SYSTEM 80+™

EMERGENCY OPERATIONS GUIDELINES

Rev. 00

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1.0 INTRODUCTION

1.1 PURPOSE

The objective of this report is to support the System 80+™ standard plant design certification by providing a general description of the Emergency Operating Guidelines for the ABB Combustion Engineering System 80+™ design. The guidance in this report incorporates use of the specific design features of the System 80+™ standard plant and is based on the Combustion Engineering Emergency Procedure Guidelines (CEN-152, Rev. 3), including all current Maintenance manual Change Packages in effect as of November 1, 1993. The Emergency Operations Guidelines provided in this report have not been validated on a plant specific simulator and include design information and parameters available at the time this report was prepared.

1.2 EXPLANATION OF MAJOR TERMS

Provided in this section are some important terms useful to the understanding of the overview presented in the next few sections.

1.2.1 Safety Functions

A safety function is any condition or action needed to either prevent core damage or to minimize radiation releases to the general public. If all safety function acceptance criteria are satisfied, the safety of the public is preserved.

1.2.2 Emergency Operations Guidelines

Emergency operations guidelines provide technical guidance for the development of plant specific emergency operating procedures for the System 80+™ plant. These guidelines provide the actions necessary for mitigation of plant events that necessitate a reactor trip.

1.2.3 Optimal Recovery Guidelines

Optimal recovery guidelines provide the technical basis for plant specific emergency operating procedures which the operator would use to treat a specific set of symptoms. Optimal recovery guidelines are written to strategically address a specific set of symptoms. Each set of symptoms usually corresponds to a specific event or class of events (e.g. LOCA, SGTR) causing the transient or accident.

1.2.4 Functional Recovery Guideline

The functional recovery guideline provides the technical basis for a plant specific functional recovery emergency operating procedures which the operator would use to verify the satisfactory control or restoration of all critical safety functions and to provide actions to restore and maintain those safety functions when degraded. A functional recovery operations (and the guideline on which it is based) is written in such a way that the operator need not diagnose an event in order to establish and maintain a safe plant configuration.

1.2.5 Emergency Operating Procedures

Emergency operating procedures are a plant specific document based on emergency operations guidelines which contain all of the steps needed to take the plant from the post-reactor trip state to a safe, stable condition. Emergency operating procedures use a specific format for clarity of procedural actions, control room personnel interactions, and compatibility with the design of the control room.

1.2.6 Verification

Verification is the process by which the technical information in emergency operations procedures is demonstrated to be accurate and complete. Verification may consist of technical analyses, workshops, or technical review. The outcome of the verification process is emergency operating procedures which are technically sound and complete.

1.2.7 Validation

Validation is the process by which emergency operating procedures are demonstrated to be useable by the operators. Validation is accomplished through workshops, control room walkthroughs, or by exercising the emergency operating procedures on simulators.

1.3 OVERVIEW OF SYSTEM 80+™ EOG SYSTEM

The System 80+™ Emergency Operations Guidelines (hereafter referred to as EOGs), represents a best estimate operator guidance for coping with design basis events (accidents).

Each plant develops an extensive network of operating procedures. Emergency operating procedures must be coordinated with these procedures. The content and scope of the emergency operating operations developed from EOGs should be designed to interface with, but neither overlap nor duplicate, plant procedures. The EOGs are designed to be used independently and cross referencing should be minimized. Cross referencing is appropriate only when the other guideline entry conditions are achieved during the course of operation (e.g., when Shutdown Cooling System entry conditions are established, then initiate it per operating instructions). The EOGs do not cover information related to overall operation of the power plant site during emergency conditions because that subject is covered by the Site Emergency Plan.

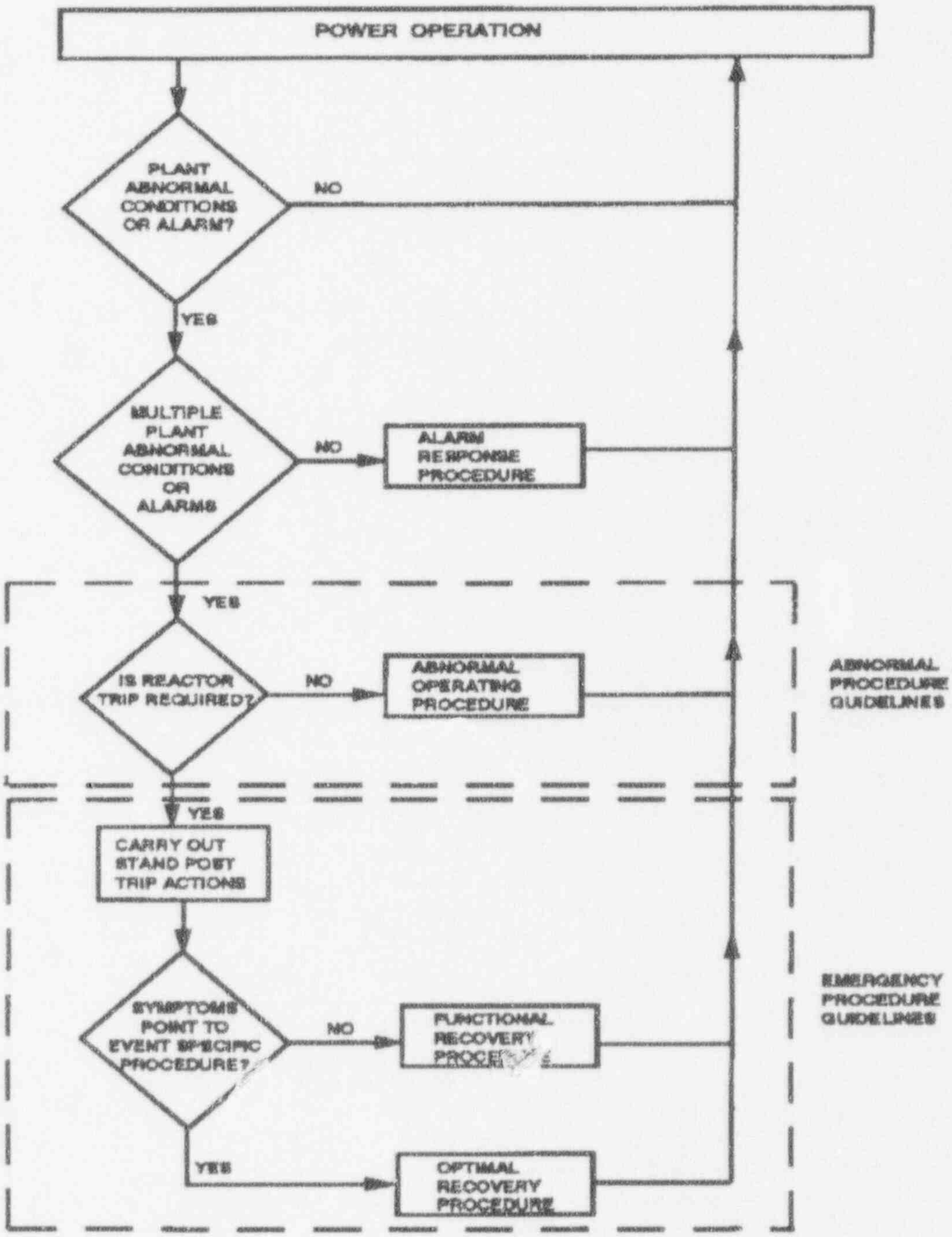
1.3.1 EOGs System Structure and Rationale

The EOGs are a collection of the best available technical information to be used for writing emergency operating procedures. An understanding of what constitutes an emergency is a prerequisite to deciding what information is to be collected and in which format that information is to be arranged. For the purpose of the EOGs, an emergency event is distinguished from other off-normal plant operations by virtue of its severity; it is sufficiently severe that a reactor trip is either activated automatically or required to be manually initiated to mitigate the event. Figure 1-1 depicts the distinction between emergency operating procedures based on these guidelines and other off-normal operations.

Emergency events can be divided into two classes. For the first class, the operators can ascertain the general type of the event by recognizing its correlated symptom set from control board indications and their knowledge of the plant and recent operating history. For these events where an accurate diagnosis can be made, it is highly desirable to provide mitigating guidance which is selected and sequenced to

FIGURE 1-1

SEQUENCE OF DECISIONS FOR OFF-NORMAL OPERATIONS



strategically address that symptom set. Since these types of events have been well analyzed and understood (e.g., LOCA, SGTR), it is possible to write the emergency operations guidelines to optimize the recovery (i.e., minimize release of radiation, minimize system leakage, reduce risk of core damage, reduce post accident recovery time to full power, etc.). For ease of use, these events have been grouped into classes of events (e.g., large and small break LOCAs inside or outside of containment are covered by one guideline). In the second class of emergency, the operators are unable to identify a unique symptom set for the event. This may be due to errors in symptom assessment by the operators; multiple, simultaneous failures in the plant (e.g., combined SGTR and LOCA); the occurrence of an heretofore unanalyzed event (e.g., loss of ECCS recirculation capability); or instrumentation failures which distort the symptom picture.

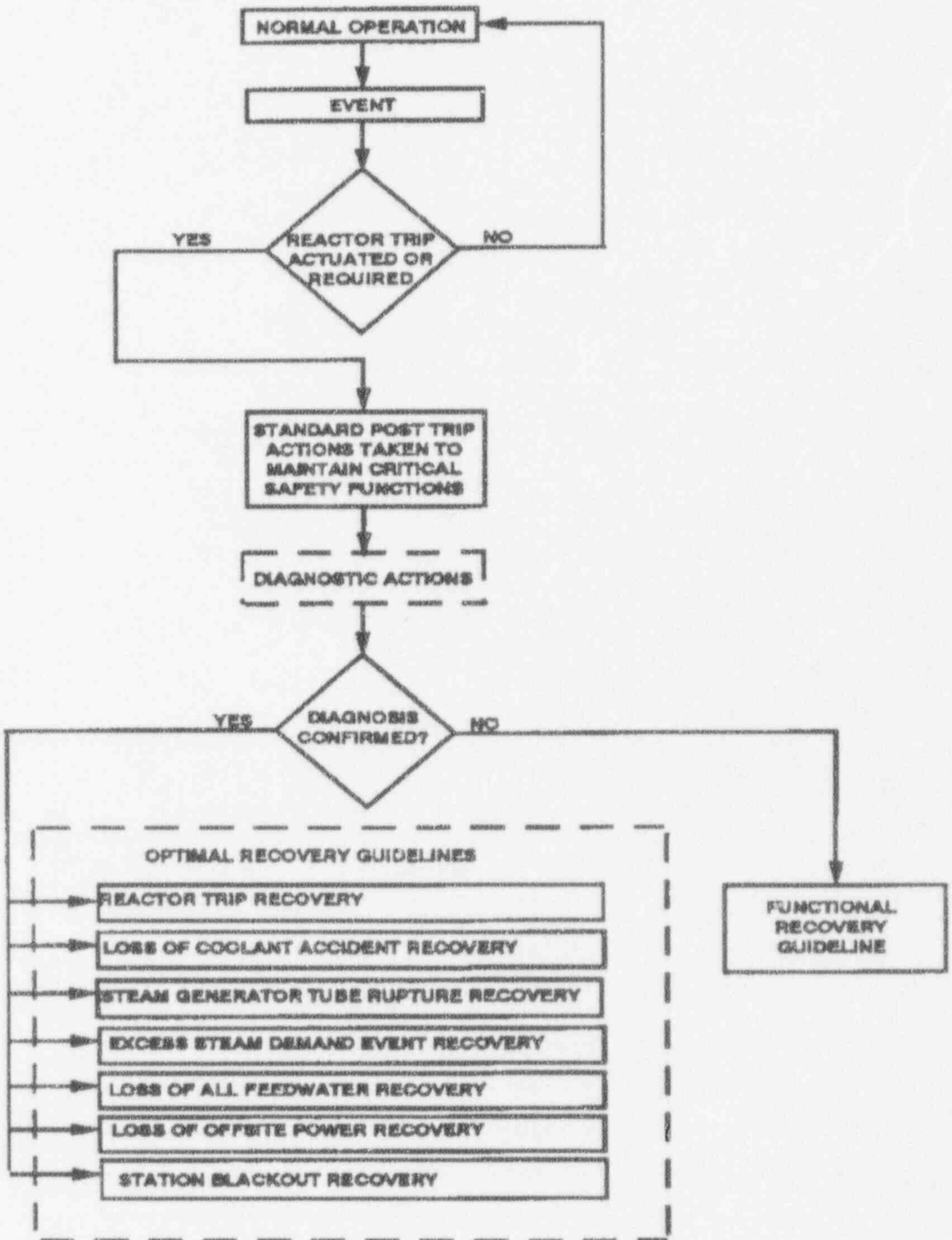
Emergency operations guidelines must provide guidance for both classes of emergencies. Thus, when a reactor trip occurs or should occur, the operators can refer to guidance which will provide a safe response whether or not a symptom set is identified. EOGs written to treat specific symptoms are called Optimal Recovery Guidelines. The EOG which provides guidance for undiagnosed events for which a reactor trip is required is called the Functional Recovery Guideline.

Figure 1-2 illustrates the system of EOGs. The Standard Post Trip Actions is the entry point for the EOGs. It is performed following all reactor trips (automatically or manually initiated). Its purpose is to evaluate the status of each safety function and to provide immediate actions which can be quickly and easily performed to improve the status of safety functions in jeopardy. During and following the Standard Post Trip Actions, diagnostic actions are performed to determine the symptom set corresponding to the type of event in progress. Depending on the operators' ability to diagnose the event, they will then select either an Optimal Recovery Guideline or the Functional Recovery Guideline.

The design of the EOGs recognizes that eventually in the course of an emergency it will become necessary for the operator to specify what resources are available to continue to satisfy safety functions. This is necessary because the operators must know what

FIGURE 1-2

OVERVIEW OF THE EMERGENCY PROCEDURE GUIDELINE SYSTEM



systems and equipment are available for use either in continued operation or for taking the plant to COLD SHUTDOWN conditions. The system of EOGs also recognizes the possibility of a misdiagnosis by the operators and makes provisions for detecting and recovering from such misdiagnoses. If the operators have selected the FRG because they cannot diagnose the event, the FRG provides action steps to bring the plant to a safe, stable condition. Once the FRG has been implemented, the operator will continue within the FRG until the exit conditions have been met. This is accomplished by satisfying the Safety Function Status Check acceptance criteria for each success path in use and meeting the entry conditions of an approved procedure. This approved procedure may be an applicable ORG. Naturally, the operators would start at the beginning of the selected ORG to ensure that all the relevant actions have been or are being taken.

Each ORG contains a section which requires the operator to confirm the diagnosis and continually review the status of all safety functions. This section is called the Safety Function Status Check. If the diagnosis is not confirmed or if the safety function acceptance criteria are not met, the operators then evaluate the need to implement the FRG. Thus, if the symptoms are not responding to treatment as anticipated or if the core is not being adequately cooled, the ORG may be exited and the Functional Recovery Guideline implemented.

Natural phenomena and other disasters are implicitly addressed in this system since all of the possible consequences of such phenomena (e.g., break in RCS pressure boundary, loss of vital auxiliaries) which affect the NSSS are addressed explicitly. Even if such phenomena result in multiple, major consequences, the FRG will provide systematic guidance for managing such a casualty. Therefore, since it is not possible to predict in advance what the consequences to the NSSS would be for a tornado or an aircraft crash, and since all possible consequences are covered by the EOGs, these phenomena need not be explicitly addressed. Plant specific procedures exist for managing non-NSSS systems and equipment in the event of certain natural phenomena or man-made disasters.

The System 80+™ EOGs are designed as the basis for emergency operating procedures which provide guidance for operating the NSSS to mitigate emergency events. Guidance is provided for operating equipment which is closely associated with but not part of the

NSSS (e.g., the turbine generator). This is in recognition of the existence of vital non-NSSS equipment and systems at each plant (i.e., balance of plant) wh ch are important to overall plant control. The guidelines are written in a two column format and do not go into greater detail than system level information. This preserves their generic nature. Each utility can write emergency operating procedures in a format which is most useful to them.

Guidance for the management of degraded core conditions is not included in these guideline

1.3.2 <u>Safety Functions</u>

1.3.2.1 <u>The Concept of Safety Functions</u>

The concept of safety functions introduces a systematic approach to plant operations based on a hierarchy of protective actions. The protective actions are directed at mitigating the consequences of an event and, once fulfilled, ensure proper control of the event in progress. A safety function is defined as a condition or action that prevents core damage or minimizes radiation release to the public. A complete set of safety functions needs to be fulfilled to ensure proper operator control of the event and public safety. The actions which ensure fulfillment of a safety function may result from automatic or manual actuation of systems, from passive system performance, from natural feedback inherent in the plant design, or when the operator follows guidance established in an event recovery guideline. The operator does not have to know what event has occurred but does have to know what success paths are being utilized and what acceptance criteria must be satisfied.

All safety functions are directed at mitigating an event and containing and/or controlling radioactivity releases. These safety functions can be grouped into four major classes as follows:

1. anti-core melt safety functions
2. containment integrity safety functions
3. indirect radioactive release safety function

4. maintenance of vital auxiliaries needed to support the other safety functions

The anti-core melt safety function class contains five safety functions:

1. reactivity control
2. RCS inventory control
3. RCS pressure control
4. core heat removal
5. RCS heat removal

The purpose of the first anti-core melt safety function, reactivity control, is to shut down the reactor and to keep it shut down, thereby reducing the amount of heat generated in the core. The purpose of reactor coolant system (RCS) inventory and pressure control is to keep the core covered with an effective coolant medium. RCS inventory and pressure control are interdependent in a PWR design. That is, actions taken to effect inventory control will affect pressure control and vice versa. The purpose of the fourth anti-core melt safety function, core heat removal, is to remove the decay heat generated in the core and transfer it to a location where it can be removed from the RCS. The fifth anti-core melt safety function is RCS heat removal. The purpose of this safety function is to transfer heat from the primary system coolant to another heat sink.

The containment integrity safety function class contains three safety functions:

1. containment isolation
2. containment temperature and pressure control
3. containment combustible gas control

The primary objective of these safety functions is to prevent major radioactive release from the containment by maintaining the integrity of the containment structure. Accomplishing the first safety function, containment isolation, assists in maintaining containment integrity by ensuring that all normal containment penetrations not required to be open for accident mitigation are closed. The purpose of the containment temperature and pressure control safety function is to prevent overstressing the containment structure and to prevent damage to other equipment in the containment resulting from a hostile environment. The purpose of the combustible gas control is to prevent containment overstress caused by explosion of hydrogen gas inside containment.

The third safety function class has one safety function associated with it: indirect radioactive release. The purpose of indirect radioactive release control is to prevent radioactive releases to the environment (gaseous, solid, and liquid, including radioactive coolant) from sources outside containment. These sources include the spent fuel pool and the radioactive waste handling and storage facilities. The systems used to control releases from these sources include the radiation monitoring system, the spent fuel pool cooling system, and the waste management and processing systems. In mitigating the types of emergencies for which this document provides guidance, the indirect radioactive release safety function does not come into play. Consequently, operator actions necessary for control of the indirect radioactive release safety function are not provided in this document.

The fourth safety function class also includes only one safety function: maintenance of vital auxiliaries. The systems used to accomplish the eight other safety functions addressed in this document are all supported by the maintenance of vital auxiliaries safety function. In general, support systems provide service such as instrument air needed for opening and closing valves, electric power for valve operation, pump motor operation, and operating instruments and an ultimate heat sink to which RCS and core heat can be transferred. Of greatest impact to the operator actions associated with CEN-152 is vital AC and DC power. AC and DC power must be maintained in order to continue to satisfy the acceptance criteria of the other safety functions.

1.3.2.2 Safety Function Hierarchy

The safety function concept incorporates a principle of safety function hierarchy. Some safety functions have precedence over others concerning their sequence of implementation during an event. Figure 1-3 summarizes the hierarchy of safety functions.

Reactivity control is the most important safety function since it responds most quickly to changes in plant conditions. Similarly, RCS inventory control must be satisfied before core heat removal can be effected (i.e., there must be a medium to remove heat) and, in general, loss of inventory can occur within a shorter time frame than that required for core heat removal. This hierarchy concept is important in the design of systems used to fulfill each function and has also been employed in developing the emergency operations guidelines.

All of the emergency operations guidelines identify each of the 9 safety functions (in the hierarchy of Figure 1-3) and the acceptance criteria which reflect accomplishment of each of the safety functions. The safety functions are provided as a complete set so that the operator can monitor and control the plant to protect the health and safety of the public. Application of the concept of safety functions in a restructured format is acceptable as long as: (1) the representation contains actions and acceptance criteria necessary to control and fulfill the nine (9) individual safety functions; (2) it is consistent with the safety function hierarchy of CEN-152, and (3) the ultimate goal of protecting the health and safety of the public is preserved. Figure 1-4 shows various arrangements of the safety functions, with each level representing another means of ensuring that the ultimate goal is preserved.

FIGURE 1-3

SAFETY FUNCTION HIERARCHY

REACTIVITY CONTROL

MAINTENANCE OF VITAL AUXILIARIES (AC AND DC POWER)

RCS INVENTORY CONTROL

RCS PRESSURE CONTROL

CORE HEAT REMOVAL

RCS HEAT REMOVAL

CONTAINMENT ISOLATION

CONTAINMENT TEMPERATURE AND PRESSURE CONTROL

CONTAINMENT COMBUSTIBLE GAS CONTROL

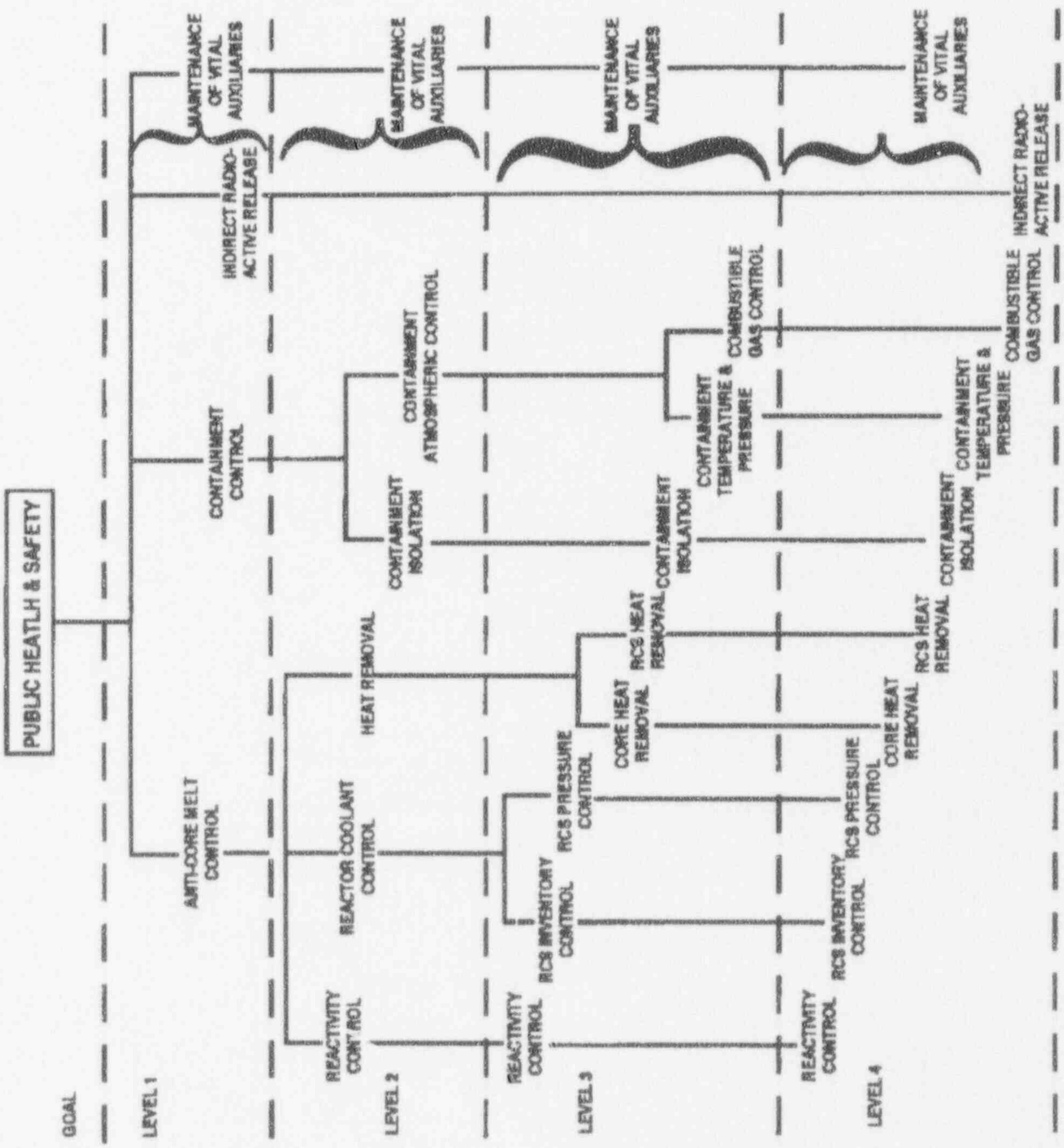
Each level, consisting of a rearrangement or combination of safety functions can achieve the same goal as the set which contains each safety function individually. This safety function subset or rearrangement may be enhanced by use of a particular control room operator aid, such as a CFMS, SPDS, etc.

Because safety functions are a complete set of actions or conditions which will provide for the safety of the public, they form the foundation of all emergency operations guidelines. In the Optimal Recovery Guidelines (ORGs), specific events such as LOCA or Excess Steam Demand Event (ESDE) are addressed. Because each event affects diverse parts of the plant, proper mitigation of different events will emphasize different safety functions. For example, in a major LOCA, RCS Pressure Control and RCS Inventory Control are the two safety functions of immediate concern. Therefore, the operator actions are sequenced to achieve control of these two safety functions first by using equipment designed for that purpose. Nonetheless, since all safety functions must be fulfilled to provide for the safety of the public, each ORG addresses all of the safety functions. In preparing emergency operations guidelines, the nine safety functions are used to audit the guideline to ensure that sufficient action steps exist to cover all safety functions. Each ORG includes a safety function status check which is used by the operator to continually determine whether the safety functions are being adequately fulfilled.

The Functional Recovery Guideline (FRG) is used by the operator when a diagnosis is not possible, when the Optimal Recovery Guideline being utilized is not adequate (as judged by the safety function status check in each ORG) or when the guideline in use is inappropriate. The FRG's structure includes an expanded version of the safety function status check which is used by the operator to continually check the status of each safety function. For those safety functions which are found to be in jeopardy, possible success paths are provided along with operator actions for implementing each success path and acceptance criteria by which successful safety function restoration is judged. For this guideline the safety functions form the main structure of the guideline.

FIGURE 1-4

SAFETY FUNCTION CLASSIFICATIONS



1.3.2.3 Success Paths

Nuclear power plants are designed such that each safety function has multiple means of fulfillment. In other words, for each safety function there exists more than one system or means of fulfillment called success paths. For example, Reactivity Control can be achieved by inserting control rods or by increasing RCS boron concentration. With respect to the latter, there are several methods of increasing RCS boron concentration. It is important that the operator be aware of the various success paths associated with each safety function.

During any emergency event, the operator needs information on plant conditions. This monitoring of plant conditions leads to identification of the safety functions in jeopardy and the systems available to satisfy the safety function acceptance criteria. The EOGs clearly indicate the alternate means of satisfying each safety function by providing success path oriented guidance.

1.4 PRINCIPLES OF EOG DEVELOPMENT

In the course of the development of the EOGs, certain principles were developed to ensure that the final products conformed to generally acknowledged rules for operational guidance, and that the rationale for the overall EOG system was preserved. The following three sections describe and explain these principles.

1.4.1 Principles of Standard Post Trip Actions

The purpose of the Standard Post Trip Actions is to provide the entry point for all EOGs. An emergency is defined as any off-normal event which either automatically actuates a reactor trip or requires a manually initiated reactor trip (RT) to properly mitigate the event. This definition is consistent with the NUREG-0899 definition and with industry operating practice. This EOG contains a check of safety functions against acceptance criteria, along with contingency actions which can be performed to restore those safety functions in jeopardy. The Standard Post Trip Actions actually serve three purposes:

1. All safety functions are checked against acceptance criteria to give the operator a complete status regarding plant conditions and safety. The acceptance criteria are chosen to be easily accessible from the control room panels and to require no interpretation or interpolation by the operator.

