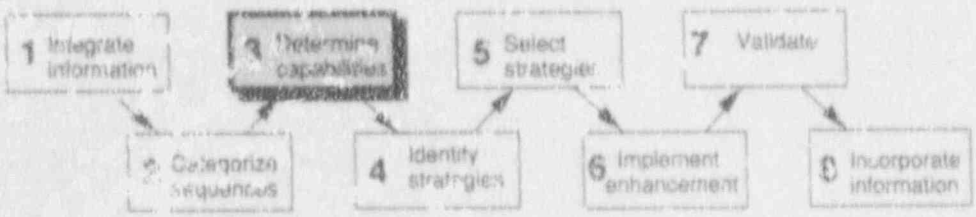
The purpose of this substep is to reduce the number of sequences so they can be reviewed and categorized with limited resources and within a reasonable time frame. Since categorization of sequences was eliminated from the process in the previous substep, this substep is no longer necessary and it will be eliminated.

Substep 2.3. Select Typical Sequences

The objective of this substep is to identify "typical sequences" for each sequence category. Criteria proposed to guide the selection of these sequences are: (1) the consequences of the sequence, (2) the sequence timing, and (3) the harsh environments that may affect equipment and personnel. The prototype process proposed using these typical sequences in later steps as the basis for analysis of proposed strategies.

Although the criteria provided for selection of typical sequences appears to be pertinent, we concluded that sequence selection at this point in the process is not appropriate for several reasons. First, the assessment categories are not strongly dependent on sequences so analysis of strategies will be made independent of the sequences whenever possible. Second, limiting conditions will vary among the strategies and there is no way of knowing what potential strategies will be selected at this point in the process. There may be some strategies that will not require analysis using typical sequences from all of the sequence categories. Selection of sequences would therefore waste time and resources if performed at this point in the process. The intent of this substep will be moved into Substep 5.1. It will be modified to make it dependent on the analysis needs for the identified potential strategies.

Step 3. Identify Accident Management Capabilities for Assessment Categories



The objective of this step is to identify the plant and personnel capabilities that could supplement the response of existing safety and support systems or replace them if they have failed. Assessment of capabilities in the following five areas was recommended in the prototype process:

Substep 3.1. Procedures and Guidelines

Identify existing procedures and guidelines (or guidance) that are used by the station operations staff and technical support teams for each of the assessment categories.

Substep 3.2. Delineate Decision-Making Authority or Responsibilities

Obtain current documentation of the roles of the personnel involved in accident management. Then, identify the key roles of the personnel for their areas of responsibility and evaluate how these roles and job duties could be extended to address severe accidents for each assessment category.

Substep 3.3. Identify Equipment

Identify the equipment important for each sequence category together with their intended functions. Identify alternate equipment that could be used to supplement or replace the failed systems. The alternate systems considered should not be limited to safety grade systems. Systems that can be repaired on site should be identified with an estimated repair time and the procedures to effect the repair.

Substep 3.4. Identify Instrumentation

Identify the key instrumentation in the plant that would be needed to define the initiation of an accident and also follow its progression. Determine whether alternate instrumentation could supply similar or identical information.

Substep 3.5. Identify Training

For each of the sequence categories, identify the training programs that are given to the station operations and technical support teams for understanding accident behavior and their roles and functions during an emergency. Perform an assessment to determine limitations in the present training program that could restrict the effectiveness of the staff.

A specific table format was suggested in Step 3 of the prototype process to organize and display information on accident management capabilities for each of the five areas listed in Substeps 3.1 through 3.5. The table has columns corresponding to the five areas listed in Substeps 3.1 through 3.5 and rows for the following five phases of an accident: Phase 1-Accident initiation to core uncovery, Phase 2-Initiation of core melt to relocation into lower plenum, Phase 3-Lower head failures, Phase 4-Containment heatup and pressurization and Phase 5-Containment failure and fission product release. We attempted to use the recommended table but found that its structure made the identified information difficult to present and understand. Major problems included inability to display and understand the information when put in the recommended column format and difficulties in subdividing the assessment categories into the five accident phases.

Since the prototype process was not adequate, two possible approaches for identifying accident management capabilities were developed and assessed. Our initial approach was to combine team discussions and brainstorming with a modified table format to organize the results. The second approach was to develop and ask a set of questions that required detailed answers to organize and provide structure to the identification process. Both approaches relied on the expertise of a team comprising personnel with operations, severe accident analysis, thermal-hydraulic safety analysis, procedures, training, human factors, PRA, and accident management experience to develop the desired information. In both cases, the amount of information was limited because some documentation was not available. This step would have produced better information on plant capabilities, and would have taken much less time, if personnel with detailed knowledge of plant hardware and operations had been participating.

For the initial approach, the table for the prototype process was to use the five areas described in substeps 3.1 through 3.5 as the basis for organizing and displaying plant capabilities. For a particular assessment category, ideas for the use of plant capabilities for each of the five areas were discussed in a meeting of team members. Proposed plant capabilities were described as well as the purpose or use of these capabilities. Results describing proposed additional uses of the plant capabilities were therefore an important part of the results. We only reviewed a sampling of assessment categories because our primary objective is to evaluate the capabilities of the prototype process, not to develop a complete accident management plan.

Table 4 is an example of the information for the Steam Generator Tube Rupture assessment category, which was identified in the PRA as a potential contributor to risk. Related assessment categories and containment failure modes identified by the hyper-text tool as co-occurring are also listed. Capabilities are then described for the five areas, recognizing that there are existing procedures and equipment to mitigate the effects of a steam generator tube rupture. Capabilities that would support other possible mitigative actions are also described. The decision making and training areas are not completed because there was insufficient information available. Appendix A presents the tables developed for all of the assessment categories that we reviewed.

After a thorough review of the capabilities tables developed using our initial approach, we concluded that the type of information and the amount of detail presented were not sufficiently detailed for the remaining steps of the prototype process. To provide the desired detail, a more structured approach was developed using a question-answer format for each of the five areas. All questions were structured so that the answers would not be a simple yes or no, but would contain specific, detailed information on plant capabilities. We found that answering the questions not only focused the attention of the team members on the existing plant capabilities, it also helped them to become aware of opportunities to improve or supplement these capabilities. Consequently, questions were modified or added to identify how plant hardware and personnel might be used in new or unique ways to provide additional accident management capabilities. Table 5 lists the questions used in our assessment of the current capabilities. These questions are general and could be applied for other commercial reactor plant types.

Capability questions for selected assessment categories were answered. Individual team members were assigned to answer questions for specif-

Table 4. Information on plant accident management capabilities (developed by team brainstorming) for one assessment category.

Accident Management Capabilities

Assessment Category Steam Generator Tube Rupture

Related Categories

Late Recovery of Containment Energy Removal, Very Late Recovery of Containment Energy Removal, Temperature Induced Degradation, Direct Containment Heating, Steam Explosions, Combustible Gas Detonation, Failure to Isolate

Containment Failure Modes

Alpha Mode Failure, Basemat Melt Through, Late Containment Overpressure

1. **Procedures**

   a. Current Procedures

   Extensive procedures exist to deal with steam generator isolation and depressurization of the RCS.

   b. Possible Additional Procedures

   Provide guidance on strategies that can be used if isolation of the affected steam generator fails. For example:

   - Increase the inventory in the steam generator to submerge the rupture location and scrub fission products.

   - Consider possible problems if there is a rupture of a relatively large number of tuber. For example, there would be a much earlier depletion of the BWST.

   Provide guidance on ways of estimating where the release location is and the quantity of fission products being released.

2. **Decision Making**

   a. Currently Described Decision Making and Authority

   Insufficient information available

   b. Additional Decision Making That May Need Clarification

   Insufficient information available.

Table 4. (Continued)

3. Equipment

a. Existing Equipment

Steam generator dump valves, pressurizer PORVs, all valves necessary for steam generator isolation, normal and auxiliary feedwater pumps and related equipment.

b. Potential use of equipment not specified

Normal or auxiliary feedwater systems used to submerge the tube break location. Diesel-driven fire water pumps or portable pumps should also be considered. Exercise caution in controlling the level in the steam generator for some plants to avoid flooding the steam line, which would cause it to fail. Alternate methods of preventing steam line failure could also be considered, such as additional analysis and, possibly, the placement of additional supports.

Fire sprays, both existing and augmented, used on failed dump valves and safety relief valves to reduce the amount of fission products escaping from the steam generator(s). The need for protective clothing and equipment should be considered if strategies call for personnel actions near points of release. Positioning this equipment near the locations where it will be needed should be considered.

4. Instrumentation

a. Existing Instrumentation

Steam generator pressure, level, temperature; RCS pressure; Reactor Vessel Level Monitoring System (RVLMS); hot leg temperature; plant and site radiation monitors

b. Potential Instrumentation

Indications that the steam generator PORVs or SRVs are stuck open. For example, downstream temperatures, videos of atmospheric release points, and radiation monitors. All instrumentation that could be used in mitigating the effects of a steam generator tube rupture should be properly grouped and displayed in the control room.

5. Training Capability

a. Current Training

Insufficient information available.

b. Potential Additions to Training

Insufficient information available.

6. Possible Interactions with Related Assessment Categories

a. Similar to an ISLOCA

b. Desire to depressurize RCS rapidly may run counter to considerations for preventing steam explosions.

Table 5. Questions for assessment of general accident management capabilities

Procedures

These questions should be applied to each assessment category. Each question would be preceded by the phrase, "For this assessment category, . . ."

1. Which of the current procedures are applicable for prevention or mitigation of the severe accident conditions?

2. What changes could be made to the current procedures and guidance to enhance the capability to prevent or mitigate the severe accident conditions?

3. If alternate systems and equipment are important, what procedures and guidance exist to facilitate their use?

4. What procedures consider long-term recovery actions that may be necessary for accident management? (Examples would be establishing long-term core cooling or long-term containment cooling.)

5. What procedures and guidance provide instructions on how to evaluate information, either from instrumentation or from other sources, that is apparently conflicting?

6. What additional procedures could be added to enhance the capability to prevent or mitigate plant damage?

Decision Making

These questions should be applied to each assessment category. Each question would be preceded by the phrase, "For this assessment category, . . ."

1. What are the current assignments of responsibility and authority for decision making?

2. How were the currently used lines of communication between the control room and the technical support center and other emergency response and planning facilities evaluated and validated?

3. To what extent is long-term accident management considered in the decision-making process, including the basis for determining when the recovery phase is complete?

4. What decision making is defined in the current procedures and guidance?

5. What decision points are identified for expediting administrative controls to facilitate the repair or recovery of equipment?

6. What guidance is given to decision makers for prioritizing alternate actions, identifying and avoiding potential negative effects, and evaluating long-term plant recovery?

7. What changes in the assignments of responsibility and authority could be made to increase the capability to prevent or mitigate plant damage?

Equipment

These questions should be applied to each assessment category. Each question would be preceded by the phrase, "For this assessment category, . . ."

Table 5. (Continued)

1. What existing plant equipment could be used to perform the function of failed safety systems, for example, non-safety-grade equipment that could supply water, or jumpering to make available alternate sources of power?

   a. What are the ultimate operating limits for the existing equipment that could be used as alternates to safety-grade equipment?

2. What provisions could be made to facilitate repair or replacement of failed equipment for this assessment category? Consider both the availability of parts and the capability to gain access to failed equipment exposed to severe accident environments.

   a. What replacement equipment and spare parts have been identified, including their location and means of transport and installation within the time available?

   b. What advance preparation of hardware, for example, spool pieces, pre-positioning of equipment, etc., would facilitate the use of existing alternate equipment to provide a significant increase in equipment capability?

   c. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

3. What resources can be managed, such as battery power or borated water, to prevent or delay severe accident consequences, and what is the technical basis for their use?

   a. Is equipment available that has the capability to replenish exhausted resources within the time frame available for recovery. Are suppliers of essential resources identified?

   b. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

4. What potential options for use of equipment from another unit have been considered and optimized?

5. What additional equipment would enhance the capability to prevent or mitigate severe accidents.

Instrumentation

These questions should be applied to each assessment category. Each question would be preceded by the phrase, "For this assessment category, . . . "

1. What instruments are necessary to identify the symptoms and applicable strategies that will enable accident management personnel to prevent or mitigate severe accident conditions?

2. What are the limitations on the instrumentation to provide needed information on plant severe accident behavior and how are they communicated to accident management personnel?

3. What means (protection from harsh environments, operator aids, etc.) have been developed to ensure existing instruments can be used under the expected severe accident conditions?

4. What methodologies have been established to identify unreliable data from instruments under severe accident conditions?

5. What changes could be made to the current instrument systems to enhance the capability to prevent or mitigate severe accident conditions?

Table 5. (Continued)

6. What additional instruments would enhance the capability to prevent or mitigate severe accident conditions?

Training

These questions should be applied to each assessment category. Each question would be preceded by the phrase, "For this assessment category, ... "

1. How does the training provide personnel involved in accident management with an understanding of the possible severe accident plant behavior, and is this training given at the proper levels and in the detail required for all personnel involved in accident management?
2. How are all personnel involved with the training simulator made aware of the limitations in representing severe accident conditions, and is it made clear when the simulation is no longer valid?
3. How are personnel trained to proceed if instruments give what appears to be conflicting readings?
4. How does the training for all personnel involved in accident management ensure that all important actions or decisions for severe accident management are included?
5. What training is provided for all accident management personnal on the possible limitations of equipment, instrumentation, and plant information?
6. What additional training is provided to implement the use of alternative systems and equipment?
7. How do drills and simulator exercises consider the following potential restrictions: inhibited access to equipment as a result of high temperature or radiation levels, limited lighting or loss of resources such as electricity, and constraints on the availability of personnel with the proper skills?
8. What are the changes that have been made to the current training program to enhance the capability to prevent or mitigate plant damage?
9. What additional training has been provided to enhance the capability to prevent or mitigate plant damage?

ic categories, and their answers were then reviewed by all team members to obtain additional information in their individual areas of expertise. We found that answering some questions required more information than was available to the team members. This lack of information is particularly evident for questions concerning training and decision making.

An example of the answers for the Steam Generator Tube Rupture assessment category is provided in Table 6. The answers developed for all reviewed assessment categories are presented in Appendix B. The information developed in answering these questions is our best understanding of the current plant capabilities together with possible changes that could improve the current accident management situation, based on the information available. Information presented in the answers contains details that may be difficult to understand without a working knowledge of the plant procedures and operations. Since these answers are only intended to serve as examples, the procedures and operations information necessary for completely understanding them are not presented in this report.

Table 6. Information on accident management capabilities (developed by question set) for one assessment category.

Assessment Category Questions
for Steam Generator Tube Rupture

Procedures

These questions should be applied to each assessment category. Each question would be preceded by the phrase, "For this assessment category, . . ."

1. Which current procedures apply to prevent or mitigate the severe accident conditions?

   Answer:

   Procedure E-3 deals directly with steam generator tube rupture (SGTR).

   Enter E-3 directly or guided there by E-0, E-1, E-2, ECA-2.1, FR-H.3, ES-1.2.

   All these deal with aspects of SGTR recovery: ES-3.1, ES-3.2, ES-3.3, ECA-3.2, ECA-3.3, ECA-3.1.

2. What changes could be made to the current procedures and guidance to enhance the capability to prevent or mitigate the severe accident conditions?

   Answer:

   Step 18 of E-0 must be reached to get referred into E-3. For other procedures the following steps must be reached to be referred to E-3: Step 4 in E-1, Step 5 of E-2, Step 5 in ECA-2.1, Step 7 in FR-H.3, and Step 4 of ES-1.2.

   Alternate procedures were examined for other transients similar to the steam generator tube rupture to see if they would "direct out" of that procedure and into the SGTR procedure. These procedures do a reasonably good job. However, considering primarily the SGTR, an improvement could be made to reach "direct-out" steps earlier in the procedures, especially in E-0. To ultimately decide the trade-off between an earlier or later "direct-out," risks should be compared for competing events.

   The procedures are primarily written for design basis conditions. They do not cover situations very well when the plant is experiencing core damage.

   Procedures could call out specific valve numbers, breaker numbers, equipment numbers (e.g., Step 5 of E-3) to increase the likelihood of successful implementation.

3. If alternate systems and equipment are important, what procedures and guidance exist to facilitate their use?

   Answer:

   Procedures ES-3.1, -3.2, -3.3 and ECA-3.1, -3.2, -3.3 do a good job of covering alternate methods and equipment for various stages of SGTR recovery. Once again, the procedures do not cover actions if there is significant core damage. The procedures do not specifically identify alternate equipment so much as they provide steps that incorporate equipment.

4. What procedures consider long-term recovery actions that may be necessary for accident management? (Examples would be establishing long-term core cooling of long-term containment cooling.)

Table 6. (continued)

Answer:

None were judged to be adequate for severe accident management, although the series ES-3.1, -3.2, -3.3 and ECA-3.1, -3.2, -3.3 may address recovery. They do cover core and containment cooling actions for design basis conditions that should be considered short to intermediate term recovery actions for severe accidents.

5. What procedures and guidance instructing how to evaluate information, either from instrumentation or from other sources, apparently conflict?

Answer:

All procedures are good at specifying parameters that help to diagnose and guide, but none seem to prioritize or give guidance for conflicting evidence. They do address it in that if a person follows a course of action based on faulty evidence, the procedures are designed to bring him or her back into line with additional information. The trouble is, valuable time is lost.

6. What additional procedures could be added to enhance the capability to prevent or mitigate plant damage?

Answer:

New procedures could be added to provide guidance on what specifically are the most reliable indications of an SGTR and how to interpret and diagnose them. (This is perhaps more of a training function-though a procedure for training should exist in any case.)

Procedures would be needed for severe accidents that start with core melt. Procedures become vague at core melt conditions. Directions to depressurize do not tell the operator how to depressurize. They just say "depressurize" (see ES-1.2, Step9).

Decision Making

These questions should be applied to each assessment category. Each question would be preceded by the phrase, "For this assessment category, . . . "

1. What are the current assignments of responsibility and authority for decision making?

Answer:

Information available is insufficient. Access to emergency plan organization, etc. would give more details. It appears (as expected) that early in the transient, up to and including the approach to a severe accident, that the Shift Supervisor would be in charge--beyond that, there is not enough information.

2. How were the currently used lines of communication between the control room and the technical support center (TSC) and other emergency response and planning facilities evaluated and validated?

Answer:

Information available is insufficient. Occasionally there are steps referring to TSC, etc.

3. To what extent is long-term accident management considered in the decision making process, including the basis for determining when the recovery phase is complete?

Table 6. (continued)

Answer:

Information available is insufficient. Access to the E-Plan organization and procedures would reveal some of the information. At some other plants, this was fairly well detailed.

4. What decision making is defined in the current procedures and guidance?

Answer:

Information available is insufficient. Complete procedures would be needed.

5. What decision points are identified for expediting administrative controls to facilitate the repair or recovery of equipment?

Answer:

Available EOPs do not provide much guidance, but some of the E-plan procedures might, based on the content of E plans for other plants.

6. What guidance is given to decision makers for prioritizing alternate actions, identifying and avoiding potential negative effects, and evaluating long-term plant recovery.

Answer:

Information available is insufficient. No guidance could be found in information that we have. Procedures are designed to lead down a path and if the wrong path is chosen, they appear to do a good job of leading you out and into the correct path. How this would work for severe accidents is not clear.

7. What changes in the assignments of responsibility and authority could be made to increase the capability to prevent or mitigate plant damage?

Answer:

Information available is inadequate. Without access to the full E-plan and E-PIPs, it is not possible to adequately answer this question.

Equipment

These questions should be applied to each assessment category. Each question would be preceded by the phrase, "For this assessment category, . . ."

1. What existing plant equipment could be used to perform the function of failed safety systems, for example, non-safety-grade equipment that could supply water, or jumpering to make available alternate sources of power?

Answer:

The procedures do not appear to address anything that requires jumpering. In some areas, it gives guidance to accomplish a requirement if the first attempts fails. This includes operation of equipment and other ways to operate the same equipment (e.g., Step 29 in E-3). For example, between Step 8 and 9 of E-3 "Caution" points out AOP-4.3 to use Service Water to supply auxiliary feedwater (AFW). Step 14 uses Condenser and Steam Dumps. There are two situations that are not covered where existing plant equipment could be used: (1) Use of AFW to submerge the break to scrub fission products and (2) Use of fire sprays to wash down releases from steam generator dump valves and safety relief valves.

Table 6. (continued)

a. What are the ultimate operating limits for the existing equipment that could be used as alternates to safety grade equipment?

Answer:

Operating limits are not available to us. Additional information would be necessary to answer this question.

2. What provisions could be made to facilitate repair or replacement of failed equipment for this assessment category. Consider both the availability of parts and the capability to gain access to failed equipment exposed to severe accident environments?

Answer:

Not much is said in the EOPs about this, other than, e.g., "If you don't have AC power, then repair it," etc. It is not clear that repair and replacement considerations during accidents are proceduralized. They may be part of the normal process for maintenance but they are not referenced.

a. What replacement equipment and spare parts have been identified, including their location and means of transport and installation within the time available?

Answer:

Information available is insufficient to answer this question.

b. What advance preparation of hardware, for example, spool pieces, prepositioning of equipment, etc., would facilitate the use of existing alternate equipment to provide a significant increase in equipment capability?

Answer:

Information available is insufficient to answer this question.

c. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

Answer:

Information available is insufficient to answer this question.

3. What resources can be managed, such as battery power or borated water, to prevent or delay severe accident consequences, and what is the technical basis for their use?

Answer:

Step 39 of E-3 directs one to Appendix C, page 30, to shutdown unneeded equipment for power conservation, but conservation of other resources are not identified.

a. Is equipment available that has the capability to replenish exhausted resources within the time frame available for recovery. Are suppliers of essential resources identified?

Answer:

The same procedure identifies refilling the BWST, but no details are given on how to carry this out.

Table 6. (continued)

3. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

Answer:

Information available is inadequate.

4. What potential options for use of equipment from another unit have been considered and optimized?

Answer:

This plant is a double unit and has opportunity for one unit to supply the other, but procedures don't indicate any formal approach for SGTR.

5. What additional equipment would enhance the capability to prevent or mitigate severe accidents?

Answer:

No additional equipment beyond that discussed in the answers to previous questions was identified. Pumps or other means of adding water to the steam generator secondary side could be used to reduce the release of fission products.

Instrumentation

These questions should be applied to each assessment category. Each question would be preceded by the phrase, "For this assessment category. . . ."

1. What instruments are necessary to identify the symptoms and applicable strategies that will enable accident management personnel to prevent or mitigate severe accident conditions?

Answer:

This instrumentation is taken from procedure E-3. Some of the other recovery procedures, such as ES-3.1, -3.2, -3.3, and ECA-3.1, -3.2, -3.3, as well as the general procedures, will require some additional information. Following are the instruments identified: condenser air ejector or steam generator (SG) blowdown radiation detector, SG level, main steamline radiation monitor, SG chemistry samples, SG pressure, MSIV and bypass indicators, PORVs and block valve position indicators, feed flow, AC buses power indicators, SI status indicators (various blocks, actuation status etc.), air compressor running indicators and status of air system, indication of pressurizer heaters and sprays, core exit thermocouples, steam dump and condenser status indicators, hot leg resistance temperature detector (RTD), primary pressure, pressurizer level, trip status of rods and reactor coolant pumps (RCPs), status of valves in auxiliary spray lineup, status of charging pump, charging flow, charging in pressure, status of residual heat removal (RHR) pumps and valve lineups, RHR heat exchanger, status of NVSW valves, charging flow and valve lineup status, spray pumps status, containment spray valve positions, VCT makeup control, diesel generator status, RCP cooling status, reactor coolant pump (RCP) labyrinth ΔP, Auxiliary Steam status, waste water treatment status, condenser hotwell overflow to CST isolation status, source range nuclear detector, intermediate range detectors, containment pressure and temperature, accumulator levels and pressures. Service water status indications (including pump, valve pressure, and flow indications).

2. What are the limitations on the instrumentation to provide needed information on plant severe accident behavior and how are they communicated to accident management personnel?

Table 6. (continued)

Answer:

We do not have access to documents with a discussion of instrument limitations for either design basis or severe accidents. It is uncertain whether an analysis for severe accident conditions has been performed.

3. What means (protection from harsh environments, operator aids, etc.) have been developed to use existing instruments under the expected severe accident conditions?

Answer:

Information available is inadequate, except that safety grade instrumentation are required to meet environmental conditions based on the design basis accident. How this relates to severe accident conditions is not in the information available for this plant.

4. What methodologies have been established to identify unreliable data from instruments under severe accident conditions?

Answer:

Information available is insufficient.

5. What changes could be made to the current instrument systems to would enhance the capability to prevent or mitigate severe accident conditions?

Answer:

Information available is insufficient to answer this question. It is not clear whether the instrument systems are inadequate, so it is difficult to identify changes. There is the possibility that the instruments should be protected from a harsh severe accident environmental.

6. What additional instruments would enhance the capability to prevent or mitigate severe accident conditions?

Answer:

Indications that steam generator dump valves or safety relief valves are stuck open, e.g., downstream temperatures, television cameras to monitor atmospheric release points, radiation monitor.

Training

These questions should be applied to each assessment category. Each question would be preceded by the phrase, "For this assessment category, . . ."

1. How does the training provide personnel involved in accident management with an understanding of the expected plant behavior, and is this training given at the proper levels and in the detail required to facilitate decision making?

Answer:

Information available is inadequate.

2. How are all personnel involved with the training simulator made aware of the limitations in representing severe accident conditions and is it made clear when the simulation is no longer valid?

Table 6. (continued)

Answer:

Limitations on performance are noted in Discrepancy Reports. During testing if invalid performance is noted, it is identified and reported. These reports were not available. The degree to which these limitations would apply for the severe accident conditions identified as important for the plant would depend on whether a detailed evaluation had been performed of the simulator capabilities for the severe accident sequences identified as important for the plant.

3. How are personnel trained to proceed if instruments gives what appears to be conflicting readings?

   Answer:

   Information available is inadequate.

4. How does the training for all personnel involved in accident management ensure that all important actions or decisions for severe accident management are included?

   Answer:

   Information available is inadequate.

5. What training is provided for all accident management personnel on the possible limitations of equipment, instrumentation, and plant information?

   Answer:

   Information available is inadequate.

6. What additional training is provided to implement the use of alternative systems and equipment?

   Answer:

   Information available is inadequate.