2. The check of safety functions provides the operator with objective decision criteria as to whether action is required in the short term to restore plant safety. This permits crisp, reliable decision making and precludes unnecessary operator action.

3. As further explained below, the check of safety functions discriminates between an uncomplicated reactor trip (e.g., one caused by technician error) and other more complex events. The safety function acceptance criteria are chosen to be consistent with the plant conditions which would prevail only in the short term after a simple and uncomplicated reactor trip. Thus, if there are other

failures which require attention, the acceptance criteria will not be satisfied, signaling that more than a simple RT has occurred.

The Standard Post Trip Actions are presented in a format chosen for ease of presentation and understanding. The relationship of safety function to acceptance criteria to contingency actions is immediately apparent. The safety function assessment and accompanying contingency actions are prioritized according to two factors. The first factor is the importance to safety in terms of the consequences of not fulfilling that safety function and in terms of the time associated with that safety function. Thus, Reactivity Control is the first priority since shutting down the reactor is of foremost importance and reactivity responds very quickly. The second factor in prioritizing operator actions relates to the natural order of steps in the control room. Since reactor trip and turbine trip are generally interlocked and since a turbine trip quickly results in automatic rearrangement of the electrical distribution system, and also since electrical power is a prerequisite to almost all other actions, it is important to check the status of electrical power early in the sequence of actions. This has been confirmed in workshops, simulator experiments, and operator interviews.

It must be stressed that the Standard Post Trip Actions (SPTAs) EOG contains the only immediate actions in the entire system of EOGs. This is an acknowledgement of the immediate actions which are performed by operators following any reactor trip and standardizes a safety function based approach to any event which causes a reactor trip. The latter is most important since the entire EOG system is designed to institute a functional approach to casualty management. The SPTAs clearly reflect this intent.

Additional principles which were adhered to during the development of the SPTA EOG are:

1. The statements are clear and concise to facilitate memorization by the operator.

2. The statements are prioritized.

3. Multiple action statements are avoided.

4. Contingency actions are clearly identified with the contingencies spelled out.

5. Cross referencing to other guidelines is minimized.

The level of detail in the Standard Post Trip Actions guideline is consistent with the other EOGs and with the intent of providing generic guidelines. The level of technical information extends to the system level only. Action statements are sufficiently detailed to indicate the system(s) to be used, including any important supporting systems, but do not provide detailed, step by step guidance for starting or stopping systems or components.

1.4.2 <u>Principles of Optimal Recovery Guidelines</u>

1.4.2.1 <u>Optimal Recovery Guideline Structure</u>

Optimal Recovery Guidelines (ORGs) are those guidelines written to address specific symptom sets. In order to minimize the number of guidelines, and thereby avoid operator confusion, those events which are difficult to distinguish from each other in the short term (e.g., inadvertently opened atmospheric steam dump valve and steam line break) or which have similar effects on the NSSS over time are grouped into classes of events. The classes of events considered are:

1. Reactor Trip (RT)
2. Loss of Coolant Accident (LOCA)
3. Steam Generator Tube Rupture (SGTR)
4. Excess Steam Demand Event (ESDE)
5. Loss of All Feedwater (LOAF)
6. Loss of Offsite Power (LOOP)
7. Station Blackout (SB)

Differences between the set of ORGs and the plant specific set of optimal recovery procedures (ORPs) are permitted, as long as all of the classes of events covered in the ORGs are covered in the ORPs (e.g., Loss of offsite power events could be covered in a

Loss of Forced Circulation operations; or the LOOP and Station Blackout ORGs could be combined in an Electrical Emergency operations).

Each ORG consists of the following sections:

a. Purpose
b. Entry Conditions
c. Exit Conditions
d. Operator Actions
e. Supplementary Information
f. Safety Function Status Check
g. Bases

PURPOSE

The purpose section provides a brief statement of the condition(s) for which the subject guideline is intended to be used and defines what the guideline is intended to accomplish.

ENTRY CONDITIONS

Entry conditions are chosen to reflect those conditions which are most likely to exist following the reactor trip and which reflect the trends which may exist for some time into the event. The entry conditions section contains parameters and indications which an operator is expected to utilize in identifying and confirming the event. These conditions were written with the following points in mind:

1. Priority is given to conditions which appear first during the initial phases of an event or which are most important with respect to associated consequences.

2. Indications listed are readily available to the operator. For example, pressurizer level is used instead of RCS inventory since pressurizer level can be read directly and RCS inventory must be derived.

3. If several indications are available for the same symptom, the best indication has been selected and used.

EXIT CONDITIONS

Exit conditions are written to explicitly identify the conditions which must exist before the operators leave the emergency operations guideline. In general, the EOG should be exited if either: 1) an inappropriate procedure has been implemented, or 2) the EOG has met its goals.

An inappropriate EOG may have been implemented if the event was misdiagnosed. A misdiagnosis may be identified by using the break identification chart, by not satisfying the acceptance criteria of the Safety Function Status Check, or by other available indications. In this case, the operators should exit that EOG and implement the appropriate ORG or the FRG. It is also possible that the event was correctly diagnosed, but additional failures beyond the scope of that ORG have occurred. This should be identified by a failure to meet one or more of the Safety Function Status Check acceptance criteria. In this case, the operators should exit that ORG and implement the FRG.

The operators should also exit the EOG once the goals of the EOG have been met. Once the event has been mitigated, and the plant is stable, the appropriate operating operations should be used. In most cases, this will be a (non-emergency) operating procedure such as COLD SHUTDOWN or HOT STANDBY. In some cases, plant conditions may require that the operating procedure be modified. These modifications should be provided by the [Plant Technical Support Center or Plant Operations Review Committee] prior to exiting the EOG.

OPERATOR ACTIONS

The operator actions section provides the operator with event specific guidance starting at the point at which the Standard Post Trip Actions leave off. This guidance is provided with instructions and appropriate contingency actions. Operator actions also contain more explanation and cover a greater range of possible failures and alternative actions. Thus, operator actions for a particular event diverge from those for other events. The purpose of the operator actions section is to provide steps which would place the plant in a safe, stable condition, permit problems to be corrected, and allow recovery operations to commence. Depending on the event, the final plant condition could be HOT STANDBY, HOT SHUTDOWN, or COLD SHUTDOWN.

In appropriate places, the primary success path plus any alternative success paths for accomplishing the intended safety function are included in the operator action steps. Where more than one success path is provided, the order of preference is indicated.

The operator actions section consists of those actions required to place the plant in a configuration from which either recovery can be accomplished or a long-term shutdown can be achieved. This section was written with the following points in mind:

1. The statements are clear and concise to avoid confusion.

2. The statements are prioritized.

3. Multiple action statements are avoided.

4. Contingency actions are clearly identified.

5. If more than one equally acceptable action sequence exists, the simpler one is stated.

6. Cross referencing to other operations is minimized.

7. Action statements are provided in a two-column format to reflect how EOPs are typically implemented.

8. Action statement content is limited to system level information. This is consistent with the intent of providing generic guidance and is sufficient to ensure accurate implementation in plant specific operations.

9. The completion of operator actions results in a plant condition which allows recovery operations to commence (i.e., return to operation, repair, clean-up, etc.).

10. Alternative success path actions are provided.

11. Steps that remain applicable or that require specific plant conditions are marked with an asterisk. This asterisk refers the operator to the footnote, "Step Performed Continuously". The designation is intended as an operator aid and a cue to frequently refer to these steps as they can optimize plant recovery.

Charts and diagrams are utilized in the EOGs. Charts and diagrams quickly and accurately deliver a large amount of technical information without the need to read long explanatory narratives and are intended to be implemented in plant specific operations as appropriate.

Charts and diagrams were developed with the following points in mind:

1. Each figure, table, or chart has a title.

2. Axes on graphs are clearly labeled.

3. Explanatory notes on graphs and figures are kept to a minimum.

4. In general, a left to right, top-to bottom flow is followed.

5. Figures and graphs are uncluttered and legible.

6. The purpose or intention of the graph or figure is immediately apparent to trained personnel.

7. Units of measurements are clear.

SUPPLEMENTARY INFORMATION

The supplementary information section contains items which should be considered when utilizing the EOGs to implement plant specific EOPs. The items should be written as precautions, cautions, or notes in the EOPs and included in the EOP training program.

SAFETY FUNCTION STATUS CHECK

Each Optimal Recovery Guideline (ORG) has its own Safety Function Status Check (SFSC) which must be used whenever an ORG is in use. The purpose of the SFSC is to continually verify the status of safety functions. This is accomplished by comparing control board indications to safety function acceptance criteria tailored for each class of event. By satisfying the SFSC acceptance criteria, the operating staff is assured that the actions being taken are maintaining the plant in a safe condition. On the other hand, if SFSC criteria are not satisfied, the operators are promptly alerted to the situation. In this case the operators will take corrective actions to satisfy the safety functions, implement another ORG, or exit to the Functional Recovery Guideline. The SFSC is designed to be used by the Shift Supervisor, Shift Technical Advisor, or other person available to provide an independent assessment of the status of safety functions.

BASES

Each guideline contains a bases section. The bases section is a dialogue between the emergency operations guideline writer and the emergency operating procedure writer. It is not intended that the bases appear in the detailed, plant specific EOPs but rather that it be used in preparing EOPs and in operator training. The guideline preparer can draw upon a large amount of information on the event including plant data, licensing analysis, realistic transient analysis, incident reports, sequence of events diagrams, and operating experience. The bases presents a condensed form of this information for the EOP writer and the operators. There is sufficient detail in the explanations without burdening the operators with specific analytical data.

The bases section provides technical information that increases the operators' ability to identify the event, to understand the plant response to an event, and to understand the reason for the corrective actions specified. The following points are addressed in the bases section:

1. A brief overview of the event is presented.

2. The general characteristics and possible causes of the event are discussed.

3. The potential effect of the event on the reactor, plant equipment, and the environment is noted.

4. The bases section includes a detailed discussion of the range and trend of plant responses to an event or class of events. The following list contains examples of the significant plant parameters that are considered:

   Reactor Power
   RCS Temperature
   Pressurizer Pressure
   Pressurizer Level
   Steam Generator Level
   Steam Generator Pressure
   Reactor Vessel Inventory

5. Trending of key parameters that can be used as valuable aids in diagnosing the event and in determining its severity is explained. These are parameters (such as those listed in 4 above) which operators frequently evaluate during an event.

6. The bases section describes the objective of the recovery actions (automatic and manual) taken in response to the event, and why these actions are taken (e.g., which safety function(s) is affected). The bases section corresponds step by step to the guideline steps.

7. The immediate and long range goals of the actions (i.e., strategy) of each guideline are explained. Each bases section contains a set of strategy charts which pictorialize the sequence of guideline goals for that event and which identify the steps that correspond to the strategy goals.

8. Preferred and alternate success paths to accomplish essential functions are included.

9. The basis for the Safety Function Status Check (including the acceptance criteria chosen for each safety function) is explained.

1.4.2.2 Use of ORGs

Optimal Recovery Guidelines (ORGs) are used to treat specific symptom sets which are identifiable or diagnosable by the operators following a reactor trip. Each ORG is designed to accommodate minor concurrent failures which do not present major complications (e.g., failure of the automatic pressurizer level control system). The Standard Post Trip Actions are performed before an ORG is implemented. If a specific symptom set can be identified, the operators will then implement the appropriate ORG. The goal of the recovery actions is to place the plant in a safe, stable condition.

The emphasis in the Optimal Recovery Guidelines is on treatment of a set of symptoms according to an optimal strategy, as contrasted to treatment of a specific event. One of the first recovery actions will be to assess the safety functions against specific acceptance criteria using the Safety Function Status Check. This serves a dual purpose. First, it is a check to verify that all safety functions are being satisfied. Second, it provides a means of verifying that the initial diagnosis was correct. This essential feature provides a correction process. If the guideline in use is adequately treating the symptoms, then the treatment is continued. If the treatment is inadequate, either because new information (symptoms) appears that is not covered in the guideline, or because the observed symptoms are not properly responding, each ORG has a step which requires the operators to exit the ORG and to implement the FRG. The checking process using the Safety Function Status Check continues as long as the guideline is in use. This is the way the EOG system manages multiple, significant failures, or misdiagnosed or undiagnosable symptom sets. The FRG is designed to provide guidance for managing any event which results in or requires a reactor trip.

Operator actions are selected and sequenced to address all safety functions in their order of importance to treating that symptom picture. Where appropriate, contingency actions are included for use when primary success paths have not been successful. Each ORG has two types of strategy charts included in the bases section which pictorially depict the intended strategy for managing the event. One chart indicates the fundamental strategy being applied for event recovery and the second is a more detailed chart which correlates the guideline steps to each strategy element.

1.4.3 Principles of the Functional Recovery Guideline

1.4.3.1 Functional Recovery Guideline Structure

The Functional Recovery Guideline (FRG) is the EOG implemented following a reactor trip in which the event cannot be diagnosed by the operators. It may also be implemented for cases where the operators have initially selected an ORG but subsequently discovered that they had misdiagnosed the event or that the ORG was not adequately maintaining safety functions.

The FRG consists of the following sections:

a. Purpose
b. Entry Conditions
c. Exit Conditions
d. FRG Entry Operations
e. Figures
f. Safety Function Status Check

g. Recovery Guideline Operator Actions

h. Bases

i. Long Term Actions

PURPOSE

The purpose section provides a brief statement of the condition(s) for which the Functional Recovery Guideline is intended to be implemented and defines what the guideline is intended to accomplish.

ENTRY CONDITIONS

Entry conditions are chosen to identify those conditions which will necessitate implementation of the FRG. Following the performance of the SPTAs, the operator may not be able to diagnose one unique event taking place. This could happen if more than one event is taking place (multiple casualties) or a condition exists for which abnormal or emergency guidance cannot be identified. During the course of the event, actions taken in an ORG may not satisfy the Safety Function Status Check acceptance criteria. Implementation of the safety function based FRG would then be evaluated.

EXIT CONDITIONS

The FRG exit conditions are written to identify the conditions which must exist before the operators leave the FRG. In general, the FRG should be exited if either:

1. The acceptance criteria for all success paths in use are being satisfied.

   and

2. An appropriate, approved procedure to implement exists or has been approved by the [Plant Technical Support Center or the Plant Operations Review Committee].

FRG ENTRY Operations

This section is the entry point for the Functional Recovery Guideline and basically functions as an outline it directs the operator to perform specific actions to enhance the operators' ability to monitor plant status and maintain the plant in a safe condition. Implementation of the Long Term Actions is directed when Safety Function Status Check acceptance criteria are satisfied and appropriate operator actions for all success paths in use have been performed.

FIGURES

Figures are utilized in the Functional Recovery Guideline to quickly and accurately deliver a large amount of technical information without the need to read long explanatory narratives. The figures utilized in this section of the FRG include:

- Post Accident P-T Limits
- Break Identification Chart
- SIS Flow vs. Pressurizer Pressure
- Condensate Inventory Curves

SAFETY FUNCTION STATUS CHECK

The Safety Function Status Check (SFSC) is used to assess the status of each safety function. The SFSC is structured to aid the operator in the selection of appropriate actions which will restore those safety functions in jeopardy. Since safety functions are a complete set of the actions or conditions which will provide for plant and public safety, an EOG which provides guidance to satisfy the acceptance criteria of all safety functions will ensure plant safety. The FRG is written to detect safety functions which do not satisfy their acceptance criteria and to provide recovery actions to satisfy the acceptance criteria of all safety functions.

The FRG Safety Function Status Check lists the safety functions which must be checked during an emergency. This list differs slightly from that in the Optimal Recovery Guidelines. RCS Heat Removal and Core Heat Removal are combined in the FRG because the success paths used to achieve these two safety functions are virtually the same. Also, since the acceptance criteria and operator actions associated with each of these success paths are identical, it makes sense to combine the safety functions to eliminate the redundancy of listing each separately.

RCS Inventory Control and RCS Pressure Control reflect the two possible trends of the monitored parameters and the different success paths and acceptance criteria associated with each (high and low conditions).

The SFSC lists the success paths associated with each safety function. Listing the success paths permits the operator to select the safety function acceptance criteria appropriate to the success path in use. For any given safety function, the appropriate acceptance criteria to use are those associated with the highest numbered success path on the list which is in use. After performing the Standard Post Trip Actions and attempting event diagnosis, the operator will be aware of what equipment is running and which success paths are in use. All possible success paths are listed for each safety function. This feature requires that there be some redundancy between the Standard Post Trip Actions and the Functional Recovery Guideline. Because some of the success paths and their methods of use may be plant specific, a somewhat redundant listing will permit utilities to arrange this information in a fashion most suitable to them in their plant specific emergency operating procedure.

The Safety Function Status Check also contains the acceptance criteria for each success path. The acceptance criteria are organized such that each success path has its respective acceptance criteria next to it. The acceptance criteria are selected to define minimum acceptable system conditions for that success path.

Similar to each ORG, the FRG Safety Function Status Check could also be used by a shift supervisor, shift technical advisor or comparable person to provide an independent assessment of the status of safety functions. It is also used to continually verify the adequacy of safety functions. This review is accomplished anytime the FRG is in use.

RECOVERY GUIDELINE OPERATOR ACTIONS

Each success path recovery guideline provides guidance on the implementation of that success path. These operator action guidelines are numbered according to the function they serve. For example, HR-2 is the second recovery guideline associated with RCS and Core Heat Removal.

Each success path recovery guideline has the following structure:

1. Name and number of the guideline
2. The operator action steps for that success path
3. The acceptance criteria for that success path
4. Supplementary information for use of that success path

It is important in using the FRG that the success path recovery guidelines be used because information located only there may alert the operator to possible misuse of a success path or to a condition which may lead to a defeat of that success path.

BASES

The bases section for the FRG serves the same purpose as the bases section for Optimal Recovery Guidelines (ORGs) and follows a similar format. The bases describe in detail the rationale for the guidance provided in the FRG.

LONG TERM ACTIONS

The Long Term Actions section of the FRG is designed to ensure that the operator continues to periodically verify the adequate maintenance of safety functions, assess the status of the plant, implement the appropriate ORG if conditions warrant, and determine the necessity, feasibility, and/or urgency to perform a cooldown to COLD SHUTDOWN conditions.

1.4.3.2 Use of the Functional Recovery Guideline (FRG)

The following gives a brief description of how to use the Functional Recovery Guideline:

The Standard Post Trip Actions (SPTAs) are performed prior to entry into the FRG. The FRG may be entered directly after completion of the SPTAs if a diagnosis is not possible. The FRG might also be entered from an ORG if an ORG had been initially selected by the operator but was subsequently found to be inadequate. The Safety Function Status Check in each ORG is the primary means used to judge this adequacy. If the safety function acceptance criteria are not satisfied at any time, then the operator is directed to evaluate the need to implement the FRG.

The entry point for the FRG is the FRG Entry Operations. The operator reviews the status of all safety functions by checking control board indications against the acceptance criteria for the success paths in use. For each safety function, the acceptance criteria for the highest numbered success path in use are the appropriate acceptance criteria to use. For example, if RCS Inventory Control is the safety function in question and success paths IC-1 (CVCS) and IC-2 (SIS) are both currently in use, the acceptance criteria for success path IC-2 must be satisfied. This would continue to be true until the SIS was secured and the CVCS was the sole success path in use. The operator notes which safety functions do not meet their appropriate acceptance criteria. These safety functions are in jeopardy. Note that the acceptance criteria for the first success path for each safety function generally correspond to the symptoms of an uncomplicated reactor trip.

Then, beginning with the first safety function which is in jeopardy, the operator reviews the success paths provided for that safety function to ascertain the availability of resources. The operator reviews each success path to determine its availability and whether or not it is already operating. If it is operating, the operator checks the acceptance criteria to see if the safety function acceptance criteria are now being satisfied. If the safety function acceptance criteria are satisfied, the operator goes on to the next safety function in jeopardy. If the success path is required to be operating, and is not operating but is available (as indicated by meeting the component or condition limits noted on each success path), the operator implements the recovery guideline referenced for that path. If the acceptance criteria associated with that success path are now satisfied, the operator goes on to the next safety function in jeopardy. If the acceptance criteria are still not satisfied, the operator goes to the next success path to the right on the tree and continues implementing success paths until the safety function is satisfied. It is possible, and desirable in many cases, to use more than one success path at a time. Even if more than one success path is in use, the acceptance criteria by which the fulfillment of the safety function is judged are those for the highest numbered success path in use.

If all of the success paths for a safety function have been implemented and none of their respective acceptance criteria are met, then the operator refers to the "Continuing Actions" section. The operator is required to continue to work on this safety function and to pursue other jeopardized safety functions simultaneously.

Once all safety functions have been satisfied and appropriate Operator Actions for all success paths in use have been performed, the operator goes to the Long Term Actions to attempt to evaluate plant status, determine a diagnosis and decide on future actions.

Concurrent with taking steps to restore jeopardized safety functions, the control room team is using the FRG Safety Function Status Check to continually review the status of safety functions. As the event progresses and/or as new success paths are available, the operator may have to shift to the new acceptance criteria which correspond to these success paths. This periodic review may reveal that a safety function is in jeopardy and requires further operator action.

STANDARD POST TRIP ACTIONS

PURPOSE

This guideline provides the immediate operator actions which must be accomplished after an automatic or manually initiated reactor trip. These actions are necessary to ensure that the plant is placed in a stable, safe condition or that the plant is configured to respond to a continuing emergency. This is the entry guideline for the entire Emergency Operations Guidelines (EOG) system. This guideline provides technical information to be used by utilities in developing a plant specific procedure for the System 80+ plant.

ENTRY CONDITIONS

Any symptom(s) of a Reactor Trip

1. Any Reactor trip alarms
2. CEA bottom lights on
3. Rapid decrease in reactor power
4. Reactor trip circuit breakers open
5. RPS trip setpoint exceeded

EXIT CONDITIONS

1. ALL INSTRUCTION steps of the SPTAs have been performed and all safety function acceptance criteria are verified to be satisfied (implement Reactor Trip Recovery ORG).

or

2. ALL INSTRUCTION steps of the SPTAs have been performed, all necessary CONTINGENCY ACTIONS have been performed, and more than an uncomplicated reactor trip has occurred (implement Diagnostic Actions).

INSTRUCTIONS	CONTINGENCY ACTIONS
1. Perform the following steps to verify all safety function acceptance criteria are satisfied.	1. If any acceptance criteria are NOT satisfied, Then perform the appropriate contingency actions.

REACTIVITY CONTROL

INSTRUCTIONS	CONTINGENCY ACTIONS
2. Verify reactivity control is established by the following:	2. If reactivity control is NOT established, Then do the following as necessary:
a. Reactor power decreasing and	a. Manually trip the reactor
b. Negative startup rate and	b. Open the reactor trip breakers
c. Maximum of one CEA not fully inserted.	c. Use Alternate Protection System to open the CEDM Motor Generator Output Contactor.
	d. Deenergize the CEA motor generator
	e. If more than one CEA NOT fully inserted, Then borate the plant in accordance with Technical Specifications.

MAINTENANCE OF VITAL AUXILIARIES
(AC & DC POWER)

INSTRUCTIONS	CONTINGENCY ACTIONS
3. Verify plant electrical power requirements are satisfied by ALL of the following:	3. If electrical power requirements are NOT satisfied, Then do the following as necessary:
a. Main turbine tripped	a. Trip the turbine
b. Generator output breakers open	b. Open the generator output breakers.
c. Non-safety load [13.8 KV] Bus X energized and Non-safety load [13.8 KV] Bus Y energized	c. If all Non-safety load [13.8 KV] Buses are deenergized, Then inform the CRS that the event is complicated by a loss of power.
d. Non-safety load [4.16 KV] Bus X energized and Non-safety load [4.16 KV] Bus Y energized	d. If all Non-safety load [4.16 KV] Buses are deenergized, Then inform the CRS that the event is complicated by a loss of power.
e. Permanent Non-safety Load [4.16 KV] Bus X energized and Permanent Non-safety Load [4.16 KV] Bus Y energized	e. If all Permanent Non-Safety Load Busses are de-energized, THEN inform the CRS of the status of the Permanent Non-safety Load Buses.

MAINTENANCE OF VITAL AUXILIARIES (Continued)
(AC & DC POWER)

INSTRUCTIONS	CONTINGENCY ACTIONS
f. i) Safety Bus A <u>and</u> C energized via Permanent Non-Safety Bus X <u>and</u> ii) Safety Bus B <u>and</u> D energized via Permanent Non-Safety Bus Y	f. <u>If</u> <u>ANY</u> of the vital [4.16 kV] buses are <u>NOT</u> energized, then start the emergency diesel generators and the alternate AC source.
g. <u>ALL</u> vital [125V] DC and [120V] AC buses are energized	g. i) If [125V] DC and [120V] AC Safety Buses A, C and Division I <u>NOT</u> energized <u>or</u> ii) [125V] DC and [120V] AC Safety Buses C, D, and Division II <u>NOT</u> energized, <u>THEN</u> notify CRS of the loss of a DC train.

RCS INVENTORY CONTROL

INSTRUCTIONS	CONTINGENCY ACTIONS
4. Verify RCS inventory control is established by the following: a. Pressurizer level: i) [2% to 78%] and ii) trending [33% to 52%] and b. The RCS is subcooled.	4. If RCS inventory control is NOT established, Then do the following as necessary: a. Verify proper operation of the PLCS. b. Take manual control of the PLCS to restore and maintain pressurizer level [33% to 52%]

RCS PRESSURE CONTROL

INSTRUCTIONS

5. Verify RCS pressure control is established by pressurizer pressure:
   a. [2160 to 2370 psia]
   and
   b. trending to [2225 to 2300 psia]

CONTINGENCY ACTIONS

5. If RCS pressure control is NOT established, Then do the following as necessary:
   a. Verify proper operation of the PPCS
   b. Take manual control of the PPCS to restore and maintain pressurizer pressure [2225 to 2300 psia]
   c. If pressurizer pressure decreases to the SIAS setpoint, Then ensure an SIAS is initiated
   d. If pressurizer pressure decreases to less than [1400 psia] following a SIAS, Then trip 2 RCPs (in opposite loops).

CORE HEAT REMOVAL

INSTRUCTIONS	CONTINGENCY ACTIONS
6. Verify core heat removal via forced circulation by the following:	6. If forced circulation core heat removal is NOT possible, Then verify natural circulation is developing by:
a. At least one RCP is operating and	a. Loop ΔT (T_H - T_c) is less than normal full power ΔT,
b. T_H - T_c is less than [3°F] and	b. Cold leg temperatures constant or decreasing,
c. The RCS is subcooled.	c. The RCS is subcooled,
	d. No abnormal difference greater than [10°F] between T_H RTDs and representative CET temperatures.

RCS HEAT REMOVAL

INSTRUCTIONS	CONTINGENCY ACTIONS
7. Verify RCS heat removal by the following:	7. a. If RCS T_{ave} > [562°F], Then do the following:
a. At least one SG has level:	i) Ensure main, startup or emergency feed is controlling or restoring level to at least one SG.
i) within the normal level band with maintain level or ii) being restored by a Main, Startup or Emergency feedwater flow	ii) Ensure the turbine bypass system is operating to control RCS T_{ave} [551 to 562°F].
and	iii) If turbine bypass system NOT available, Then use ADVs to control T_{ave} [551 to 562°F]
b. RCS T_{ave} [551 to 562°F] and c. SG pressure [1050 to 1150 psia]	b. If RCS T_{ave} < [551°F] then do the following:
	i) Ensure feed flow not excessive. Control main, startup or emergency feed flow as necessary.
	ii) If SG pressure < [1000 psia], Then ensure turbine bypass valves, ADVs, and MSSVs are closed.
	iii) If SG pressure ≤ [843 psia], Then ensure MSIS activated and consider ESDE.

CONTAINMENT ISOLATION

INSTRUCTIONS	CONTINGENCY ACTIONS
8. Verify normal containment environment by:	8. If normal containment environment is NOT indicated, Then do the following as necessary:
a. Containment pressure less than [2 psig] and	a. If containment pressure is greater than or equal to [2.7 psig], Then ensure a CIAS
b. No containment area radiation monitors alarming and	b. If Nuclear Annex radiation levels are at or above the alarm setpoint, Then consider a LOCA outside containment.
c. No Nuclear Annex radiation alarms. and	c. If Reactor Building radiation levels are at or above the alarm setpoint, Then consider a LOCA outside containment.
d. No Reactor Building radiation alarms. and	d. If Steam Plant radiation levels are at or above the alarm setpoint, Then consider SGTR.
e. No Steam Plant radiation alarms.	

CONTAINMENT TEMPERATURE & PRESSURE CONTROL

INSTRUCTIONS	CONTINGENCY ACTIONS
9. Verify normal containment temperature and pressure parameters by the following: a. Containment temperature less than [110°F] and b. Containment pressure less than [2 psig]	9. If normal containment temperature and pressure parameters are NOT indicated, Then do the following as necessary: a. Verify All available containment fan coolers operating or b. If containment pressure greater than or equal to [8.5 psig], Then ensure at least one containment spray header is delivering at least [5000 gpm]

CONTAINMENT COMBUSTIBLE GAS CONTROL

INSTRUCTIONS	CONTINGENCY ACTIONS
10. Verify no expected increase in containment combustible gas concentration by the following: a. Containment temperature less than [110°F] and b. Containment pressure less than [2 psig]	10. If normal containment temperature and pressure parameters are NOT indicated, Then do the following as necessary: a. Verify proper functioning of all available containment recirculation cooling units b. Verify proper functioning of all available containment air recirculation fans, including the pressurizer compartment, reactor compartment, and CEDM cooling units, if they are available.
11. Verify all safety function acceptance criteria are satisfied and the event is an uncomplicated reactor trip, Then implement the Reactor Trip Recovery Guideline.	11. If all safety function acceptance criteria are NOT satisfied, Then more than a uncomplicated reactor trip has occurred and the Diagnostic Actions guideline must be implemented.

Bases for Operator Actions

This is the entry guideline for the SYSTEM 80+ EOG System. This guideline is used for any event which actuates or requires a reactor trip. It is intended that the operator check each safety function and perform the contingency actions if necessary. The acceptance criteria are selected from best estimate analysis to reflect the range for each parameter which would be expected following a relatively uncomplicated reactor trip. The recovery actions are selected to reflect the need to verify the actuation of automatic systems and to perform appropriate post trip actions which will ready the plant to respond to any event.

1. Standard Post Trip Actions (SPTAs) are organized around those critical safety functions which must be satisfied when a reactor trip is actuated or required, in order to ensure that the plant is placed in a stable, safe condition or that the plant is configured to further respond to a continuing casualty. In order to provide for this, the operator is given specific, unambiguous acceptance criteria which can be evaluated without interpolation directly from the control room instruments. These acceptance criteria are located under the "INSTRUCTIONS" heading. These criteria (and the range of the numerical criteria) are chosen from best estimate analyses to bound the expected conditions which would follow a relatively uncomplicated reactor trip. Thus, checking the acceptance criteria serves two purposes: if the acceptance criteria are met, this serves as a verification that the safety function is being fulfilled; second, meeting the acceptance criteria is a diagnostic indicator (i.e., meeting all of the acceptance criteria implies that nothing more serious than a relatively uncomplicated reactor trip has occurred). If the acceptance criteria are not met, then this serves as a cue to perform the appropriate contingency actions located under the heading of the same name. These actions are chosen to reflect the verification of expected automatic system responses and the usual, easy to accomplish actions which operators always take in response to a trip.

2. The Reactivity Control safety function is designed to ensure that the reactor is shutdown in order to reduce heat input to the RCS. The Reactivity Control acceptance criteria are chosen to reflect those reactor conditions which would prevail during the first ten minutes following a trip. No more than one CEA stuck out is chosen as the cutoff point in the third criterion since it is a core design criterion that the reactor will be shutdown even with the most reactive rod stuck out. Contingency actions a) through d) are directed at inserting the CEAs. Contingency action e) reflects the Technical Specification requirement to borate the RCS should more than one CEA not be fully inserted.

3. Maintenance of Vital Auxiliaries is chosen as the next safety function to address since the electrical system is essential to the continued fulfillment of succeeding safety functions. The acceptance criteria reflect the automatic disconnect of the main turbine generator and the transfer of power to offsite which should occur immediately upon a trip. Contingency actions are chosen to remedy the failure of automatic system responses and to ensure that the emergency diesel generators and the alternate AC source are available to supply AC power, if necessary.

4. RCS Inventory Control and RCS Pressure Control are next in order of priority due to their importance to core cooling and their potential for rapid change. RCS Inventory Control is intended to ensure an adequate amount of fluid is in a subcooled state to remove decay heat. During a relatively uncomplicated reactor trip, the pressurizer will retain an indicated level between [2% to 78%] (even though the pressurizer heaters may be deenergized briefly on low pressurizer level) which is acknowledged in the acceptance criteria. The upper limit of pressurizer level is based on avoiding solid water operations. The lower limit is based on having some water in the pressurizer. If the pressurizer level control system functions properly, level in the pressurizer should be trending to [33% to 52%]. Contingency actions are selected to observe proper operation of charging and letdown by the PLCS. Failing that, manual control of the PLCS or the charging and letdown is taken to restore and maintain pressurizer level [33% to 52%].

5. RCS Pressure Control relates to the maintenance of RCS fluid in a subcooled condition in order to adequately remove decay heat. Best estimate analyses reveal that for a relatively uncomplicated reactor trip, pressure will remain within the range of [2160 to 2370 psia]. The limits are adequate to ensure adequate RCS subcooling and to prevent the lifting of primary safety valve. If the pressurizer pressure control system functions properly and pressurizer level is above the heater cutoff setpoint, pressurizer pressure should be trending to between [2225 and 2300 psia]. Contingency actions are directed at observing proper operation of pressurizer heaters and spray by the PPCS. Failing that, actions are directed at restoring or maintaining pressure [2225 to 2300 psia] with manual control of the PPCS or the pressurizer heaters and spray. If pressurizer pressure decreases to or below the SIAS setpoint, SIAS should be initiated automatically. If this does not occur, the operator should manually initiate SIAS. While performing the Standard Post Trip Actions, the operator is instructed to trip two RCPs (in opposite loops) if pressurizer pressure decreases to less than [1400 psia] following SIAS. A SIAS is specified to distinguish between a controlled and an uncontrolled depressurization. If two RCPs are tripped early in the event, the plant can be maintained in a safe condition regardless of event diagnosis. This action provides the operator with maximum flexibility for plant control while still ensuring a conservative approach to event recovery.

6. Core Heat Removal is related to circulating cooling fluid in a subcooled state through the core to remove decay heat. The acceptance criteria assume RCPs are running (as they would be following a relatively uncomplicated trip) thereby providing the small loop ΔT [<3°F] expected with decay heat. Subcooling is concerned with maintaining adequate fluid conditions surrounding the core. Contingency actions are directed at removing heat via the steam generators using subcooled natural circulation.

   If all RCP operation is terminated and inventory and pressure are controlled, then natural circulation is monitored by heat removal via at least one steam generator. Natural circulation flow should occur within 5-15 minutes after the

RCPs are tripped and, thus, may not be established during the time frame in which the SPTAs are being performed.

Natural circulation is governed by decay heat, component elevations, primary to secondary heat transfer, loop flow resistance, and voiding. Component elevations on the System 80+ plant are such that satisfactory natural circulation decay heat removal is obtained by fluid density differences between the core region and the steam generator tubes.

The operator has adequate instrumentation to monitor natural circulation for the single phase liquid natural circulation process. The RCS temperature instrumentation, namely loop ΔT, can be used along with other information to confirm that the single phase natural circulation process is effective. The natural circulation process involving two phase cooling is complex and varied enough so that RCS loop ΔT may not he a meaningful indication of adequate natural circulation cooling. The guidelines are written to alert the operator to use explicit acceptance criteria for natural circulation only when RCS inventory and pressure are controlled.

The RCS temperature response during natural circulation will usually be slow 5-15 minutes as compared to a normal forced flow system response time of 6-12 seconds, since the coolant loop cycle time will be significantly longer.

When single phase circulation is established in at least one loop, the RCS indicates all of the following conditions:

a. Loop ΔT (T_H - T_c) less than normal full power ΔT,
b. Cold leg temperatures constant or decreasing,
c. RCS at least subcooled (verifies single phase flow),
d. No abnormal differences between T_H RTDs and core exit thermocouples. Hot leg RTD temperature should be consistent with the core exit thermocouples.

Adequate natural circulation flow ensures that core exit thermocouple temperatures will be approximately equal to the hot leg RTD temperatures.

If the criteria listed above are not satisfied, then the operators should ensure that RCS pressure and inventory, and SG steaming and feeding, are being controlled properly.

7. RCS Heat Removal is next in priority because the parameters associated with it are concerned mostly with steam generators, which are the primary means of removing heat from the RCS. Furthermore, steam generator level and pressure also have the potential for rapid change. Instruction step a) is to ensure the presence of an operable steam generator for removing heat. The steam generator level may briefly transit below the narrow range steam generator level indication. Emergency feedwater flow will be initiated automatically from either the Plant Protection System or the Alternate Protection System on low steam generator level or can be initiated manually by the operator. RCS average loop temperature (criterion b) in the range of [551 to 562°F] is indicative that steam generators are adequately removing heat. Instruction Step c) also ensures an operable steam generator for controlled removal of heat. The steam generator pressure range given provides the expected range maintained by the steam bypass control system. The upper steam generator pressure limit, [1150 psia] is below the MSSVs setpoint and the lower limit, [1050 psia] would be indicative of an excessive cooldown. The contingency actions relate to feed and or steam flow to the steam generator under one of two conditions:

a. RCS heat removal is <u>NOT</u> sufficient (RCS T_{ave} > [562°F]

or

b. RCS heat removal is excessive (RCS T_{ave} < [551°F]

If RCS Heat removal is not sufficient (e.g., RCS T_{ave} > [562°F] due to loss of condenser vacuum), the operator is provided several items to check in order to re-establish RCS heat removal. Feedwater must be supplied to at least one steam generator in order to ensure adequate heat removal will be maintained. If the turbine bypass system is not functioning properly in automatic, the operator should attempt to take manual control to restore RCS T_{ave} to [551 to 562°F]. If manual control of the turbine bypass system is not possible or condenser vacuum is lost, then the atmospheric dump valves are operated to control T_{ave} between [551 and 562°F].

If RCS heat removal is excessive (e.g., RCS T_{ave} < [551°F] due to stuck open main steam safety valves), then guidance is provided on how to mitigate this transient. The operator should ensure that the feed rate to the steam generators is not excessive. Because decay heat and power history will vary over core life, the operator must use judgement in feeding the steam generators. If the refill rate is too fast, RCS temperature can easily be driven below the desired no load value. If an overfeed condition is not corrected, pressurizer level may decrease to the point where the pressurizer is drained and the safety injection system is actuated. Following a reactor trip, steam generator pressure should increase to approximately [1150 psia], and a band of [1050 to 1150 psia] is specified in the acceptance criteria. If steam generator pressure decreases to less than [1000 psia], then some system abnormality exists that should be investigated and corrected. The limit of [1000 psia] was chosen because it is far enough below the turbine bypass system control program to minimize unnecessary operator actions while still high enough to give the operator time to find and correct the problem prior to a main steam isolation signal (MSIS). Possible sources of the excessive heat removal (turbine bypass valves, ADVs, MSSVs) should be checked shut or manually closed, if possible. If steam generator pressure decreases to or below [843 psia], then an MSIS should be actuated. The operator should ensure this has occurred, taking manual actions as necessary, and consider an ESDE when performing Diagnostic Actions.

8. Containment Isolation serves to ensure that radionuclides are contained inside the containment building. The acceptance criteria are designed to ensure that a normal containment environment exists. High containment pressure, (above the

alarm setpoint [2 psig]) or radiation alarms in the and steam plant, the Nuclear Annex and/or the Reactor Building are indications that more than a relatively uncomplicated reactor trip has occurred. Contingency actions are designed to ensure that the containment is isolated when necessary (CIAS occurs when containment pressure is greater than or equal to [2.7 psig]) and that a SGTR is considered when performing Diagnostic Actions if turbine building radiation alarms are obtained.

9. Containment Temperature and Pressure Control has as its goal the preservation of the containment building boundary by preventing or minimizing pressure excursions. Since containment temperature and pressure are not expected to change noticeably for a relatively uncomplicated reactor trip, the acceptance criteria are selected to be sensitive to any change. Contingency actions focus on restoring or initiating containment cooling either with the containment cooling fans, with the containment spray system, or with a combination of these two systems. If containment temperature and/or pressure have exceeded their expected values but containment pressure is less than [8.5 psig], then the operator should verify that ALL available containment fan coolers are operating. If containment fan cooler operation is not adequate to maintain containment pressure less than [8.5 psig], then the containment spray system should be actuated automatically. If containment pressure reaches [8.5 psig], then the operator should verify that containment sprays have automatically actuated. If this has not occurred automatically, then the operator should take necessary steps to manually actuate containment spray. In order to maintain containment pressure below design pressure in the event of a design basis event, there exist redundant containment spray trains for containment heat removal.

10. In the Standard Post Trip Actions, checking Containment Combustible Gas Control serves to alert the operator of the potential for hydrogen generation. Hydrogen can be generated (and released to the containment) by several mechanisms:

a. metal-water reactions involving Zirconium or stainless steel in the RCS,

b. corrosion reactions involving the containment spray solution and metals (Zinc and aluminum) inside containment,

c. radiolytic decomposition of water due to fission product decay.

The metal-water reactions and the radiolysis are of concern during LOCAs when the hydrogen generated by these mechanisms can escape to the containment atmosphere (through the RCS break). The corrosion reactions require high temperatures to produce significant amounts of hydrogen. This mechanism is of concern during LOCAs and steam line breaks inside containment, since these events may result in high temperatures and containment spray actuation.

The potential for hydrogen generation is identified by increasing containment pressure and temperature, since these indicate that a LOCA or steam line break may be occurring inside containment and may result in containment spray actuation. Contingency actions are intended to minimize the amount of hydrogen generated due to corrosion reactions (by reducing the containment temperature), and to prevent local accumulations of hydrogen (by mixing the containment atmosphere with all available fans).

11. If all safety function acceptance criteria (located under the INSTRUCTIONS heading) are verified to be satisfied and the operator has determined that nothing more than a relatively uncomplicated reactor trip has occurred, the Reactor Trip Recovery Guideline should be implemented. This guideline will provide the guidance necessary to place the plant in a stable, safe condition, to perform an RCS cooldown, or to prepare for a possible reactor startup.

If all acceptance criteria are not satisfied, then more than a uncomplicated reactor trip has occurred. While performing the Standard Post Trip Actions the operator will be obtaining diagnostic information. The EOG Diagnostic Actions guideline must be utilized to obtain event diagnosis.

DIAGNOSTIC ACTIONS

PURPOSE

This guideline provides the Diagnostic Actions which must be performed to attempt to determine a preliminary diagnosis of the event(s) which has resulted in a reactor trip. These actions are performed to best enable the operator to determine whether to implement an ORG or the FRG. This guideline contains no specific operator action steps but does provide technical information to be used by utilities in developing a plant specific diagnostic procedure.

ENTRY CONDITIONS

The Standard Post Trip Actions have been performed.

EXIT CONDITIONS

The Diagnostic Actions have been performed and the preliminary diagnosis indicates one of the following:

a. The diagnosis of one event is apparent and an appropriate Optimal Recovery Guideline can be implemented to mitigate the event.

b. The diagnosis of one event for which emergency guidance exists is not possible and the Functional Recovery Guideline must be implemented.

FIGURE 3-1

DIAGNOSTIC ACTIONS

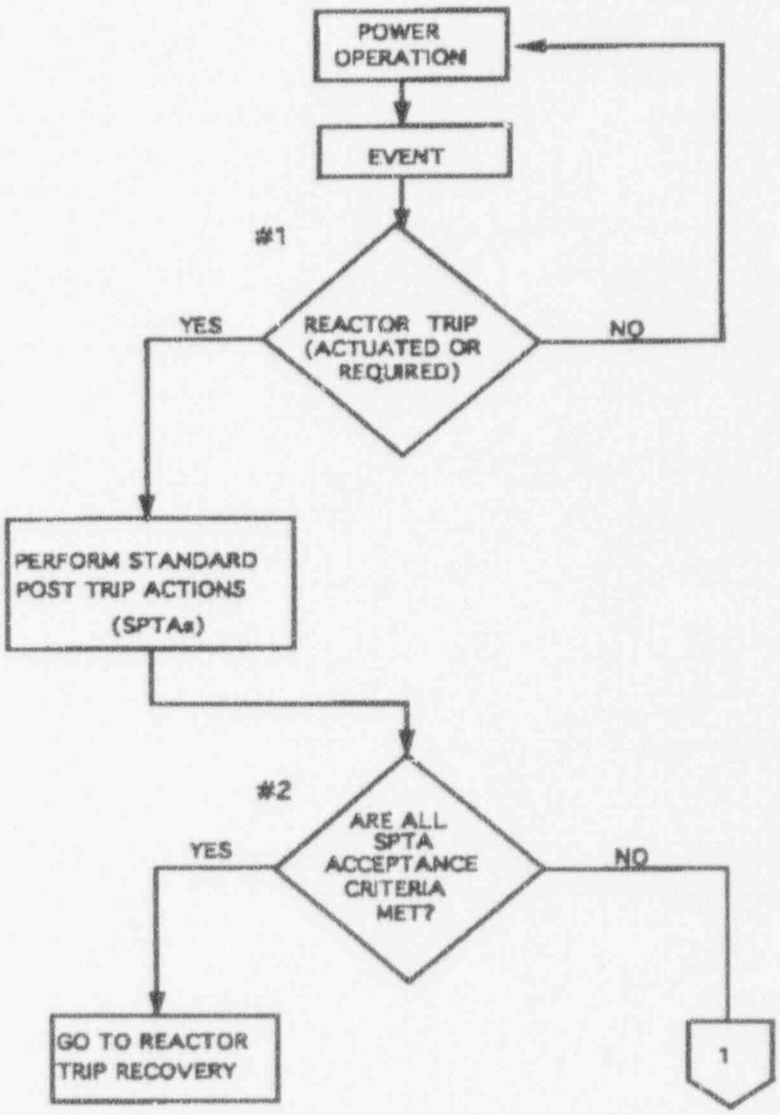


FIGURE 3-2
DIAGNOSTIC ACTIONS

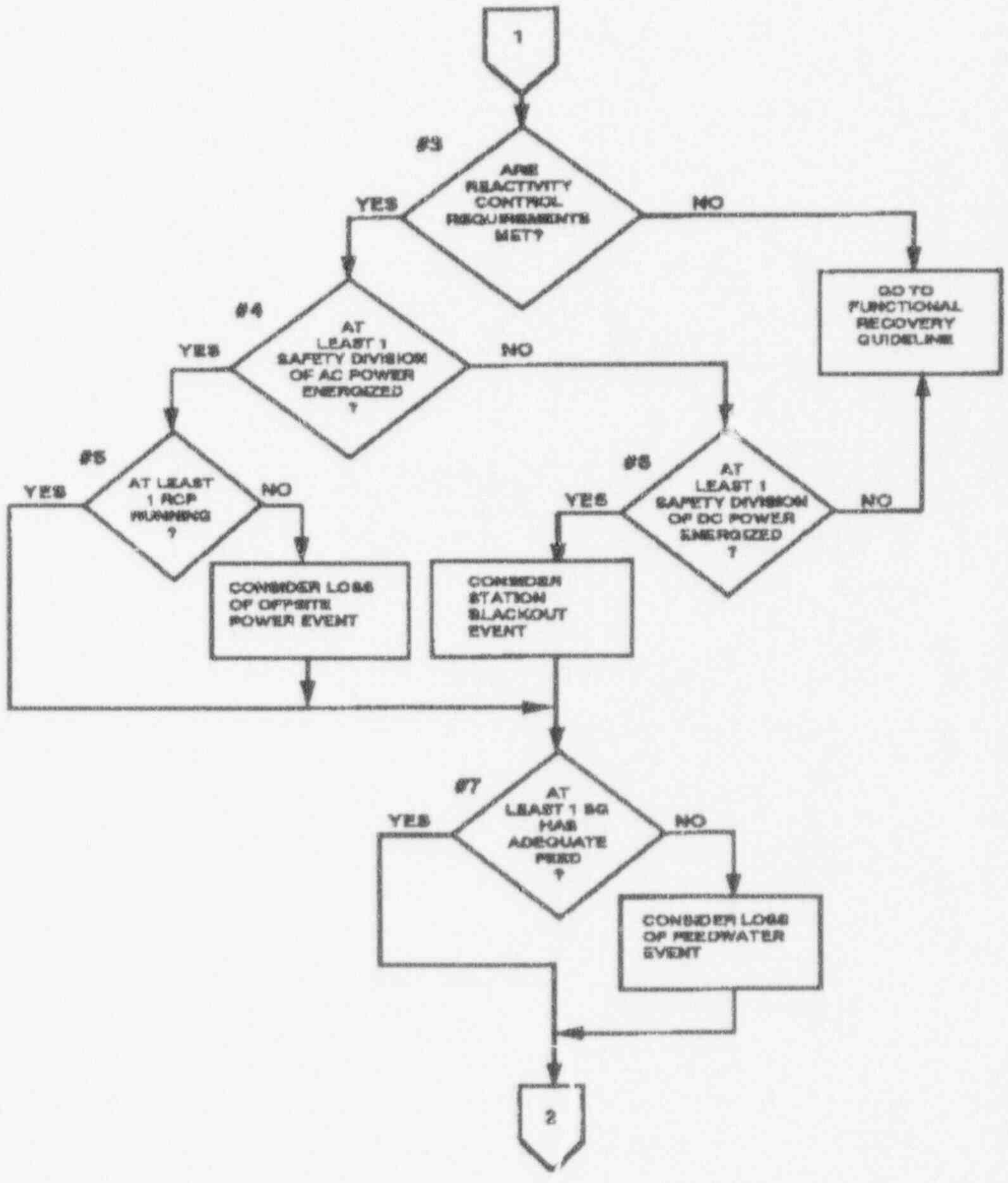


FIGURE 3-3

DIAGNOSTIC ACTIONS

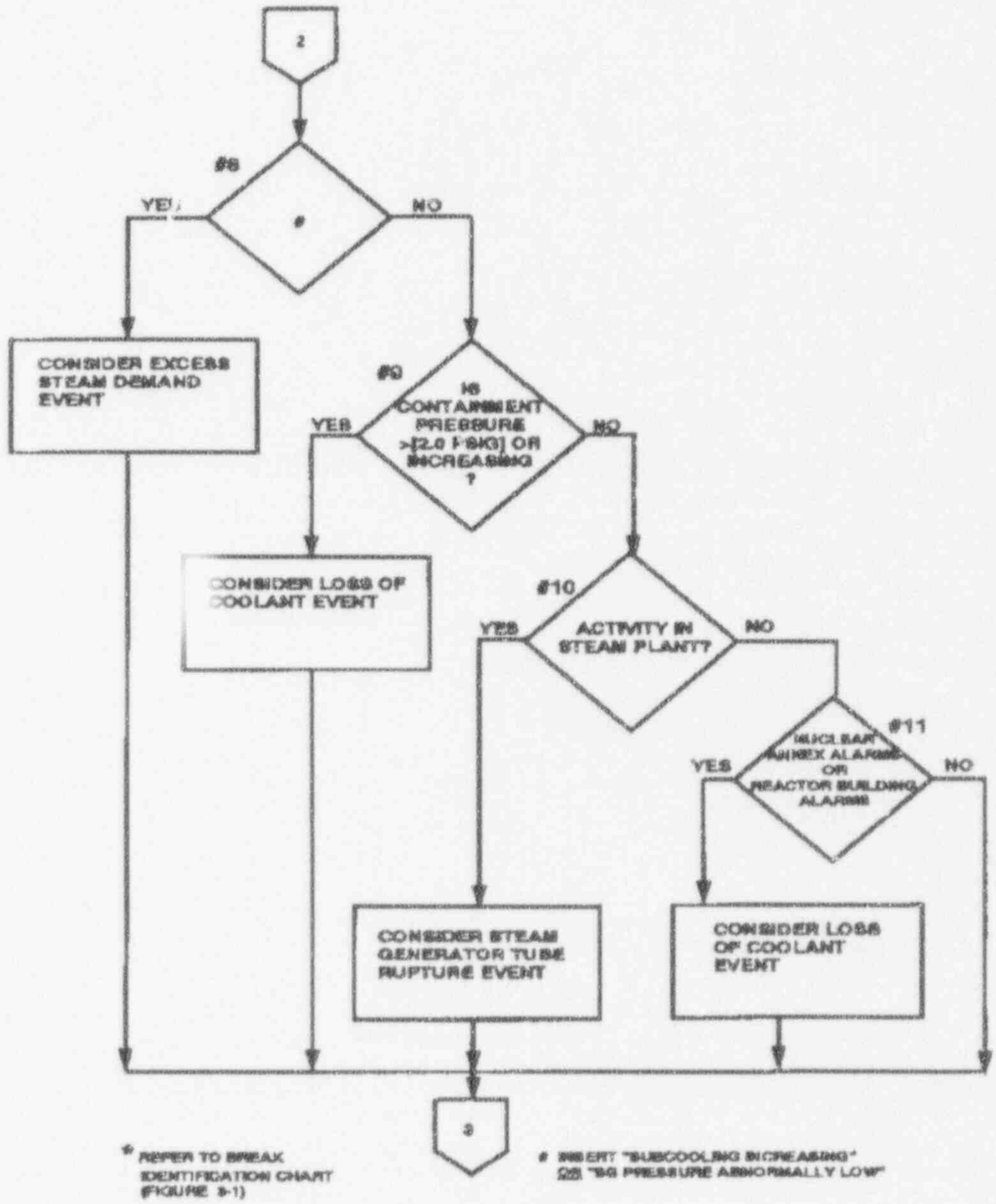
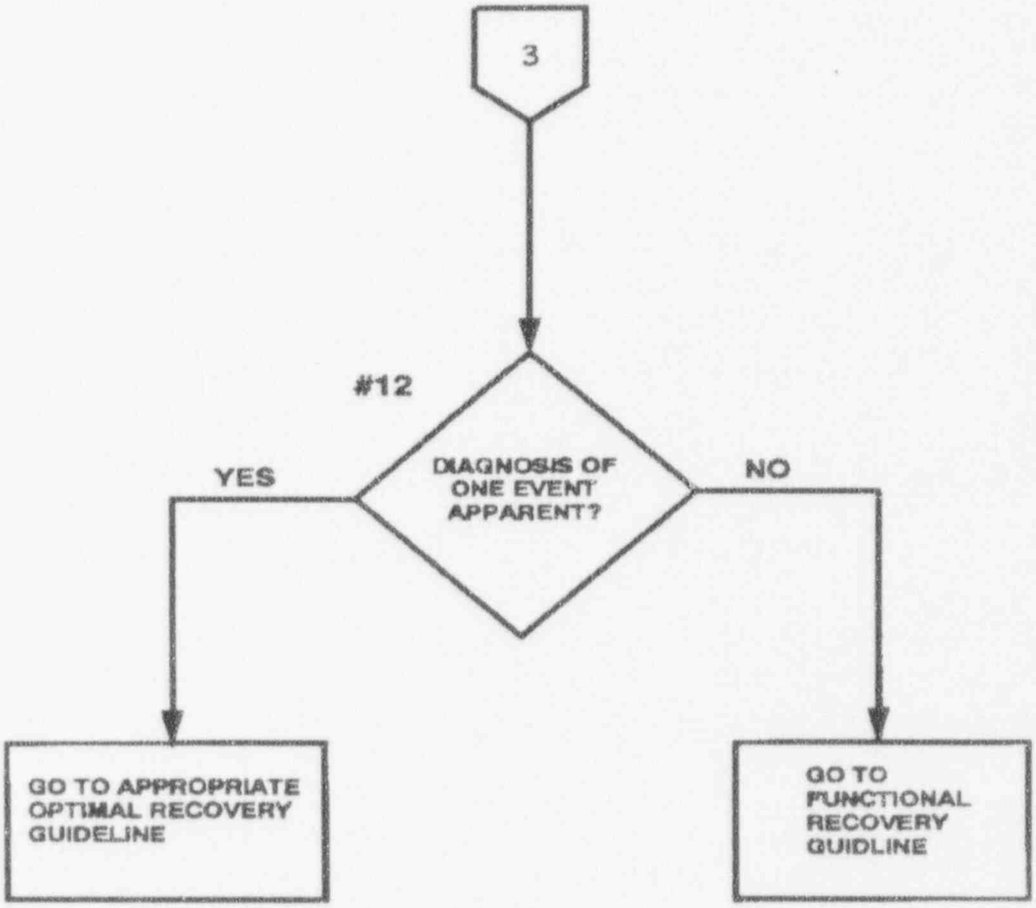


FIGURE 3-4

DIAGNOSTIC ACTIONS



When the Diagnostic Actions are complete, a preliminary diagnosis should be apparent with an appropriate ORG available to be implemented (Reactor Trip Recovery is an ORG), or a preliminary diagnosis of one event is not possible and the FRG must be implemented.