7. How do drills and simulator exercises consider the following potential restrictions: inhibited access to equipment as a result of high temperature or radiation levels, limited lighting or loss of resources such as electricity, and constraints on the availability of personnel with the proper skills?

   Answer:

   Drills and simulations may not incorporate actual real-time performance attributes or adequate representation of the limiting factors of radiation fields, lighting or loss of other resources. EOP inspections by NRC does look at this and the AOP/EOP should incorporate this information in the actions.

8. What are the changes that have been made to the current training program to enhance the capability to prevent or mitigate plant damage?
   Answer:

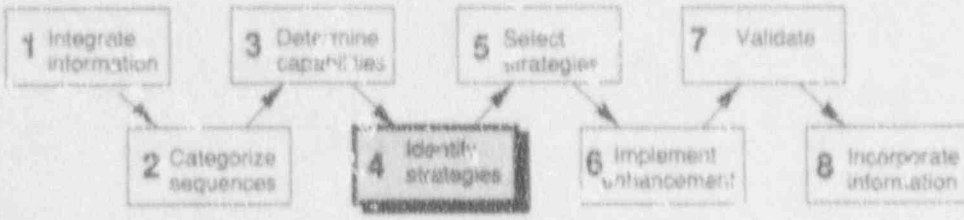
   Training material was not available for evaluation. In general, a more in-depth approach to problem-solving techniques and accident management courses that provide decision making techniques would be beneficial.

9. What additional training has been provided to enhance the capability to prevent or mitigate plant damage?

   Answer:

   Information available is inadequate.

Step 4. Identify Potential Strategies



The objective of Step 4 is to identify accident management strategies that have the potential to prevent or mitigate the consequences of the severe accidents in the assessment categories identified in Step 2. There are three substeps in the prototype process for Step 4: (1) determine where additional strategies would be beneficial, (2) develop proposed strategies, and (3) identify proposed strategy characteristics. In the first substep, the challenges to plant safety functions are reviewed to identify important phenomenological behavior, personnel actions, or hardware performance that are influencing these challenges. The second substep proposes identifying potential strategies by examining how plant capabilities can be used to eliminate challenges to safety functions and by reviewing the applicability of strategies from sources outside of the plant. Information on implementation of the proposed strategies is documented in the final substep.

We found it more efficient to combine Substeps 1 and 2 because the questions and answers for the assessment categories developed during Step 3 already integrated the necessary information. The team reviewed each answer for the assessment categories to identify potential new strategies in the five areas: procedures and guidelines, decision making, equipment, instrumentation, and training. Consideration was also given to repair or replacement of existing equipment, conservation of resources, capabilities of plant personnel, use of alternate equipment, and use of alternate resources. A list of potential new strategies was developed based on this review. This list was then compared to a list of strategies from sources outside of the plant, which was compiled primarily using the "A and B strategies" developed by the NRC (Luckas and Vandenkieboom 1990) and strategies that had been considered and evaluated in Sweden, Germany, and France. In some cases, the strategies from external sources required major hardware changes, which is not within the definition of accident management in the United States, but they were included in the list to highlight strategies that others consider important.

About thirty-five potential strategies were identified for all assessment categories using the process. These potential strategies, listed in Table 7, cover a wide range of possible changes or additions to plant procedures, hardware, or analysis aids. Several involve using the capabilities of the second unit at the Zion site to provide a source of additional coolant injection or provide additional water to lengthen the period of injection. Most modifications would not involve the addition of major pieces of hardware. However, a major exception is the proposed use of containment venting, which is included to reflect an accident management approach common in Europe. The number of potential strategies would likely have been larger if there had been more information available in the areas of decision making and training.

The intent of the final substep is to describe the potential strategies in sufficient detail that further assessments can be performed. Since identification of strategy characteristics for all of the potential strategies would require a substantial amount of time, a sample of six potential strategies were selected to cover a variety of different strategy types. The potential strategies selected for development of more detailed information are as follows:

- Reactor vessel cavity flooding system (Direct Containment Heating, Strategy 2; Core Concrete Interaction, Strategy 2)

Table 7. Potential strategies for selected assessment categories.

Potential Strategies for Steam Generator Heat Removal

1. Depressurize the steam generator and use diesel driven firewater system pumps to provide feedwater to the steam generator.

2. Depressurize the steam generator and use low head portable pumps or fire engines to provide feedwater to the steam generator.

3. Provide the capability (procedures and hardware) to cross tie the auxiliary feedwater from the second unit to provide feedwater to the steam generator.

4. Provide the capability (procedures and hardware) to cross tie the auxiliary feedwater to the condensate storage tank of the second unit.

5. Provide alternate water sources, for example, potable water, for refilling the condensate storage tank.

Potential Strategies for RCS Inventory Control

1. Implement procedure changes to access other water sources, for example, primary water storage tank or demineralized water storage tank (boration of this water may be necessary).

2. Modify the reactor coolant pump seals and the injection systems to prevent inventory loss under accident conditions.

3. Provide the capability (procedures and hardware) to cross tie the safety injection systems from the second unit to provide injection to the RCS.

4. Provide the capability (procedures and hardware) to cross tie the safety injection systems to the borated water storage tank of the second unit.

5. Identify portable pumps and make arrangements to transport them to the facility and provide connections that will allow them to inject into the RCS.

Potential Strategies for Containment Heat Removal

1. Develop procedure modifications (and possibly some hardware changes) to tie service water into the fan cooler heat exchangers.

2. Use diesel-driven fire pumps to supply water to the fan cooler heat exchangers.

3. Enable service water and, possibly, component cooling water to be shared between units during accidents.

4. Provide the capability (procedures and hardware) to align the diesel driven spray pump to the containment sumps.

5. Provide the capability (procedures and hardware) to align the RHR pumps to the containment spray system.

6. Install a filtered containment venting system similar to those on European reactors (Sweden, Germany, France)

Table 7. (continued)

Potential Strategies for Direct Containment Heating (DCH)

1. Add information to the procedures in the form of a caution or a note to alert the operators to conditions that indicate the approach to DCH and potential consequences, and discuss strategies that could mitigate the effects of DCH including RCS depressurization and the possible effectiveness of cavity flooding.

2. Flood the water vessel cavity to delay or prevent lower head failure and to cool the effluent of a high-pressure core melt ejection.

3. Add a large capacity vent system (patterned after the Swedish or German designs).

4. Install barriers along the release path from the reactor cavity to other parts of the containment to reduce core dispersion into the containment.

5. Install instrumentation to indicate lower head temperature and analysis aids for predicting lower head failure time. Both could be used to indicate when strategies should be initiated, for example, cavity flooding.

Potential Strategies for Combustible Gas Burn

1. If hydrogen is detected as increasing through the alarm response procedures, steps should be added to enter SOI-9, which would initiate early hook-up of the recombiners and other actions that could be effective against hydrogen deflagration and detonation.

2. Strategies such as igniters inside the containment or venting of the containment should be considered since there are restrictions on the use of recombiners when containment pressure exceeds 10 psig or hydrogen concentration exceeds 4%.

3. Develop an analysis aid to predict steam, hydrogen, and oxygen concentrations to estimate the time that the hydrogen concentration will reach deflagration and detonation limits.

4. A dedicated power source should be made available to power the recombiners so that they are available during station blackouts.

5. Develop the capability (procedures and hardware) to inert the containment to reduce the likelihood of combustible gas burns.

Potential Strategies for Core Concrete Interaction (CCI)

1. Add information to the procedures in the form of a caution or a note to alert the operators to conditions that indicate the approach to CCI and potential consequences, and provide a discussion of strategies that could mitigate the effects of CCI, including the effectiveness of cavity flooding.

2. A cavity flooding system should be considered to limit the progression of CCI and to scrub fission products that are released during CCI.

3. Develop the capability for additional sampling to obtain carbon dioxide and carbon monoxide concentrations and an analysis aid to estimate the amount of concrete abiated (this could give an indication of the potential for basemat meltthrough).

Table 7. (continued)

Potential Strategies for Steam Generator Tube Rupture

1. Preposition fire hoses to spray expected steam generator release points (for example, the dump valve and safety relief valve release points) to reduce the release of fission products. Develop procedures for use of these firehoses.

2. Provide the capability (procedures and hardware) to cross-tie the safety injection systems to the BWST of the other unit to provide added inventory to make up for inventory lost through the steam generators which may not be in the containment.

Potential Strategies for Interfacing System Loss-of-Coolant Accident

1. Incorporate instructions in the procedures on how to integrate and interpret the following instruments to aid in ISLOCA diagnosis: specific auxiliary building area radiation alarms, auxiliary building sump levels, containment sump level, fire alarms in the auxiliary building, room or area temperatures in the auxiliary building.

2. Incorporate the capability (procedures and hardware) to cross connect the safety injection systems to the second unit borated water storage tank (BWST).

3. Develop procedural steps that will instruct the operator to conserve safety injection (SI) water resources when symptoms indicate that RCS inventory is being lost but is not showing up in the containment. Develop procedures to use these pathways.

4. Identify pathways for returning inventory from the auxiliary building sumps to the containment sump so the water can be recirculated to cool the core. Develop procedures and hardware to use these pathways.

5. Identify interfacing system valves necessary for isolation and ensure (through analysis and possible changes to actuators) that they will close for the full range of interfacing system break sizes.

- Analysis aid to project lower head failure (Direct Containment Heating, Strategy 4)
- Cross-tie of secondary Condensate Storage Tanks between units (Steam Generator Heat Removal, Strategy 4)
- Use of fire water spray to reduce off-site releases (Steam Generator Tube Rupture, Strategy 1)
- Change to procedures and instrumentation for ISLOCA (ISLOCA, Strategy 1)
- Change to procedures to provide access to other water sources (RCS Inventory Control, Strategy 4).

Once the potential strategies were identified, we followed the process proposed in the final substep to identify the strategy characteristics. Team members described the characteristics of each of these potential strategies by documenting the following information:

- Assessment categories for which the proposed strategy is expected to be used
- Plant hardware and operations necessary to carry out the proposed strategy, including changes in the traditional ways of using existing hardware or operations or additions to hardware or operations that would be needed to accomplish the strategy

- Information and instrumentation needed to determine whether the strategy is effective
- The resources needed in terms of the personnel and equipment having the capability to restore the safety functions and the water, power, air, and other resources necessary
- The expected timing of the key phenomena and the influence of this timing on the effectiveness of the strategy.

Table 8 is an example of the strategy characteristics determined for one potential strategy, Cross-tie of Secondary Condensate Storage Tanks Between Units. The identified characteristics for all six of the proposed strategies selected for evaluation are included in Appendix C. These characteristics will be used in Step 5 to evaluate and select strategies and identify enhancements.

Table 8. Example of characteristics of one proposed strategy.

Proposed Strategy Characteristics
Cross-tie of Secondary Condensate Storage Tanks Between Units

1. Sequence categories for which strategy may be effective

   The expected sequences in which this strategy is expected to be used include

   a. Loss of Heat Sink (extended steam generator heat removal).
   b. Steam Generator Tube Rupture (maintain coverage of break).

   and to a lesser extent

   c. ISLOCA (extended SG feed, if needed, and bleed to maintain low system pressure).
   d. Direct Containment Heating (heat removal to accomplish or enhance RCS depressurization).

2. Changes or additions in plant hardware or operation

   No Changes to plant hardware are noted to be required. The following cross-tie capability for the Unit 1 and Unit 2 secondary condensate storage tanks (CST) exist:

   a. A 4 inch cross-tie (2FW027) in the turbine building between each CST auxiliary feedwater recirculation line return to the CSTs (0CD006 & 0CD066) with a single isolation valve 0FW0169 (normally closed). This appears to be a line that taps into the CST at a relatively high elevation, but may provide a limited source of water flow to the other tank.

   b. A set of 12 inch cross-ties exist on the non-seismic portion of suction piping to the Condensate Make-up Pumps in the turbine building. Unit 2 pipe (2CD272) ties into the Unit 1 suction header (0SC001) isolated by valve 0CD0385 (normally closed), and Unit 1 pipe (1CD278) ties into the Unit 2 suction header (2CD278) isolated by valve 1CD0386 (normally closed). This piping can be isolated from a ruptured CST by closing the appropriate CST isolation (0CD0101, 0CD0100).

   c. A set of 12 inch cross-ties exist on the Condenser overflow lines returning to the CST piping headers. It appears that the Unit 1 and Unit 2 CSTs are cross-tied at this point, and one of these lines is normally open. This may allow for level equalization. Unit 1 pipe (0CD087) ties into the Unit 2 CST header (2CD279) with valve 0CD0375 normally open, and Unit 2 pipe (0CD086) ties into the Unit 1 CST header (0CD068) isolated by valve 0CD0394 (normally closed). This piping can also be isolated from a ruptured CST by closing the appropriate CST isolation (0CD0101, 0CD0100).

Table 8. (continued)

d. A 12 inch cross-tie (0CD085) exists in the turbine building prior to entry of the CST piping into the auxiliary building and the suction headers for the AFW pumps. This line is isolated by valve 0CD0370 (normally closed) and can be isolated from a ruptured CST piping in the turbine building by closing the appropriate manual (turbine building) isolation valves (1CD0369, 2CD0369).

e. An 8 inch cross-tie (0SW098) exists on one of the service water emergency supply headers to the motor-driven AFW pumps. This line is normally open (valve 0SW0670). CST supplied to the AFW pumps is normally flowing through this piping and can be supplied to the other motor-driven AFW pump via the normally open service water cross-tie, or can be supplied to all AFW pumps via the normally open CST suction headers. This portion can be isolated from ruptured CST piping in the turbine building by closing the appropriate manual (turbine building) isolation (1CD0369, 2CD0369), or an individual pump may be isolated by closing its discharge isolation valve or suction isolation valve, or both.

The influence of the cross-tie on the operation of the second unit must be determined to ensure that there are no negative effects on the safety of that unit. Restrictions on the operation of the second unit may be necessary when this strategy is implemented if negative effects are identified.

3. Information needed and instrumentation available

Information needed to keep apprised of CST conditions is currently available and used to ensure AFW suction by monitoring CST level, AFW pump suction pressure, and service water supply to the AFW system. Current operator actions are delineated in CAUTIONS contained within procedures of the EOP network that direct restoration of level in accordance with AOP-4.3 if CST level is less than 3 feet, and ensuring service water is aligned in accordance with AOP-4.3 if CST level falls below 0.5 feet. (An example is CAUTION at top of page 10 of FR-H.1, "Response To Loss Of Secondary Heat Sink")

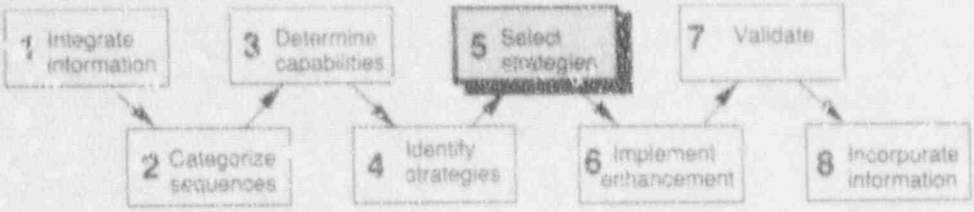
4. Resources needed

Currently, personnel are directed to perform some required actions [e.g., AOP-4.3 provides instructions for aligning service water (SW) to the AFW pumps]. It is expected no additional personnel would be required to complete tasks to cross-tie the CSTs to provide an extended source to the AFW pumps. Some decision making on which cross-connect would be best to use, based on current plant conditions and projected plant conditions, will be required prior to reaching the 0.5-foot limit in the one CST. Procedures may be redirected to ensuring the inventories of the CST are maximized for supply to the AFW system. Additional training in the use of the procedures would be required.

5. Expected timing of key events

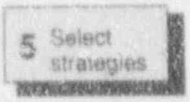
Timing is important to maximize available water resources for supply to the AFW system and to protect from a loss of both CST inventories. Adequate time is allowed by alerting the control room operator via low level alarms and caution steps within the EOPs. It is expected that all operator actions could be completed within a half-hour if at least 2 persons are assigned to the task.

Step 5. Evaluate and Select Strategies and Identify Enhancements



The objective of this step is to evaluate the potential strategies for each assessment category, select those that should be implemented, and, [illegible] information for these strategies and related improvements, to identify the accident management enhancements that should be implemented at the plant. Figure 1 shows the process, with seven substeps that will accomplish this objective. Substeps 5.1 through 5.5 are used to evaluate the capabilities of the strategies and provide input to the final substeps, where strategies are selected to be implemented and plant enhancements associated with these strategies are identified. Recognize that the results from one substep may influence substeps both below and above it, so iterations may be necessary between substeps to accomplish strategy evaluation and selection.

A full assessment of this step requires a detailed review of several proposed strategies. Examining the six proposed strategies in Appendix C, we concluded that we did not have sufficient plant information available to complete all of the substeps for any of the strategies. One strategy was chosen to partially assess the prototype process for Substeps 5.1 through 5.5, using the available information. We chose the Cross-tie of Secondary Condensate Storage Tanks Between Units strategy (discussed in Step 4 and described in Table 8) because there was more information available than for the other strategies. An assessment of Substeps 5.6 and 5.7 could not be performed because these substeps require the assessment of several strategies, and we did not have sufficiently detailed plant information to make these assessments.



Substep 5.1. Develop Preliminary Procedures and Guidelines

Preliminary procedures were developed for the strategy to cross-tie secondary condensate storage tanks between units. These preliminary procedures define the tasks needed to implement the strategy and can be used to identify the organizational units within the accident management staff to which the tasks are assigned. A team member with operator examination experience used the existing Zion Unit 1 EOPs and the available plant piping and instrumentation diagrams to develop the preliminary procedure. A flow diagram for this procedure is shown in Figure 9, and the preliminary procedure is presented in Appendix D. Although we chose to put the steps in the form of an actual procedure, a simple tabulation of the steps would be adequate to supply the needed information.

The example procedure delineates actions to ensure adequate secondary water supply for the steam generators by identifying unusual level conditions, diagnosing the likely occurrences that created the condition, and ensuring that an adequate supply is maintained by establishing a cross-tie between the CSTs for each unit. Step 1 identifies the possible makeup system failure to the CSTs and directs actions to re-establish flow. Steps 2 through 4 initiate the diagnostic to determine alternate paths for CST water flow other than the steam generators. These flowpaths include makeup to the condenser hotwell for each unit and leak paths resulting from faults (e.g., leaking valves

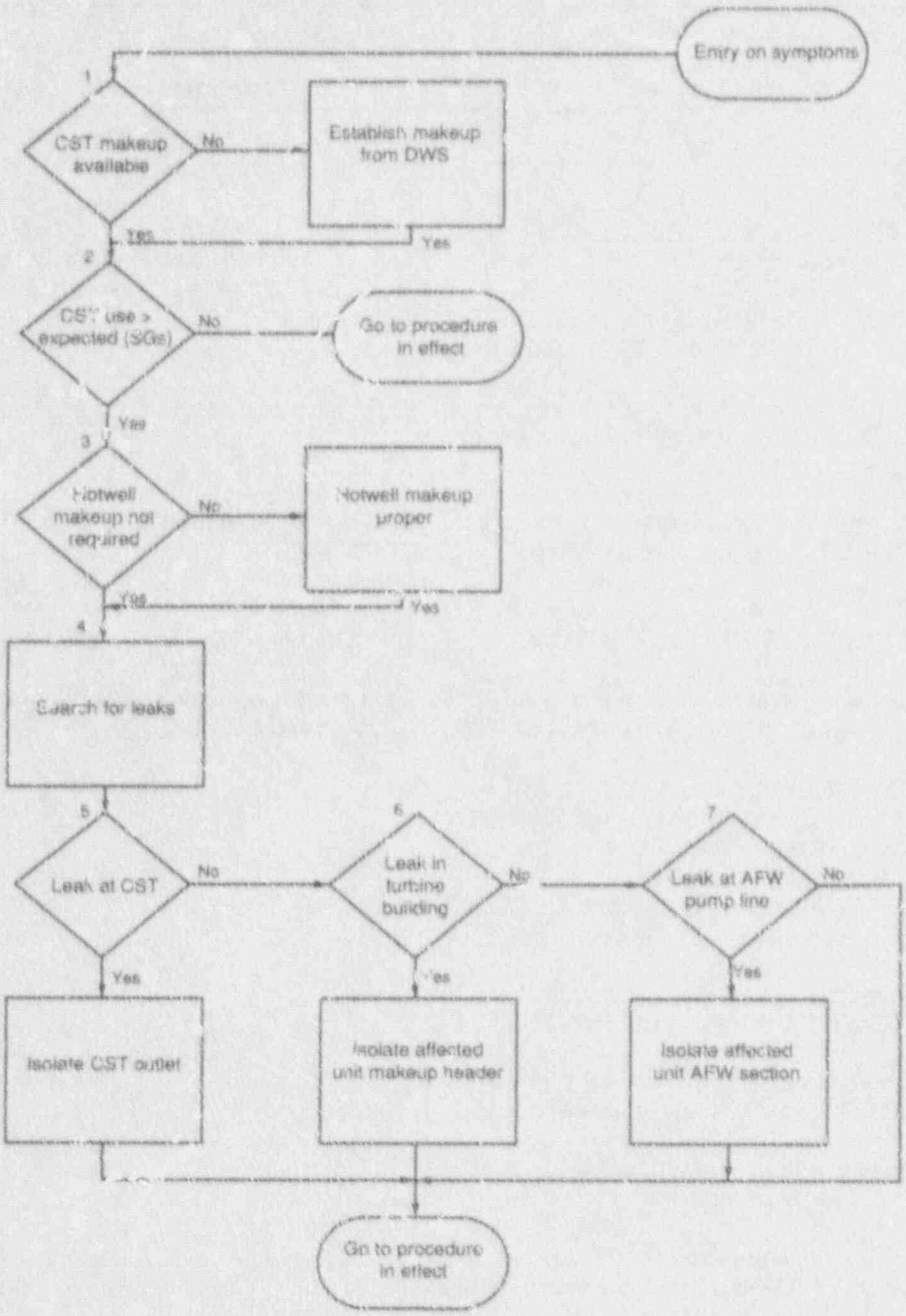


Figure 9. Flow diagram for the preliminary procedure.

and pipe breaks). Steps 3 and 5 through 7 define corrective actions to isolate the leakage flowpaths while ensuring adequate secondary water supply to the steam generators through a cross-tie of the CSTs at an appropriate location.

The chosen strategy could supply additional water for several assessment categories. It was therefore difficult to develop a timeline for this strategy. Comparing the time available to implement the cross-tie to the time expected to be available, we concluded that time should not be a factor in implementing this strategy. The preliminary procedures contain sufficient information that developing a timeline based on the process described in Substep 5.1 was not necessary for this particular potential strategy.

Table 9. Equipment and instrumentation identified in Example Procedure AOP SEC-1

Step	Equipment	Instrumentation
1 (CAUTION)		CST Level - 1(2)LT-CD139 (standpipe); 1(2)LI-CD94 (tank)
1	CST makeup valve - 1(2)LCV-CD139 4 in. Air-operator fail-closed.	Makeup demineralizer to CST flow - 0FQMUU7 (recorder - green pen); 0FQMUU8 (flow totalizer) at demin. control panel.
	Makeup demineralizer booster pumps 0MU011(0A)/12(0B)/57 (3) [non-safety].	
	CST makeup valve bypass - 0CD0121 (2CD0373) 8 in. manual globe valve normally closed.	
3	Hotwell normal makeup valve - 1(2)LCV-CD08A 4 in. Air-operator fail- closed.	Hotwell 1(2)A level - 1(2)LI-CD08 [Non-Safety].
	Hotwell emergency makeup valve - 1(2)LCV-CD08B 6 in. Air-operator fail-closed.	Hotwell makeup line flow element with output to 1(2)FR-CD06, point 1.
	Hotwell manual makeup valve - 1(2)CD0032 4 in. manual globe valve normally closed.	Hotwell makeup line flow element with output to 1(2)FR-CD06, point 2.
5	CST outlet isolation - 0CD0101(0CD0100) 20 in. gate valve with bellows seal (diaphragm valve) normally open.	
6	Makeup header isolation valve - 1(2)CD0369 10 in. gate valve normally open.	
	Makeup header downstream cross-tie valve - 0CD0370 12 in. gate valve normally closed.	
	Makeup header upstream cross-tie valve - 0CD0375 1 in. gate valve normally open.	
7	Makeup header isolation valve [1(2)CD0369 as in Step 6 above].	
	AFW suction header from SW manual cross-tie valve - 0SW0670 8 in. gate valve normally open.	
	MDAFW suction header from SW cross-tie valves - 1(2)MOV-SW106, 1(2)MOV-SW107 8 in. series motor-operator gate valves normally open between suction headers to the motor-driven AFW pumps [safety-related].	
	AFW pump suction isolation valves 1(2)MOV-FW0074, 1(2)MOV-FW0076 6" motor-operator gate valves normally open [safety related]; 1(2)MOV-FW0075 10" motor-operator gate valves normally open [safety related].	

One of the original tasks in Step 2, categorization of sequences, selected a "typical sequence" for each assessment category to reduce the amount of work necessary for assessing strategy. We moved that task to this substep because it was not clear that selecting a typical sequence would be necessary for every proposed strategy. For the proposed strategy, cross-tie of the CSTs, typical sequences were not selected because the strategy does not require extensive sequence evaluation to judge its effectiveness. The effectiveness could be evaluated based on the assessment categories, but there was not enough information available.

The equipment and instrumentation identified in the example preliminary procedure are listed in Table 9 with their relationship to the instructions or steps. This information is used in Substeps 5.2 through 5.7 to evaluate the potential strategy and rank it against the other potential strategies.

Substep 5.2. Evaluate Phenomenological Behavior

The objective of this substep is to judge the effectiveness of the proposed strategies by evaluating the thermal, hydraulic, radiological, and chemical phenomena. For the proposed strategy to cross-tie the CSTs, as long as specified levels are maintained in the CST, the important phenomena are strictly related to single phase water flow in the piping and components that connect the two tanks. An assessment of the flow resistance of the cross-tie paths between the units should be performed to assess the possible flow rates between the two CSTs. However, we were not able to perform these calculations because we do not have detailed information on the length and routing of the interconnecting piping, the pressure drop characteristics of the valves, or the head-flow characteristics of the pumps that would be used. No other phenomenological analysis was judged to be necessary for this strategy.

5.3. Evaluate Human Performance

The objective of this substep is to estimate the likelihood that the personnel would successfully implement the proposed strategy and to identify what might be done to increase the likelihood of success. For this proposed strategy, the expertise of our team members included operations, human factors, and systems engineering.