END

SUPPLEMENTARY INFORMATION

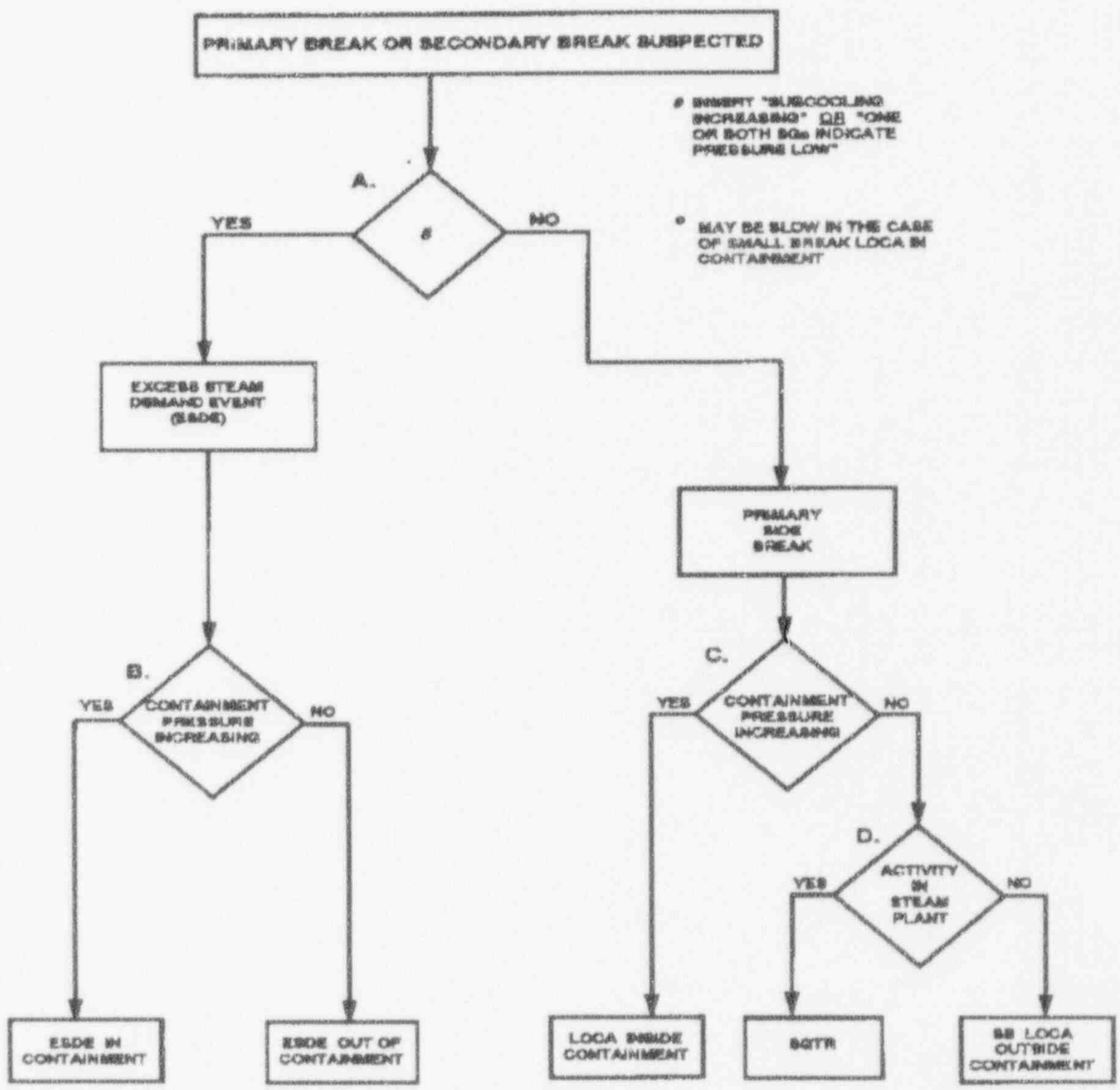
This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. All available indications should be used to aid in evaluating plant conditions since the accident may cause irregularities in a particular instrument reading. Instrumentation readings must be corroborated when one or more confirmatory indications are available (e.g., during rapid depressurization the indicated level in the pressurizer may be too high).

2. Instrumentation required to provide key parameters for event diagnosis early in an event should be obtained for the most reliable sources, e.g. DIAS-P.

FIGURE 3-5

BREAK IDENTIFICATION CHART



BASES

For the purpose of the bases explanations, each question block on the chart has a unique identification number. These numbers would not be necessary for the actual plant specific EOP Diagnostic Flowchart (except in the bases section if desired).

Block #1

If an abnormal condition occurs while the reactor is in MODE 1 or 2, as long as a reactor trip does not occur or is not required, plant operation can continue. The plant Abnormal Operating Procedures (AOPs) would most likely be the governing documents. Once a plant trip occurs or is required, the Standard Post Trip Actions (SPTAs) are implemented.

Block #2

By the time the Diagnostic Actions are implemented, the operator has already completed the Standard Post Trip Actions (SPTA) in response to the reactor trip and any other concurrent plant component or system failures. The operator has already made an initial evaluation of plant status and because the Standard Post Trip Actions also constitute a check of the safety functions, the operator is also aware of the status of safety functions. If no safety functions were in jeopardy, that is, all of the safety functions met their respective acceptance criteria (only instruction steps performed), then nothing more than an uncomplicated reactor trip has occurred. If one or more safety functions did not meet the acceptance criteria of the SPTA (one or more contingency actions performed), the operator must attempt to determine a preliminary diagnosis of the event(s) which has resulted in a reactor trip.

The Diagnostic Actions Guideline has been developed to assist the operator in logically deciding whether to implement an appropriate ORG or to implement the FRG. Minor system failures will not impair the use of this diagnostic flowchart in distinguishing symptom sets. To go much beyond the complexity of this diagnostic flowchart will require too much operator time and may hinder the operator in performing the required actions in a timely manner. For depressurization events, the operator can also refer to the Break Identification Chart (Figure 3-5) to aid in diagnosing the event. As noted in these diagnostic aids, the trending of key parameters provides valuable information which should be utilized in determining the preliminary diagnosis.

A particular ORG would be implemented after the operator has completed the Standard Post Trip Actions and has been able to diagnose one event taking place. Certain events (i.e, LOCA, SGTR, ESDE, and LOAF) do not require offsite power in order to adequately mitigate the effects of the accident. For this reason the LOCA, SGTR, ESDE, or LOAF ORG is to be implemented even if a Loss of Offsite Power has also occurred. The ORG will mitigate the event and maintain the health and safety of the public. The ORGs provide a continual verification that the preliminary diagnosis was correct. In essence, this diagnostic confirmation process is provided by checking the status of safety functions using the ORG Safety Function Status Checks. If the ORG in use continues to satisfy SFSC acceptance criteria, the ORG guidance is followed. If the ORG in use is inadequate, either because new information on symptoms appears that is not covered in the ORG, or because the SFSC acceptance criteria are not being satisfied, then a transfer is made to the appropriate ORG. If identification of a particular symptom set is not possible, the operator implements the Functional Recovery Guideline.

Figure 3-6 provides a basic flowchart showing how the Diagnostic Actions and the ORG diagnostic confirmation process are utilized to ensure that the proper guideline is implemented to mitigate the event(s) in progress.

Since the flowchart is attempting to diagnose a specific event through the investigation of a series of symptoms, it is not arranged in the order of the safety function hierarchy. Instead, the integrated plant and integrated safety functions have been considered, and the symptoms to be investigated have been prioritized so that a determination of the event in progress can be made in the most efficient manner. The operator should implement the entire Diagnostic Flowchart to determine if a single event is in progress, or if there are multiple events in progress. There are two exceptions to this guidance. If Reactivity Control has not yet been established, or if a complete loss of station power has occurred, the operator should proceed directly to the Functional Recovery Guideline (FRG). These exceptions are necessary because no ORG will be successful unless the reactor is shut down, or if there is no vital AC or DC power available.

When evaluating parameters and to answer questions contained in the Diagnostic Flowchart, the operator should consider past and present trends such that all available information is used to decide which event is in progress. For example, if a Steam Generator Tube Rupture (SGTR) event occurs, it is possible that the main steam line radiation monitors will alarm prior to the reactor trip due to the N-16 present in the primary system leaking into the Steam Generators. However, after the reactor trips, the alarms may clear (unless latched) due to the significantly lower production of N-16. In this case, the operator should still consider the fact that the main steam line radiation monitors had alarmed (and latched) prior to the trip (even though they are not currently in alarm). When this information is combined with the N-16 monitor information, the operator will answer "YES" to block #10. That way, the operator will be appropriately directed to consider a Steam Generator Tube Rupture event.

Block #3

If the reactivity control requirements are not met, the operator should proceed directly to the Functional Recovery Guideline, since no ORG will be successful unless the reactor is shut down. Therefore, if the operator answers "NO" to the Reactivity Control question, the next block on the flowchart says "GO TO FUNCTIONAL RECOVERY GUIDELINE" instead of "Consider" Functional Recovery Guideline.

Block #4

If the plant safety equipment has no electrical power, cooling water, ventilation, etc., the steps in the ORGs will not be effective. Therefore, the status of the Vital Auxiliaries is considered next.

If at least one safety division of AC power is available, the operator proceeds to the next question on the flowchart (Block #5), since all of the ORGs are written to accommodate the availability of only one safety division of AC power.

If there is no Vital AC power, the event in progress could be a Station Blackout, a combination of a Station Blackout and another event, or a complete loss of station power. The operator is directed to Block #6 to consider the status of DC power.

Block #5

The operator is asked if at least one RCP is running. There could be several reasons why all four RCPs are not running (Loss of Offsite Power, Loss of CCW to the RCPs, electrical faults on the 13.8 KV buses, etc.). The question is asked this way to determine if a "loss of flow" event has occurred either from a Loss Of Offsite Power (LOOP), or for any other reason. If it has, this would not be considered an uncomplicated reactor trip and the Reactor Trip Recovery ORG would not be appropriate because the RTR ORG assumes forced RCS flow conditions exist. The Loss Of Offsite Power (LOOP) ORG is written for either a LOOP or a Loss of Forced Circulation, since LOOP is essentially a maintenance of natural circulation event coupled with actions to restore offsite power to the station if applicable. It is implemented only if the Loss of Offsite Power/Loss of Forced Circulation event is the only event in progress. Therefore, for the Loss of Offsite Power/Loss of Forced Circulation event, the operator is instructed to "Consider" the LOOP and proceed to the next block on the flowchart to determine if other events are also in progress.

Block #6

If there is no station power (i.e., no vital AC and no vital DC), the operator is directed to the FRG since no ORG will be effective. If at least one safety division of DC power is available and not other event is in progress, the Station Blackout (SBO) ORG should be implemented. However, since only the Reactivity Control and Vital Auxiliaries safety functions have been investigated thus far, the Diagnostic Flowchart instructs the operator to "Consider" SBO. The operator will then continue to proceed through the rest of the Diagnostic Flowchart to determine if only an SBO is in progress, or if it is combined with some other event.

Block #7

The operator is asked if at least one Steam Generator (SG) has adequate feed (as defined by the SPTA steps). If the answer is "NO", the operator is instructed to "Consider" the Loss of All Feedwater (LOAF) event, and proceed to the next block on the flowchart. Otherwise, SG feeding is considered adequate and the operator proceeds directly to the next block on the flowchart.

Block #8

The purpose of this block is to help the operator distinguish a Loss Of Coolant Accident (LOCA) or Steam Generator Tube Rupture (SGTR), from an Excess Steam Demand Event (ESDE). When the plant specific EOPs are developed, the plant has the option of either placing the question "IS SUBCOOLING INCREASING?", or the question "IS SG PRESSURE ABNORMALLY LOW?", or both questions in this block. If a LOCA or SGTR is in progress, it is not expected that subcooling would be increasing (unless it is a small break of a size that allows the SI system to refill the Pressurizer, thereby causing Pressurizer pressure to increase). If the event in progress is an ESDE, subcooling should be increasing (unless the affected SG has already blown dry). In either case the operator should consider past and present trends to determine which event is in progress. This block will assume that at least during the initial stage of the LOCA or SGTR, the break is large enough to cause subcooling to be constant, or to decrease. In this case, the Diagnostic Flowchart will direct the operator to block #9. This block will also assume that at least during the initial stage (blowdown phase) of the ESDE, subcooling will increase and/or pressure will be abnormally low in the affected SG. The operator will be instructed to consider an ESDE.

Block #9

The purpose of this block is to help the operator distinguish between a LOCA inside containment, and a LOCA outside of containment or an SGTR. If containment pressure is increasing, it is assumed that a LOCA exists inside of containment and the operator is directed to consider the LOCA event. If containment pressure is not increasing, the operator is directed to block #10.

Block #10

The purpose of this block is to help the operator distinguish between and SGTR or a LOCA outside of containment. If there is activity indicated in the steam plant, a Steam Generator Tube Rupture should be considered. Alarms are not used as the sole means of determining whether or not and SGTR event is occurring because the activity levels in the secondary system may not yet be high enough to trip the alarm setpoints. Alarms were used in SPTA to get a quick "big picture" of the plant status (SPTA is not intended to be used for diagnosing the event, although some events are suggested based upon fairly definitive indications). If the steam plant activity alarms were energized in SPTA, it could be assumed with reasonable certainty that at least an SGTR event was occurring. However, this Diagnostic Flowchart takes a closer look at the plant and its indications for the purpose of identifying the actual event(s) in progress. If there is no significant activity in the steam plant (and activity levels are not increasing), an SGTR is not assumed to exist and the operator is directed to block #11.

Block #11

This block is used to determine if a LOCA exists outside of containment. If there are activity alarms present in the Nuclear Annex or Reactor Building, the operator should consider a LOCA outside of containment. Otherwise, the operator should proceed to block #12.

Block #12

The operator is asked if the diagnosis of one event is apparent. Since all significant parameters have been considered when proceeding through the Diagnostic Flowchart, the operator should be able to answer this question. If one event is apparent, the operator should implement the appropriate ORG. If the diagnosis of one event was not apparent, or if the operator was not sure of which event was in progress, the FRG would be implemented.

For the purposes of this flowchart, an uncomplicated reactor trip is considered an event. Therefore, if the operator entered the Diagnostic Flowchart after an uncomplicated reactor trip, the operator would never be directed to consider any event. Yet the question would be asked in block #12 if the diagnosis of one event is apparent. For an uncomplicated trip, the answer would be "YES" and the operator would implement the Reactor Trip Recovery (RTR) ORG.

Break Identification Flowchart

For the purpose of the bases explanations, each question block on the Break Identification Flowchart has a unique identification letter. The letters would not be necessary for the actual plant specific EOP Break Identification Flowchart (except in the bases section if desired).

The Break Identification Flowchart is attempting to diagnose the type (i.e., Loss Of Coolant Accident, Steam Generator Tube Rupture, Excess Steam Demand Event) and location (with respect to the containment barrier) of a suspected break, through the investigation of a series of symptoms. Therefore, it is not arranged in the order of the safety function hierarchy. Instead, the integrated plant and integrated safety functions have been considered, and the symptoms to be investigated have been prioritized so that a determination of the break type and locations can be made in the most efficient manner.

When evaluating parameters necessary to answer the questions contained in the Break Identification Flowchart, the operator should consider past and present trends such that all available information is considered when deciding the type and location of the break. For example, if a Steam Generator Tube Rupture (SGTR) event occurs, it is possible that the main steam line radiation monitors will alarm prior to the reactor trip due to the N-16 present in the primary system leaking into the Steam Generators. However, after the reactor trips, the alarms may clear due to the significantly lower production of N-16. In this case the operator should still consider the fact that the main steam line radiation monitors had alarmed prior to the trip (even though they are not currently in alarm). When this information is combined with the N-16 monitor information, the operator will answer "YES" to block (D). That way, the operator will be appropriately directed to consider a Steam Generator Tube Rupture event.

Block A

The purpose of this block is to help the operator distinguish a primary side break from an Excess Steam Demand Event (ESDE). When the plant specific EOPs are developed, the plant has the option of either placing the question "IS SUBCOOLING INCREASING?", or the question "IS SG PRESSURE ABNORMALLY LOW?", or both questions in this block. If a Loss of Coolant Accident (LOCA) or Steam Generator Tube Rupture (SGTR) is in progress, it is not expected that subcooling would be increasing (unless the event is a small break of a size that allows the SI system to refill the Pressurizer, thereby causing Pressurizer pressure to increase). If the event in progress is an ESDE, subcooling should be increasing (unless the affected SG has already blown dry). In either case the operator should consider past and present trends to determine which event is in progress. Block (A) will assume that at least during the initial stages of the LOCA, or SGTR, the break is large enough to cause subcooling to be constant or to decrease. In this case, the Break Identification Flowchart will direct the operator to Block (C). Block (A) will also assume that at least during the initial stages (blowdown phase) of the ESDE, subcooling will increase and/or pressure will be abnormally low in at least the affected SG. Since these symptoms indicate an ESDE, the operator will proceed to Block (B).

Block B

This block asks if Containment pressure is increasing. If it is, the Break Identification Flowchart identifies the event as an Excess Steam Demand Event inside of containment. Otherwise, the ESDE is assumed to be outside of containment.

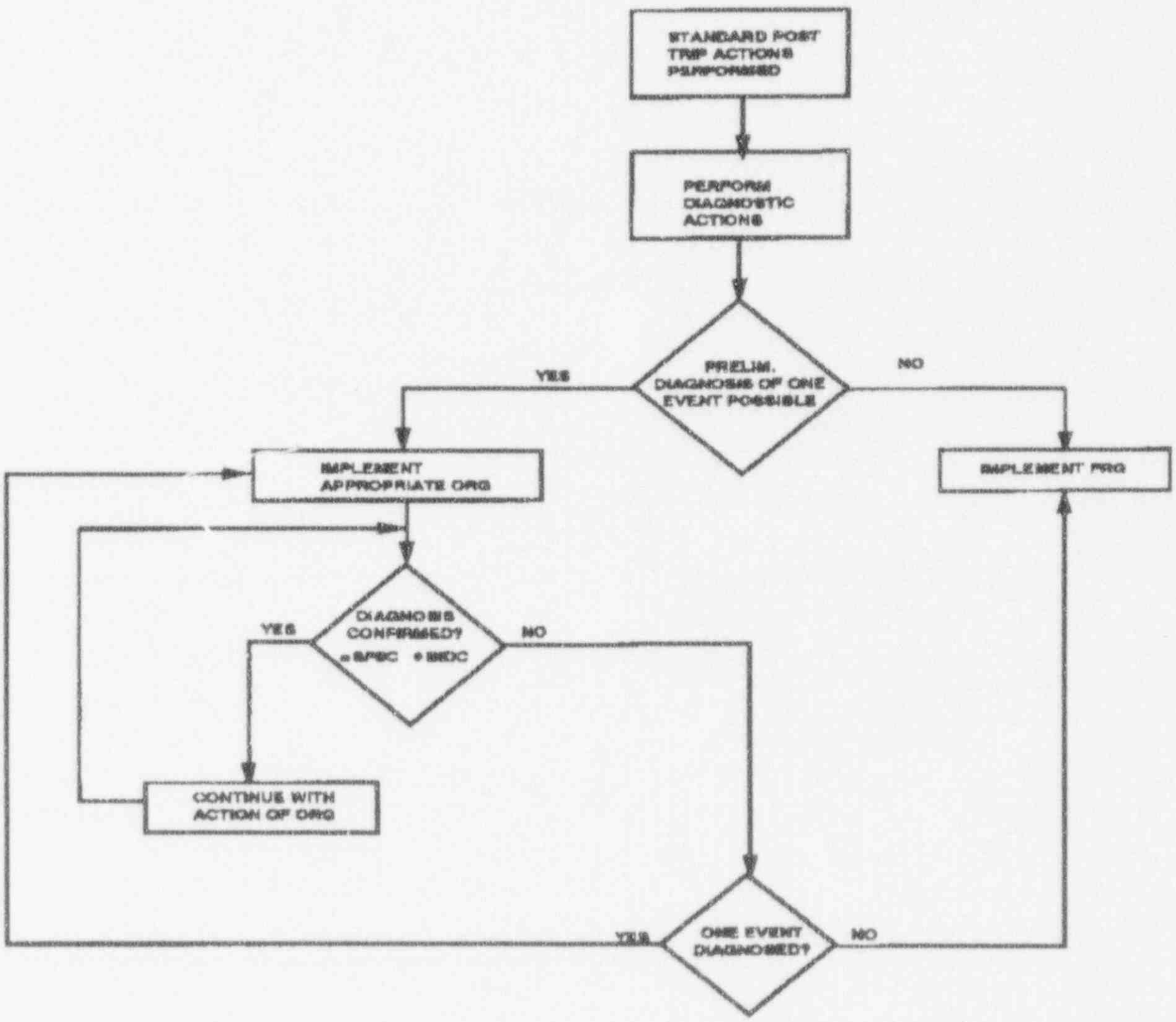
Block C

The purpose of this block is to help the operator distinguish between a LOCA inside containment, and a LOCA outside of containment or an SGTR. If containment pressure is increasing, it is assumed that a LOCA exists inside of containment. If containment pressure is not increasing, the operator is directed to Block (D) to determine if an SGTR exists, or if the event is a LOCA outside of containment.

Block D

The purpose of this block is to help the operator distinguish between an SGTR or a LOCA outside of containment. If there is activity indicated in the steam plant, a Steam Generator Tube Rupture should be considered. Alarms are not used as the sole means of determining whether or not an SGTR event is in progress because the activity levels in the secondary system may not yet be high enough to trip the alarm setpoints (except perhaps the N-16 monitors). If there is no significant activity in the steam plant (and the activity levels are not increasing), an SGTR is not assumed to exist and it is assumed that a LOCA exists outside of containment. Otherwise, it is assumed that an SGTR is in progress.

FIGURE 3-6
OVERVIEW OF EPG
DIAGNOSTIC PROCESS



REACTOR TRIP RECOVERY

PURPOSE

This guideline provides the operator actions which must be accomplished subsequent to a relatively uncomplicated reactor trip. The actions in this guideline are necessary to ensure that the plant is placed in a stable, safe condition. The goal of the guideline is to safely establish the plant in a mode 3 condition (HOT STANDBY) while minimizing any radiological releases to the environment. If necessary, the RCS may be cooled and depressurized.

ENTRY CONDITIONS

1. The Standard Post Trip Actions have been performed

and

2. Plant conditions indicate that an uncomplicated reactor trip has occurred.

EXIT CONDITIONS

1. The diagnosis of an uncomplicated reactor trip is not confirmed

or

2. Any of the Reactor Trip Safety Function Status Check acceptance criteria are not satisfied

or

3. The Reactor Trip Recovery EOG has accomplished its purpose by satisfying ALL of the following:

   a. All Safety Function Status Check acceptance criteria are being satisfied.
   b. RCS conditions are being controlled and maintained in a mode 3 or 4 condition (HOT STANDBY or HOT SHUTDOWN).
   c. An appropriate procedure to implement has been provided and administratively approved.

INSTRUCTIONS	CONTINGENCY ACTIONS
1. Ensure Standard Post Trip Actions performed.	1.
* 2. Confirm diagnosis of uncomplicated Reactor Trip by verifying Safety Function Status Check acceptance criteria are satisfied.	2. Rediagnose event and exit to appropriate Optimal Recovery Guideline or to Functional Recovery Guideline.
3. Verify pressurizer level is: a. [2% to 78%] and b. trending to [33% to 52%]	3. Manually operate PLCS or charging and letdown to restore and maintain pressurizer level [33% to 52%].
4. Verify pressurizer pressure is: a. [2160 to 2370 psia] and b. trending to [2225 to 2300 psia] and c. within the Post Accident P-T limits of Figure 4-1.	4. Manually operate PPCS or pressurizer heaters and spray to control RCS pressure: a. [2225 to 2300 psia] and b. within the Post Accident P-T limits of Figure 4-1.

INSTRUCTIONS	CONTINGENCY ACTIONS
5. Verify steam bypass control system is controlling RCS T_{ave} [551-562°F].	5. If condenser vacuum is lost, steam bypass control system is unavailable, or the MSIVs are closed, Then use the atmospheric dump valves to control RCS T_{ave} [551-562°F].
6. Ensure at least one steam generator has level being maintained or restored in the normal band using main, startup or emergency feedwater.	6.
7. Evaluate the need for a plant cooldown based on: a. plant status b. auxiliary systems availability c. emergency feedwater inventory.	7.
8. If a plant cooldown is necessary, Then exit this guideline and implement the appropriate plant cooldown procedure.	8. a. Maintain the plant in a stabilized condition, and b. Exit to appropriate procedure as directed by [Plant Technical Support Center or Plant Operations Review Committee].

When the steps of the Reactor Trip Recovery Guideline are complete, the plant should be in a condition where all of the SFSC acceptance criteria are satisfied, and the entry conditions of an appropriate procedure are satisfied. In most cases, the plant will be maintained in HOT STANDBY or directed to be cooled down to mode 4 or 5.

END

SUPPLEMENTARY INFORMATION

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Pressurizer level should be closely monitored since it normally decreases to, or near, the pressurizer heater cutoff level following a reactor trip.

2. All available indications should be used to aid in evaluating plant conditions since the accident may cause irregularities in a particular instrument reading. Instrumentation readings must be corroborated when one or more confirmatory indications are available, (e.g., during rapid depressurization the indicated level in the pressurizer may be too high).

3. A plant cooldown and entry into shutdown cooling (if necessary) should be conducted prior to depleting the emergency feedwater storage.