The first step in evaluating human performance was to review the timing and to review procedural guidelines. Because this is not a time-driven sequence--several hours could pass between the initial low-level alarms and the time that the CST would essentially empty-- there was no adverse effect of timing on successfully implementing the strategy.

The second step was to model the strategy, as defined by the preliminary procedures, using human reliability analysis techniques. A simplified analysis was performed to estimate the probability that the plant personnel would fail to implement the strategy. The results are shown in Figures 10, 11, and 12. Probabilities were estimated based on experience with similar human reliability analyses. They are to be considered order-of-magnitude numbers. The total failure probability for this sequence is estimated to be 3.1×10^{-3}, which is judged an acceptable rate for human performance in situations of this type. Figure 10 shows the overall tree, which includes detecting the loss of level in the CST, and then establishing the make-up path. Figure 11 shows a fault tree for the level instrumentation signals available to the operator to detect the loss of level in the CST, any one of which would be sufficient to detect that the level was decreasing. The probability value from this tree is then combined with the value from Figure 12, which shows a fault tree that represents the failure to establish the make-up path. Two activities are required to establish the make-up path. The first is to establish the flow; the second is to isolate any leak or loss of fluid from the system. The failure probabilities were estimated taking into consideration the number of possible paths and sources of leakage.

The final step was to ascertain whether any changes might be helpful to improve the overall probability of success. Fine tuning of the procedure is not possible without the ability to actually walk down the procedure in a facility. Instrumen-

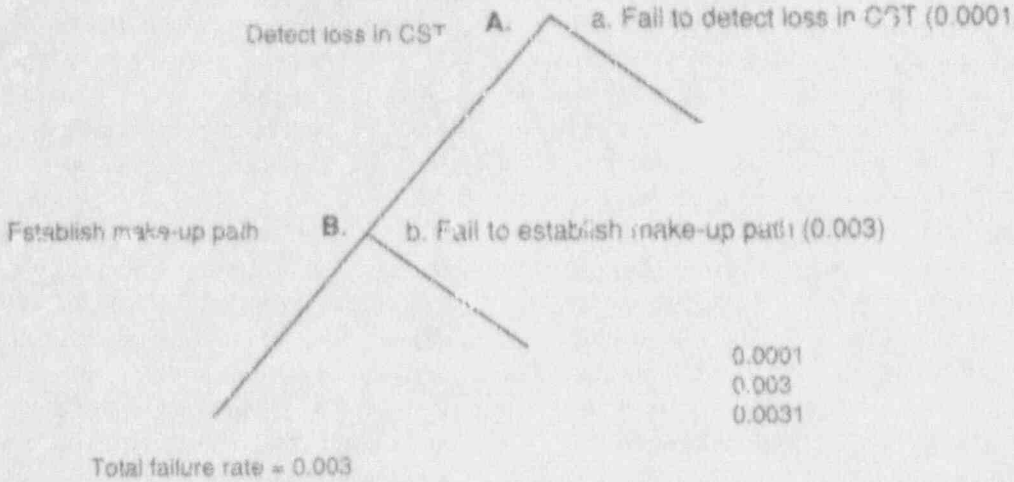


Figure 10. Response to the loss of CST level.

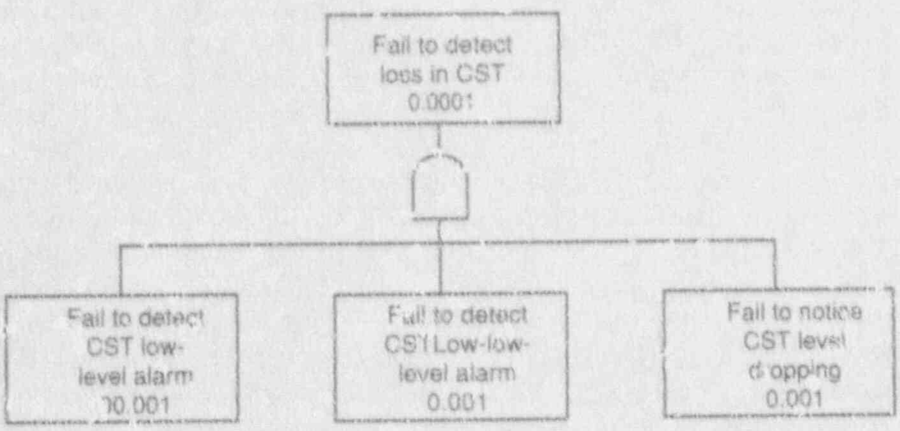


Figure 11. Failure to detect a loss of level in the CST.

tation as identified in the procedure is adequate, and we do not believe that any equipment modifications will make significant improvements. Therefore, no reanalysis of the sequence is warranted.

5 Select strategies

Substep 5.4. Evaluate Equipment Performance

The objective of this substep is to determine whether the equipment used to cross-tie the CSTs will perform the necessary functions for the strategy to be successful. Equipment important for this strategy is identified in Table 9. Although we do not have information on the design characteristics and limitations of this equipment, a review of the equipment types and the expected single-phase flow conditions would indicate that there is a high likelihood that the equipment will perform satisfactorily. An evaluation of the effect of loss of support systems, such as electrical power or plant air, was not possible with the information available to us. This type of assessment should be made and compared to the assessment categories to determine whether the loss of support systems would significantly affect this strategy. The equipment would not be located where harsh environments would be a major contributor to equip-

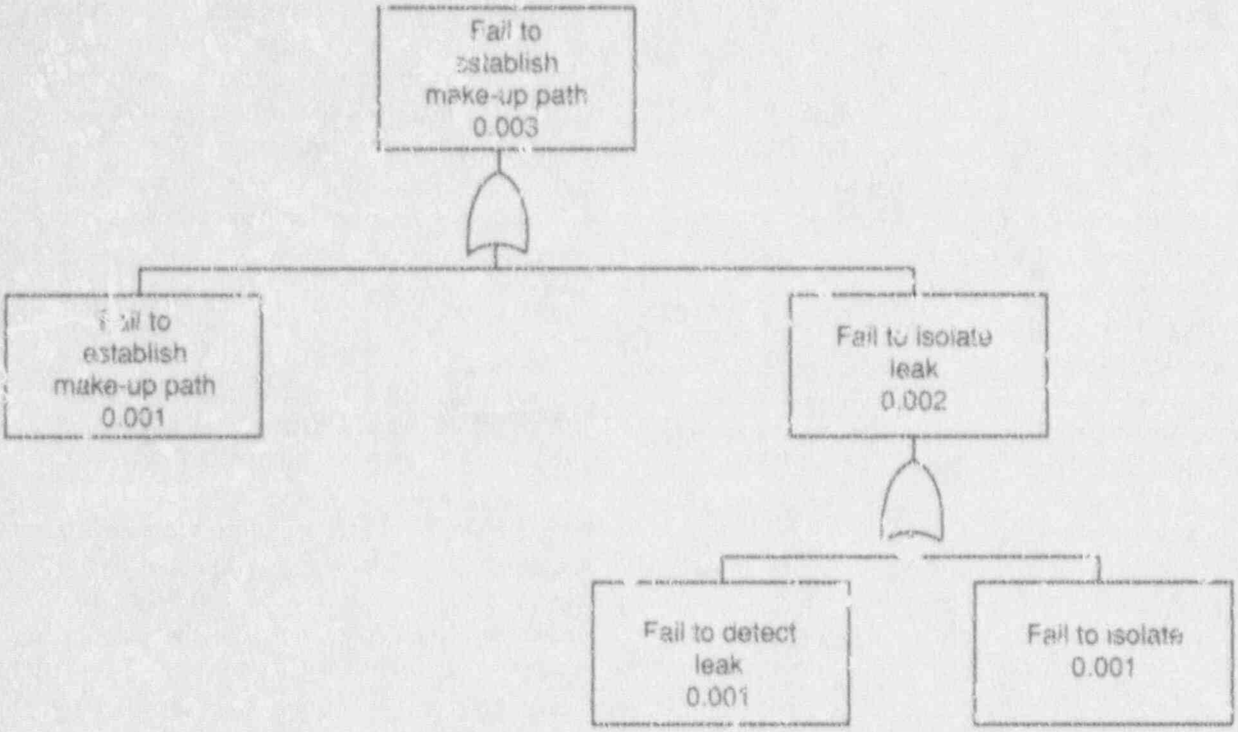


Figure 12. Failure to establish a make-up path.

ment performance. No other equipment performance evaluations were judged to be necessary for this strategy.

5 Select strategies

5.5 Evaluate Instrument Performance

A review of the instrumentation identified in Table 9 for the potential strategy under evaluation indicates that it should be adequate to identify that the CST level is decreasing under accident conditions. There is also sufficient instrumentation to monitor whether the potential strategy has been implemented. If success is defined as the refilling of the affected plant's CST, then there is sufficient instrumentation to indicate that the level is increasing or is within the desired operating band. With the plant information we have available, it is not clear how a loss of electrical power or a loss other support services would affect these instruments. An assessment of this effect should be made based on more detailed information.

5 Select strategies

Substep 5.6. Select Strategies

The objective of this substep is to rank the potential strategies and select those that should be implemented. Since we did not have sufficient information to thoroughly evaluate any of the potential strategies, only one strategy was evaluated, and that as a trial of the process steps. Therefore, it was not possible to rank potential strategies and evaluate the prototype process for this substep. Following is an example of how the information developed in the previous substeps would be used for ranking the potential strategy to cross-tie the CSTs. The following five areas are suggested in the potential process substep.

Likelihood of Successful Implementation. The results indicate that the potential strategy should have a high likelihood of successfully establishing a cross-tie for the two units if the support systems (electric power, air, etc., are available or their loss is compensated for.

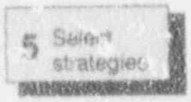
Effectiveness. This strategy could be effective in supplying water from one unit's condensate storage tank to the other unit's condensate storage tank. The effectiveness of this sharing on the capability to prevent or mitigate severe accidents is difficult to assess because there was not sufficient information for a detailed evaluation of the severe accident calculations and PRA studies.

Potential for Negative Effects. There is potential for negative effects on the unaffected unit if that unit is not properly notified and action taken to shut down the unit or otherwise minimize the influence of removing inventory from its CST.

Availability of Support Systems. Support systems can strongly affect the capability of the valves and pumps to operate for this potential strategy. The support systems are necessary for the strategy to be successful.

Impact on Existing Procedures and Plant Equipment. A procedure would be added to the EOPs and training would be necessary. There would be no major effect on equipment unless plant changes were made to compensate for the effect of a loss of the support systems. The impact of these changes is judged to be less.

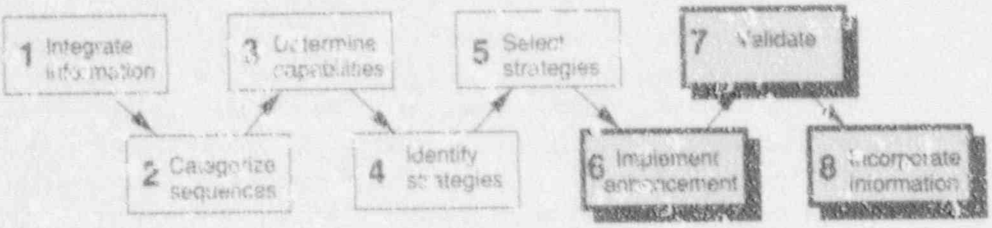
Information on each of the potential strategies, similar to that presented in the preceding discussion but with more detail, would be used to rank the potential strategies and select those that would be most beneficial to implement at the plant. Additional criteria based on need are also described in the prototype process, but these criteria were not assessed because it was not possible to assess multiple strategies.



Substep 5.7. Select Accident Management Enhancements for Implementation

The objective of this substep is to select the enhancements for accident management that will provide the mechanism for successful implementation of the selected strategies. If the strategy to cross-tie the CSTs was chosen, the primary enhancements would be to develop and incorporate a procedure based on the preliminary procedure developed in Substep 5.1. Further enhancements in some plant equipment may be needed, based on the results of the evaluation of the role of the support systems and the degree to which the equipment in the lines that cross-connect the CSTs rely on these support systems.

Steps 6, 7, and 8: Implement Enhancements and Strategies, Perform Program Validation, and Incorporate New Information

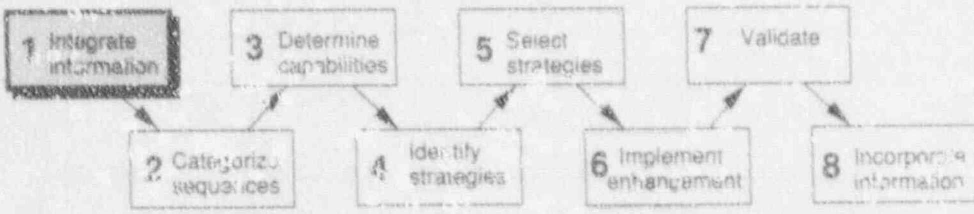


There was not sufficient information to evaluate Steps 6, 7, or 8 because they are associated more closely with the implementation of accident management plans. Utility involvement in Steps 6 and 7 would be necessary to provide a comprehensive evaluation of them.

4. REVISED ASSESSMENT CRITERIA

The objective of Phase 4 is to develop a finalized set of criteria that can be used to assess (a) the adequacy of methods suggested for developing severe accident management plans, and (b) the adequacy of proposed or implemented severe accident management plans. To accomplish this development, the preliminary criteria for Steps 1 through 4 and Substep 5.1 were reviewed to determine whether (a) they were still applicable, (b) they should be revised to account for changes that resulted from the process evaluation, and (c) the addition of criteria was necessary. Modifications to these criteria were made based on the results from Phase 3. It was not possible to update the criteria associated with Substeps 5.2 through 5.7 and Steps 6 through 8 because they were not assessed to identify potential areas of improvement. The preliminary criteria developed for these steps during Phase 2 are considered to be the best evaluation criteria currently available. A discussion of the criteria for all steps is presented in Volume 1 of this NUREG/CR.

Step 1. Assemble and Integrate Information



The preliminary criteria for assembling and integrating information was only modified slightly. The first two criteria were not changed, but the third criterion was expanded to include not only resources but other important components and systems in the plant. This criterion was modified to incorporate results from the evaluation of the prototype process, which indicated it is important to understand the limitations on the plant hardware and equipment.

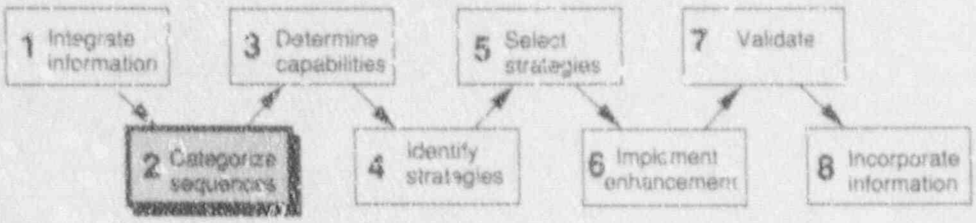
Criteria: Step 1

1. **The information should clearly identify those severe accident sequences to which the plant could be vulnerable, including high-consequence low-probability sequences and sequences with a high probability of core damage.**

2. **For each accident sequence, the information should be sufficiently detailed to describe important failures of equipment or human error, important events and their timing, and current and potential preventative or mitigative actions.**

3. **Detailed descriptions of the plant equipment, instrumentation, operations, and training should be available. These descriptions must include design and operational limitations.**

Step 2. Categorize Severe Accident Sequences



Step 2 criteria were modified substantially because major changes were made in the process for categorizing severe accident sequences. A revised set of criteria is presented below. The purpose of the first revised criterion is to characterize how the categories that will be used to evaluate conditions for later steps should be developed. Evaluation of the prototype process indicates that use of events from the event trees or mechanisms from the safety objective trees would provide adequate assessment categories.

The second revised criterion was developed to ensure that the assessment categories represent the severe accidents that have been identified as important for the plant. If events were used directly from the PRA event trees, this step would not be necessary. The final criterion was included to ensure that a sufficient number of assessment categories are established to differentiate plant conditions that may require different strategies.

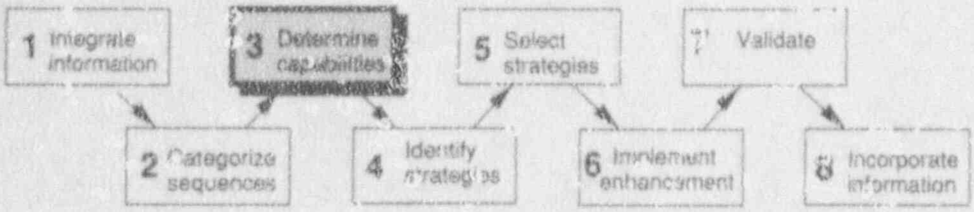
Criteria: Step 2

1. **Assessment categories should represent severe accident behavior that would cause challenges to the plant safety functions.**

2. **The assessment categories should correlate with the plant IPE or PRA results to ensure that all severe accident behavior that may challenge the plant safety functions are included in the set of categories.**

3. **Assessment categories should be separate if significant differences are noted in timing of key events, system conditions, support system availability, or system environmental conditions.**

Step 3. Identify Accident Management Capabilities for Sequence Categories



Preliminary Step 3 criteria identified areas where plant capabilities should be examined but they were not clear on how capabilities should be identified. Based on the findings from evaluation of the prototype process, the preliminary criteria were revised and are presented below. The purpose of the first revised criterion is to clarify the method of identifying capabilities. Portions of the preliminary criteria were retained to supplement information in areas where capabilities should be evaluated.

The second criterion was added because we found that identifying improvements to plant capabilities was a natural extension of the identification of the capabilities themselves. The purpose of this criterion is to ensure that identification and improvement of capabilities are considered in the same step so that synergism is included in the process.

Criteria: Step 3

1. **The method of identifying existing accident management capabilities should be formal. An example would be a structured set of questions designed to determine accident management capabilities in the following areas:**

   a. **Procedures. All procedures and guidelines available to the operations and technical support team staff necessary to manage accidents should be identified.**

   b. **Decision Making. All information that describes the roles of the personnel involved in accident management (for example, the plant operations staff, corporate technical support teams, etc), with emphasis on the decision-making responsibilities and duties during severe accident conditions, should be identified.**

   c. **Equipment. Key equipment and systems that can be repaired on site should be identified, along with the estimated time required and the procedures available to effect the repair.**

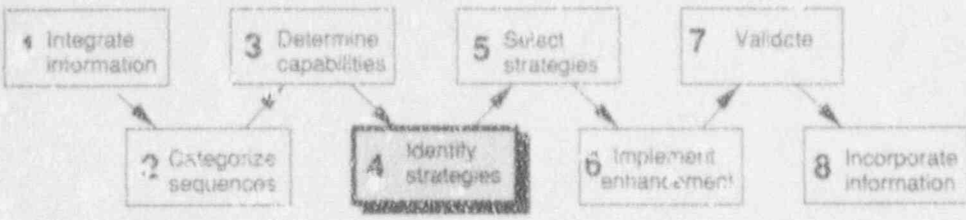
   Equipment that can be used to supplement or replace safety-related equipment should be identified.

   d. **Instruments. The key instruments installed in the plant that have the capability to identify the initiation and to follow the progression of the plant accidents should be identified.**

   e. **Training. Training that provides an understanding of the accident assessment categories or that is used to identify or manage them should be identified.**

2. **The method for identifying accident management capabilities should consider changes that have the potential for preventing or mitigating challenges to plant safety functions for**

Step 4. Identify Potential Strategies



The preliminary criteria previously developed for Step 4 were found to be adequate and are repeated below. Based on the revised process, detailed background information for identifying potential strategies is developed in Step 3. Step 4 uses this information and combines it with consideration of various methods for using existing equipment, instrumentation, and other plant resources to formulate potential strategies that would be effective for each of the assessment categories.

Criteria: Step 4

1. **Potential strategies that could enhance the capability to prevent or mitigate the challenges to safety functions should exist based on the accident management capabilities described for the sequence categories in Step 3.**

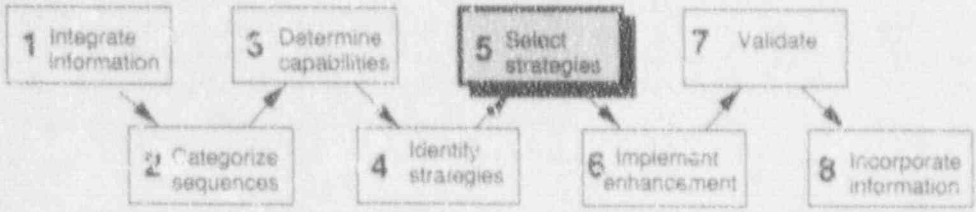
2. **Potential strategies should consider, but no be limited to**

   a. **Repair and restoration of equipment**
   b. **Use of alternate equipment**
   c. **Use of alternate resources**
   d. **Conservation of resources**
   e. **Timing for effectiveness**

3. **A minimum of one potential strategy should be identified for each of the assessment categories identified in Step 2. Whenever possible, strive for redundancy and diversity in the strategies identified.**

4. **The potential strategies should be described in terms of the personnel resources, equipment resources, and the information needed to understand plant status.**

Step 5. Evaluate and Select Strategies and Identify Enhancements



Owing to the lack of detailed information, none of the substeps in Step 5 were adequately evaluated. Only minor changes were made to the criteria for Substep 5.1; no changes were made to any of the other substeps.

All preliminary criteria remained unchanged, with the exception of the second criterion. It was modified to indicate that some of the strategies may not have a strong time dependence and therefore, the use of timelines in the preliminary procedures should be examined but would be optional.

Criteria: Substep 5.1

1. The tasks necessary to execute each proposed strategy should be identified and listed.

2. The identified tasks should be put in order. The time constraints should be examined and a timeline for each of the assessment categories should be used where time is determined to be a factor.

3. There should be a clear definition of who is responsible for initiating tasks and who is responsible for performing the tasks included in the preliminary procedures and guidance.

4. The need for special tools, materials, information aids, plant access, or necessary repair or modification information should be identified.

5. The potential for the exposure of plant equipment or plant personnel to abnormal environmental conditions should be identified.

5. CONCLUSIONS AND RECOMMENDATIONS

A prototype process for developing accident management plans was evaluated through a trial application under conditions similar to those expected at a nuclear power plant. The objective of the application was not to develop an accident management plan but to determine whether (a) the activities described for each step provide the products specified, and (b) the steps are integrated to provide the information necessary for a technically accurate and useful accident management plan.

We were not able to obtain the agreements necessary for the participation of a utility in this evaluation. Without this participation, it was not possible to obtain a detailed set of integrated information for an individual plant. Lack of detailed information restricted the extent of the evaluation.

The following are general results from the evaluation of the prototype process, followed by results that are specific to individual process steps.

General Prototype Process Application Results

1. The lack of utility participation restricted our ability to adequately evaluate all steps of the prototype process using detailed plant hardware and operations information. As a consequence, evaluation of Steps 1 through 4 was completed but Step 5 was only partially evaluated. It was not possible to evaluate Steps 6 through 8.

2. The general content of Steps 1 through 5 of the prototype process are adequately integrated. Some modifications to the individual steps were identified to correct shortcomings in the process and make it more efficient. Using these modifications, Steps 1 through 5 will produce the results described in the prototype process.

3. The team approach was very effective in performing the steps of the prototype process because it helped generate synergism and creativity, especially when identifying plant capabilities and potential strategies. We expect that this approach would be even more effective in a setting where plant personnel with a higher level of plant knowledge and expertise were involved.

Specific Prototype Process Application Results

1. The method described in Step 2 for categorizing sequences was not effective because it did not adequately group sequences, but rather resulted in the definition of a large number of sequence categories. We concluded that the events that lead to severe accident conditions provide more insight into possible accident management actions than categories that can be defined through sequence categorization or sequence binning. Three alternate methods of developing categories were examined that considered the individual events as important indicators of opportunities to manage the accidents.

   The first method used the events directly from the event trees to act as severe accident management evaluation categories. The categories for this approach would be easy to identify and would produce a reasonable number of categories. The second method used the structure of the safety objective trees described in NUREG/CR-5543 to define important events. Mechanisms that can cause challenges to plant safety functions were selected to define the assessment categories. Examples of categories based on mechanisms are inadequate RCS inventory, inadequate containment heat removal, core concrete interaction, failure to isolate containment, and interfacing system loss-of-coolant accident. In the third method, we transcribed the severe accident sequences for Zion Unit 1 onto the safety objective trees and found that all of the events associated with these sequences were accounted for by the safety objective tree mechanisms.

   We conclude that all methods could be successful in categorizing sequences, but we preferred the method that transcribed events to the safety objective tree mechanisms because it was easy to relate the assessment categories to both plant safety functions and to possible strategies, through the safety objective tree structure. This is the method used in the application of the prototype process.

2. Identification of plant capabilities was determined to be a very important step in developing an accident management plan. We found it was difficult to separate the identification of plant capabilities and the identification of how these capabilities could be used to improve accident management for the plant. The method described for the prototype process was determined to be inefficient. A more structured approach was developed, using a question-answer format that proved to be effective in identifying plant and personnel capabilities and how they could be used to prevent or mitigate conditions affecting the sequence categories. The questions developed are general and could be applied for identification of capabilities for other nuclear power plants.

3. About thirty-five strategies were identified with the potential to improve severe accident management, using a process similar to that described for Step 4. Results from the question-answer session conducted as part of Step 3 focused the identification of potential strategies and helped to determine how they should be conducted.

4. Development of preliminary procedures was a successful first step in determining the personnel, hardware, and instrumentation involved in potential strategies. Although there was not enough information to thoroughly assess Step 5, our judgment is that the assessment and ranking process described would be effective.

A final set of evaluation criteria were developed after completion of the process evaluation. The preliminary criteria for Steps 1 through 5 were reviewed and discussed to determine whether they were compatible with the findings of the evaluation, they should be revised to account for changes that were made to the process, and whether the addition of criteria was necessary. It was not possible to revise the criteria associated with Steps 6 through 8 because these steps could not be evaluated to identify potential areas of improvement. The preliminary criteria developed for these three steps are judged to be adequate for severe accident management plan development and evaluation.

5. REFERENCES

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Appendix A

Assessment of Plant Capabilities Based on Brainstorming

Appendix A

Assessment of Plant Capabilities Based on Brainstorming

This appendix presents examples of information developed by the assessment team who, in this instance, combined discussion and brainstorming to identify the accident management capabilities of Zion Unit 1. The team comprised personnel with operations, severe accident analysis, thermal-hydraulic safety analysis, procedures, training, human factors, PRA, and accident management experience. They developed a table based on the following five areas to organize and display the plant capabilities:

- Procedures and guidelines
- Delineate Decision Making Authority or Responsibilities
- Equipment
- Instrumentation
- Training

For a particular assessment category, ideas for the use of plant capabilities for each of the five areas were discussed in a meeting of team members. Each proposed plant capability was described, as was the purpose or use of the capability. Results describing proposed additional uses of the plant capabilities were therefore an important part of the results. We only reviewed a sampling of assessment categories because our primary objective is to evaluate the capabilities of the prototype process, not to develop a complete accident management plan. Tables for the following assessment categories are presented:

- Loss of Secondary Heat Sink (Table A-1)
- Inadequate RCS Inventory (Table A-2)
- Containment Heat Removal (Table A-3)
- Direct Containment Heating (Table A-4)
- Combustible Gas Burns (Table A-5)
- Pre-existing Leak/Failure to Isolate (Table A-6)
- Steam Generator Tube Rupture (Table A-7)
- Interfacing System Loss-of-Coolant Accident (ISLOCA) (Table A-8).

Table A-1. Accident management capabilities for loss of secondary heat sink.

Sequence Category: Loss of Secondary Heat Sink

Related Sequence Categories: Restricted RCS Bleed, Inadequate RCS Inventory, Noncoolable Relocation

Containment Failure Modes: Alpha Mode Failure, Basemat Melt Through

1. Procedures:

   a. Procedures currently include:

   MFW - AFW - Depressurization to use Condensate Booster Pumps - CST Inventory Crossties to other units CST, service water, Primary Feed and Bleed, Charging Pumps and SI.

   b. Possible additional procedures:

   Depressurization to use Fire Pumps

   Use of portable pumps e.g., fire engines.

   Alternate sources of water (other units CST, refill CST)

2. Decision Making:

   a. Important decisions that will need clear lines of responsibility and authority are:

   There is insufficient information in this area. Possible important decisions are:

   Decision on Crossties to other unit.

   Decisions on Repair or Replacement of failed equipment.

3. Equipment:

   a. Existing equipment:

   Feedwater pumps, Auxiliary feedwater pumps, Diesel driven firewater pumps, Condensate storage tank, Dump valves, Safety relief valves.

   b. Potential use of equipment not currently specified:

   Availability of portable pumps to supply feedwater, planned location and method of tie in to the feedwater system for portable pumps.

Table A-1. (continued).

Capability for repair or replacement of electrical or mechanical equipment.

4. Instrumentation:

a. Existing instrumentation:

SG Level (wide and narrow), Hotwell Level, CST Level, SG Pressure, AFW & FW Flow, Core Exit TCs, RCS Hot Leg RTD, MF & AFW pump discharge pressure, charging pump and SI parameters, RVLMS, Pressurizer level.

5. Training Capability:

a. Current training:

There is insufficient information in this area.

6. Possible Interactions with Related Sequence Categories

a. Steam Generator Tube Rupture

Table A-2. Accident management capabilities for inadequate RCS inventory.

Sequence Category: Inadequate RCS Inventory

Related Sequence Categories: Inadequate Secondary Inventory, Restricted RCS Bleed, RHR Systems Operable, SCRAM Failure, Noncoolable Relocation

Containment Failure Modes: Alpha Mode Failure, Basemat Melt Through, Overpressure Failure

1. Procedures:

   a. Procedures currently include:

   Existing procedures cover use of the charging system high head pumps and the transition to SI (intermediate head), and transition to RHR (lower head). Procedures also exist for switching to recirculation and for refilling RWST.

   b. Possible additional procedures:

   Alternate methods to refill the RWST should be examined.

2. Decision Making:

   a. Important decisions that will need clear lines of responsibility and authority are:

   There is insufficient information in this area. Possible important decisions are:

   Decisions regarding preparation of borated water or the use of non-borated water for extended periods of time.

   Decisions regarding use of containment sprays versus RCS injection.

   Decisions on which instruments to trust and which procedures to identify or give guidance.

   b. Possible additional Decision Making

   Based on the limited information, additional guidance would be beneficial on any transition needed from control room responsibility to Technical Support Center responsibility.

Table A-2. (continued).

3. Equipment:

   a. Existing equipment:

   High and low pressure injection systems, RHR system, charging system, containment spray, cross-connects to second unit, means to refill RWST.

   b. Potential use of equipment not specified:

   Use of portable pumps or diesel driven fire pumps to refill water storage tanks or inject into system (capability to borate may be needed.

4. Instrumentation:

   a. Existing instrumentation:

   Core exit thermocouples, pressure, RTDs, RVLMS, ELLS instrumentation (levels, pressure, flows, temperatures)

   b. Possible additional instrumentation:

   Bottom head thermocouples, TV cameras for lower head visual observations, analysis aids to estimate core level by interpreting nuclear instrumentation (source range or SPNDs).

5. Training Capability:

   a. Current training:

   Sufficient information not available

   b. Possible additional training:

   Based on the limited information available, potential additional training may be:

      Use of alternate sources of water

      Additional cross-connects to other units

      Meaning/significance of instrumentation readings

6. Possible Interactions with Related Sequence Categories

   a. Possible interactions with long term containment cooling for some severe accidents.

Table A-3. Containment heat removal.

Sequence Category: Containment Heat Removal (Early, Late, Very Late)

Related Sequence Categories: CCI, Steam Generator Tube Rupture, DCH, Combustible Gas Detonation, Steam Explosions, Noncondensible Gas Buildup

Containment Failure Modes: Basemat Meltthrough, DCH Early Containment Failure, Late Containment Overpressure.

1. Procedures:

   a. Procedures currently include:

      Guidance is provided on spray initiation

      Guidance is provide on the use of the fan coolers

   b. Possible additional procedures

      Guidance should be given for the use of alternate pumping systems for the sprays or alternate sources of water

      Additional guidance should be provided on alternate means of supplying cooling to the heat exchangers

      Guidance to help evaluate the capability of containment heat removal options for the possible sequences using a damage control matrix format

2. Decision Making:

   a. Important decisions that will need clear lines of responsibility and authority

      There is insufficient information in this area. Possible important decisions are:

         Decisions could be needed on whether sprays should be used to remove heat when there may be problems with hydrogen detonation or deflagration

         A decision structure could be incorporated for prioritizing strategies consistent with a damage control matrix

         Decisions could be needed on the use of containment venting if it is an adopted strategy

Table A-3. (continued).

3. Equipment:

   a. Existing equipment:

   The current spray systems and fan cooler systems provide diverse means to remove containment heat.

   b. Potential use of equipment not currently identified:

   Consider how to use alternate systems to supply sprays. Examples are diesel driven fire pumps, mobile pumps, or fire engines. A determination will be needed to assess the effects of these systems on the potential for recriticality.

   Consider alternate sources of water, either to the sprays or to the heat exchangers used by the fan coolers.

4. Instrumentation:

   a. Existing instrumentation:

   Containment pressure, temperature, and radiation levels will supply information that can be used to make decisions to initiate and regulate containment cooling.

   b. Potential use of instrumentation:

   Additional instrumentation that would determine where the containment is breached

   Additional instrumentation to determine the location of the core material once it has left the vessel and is in the containment

   The capability to identify which instruments are reliable or techniques to read damaged or instruments beyond their range would enhance accident management

5. Training Capability:

   a. Current training

   Sufficient information not available.

Table A-3. (continued).

6. Possible Interactions with Related Sequence Categories

   a. Spray reduce the inerting in the containment an increases the likelihood of hydrogen detonation or deflagration.

   b. Sprays will be very effective in scrubbing out radioisotopes from the containment atmosphere.

Table A-4. Direct containment heating.

Sequence Category: Direct Containment Heating

Related Sequence Categories: CCI, Late and Very Late Containment Heat Removal, Steam Explosion, Combustible Gas Detonation, SGTR

Containment Failure Modes: Failure To Isolate, Basemat Meltthrough, DCH Early Containment Failure, Late Containment Overpressure

1. Procedures:

   a. Procedures currently include:

   RCS depressurization is initiated using PORVs and upper head vents when core exit thermocouples are greater than 1200 F.

   b. Possible additional procedures

   The existing procedures should specifically recognize the consequences of DCH and alert the operator to selected mitigative strategies

2. Decision Making:

   a. Important decisions that will need clear lines of responsibility and authority are:

   There is insufficient information in this area. Possible important considerations are:

   The existing decision making process may not recognize DCH or its potential effects

   With the current procedures calling for RCS depressurization, decisions on effects of depressurization (mitigation of large pressure rise due to dispersal of core material versus an increased likelihood of in-vessel steam explosions) must be considered prior to an accident.

3. Equipment:

   a. Existing equipment:

   PORVs and the upper head vents.

   b. Potential use of equipment not currently specified

   Position shields or other equipment to deflect and minimize dispersal of flows from the lower head

Table A-4. (continued).

Use systems to flood the reactor vessel cavity to prevent vessel failure or to mitigate the effects of DCH

4. Instrumentation:

   a. Existing instrumentation:

      RCS pressure, core exit thermocouples, reactor vessel water level, and RCS and containment radiation levels could indicate the approach to conditions that are typical of DCH.

   b. Potential use of instrumentation

      Bottom head thermocouples, TV cameras for lower head visual observations, analysis aids to estimate core level by interpreting nuclear instrumentation (source range or SPNDs).

5. Training Capability:

   a. Current training:

      Sufficient information not available

6. Possible Interactions with Related Sequence Categories

   a. Reducing RCS pressure mitigates the effects of DCH but increases the likelihood of steam explosions.

Table A-5. Combustible gas burns

Sequence Category: Combustible Gas Burns

Related Sequence Categories: Late and Very Late Recovery of Containment Heat Removal, SGTR, Steam Explosions, DCH, CCI

Containment Failure Modes: Basemat Meltthrough, DCH Early Containment Failure, Late Containment Overpressure.

1. Procedures:

   a. Procedures currently include:

   Operating Procedures are available for operation of Recombiners and the hydrogen purge.

   b. Possible additional procedures

   Procedures that apply if the hydrogen concentration is greater than 3 1/2% or if the containment pressure is greater than 10 psi.

2. Decision Making:

   a. Important decisions that will need clear lines of responsibility and authority are:

   There is insufficient information in this area. Possible important decisions are:

   A decision that the Hydrogen concentration is within limits is required for use of recombiners.

   As the concentration of hydrogen increases, the decision on whether to initiate or continue containment sprays will become more complex since sprays will reduce the quantity of steam which could result in hydrogen concentrations that are in the deflagration or detonation regions.

   Decisions on the effects of containment compartments on its vulnerability to hydrogen deflagration or detonation.

3. Equipment:

   a. Existing equipment

   Hydrogen recombiner & hydrogen purge systems will be adequate if the concentration of hydrogen remains low and there is sufficient time to utilize these systems.

Table A-5. (continued).

b. Potential use of equipment not currently specified:

Hydrogen igniters installed inside the containment if hydrogen burns are a threat to containment

4. Instrumentation:

a. Existing instrumentation:

Hydrogen concentration, containment pressure

b. Potential use of instruments:

The concentration of both steam and air are not measured making it difficult to clearly identify the flammability limits.

An estimate of the pressure rise that would result from hydrogen burns at different concentrations would provide insights for accident management.

The effect of hydrogen burns on the cabling and components in containment should be evaluated.

5. Training Capability:

a. Current training:

Sufficient information not available.

6. Possible Interactions with other Sequence Categories

a. CCI is a direct contributor to H_2 production.

b. Spraying the containment will reduce pressure but it will also condense steam and enrich the hydrogen mixture making deflagration or detonation more likely.

c. High pressure core melt ejection producing DCH combined with an H_2 explosion could occur.

Table A-6. Pre-existing leak/failure to isolate.

Sequence Category: Pre-existing leak/failure to isolate

Related Sequence Categories: CCI, Late and Very Late Recovery of Containment Heat Removal, Steam Explosions, DCH, ISLOCA, Noncondensable Gas Buildup,

Containment Failure Modes: Early Alpha Mode Failure

1. Procedures:

   a. Existing procedures:

   Current procedures call for shutting all containment isolation valves.

   Procedures are available to monitor radiation leaks.

   b. Possible additional procedures

   Procedures and guidance for pre-evaluation, prioritization, and dealing with likely/troublesome points for pre-leaks.

   Provide guidance on ways to estimate the amount of effluent being released.

2. Decision Making:

   a. Important decisions that will need clear lines of responsibility and authority are:

   There is insufficient information in this area. Possible important decisions are:

   Decisions on how to locate the leak point and what means to use to prevent further release

   There could be trade off decisions such as whether to activate the fire protection system or to spray using fire hoses considering possible negative affects on other equipment.

3. Equipment:

   a. Existing equipment

   Isolation valves

Table A-6. (continued).

b. Potential use of equipment not currently specified:

Use sprays to reduce containment pressure and fission product inventory (or alternatives that would reduce pressure).

Find ways to pressurize the location where leak is emanating from.

Pre-position portable fire hose spray nozzles to spray on possible release points so that they could be actuated to reduce the fission product release.

4. Instrumentation:

a. Existing instrumentation:

Radiation detectors, pressures, and temperatures

b. Potential use of instrumentation:

Locate portable radiation detectors in general areas where they can be re-positioned based on individual circumstances.

5. Training Capability:

a. Current Training

Sufficient information is not available.

6. Possible Interactions with Related Sequence Categories

a. Reduction of pressure in containment will eliminate or reduce consequences of preexisting leak. Containment sprays will reduce pressure and scrub the atmosphere, but will create an environment the would increase the likelihood of a hydrogen explosion. However, hydrogen explosions did not show up as a related sequence category.

b. Because there is already a leak (depending on the magnitude) there is less worry about things that would fail the containment than things that will reduce fission product release, core melt, or high pressure. The best strategy for prevention of fission product release would be to prevent core damage since the containment is already breached.

Table A-7. Steam generator tube rupture.

Sequence Category: Steam Generator Tube Rupture (SGTR)

Related Categories: Late Recovery of Containment Energy Removal, Very Late Recovery of Containment Energy Removal, Temperature Induced Degradation, Direct Containment Heating, Steam Explosions, Combustible Gas Detonation, Failure to Isolate

Containment Failure Modes: Alpha Mode Failure, Basemat Melt Through, Late Containment Overpressure

1. Procedures:

   a. Procedures currently include:

   Extensive procedures exist to deal with steam generator isolation and depressurization of the RCS.

   b. Possible additional procedures:

   Provide guidance on strategies that can be used if isolation of the affected steam generator fails. For example:

   - Increase the inventory in the steam generator to submerge the rupture location and scrub fission products.

   - Consider possible problems if there is a rupture of a relatively large number of tubes. For example, there would be a much earlier depletion of the RWST.

   Provide guidance on ways of estimating where the release location is and the quantity of fission products being released.

2. Decision Making:

   a. Currently described decision making and authority

   Insufficient information available.

   b. Additional decision making that may need clarification

   There is insufficient information in this area.

Table A-7. (continued).

3. Equipment:

   a. Existing equipment:

   Steam generator dump valves, pressurizer PORVs, all valves necessary for steam generator isolation, normal and auxiliary feedwater pumps and related equipment.

   b. Potential use of equipment not specified:

   Use of normal or auxiliary feedwater systems to submerge the tube break location. Use of diesel driven fire water pumps or portable pumps should also be considered.

   Caution may need to be exercised in controlling the level in the steam generator for some plants to avoid flooding the steam line which would cause it to fail. Alternate methods of preventing steam line failure could also be considered, such as additional analysis and possibly the placement of additional supports.

   Use of fire sprays, both existing and augmented, on failed dump valves and safety relief valves should be considered to reduce the amount of fission products escaping from the steam generator(s).

   The need for protective clothing and equipment should be considered if strategies call for personnel actions near points of release. Positioning this equipment near the locations where it will be needed should be considered.

4. Instrumentation:

   a. Existing instrumentation:

   Steam generator pressure, level, temperature; RCS pressure; Reactor Vessel Level Monitoring System (RVLMS); hot leg temperature; plant and site radiation monitors

   b Potential use of Instrumentation:

   Indications that the steam generator PORVs or SRVs are stuck open. For example, downstream temperatures, videos of atmospheric release points, and radiation monitors.

   All instrumentation that could be used in mitigating the effects of a steam generator tube rupture should be properly grouped and displayed in the control room.

Table A-7. (continued).

5. Training Capability:

   a. Current training

      Sufficient information not available.

6. Possible Interactions with Related Assessment Categories

   a. Similar to an ISLOCA

   b. Desire to depressurize RCS rapidly may run counter to considerations for preventing steam explosions.

Table A-8. Interfacing loss-of-coolant accident (ISLOCA).

Sequence Category: ISLOCA

Related Sequence Categories: Failure to Isolate, Steam Explosion.

Containment Failure Modes: Alpha Mode Failure, Basemat Melt Through

1. Procedures:

   a. Procedures currently include:

      There are extensive procedures on ISLOCA

   b. Possible additional procedures:

      Ensure that the procedures contain specific steps for identification of ISLOCA symptoms using control room instrumentation. Sequence identification is necessary since the strategies for this sequence category are different from those used for other LOCAs.

      Add specific steps in the procedures for prevention and mitigation strategies.

      Guidance on ways of estimating the release location and the quantity of fission products released.

2. Decision Making:

   a. Important decisions that will need clear lines of responsibility and authority are:

      There is insufficient information in this area. Possible important decisions are:

      Decisions on selection of isolation methods including the potential effects of isolation and the criteria for initiating isolation and determining whether it is successful

3. Equipment:

   a. Existing equipment:

      Isolation valves, SI pumps, charging pumps, RWST

   b. Potential use of equipment not currently specified:

      Actuators of valves that have the potential to isolate an ISLOCA should be sized to close under the high flow and pressure conditions calculated for the range of expected break sizes.

Table A-8. (continued).

Use of fire sprays, both existing and augmented, should be considered to reduce the escape of fission products from the auxiliary building and the containment.

Strategies for returning liquid from sumps in the auxiliary building to the containment should be examined.

Means of flooding the location of the break and submerging the break to scrub fission products should be examined. Possible negative effects on equipment of this flooding should be considered.

4. Instrumentation:

a. Existing instrumentation:

Radiation detectors, RCS pressure, Auxiliary building fire system status, containment sump level, RVLMS, pressurizer level

b. Potential use of instrumentation

The following auxiliary building instrumentation should be available and displayed in the control room: sump levels, radiation alarms (stack gas monitor and area monitors), area temperature, area fire alarms.

5. Training Capability:

a. Current Training:

Sufficient information not available.

6. Possible Interactions with other Sequence Categories

a. Differentiating between ISLOCA and SGTR and other LOCAs is important in order to carry out actions in timely manner and minimize damage and a release. Symptoms will be similar but actions will be different.

b. In order to reduce the release to the environment it may be necessary to reduce pressure. This action is somewhat contrary to maintaining minimum subcooling and also creating adverse conditions for in-vessel steam explosions.

c. There should be an effort to conserve injection inventory since the injected water will be going to a location outside of the containment where it can not be recirculated. This conservation may be contrary to some proceduralized actions.

Appendix B

Assessment Category Questions for Framework Application

Appendix B

Assessment Category Questions for Framework Application

This appendix presents examples of information developed by the assessment team who, in this instance, used a question-answer format to identify the accident management capabilities of Zion Unit 1. The team comprised personnel with operations, severe accident analysis, thermal-hydraulic safety analysis, procedures, training, human factors, PRA, and accident management experience. They developed a table based of the following five areas to organize and display the plant capabilities.

- Procedures and guidelines
- Delineate Decision-Making Authority or Responsibilities
- Equipment
- Instrumentation
- Training.

Answers to the capability questions were developed for selected assessment categories. Individual team members were assigned to answer questions for specific assessment categories, which were then reviewed by all team members to provide additional information from their individual areas of expertise. We found that answering some of the questions required more information than was available to the team. This lack of information is particularly evident for questions concerning training and decision making. The information developed in answering these questions is our best understanding of the current plant capabilities together with possible changes that could improve the current accident management situation, based on the information available. Information presented in the answers contains details that may be difficult to understand without a working knowledge of the plant procedures and operations. Since these answers are only intended to serve as examples, the procedures necessary for completely understanding them is not presented in this report. Tables for the following assessment categories are presented:

- Loss of Secondary Heat Sink (Table B-1)
- Inadequate Inventory Control (Table B-2)
- Containment Heat Removal (Table B-3)
- Direct Containment Heating (Table B-4)
- Combustible Gas Burns (Table B-5)
- Core Concrete Interactions (Table B-6)

- Steam Generator Tube Rupture (Table B-7)
- Interfacing System Loss-of-Coolant Accident (ISLOCA) (Table B-8).

Table B-1. Sequence category questions for framework application for loss of secondary heat removal.

Procedures

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. Which of the current procedures are applicable for prevention or mitigation of the severe accident conditions?

   Answer:

   Main procedure FR-H.1 and F-0.3
   FR-H.1 entered from:
   - E-0—Step 10
   - ES-0.1—Step 4d
   - F-0.3

   FR-H.1 can lead into E-1, AOP-4.3, SOI-10, ES-1.3.

2. What changes could be made to the current procedures and guidance to enhance the capability to prevent or mitigate the severe accident conditions?

   Answer:

   As the accident progress toward core damage the procedures include less and less detail. Having procedures for severe accident conditions that integrate well with the existing EOPs but give more detailed guidance for the prevention and mitigation of severe accident conditions would be an improvement. They also need to be based on improved technical detail.

3. If alternate systems and equipment are important, what procedures and guidance exist to facilitate their use?

   Answer:

   Procedures cover using Main Feed, Emergency Feed, and Condensate Feed. Primary feed and bleed, charging & SI. Procedures could not be found that would facilitate the use of alternate equipment to provide water to the steam generators such as diesel fire water system pumps, portable pumps or fire engines pumps and water sources.

4. What procedures consider long term recovery actions that may be necessary for accident management? (Examples would be establishing long term core cooling or long term containment cooling.)

Table B-1. (continued).

Answer:

Based on the information we have available, the current procedures do not seem to stress long term recovery actions. They do cover core and containment cooling actions for design basis accident conditions that should be considered short to intermediate term recovery actions.

5. What procedures and guidance provide instructions on how to evaluate information, either from instrumentation or from other sources, that is apparently conflicting?

Answer:

The current procedures do not specifically give guidance on how to evaluate information that may be conflicting. The procedures are constructed such that you are lead from one step to another with a basically binary (yes/no) decision process. If an instrument was providing erroneous information that leads you down a wrong path, later steps should guide you back. There is not enough information do determine whether they do an adequate job during severe accidents.

6. What additional procedures could be added to enhance the capability to prevent or mitigate plant damage?

Answer:

Based on the information available to us, no significant improvements were identified. See answer to question 2 above.

Decision Making

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ". (Answers to most of these questions are good for all accident sequences)

1. What are the current assignments of responsibility and authority for decision making?

Answer:

The answer to this question and the other questions on decision making are based on the Emergency Plan information we were able to obtain. Since this information was not complete, the resulting answers to the decision making questions are generally incomplete.

EPIP 100-1 describes organization and lines of authority. We lack the necessary documents to answer this question.

Table B-1. (continued).

2. How were the currently used lines of communication between the control room and the technical support center and other emergency response and planning facilities evaluated and validated?

   Answer:

   Our information indicates that EPIP 440-1 covers this subject but it was not available to us for evaluation.

3. To what extent is long term accident management considered in the decision making process including the basis for determining when the recovery phase is complete?

   Answer:

   Our information indicates that the EPIPs address this, however we did not have access to the necessary EPIPs

4. What decision making is defined in the current procedures and guidance?

   Answer:

   EOPs essentially create a binary type of decision process that leads the operator through the procedures. Based on our review of a limited, incomplete set of the EPIPs, they use decision trees for recommended protective action (included in EPIP 100-1 and perhaps other EPIPs as well). The recovery phase has been relatively well defined by other utilities EPIPs and we believe the same to be true here, but we could not verify this (EPIP-100-3 covers this but was not available).

5. What decision points are identified for expediting administrative controls to facilitate the repair or recovery of equipment?

   Answer:

   Sufficient information was not available. Our experience with some other E-Plans is that such things are accounted for but the amount of detail varies from plant-to-plant.

6. What guidance is given to decision makers for prioritizing alternate actions, identifying and avoiding potential negative effects, and evaluating long term plant recovery?

   Answer:

   The EOPs basically guide the operator but don't provide guidance on prioritizing alternate actions. We could not find anything in the limited set of EPIPs available that provides prioritization.

Table B-1. (continued).

7. What changes in the assignments of responsibility and authority could be made to increase the capability to prevent or mitigate plant damage?

   Answer:

   We do not have enough information available to us to answer this question.

Equipment

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. What existing plant equipment could be used to perform the function of failed safety systems, for example, non-safety-grade equipment that could supply water, or jumpering to make available alternate sources of power?

   a. What are the ultimate operating limits for the existing equipment that could be used as alternates to safety grade equipment?

   Answer:

   The following systems could be used: RHR (a safety system) if the RCS fluid temperature and pressure meets the specified design limits(RCS fluid temperature is less than 350°F and pressure less than 300 psi), auxiliary or main feed, alternate power sources, primary feed and bleed. Use condensate booster pumps to feed the steam generators (if the steam generators can be depressurized). Atmospheric dumps, condenser steam dumps, RCS feed & bleed via charging and SI, PORV and head vent can be used. Use Service Water to supply the Steam Generator (AOP-4.3). Anything that requires jumpering does not show in procedures, and we can not tell if such things have been addressed by reviewing just the EOPs. Really long term types of issues have not been included in the EOPs and we do not have enough information to make a determination about EPIPs.

   a. The ultimate operating limits are not formally recorded or listed in the information available to us. Additional information would be necessary to answer this question.

2. What provisions could be made to facilitate repair or replacement of failed equipment for this sequence category. Consider both the availability of parts and the capability to gain access to failed equipment exposed to severe accident environments?

   a. What replacement equipment and spare parts have been identified including their location and means of transport and installation within the time available?

   b. What advance preparation of hardware, for example, spool pieces, pre-positioning of equipment, etc., would facilitate the use of existing alternate equipment to provide a significant increase in equipment capability?