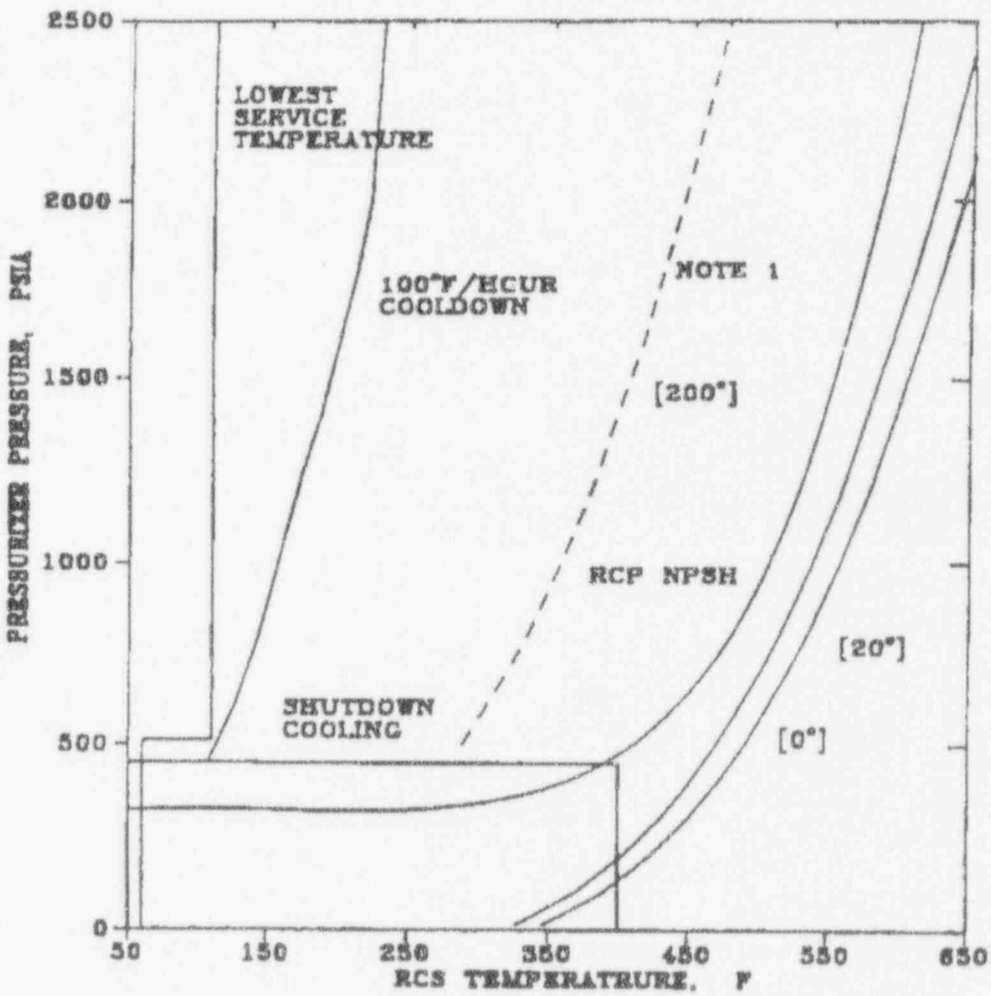
4. During all phases of the cooldown, RCS temperature and pressure should be monitored to avoid exceeding a cooldown rate greater than Technical Specification limitations.

5. Do not place systems in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation.

6. If the initial cooldown rate exceeds Technical Specification Limits, then there may be a potential for pressurized thermal shock (PTS) of the reactor vessel. Post accident pressure/temperature should be maintained within the limits of Figure 4-1.

FIGURE 4-1

TYPICAL POST ACCIDENT PRESSURE-TEMPERATURE LIMITS



NOTES: (1) THIS CURVE SUPERSEDES THE 100° F/HR COOLDOWN CURVE ANYTIME THE RCS HAS EXPERIENCED AN UNCONTROLLED COOLDOWN WHICH CAUSES RCS TEMPERATURE TO GO BELOW 500° F. THIS CURVE IS AN OPERATIONAL LIMIT BASED ON ENGINEERING JUDGEMENT AND INTENDED TO MINIMIZE THE POTENTIAL OF A PRESSURIZED THERMAL SHOCK.

(2) THESE CURVES MUST BE ADJUSTED FOR INSTRUMENT INACCURACIES.

SAFETY FUNCTION STATUS CHECK

SAFETY FUNCTION	ACCEPTANCE CRITERIA
1. Reactivity Control	1. a. Reactor power decreasing and b. Negative Startup Rate and c. Maximum of 1 CEA NOT fully inserted or RCS borated per Tech specs.
2. Maintenance of Vital Auxiliaries (AC and DC Power)	2. a. All vital Division I [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized, or All vital Division II [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized. and b. Non-safety load [13.8 KV] Bus X energized or Non-safety load [13.8 KV] Bus Y energized and c. Non-safety load [4.16 KV] Bus X energized or Non-safety load [4.16 KV] Bus Y energized and

SAFETY FUNCTION	ACCEPTANCE CRITERIA
2. (Continued)	d. Permanent Non-safety load [4.16 KV] Bus X energized or Permanent Non-safety load [4.16 KV] Bus Y energized
3. RCS Inventory Control	3. a. Pressurizer level is [2% to 78%] and b. Charging and letdown are restoring pressurizer level to [33% to 52%] and c. The RCS is subcooled and d. No reactor vessel voiding as indicated by the HJTC RVLMS.
4. RCS Pressure Control	4. a. Pressurizer pressure is: i) [2160-2370 psia] and ii) trending to [2225 to 2300 psia] and b. Pressurizer heaters and spray are controlling pressure within P-T limits of Figure 4-1.

SAFETY FUNCTION	ACCEPTANCE CRITERIA
5. Core Heat Removal	5. a. T_H - T_C is less than [3°F] and b. The RCS is subcooled.
6. RCS Heat Removal	6. a.i) At least one steam generator has level within normal level band with feedwater available to maintain level or ii) At least one steam generator has level being restored to the normal band by feedwater flow with level increasing or iii) Total feedwater flow to either or both steam generators greater than [500 gpm] and b. RCS T_{ave} is [551-562°F].

SAFETY FUNCTION	ACCEPTANCE CRITERIA
7. Containment Isolation	7. a. Containment pressure less than [2.0 psig] and b. No containment area radiation monitors alarming and c. No steam plant radiation monitors alarming and d. No nuclear annex radiation monitors alarming and e. No reactor building radiation monitors alarming
8. Containment Temperature & Pressure Control	8. a. Containment temperature less than [110°F] and b. Containment pressure less than [2.0 psig].
9. Containment Combustible Gas Control	9. a. Containment temperature less than [110°F] and b. Containment pressure less than [2.0 psig].

BASES

The bases section of the Reactor Trip (RT) Recovery Guideline describes the RT transient in relation to the actions which the operator takes during the recovery from a relatively uncomplicated RT. The purpose of the bases section is to provide the operators with information which will enable them to understand the reasons for, and the consequences of, the actions they take during a RT.

Characterization of a Reactor Trip

A reactor trip is a shutdown of the reactor accomplished by the rapid insertion of the control element assemblies (CEAs). It is automatically initiated by the reactor protective system when certain continuously monitored parameters exceed predetermined setpoints, or it can be initiated manually by the operator if plant conditions warrant. A malfunction in the reactor protective system may also cause a reactor trip signal.

A reactor trip may be the result of automatic action initiated by the reactor protective system in response to any of the following typical parameters:

a. High reactor power.
b. Low pressurizer pressure.
c. Low reactor coolant flow.
d. Low steam generator level.
e. Low steam generator pressure.
f. High pressurizer pressure.
g. High steam generator level.
h. High containment pressure.
i. Turbine trip.
j. DNBR trip.
k. LPD trip.

Safety Functions Affected

A reactor trip results in a decrease of primary system heat generation to decay heat levels. It is a safety action performed for reactivity control and does not directly challenge the maintenance of any safety function required to place the plant in a safe, stable condition. However, all safety functions should be monitored to assure public safety or to detect failures which may lead to unsafe conditions.

Trending of Key Parameters

Reactor Power (Figure 4-2)

As a result of the reactor trip, the control element assemblies (CEAs) will be rapidly inserted. Steam flow to the turbine generator will be terminated, the turbine generator output breakers will open and the feedwater flow will automatically ramp down. A rapid decrease in reactor power and a negative startup rate will be observed. This rapid decrease is followed by a decrease in indicated power (approximately -1/3 decade per minute) until the subcritical multiplication level is reached. Indicated power will stabilize at the subcritical multiplication level and decrease slowly over a period of hours.

RCS Temperature (Figure 4-3)

Initially, feedwater temperature decreases sharply due to the loss of steam heating to the feedwater heaters (450°F to about 200°F feedwater temperature) or due to actuation of startup or emergency feed (may be as low as 40°F). Heat from the RCS is absorbed by the cooler feedwater supplied to the steam generators. At power, there is a large differential between RCS Tave and average steam generator temperature. Following the trip of the reactor and the turbine, the heat transfer rate from the RCS to the steam generator decreases to decay heat removal levels and the RCS to steam generator ΔT decreases to a few degrees with RCPs running. As a new equilibrium is achieved, the combined effect of the cooler feedwater and the steam generator heating up to an average temperature closer to RCS temperature results in a net heat extraction from the RCS. Loop differentials between hot and cold leg temperatures will drop to less than ten degrees with RCPs running and RCS average temperature will decrease to [551-562°F] controlled by the steam bypass control system or the atmospheric dump valves.

Reactor Vessel Level

For an uncomplicated reactor trip, it is expected that the reactor vessel will remain full. The subcooled margin in the RCS loops is typically [50°F] or higher, and RVUH subcooling margin can be significantly lower than that for the RCS loops but still high enough to prevent voids from forming. At steady state conditions, the upper head region is about 1°F cooler than the core exit temperature and, therefore, the subcooled margin of the RVUH is essentially equal to that of the hot leg. Under transient conditions, with RCPs running, there is a time lag between the change in the core exit temperature and the change in RVUH temperature to approximately the same temperature. Under RCS cooling transients up to [75°F/hour], the time lag is small enough so that the subcooling margin in the RVUH will not allow voids to form.

Pressurizer Pressure and Level (Figures 4-4, 4-5)

Pressurizer pressure and level will initially decrease due to the lowering of RCS temperature. However, this effect will usually be tempered by operation of pressurizer heaters and the charging pump which restore level to the programmed hot zero power band.

Steam Generator Pressure (Figure 4-6)

Steam generator pressure will usually increase. Since heat is being removed from the RCS but not from the steam generator (except for the cooling from the feed), the steam generator heats up to decrease RCS to steam generator differential temperature. Steam generator pressure increases as temperature increases. As steam generator pressure increases, the steam bypass valves will usually open or the atmospheric dump valves will be opened to control steam generator pressure at hot STANDBY pressure (which is above normal 100% power steam generator pressure).

Steam Generator Level (Figure 4-7)

After a reactor trip the steam generator level decreases rapidly. This is explained as follows. Steam generator level is inferred from the steam generator downcomer level. During normal 100% power operation, the steam generator has a recirculation ratio of approximately 4 to 1 (ratio of water returning to the downcomer from the dryers and separators to feedwater entering the downcomer). This accounts for a major portion of the water level entering the downcomer. When steam flow is stopped by the turbine trip, recirculation stops. The reduced flowrate into the downcomer results in reduced head losses through the downcomer and up the riser section. The downcomer water level, and thus the steam generator indicated level, both drop. This drop in level will occur even before the feedwater system automatically readjusts. Another contributing factor to the observed decrease in post trip S/G water level is the increased steam generator pressure. This increase in pressure causes an increase in the saturation temperature, thus causing the voids in the S/G to collapse.

Plant operators should be cautioned not to overreact to this lowered level in the steam generators. Excessive feeding of the steam generator with cooler feed to recover level results in RCS temperatures being driven down below the desired no load value. This could cause pressurizer level to fall to a point where the pressurizer is drained. RCS pressure will then drop until the safety injection system is actuated. This complicates the recovery from a simple reactor trip considerably.

FIGURE 4-2

REPRESENTATIVE REACTOR TRIP
REACTOR POWER

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 4-3

REPRESENTATIVE REACTOR TRIP
RCS WIDE RANGE TEMPERATURES

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 4-4

REPRESENTATIVE REACTOR TRIP
PZR WIDE RANGE PRESSURE

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 4-5

REPRESENTATIVE REACTOR TRIP
PZR LEVEL

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 4-6

REPRESENTATIVE REACTOR TRIP
STEAM GENERATOR PRESSURE

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 4-7

REPRESENTATIVE REACTOR TRIP
STEAM GENERATOR WIDE RANGE LEVEL

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

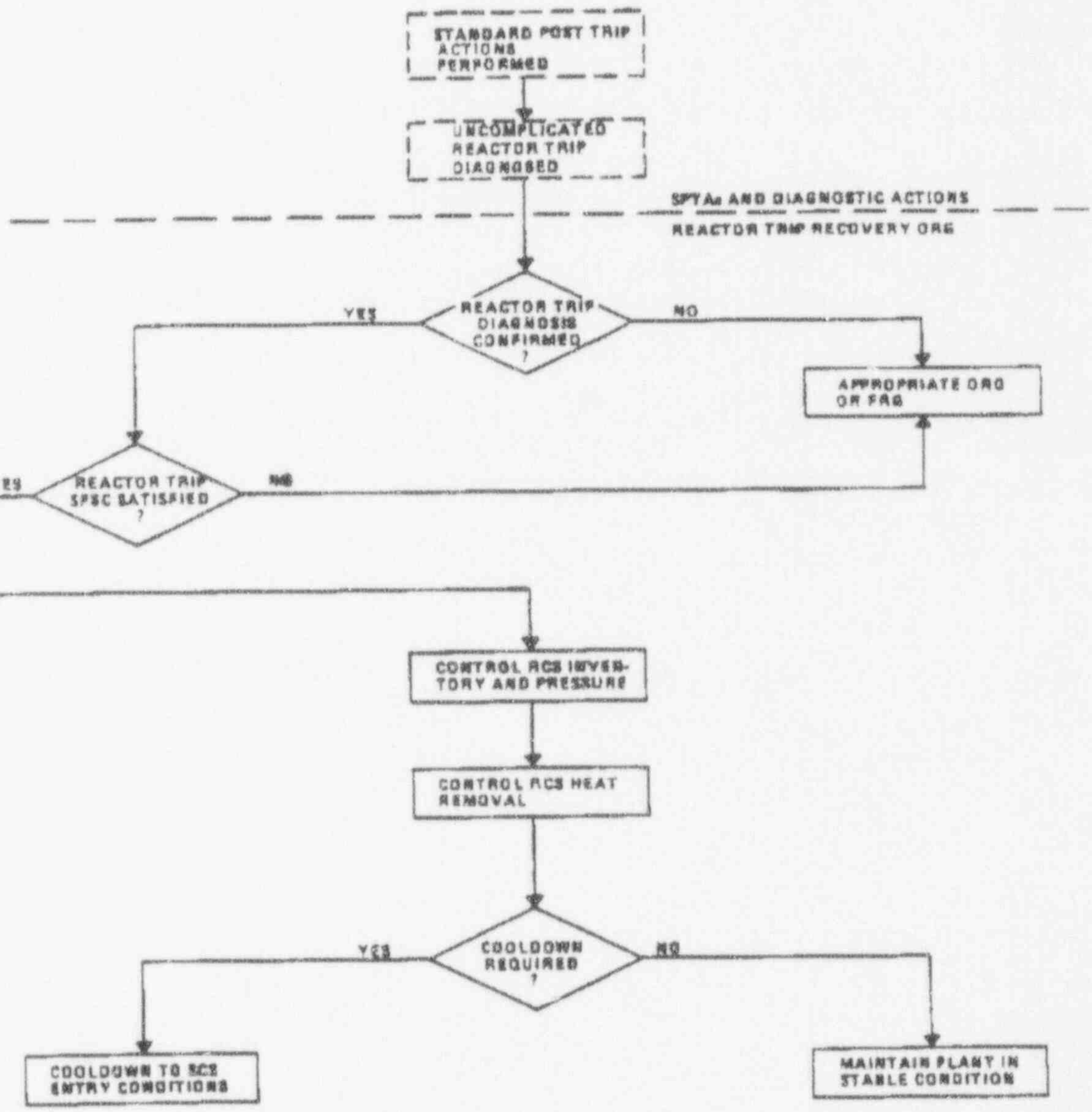
Guideline Strategy

Figure 4-8 provides a summary of the Reactor Trip (RT) Recovery Guideline's strategy. Prior to implementing the actions provided in the RT Recovery Guideline, the operator would have performed the Standard Post Trip Actions and concluded that an uncomplicated reactor trip had occurred. In the RT Recovery Guideline the operator begins using the Safety Function Status Check to confirm that the plant is recovering and the correct guideline has been implemented. RT Recovery actions provide instructions on regaining and maintaining RCS inventory control, RCS pressure control, and RCS heat removal.

A more detailed RT Recovery strategy chart is provided. It lists the guideline steps which correspond to each strategy objective. Refer to Figure 4-9.

FIGURE 4-8

REACTOR TRIP



Bases for Operator Actions

The operator actions are directed at bringing the plant to a safe, stable condition following an uncomplicated reactor trip and ensures that a proper heat sink for the reactor is being maintained.

1. The operator is directed to ensure that the Standard Post Trip Actions have been performed. This action ensures that all safety functions have been monitored, and appropriate contingency actions performed, prior to implementing the Reactor Trip Recovery EPG.

* 2. The operator is required to continually verify that Safety Function Status Check acceptance criteria are satisfied by comparing control board parameters to the acceptance criteria in the Safety Function Status Check. This ensures that the safety functions are satisfied and the core is being adequately cooled. If the Safety Function Status Check acceptance criteria are satisfied adequately mitigating the effects of the RT. Thus, the implementation of the remaining actions of this guideline is continued. If the diagnosis of an uncomplicated reactor trip is found to be in error (i.e., any of the Safety Function Status Check acceptance criteria are not satisfied), the procedure is not adequately mitigating the event. If another event is diagnosed, the operator exits the RT guideline and implements the appropriate Optimal Recovery Guideline (ORG). If a diagnosis of one event cannot be made, the Functional Recovery Guideline (FRG) is implemented. The FRG is safety function based and will ensure all safety functions are addressed regardless of what event(s) is occurring.

3. Following a relatively uncomplicated reactor trip, pressurizer level should not decrease below [2%] or increase above [78%]. The value of [78%], was chosen as an upper limit for pressurizer level to account for some process fluid uncertainties in order to avoid solid plant operation. The process uncertainties include maintaining an operable steam bubble following a 20 second inadvertent initiation of auxiliary spray The value of [2%] was chosen as the lower limit in order to avoid draining the pressurizer. If the pressurizer

level control system functions properly, level in the pressurizer should be trending to [33% to 52%]. This will ensure that the PLCS is working properly to control level. If automatic pressurizer level control system operation is not maintaining/restoring level, the operator is instructed to take manual control of charging and letdown to control pressurizer level to [33% to 52%].

4. Following a relatively uncomplicated reactor trip, automatic control of pressurizer heaters and spray should be sufficient to maintain pressurizer pressure [2160 to 2370 psia]. The availability of pressurizer heaters will be dependent upon the ability to restore pressurizer level to above the heater level of [14.3%]. The lower value of [2160 psia] corresponds to the RCS low pressure alarm setpoint. The higher value of [2370 psia] is the RCS high pressure alarm setpoint. If the pressurizer pressure control system functions properly, pressurizer pressure should be trending to [200°F] psia. Satisfying the Post Accident P-T limits of Figure 4-1 will ensure that brittle fracture limits are not exceeded, RCP NPSH and RCS subcooling requirements are satisfied, and RCS cooldown rate 100°F/Hour or upper subcooling limit [200°F] are not exceeded. If automatic pressurizer pressure control system operation is not maintaining/restoring pressure, the operator is instructed to take manual control of pressurizer heaters and spray to control pressurizer pressure to [2225-2300 psia].

5. RCS T_{ave} should be controlled at [551-562°F] by the steam bypass control system. If condenser vacuum is lost, the steam bypass control system is not available, or the MSIVs have closed, the atmospheric dump valves must be used to control RCS T_{ave} in a [551-562°F] band. This step provides a verification that the steam generator(s) are adequately removing decay heat, that control systems are functioning properly, or that manual actions are taken as appropriate.

6. Following a relatively uncomplicated reactor trip, steam generator levels should automatically be restored and maintained in the normal level band. The operator will ensure that automatic or manual control of main, startup, or emergency

feedwater is capable of maintaining at least one steam generator's level in the normal band. Adequate RCS heat removal will be maintained if at least one steam generator is available for removing heat (capable of feed and steam flow). The operator must use caution when manually feeding steam generators to avoid an excessive RCS cooldown rate with subsequent pressurizer level and pressure transient or overfilling steam generators. Steam generator levels should be increased at a rate consistent with decay heat levels and any desired cooldown rate. A flowrate of [250 gpm per steam generator] is sufficient feed flow to remove decay heat (approximately 2% of rated thermal power).

7. At this point in the recovery, the operator should determine whether a plant cooldown is necessary. If the continued availability of any systems required for maintenance of HOT STANDBY is in doubt, a cooldown may be appropriate. For example, if the available emergency feedwater inventory is marginally adequate, a cooldown should be performed in order to avoid running out of emergency feedwater before the shutdown cooling system can be placed into operation. Similarly, consideration should be given to the availability of compressed air and cooling water systems as well as the continued availability of electrical power. A cooldown may also be required in order to provide the plant conditions necessary to perform system or component repairs.

8. If a plant cooldown is necessary and the RT Recovery Guideline exit conditions are satisfied, this guideline should be exited and the plant cooldown procedure implemented. If it is decided that a cooldown is not necessary, the plant should be maintained in a stable condition until the operators and the support staff [Plant Technical Support Center or Plant Operations Review Committee] determine which procedure is appropriate to implement.

Safety Function Status Checks

The Safety Function Status Check (SFSC) is used to continually verify the status of safety functions. The safety function acceptance criteria are selected from best estimate analysis to reflect the range for each parameter which would be expected following a relatively uncomplicated reactor trip. If all SFSC acceptance criteria are being satisfied, the adequacy of this guideline for mitigating the event in progress is confirmed and the health and safety of the public is ensured.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
1. Reactivity Control	a. Reactor Power Decreasing and b. Negative Startup Rate and c. Maximum of 1 CEA NOT fully inserted or the RCS is borated per Tech. Specs.	For all emergency events, the reactor must be shutdown. Decreasing reactor power is one positive indication that reactivity control has been established. A negative startup rate can be used in the short-term post trip to verify that reactivity control is established. The Technical Specification requirement is that not more than 1 rod be stuck out. If more than 1 rod is stuck out, the RCS must be borated to compensate for the negative reactivity not inserted into the core.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
2. Maintenance of vital Auxiliaries (AC and DC power)	a. All vital Division I [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized, <u>or</u> All vital Division II [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized. <u>and</u> b. Non-safety load [13.8 KV] Bus X energized <u>or</u> Non-safety load [13.8 KV] Bus Y energized <u>and</u> c. Non-safety load [4.16 KV] Bus X energized <u>or</u> Non-safety load [4.16 KV] Bus Y energized d. Permanent Non-safety load [4.16 KV] Bus X energized <u>or</u> Permanent Non-safety load [4.16 KV] Bus Y energized	One safety division of AC power is required to power equipment necessary to maintain control of all other safety functions. One safety division of DC is required as a minimum to provide monitoring and limited control of the other safety functions. Non-safety [13.8 KV] and [4.16 KV] AC divisions must be available to power at least one RCP and any other non-vital equipment typically used in the recovery from a relatively uncomplicated reactor trip.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
3. RCS Inventory Control	a. Pressurizer level is [2% to 78%] <u>and</u> b. Charging and letdown are restoring pressurizer level to [33% to 52%] <u>and</u> c. The RCS is subcooled based on T_H RTD temperature <u>and</u> d. No reactor vessel voiding as indicated by the HJTC RVLMS.	The value of [78%] was chosen as an upper limit to ensure that the pressurizer has an operable steam bubble. A value of [2%], was chosen as the lower limit to ensure that the pressurizer is not drained. Following a relatively uncomplicated reactor trip, automatic or manual control of charging and letdown should be sufficient to maintain RCS inventory control within [33% to 52%] A subcooling margin coexisting with adequate pressurizer level indicates RCS inventory control via a saturated bubble in the pressurizer. T_H RTDs are to be used during forced circulation flow conditions. For an uncomplicated reactor trip, reactor vessel voiding should not result.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
4. RCS Pressure Control	a. Pressurizer pressure is: i) [2160-2370 psia] and ii) trending to [2225-2300 psia] and b. Pressurizer heaters and spray are controlling pressurizer pressure within the P-T limits of Figure 4-1.	The lower value of [2160 psia] corresponds to the RCS low pressure alarm setpoint. The higher value of [2370 psia] is the high pressure alarm setpoint. Pressurizer pressure for an uncomplicated reactor trip is expected to fall within this range. Operation of pressurizer heaters and spray should be capable of maintaining pressurizer pressure within [2225-2300 psia] and within the Post Accident P-T limits of Figure 4-1.
5. Core Heat Removal	a. The RCS loop $\Delta T(T_H - T_C)$ is less than [3°F] and b. The RCS is subcooled based on T_H RTD temperature.	Best estimate analysis shows that SG ΔT will be less than [3°F] in the steaming loop with RCPs running. Subcooled margin assures adequate core cooling while also accounting for temperature variations in the RCS.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
6. RCS Heat Removal	a.i) At least one steam generator has level within normal level band with feedwater available to maintain level <u>or</u> ii) At least one steam generator has level being restored to the normal band by feedwater flow with level increasing <u>or</u> iii) Total feedwater flow to either or both steam generators greater than [500 gpm]	Adequate RCS heat removal will be maintained if at least one steam generator is available for removing heat (capable of steam flow and feed flow). The value of [500 gpm total feedwater flow] is sufficient feed flow to remove decay heat (approximately 2% rated thermal power) from the core. Decay heat levels may not be high enough to require 500 gpm] feed flowrate. In this case, steam generator levels in the normal band satisfies RCS heat removal.
	<u>and</u> b. RCS T_{ave} is [551-562°F].	The criteria for a T_{ave} of [551-562°F] corresponds to the control program for steam bypass control valves.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
7. Containment Isolation	a. Containment Pressure less than [2.0 psig] and b. No containment area radiation monitors alarming and c. No steam plant activity monitors alarming and d. No nuclear annex alarms and e. No reactor building alarms.	[2.0 psig] is based on the containment pressure alarm. It is not expected for an uncomplicated reactor trip that containment pressure will increase to the alarm setpoint. During an uncomplicated reactor trip it is not expected that radiation will be detected inside containment. Steam plant activity is an indication of a SGTR and is not anticipated for a RT. During an un complicated reactor trip, it is expected that Nuclear Annex and Reactor Building alarms will not be received.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
8. Containment Temperature and Pressure Control	a. Containment temperature less than [110°F] <u>and</u> b. Containment pressure less than [2.0 psig].	Containment temperature less than [110°F] observes a typical Technical Specification requirement which should not be exceeded for an uncomplicated reactor trip. [2.0 psig] is based on the containment pressure alarm. It is expected that the containment pressure will not reach this value following an uncomplicated reactor trip.
9. Containment Combustible Gas Control	a. Containment temperature less than [110°F] <u>and</u> b. Containment pressure less than [2.0 psig].	Following an uncomplicated reactor trip, containment temperature and pressure should not reach [110°F] and [2.0 psig], respectively. Maintaining these containment conditions provides an indirect indication that the conditions required for H_2 generation do not exist.

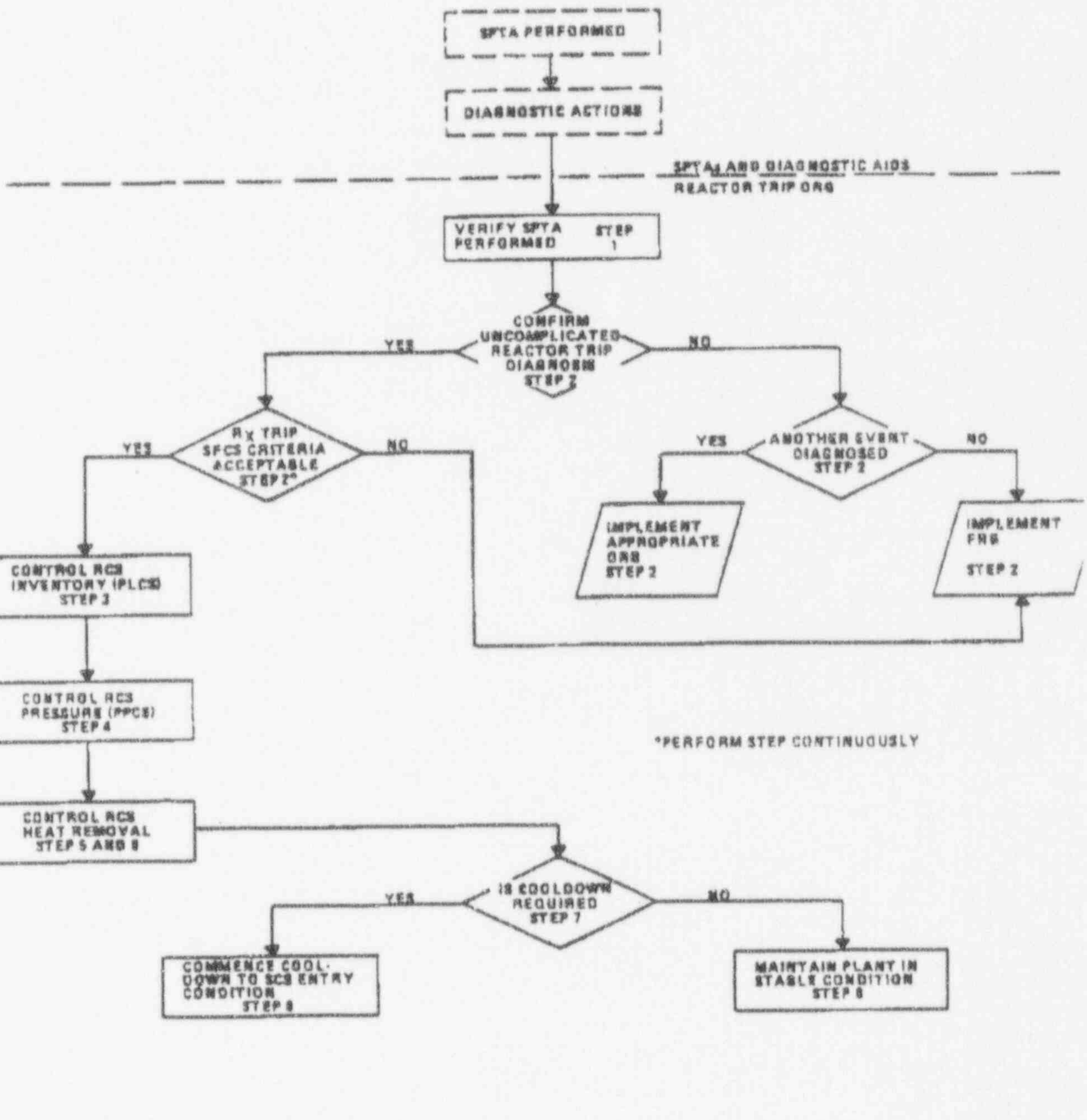
Event Strategy

This section contains the detailed RT operator actions strategy flowchart, Figure 4-9. The flowchart pictorially depicts the strategy around which the RT guideline is built. It is intended to assist the procedure writer in understanding the intent of the guideline and for use in training. Operators should understand the major objectives of the guideline in order to permit them to evaluate their progress toward those goals.

The strategy chart shows the recovery guideline strategy in detail and lists the guideline steps which correspond to each strategy objective. Those steps which have an asterisk next to the step number can be performed at any time during the event.

FIGURE 4-9

STRATEGY CHART FOR REACTOR TRIP



LOSS OF COOLANT ACCIDENT RECOVERY

PURPOSE

This guideline provides operator actions which must be accomplished in the event of a Loss of Coolant Accident (LOCA). The actions in this guideline are necessary to ensure that the plant is placed in a stable, safe condition. The goals of this guideline are to mitigate the effects of a LOCA, to isolate the break, and if this is not possible, to establish either long term core cooling using the safety injection system or core cooling using the shutdown cooling system. This guideline achieves this goal while maintaining adequate core cooling and minimizing radiological releases to the environment. This guideline provides technical information to be used by utilities in developing a plant specific procedure.

ENTRY CONDITIONS

1. The Standard Post Trip Actions have been performed

   or

   All of the following conditions exist

   a. Event initiated from MODE 3 or MODE 4
   b. SIAS has NOT been blocked
   c. LTOP has NOT been initiated

   and

2. Plant conditions indicate that a Loss of Coolant Accident has occurred. Any one or more of the following may be present:

   a. Pressurizer level low (for a break in the pressurizer, the level may be high).
   b. Safety injection system (SIS) actuated automatically.
   c. Increase in containment pressure, temperature, radiation, humidity and Holdup Volume level.
   d. IRWST Temperature increasing
   e. Pressurizer pressure decreasing
   f. HJTC RVLMS indicates head voiding
   g. Loss of subcooling

h. CIAS

i. CSAS

j. Increase in Nuclear Annex Radiation, Temperature, Humidity or Sump Level.

EXIT CONDITIONS

1. The diagnosis of a Loss of Coolant Accident is not confirmed.

<u>or</u>

2. Any of the Loss of Coolant Accident Safety Function Status Check acceptance criteria are not satisfied.

<u>or</u>

3. The Loss of Coolant Accident EOG has accomplished its purpose by satisfying <u>ALL</u> of the following:

   a. All Safety Function Status Check acceptance criteria are being satisfied.
   b. Shutdown Cooling System Entry Conditions are satisfied, <u>or</u> the break has been isolated, <u>or</u> the RCS is in long term core cooling.
   c. An appropriate, approved procedure to implement exists or has been approved by the [Plant Technical Support Center or the Plant Operations Review Committee].

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. Confirm diagnosis of Loss of Coolant Accident by: a. verifying Safety Function Status Check acceptance criteria are satisfied, and b. referring to the Break Identification Chart (Figure 5-2), and c. sampling both steam generators for activity.	1. Rediagnose event and exit to either appropriate Optimal Recovery Guideline or to the Functional Recovery Guideline.
* 2. If pressurizer pressure decreases to or below the SIAS setpoint, Then verify an SIAS is actuated.	2. If pressurizer pressure decreases to or below the SIAS setpoint and an SIAS has NOT been initiated automatically, Then manually initiate an SIAS.
* 3. Ensure maximum safety injection and charging flow to the RCS by the following: a. start idle SI pumps and verify SIS flow in accordance with Figure 5-3, and b. start charging pump if necessary.	3. If safety injection and charging flow NOT maximized, Then do the following as necessary: a. ensure electrical power to valves and pumps b. ensure correct SIS valve lineup, c. ensure operation of necessary auxiliary systems.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
* 4. If pressurizer pressure decreases to less than [1400 psia] following a SIAS, then do either of the following: a. If RCS is subcooled then ensure two of four RCPs are tripped (in opposite loops). or b. If RCS is NOT subcooled then ensure all four RCPs are tripped.	4. Continue RCP operation.
* 5. Verify RCP operating limits are satisfied.	5. Trip the RCP(s) which do not satisfy RCP operating limits.
6. Record the time of day.	6.
7. Attempt to isolate the LOCA by performing the following: a. verify letdown line is isolated, b. verify sample lines are isolated, c. Verify NO leakage into CCW system by CCW radiation monitor NOT alarming and no abnormal increase in CCW surge tank level.	7. a. manually isolate letdown, b. manually isolate sample lines, c. If RCS to CCW leak is evident, Then attempt to isolate CCW affected RCPs and trip affected operating RCPs.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
7. (Continued) d. verify rapid depressurization valves are closed e. verify reactor coolant gas vent valves are closed	7. (Continued) d. manually isolate rapid depressurization valves. e. manually isolate reactor coolant gas vent valves.
8. <u>Verify</u> LOCA <u>NOT</u> occurring outside of containment by the following: a. nuclear annex radiation temperature, humidity alarms <u>NOT</u> alarming, b. no unexplained increase in nuclear annex sump levels. c. no unexplained increase in subsphere sump levels.	8. <u>If</u> LOCA occurring outside of containment, <u>Then</u> do the following: a. attempt to locate and isolate leak, b. isolate the nuclear annex

INSTRUCTIONS	CONTINGENCY ACTIONS
* 9. If containment pressure is greater than or equal to [2.7 psig] Then ensure the following:	9.
a. containment isolation is actuated automatically from the ESF panel and	a. If containment isolation does not occur automatically or all containment isolation valves are not in their accident positions, Then manually initiate containment isolation. [Plant specific method for manually isolating containment will be provided in the plant specific EOPs].
b. all available containment recirculation fan coolers operating	
*10. If containment pressure is greater than or equal to [8.5 psig], Then do the following:	10.
a. ensure containment spray actuation, and	a. manually actuate containment spray
b. ensure adequate containment temperature-pressure control by verifying at least one containment spray header delivering greater than [5000 gpm]	b.
c. Ensure that hydrogen recombiners are available use	c.

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS	
10.	(Continued) d. verify Annulus Ventilation System fans have started and pressure in annulus is decreasing to < [0" w.g.] e. verify subsphere building ventilation system operating	10.	(Continued) d. manually start annulus ventilation system e. manually start subsphere building ventilation system operating.
*11.	_If_ containment spray system is operating and containment pressure is less than [5.5 psia], _Then_ containment spray may be terminated. Upon termination the CSS must be aligned and reset for automatic operation or manual restart and the annulus ventilation system secured.	11.	_Continue_ containment spray system operation
*12.	_Place_ the hydrogen monitors in service	12.	
*13.	_If_ the containment hydrogen concentration is greater than or equal to 0.5%, _Then_ operate the hydrogen recombiners.	13.	

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS
*14. Monitor containment radiation level and provide input to [Plant Technical Support Center or Plant Operations Review Committee] for evaluating the impact of potential environmental releases.	14.	Operate CSS, as necessary
15. <u>If</u> the LOCA <u>NOT</u> isolated, <u>Then</u> perform steps 16 through 36.	15.	<u>If</u> the LOCA has been isolated, <u>Then</u> perform steps 37 through 55.
16. <u>If</u> the LOCA has <u>NOT</u> been isolated, <u>Then</u> perform a rapid cooldown to SCS entry conditions at a rate within Technical Specification Limits by (listed in preferred order): a. <u>If</u> the condenser is available, <u>Then</u> cooldown using the steam bypass system, or b. <u>If</u> the condenser or steam bypass system <u>NOT</u> available, <u>Then</u> cooldown using the atmospheric dump valves.	16.	

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS
*17. <u>Maintain</u> steam generator levels in the normal band throughout the cooldown using main, startup or emergency feedwater.	17.	
*18. <u>Ensure</u> the available emergency feedwater inventory is adequate per Figures 5-4 and 5-5.	18.	
*19. <u>When</u> pressurizer level is greater than or equal to [2%], <u>Then</u> ensure charging and letdown, and the SIS (unless SIS termination criteria met) are being operated to maintain pressurizer level [2% to 78%]	19.	<u>Continue</u> to operate available charging and SI pumps for maximum available flow.
20. <u>Depressurize</u> the RCS to ≤ [450 psia] by using the following: a. pressurizer spray. <u>or</u> b. control of charging and letdown. <u>or</u> c. operating/throttling SI pumps <u>or</u> d. using reactor coolant gas vent system.	20.	

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*21. Maintain RCS pressure within the Post Accident P-T limits of Figure 5-1.	*21. If RCS subcooling greater than P-T limits or cooldown rate greater than [100°F/Hr.], Then do the following as appropriate: a. stop the cooldown b. depressurize the plant using main or auxiliary spray or the Reactor Coolant Gas Vent System to restore and maintain pressurizer pressure within the Post Accident P-T limits of Figure 5-1. c. attempt to maintain the plant in a stable pressure-temperature configuration or continue to cooldown within the limits of Figure 5-1. d. If overpressurization due to SI/charging flow, Then throttle or secure flow (refer to step 27 and manually control letdown to restore and maintain pressurizer pressure within the limits of Figure 5-1.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*22. If RCPs are NOT operating, Then evaluate the need and desirability of restarting RCPs. Consider the following:	22.
a. adequacy of RCS and core heat removal using natural circulation,	a. If RCP operation NOT desired, Then go to step 25.
	or
b. existing RCS pressure and temperatures,	b. If at least one RCP is operating in each loop, Then go to step 27.
c. the need for main pressurizer spray capability,	
d. the duration of CCW interuption to RCPs,	
e. RCP seal staging pressures and temperatures.	
*23. Determine whether RCP restart criteria are met by ALL of the following:	23. Go to step 25
a. electrical power is available to the RCP's	
b. RCP auxiliaries (CCW) to maintain seal cooling, bearing, and motor cooling are operating, and there are no high temperature alarms on the selected RCPs,	

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
23. (Continued) c. at least one steam generator is available for removing heat from the RCS (ability for feed and steam flow), d. pressurizer level is greater than [33%] and not decreasing, e. RCS is subcooled based on representative CET temperature (Figure 5-1), f. [other criteria satisfied per RCP operating instructions] g. Natural circulation has been established per Step 25 for the preceding 20 minutes.	
*24. _If_ RCP restart desired and restart criteria satisfied, _Then_ do the following: a. start one RCP in each loop, b. ensure proper RCP amperage and NPSH, c. operate charging (and SI) pumps until pressurizer level greater than [14.3%]	24. _Go to_ step 25.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*25. If no RCPs are operating, Then verify natural circulation flow in at least one loop by ALL of the following: a. loop $\Delta T(T_H - T_c)$ less than normal full power ΔT, b. hot and cold leg temperatures constant or decreasing, c. RCS subcooled based on representative CET temperature, d. no abnormal difference [greater than 10°F] between T_H RTDs and representative CET temperature.	25. Ensure proper control of steam generator steaming and feeding (refer to steps 16 and 17) and RCS inventory and pressure control (refer to steps 19 and 20).
*26. If no RCPs are operating and single-phase natural circulation can NOT be maintained, then flow through the break and two-phase natural circulation can maintain the heat removal process. The operator should ensure the following: a. SIS flow per Figure 5-3, and b. proper steaming and feeding of the SG (refer to steps 16 and 17),	26.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*26. (Continued) and c. representative CET temperature is less than superheated.	
*27. If SI pumps are operating, Then they may be throttled or stopped, one pump at a time, if ALL of the following are satisfied: a. RCS subcooled based on representative CET temperature (Figure 5-1), b. pressurizer level is greater than [14.3%] and not decreasing, c. at least one steam generator is available for removing heat from the RCS (ability for feed and steam flow), d. the HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles.	27. Continue SI pump operation.
*28. If the criteria of step 27 cannot be maintained after SI pumps throttled or stopped, Then appropriate SI pumps must be restarted and full SIS flow restored.	28.

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS	
*29.	Monitor In-containment Refueling Water Storage Tank (IRWST) level and verify reactor cavity sump level or Holdup Volume Tank (HVT) increases as IRWST level decreases.	29.	Maintain IRWST level by replenishment from available sources as necessary.
30.	Bypass or lower the automatic initiation setpoint of [MSIS] as the cooldown and depressurization proceed.	30.	
31.	When pressurizer pressure reaches [740 psia] Then reduce safety injection tank pressure to [300 psia].	31.	
*32.	When pressurizer pressure reaches [445 psia], Then isolate, vent or drain the safety injection tanks (SITs).	32.	
33.	Initiate low temperature overpressurization protection at T_c [259°]	33.	

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
34. *If* SI throttle stop criteria of step 27 are met, *Then* go to Step 36.	34.
35. At [2-4 hours] after start of LOCA, *If* at least one steam generator is available for RCS heat removal, *Then* do the following: a. establish simultaneous hot leg and direct vessel injection (unless SCS operation can be established before the [4 hour] time limit), *and* b. maintain steam generator heat removal and continue RCS cooldown (refer to steps 16 and 17).	35.

INSTRUCTIONS

36. When the following SCS entry conditions are established:

a. pressurizer level > [14.3%] and constant or increasing,
b. RCS subcooled,
c. RCS pressure ≤ 450 psia
d. RCS T_H ≤ [400°F],
e. RCS activity level within plant specific limits

Then exit this guideline and initiate SCS operation per [operating instruction]. Include any special precautions or procedure modifications from the [Plant Technical Support Center or Plant Operations Review Committee].

CONTINGENCY ACTIONS

36. If SCS entry conditions can NOT be established, then do the following as appropriate:
a. maintain natural circulation (refer to steps 25 and 26),
b. maintain simultaneous hot and direct vessel injection if necessary (Refer to step 35),
c. If the RCS fails to depressurize and voiding is suspected, Then monitor for voids by the following indications, parameter changes, or trends:
   i) letdown flow greater than charging flow,
   ii) pressurizer level increasing significantly more than expected while operating pressurizer spray
   iii) the HJTC RVLMS indicates that voiding is present in the reactor vessel,
   iv) HJTC unheated thermocouple temperature indicates saturated conditions in the reactor vessel upper head,

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
36. (Continued)	d. _If_ voiding inhibits RCS depressurization to SCS entry pressure, _Then_ attempt to eliminate the voiding by: i) verify letdown is isolated, _and_ ii) stop the depressurization _and_ iii) pressurize and depressurize the RCS within the limits of Figure 5-1 by operating pressurizer heaters and spray or SI and the charging pump. Monitor pressurizer level and the HJTC RVLMS for trending of RCS inventory. e. _If_ depressurization of the RCS to the SCS entry pressure is still not possible, _and_ voiding is suspected to exist in the steam generator tubes, _Then_ attempt to eliminate the voiding by:

INSTRUCTIONS	CONTINGENCY ACTIONS
36. (Continued)	i) cool the suspected steam generator (by steaming and/or blowdown, and feeding) to condense the steam generator tube void, <u>and</u> ii) monitor pressurizer level for trending RCS inventory. f. <u>If</u> depressurization of the RCS to the SCS entry pressure is still not possible, <u>then</u> attempt to eliminate the voiding by: i) operate the pressurizer vent or the reactor coolant gas vent to clear trapped non-condensible gases. <u>and</u> ii) monitor pressurizer level and/or the HJTC RVLMS for trending of RCS inventory.
37. <u>If</u> LOCA is isolated, <u>Then</u> perform steps 38 though 55.	37.

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS	
*38.	If SI pumps are operating, Then they may be throttled or stopped, one pump at a time, if ALL of the following are satisfied: a. RCS subcooled based on representative CET temperature (Figure 5-1), b. pressurizer level is greater than [14.3%] and not decreasing, c. at least one steam generator is available for removing heat from the RCS (ability for feed and steam flow), d. the HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles.	38.	Continue SI pump operation.
*39.	If criteria of step 38 cannot be maintained after SI pumps throttled or stopped, Then appropriate SI pumps must be restarted and full SIS flow restored.	39.	
*40.	Control charging if available and letdown, and SI (unless SIS termination criteria met) to restore and maintain pressurizer level [2% to 78%].	40.	If RCS subcooling can NOT be maintained, Then [78%] may be exceeded to restore RCS subcooling.

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS	
41.	Depressurize the RCS to ≤ [450 psia] by using the following: a. pressurizer spray, or b. control of charging and letdown or c. operating/throttling SI pumps. or d. operating reactor coolant gas vent system	41.	
*42.	Maintain pressurizer pressure within the Post Accident P-T limits of Figure 5-1.	42.	RCS subcooling greater than P-T limits or cooldown rate greater than [100°F/Hr], Then do the following as appropriate: a. stop the cooldown b. depressurize the plant using main or auxiliary spray if available or use the Reactor Coolant Gas Vent System to restore and maintain pressurizer pressure within the Post Accident P-T limits of Figure 5-1. c. attempt to maintain the plant in a stable pressure-temperature configuration or continue to cooldown within the limits of Figure 5-1.

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS
42. (Continued)		d. If overpressurization due to SI/charging flow, Then throttle or secure flow (refer to step 38) and manually control letdown to restore and maintain pressurizer pressure within the limits of Figure 5-1.
*43. Maintain steam generator levels in the normal band using main, startup or emergency feedwater.	43.	
*44. Ensure the available emergency feedwater inventory is adequate per Figures 5-4 and 5-5.	44.	
*45. Borate the RCS to maintain shutdown margin in accordance with Technical Specifications. and Prevent boron dilution by pressurizer outsurge by the following (listed in preferred order): a. borate the entire RCS (inluding the mass in the pressurizer) to cold shutdown conditions.	45.	

INSTRUCTIONS	CONTINGENCY ACTIONS
45. (Continued) or b. use main or auxiliary spray if available to increase and maintain pressurizer boron concentration within [50 ppm] of RCS boron concentration.	
46. Perform a controlled cooldown in accordance with Technical Specifications by (listed in preferred order): a. steam bypass system or b. atmospheric dump valves.	46.
*47. If RCPs are NOT operating, Then evaluate the need and desirability of restarting RCPs. Consider the following: a. adequacy of RCS and core heat removal using natural circulation b. existing RCS pressure and temperatures, c. the need for main pressurizer spray capability,	a. If RCP operation NOT desired, Then go to step 50. or b. If at least one RCP is operating in each loop, Then go to Step 51.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
47. (Continued) d. the duration of CCW interruption to RCPs, e. RCP seal staging pressures and temperatures.	
*48. Determine whether RCP restart criteria are met by ALL of the following: a. electrical power is available to the RCP bus, b. RCP auxiliaries (CCW) to maintain seal cooling, bearing, and motor cooling are operating, and there are no high temperature alarms on the selected RCPs, c. at least one steam generator is available for removing heat from the RCS (ability for feed and steam flow), d. pressurizer level is greater than [33%] and not decreasing, e. RCS is subcooled based on representative CET temperature (Figure 5-1), f. [other criteria satisfied per RCP operating instructions].	48. Go to step 50.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*48. (Continued) g. Natural circulation has been established per Step 50 for the preceding 20 minutes.	
*49. _If_ RCP restart desired and restart criteria satisfied, _Then_ do the following: a. start one RCP in each loop, b. ensure proper RCP operation by monitoring RCP amperage and NPSH, c. operate charging (and SI) pumps until pressurizer level greater than [14.3%] (and SI termination criteria met. Refer to step 38).	49.
*50. _If_ no RCPs are operating, _Then_ verify natural circulation flow in at least one loop by _ALL_ of the following: a. loop $\Delta T(T_H - T_c)$ less than normal full power ΔT, b. hot and cold leg temperatures constant or decreasing, c. RCS subcooled based on representative CET temperature,	50. _Ensure_ proper control of RCS inventory and pressure control (refer to Steps 40 and 41) and steam generator feeding and steaming (refer to Steps 43 and 46).

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS
*50.	(Continued)	
	d. no abnormal difference [greater than 10°F] between T_H RTDs and representative CET temperature.	
51.	Bypass or lower the automatic initiation setpoints of MSIS, and SIAS as the cooldown and depressurization proceed.	51.
*52.	When pressurizer pressure reaches [740 psia] Then reduce safety injection tank pressure to [300 psia].	52.
*53.	When pressurizer pressure reaches [445 psia], Then isolate, vent or drain the safety injection tanks (SITS).	53.
54.	Initiate low temperature overpressurization protection (LTOP) at T_c < [259°F].	54.

* Step Performed Continuously

INSTRUCTIONS

55. When the following SCS entry conditions are established:

    a. pressurizer level > [33%] and constant or increasing.
    b. RCS subcooled
    c. RCS pressure ≤ [450 psia]
    d. RCS T_H ≤ [400°F],
    e. RCS activity level within plant specific limits

    Then exit this guideline and initiate SCS operation per operating instruction. Include any special precautions or procedure modifications from the Plant Technical Support Center or Plant Operations Review Committee.

CONTINGENCY ACTIONS

55. If the RCS fails to depressurize, Then a void should be suspected.
    a. voiding in the RCS may be indicated by any of the following indications, parameter changes, or trends:
        i) letdown flow greater than charging flow,
        ii) pressurizer level increasing significantly more than expected while operating pressurizer spray.
        iii) the HJTC RVLMS indicates that voiding is present in the reactor vessel
        iv) HJTC unheated thermocouple temperature indicates saturated conditions in the reactor vessel upper head,
    b. If voiding inhibits RCS depressurization to SCS entry pressure, Then attempt to eliminate the voiding by:
        i) verify letdown is isolated,

        and

INSTRUCTIONS	CONTINGENCY ACTIONS
55. (Continued)	ii) stop the depressurization, _and_ iii) pressurize and depressurize the RCS within the limits of Figure 5-1 by operating pressurizer heaters and spray or SI and charging pumps. Monitor pressurizer level and the HJTC RVLMS for trending of RCS inventory. c. _If_ depressurization of the RCS to the SCS entry pressure is still not possible, _and_ voiding is suspected to exist in the steam generator tubes, _Then_ attempt to eliminate the voiding by: i) cool the suspected steam generator (by steaming and/or blowdown, and feeding) to condense the steam generator tube void, _and_ ii) monitor pressurizer level for trending RCS inventory.

INSTRUCTIONS	CONTINGENCY ACTIONS
55. (Continued)	d. If depressurization of the RCS to the SCS entry pressure is still not possible, Then attempt to eliminate the voiding by: i) operate the pressurizer vent or the Reactor Coolant Gas Vent System to clear trapped non-condensible gases, and ii) monitor pressurizer level and/or the HJTC RVLMS for trending of RCS inventory.

The LOCA Guideline has accomplished its purpose if the plant is in a condition where all of the Safety Function Status Check acceptance criteria are being satisfied, and the RCS is either in long term core cooling (i.e., recirculation through the SIS), the break has been isolated, or SCS entry conditions are satisfied. Further recovery actions must be identified by the [Plant Technical Support Center].

END

SUPPLEMENTARY INFORMATION

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. During all phases of the cooldown, monitor RCS temperature and pressure to avoid exceeding a maximum cooldown rate greater than Technical Specification Limitations.

2. Do not place systems in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation.

3. All available indications should be used to aid in the evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available (e.g., during rapid depressurization the indicated level in the pressurizer may be too high).

4. If there is a high radioactivity level in the reactor coolant system, then circulation of this fluid through the SCS or the CVCS may result in high area radioactivity readings in the subsphere or nuclear annex. The activity level of the RCS should be determined prior to initiating SCS or letdown flow.

5. For small breaks in the RCS where the steam generators are important for heat removal, one steam generator must be used for this purpose even if primary to secondary leaks are detected. Use the unaffected steam generator, or the least affected steam generator, if both have primary to secondary leaks.

6. If operation of the containment spray system is necessary, the annulus ventilation should be operated in conjunction with containment spray system.

7. If the initial cooldown rate exceeds Technical Specification Limits, then there may be a potential for pressurized thermal shock (PTS) of the reactor vessel. Post Accident Pressure/Temperature Limits should be maintained within the limits of Figure 5-1.

8. Minimize the number of auxiliary spray cycles whenever the temperature differential between the spray water and the pressurizer is greater than [200°F] in order to minimize the increase in the spray nozzle thermal stress accumulation factor.

9. High containment temperature conditions may adversely impact the accuracy of instruments whose transmitters are located inside containment (e.g., pressurizer level and pressure, steam generator pressure and level, RCS loop RTDs) and may impact the continued availability of equipment located in containment.

10. Verification of an RCS temperature response to a plant change during natural circulation cannot be accomplished until approximately 5 to 15 minutes following the action due to increased loop cycle times.

11. Solid water operation of the pressurizer should be avoided unless subcooling cannot be maintained in the RCS (Figure 5-1). If the RCS is solid, closely monitor any makeup or draining, and any system heatup or cooldown, to avoid any unfavorable rapid pressure excursions.

12. Hot leg and cold leg RTD temperature indication may be influenced by charging pump or SIS injection water temperatures. Use multiple RTD indications and/or CET indications for temperature when injection is occurring.

13. During the process of establishing entry conditions (RCS pressure and temperature) for SCS operation, it may be necessary to eliminate or reduce the size of the steam void in the reactor head. Ensure sufficient condensate availability to continue steam generator heat removal until the RCS pressure and temperature are reduced sufficiently, and SCS operation is accomplished.

14. When a void exists in the reactor vessel, and RCPs are not operating, the HJTC RVLMS provides an accurate indication of reactor vessel liquid inventory. When a void exists in the reactor vessel, and RCPs are operating, it is not possible to obtain an accurate reactor vessel liquid level indication due to the effect of the RCP induced pressure head on the HJTC RVLMS. Information concerning reactor vessel liquid inventory trending may still be discerned. However, the operator is cautioned not to rely solely on the HJTC RVLMS indication when RCPs are operating, and to use other means of level indication if available.

15. The operator should continuously monitor for the presence of RCS voiding and take steps to eliminate voiding any time voiding causes the heat removal, or inventory control, safety functions to begin to be threatened. Void elimination should be started soon enough to ensure heat removal and inventory control are not lost.