Table B-1. (continued).

c. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

Answer:

Providing the utility applied their PRAs to this issue, they could optimize and prioritize their spare parts and pre-evaluate what was and what was not feasible. From the information that we have available, there is no way to tell whether this was done.

a. We do not have enough information to make a determination, although previous experience at other plants indicates that the results would be dependant on the plant policies. The timing of loss of all feedwater sequences would indicate that there is time available for simple repair or replacement.

b. We do not have enough information to make a determination. An example could be identification of portable resources, such as diesel generators or battery chargers, located within a 100 mile radius.

c. We do not have enough information to make a determination.

3. What resources can be managed, such as battery power or borated water, to prevent or delay severe accident consequences and what is the technical basis for their use?

a. Is equipment available that has the capability to replenish exhausted resources within the time frame available for recovery. Are suppliers of essential resources identified?

b. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

Answer:

Although some EOP procedures specified shutting down unneeded equipment (E-3 Step 39 e.g.), there was not a similar step in this procedure (FR-H.1). We could not find a reason why this procedure should not addressed such things.

a. We do not have enough material to answer this question. Based on experience with other plants, some resources could be available through formal E Plan agreements, made with suppliers for support in an emergency situation.

b. We do not have enough information to answer this question.

4. What potential options for use of equipment from another unit have been considered and optimized?

Table B-1. (continued).

Answer:

The procedures for this sequence category do not discuss the use of equipment from other units.

5. What additional equipment would enhance the capability to prevent or mitigate severe accidents?

There is the potential to use diesel driven fire pumps or portable pumps to supply water.

Instrumentation

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. What instruments are necessary to identify the symptoms and applicable strategies that will enable accident management personnel to prevent or mitigate severe accident conditions?

Answer:

From just FR-H.1 procedure the following instruments/indications were listed.

RCS pressure and temperature, SG temperature and pressure, RHR valve and pumps status, valve position and SG blowdown, AFW flow, RCP status, centrifugal charging pump status, offsite power status, condensate system pumps and valves indicators, SI status, safeguards status, auto safety injection blocked indicator, DG status, reactor trip breaker status, rod position status, main feed valve and pump status, main feed flow, feed water system pump and valve status, condenser hotwell level, SG levels (wide and narrow) core exit TCs, RCS hot leg temperatures, power to pressurizer (PZR) PORV and block valves, and PORV and block valve position indication, service water status (pumps, valves etc.). Dump valve status, atmosphere relief valve status, Pzr level, various valve positions for re-circulation (step 25), charging flow status (pumps and valves), charging flow, CST level.

2. What are the limitations on the instrumentation to provide needed information on plant severe accident behavior and how are they communicated to accident management personnel?

Answer:

We do not have access to documents with a discussion of instrument limitations for either design basis or severe accidents. It is uncertain whether an analysis for severe accident conditions has been performed.

3. What means (protection from harsh environments, operator aids, etc.) have been developed to use existing instruments under the expected severe accident conditions?

Table B-1. (continued).

Answer:

We have no information on how existing instrumentation would be considered for use under severe accident conditions.

4. What methodologies have been established to identify unreliable data from instruments under severe accident conditions?

Answer:

We do not have adequate information to answer this question. None were identified.

5. What changes could be made to the current instrument systems that enhance their capability to prevent or mitigate severe accident conditions?

Answer:

It is difficult to tell from the available information. The feedwater and steam flow as well as level information would be most critical. We are not sure whether they would be operational when containment conditions are severe.

6. What additional instruments would enhance the capability to prevent or mitigate severe accident conditions?

Answer:

A measure of steam flow out all possible flow paths. Also a measure of all possible water flow paths into the steam generator.

Training

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase. "For this sequence category, ... ".

Answer:

1. How does the training provide personnel involved in accident management with an understanding of the expected plant behavior, and is this training given at the proper levels and in the detail required to facilitate decision making?

Answer:

We do not have sufficient training information to answer this question.

Table B-1. (continued).

2. How are all personnel involved with the training simulator made aware of the limitations in representing severe accident conditions and is it made clear when the simulation is no longer valid?

Answer:

Limitations on performance are noted in Discrepancy Reports. During testing if invalid performance is noted, it is identified and reported. These reports were not available to us. The degree to which these limitations would apply for severe accident conditions would depend on whether a detailed evaluation had been performed of the simulator capabilities for the severe accident sequences identified as important for the plant.

3. How are personnel trained to proceed if instruments give what appears to be conflicting readings?

Answer:

We do not have sufficient training information to answer this question.

4. How does the training for all personnel involved in accident management ensure that all important actions or decisions for severe accident management are included?

Answer:

We do not have sufficient training information to answer this question.

5. What training is provided for all accident management personnel on the possible limitations of equipment, instrumentation, and plant information?

Answer:

We do not have sufficient training information to answer this question.

6. What additional training is provided to implement the use of alternative systems and equipment?

Answer:

We do not have sufficient training information to answer this question.

7. How do drills and simulator exercises consider the following potential restrictions: inhibited access to equipment as a result of high temperature or radiation levels, limited lighting or loss of resources such as electricity, and constraints on the availability of personnel with the proper skills?

Table B-1. (continued).

Answer:

Drills and simulations may not incorporate actual real-time performance attributes or adequate representation of the limiting factors of radiation fields, lighting or loss of other resources. EOP inspections by NRC does look at this and the AOP/EOP should incorporate this information in the actions.

8. What are the changes that have been made to the current training program to enhance the capability to prevent or mitigate plant damage?

   Answer:

   We do not have sufficient training information to answer this question.

9. What additional training has been provided to enhance the capability to prevent or mitigate plant damage?

   Answer:

   We do not have sufficient training information to answer this question.

Table B-2. Sequence category questions for framework application for inadequate RCS inventory.

Procedures

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. Which of the current procedures are applicable for prevention or mitigation of the severe accident conditions?

   Answer:

   EOPs

   E-0: steps 7,8,9 check for ECCS flow to RCS; step 15 checks for PORV position; step 26 checks PRT conditions for leakage into PRT.

   E-1: Foldout page list ECCS re-initiation criteria including Pzr level; step 7 checks Pzr level as part of SI termination criteria; step 14 evaluates long-term cooling/recirculation mode based on RHR pumps/valve power and directs to ECA-1.1 LOSS OF EMERG. COOLANT RECIRC.; step 15 evaluates plant status including ECCS operation and need to refill RWST (refers to SOI-2); step 17 provides conditions for transition to ES-1.3 TRANSFER TO COLD LEG RECIRC. based on RWST volume.

   ES-1.2: step 9 depressurizes RCS to allow ECCS refill of Pzr; steps 12,13,17,18,19 check Pzr level as ECCS pumps stopped and normal charging established; step 23 verifies addition ECCS NOT required.

   ES-1.3: steps provide for transfer to recirculation mode for ECCS.

   E-3: Foldout page list ECCS re-initiation criteria including Pzr level; step 7 checks PORV position and provides transition to ECA-3.1 SGTR WITH LOCA - SUBCOOLED RECOVERY; step 15,16 provides transition to ECA-3.1 SGTR WITH LOCA - SUBCOOLED RECOVERY; *step 18 depressurizes RCS to minimize primary to secondary loss; step 21 checks Pzr level as ECCS pumps stopped and normal charging established; step 26 verifies addition ECCS NOT required; step 31 provides decision chart for balancing the SG (ruptured) and Pzr levels based on SG and Pzr levels; *ES-3.1, 3.2 and 3.3 provide POST-SGTR cooldown methods based on availability of equipment, limiting contamination, water inventories and time. E-3 identifies all three methods in step 43 stating as directed by TSC or Shift Engineer. Basis for selection are identified in Background Document.

   ECA-0.0: step 3 verifies all paths from RCS are isolated to maximize water inventory until ECCS flow can be established (LOSP); step 7 locally isolates RCP seal and cooling paths (primarily thermal shock prevention but does isolate possible leak path); step 16 instructs depressurization of SG to lower RCS pressure to allow SI Accumulators to inject and provide their water volume; step 32 identifies recovery procedure based on ECCS requirements including Pzr level.

Table B-2. (continued).

ECA-0.2 steps 1,2,3 check RWST inventory and ECCS alignment and provides instruction for establishing recirc based on RWST level;

ECA-1.1: Step 2 provides instructions for makeup to RWST, including alternative sources (Other Unit RWST, SFP, Primary Water, Demineralized Water, Fire water) if recirc cannot be established; Entire procedure looks a ways of ensuring adequate flow to RCS yet maintaining maximum source capability.

F-0.6 CSFST: looks at Pzr level and RVLIS inventory. All are yellow path since the major inventory concerns are addressed by other CSF concerns (Core Cooling and Integrity).

FR-C.1: steps 2,3,4,16,23 check flow; step 6 verifies SI Accumulator availability; steps 7,17,24 check RVLIS if available; step 11 checks RCVS vent paths isolated; steps 12,20 depressurize SGs to cause Accumulator injection.

FR-C.2: steps 2,3,4,17 check ECCS flow; step 5 checks RCS vent paths isolated; steps 7,9,20 checks RVLIS indication; step 10 verifies SI Accumulator availability; step 12 depressurizes SGs to cause Accumulator injection.

FR-C.3: steps 2,3,4 check ECCS flow; step 5 checks RCS vent paths isolated.

FR-H.1: steps 14-18 establish Primary Feed & Bleed with ECCS.

FR-I.1 HIGH PZR LEVEL directs concern to limiting flow into RCS, establishing letdown and controlling RCS pressure (possible PTS).

FR-I.2 LOW PZR LEVEL directs concern toward ensuring letdown isolated and normal charging flow established. step 5 includes alternatives to normal charging including operating SI pumps and establishing BIT flow or transition to E-1)

FR-I.3 VOIDS directs concern toward insuring normal letdown and charging in service, maintaining adequate Pzr level for pressure control and void collapse.
AOPs

AOP-1.1: step 1 directs the star of addition charging pumps and increase in charging flow based on decreasing Pzr level. Directs SI initiation if level cannot be maintained.

2. What changes could be made to the current procedures and guidance to enhance the capability to prevent or mitigate the severe accident conditions?

Answer:

Identification of other sources of water and how they should be accessed could be identified and procedurally incorporated (see 1. ECA-1.1).

Table B-2. (continued).

3. If alternate systems and equipment are important, what procedures and guidance exist to facilitate their use?

Answer:

Reference to SOI-2 provides the procedure for normal makeup to the RWST from the blender system but does not identify alternatives.

4. What procedures consider long term recovery actions that may be necessary for accident management? (Examples would be establishing long term core cooling or long term containment cooling.)

Answer:

The following procedures apply: ES-1.2, 1.3, 1.4; ES-3.1, 3.2, 3.3; ECA-1.1. We were not able to determine whether these procedures would be adequate for long term recovery under severe accident conditions. Based on the information we have available, the current procedures do not seem to stress long term recovery actions. They do cover core and containment cooling actions for design basis accident conditions that should be considered short to intermediate term recovery actions for severe accidents.

5. What procedures and guidance provide instructions on how to evaluate information, either from instrumentation or from other sources, that is apparently conflicting?

Answer:

RNO section provides some guidance. General guidance is detailed in Administrative Procedure ZAP-0 5.3.15 Policy Regarding Operational Practices and ZAP 5-51-3A 3 Policy on Operator Use of EOPs.

6. What additional procedures could be added to enhance the capability to prevent or mitigate plant damage?

Answer:

Based on the information available, we did not identify additional procedures.

Decision Making

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. What are the current assignments of responsibility and authority for decision making?

Table B-2. (continued).

Answer:

The assignments appear to be specified in EPIPs and ZAP-0 section 5.1 and ZAP-5-51-3A Section 3 & Appendix A (specific for EOP responsibilities). We did not have access to these documents.

2. How were the currently used lines of communication between the control room and the technical support center and other emergency response and planning facilities evaluated and validated?

Answer:

Specified in EPIPs and communications systems evaluated in EPIP-440-1. We did not have access to these documents.

3. To what extent is long term accident management considered in the decision making process including the basis for determining when the recovery phase is complete?

Answer:

The availability of decision making guidance is limited. The guidance that exists is specified in EPIP-100-1 (section 8), EPIP-330-1 CLASSIFICATION OF GSEP CONDITIONS and EPIP-100-3 RECOVERY, REENTRY AND TERMINATION (not available). Some existing guidance includes categories for classifying and review; PAG recommendations; identification of operating equipment; core damage assessment; dose assessment. Mitigation strategies are not identified in the information that we have.

4. What decision making is defined in the current procedures and guidance?

Answer:

see 3. above.

5. What decision points are identified for expediting administrative controls to facilitate the repair or recovery of equipment?

Answer:

None were identified based on the limited information available.

6. What guidance is given to decision makers for prioritizing alternate actions, identifying and avoiding potential negative effects, and evaluating long term plant recovery?

Table B-2. (continued).

Answer:

None were identified based on the limited information available.

7. What changes in the assignments of responsibility and authority could be made to increase the capability to prevent or mitigate plant damage?

Answer:

We did not have sufficient information to answer this question.

Equipment

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. What existing plant equipment could be used to perform the function of failed safety systems, for example, non-safety-grade equipment that could supply water, or jumpering to make available alternate sources of power?

   a. What are the ultimate operating limits for the existing equipment that could be used as alternates to safety grade equipment?

   Answer:

   Specified sources with existing piping from other unit BWST. If it is determined that borated water is not necessary to prevent criticality, several sources could be used. Considered makeup from SFP via normal SFPC&PS and permanent piping; The lineup and operation is NOT covered in procedure. Consider makeup from Primary Water via any available path. The lineup,temporary hookups and operation is NOT covered in procedure. Consider makeup from Demineralized Water via normal SFPC&PS and permanent piping; The lineup and operation is NOT covered in procedure. Consider makeup from Fire Water via any available path. The lineup,temporary hookups and operation is NOT covered in procedure. Other system/sources are not considered since most are redundant or loss of non-redundant items are procedurally covered (EOPs).

   a. The ultimate operating limits are not formally recorded or listed in the information available to us. Additional information would be necessary to answer this question. Possible sources are SOPs and vendor information ZAP 6-52-5 (unavailable). Other may include ZAP 18-5 PLANNED AVAILABILITY OF COMPONENTS AND SYSTEMS (PACS) WALKDOWN PROCEDURE.

2. What provisions could be made to facilitate repair or replacement of failed equipment for this sequence category. Consider both the availability of parts and the capability to gain access to failed equipment exposed to severe accident environments?

Table B-2. (continued).

a. What replacement equipment and spare parts have been identified including their location and means of transport and installation within the time available?

b. What advance preparation of hardware, for example, spool pieces, pre-positioning of equipment, etc., would facilitate the use of existing alternate equipment to provide a significant increase in equipment capability?

c. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

Answer:

We did not have adequate information available to answer this question.

3. What resources can be managed, such as battery power or borated water, to prevent or delay severe accident consequences and what is the technical basis for their use?

   a. Is equipment available that has the capability to replenish exhausted resources within the time frame available for recovery. Are suppliers of essential resources identified?

   b. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

Answer:

We did not have sufficient information available to answer this question.

a. None noted. They are possibly in Administrative Procedures not available to us.

b. None noted. Use of portable pumps, fire engines, or other portable equipment was not considered in the available information.

4. What potential options for use of equipment from another unit have been considered and optimized?

Answer:

Use of the BWST from the other unit is included via Administrative Control. The crosstie would be made using permanent plant equipment. No reference could be found in the current procedures to consider the use of pumping systems from one unit to supply injection to the other unit.

5. What additional equipment would enhance the capability to prevent or mitigate severe core damage?

Table B-2. (continued).

Answer:

Sufficient information was not available to us to adequately answer this question.

Instrumentation

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. What instruments are necessary to identify the symptoms and applicable strategies that will enable accident management personnel to prevent or mitigate severe accident conditions?

Answer:

RVLIS, Pressurizer level, ECCS flows, ECCS valve indications, RWST level, CNMT sump levels, SI Accumulator pressures and levels, Steam Generator pressures, RCS pressure, charging flow, letdown flow, RCP seal injection flows. Core Exit Thermocouples can provide indirect comparison for level problems.

2. What are the limitations on the instrumentation to provide needed information on plant severe accident behavior and how are they communicated to accident management personnel?

Answer:

We do not have access to documents with a discussion of instrument limitations for either design basis or severe accidents. It is uncertain whether an analysis for severe accident conditions has been performed.

3. What means (protection from harsh environments, operator aids, etc.) have been developed to use existing instruments under the expected severe accident conditions?

Answer:

The available information was not adequate to answer this question.

4. What methodologies have been established to reduce and resolve data from instruments under severe accident conditions?

Answer:

None noted from the limited information available.

5. What changes could be made to the current instrument systems that would enhance the capability to prevent or mitigate severe accident conditions?

Table B-2. (continued).

Answer:

Although there is not sufficient information available, one possibility would be a more reliable computer system for RVLIS?

6. What additional instruments would enhance the capability to prevent or mitigate severe accident conditions?

Answer:

Improved measurement of core and RCS conditions if the core is near or experiencing core damage. An example would be temperature readings of the lower head either through thermocouples or by optical means.

Training

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. How does the training provide personnel involved in accident management with an understanding of the possible severe accident plant behavior, and is this training given at the proper levels and in the detail required to facilitate decision making?

Answer:

There was not sufficient training material available to make an adequate evaluation. EOP training is yearly. JTAs identified with K/A identified and LP objectives identified where appropriate (e.g. JT 0000110501 RESPOND TO A LOCA, K/A 000011PK3.03 KNOWLEDGE OF THE SYMPTOMS AND INDICATIONS OF SELECTED CASUALTIES, Objective 672-01).

2. How are all personnel involved with the training simulator made aware of the limitations in representing severe accident conditions and is it made clear when the simulation is no longer valid?

Answer:

Limitations on performance are noted in Discrepancy Reports. During testing if invalid performance is noted, it is identified and reported. These reports were not available to us. The degree to which these limitations would apply for severe accident conditions would depend on whether a detailed evaluation had been performed of the simulator capabilities for the severe accident sequences identified as important for the plant.

3. How are personnel trained to proceed if instruments give what appears to be conflicting readings?

Table B-2. (continued).

Answer:

Adequate information was not available to answer this question.

4. How does the training for all personnel involved in accident management ensure that all important actions or decisions for severe accident management are included?

Answer:

Adequate information was not available to answer this question.

5. What training is provided for all accident management personnel on the possible limitations of equipment, instrumentation, and plant information?

Answer:

Material for evaluation was not available. Individual lesson plans cover the equipment and instrumentation on a system and component level. Some limitations may be covered during this presentation.

6. What additional training is provided to implement the use of alternative systems and equipment?

Answer:

Alternative actions and local operator actions are not evaluated during most simulator scenarios. The ability to make decisions and utilize local operators is evaluated. Some JPMs may cover these local actions but are generally based on JTs covered by existing procedures. RNOs and alternate actions that do not list specific instructions or are not covered in AOP/SOI are not performed.

7. How do drills and simulator exercises consider the following potential restrictions: inhibited access to equipment as a result of high temperature or radiation levels, limited lighting or loss of resources such as electricity, and constraints on the availability of personnel with the proper skills?

Answer:

Drills and simulations may not incorporate actual real-time performance attributes or adequate representation of the limiting factors of radiation fields, lighting or loss of other resources. EOP inspections by NRC does look at this and the AOP/EOP should incorporate this information in the actions.

8. What are the changes that have been made to the current training program to enhance the capability to prevent or mitigate plant damage?

Table B-2. (continued).

Answer:

Training material was not available for evaluation. In general, a more in-depth approach to problem-solving techniques and accident management courses that provide decision making techniques would be beneficial. Also training for team-based decision making should be included.

9. What additional training has been provided to enhance the capability to prevent or mitigate plant damage?

Answer:

Training material was not available to answer this question.

Table B-3. Sequence category questions for framework application for containment heat removal.

Procedures

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ...".

1. Which of the current procedures are applicable for prevention or mitigation of the severe accident conditions?

   Answer:

   The following EOPs:

   E-0: step 5 check of ECCS equipment lineup; step 11 check of Containment Spray (based on containment pressure).

   E-1: step 11 check of Containment Spray; step 15.c check of ECCS equipment (non-specific), step 19 check of RHR spray.

   ES-1.3: step 2 check of Containment Spray; step 13 alignment of RHR spray.

   E-3: step 27 check of Containment Spray; step 40 places RCFCs to normal operation (based on containment pressure).

   ECA-0.0: step 20 RNO checks Containment Spray pumps (DG pump requires cooling of SW & electrical discharge valve OPEN).

   ECA-0.2: steps 2 & 3 set conditions for running and start RCFCs; step 6 set Containment Spray pump hand switches in STBY.

   F-0.5: Status Tree for Containment checks pressure and water level.

   FR-Z.1: step 3 checks containment spray flow; step 4 checks RHR spray flow; step 5 checks RCFCs operation (SW valve position & fans running in LOW).

2. What changes could be made to the current procedures and guidance to enhance the capability to prevent or mitigate the severe accident conditions?

   Answer:

   Operation of the RCFCs with or without cooling water (SW) availability is not covered.

3. If alternate systems and equipment are important, what procedures and guidance exist to facilitate their use?

Table B-3. (continued).

Answer:

No alternates are identified. Systems are safety related and redundant. Tech Specs provide for required operations and testing.

4. What procedures consider long term recovery actions that may be necessary for accident management? (Examples would be establishing long term core cooling or long term containment cooling.)

Answer:

Recovery appears to be included in ES-1.3 Transfer to cold leg recirculation. However, based on the information we have available, the current procedures do not seem to stress long term recovery actions. They do cover core and containment cooling actions for design basis accident conditions that should be considered short to intermediate term recovery actions for severe accidents.

5. What procedures and guidance provide instructions on how to evaluate information, either from instrumentation or from other sources, that is apparently conflicting?

Answer:

RNO section provides some guidance. General guidance is detailed in Administrative Procedure ZAP-0 5 3.15 Policy Regarding Operational Practices and ZAP 5-51-3A.3 Policy on Operator Use of EOPs.

6. What additional procedures could be added to enhance the capability to prevent or mitigate plant damage?

Answer:

A procedure could be added to describe the use of the fire water system tie into the Service Water (at the Diesel Generator coolers) to also provide cooling to the RCFCs during accident conditions.

Decision Making

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. What are the current assignments of responsibility and authority for decision making?

Table B-3. (continued).

Answer:

Adequate information is not available to answer this question. Appears to be specified in EPIPs and ZAP-0 section 5.1 and ZAP-5-51-3A section 3 & Appendix A (specific for EOP responsibilities).

2. How were the currently used lines of communication between the control room and the technical support center and other emergency response and planning facilities evaluated and validated?

Answer:

Adequate information is not available to answer this question. Appears to be specified in EPIPs and communications systems evaluated in EPIP-440-1.

3. To what extent is long term accident management considered in the decision making process including the basis for determining when the recovery phase is complete?

Answer:

Adequate information is not available to answer this question. The guidance that exists is specified in EPIP-100-1 (section 8), EPIP-330-1 CLASSIFICATION OF GSEP CONDITIONS and EPIP-100-3 RECOVERY, REENTRY AND TERMINATION (not available). Some existing guidance includes categories for classifying and review; Protective Action Guidelines (PAG) recommendations; identification of operating equipment; core damage assessment; dose assessment. Mitigation strategies are not identified.

4. What decision making is defined in the current procedures and guidance?

Answer:

See 3. above.

5. What decision points are identified for expediting administrative controls to facilitate the repair or recovery of equipment?

Answer:

We do not have sufficient information available to answer this question.

6. What guidance is given to decision makers for prioritizing alternate actions, identifying and avoiding potential negative effects, and evaluating long term plant recovery?

Table B-3. (continued).

Answer:

We do not have sufficient information available to answer this question.

7. What changes in the assignments of responsibility and authority could be made to increase the capability to prevent or mitigate plant damage?

Answer:

We do not have sufficient information available to answer this question.

Equipment

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. What existing plant equipment could be used to perform the function of failed safety systems, for example, non-safety-grade equipment that could supply water, or jumpering to make available alternate sources of power?

   a. What are the ultimate operating limits for the existing equipment that could be used as alternates to safety grade equipment?

Answer:

Fire water system may be capable of being utilized to provide cooling water to RCFCs.

a. The ultimate operating limits are not formally recorded or listed in the information available to us. Additional information would be necessary to answer this question. Although NOT an alternative system, specific limits on operation of the diesel driven Containment Spray pump exists based on availability of cooling water (SW) and position of header discharge valve.

2. What provisions could be made to facilitate repair or replacement of failed equipment for this sequence category. Consider both the availability of parts and the capability to gain access to failed equipment exposed to severe accident environments?

   a. What replacement equipment and spare parts have been identified including their location and means of transport and installation within the time available?

   b. What advance preparation of hardware, for example, spool pieces, pre-positioning of equipment, etc., would facilitate the use of existing alternate equipment to provide a significant increase in equipment capability?

Table B-3. (continued).

c. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

Answer:

We are not able to answer any parts of this question based on the material available to us.

3. What resources can be managed, such as battery power or borated water, to prevent or delay severe accident consequences and what is the technical basis for their use?

   a. Is equipment available that has the capability to replenish exhausted resources within the time frame available for recovery. Are suppliers of essential resources identified?

   b. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

   Answer:

   We did not have sufficient information available to answer this question.

   a. None noted, possibly in Administrative Procedures that we do not have.

   b. None noted based on the available information.

4. What potential options for use of equipment from another unit been considered and optimized?

   Answer:

   None noted based on the available information. The capability to share service water and component cooling water would provide additional flexibility for this sequence category.

5. What additional equipment would enhance the capability to prevent or mitigate severe core damage?

   Answer:

   Sufficient information is not available to us to answer this question.

Instrumentation

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. What instruments are necessary to identify the symptoms and applicable strategies that will enable accident management personnel to prevent or mitigate severe accident conditions?

Table B-3. (continued).

Answer:

Containment air pressure (SR), temperature, humidity; Containment sump levels. RCFCs: SW outlet rad monitor; SW valve positions. Containment Spray: outlet header valve positions; suction pressure; discharge pressure; flow. RHR: heat exchanger inlet/outlet temperatures; spray header discharge valves; flow.

2. What are the limitations on the instrumentation to provide needed information on plant severe accident behavior and how are they communicated to accident management personnel?

Answer:

We do not have access to documents with a discussion of instrument limitations for either design basis or severe accidents. It is uncertain whether an analysis for severe accident conditions has been performed.

3. What means (protection from harsh environments, operator aids, etc.) have been developed to use existing instruments under the expected severe accident conditions?