16. Operation of the CSS may be desirable in the event of an iodine buildup in containment.

17. Small breaks located at the top of the pressurizer (e.g., stuck open safety relief valve) will result in flashing and steam production in the reactor vessel and hot legs. This steam will flow towards the break through the pressurizer surge line and oppose the draining of the pressurizer liquid. Thus, the liquid level in the pressurizer may increase or exhibit erratic behavior due to the competing steam-water counter current flow condition. A similar behavior may be observed if the break is in the surge line.

18. Operation of any equipment in the containment building when containment hydrogen concentration $\geq$ 4% should consider the possibility of hydrogen ignition. Consideration should be given to the following:
    a. The importance to safety of equipment operation,
    b. The urgency of equipment operation,
    c. The use of alternative equipment located outside containment,
    d. The current hydrogen level and the anticipated time to reduce $H_2 \leq$ [4%]

19. Measured containment hydrogen typically represents a value of hydrogen in units of percent by volume of dry air. The measured hydrogen will typically indicate higher than the actual containment hydrogen for a steam/air mixture inside containment. The indicated value should, therefore, be corrected to account for any steam/air mixture inside containment.

20. The loss of one vital AC or DC train will not prevent the operators from performing the actions of this guideline. However, it is desirable to have a complete complement of electrical equipment to mitigate and to recover from an event. Therefore, the operators should attempt to restore electrical power to all vital AC or vital DC buses.

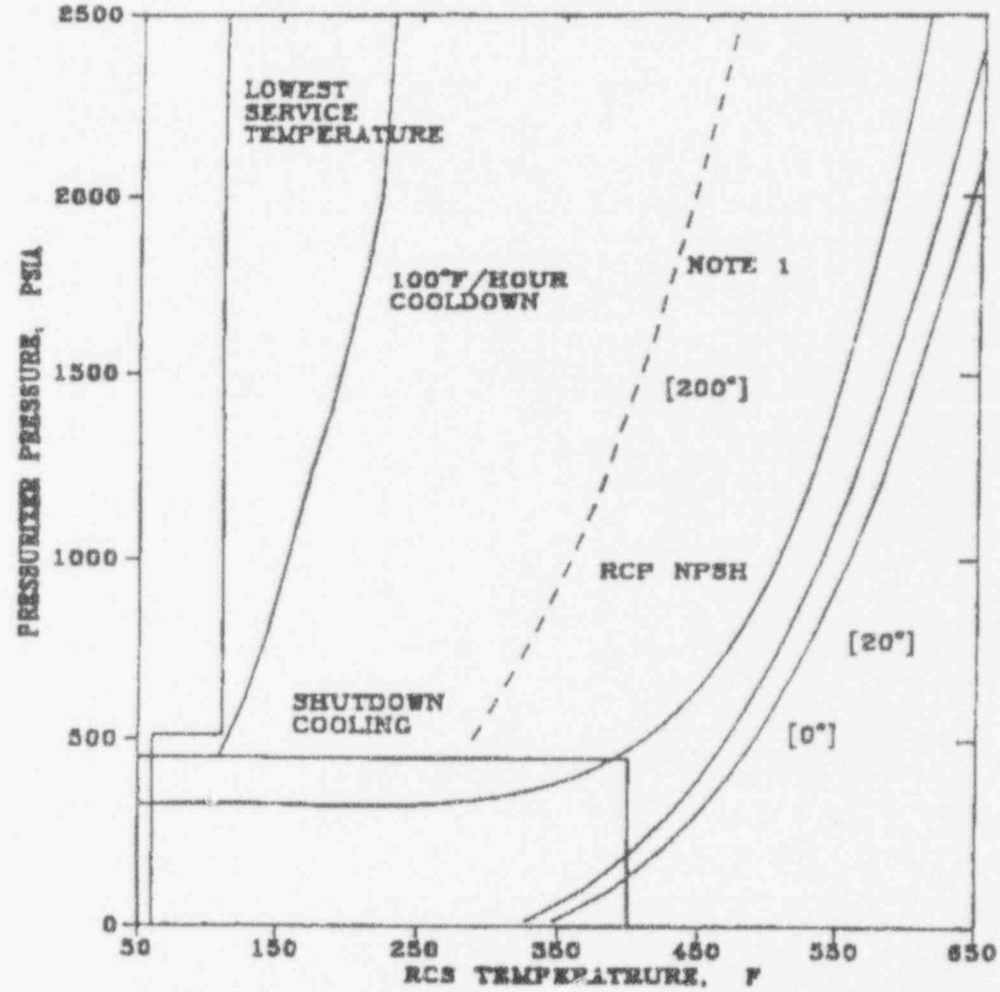
21. SI pumps 1 and 2 are provided with low flow throttle valves installed in parallel to the SIAS actuated main discharge path valves. Low flow throttle valves should be used when very low SI pump flow rates are required for contolling RCS pressure.

22. Prior to RCP restart, verify loops with restart RCP(s) have been in natural circulation continuously for the preceding 20 minutes.

23. The Shutdown Cooling Pumps and the Containment Spray Pumps are functionally interchangeable. Therefore, if containment spray or shutdown cooling is required but not available due to pump malfunction, the backup pump(s) may be aligned, if not already being used for their intended function, and operated as an alternate success path.

FIGURE 5-1

TYPICAL POST ACCIDENT PRESSURE-TEMPERATURE LIMITS



NOTES: (1) THIS CURVE SUPERSEDES THE 100° F/HR COOLDOWN CURVE ANYTIME THE RCS HAS EXPERIENCED AN UNCONTROLLED COOLDOWN WHICH CAUSES RCS TEMPERATURE TO GO BELOW 500° F. THIS CURVE IS AN OPERATIONAL LIMIT BASED ON ENGINEERING JUDGEMENT AND INTENDED TO MINIMIZE THE POTENTIAL OF A PRESSURIZED THERMAL SHOCK.

(2) THESE CURVES MUST BE ADJUSTED FOR INSTRUMENT INACCURACIES.

FIGURE 5-2

BREAK IDENTIFICATION CHART

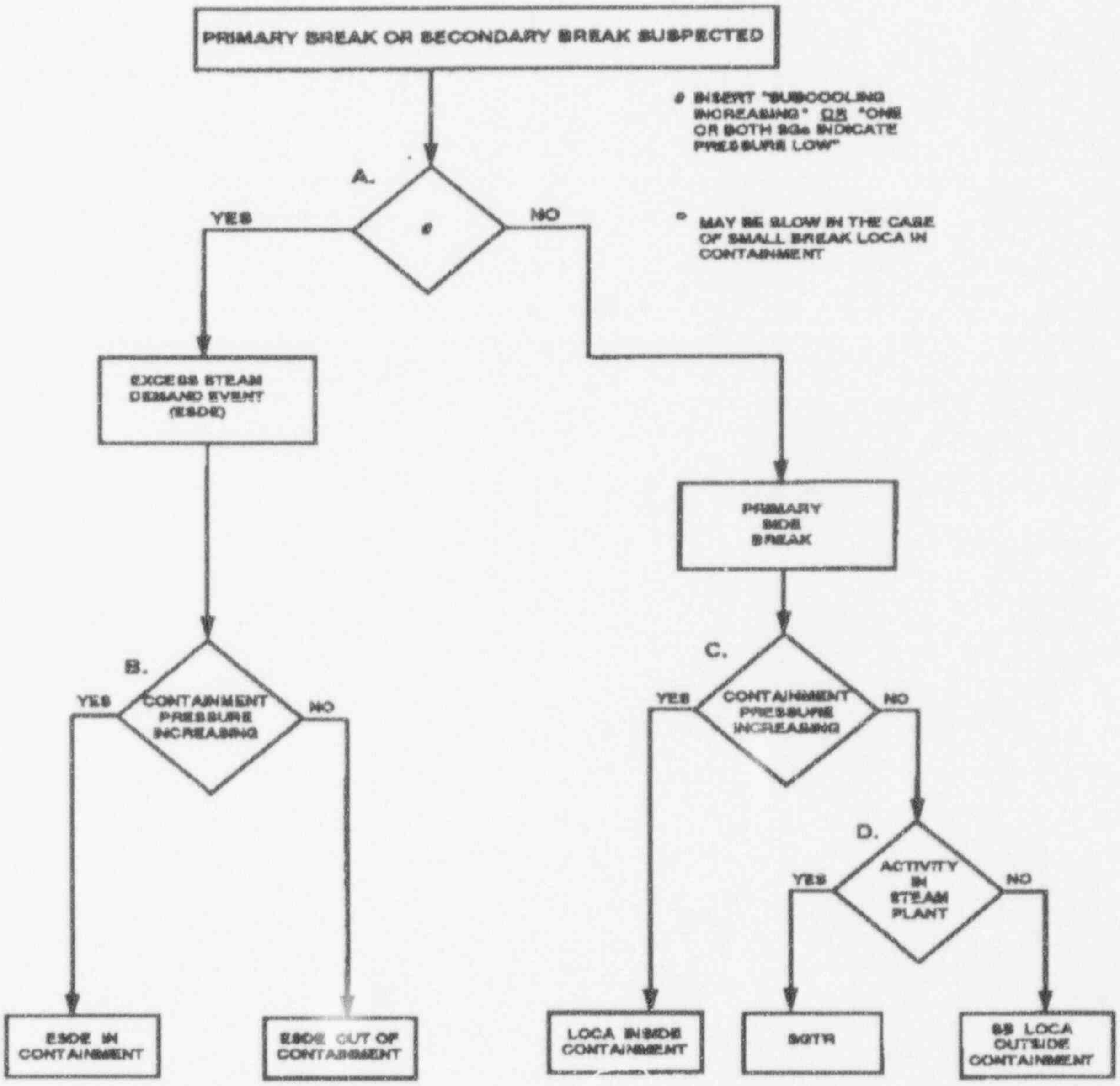
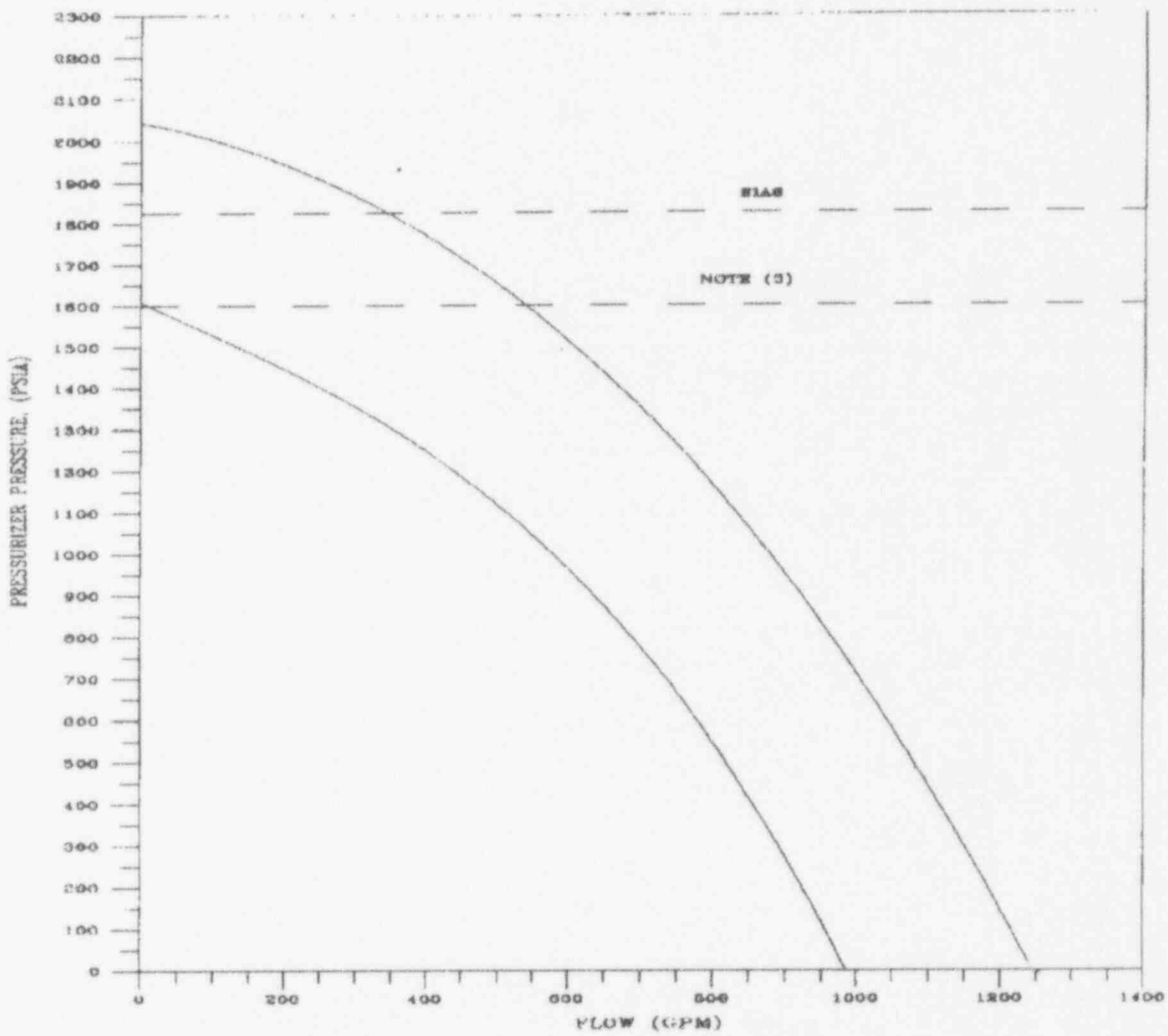


FIGURE 5-3

TYPICAL ACCEPTABLE SIS FLOW VS RCS PRESSURE [1]

INJECTION MODE[2]



NOTES: (1) SEE IMPLEMENTATION SECTION FOR DEVELOPMENT OF PLANT SPECIFIC CURVE.
(2) FOR HOT LEG AND DVI INJECTION, FULL FLOW FROM SIS PUMPS 1 AND 2 IS DIRECTED TO THE HOT LEGS.
(3) BELOW THE SIAS SETPOINT, THE SIS PUMPS WILL BE OPERATING, BUT THERE WILL BE NO INJECTION FLOW UNTIL SYSTEM PRESSURE FALLS BELOW THE SHUTOFF HEAD OF THE SIS PUMPS.
(4) THESE CURVES DO NOT ACCOUNT FOR INSTRUMENTATION INACCURACIES

FIGURE 5-4

TYPICAL FEEDWATER CAPACITY VS TIME UNTIL SHUTDOWN COOLING REQUIRED

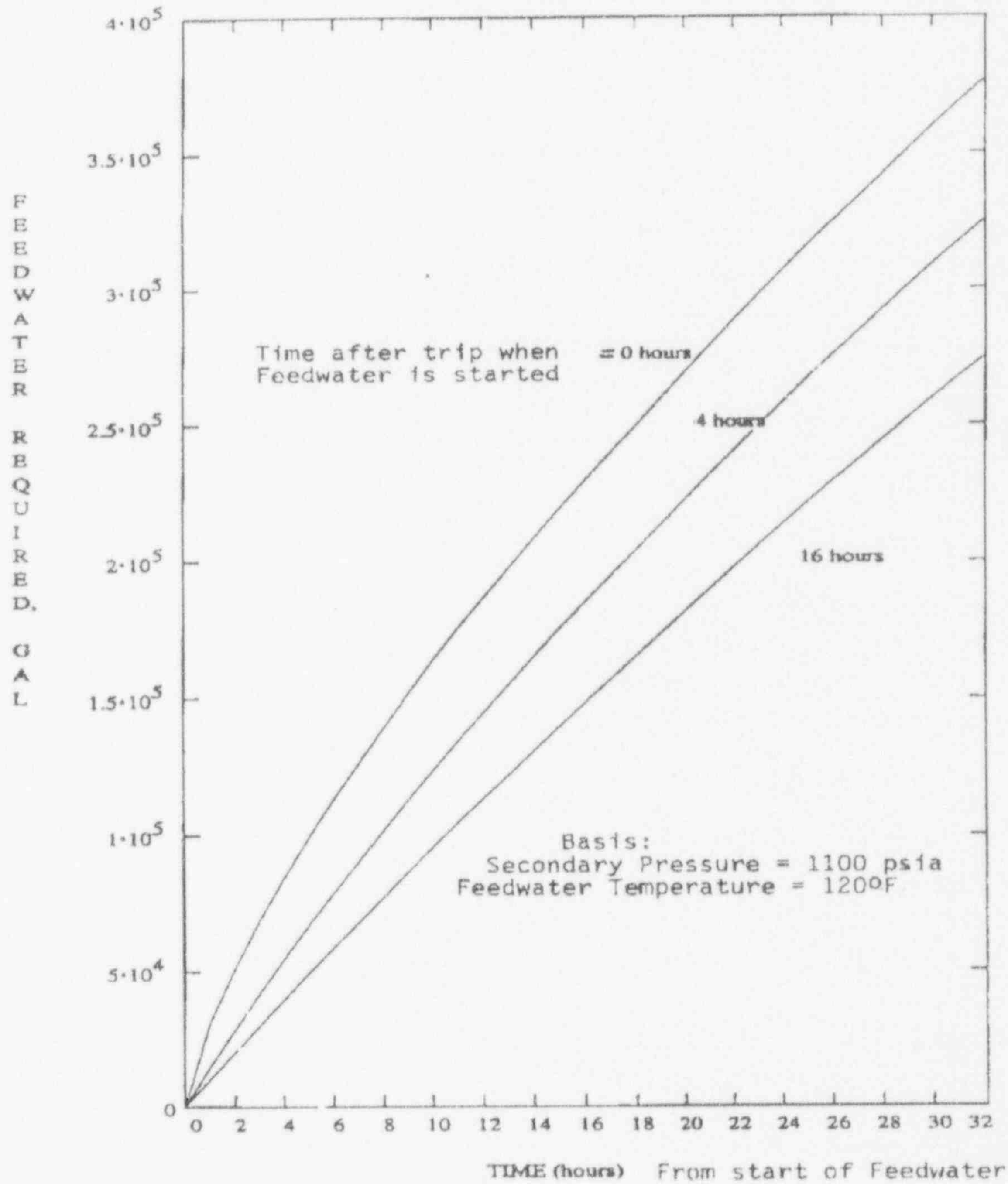
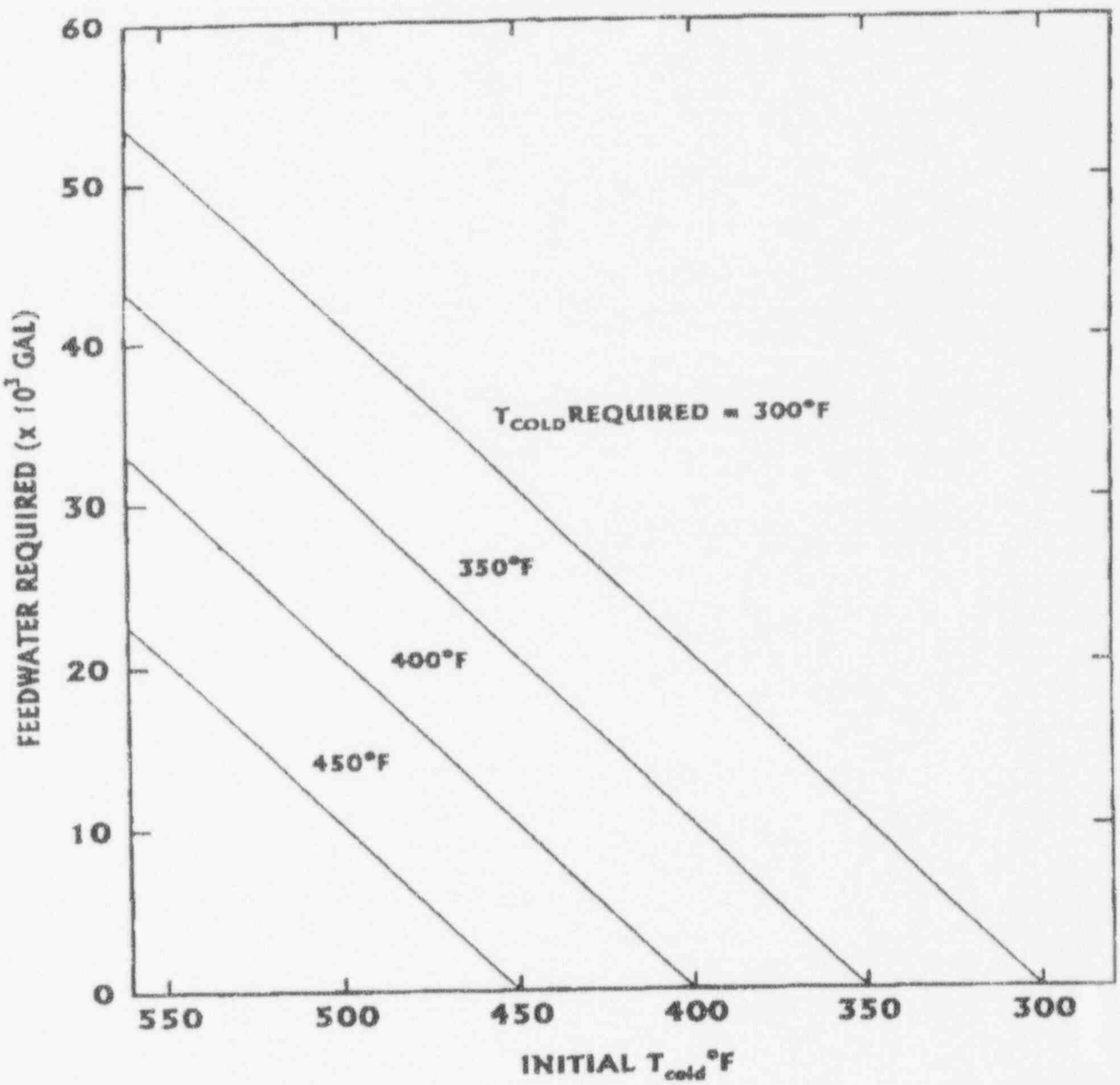


FIGURE 5-5

TYPICAL FEEDWATER REQUIRED FOR SENSIBLE HEAT REMOVAL

T_{cold} (Required) vs T_{cold} (Initial)



SAFETY FUNCTION STATUS CHECK

SAFETY FUNCTION	ACCEPTANCE CRITERIA
1. Reactivity Control	1. a. Reactor power decreasing and b. Negative Startup Rate and c. Maximum of 1 CEA NOT fully inserted or borate per Tech. Specs.
2. Maintenance of Vital Auxiliaries (AC and DC Power)	2. All vital Division I [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized, or All vital Division II [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized.
3. RCS Inventory Control	3. a. If LOCA is isolated, Then ensure: i) charging and letdown, and SIS flow (per Figure 5-3) maintaining or restoring pressurizer level [2% to 78%] (unless SIS termination criteria met) and ii) the RCS is subcooled and iii) the HJTC RVLMS indicates the core is covered or

SAFETY FUNCTION STATUS CHECK

SAFETY FUNCTION	ACCEPTANCE CRITERIA
3. RCS Inventory Control (Continued)	b. If LOCA NOT isolated, Then ensure: i) available charging pump is operating and the SI pumps are injecting water into the RCS per Figure 5-3, and ii) the HJTC RVLMS indicates the core is covered.
4. RCS Pressure Control	4. a. Pressurizer heaters and spray, or charging pump and SI pumps, are maintaining or restoring pressurizer pressure within the limits of Figure 5-1. or b. available charging pump is operating and the SI pump(s) are injecting water into the RCS per Figure 5-3 (unless SIS termination criteria are met).

SAFETY FUNCTION STATUS CHECK

SAFETY FUNCTION	ACCEPTANCE CRITERIA
5. Core Heat Removal	5. T_H RTD and representative CET temperatures less than superheated.
6. RCS Heat Removal	6. a. At least one steam generator has level: i) within the normal level band with feedwater available to maintain level or ii) being restored by main, emergency or startup feedwater flow
7. Containment Isolation	7. a. No steam plant activity monitors alarming and b. i) Containment pressure less than [2.7 psig] or ii) CIAS present or manually initiated and c. i) No containment area radiation monitors alarming or

SAFETY FUNCTION STATUS CHECK

SAFETY FUNCTION	ACCEPTANCE CRITERIA
7. Containment Isolation (Continued)	ii) CIAS present or manually initiated and annulus vent system is operating <u>and</u> Subsphere building ventilation system operating.
8. Containment Temperature & Pressure Control	8. a. i) Containment temperature less than [236°F] and ii) Containment pressure less than [8.5 psig] or b. At least one containment spray header delivering at least [5000 gpm].
9. Containment Combustible Gas Control	9. a. Hydrogen concentration less than 0.5% or b. i) available hydrogen recombiners energized and ii) Hydrogen concentration less than 4%. or c. Hydrogen mitigation system operating in accordance with plant specific operating instructions.

BASES

The bases section of the Loss of Coolant Accident (LOCA) Recovery Guideline describes the LOCA transient in relation to the actions which the operator takes during a LOCA. The purpose of the bases section is to provide the operators with information which will enable them to understand the reasons for, and the consequences of, the actions they take during a LOCA.

Characterization of a LOCA

A LOCA is an accident which is caused by a break in the reactor coolant system (RCS) pressure boundary. The break can be as large as a double ended guillotine break in the hot leg or as small as a break which results in a loss of RCS fluid at a rate that is just in excess of the available charging capacity of the plant.

Small and large break LOCAs differ in their effect on the post-LOCA RCS heat removal process. For a large break, the only path necessary for RCS heat removal in both the short and long term is the break flow with core boiloff. For small breaks, heat removal via the flow out the break is not sufficient to provide cooling and, therefore, steam generator heat removal is required. The guidelines take this into account with the decisions which must be made. Although distinct small and large break LOCA information is contained in the bases section of this guideline, the action steps to be used during the actual emergency do not require the operator to distinguish between break sizes.

A LOCA is characterized by an initial decrease in RCS pressure and inventory. Subsequent RCS inventory and pressure response depends on the size of the break. For large breaks inside containment, an increase in containment temperature and pressure occurs relatively soon after the LOCA. However, a small LOCA may not be detectable on containment temperature and pressure instruments in the short term. The actions taken by the operator during a LOCA, and more detailed descriptions of LOCA response, are provided in the following sections.

Safety Functions Affected

The LOCA primarily affects RCS inventory and pressure control, and RCS and core heat removal. To a lesser degree, reactivity control, containment isolation, and containment temperature and pressure control are also affected. All safety functions should be monitored to assure public safety or to detect failures which might lead to unsafe conditions.

RCS inventory control is initially lost since the break flow rate exceeds the available charging pump capacity. For small breaks, RCS inventory control is regained via injection from the safety injection (SI) pumps and the charging pumps. It is maintained in the long-term by injection from these pumps. For large breaks, inventory control is regained through the injection of water into the RCS by the safety injection tanks (SITs) and the safety injection (SI) pumps. It is maintained in the long-term through the recirculation of sump water through the RCS by the HPSI pumps. Note that for large breaks, the RCS may not totally refill and pressurizer level may not be regained. If the large break is unisolable, continuous injection is required to make up for the loss out the break and to prevent boron precipitation.

RCS pressure control is initially lost as the RCS depressurizes because of the loss of inventory out the break. For large breaks, the RCS depressurizes in 10 seconds to 3 minutes to pressures typically below 300 psia. In the case of the largest breaks, the RCS pressure will reach equilibrium with containment pressure, and will be nearly equal to that pressure. Because of the size of the break, the operator never regains direct control of RCS pressure and the RCS remains depressurized. For small breaks, the RCS depressurizes during the short-term (10 to 30 minutes) to an equilibrium condition with the steam generators. It then continues to depressurize as the operator cools down the steam generators. Pressure control is regained when the safety injection system (SIS) refills the RCS and pressurizer level is regained. Once pressure control is regained, subsequent small break post-LOCA operator actions which are associated with pressure control are (1) decreasing RCS pressure by means of auxiliary sprays, (2) controlling SI pumps and charging, (3) heat removal via the steam generators in order to establish shutdown cooling entry conditions and, (4) isolating or depressurizing the SITs. For small break LOCAs, during the period of time when the RCS is refilling (pressure control has not yet been achieved), there may be significant voiding in the RCS. The voided areas may be located in the reactor vessel head region as indicated by the HJTC RVLMS, the RCS loops, or the steam generator u-tubes, and may be made up of steam or non-condensible gases. Steam voids may occur from fluid flashing in local hot spots within the RCS. This voiding is not a problem as long as heat removal is not inhibited or the ability to reduce primary pressure is not greatly reduced. The presence of small amounts of non-condensible gases may be present from sources such as gases evolving from the primary coolant and pressurizer vapor space. If their presence is detected in the RCS the reactor vessel head vent may be operated. The presence of non-condensible gases in the steam generator tubes is characterized by a decrease in primary to secondary heat removal capability. RCS heat removal is not jeopardized by the presence of non-condensibles until a significant number of steam generator tubes are blocked. A significant number of tubes will not be blocked unless there is considerable oxidation of fuel cladding, and this is not expected for the small break LOCA, unless significant core uncovery occurs.