Answer:

Pressure is post-accident qualified instrument for design basis conditions. Its survivability under severe accident conditions is not known. Most other instruments for this category are not subject to extreme conditions, other than possibly radiation.

4. What methodologies have been established to identify unreliable data from instruments under severe accident conditions?

Answer:

None noted based on the material available to us.

5. What changes could be made to the current instrument systems that would enhance the capability to prevent or mitigate severe accident conditions?

Answer:

We did not have sufficient information available to answer this question.

6. What additional instruments would enhance the capability to prevent or mitigate severe accident conditions?

Table B-3. (continued).

Answer:

Containment liner temperature sensors might enable better tracking of containment heating/lack of adequate cooling.

Training

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. How does the training provide personnel involved in accident management with an understanding of possible severe accident plant behavior, and is this training given at the proper levels and in the detail required to facilitate decision making?

Answer:

The training material available was not adequate to make this evaluation. EOP training yearly.

2. How are all personnel involved with the training simulator made aware of the limitations in representing severe accident conditions and is it made clear when the simulation is no longer valid?

Answer:

Limitations on performance are noted in Discrepancy Reports. During testing if invalid performance is noted, it is identified and reported. These reports were not available to us. The degree to which these limitations would apply for severe accident conditions would depend on whether a detailed evaluation had been performed of the simulator capabilities for the severe accident sequences identified as important for the plant.

3. How are personnel trained to proceed if instruments give what appears to be conflicting readings?

Answer:

Material for evaluation was not available to us.

4. How does the training for all personnel involved in accident management ensure that all important actions or decisions for severe accident management are included?

Answer:

Material for evaluation was not available to us.

Table B-3. (continued).

5. What training is provided for all accident management personnel on the possible limitations of equipment, instrumentation, and plant information?

   Answer:

   Material for evaluation not available to us. Individual lesson plans cover the equipment and instrumentation on a system and component level. Some limitations may be covered during this presentation.

6. What additional training is provided to implement the use of alternative systems and equipment?

   Answer:

   Alternative actions and local operator actions are not evaluated during most simulator scenarios. The ability to make decisions and utilize local operators is evaluated. Some JPMs may cover these local actions but are generally based on JTs covered by existing procedures. RNOs and alternate actions that do not list specific instructions or are not covered in AOP/SOI are not performed.

7. How do drills and simulator exercises consider the following potential restrictions: inhibited access to equipment as a result of high temperature or radiation levels, limited lighting or loss of resources such as electricity, and constraints on the availability of personnel with the proper skills?

   Answer:

   Drills and simulations may not incorporate actual real-time performance attributes or adequate representation of the limiting factors of radiation fields, lighting or loss of other resources. EOP inspections by NRC does look at this and the AOP/EOP should incorporate this information in the actions.

8. What are the changes that have been made to the current training program to enhance the capability to prevent or mitigate plant damage?

   Answer:

   Training material was not available for evaluation. In general, a more in-depth approach to problem-solving techniques and accident management courses that provide decision making techniques would be beneficial. Also training for team-based decision making, for example in the TSC, should be included.

Table B-3. (continued).

9. What additional training has been provided to enhance the capability to prevent or mitigate plant damage?

   Answer:

   Material for evaluation was not available to us.

Table B-4. Sequence category questions for direct containment heating (DCH).

Procedures

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... "

1. Which of the current procedures are applicable for prevention or mitigation of the severe accident conditions?

   Answer:

   The procedures that we have do not specifically discuss the possible consequences of DCH (for example that it can cause rapid pressurization of the containment). If DCH has occurred, operator actions would have little effect on whether the containment fails in the short term.

   RCS depressurization is in the procedures. It is initiated using PORVs and upper head vents when core exit thermocouples are greater than 1200 F.

2. What changes could be made to the current procedures and guidance to enhance the capability to prevent or mitigate the severe accident conditions?

   Answer:

   Cautions on the likelihood and consequences of DCH if the RCS pressure remains high

   Cautions on the likelihood of steam explosions may also be needed if research indicates steam explosions at low pressures would have negative consequences.

3. If alternate systems and equipment are important, what procedures and guidance exist to facilitate their use?

   Answer:

   There are no alternate systems and equipment that are recognized as being specifically used for DCH and consequently, there are no procedures. RCS depressurization is one preventative measure for DCH that is already included in the procedures.

4. What procedures consider long term recovery actions that may be necessary for accident management? (Examples would be establishing long term core cooling or long term containment cooling.)

Table B-4. (continued).

Answer:

Only depressurization is currently included in the procedures and it would not be considered to be long term. Based on the information we have available, the current procedures do not seem to stress long term recovery actions. They do cover core and containment cooling actions for design basis accident conditions that should be considered short to intermediate term recovery actions for severe accidents.

5. What procedures and guidance provide instructions on how to evaluate information, either from instrumentation or from other sources, that is apparently conflicting?

Answer:

The current procedures do not specifically give guidance on how to evaluate information that may be conflicting for DCH. The procedures are constructed such that you are lead from one step to another with a basically binary (yes/no) decision process. If an instrument was providing erroneous information that leads down a wrong path, later steps should guide you back. We do not have enough information to determine whether they do an adequate job during severe accidents.

6. What additional procedures could be added to enhance the capability to prevent or mitigate plant damage?

Answer:

Procedural fixes to DCH could only help if there was a means to identify that the lower head was heating up and a way to prevent lower head failure, such as cavity flooding, or to mitigate the effects of lower head failure.

Decision Making

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. What are the current assignments of responsibility and authority for decision making?

Answer:

In the information available to us, there are none directly for DCH. Indirectly, the operator will follow the procedures and has the responsibility and authority to initiate RCS depressurization using the PORVs and upper head vents.

Table B-4. (continued).

2. How were the currently used lines of communication between the control room and the technical support center and other emergency response and planning facilities evaluated and validated?

   Answer:

   We do not have sufficient information available to answer this question for this sequence category.

3. To what extent is long term accident management considered in the decision making process including the basis for determining when the recovery phase is complete?

   Answer:

   We do not have sufficient information available to answer this question for this sequence category.

4. What decision making is defined in the current procedures and guidance?

   Answer:

   We do not have sufficient information available to answer this question for this sequence category.

5. What decision points are identified for expediting administrative controls to facilitate the repair or recovery of equipment?

   Answer:

   Equipment repair will not prevent or mitigate DCH directly. It could have and indirect effect by preventing or mitigating conditions that lead to DCH.

6. What guidance is given to decision makers for prioritizing alternate actions, identifying and avoiding potential negative effects, and evaluating long term plant recovery?

   Answer:

   We do not have sufficient information available to answer this question for this sequence category.

7. What changes in the assignments of responsibility and authority could be made to increase the capability to prevent or mitigate plant damage?

Table B-4. (continued).

Answer:

We do not have sufficient information available to answer this question for this sequence category.

Equipment

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ...".

1. What existing plant equipment could be used to perform the function of failed safety systems, for example, non-safety-grade equipment that could supply water, or jumpering to make available alternate sources of power?

   a. What are the ultimate operating times for the existing equipment that could be used as alternates to safety grade equipment?

Answer

Prevention of DCH has the potential to be accomplished in several ways: (1) prevention of core melt, relocation, and vessel failure, (2) ensuring that the RCS is at a low pressure prior to vessel failure, and (3) flooding the cavity surrounding the reactor vessel to cool the vessel and prevent failure. Existing plant equipment that would be applicable for the first way would be addressed in the assessment of sequence categories associated with the Prevent Core Dispersal from Vessel Safety Objective. The use of existing equipment to depressurize the RCS, number two above, could be accomplished using the PORV and the upper head vents. There is no alternate equipment on the RCS that the operator has direct control over. Depressurization using secondary cooling may be an option if there is sufficient coolant remaining in the RCS to transport large amounts of energy to the steam generators. Alternate equipment in this case would be use of the atmospheric dump valves, secondary PORVs, turbine bypass, and main steam control valves. There would also need to be means of feeding the steam generators. These have been discussed for other sequence categories and range from auxiliary feedwater to the use of diesel driven fire pumps. Flooding the cavity surrounding the reactor vessel would likely be accomplished using containment sprays. No alternate equipment was identified to accomplish this task.

Mitigation of DCH may not be practical since it occurs over a very short time period. Inerting the containment could eliminate some of the energy addition resulting from hydrogen burns but the reduction in energy addition may not be sufficient to prevent high pressures and possible containment failure. Some European countries have installed large vent lines with rupture disks. The effluent would not be filtered so a release to the environment would be certain. There would not be alternate equipment that could accomplish this task since the pressurization is so rapid.

Table B-4. (continued).

a. The ultimate operating limits are not formally recorded or listed in the information available to us. Additional information would be necessary to answer this question.

2. What provisions could be made to facilitate repair or replacement of failed equipment for this sequence category. Consider both the availability of parts and the capability to gain access to failed equipment exposed to severe accident environments?

   a. What replacement equipment and spare parts have been identified including their location and means of transport and installation within the time available?

   b. What advance preparation of hardware, for example, spool pieces, pre-positioning of equipment, etc., would facilitate the use of existing alternate equipment to provide a significant increase in equipment capability?

   c. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

Answer:

The PORVs and upper head vent equipment is inside the containment and could not be repaired or replaced. Repair of equipment associated with the steam generator feed and bleed operation may be possible but would depend strongly on the timing of the accident and the areas contaminated by radiation released as a consequence of the accident. These types of repairs would be considered a part of the Loss of Secondary Heat Sink Sequence Category. Repairs of equipment that could be used to flood the cavity would be considered for sequence categories associated with containment heat removal.

   a. We did not have enough information available to assess the availability of spare parts.

   b. We did not have enough information available to assess the use of alternate equipment and resources and the prepositioning of equipment.

   c. We did not have enough information available to assess the availability of offsite resources.

3. What resources can be managed, such as battery power or borated water, to prevent or delay severe accident consequences and what is the technical basis for their use?

   a. Is equipment available that has the capability to replenish exhausted resources within the time frame available for recovery. Are suppliers of essential resources identified?

   b. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

Table B-4. (continued).

Answer:

Management of the resources for the prevention of DCH will be dependant on strategies that are not unique to DCH. This question will be answered based on other sequence categories. No alternate resources for strategies that could mitigate DCH were identified.

4. What the potential options for use of equipment from another unit been considered and optimized?

Answer:

Use of equipment for prevention or mitigation of DCH will depend on strategies that are not unique to DCH. This question will be answered for other sequence categories.

5. What additional equipment would enhance the capability to prevent or mitigate severe core damage?

Answer:

Equipment to depressurize the RCS more rapidly than the PORVs could ensure the plant was at low pressure if the reactor vessel lower head failed.

Instrumentation

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. What instruments are necessary to identify the symptoms and applicable strategies that will enable accident management personnel to prevent or mitigate severe accident conditions?

Answer:

Existing instruments that will indicate that will indicate potential DCH conditions are being approached are: Pressurizer Level, RCS Pressure, Hot Leg RTDs, Core Exit TCs, RCS Coolant Activity Level, and RVLMS. Additional instrumentation to indicate the temperature of the vessel lower head would enhance the capability to understand the potential timing of vessel failure and to ensure that mitigative strategies, such as RCS depressurization or cavity flooding, are being effective.

2. What are the limitations on the instrumentation to provide needed information on plant severe accident behavior and how are they communicated to accident management personnel?

Table B-4. (continued).

Answer:

The instrumentation in the vessel is likely qualified to 2500 F which means it will fail prior to significant core degradation and relocation. RCS pressure could fail sometime later, depending on the containment conditions. We do not have access to documents with a discussion of instrument limitations for either design basis or severe accidents. It is uncertain whether an analysis for severe accident conditions has been performed.

3. What means (protection from harsh environments, operator aids, etc.) have been developed to use existing instruments under the expected severe accident conditions?

Answer:

None were identified from the information we had available.

4. What methodologies have been established to identify unreliable data from instruments under severe accident conditions?

Answer:

None were identified from the information we had available.

5. What changes could be made to the current instrument systems that would enhance the capability to prevent or mitigate severe accident conditions?

Answer:

The lack of instrumentation that will indicate all important RCS conditions as the core begins to melt and relocate could be compensated for by the development of analysis aids that can be used to help project the possible timing of the accident including vessel water level, core relocation, and failure of the vessel lower head.

One means of indicating significant in-vessel events would be to track the trends in RCS pressure to identify the timing of large pressure increases concurrent with increases in the source range monitor output or the hot leg RTDs. These results should signify the relocation of core material (the potential for large increases from sources other than DCH would have to be examined and characterized).

6. What additional instruments would enhance the capability to prevent or mitigate severe accident conditions?

Answer:

A measurement of Vessel Lower Head Temperature would indicate when the core has relocated and when the lower head is approaching its failure point.

Table B-4. (continued).

Training

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. How does the training provide personnel involved in accident management with an understanding of the possible severe accident behavior, and is this training given at the proper levels and in the detail required to facilitate decision making?

   Answer:

   Sufficient information was not available to us to answer this question.

2. How are all personnel involved with the training simulator made aware of the limitations in representing severe accident conditions and is it made clear when the simulation is no longer valid?

   Answer:

   Limitations on performance are noted in Discrepancy Reports. During testing if invalid performance is noted, it is identified and reported. These reports were not available to us. The degree to which these limitations would apply for severe accident conditions would depend on whether a detailed evaluation had been performed of the simulator capabilities for the severe accident sequences identified as important for the plant.

3. How are personnel trained to proceed if instruments give what appears to be conflicting readings?

   Answer:

   Sufficient information was not available to us to answer this question.

4. How does the training for all personnel involved in accident management ensure that all important actions or decisions for severe accident management are included?

   Answer:

   Sufficient information was not available to us to answer this question.

5. What training is provided for all accident management personnel on the possible limitations of equipment, instrumentation, and plant information?

   Answer:

   Sufficient information was not available to us to answer this question.

Table B-4. (continued).

6. What additional training is provided to implement the use of alternative systems and equipment?

Answer:

Sufficient information was not available to us to answer this question.

7. How do drills and simulator exercises consider the following potential restrictions: inhibited access to equipment as a result of high temperature or radiation levels, limited lighting or loss of resources such as electricity, and constraints on the availability of personnel with the proper skills?

Answer:

Drills and simulations may not incorporate actual real-time performance attributes or adequate representation of the limiting factors of radiation fields, lighting or loss of other resources. EOP inspections by NRC does look at this and the AOP/EOP should incorporate this information in the actions.

8. What are the changes that have been made to the current training program to enhance the capability to prevent or mitigate plant damage?

Answer:

Training material was not available for evaluation. In general, a more in-depth approach to problem-solving techniques and accident management courses that provide decision making techniques would be beneficial. Also training for team-based decision making should be included.

9. What additional training has been provided to enhance the capability to prevent or mitigate plant damage?

Answer:

Sufficient information was not available to us to answer this question.

Table B-5. Sequence category questions for framework application for combustible gas burn.

Procedures

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. Which of the current procedures are applicable for prevention or mitigation of the severe accident conditions?

   Answer:

   EOPs

   E-1: step 15.c calls for notification of Rad Chem to align Post-accident H_2 analyzers.

   ECA-3.1: step 5.b calls for notification of Rad Chem to align Post-accident H_2 analyzers.

   FR-C.1: step 8 calls for notification of Rad Chem to align Post-accident H_2 analyzers, and determination of actions based on H_2 concentration (refers to TSC).

   FR-Z.1: step 8 calls for notification of Rad Chem to align Post-accident H_2 analyzers, and determination of actions based on H_2 concentration (refers to TSC); step 9 calls for notification of Tech Staff of H_2 concentration; step 10 calls for periodic monitoring of H_2 concentration.

   SOIs

   SOI-9, section 4.5 provides criteria for use, system alignment and operation for the Hydrogen Purge Fans (second backup to the recombiners); section 4.6 provides system alignment and operation for the hydrogen recombiners, including limits of operation.

   ARPs

   Annunciator Panel 1 4E: Annunciator alarm response for possible HIGH H_2 concentration including reference to SOI-9.

2. What changes could be made to the current procedures and guidance to enhance the capability to prevent or mitigate the severe accident conditions?

   Answer:

   Better identification of methods and strategies available for H_2 reduction. ALARM Response Procedure only instructs on use of recombiners if directed by EOP.

3. If alternate systems and equipment are important, what procedures and guidance exist to facilitate their use?

Table B-5. (continued).

Answer:

SOI-9 describes use of hydrogen recombiners and has a drawing of the system and a picture of the required flange connectors for installation. ZRP-1810-4 which provides instructions on post-accident H_2 was not available.

4. What procedures consider long term recovery actions that may be necessary for accident management? (Examples would be establishing long term core cooling or long term containment cooling.)

Answer:

Based on the information we have available, the current procedures do not seem to stress long term recovery actions. They do cover core and containment cooling actions for design basis accident conditions that should be considered short to intermediate term recovery actions for severe accidents.

5. What procedures and guidance provide instructions on how to evaluate information, either from instrumentation or from other sources, that is apparently conflicting?

Answer:

RNO section provides some guidance. General guidance is detailed in Administrative Procedure ZAP-0 5.3.15 Policy Regarding Operational Practices and ZAP 5-51-3A 3 Policy on Operator Use of EOPs.

6. What additional procedures could be added to enhance the capability to prevent or mitigate plant damage?

Answer:

A procedure describing the strategies when H_2 is in the action range between 0.5% and 6%, and possible contingencies if H_2 exceeds 6% or containment pressure exceeds the 10 psig (maximum pressure limit on external piping). May need an AOP that addresses abnormal H_2 concentrations.

Decision Making

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ...".

1. What are the current assignments of responsibility and authority for decision making?

Table B-5. (continued).

Answer:

We do not have sufficient information to answer this question. Specified in EPIPs and ZAP-0 section 5.1 and ZAP-5-51-3A section 3 & Appendix A (specific for EOP responsibilities).

2. How were the currently used lines of communication between the control room and the technical support center and other emergency response and planning facilities evaluated and validated?

Answer:

This information is typically specified in EPIPs and communications systems evaluated in EPIP-440-1. We do not have sufficient information to answer this question.

3. To what extent is long term accident management considered in the decision making process including the basis for determining when the recovery phase is complete?

Answer:

Based on the information available to us, decision making guidance is limited. The guidance that exist is specified in EPIP-100-1 (section 8), EPIP-330-1 CLASSIFICATION OF GSEP CONDITIONS and EPIP-100-3 RECOVERY, REENTRY AND TERMINATION (not available). Some guidance existing includes categories for classifying and review; PAG recommendations; identification of operating equipment; core damage assessment; dose assessment. Mitigation strategies are not identified.

4. What decision making is defined in the current procedures and guidance?

Answer:

See the answer to question 3, above.

5. What decision points are identified for expediting administrative controls to facilitate the repair or recovery of equipment?

Answer:

We do not have sufficient information available to answer this question.

6. What guidance is given to decision makers for prioritizing alternate actions, identifying and avoiding potential negative effects, and evaluating long term plant recovery?

Table B-5. (continued).

Answer:

SOI-9 provides general prioritization instructing that the Hydrogen Purge Fans are a secondary choice to the use of the Hydrogen Recombiners.

7. What changes in the assignments of responsibility and authority could be made to increase the capability to prevent or mitigate plant damage?

Answer:

We do not have sufficient information available to answer this question.

Equipment

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. What existing plant equipment could be used to perform the function of failed safety systems, for example, non-safety-grade equipment that could supply water, or jumpering to make available alternate sources of power?

   a. What are the ultimate operating limits for the existing equipment that could be used as alternates to safety grade equipment?

Answer:

None identified based on the limited amount of information available, although multiple methods are addressed for accomplishing sampling and reduction of the H_2 concentration in containment.

   a. The ultimate operating limits are not formally recorded or listed in the information available to us. Additional information would be necessary to answer this question.

2. What provisions could be made to facilitate repair or replacement of failed equipment for this sequence category. Consider both the availability of parts and the capability to gain access to failed equipment exposed to severe accident environments?

   a. What replacement equipment and spare parts have been identified including their location and means of transport and installation within the time available?

   b. What advance preparation of hardware, for example, spool pieces, pre-positioning of equipment, etc., would facilitate the use of existing alternate equipment to provide a significant increase in equipment capability?

Table B-5. (continued).

c. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

Answer:

None noted based on the limited information available.

a. None Noted based on the limited information available.

b. Some of these items exist as delineated in SOI-9. Location and pre-positioning are not discussed in our limited information.

c. None noted based on the limited information available.

3. What resources can be managed, such as battery power or borated water, to prevent or delay severe accident consequences and what is the technical basis for their use?

a. Is equipment available that has the capability to replenish exhausted resources within the time frame available for recovery. Are suppliers of essential resources identified?

b. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

Answer:

None noted based on the limited information available.

a. None noted based on the limited information available. Possibly in Administrative Procedures that were not available.

b. Based on the limited amount of information, there were none noted.

4. What potential options for use of equipment from another unit been considered and optimized?

Answer:

None noted based on the limited amount of information available.

5. What additional equipment would enhance the capability to prevent or mitigate severe core damage?

Answer:

None noted based on the limited amount of information available.

Table B-5. (continued).

Instrumentation

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. What instruments are necessary to identify the symptoms and applicable strategies that will enable accident management personnel to prevent or mitigate severe accident conditions?

   Answer:

   H_2 monitors; containment pressure; containment temperature; recombiner inlet pressure, flow and catalytic bed/outlet temperatures, power, Damper/valve positions.

2. What are the limitations on the instrumentation to provide needed information on plant severe accident behavior and how are they communicated to accident management personnel?

   Answer:

   We do not have access to documents with a discussion of instrument limitations for either design basis or severe accidents. It is uncertain whether an analysis for severe accident conditions has been performed.

3. What means (protection from harsh environments, operator aids, etc.) have been developed to use existing instruments under the expected severe accident conditions?

   Answer:

   Pressure is post-accident qualified instrument for design basis conditions. We do not have sufficient information to determine what means have been developed for severe accident conditions.

4. What methodologies have been established to identify unreliable data from instruments under severe accident conditions?

   Answer:

   None noted in the information that we have available.

5. What changes could be made to the current instrument systems to would enhance the capability to prevent or mitigate severe accident conditions?

Table B-5. (continued).

Answer:

Use of O_2 monitors may allow determination of likelihood of explosion/detonation (note that oxygen deprivation in a large containment is considered unlikely). Higher ranges on the H_2 monitors may provide needed information during some severe accidents. Sufficient material for additional evaluation was not available.

6. What additional instruments would enhance the capability to prevent or mitigate severe accident conditions?

Answer:

O_2 monitors.

Training

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. How does the training provide personnel involved in accident management with an understanding of the possible severe accident plant behavior, and is this training given at the proper levels and in the detail required to facilitate decision making?

Answer:

The available training material is not sufficient to answer this question. EOP training is yearly. Use of the recombiners is limited since they are temporary equipment.

2. How are all personnel involved with the training simulator made aware of the limitations in representing severe accident conditions and is it made clear when the simulation is no longer valid?

Answer:

Limitations on performance are noted in Discrepancy Reports. During testing if invalid performance is noted, it is identified and reported. These reports were not available to us. The degree to which these limitations would apply for severe accident conditions would depend on whether a detailed evaluation had been performed of the simulator capabilities for the severe accident sequences identified as important for the plant.

3. How are personnel trained to proceed if instruments give what appears to be conflicting readings?

Table B-5. (continued).

Answer.

Material for evaluation was not available.

4. How does the training for all personnel involved in accident management ensure that all important actions or decisions for severe accident management are included?

Answer:

Material for evaluation was not available.

5. What training is provided for all accident management personnel on the possible limitations of equipment, instrumentation, and plant information?

Answer:

Material for evaluation was not available. Individual lesson plans cover the equipment and instrumentation on a system and component level. Some limitations may be covered during this presentation.

6. What additional training is provided to implement the use of alternative systems and equipment?

Answer:

Alternative actions and local operator actions are not evaluated during most simulator scenarios. The ability to make decisions and utilize local operators is evaluated. Some JPMs may cover these local actions but are generally based on JTs covered by existing procedures. RNOs and alternate actions that do not list specific instructions or are not covered in AOP/SOI are not performed.

7. How do drills and simulator exercises consider the following potential restrictions: inhibited access to equipment as a result of high temperature or radiation levels, limited lighting or loss of resources such as electricity, and constraints on the availability of personnel with the proper skills?

Answer:

Drills and simulations may not incorporate actual real-time performance attributes or adequate representation of the limiting factors of radiation fields, lighting or loss of other resources. EOP inspections by NRC does look at this and the AOP/EOP should incorporate this information in the actions.

8. What are the changes that have been made to the current training program to enhance the capability to prevent or mitigate plant damage?

Table B-5. (continued).

Answer:

Training material was not available for evaluation. In general, a more in-depth approach to problem-solving techniques and accident management courses that provide decision making techniques would be beneficial. Also training for team-based decision making should be included.

9. What additional training has been provided to enhance the capability to prevent or mitigate plant damage?

Answer:

Sufficient information was not available to us to answer this question.

Table B-6. Sequence category questions for core concrete interactions.

Procedures

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. Which of the current procedures are applicable for prevention or mitigation of the severe accident conditions?

   Answer:

   Sufficient information was not available to us to answer this question. It is doubtful that there are procedures that directly discuss preventing or mitigating CCI.

2. What changes could be made to the current procedures and guidance to enhance the capability to prevent or mitigate the severe accident conditions?

   Answer:

   Guidance should be provided to help the accident management personnel recognize the approach to vessel failure and provide cautions on the possible effects of CCI. One possible strategy for CCI is to ensure that the concrete is covered with water either before or shortly after core relocation. The effect of water in the cavity on the progression of CCI may not be large but the scrubbing of fission products by the water would make this strategy worthwhile. This strategy is not in the current procedures and guidance.

3. If alternate systems and equipment are important, what procedures and guidance exist to facilitate their use?

   Answer:

   There are no procedures and guidance for the use of alternate equipment to prevent or mitigate the effects of CCI. If it is concluded that alternate equipment and sources of water are necessary to flood the cavity, appropriate procedures and guidance should be added.

4. What procedures consider long term recovery actions that may be necessary for accident management? (Examples would be establishing long term core cooling or long term containment cooling.)

Table B-6. (continued).

Answer:

Sufficient information was not available to us to answer this question. Long term recovery actions that could be necessary as a result of CCI would include actions to mitigate the effects of the large quantities of noncondensibles, actions to mitigate the effects on the subsoil and groundwater of basemat melt through, and actions to mitigate the continued release of fission products if the containment shell has failed. Based on the information we have available, the current procedures do not seem to stress long term recovery actions. They do cover core and containment cooling actions for design basis accident conditions that should be considered short to intermediate term recovery actions for severe accidents.

5. What procedures and guidance provide instructions on how to evaluate information, either from instrumentation or from other sources, that is apparently conflicting?

Answer:

No procedures and guidance was found in the information available to us to deal with conflicting information resulting from CCI. However, situations where not identified where conflicting information would be developed as a result of CCI and the need for additional procedures and guidance for this situation is not clear.

6. What additional procedures and guidance could be added to enhance the capability to prevent or mitigate plant damage?

Answer:

Procedures and/or guidance should be added that would support recognition of the need for the addition of water to the cavity if it appears that the vessel is approaching failure conditions and CCI may occur. Additional procedures and guidance should also be incorporated to carry out water addition to the cavity using containment sprays or alternate means.

Decision Making

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. What are the current assignments of responsibility and authority for decision making?

Answer:

There was not sufficient information available to answer the question for this sequence category.

2. How were the currently used lines of communication between the control room and the technical support center and other emergency response and planning facilities evaluated and validated?

Table B-6. (continued).

Answer:

There was not sufficient information available to answer the question for this sequence category.

3. To what extent is long term accident management considered in the decision making process including the basis for determining when the recovery phase is complete?

Answer:

There was not sufficient information available to answer the question for this sequence category.

4. What decision making is defined in the current procedures and guidance?

Answer:

There was not sufficient information available to answer the question for this sequence category.

5. What decision points are identified for expediting administrative controls to facilitate the repair or recovery of equipment?

Answer:

There was not sufficient information available to answer the question for this sequence category.

6. What guidance is given to decision makers for prioritizing alternate actions, identifying and avoiding potential negative effects, and evaluating long term plant recovery?

Answer:

There was not sufficient information available to answer the question for this sequence category.

7. What changes in the assignments of responsibility and authority could be made to increase the capability to prevent or mitigate plant damage?

Answer:

There was not sufficient information available to answer the question for this sequence category.

Equipment

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

Table B-3. (continued).

1. What existing plant equipment could be used to perform the function of failed safety systems, for example, non-safety-grade equipment that could supply water, or jumpering to make available alternate sources of power?

   a. What are the ultimate operating limits for the existing equipment that could be used as alternates to safety grade equipment?

   Answer:

   There was not sufficient information available to answer the question for this sequence category. The failed safety systems that have lead to core concrete interaction would have been identified for other sequence category evaluations. Equipment important to this sequence category would be systems to flood the reactor cavity floor. No systems beyond the sprays were identified to flood the cavity. Alternate equipment to make the sprays operable and supply water to the sprays would be needed.

   a. The ultimate operating limits are not formally recorded or listed in the information available to us. Additional information would be necessary to answer this question.

2. What provisions could be made to facilitate repair or replacement of failed equipment for this assessment category? Consider both the availability of parts and the capability to gain access to failed equipment exposed to severe accident environments.

   a. What replacement equipment and spare parts have been identified including their location and means of transport and installation within the time available?

   b. What advance preparation of hardware, for example, spool pieces, pre-positioning of equipment, etc., would facilitate the use of existing alternate equipment to provide a significant increase in equipment capability?

   c. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

   Answer:

   We do not have sufficient information to answer this question.

3. What resources can be managed, such as battery power or borated water, to prevent or delay severe accident consequences and what is the technical basis for their use?

   a. Is equipment available that has the capability to replenish exhausted resources within the time frame available for recovery. Are suppliers of essential resources identified?

   b. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

Table B-6. (continued).

Answer:

We do not have sufficient information to answer this question. The types of resources that should be looked for are portable pumps to supply water to the spray system or other systems with the capability to flood the cavity. Alternate portable sources, such as fire engines should also be considered.

4. What potential options for use of equipment from another unit have been considered and optimized?

Answer:

We do not have sufficient information to answer this question.

5. What additional equipment would enhance the capability to prevent of mitigate severe accidents.

Answer:

We do not have sufficient information to answer this question.

Instrumentation

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. What instruments are necessary to identify the symptoms and applicable strategies that will enable accident management personnel to prevent or mitigate severe accident conditions?

Answer:

Containment pressure and temperature would indicate the possibility of core concrete interaction but would not be definitive. Samples of the containment atmosphere could indicate high levels of noncondensible gases if the proper analysis equipment is available within a reasonable timeframe. Precursor instruments would include core exit thermocouples, hot leg RTDs, RVLMS, RCS pressure, and RCS coolant activity level.

2. What are the limitations on the instrumentation to provide needed information on plant severe accident behavior and how are they communicated to accident management personnel?

Answer:

We do not have access to documents with a discussion of instrument limitations for either design basis or severe accidents. It is uncertain whether an analysis for severe accident conditions has been performed.

Table B-6. (continued).

3. What means (protection from harsh environments, operator aids, etc.) have been developed to use existing instruments under the expected severe accident conditions?

   Answer:

   We do not have sufficient information to answer this question.

4. What methodologies have been established to identify unreliable data from instruments under severe accident conditions?

   Answer:

   We do not have sufficient information to answer this question.

5. What changes could be made to the current instrument systems to would enhance the capability to prevent or mitigate severe accident conditions?

   Answer:

   We do not have sufficient information to answer this question. If they did not already have the capability, the containment atmosphere sampling systems could be modified to indicate the levels of carbon dioxide and carbon monoxide and other gases that would be indicative of core concrete interactions.

6. What additional instruments would enhance the capability to prevent or mitigate severe accident conditions?

   Answer:

   Instruments to provide a definite indication of vessel breach would indicate that molten material was in contact with the concrete and would aid in determining that core concrete interactions were taking place. Either optical or contact measurements of the lower head temperature could provide this capability.

Training

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. How does the training provide personnel involved in accident management with an understanding of the expected plant behavior, and is this training given at the proper levels and in the detail required to facilitate decision making?

Table B-6. (continued).

Answer:

We do not have sufficient information to answer this question.

2. How are all personnel involved with the training simulator made aware of the limitations in representing severe accident conditions and is it made clear when the simulation is no longer valid?

Answer:

Limitations on performance are noted in Discrepancy Reports. During testing if invalid performance is noted, it is identified and reported. These reports were not available to us. The degree to which these limitations would apply for severe accident conditions would depend on whether a detailed evaluation had been performed of the simulator capabilities for the severe accident sequences identified as important for the plant.

3. How are personnel trained to proceed if instruments give what appears to be conflicting readings?

Answer:

We do not have sufficient information to answer this question.

4. How does the training for all personnel involved in accident management ensure that all important actions or decisions for severe accident management are included?

Answer:

We do not have sufficient information to answer this question.

5. What training is provided for all accident management personnel on the possible limitations of equipment, instrumentation, and plant information?

Answer:

We do not have sufficient information to answer this question.

6. What additional training is provided to implement the use of alternative systems and equipment?

Answer:

We do not have sufficient information to answer this question.

Table B-6. (continued).

7. How do drills and simulator exercises consider the following potential restrictions: inhibited access to equipment as a result of high temperature or radiation levels, limited lighting or loss of resources such as electricity, and constraints on the availability of personnel with the proper skills?

   Answer:

   Drills and simulations may not incorporate actual real-time performance attributes or adequate representation of the limiting factors of radiation fields, lighting or loss of other resources. EOP inspections by NRC does look at this and the AOP/EOP should incorporate this information in the actions.

8. What are the changes that have been made to the current training program to enhance the capability to prevent or mitigate plant damage?

   Answer:

   Training material was not available for evaluation. In general, a more in-depth approach to problem-solving techniques and accident management courses that provide decision making techniques would be beneficial. Also training for team-based decision making should be included.

9. What additional training has been provided to enhance the capability to prevent or mitigate plant damage?

   Answer:

   We do not have sufficient information to answer this question.

Table B-7. Sequence category questions for steam generator tube rupture.

Procedures

Note: These questions should be applied to each assessment category. Each question would be preceded by the phrase, "For this assessment category, ... ".

1. Which of the current procedures are applicable for prevention or mitigation of the severe accident conditions?

   Answer:

   Procedure that deals with SGTR directly is E-3.

   Enter E-3 directly or guided there by E-0, E-1, E-2, ECA-2.1, FR-H.3, ES-1.2.

   All these deal with aspects of SGTR recovery, ES-3.1, ES-3.2, ES-3.3, ECA-3.2, ECA-3.3, ECA 3.1.

2. What changes could be made to the current procedures and guidance to enhance the capability to prevent or mitigate the severe accident conditions?

   Answer:

   Step 18 of E-0 must be reached to get referred into E-3. Similarly, the following steps must be reached to be referred to E-3: Step 4 in E-1, Step 5 of E-2, Step 5 in ECA-2.1, Step 7 in FR-H.3, and Step 4 of ES-1.2.

   Alternate procedures were examined for other transients similar to the steam generator tube rupture to see if they would "direct out" of that procedure and into the SGTR procedure. These procedures do a reasonably good job. However, considering primarily the SGTR, an improvement could be made to reach "direct-out" steps earlier in the procedures, especially in E-0. To ultimately decide the trade-off between an earlier or later "direct-out", risks should be compared for competing events.

   The procedures are primarily written for design basis conditions. They do not cover situations very well when the plant is experiencing core damage.

   Procedures could call out specific valve numbers, breaker numbers, equipment numbers (e.g., Step 5 of E-3) to increase the likelihood of successful implementation.

3. If alternate systems and equipment are important, what procedures and guidance exist to facilitate their use?

Table B-7. (continued).

Answer:

Procedures ES-3.1, 3.2, 3.3 and ECA-3.1, 3.2, 3.3 do a good job of covering alternate methods and equipment for various stages of SGTR recovery. Once again, the procedures do not cover actions if there is significant core damage. The procedures don't specifically identify alternate equipment so much as they provide steps that incorporate equipment.

4. What procedures consider long term recovery actions that may be necessary for accident management? (Examples would be establishing long term core cooling of long term containment cooling.)

Answer:

None were judged to be adequate for severe accident management, although the series ES-3.1, 3.2, 3.3 and ECA-3.1, 3.2, 3.3 address recovery. They do cover core and containment cooling actions for design basis accident conditions that should be considered short to intermediate term recovery actions for severe accidents.

5. What procedures and guidance provide instructions on how to evaluate information, either from instrumentation or from other sources, that is apparently conflicting?

Answer:

All procedures are good at specifying parameters that help to diagnose and guide but none seem to prioritize or give guidance for conflicting evidence. They somewhat address it in that if a person follows a course of actions based on faulty evidence, the procedures are designed to bring him back into line with additional information. The trouble is, valuable time is lost.

6. What additional procedures could be added to enhance the capability to prevent or mitigate plant damage?

Answer:

New procedures could be added to provide guidance on what specifically are the most reliable indications of a SGTR and how to interpret and diagnose them. (This is perhaps more of a training function—although a procedure for training should exist in any case.)

Procedures that pick up at core melt and go on would be needed for severe accidents. Procedures become vague at core melt conditions. Directions to depressurize are hard to follow and they don't really say how the operator should depressurize. They just say "depressurize" (see ES-1.2, Step 9).

Table B-7. (continued).

Decision Making

Note: These questions should be applied to each assessment category. Each question would be preceded by the phrase, "For this assessment category, ... ".

1. What are the current assignments of responsibility and authority for decision making?

   Answer:

   Insufficient information available--access to emergency plan organization, etc, would give more details.

2. How were the currently used lines of communication between the control room and the technical support center and other emergency response and planning facilities evaluated and validated?

   Answer:

   Insufficient information available to us to adequately answer this question.

3. To what extent is long term accident management considered in the decision making process including the basis for determining when the recovery phase is complete?

   Answer:

   Insufficient information available--access to the E-Plan organization, and procedures would reveal some of the information.

4. What decision making is defined in the current procedures and guidance?

   Answer:

   Insufficient information available--complete procedures would be needed.

5. What decision points are identified for expediting administrative controls to facilitate the repair or recovery of equipment?

   Answer:

   The available EOPs don't provide much guidance but some of the E-plan procedures should, based on the knowledge that E-plans for other plants addressed this subject.

6. What guidance is given to decision makers for prioritizing alternate actions, identifying and avoiding potential negative effects, and evaluating long term plant recovery.

Table B-7. (continued).

Answer:

Insufficient information available—None could be found in the information that we have.

7. What changes in the assignments of responsibility and authority could be made to increase the capability to prevent or mitigate plant damage?

Answer:

Inadequate information available. Without access to the full E-plan and E-PIPs, it is not possible to adequately answer this question.

Equipment

Note: These questions should be applied to each assessment category. Each question would be preceded by the phrase, "For this assessment category, ... ".

1. What existing plant equipment could be used to perform the function of failed safety systems, for example, non-safety-grade equipment that could supply water, or jumpering to make available alternate sources of power?

   a. What are the ultimate operating limits for the existing equipment that could be used as alternates to safety grade equipment?

Answer:

The procedures do not appear to address anything that requires jumpering. In some areas, it gives guidance to accomplish a requirement if the first attempts fails. This can include some efforts for equipment and some for other ways to operate the same equipment (e.g., Step 29 in E-3). For example, between Step 8 and 9 of E-3 "Caution" points out AOP-4.5 to use Service Water to supply AFW. Step 16 uses Condenser and Steam Dumps. There are two situations that are not covered where existing plant equipment could be used: (1) Use of AFW to submerge the break to scrub fission products and (2) Use fire sprays to wash down releases from steam generator dump valves and safety relief valves.

   a. The ultimate operating limits are not formally recorded or listed in the information available to us. Additional information would be necessary to answer this question.

2. What provisions could be made to facilitate repair or replacement of failed equipment for this assessment category. Consider both the availability of parts and the capability to gain access to failed equipment exposed to severe accident environments?

Table B-7. (continued).

Answer:

Not much is said in the EOPs about this other than, e.g., "If you don't have AC power, then repair it", etc. It is not clear that repair and replacement considerations during accidents are proceduralized. They may be part of the normal process for maintenance but they are not referenced.

a. What replacement equipment and spare parts have been identified including their location and means of transport and installation within the time available?

Answer:

Sufficient information is not available to answer this question.

b. What advance preparation of hardware, for example, spool pieces, pre-positioning of equipment, etc., would facilitate the use of existing alternate equipment to provide a significant increase in equipment capability?

Answer:

Sufficient information is not available to answer this question.

c. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

Answer:

Sufficient information is not available to answer this question.

3. What resources can be managed, such as battery power or borated water, to prevent or delay severe accident consequences and what is the technical basis for their use?

Answer:

Step 39 of E-3 directs you to Appendix C, page 39 to shutdown unneeded equipment for power conservation. Conservation of other resources not identified

a. Is equipment available that has the capability to replenish exhausted resources within the time frame available for recovery. Are suppliers of essential resources identified?

Answer:

The same procedure identifies refilling the RWST, but no details are given on how to carry this out.

Table B-7. (continued).

b. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

Answer:

There was not adequate information to answer this question.

4. What potential options for use of equipment from another unit have been considered and optimized?

Answer:

This plant is a double unit and has opportunity for one unit to supply the other, but procedures don't indicate any formal approach for SGTR.

5. What additional equipment would enhance the capability to prevent or mitigate severe accidents.

Answer:

No additional equipment beyond that discussed in the answers to previous questions was identified. Pumps or other means of adding water to the steam generator secondary side could be used to reduce the release of fission products.

Instrumentation

Note: These questions should be applied to each assessment category. Each question would be preceded by the phrase, "For this assessment category, ... ".

1. What instruments are necessary to identify the symptoms and applicable strategies that will enable accident management personnel to prevent or mitigate severe accident conditions?

Table B-7. (continued).

Answer:

This instrumentation is taken from procedure E-3. Some of the other recovery procedures like ES-3.1, 3.2, 3.3, and ECA-3.1, 3.2, 3.3 as well as the general procedures will require some additional information. Following is the instruments identified: Condenser air ejector or steam generator (SG) blowdown radiation detector, SG level, main steam line radiation monitor, SG chemistry samples, SG pressure, MSIV and bypass indicators, PORVs and block valve pos. indicators, feed flow, AC buses power ind., SI status indicators (various blocks, actuation status etc.), air compressor running ind. and status of air system, indication of pressurizer heaters and sprays, core exit thermocouples, steam dump and condenser status indicators, hot leg RTD, primary pressure, pressurizer level, trip status of rods and RCPs, status of valves in auxiliary spray lineup, status of charging pump, charging flow, charging in pressure, status of RHR pumps and valve lineups, RHR heat exchanger, status of IVSW valves, charging flow and valve lineup status, spray pumps status, containment spray valve positions, VCT makeup control, diesel generator status, RCP cooling status, RCP LBRTH ΔP, Aux Steam status, waste water treatment status, condenser hotwell overflow to EST isolation status, source range nuclear detector, intermediate range detectors, containment pressure and temp., accumulator levels and pressures. Service water status indications (including pump, valve pressure and flow indications).

2. What are the limitations on the instrumentation to provide needed information on plant severe accident behavior and how are they communicated to accident management personnel?

Answer:

We do not have access to documents with a discussion of instrument limitations for either design basis or severe accidents. It is uncertain whether an analysis for severe accident conditions has been performed.

3. What means (protection from harsh environments, operator aids, etc.) have been developed to use existing instruments under the expected severe accident conditions?

Answer:

Inadequate information available--except that safety grade instrumentation is required to meet environmental conditions based on the design basis accident. How this relates to severe accident conditions is not in the information available for this plant.

4. What methodologies have been established to identify unreliable data from instruments under severe accident conditions?

Answer:

Insufficient information available.

Table B-7. (continued).

5. What changes could be made to the current instrument systems to would enhance the capability to prevent or mitigate severe accident conditions?

Answer:

There is insufficient information was available to answer this question. It is not clear whether the instrument systems are inadequate so it is difficult to identify changes. There is the possibility that the instruments should be protected from harsh severe accident environmental conditions.

6. What additional instruments would enhance the capability to prevent or mitigate severe accident conditions?

Answer:

Instrumentation to indicate that Steam Generator dump valves or safety relief valves are stuck open e.g., downstream temperatures, television cameras to monitor atmospheric release points, radiation monitor.

Training

Note: These questions should be applied to each assessment category. Each question would be preceded by the phrase, "For this assessment category, ... ".

1. How does the training provide personnel involved in accident management with an understanding of the expected plant behavior, and is this training given at the proper levels and in the detail required to facilitate decision making?

Answer:

Inadequate information was available to answer this question.

2. How are all personnel involved with the training simulator made aware of the limitations in representing severe accident conditions and is it made clear when the simulation is no longer valid?

Answer:

Limitations on performance are noted in Discrepancy Reports. During testing if invalid performance is noted, it is identified and reported. These reports were not available to us. The degree to which these limitations would apply for severe accident conditions would depend on whether a detailed evaluation had been performed of the simulator capabilities for the severe accident sequences identified as important for the plant.

Table B-7. (continued).

3. How are personnel trained to proceed if instruments gives what appears to be conflicting readings?

Answer:

Inadequate information was available to answer this question.

4. How does the training for all personnel involved in accident management ensure that all important actions or decisions for severe accident management are included?

Answer:

Inadequate information was available to answer this question.

5 What training is provided for all accident management personnel on the possible limitations of equipment, instrumentation, and plant information?

Answer:

Inadequate information was available to answer this question.

6. What additional training is provided to implement the use of alternative systems and equipment?

Answer:

Inadequate information was available to answer this question.

7. How do drills and simulator exercises consider the following potential restrictions: inhibited access to equipment as a result of high temperature or radiation levels, limited lighting or loss of resources such as electricity, and constraints on the availability of personnel with the proper skills?

Answer:

Drills and simulations may not incorporate actual real-time performance attributes or adequate representation of the limiting factors of radiation fields, lighting or loss of other resources. EOP inspections by NRC does look at this and the AOP/EOP should incorporate this information in the actions.

8. What are the changes that have been made to the current training program to enhance the capability to prevent or mitigate plant damage?

Table B-7. (continued).

Answer:

Training material was not available for evaluation. In general, a more in-depth approach to problem-solving techniques and accident management courses that provide decision making techniques would be beneficial.

9. What additional training has been provided to enhance the capability to prevent or mitigate plant damage?

Answer:

Inadequate information was available to answer this question.

Table B-8. Sequence category questions for interfacing system loss-of-coolant accident.

Procedures

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. Which of the current procedures are applicable for prevention or mitigation of the severe accident conditions?

   Answer:

   The required procedures are E-0 , ECA 1.2, ECA-1.1, and E-1.

2. What changes could be made to the current procedures and guidance to enhance the capability to prevent or mitigate the severe accident conditions?

   Answer:

   Addition of specific steps for identification of ISLOCA symptoms using instrumentation, e.g., what radiation alarms in auxiliary building are indicative of an ISLOCA and how they correlate with other potential indicators such as fire (high temperature) alarms.

3. If alternate systems and equipment are important, what procedures and guidance exist to facilitate their use?

   Answer:

   No alternate systems or equipment were identified.

4. What procedures consider long term recovery actions that may be necessary for accident management? (Examples would be establishing long term core cooling or long term containment cooling.)

   Answer:

   After the break is isolated long term mitigative actions will be identified through the application of E-0. Whether these actions would be adequate for this sequence category was not determined. Based on the information we have available, the current procedures do not seem to stress long term recovery actions. They do cover core and containment cooling actions for design basis accident conditions that should be considered short to intermediate term recovery actions for severe accidents.

5. What procedures and guidance provide instructions on how to evaluate information, either from instrumentation or from other sources, that is apparently conflicting?

Table B-8. (continued).

Answer:

Based on the limited information available, none were identified.

6. What additional procedures could be added to enhance the capability to prevent or mitigate plant damage?

Answer:

Based on the limited information available, none were identified.

Decision Making

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. What are the current assignments of responsibility and authority for decision making?

Answer:

Insufficient information available was answer this question.

2. How were the lines of communication between the control room and the technical support center and other emergency response and planning facilities evaluated and validated?

Answer:

Insufficient information available--it is likely through the procedures and the E-plan

3. To what extent is long term accident management considered in the decision making process including the basis for determining when the recovery phase is complete?

Answer:

Insufficient information available to answer this question.

4. What decision making is defined in the current procedures and guidance?

Answer:

Insufficient information available to answer this question.

5. What decision points are identified for expediting administrative controls to facilitate the repair or recovery of equipment?

Table B-8. (continued).

Answer:

Sufficient information was not available to answer this question.

6. What guidance is given to decision makers for prioritizing alternate actions, identifying and avoiding potential negative effects, and evaluating long term plant recovery?

   Answer:

   Insufficient information available to answer this question—there is the potential to prioritize potential leak locations using radiation alarms.

7. What changes in the assignments of responsibility and authority could be made to increase the capability to prevent or mitigate plant damage?

   Answer:

   Sufficient information was not available to answer this question.

Equipment

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. What existing plant equipment could be used to perform the function of failed safety systems, for example, non-safety grade equipment that could supply water, or jumpering to make available alternate sources of power?

   a. What are the ultimate operating limits for the existing equipment that could be used as alternates to safety grade equipment?

   Answer:

   Access to the inventory of other water storage tanks, for example the CST, could help to lengthen the time that water is available for injection. If recriticality was found to be a problem, ways to borate the water would have to be devised. Means of opening a flow path from the RCS would have to rely on the PORVs, the upper head vents, and possibly the pressurizer vents.

   a. The ultimate operating limits are not formally recorded or listed in the information available to us. Additional information would be necessary to answer this question.

2. What provisions could be made to facilitate repair or replacement of failed equipment for this sequence category. Consider both the availability of parts and the capability to gain access to failed equipment exposed to severe accident environments?

Table B-8. (continued).

a. What replacement equipment and spare parts have been identified including their location and means of transport and installation within the time available?

b What advance preparation of hardware, for example, spool pieces, pre-positioning of equipment, etc., would facilitate the use of existing alternate equipment to provide a significant increase in equipment capability?

c. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

Answer:

There is insufficient information available to answer this question. However, there would be the capability to examine the largest loads possible on the isolation valves during an ISLOCA and to upgrade the valve actuators to ensure they can shut the isolation valves for ISLOCA conditions. Bringing in offsite equipment could be helpful for ISLOCA conditions if the radiation fields were such that personnel would have interface the equipment with the plant.

3. What resources can be managed, such as battery power or borated water, to prevent or delay severe accident consequences and what is the technical basis for their use?

a. Is equipment available that has the capability to replenish exhausted resources within the time frame available for recovery. Are suppliers of essential resources identified?

b. What offsite resources are there that could be identified and adequately prepared for transport to the site under accident conditions?

Answer:

RWST water could be managed if an ISLOCA sequence was diagnosed. It would be possible to have an analysis aid that would indicate the injections rates that would make up for decay heat. Cutting back the injection rates to near this value would minimize loss of water out of the RCS and prolong the time that water is available.

Means of refilling the RWST could be developed using resources such as diesel driven fire pumps or pumps brought in from off site. Boration of sources of water would need to be considered. It is not apparent that the capability to borate alternate sources of water currently exists.

4. What potential options for use of equipment from another unit have been considered and optimized?

Table B-8 (continued).

Answer:

There are provisions to cross tie the RWST from the second unit to prolong the injection time and allow more time to provide makeup to either units RWST.

5. What additional equipment would enhance the capability to prevent or mitigate severe core damage?

Answer:

Sufficient information was not available to us to answer this question.

Instrumentation

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. What instruments are necessary to identify the symptoms and applicable strategies that will enable accident management personnel to prevent or mitigate severe accident conditions?

Answer:

Radiation alarms in the auxiliary building. Sufficient information was not available to determine whether there were temperature and water level measurements available. Auxiliary building alarms could be arranged in the control room to aid in understanding the accident conditions.

2. What are the limitations on the instrumentations to provide needed information on plant severe accident behavior and how are they communicated to accident management personnel?

Answer:

We do not have access to documents with a discussion of instrument limitations for either design basis or severe accidents. It is uncertain whether an analysis for severe accident conditions has been performed.

3. What means (protection from harsh environments, operator aids, etc.), have been developed to use existing instruments under the expected severe accident conditions?

Answer:

Insufficient information available. There could be limitations on the access to sampling stations generally located in the auxiliary building during an ISLOCA but this information could not be obtained from the available information.

Table B-8. (continued).

4. What methodologies have been established to identify unreliable data from instruments under severe accident conditions?

   Answer:

   Sufficient information was not available to answer this question.

5. What changes could be made to the current instrument systems to enhance the capability to prevent or mitigate severe accident conditions?

   Answer:

   Sufficient information was not available to answer this question--but probably the location of radiation alarms in the auxiliary building and perhaps grouping of indicators for alarms indicative of an ISLOCA.

6. What additional instruments would enhance the capability to prevent or mitigate severe accident conditions?

   Answer:

   Additional indicators of pressure or area temperature specifically designed to identify breaks in the vicinity of low pressure systems where ISLOCA is possible. Water levels in compartments found to contain equipment that is vulnerable to severe accidents

Training

Note: These questions should be applied to each sequence category. Each question would be preceded by the phrase, "For this sequence category, ... ".

1. How does the training provide personnel involved in accident management with an understanding of the possible severe accident plant behavior, and is this training given at the proper levels and in the detail required to facilita[illegible]sion making?

   Answer:

   Sufficient information was not available to answer this question.

2. How are all personnel involved with the training simulator made aware of the limitations in representing severe accident conditions and is it made clear when the simulation is no longer valid?

Table B-8. (continued).

Answer:

Limitations on performance are noted in Discrepancy Reports. During testing if invalid performance is noted, it is identified and reported. These reports were not available to us. The degree to which these limitations would apply for severe accident conditions would depend on whether a detailed evaluation had been performed of the simulator capabilities for the severe accident sequences identified as important for the plant.

3. How are personnel trained to proceed if instruments give what appears to be conflicting readings?

Answer:

Sufficient information was not available to answer this question.

4. How does the training for all personnel involved in accident management ensure that all important actions or decisions for severe accident management are included?

Answer:

Sufficient information was not available to answer this question.

5. What training is provided for all accident management personnel on the possible limitations of equipment, instrumentation, and plant information?

Answer:

Sufficient information was not available to answer this question.

6. What additional training is provided to implement the use of alternative systems and equipment?

Answer:

Sufficient information was not available to answer this question.

7. How do drills and simulator exercises consider the following potential restrictions: inhibited access to equipment as a result of high temperature or radiation levels, limited lighting or loss of resources such as electricity, and constraints on the availability of personnel with the proper skills?

Table B-8. (continued).

Answer:

Drills and simulations may not incorporate actual real-time performance attributes or adequate representation of the limiting factors of radiation fields, lighting or loss of other resources. EOP inspections by NRC does look at this and the AOP/EOP should incorporate this information in the actions.

8. What are the changes that have been made to the current training program to enhance the capability to prevent or mitigate plant damage?

Answer:

Sufficient information was not available to answer this question.

9. What additional training has been provided to enhance the capability to prevent or mitigate plant damage?

Answer:

Sufficient information was not available to answer this question.

Appendix C

Characteristics of Proposed Strategies

Appendix C

Characteristics of Proposed Strategies

Substep 4.3 of the proposed process for developing and assessing accident management plans was used to identify the strategy characteristics for the potential strategies. Team members described the characteristics for each potential strategy by documenting the following information:

- Assessment categories for which the proposed strategy is expected to be used
- Plant hardware and operations necessary to carry out the proposed strategy, including changes in the traditional ways of using existing hardware or operations or additions to hardware or operations that would be needed to accomplish the strategy
- Information and instrumentation needed to determine whether the strategy is effective
- The resources needed in terms of the personnel and equipment having the capability to restore the safety functions and the water, power, air, and other resources necessary (does not include manpower or costs associated with the development of a potential strategy)
- The expected timing of the key phenomena and the influence of this timing on the effectiveness of the strategy.

The identified characteristics for a sample of six potential strategies are included in this appendix. Descriptions of the characteristics are based on our understanding of plant hardware and operations, which is not always complete. Some strategy characteristics are lacking in detail as a result of this lack of information.

Characteristics of the following potential strategies are presented as tables:

- Reactor vessel cavity flooding system (Table C-1)
- Analysis aid to project lower head failure (Table C-2)
- Cross-tie of secondary Condensate Storage Tanks between units (Table C-3)
- Use of fire water spray to reduce off-site releases (Table C-4)
- Change to procedures and instrumentation for ISLOCA (Table C-5)
- Change to procedures to provide access to other water sources (Table C-6).

Table C-1. Proposed strategy characteristics for the Reactor Vessel Cavity Flooding System

Reactor Vessel Cavity Flooding System

1. Sequence Categories For Which Strategy May Be Effective

The sequences for which this strategy is expected to be used include

a. Non-coolable relocation to the lower plenum

There is the potential to cool the core while still in the vessel if water can be injected early enough and in sufficient quantities.

b. Direct Containment Heating

Water may mitigate some of the effects of DCH by supplying some cooling of the debris as it is ejected. Experiments show the benefit is not large.

c. Core Concrete Interactions

Water can slow the progression of CCI and has a direct benefit by scrubbing some of the fission products,

2. Changes or Additions in Plant Hardware or Operation

Hardware changes would have to be made to provide water to the reactor vessel cavity. Since the containment spray systems would need to continue to operate to condense steam generated during the vessel cooling process, use of these systems for cavity flooding would require evaluation to ensure that their heat removal capability was not interrupted or significantly diminished. One option for use of these systems would be a connection to allow water from containment sprays to accumulate in the cavity more rapidly and in larger quantities. A dedicated system to inject directly in the cavity may be the simplest and least costly in terms of both hardware and possible additional analysis. The reactor vessel lower head insulation should be examined to determine if it could be removed, or if it remains in place, whether it will restrict contact of the water with the vessel. The potential for equipment or instrumentation failure due to flooding of compartments connected to the reactor vessel cavity must be examined and the safety implications of the failures of any safety related equipment must be determined.

Plant operations changes would be needed in the form of additional procedures or guidance to ensure that the proper instruments would be selected, initiation conditions would be correctly interpreted, and the flow would be initiated and the results monitored. There may also need to be additional monitoring of the sprays or fan coolers to ensure that adequate long term cooling is available.

Table C-1. (continued).

3. Information Needed and Instrumentation Available

There are no direct measurements that would indicate that core material has relocated to the lower plenum and that the integrity of the vessel is being threatened. However, there are measurements that indicate that severe core damage is being approached:

- Core exit thermocouples
- Hot leg RTDs
- Source range monitors
- Reactor Vessel Level Monitoring System (RVLMS)

Of these measurements, the core exit thermocouples would provide the most reliable indication since they are located close to the core and can provide a reasonable indication of the approach to extensive core damage. The source range monitors would be the least reliable indicator of core damage since there several different phenomena that can cause changes in the measurement. Although these phenomena are indicative of core damage, there is much more uncertainty in what changes in the measurement mean in relationship to the extent of core damage.

We could not find any indication that reactor vessel cavity water level is measured. This level would be needed to ensure that personnel involved in accident management can verify that water is covering the vessel lower head. A measurement of vessel lower head temperature would provide information on the possible timing of vessel lower head failure and would indicate whether flooding of the reactor vessel cavity is successful. This measurement could be made directly by thermocouples or indirectly through optics.

4. Resources Needed

A water source to fill the cavity to about the top of the lower plenum is estimated to require a capacity of about 70,000 gallons. If analysis shows that more of the vessel needs to be submerged, substantially more water would be needed since other parts of the containment would also need to be flooded to raise the level in the cavity. Using the minimum injection time of one hour, described in the timing of key events, the injection rate to fill the cavity to the top of the lower plenum would be about 1200 gpm. If it is necessary to fill the cavity to near the top of the core, the pump capacity could be up to a factor of 10 higher. The BWST easily has the capacity to flood up to the top of the lower plenum but for much larger volumes its use may detract from the inventory needed by the SI and Containment spray systems. Alternate sources of water could include the CST or water resources from the other unit. The proposed use of unborated water would require an analysis to confirm that recriticality will not occur for the spectrum of severe accidents or provisions made to borate the water before it enters the RCS.

Table C-1. (continued).

Pumps for a system to flood the cavity should use a diverse power source so that it is available during incidents where electrical power is lost. The valves necessary for system operation should be able to actuate if there is a station blackout or loss of air.

Training for flooding the cavity would be necessary.

5. Expected Timing of Key Phenomena

The elapsed time between detection of substantial core damage (for example core exit thermocouples greater than 1800 F) and relocation of fuel to the lower plenum could be as short as one to two hours. One hour should be used as a conservative time frame to assess the needed flow rates and response times.

Table C-2. Proposed strategy characteristics for an analysis aid to project lower head failure.

Analysis Aid to Project Lower Head Failure

1. Sequence Categories For Which Strategy May Be Effective

a. RCS Inventory Control

The sequences for which this strategy is expected to be used include

An estimate of the possible failure time of the lower head would help plant personnel judge between strategies if they require significantly different amounts of time to implement. For example it could assist the plant personnel in determining whether there was sufficient time to repair or replace equipment or utilize mobile equipment.

b. Non-coolable Relocation to the Lower Plenum

An estimate of the possible failure time of the lower head would help plant personnel judge between strategies, for example, continued efforts to inject water into the RCS versus preparation for injection into the vessel cavity.

c. Direct Containment Heating

An estimate of the possible failure time would allow personnel to assess the time available to depressurize the system and take advantage of accumulator injection.

2. Changes or Additions in Plant Hardware or Operation

There would not be any changes to plant hardware. There could be changes in plant operations because there could be changes in the procedures to assess the results from the Analyses Aid and make decisions on the strategies. There would also need to be guidance for use of the Analysis Aid and responsibility and authority for its use would have to be assigned. Training in its use and interpretation would also have to be performed.

3. Information Needed and Instrumentation Available

There are no measurements that provide an unambiguous indication of the condition of a degraded core or of the location of relocated core material. The following measurements would be available to provide input to the analysis aid: (a) core exit thermocouples (up to a temperature of 2500 F) to project fuel rod failure and core relocation times, (b) reactor vessel level to project fuel failure times, (c) RCS or containment radiation levels to indicate the timing of cladding rupture, (d) source range power monitor to be interpreted based on the TMI-2 accident and additional calculations, and RCS pressure to determine whether pressure spikes occur that may be indicative of the relocation of core material.

Table C-2. (continued).

4. Resources Needed

Resources would be needed to implement the analysis aid software at the proper location, probably in the technical support center. The software would require use of input from existing measurements. This input could be either automated using direct measurement output data or it could be input by the person responsible for making the projection of core failure. An uncertainty estimate on the accuracy of the analysis aid should be performed early in the development to ensure that the projections of timing are used properly in making accident management decisions. Training would be necessary.

5. Expected Timing of Key Events

The timing of key events can vary substantially for the possible sequence categories. The objective of this analysis aid is to provide projections of timing that can be used to make informed judgements on the need for implementation of strategies such repair of failed equipment or the flooding of the reactor vessel cavity.

Table C-3. Proposed strategy characteristics for cross-tie of secondary condensate storage tanks between units.

Cross-tie of Secondary Condensate Storage Tanks Between Units

1. Sequence Categories For Which Strategy May be Effective

The sequences for which this strategy is expected to be used include

a. Loss of Heat Sink (extended steam generator heat removal).
b. Steam Generator Tube Rupture (maintain coverage of break).

and to a lesser extent

c. ISLOCA (extended SG feed, if needed, and bleed to maintain low system pressure).
d. Direct Containment Heating (heat removal to accomplish or enhance RCS depressurization).

2. Changes or Additions in Plant Hardware or Operations

No Changes to plant hardware are noted to be required. The following cross-tie capability for the Unit 1 and Unit 2 secondary condensate storage tanks (CST) exist:

a. A 4 inch cross-tie (2FW027) in the turbine building between each CST auxiliary feedwater recirculation line return to the CSTs (0CD006 & 0CD066) with a single isolation valve 0FW0169 (normally closed). This appears to be a line that taps into the CST at a relatively high elevation, but may provide a limited source of water flow to the other tank.

b. A set of 12 inch cross-ties exist on the non-seismic portion of suction piping to the Condensate Make-up Pumps in the turbine building. Unit 2 pipe (2CD272) ties into the Unit 1 suction header (0SC001) isolated by valve 0CD0385 (normally closed), and Unit 1 pipe (1CD278) ties into the Unit 2 suction header (2CD278) isolated by valve 1CD0386 (normally closed). This piping can be isolated from a ruptured CST by closing the appropriate CST isolation (0CD0101, 0CD0100).

c. A set of 12 inch cross-ties exist on the Condenser overflow lines returning to the CST piping headers. It appears that the Unit 1 and Unit 2 CSTs are cross-tied at this point, and one of these lines is normally open. This may allow for level equalization. Unit 1 pipe (0CD087) ties into the Unit 2 CST header (2CD279) with valve 0CD0375 normally open, and Unit 2 pipe (0CD086) ties into the Unit 1 CST header (0CD068) isolated by valve 0CD0394 (normally closed). This piping can also be isolated from a ruptured CST by closing the appropriate CST isolation (0CD0101, 0CD0100).

Table C-3. (continued).

d. A 12 inch cross-tie (0CD085) exists in the turbine building prior to entry of the CST piping into the auxiliary building and the suction headers for the AFW pumps. This line is isolated by valve 0CD0370 (normally closed) and can be isolated from a ruptured CST piping in the turbine building by closing the appropriate manual (turbine building) isolation valves (1CD0369, 2CD0369).

e. An 8 inch cross-tie (0SW098) exists on one of the service water emergency supply headers to the motor-driven AFW pumps. This line is normally open (valve 0SW0670). CST supplied to the AFW pumps is normally flowing through this piping and can be supplied to the other motor-driven AFW pump via the normally open service water cross-tie, or can be supplied to all AFW pumps via the normally open CST suction headers. This portion can be isolated from ruptured CST piping in the turbine building by closing the appropriate manual (turbine building) isolation (1CD0369, 2CD0369), or an individual pump may be isolated by closing its discharge isolation valve or suction isolation valve, or both.

3. Information Needed and Instrumentation Available

Information needed to keep apprised of CST conditions is currently available and used to ensure AFW suction by monitoring CST level AFW pump suction pressure, and service water supply to the AFW system. Current operator actions are delineated in CAUTIONS contained within procedures of the EOP network that direct restoration of level in accordance with AOP-4.3 if CST level is less than 8 feet, and ensuring service water is aligned in accordance with AOP-4.3 if CST level falls below 0.5 feet. (An example is CAUTION at top of page 10 of FR-H.1, "Response To Loss Of Secondary Heat Sink")

4. Resources Needed

Currently, personnel are directed to perform some required actions [e.g., AOP-4.3 provides instructions for aligning service water (SW) to the AFW pumps]. It is expected no additional personnel would be required to complete tasks to cross-tie the CSTs to provide an extended source to the AFW pumps. Some decision making on which cross-connect would be best to use based on current plant conditions and projected plant conditions will be required prior to reaching the 0.5-foot limit in the one CST. Procedures may be redirected to ensuring the inventories of the CST are maximized for supply to the AFW system. Additional training in the use of the procedures would be required.

5. Expected Timing of Key Events

Timing is important to maximize available water resources for supply to the AFW system and to protect from a loss of both CST inventories. Adequate time is allowed by alerting the control room operator via low level alarms and caution steps within the EOPs. It is expected that all operator actions could be completed within a half-hour if at least 2 persons are assigned to the task.

Table C-4. Proposed strategy characteristics for the use of fire water spray to reduce off-site releases.

Use Of Fire Water Spray To Reduce Off-Site Releases

1. Sequence Categories For Which Strategy May be Effective

The sequences for which this strategy is expected to be used include

a. Steam Generator Tube Rupture (reduce fission product release)
b. Combustible Gas Burns (reduce fission product release).
c. Containment Heat Removal (reduce fission product release).
d. Direct Containment Heating (reduce fission product release).
e. Pre-existing Leak/Failure To Isolate (reduce fission product release).

and to some extent can be applied to

f. ISLOCA (submerging the break to reduce fission product release).

2. Changes or Addition in Plant Hardware or Operation

No major changes to plant hardware are believed to be required. There may be some hardware enhancements needed including:

a. Procurement and pre-staging of nozzle apparatus and adequate length(s) of 2½ inch fire hose in close proximity to containment/main steam relief/safety valves to support full coverage of area with maximum spray capability.

b. Placement of nozzle apparatus tie downs to provide best coverage and allow for unmanned coverage of main steam dump/safety relief valve discharges.

An assessment should be performed to ensure that the availability of water for fire fighting would not be diminished to the point that a hazard would exist. The local effect of sprays on equipment and instrumentation should also be examined to ensure that degradation would not result in safety problems.

3. Information Needed and Instrumentation Available

Information needed to identify those situations requiring use of water sprays is contained within procedures in the EOPs. Procedures do NOT currently exist that call for use of this strategy, so additional material on timing and direction would need to be added. Additional instrumentation may be needed to identify the release location or locations. This information

Table C-4. (continued).

would need to generally identify the sequence category so that release points could be determined. Examples of possible sequences would be: a SGTR (high steam generator pressure, radiation alarms on the secondary, etc.); ISLOCA (low containment pressure readings during an RCS inventory reduction when containment pressure is should rise, auxiliary building radiation alarms and fire sprays); containment leak (increasing radiation levels in the auxiliary building or outside containment), or containment failure (high containment pressure followed by reports of increasing radiation levels in the auxiliary building or outside containment).

4. Resources Needed

The quantities of water available for fire fighting should be sufficient to spray several release locations for extended periods of time. It is expected that prepositioning of equipment would streamline use of the sprays and consequently no additional personnel would be required to complete the tasks necessary to set up fire water sprays. Some decision making will be required to determine when it would be appropriate to set up the sprays based on current plant conditions and projected conditions, release rates, and times. Procedures would need to be rewritten to direct placing sprays into service based on plant conditions and procedures need to be written to direct accomplishment of this task.

5. Expected Timing of Key Events

Timing is important to allow adequate time to set up the sprays before the effect of the release prevents or limits action due to local radiation fields and exposure limitations. It is expected all operator actions could be completed within 15 minutes from notification to set up sprays if hardware is in place to properly direct the sprays to identified release locations and if at least 2 individuals are assigned to the task. If placement of nozzle apparatus tie downs are used, then the operators would be free for other tasks once the sprays are initiated and only periodic monitoring of the sprays would be required.

Table C-5. Proposed strategy characteristics for a change to procedures and instrumentation for ISLOCA.

Change to Procedures and Instrumentation for ISLOCA

1. Sequence Categories for which Strategy may be Effective

The sequences for which this strategy is expected to be used include

a. ISLOCA (identification of break location and mitigation of release).

2. Changes or Additions in Plant Hardware or Operation

The procedures need to be modified to aid in the diagnosis of an ISLOCA. Specifically the auxiliary building radiation alarms, sump level in the auxiliary building, containment pressure, containment sump level, fire alarms in the auxiliary building, and room or area temperatures in the auxiliary building need to be specifically referenced in the procedure (E-0) to allow the operator to make a quick positive diagnosis of the ISLOCA event and a determination of the approximate location.

3. Information Needed and Instrumentation Available

Instrumentation must be available to indicate sump levels and room or area temperatures, and to activate local radiation alarms and fire alarms. If the time required to reach some of the auxiliary building locations where local instrument readings are available is excessive, then it is recommended that these readings be provided directly in the control room. The potential for restricted access to instrument readings in the auxiliary building as a result of radiation fields should also be considered when deciding whether instrument readings should be displayed in the control room.

4. Resources Needed

It is expected that no additional personnel or other resources such as water inventory or power will be needed to implement this strategy. Additional instrumentation and displays may be needed. Additional training will be needed.

5. Expected Timing of Key Events

The timing of this phenomena is dependent upon the break size which is strongly dependant on break location. The time available for diagnosis could vary from 1 hour to as much as 8 hours.

Table C-6. Proposed strategy characteristics for a change to procedures to incorporate access to other water sources.

Change to Procedures to Incorporate Access to Other Water Sources

1. Sequence Categories for which Strategy may be Effective

   a. RCS Inventory Control (provide adequate water inventory to make up for long term losses from the RCS).

2. Changes or Additions in Plant Hardware or Operation

   The procedures need to be modified to list additional available water sources including use of water inventory from the second unit. This list should be incorporated into the existing procedure ECA-1.1. This might also include refilling the BWST with borated water, or condensate storage tank, municipal water sources, reservoirs or rivers. The need to borate the water to prevent recriticality must be evaluated. We do not have adequate information to fully assess this characteristic.

3. Information Needed and Instrumentation Available

   No additional information or instrumentation is needed.

4. Resources Needed

   It is possible that cross ties, or portable pumps and hoses may be needed to refill from some water sources. We do not have adequate information to fully assess this characteristic.

5. Expected Timing of Key Events

   Timing of the key events is dependent upon the rate of inventory loss and the amount of water available in the BWST and other sources. We do not have adequate information to fully assess this characteristic.

Appendix D

Preliminary Procedure for CST Cross-Tie

Table D-1. Preliminary procedure for CST cross-tie.

AOP SEC-1	RESPONSE TO LOSS OF CST LEVEL	Rev. A Nov 18, 1991

A. PURPOSE

This procedure provides actions to respond to a loss of Condensate Storage Tank Level.

B. ENTRY CONDITIONS

The following conditions may cause entry into this procedure:

- Rapidly dropping CST level in excess of AFW and condensate usage.
- CST LOW LEVEL - alarm, and CST level dropping.
- CST LOW-LEVEL - alarm.

Table D-1. (continued).

AOP SEC-1	RESPONSE TO LOSS OF CST LEVEL	Rev. A Nov 18, 1991

STEP	INSTRUCTIONS	RESPONSE NOT OBTAINED
	CAUTION Cavitation of the AFW pumps may occur when CST levels fall below 0.5 feet. Procedure AOP SEC-4 which provides instructions for aligning SW to the AFW pump suction should be performed in conjunction with this procedure.	
1.	Verify CST Makeup from Demineralized Water System: • 1LCV-CD139 (2LCV-CD139) - OPEN	Align Demineralized Water System for filling the CST: • Verify Booster pumps - AT LEAST TWO RUNNING. • Verify Flow - INDICATED ON OFQMUU8 OR OFRMUU7 (Green Pen). <u>IF</u>: 1LCV-CD139 (1LCV-CD139) can be opened, <u>THEN</u>: OPEN the valve to establish flow to the CST. <u>IF NOT</u>: Open the bypass valve 0CD0121 (2CD0373) to establish flow to the CST.
2.	Check CST level - DECREASING IN EXCESS OF KNOWN USAGE.	Return to procedure and step in effect.

Table D-1. (continued).

AOP SEC-1	RESPONSE TO LOSS OF CST LEVEL	Rev. A Nov 18, 1991

STEP	INSTRUCTIONS	RESPONSE NOT OBTAINED
3.	a. Check Condenser Hotwell 1A(2A) Level on 1LI-CD08 (2LI-CD08) - GREATER THAN 548 feet.	a. Verify Condenser Hotwell Makeup Operation for the affected unit: (1) __IF__: Hotwell level - LESS THAN 548 feet, __THEN__: Verify OPEN Hotwell Normal Makeup 1LCV-CD08A (2LCV-CD08A). __IF NOT__: Open Bypass valve 1CD0032 (2CD0032) and control makeup to the Hotwell. (2) __IF__: Hotwell level - LESS THAN 583 feet, __THEN__: Verify OPEN Hotwell Emergency Makeup 1LCV-CD08B (2LCV-CD08B). __IF NOT__: Open Bypass valve 1CD0032 (1CD0032) and control makeup to the Hotwell. (3) Monitor Hotwell level and isolate makeup when level returns to normal.
	b. Verify CLOSED Hotwell Makeup Valves to the affected unit: • 1LCV-CD08A (2LCV-CD08A) • 1LCD-CD08B (2LCV-CD08B) • 1CD0032 (2CD0032)	

Table D-1. (continued).

AOP SEC-1	RESPONSE TO LOSS OF CST LEVEL	Rev. A Nov 18, 1991

STEP	INSTRUCTIONS	RESPONSE NOT OBTAINED
4.	Dispatch Operators to the following areas to check for evidence of leaks: • CST Enclosure • Turbine Building 560' and 592' elevations. • Auxiliary Building 579' elevation.	
5.	IF: A leak is discovered on the CST, THEN: Isolate the affected CST - CLOSE Outlet Isolation Valve OCD0101 (OCD0100).	GO TO STEP 6.
6.	IF: A leak is discovered on the piping between the CST and the Makeup Header Isolation Valve 1CD0369 (2CD0369), THEN: a. Isolate the affected line - CLOSE Makeup Header Isolation Valve 1CD0369 (2CD0369). b. Cross-tie the downstream headers - OPEN the Makeup Header Downstream Cross-tie Valve 0CD0370. c. Isolate the upstream headers - CLOSE the Makeup Header Upstream Cross-tie Valve 0CD0375.	GO TO STEP 7.

Table D-1. (continued).

AOP SEC-1	RESPONSE TO LOSS OF CST LEVEL		Rev. A Nov 18, 1991
STEP	INSTRUCTIONS	RESPONSE NOT OBTAINED	

NOTE
During the following step normal suction will be lost to the Turbine-driven AFW Pump for the affected unit. Ensure the pump suction is aligned to service water if that pump is required to be operating.

STEP	INSTRUCTIONS	RESPONSE NOT OBTAINED
7.	IF: A leak is discovered on the piping between the Makeup Header Isolation Valve 1CD0369 (2CD0369) and the AFW pump suction isolation valves. THEN: a. Ensure Turbine-driven AFW pump on affected unit - 1FW004 (2FW004) STOPPED. b. Isolate the affected line - CLOSE Makeup Header Isolation Valve 1CD0369 (2CD0369). c. Verify AFW suction headers cross tied: • 0SW0670 OPEN • 1(2)MOV-SW0106 OPEN • 1(2)MOV-SW0107 OPEN d. Close the AFW pump suction isolation valves on the affect unit: • 1(2)MOV-FW0074 • 1(2)MOV-FW0075 • 1(2)MOV-FW0076	Return to procedure and step in effect

END OF PROCEDURE

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10. SUPPLEMENTARY NOTES

11. ABSTRACT (200 words or less)

This document is the second of a two-volume NUREG/CR that discusses development of accident management plans for nuclear power plants. The first volume (a) describes a four-phase approach for developing criteria that could be used for assessing the adequacy of accident management plans, (b) identifies the general attributes of accident management plans (Phase 1), (c) presents a prototype process for developing and implementing severe accident management plans (Phase 2), and (d) presents criteria that can be used to assess the adequacy of accident management plans. This volume (a) describes results from an evaluation of the capabilities of the prototype process to produce an accident management plan (Phase 3) and (b), based on these results and preliminary criteria included in NUREG/CR-5543, presents modifications to the criteria where appropriate.

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