There are two paths initially available for RCS heat removal: heat transfer to the secondary side via the steam generators, and heat transfer via the fluid flowing out the break. Large break LOCAs have sufficient fluid flowing out the break to provide adequate heat removal without relying on steam generators. Small break LOCAs do not have sufficient fluid flowing out of the break to provide adequate heat removal. Therefore, steam generator heat removal is required in addition to break flow for adequate heat removal. Because the LOCA ORG does not distinguish between large and small break LOCAs, steam generator heat removal capability is required at all times during a LOCA.

The large break LOCA heat removal process is not complex. For cold leg breaks the SIS refills the reactor vessel (RV) and provides only enough fluid to the core to match boil off. The excess injected fluid spills out of the cold leg break. The steam from core boil off passes out the hot leg and through the steam generators on its way out the cold leg break. For the hot leg break, the injected water builds up in the cold legs and provides the core with water for boil off heat removal and some single phase cooling. In the long term, heat removal is provided by simultaneous hot and cold leg injection. This process provides heat removal for either hot or cold leg large break LOCAs while providing the added benefit of ensuring adequate flushing of the RV to avoid buildup of non-volatile materials produced in the boil off cooling process. Figures 5-6 and 5-7 illustrate the heat removal process for large break LOCAs.

The small break LOCA heat removal process is more complex than that described above for the large break. In the short-term, after the RCPs are tripped, core heat removal is maintained by natural circulation. Since the break is not large enough to adequately remove the heat, heat removal via a steam generator is required. This requires that the operator maintain feedwater (either main, startup or emergency) to the steam generators and control steam flow from the steam generators via the steam bypass system or the atmospheric dump valves; Figures 5-8 and 5-9 illustrate the heat removal process for typical small break LOCAs. The typical percentage of required RCS heat removed by the steam generators for various break sizes is illustrated in Figures 5-10 and 5-11.

FIGURE 5-6

HEAT REMOVAL VIA LARGE HOT LEG BREAK

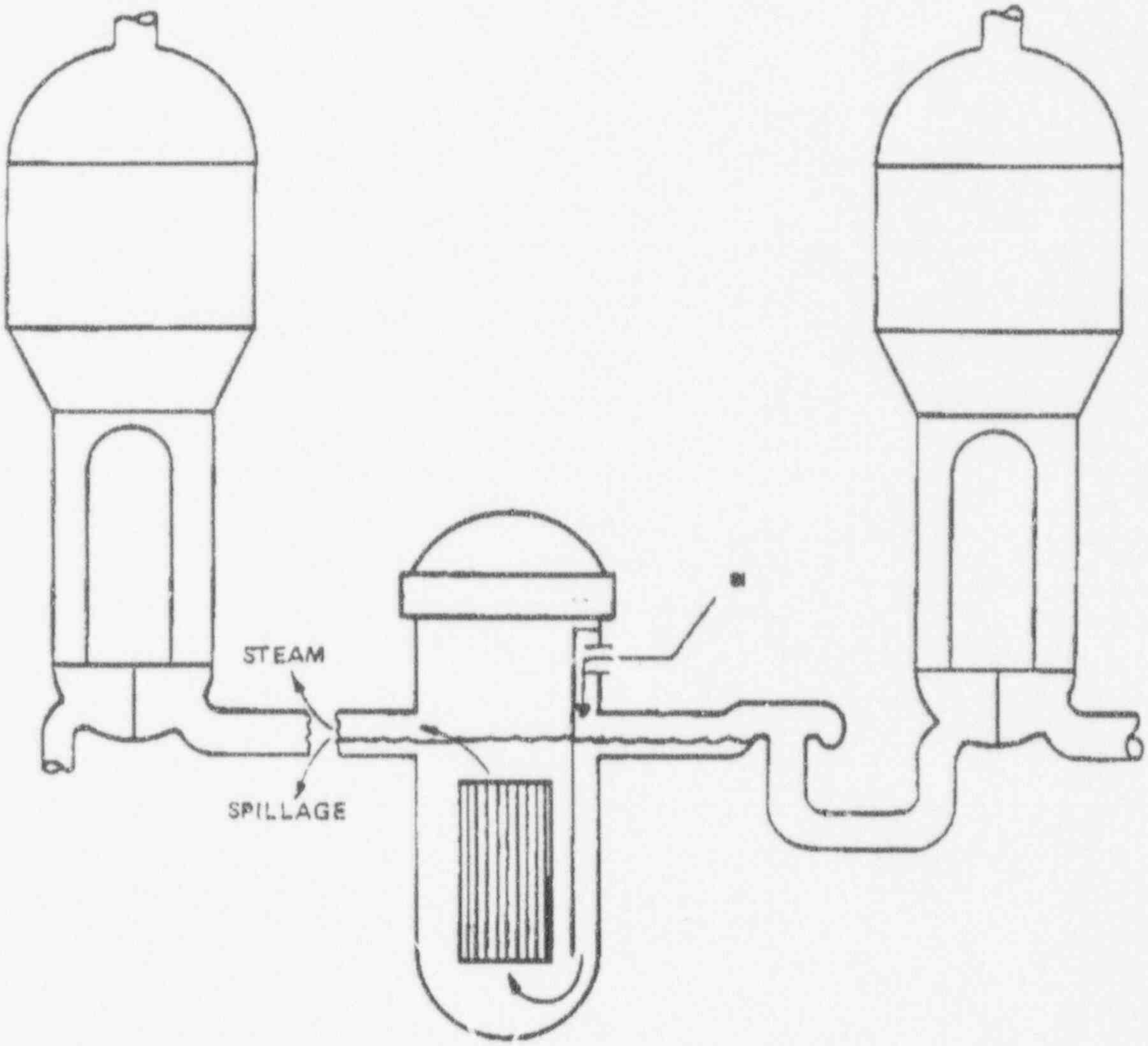


FIGURE 5-7

HEAT REMOVAL VIA LARGE COLD LEG BREAK

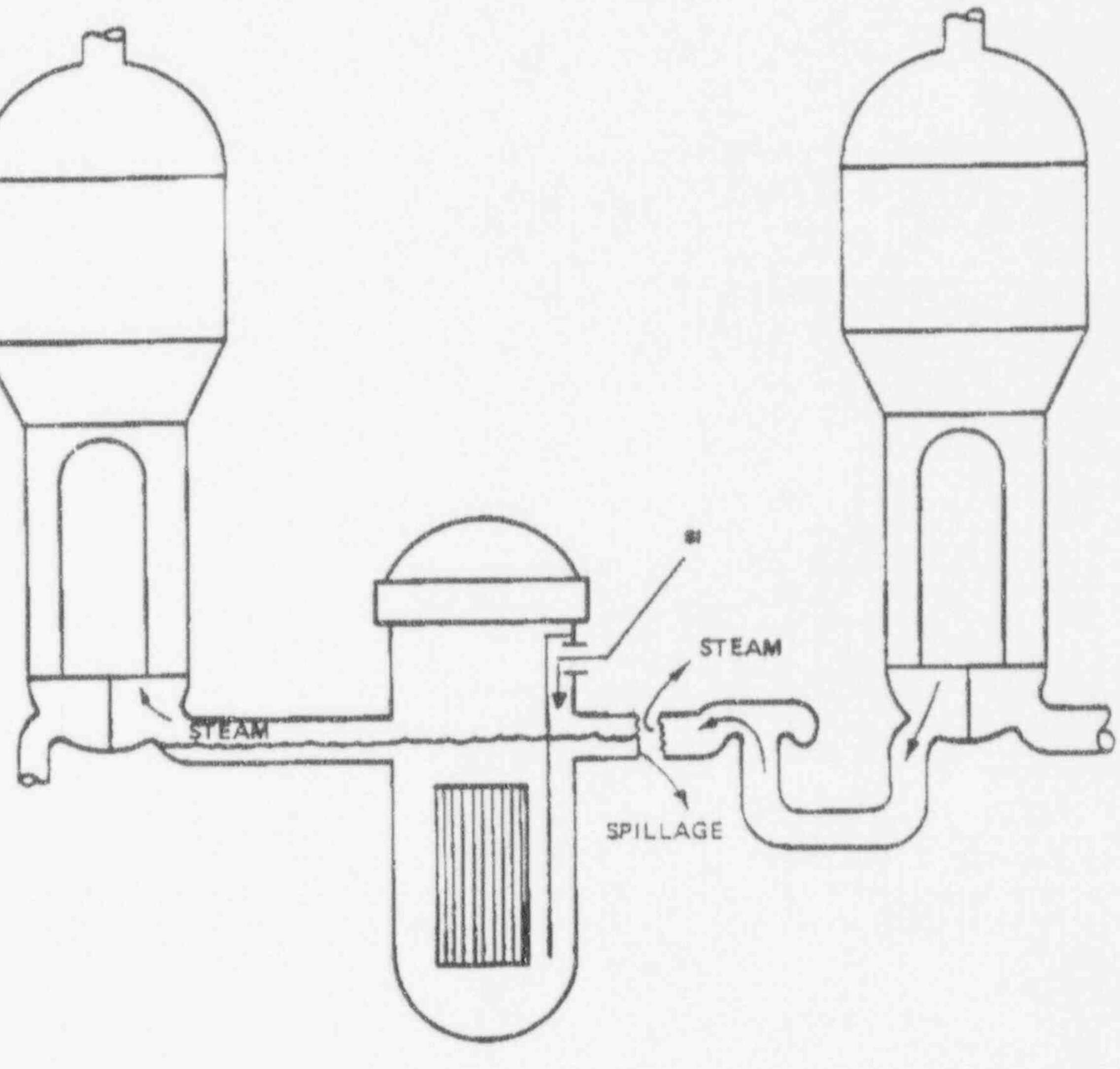


FIGURE 5-8
HEAT REMOVAL VIA SMALL (RCS FILLED)

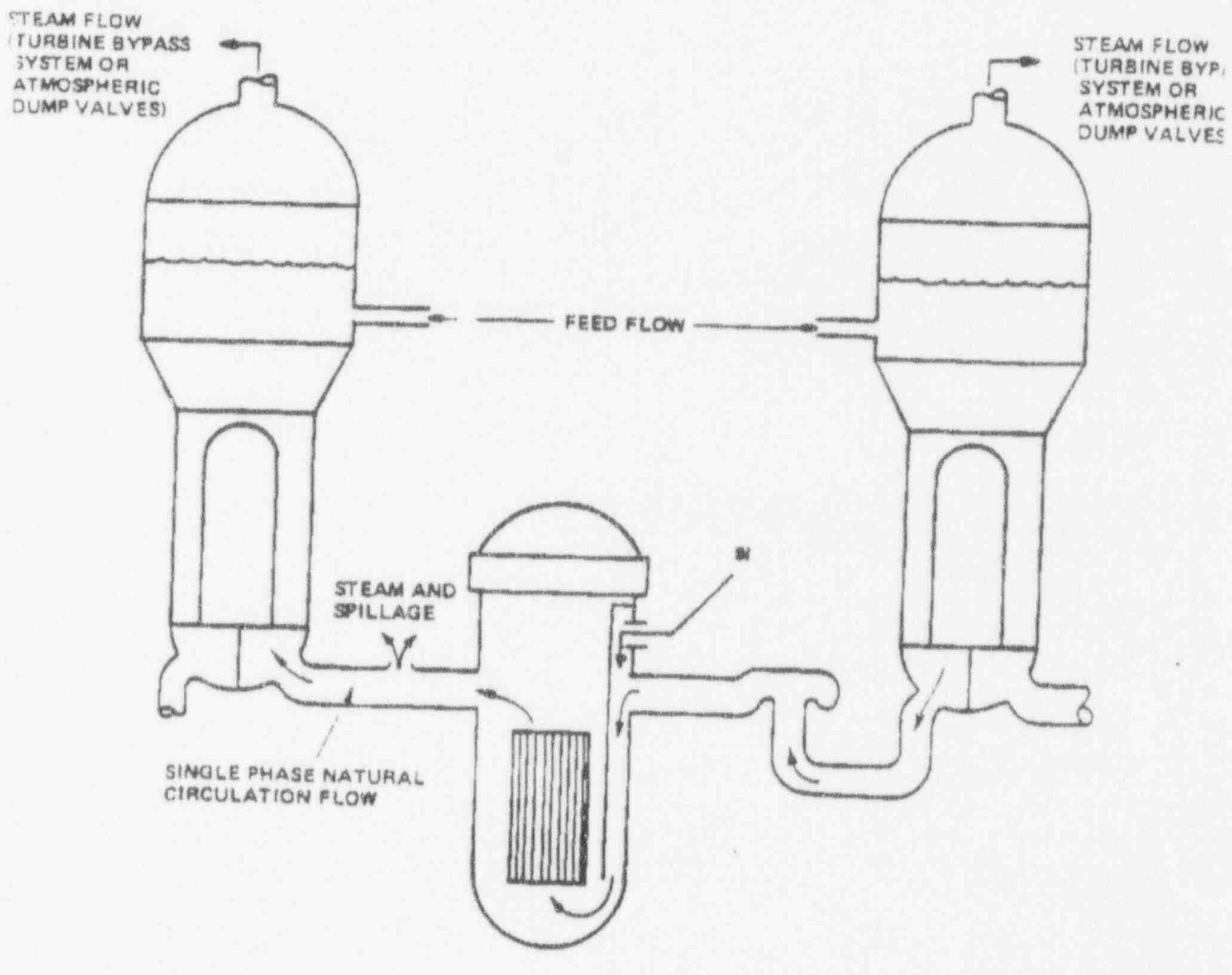


FIGURE 5-9

HEAT REMOVAL VIA SMALL BREAK (REFLUX COOLING)

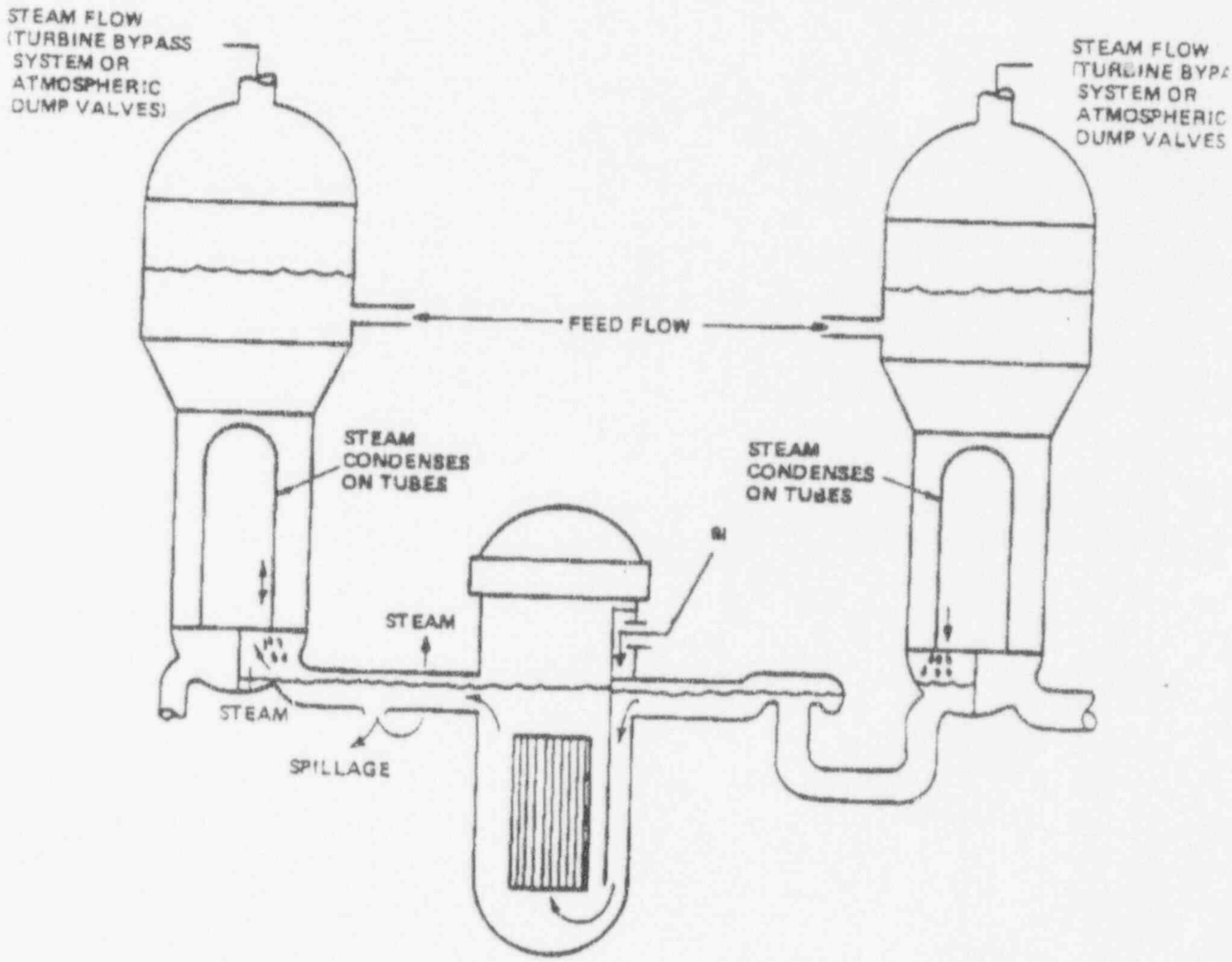


FIGURE 5-10

BREAK DIAMETER VS % OF DECAY HEAT REMOVED BY STEAM GENERATORS

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 5-11

BREAK DIAMETER VS % OF DECAY HEAT REMOVED BY STEAM GENERATORS

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

The small break natural circulation process can take different forms. These forms include single phase natural circulation and a more complex two phase natural circulation. The simplest form of natural circulation is single phase, liquid cooling. Single phase natural circulation is possible for cases where RCS inventory and pressure are controlled. Single phase cooling transports heat using the same flow path involved in forced circulation cooling with the liquid density difference between SG and RV driving the flow. Two phase natural circulation involving steam and water is more complex and can take several forms, which depends on the amount of decay heat, the amount of inventory and pressure control degradation, the break size and the status of the SIS and the steam generators. One form of two phase natural circulation is known as reflux. In the reflux process, steam leaves the core region and travels to the steam generator via the hot leg; the steam is condensed in the steam generator before reaching the top of the "U" tubes and flows back to the core via the hot leg where it is once again turned to steam. Another two phase natural circulation process is similar to reflux but differs in that the steam from the core goes past the steam generator "U" bend and is condensed in the tubes on the cold leg side; thus condensate flows back to the core via the cold leg. A combination of the two processes is also possible.

The operator has adequate instrumentation to monitor natural circulation for the single phase liquid natural circulation process. The RCS temperature instrumentation, and loop ΔT can be used along with other information to confirm that the single phase natural circulation process is effective. The natural circulation processes involving two phase cooling are complex and varied enough so that RCS loop ΔT may not be a meaningful indication of adequate natural circulation cooling. The guidelines are written to alert the operator to use explicit acceptance criteria for natural circulation only when RCS inventory and pressure are controlled.

For cases where two phase natural circulation cooling is the heat removal process, the operator relies upon maintaining the steam generator heat removal process and the strict rules that require the SIS to remain operating to restore inventory control. In addition, the core exit thermocouple temperature and T_H temperature indication are important in monitoring heat removal during two phase natural circulation cooling. As long as these temperatures remain within acceptable limits they indicate that heat removal and inventory functions are being satisfied.

The time frame for the transition from single phase liquid natural circulation cooling to the reflux mode is determined by the relative size of the small break. The operator should be aware that this transition may cause confusing temperature indications as the RCS loop ΔTs readjust to reflect the transition in progress. The emphasis in the guideline is to continue the steam generator heat removal process, continue restoring inventory control, and to continue monitoring the core exit thermocouples to confirm the heat removal process is adequate.

Once RCS pressure and temperature are reduced, RCS heat removal is provided by the shutdown cooling system-if possible. In the event that liquid inventory in the steam generators is not adequate to remove decay heat, a source of feedwater is unavailable, and the SCS is inoperable, the operator is instructed to implement the Functional Recovery Guideline because a multiple casualty condition is in effect (LOCA and Loss of All Feedwater). Specific guidance for initiating once-through-cooling is provided here. As discussed previously, although steam generator heat removal is only required for the small break LOCA event, the LOCA EPG does not require the operator to distinguish between large and small break LOCAs so the action is taken whenever SG heat removal capability is lost.

Short-term reactivity control is accomplished by the negative moderator effects for large breaks and by the reactor trip for small breaks. The reactor trip decreases core heat generation to decay heat levels which aids in the control of heat removal. Long-term reactivity control is accomplished through injection of borated water by the safety injection system and the charging pumps.

Containment isolation occurs either automatically, or is performed manually after an evaluation of the plant conditions (containment temperature, pressure, and activity level; and for plants which generate a CIAS on SIAS, pressurizer pressure).

If the LOCA occurs inside containment, then containment temperature and pressure control can be accomplished by various combinations of containment fan coolers (in the emergency mode) and/or the containment spray system. These systems act to remove heat from the containment atmosphere, thus reducing the temperature and pressure.

Containment Combustible Gas Control may become a concern due to hydrogen generated during LOCA events. The ultimate goal of the Containment Combustible Gas Control safety function is to prevent a hydrogen burn from causing containment pressure to reach or exceed containment design pressure. Preferentially this is accomplished by operation of the hydrogen recombiner. If recombiner operation is not possible or sufficient, then a hydrogen purge may be performed if deemed necessary by the Plant Technical Support Center. These actions are performed to prevent or minimize the release of fission products to the environment.

Three significant sources of hydrogen exist during LOCA events. These are:

(1) <u>Metal-water reactions involving zircaloy or stainless steel in the RCS</u>

These reactions take place at high temperatures during the core uncovery phase of a LOCA. Thus, hydrogen generated will be released to the containment atmosphere if the primary break is inside containment. The amount of hydrogen produced depends on the duration of core uncovery and the maximum core temperature reached.

(2) <u>Radiolysis of water by fission product decay</u>

As a result of the decay of the fission products, water molecules in the RCS and in the RCS fluid which has been released into the containment may be broken down into hydrogen and oxygen. The gases are released to the containment atmosphere. This is a slow process but over a period of time can be the most significant source of hydrogen. It may take [12 to 16] days for hydrogen concentration to reach 4%. The rate of buildup will increase with an increase of fission products in the RCS.

(3) Corrosion of aluminum and zinc by the containment sprays

The reaction between the aluminum and zinc materials in the containment with the borated spray solution generates hydrogen. The reactions occur at higher rates with increasing temperatures. Hydrogen may be generated in this way during the first hours of a LOCA event.

Figure 5-12 provides the results of a typical safety analysis calculation of the hydrogen concentration for a large break LOCA event. The initial increase in hydrogen concentration is due to the metal-water reactions and the corrosion reactions. The long term increase is due to the radiolysis of water.

The containment hydrogen concentration can be reduced by recombining hydrogen and oxygen to form water. The hydrogen recombiners do this by raising the temperature of the air passing through them to the point where the recombination reaction takes place. Electric heating elements are used to heat the incoming mixture, while flow through the units is provided by natural circulation.

Since the recombination rate (cubic feet of hydrogen removed per hour) depends on the hydrogen concentration in the atmosphere, use of the recombiners will result in an exponential decrease in the hydrogen concentration. Typically, one recombiner will remove hydrogen at a rate that is compatible with the long term hydrogen generation rate following a large break LOCA due to radiolysis of reactor coolant water.

Figure 5-12 provides typical curves showing the effect of one and two recombiners that are started nine days after the LOCA.

FIGURE 5-12

TYPICAL HYDROGEN CONCENTRATION BUILDUP AND REMOVAL FOLLOWING A LARGE BREAK LOCA

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

The containment hydrogen concentration can also be reduced by purging the containment atmosphere with fresh air. The hydrogen purge system accomplishes this by providing controlled intakes and exhausts to the containment atmosphere. This method of hydrogen control is utilized after the Plant Technical Support Center has evaluated several factors - including the expected effects of a hydrogen burn.

The hydrogen removal rate (cubic feet of hydrogen removed per hour) depends on the purge system flow rate, the containment free volume, and the containment hydrogen concentration. Typically, the hydrogen purge system will remove hydrogen at a rate that is comparable with the long term hydrogen generation rate following a large break LOCA. Higher purge rates will result in higher removal rates. The hydrogen purge rate can be approximated by the hydrogen removal rate of one recombiner as shown in Figure 5-12.

Trending of Key Parameters (Representative of small break LOCAs)

Reactor Power (Figure 5-13)

A reactor trip will occur on thermal margin/low pressure, and reactor power will be decreasing as a result of the reactor trip. Additional negative reactivity insertion will be provided by moderator voiding, and boron addition by charging pump and/or SIS flow.

RCS Temperature (Figures 5-14, 5-15)

Following the reactor trip, RCS temperature initially decreases for all size LOCAs due to the reduction in heat input into the RCS, and due to the heat removed out the break and by the steam generators.

Pressurizer Pressure (Figure 5-16)

Pressurizer pressure initially decreases due to the loss of coolant and reactor power reduction following reactor trip.

Pressurizer Level (Figure 5-17)

Pressurizer level may decrease or increase. For breaks not located in the pressurizer, the pressurizer will empty and, depending on the size of the break, not refill during the course of the accident. Breaks located in the pressurizer may lead to increased pressurizer level since water from the hot leg flows into the pressurizer surge line while significant voiding of the RCS loop is occurring. If there is a break on or near the pressurizer level instruments, this may cause this instrument to be grossly inaccurate and misrepresent pressurizer level (high or low).

For small break LOCAs where the pressurizer refills as a result of safety injection, pressurizer level may not be representative of RCS inventory or core coverage. As indicated above, the depressurization associated with a leak in the RCS will usually result in the formation of voids in

RCS hot spots (reactor vessel head, hot legs, S/G tube bundle). The growth or persistence of these voids, after refill of the pressurizer by the SIS, may cause pressurizer level to increase or remain constant in spite of continuing loss of inventory through the break.

Reactor Vessel Level (Figure 5-18)

Some degree of voiding is expected for LOCAs; but the extent and duration is largely dependent on break size and location. Most small break (SB) LOCA events will not result in core uncovery without some other failure occurring concurrently. Some small breaks can lead to some core uncovery. However, when SI delivery is established, the core will be covered. For very small breaks, the RCS will repressurize to slightly below the shut-off head of the HPSI pumps and voiding will not uncover the core. For large breaks, the RCS saturates almost immediately and voids start to form. Core uncovery is expected in the short term but RCS pressure decrease is also very rapid and SIS flow restores core cooling.

Steam Generator Pressure (Figure 5-19)

Steam generator pressure may increase or remain constant in the short term if the break is small. However, for all sized LOCAs, steam generator pressure will usually decrease in the long term as a result of operator action.

Steam Generator Level (Figure 5-20)

Steam generator level will decrease rapidly following the reactor trip and then increase to the hot standby level. Level may then remain constant or increase somewhat based on automatic or manual control of feedwater.

FIGURE 5-13
REPRESENTATIVE SMALL BREAK LOCA
REACTOR POWER

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 5-14

REPRESENTATIVE SMALL BREAK LOCA

RCS HOT LEG TEMPERATURE

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 5-15

REPRESENTATIVE SMALL BREAK LOCA

RCS COLD LEG TEMPERATURE

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 5-16

REPRESENTATIVE SMALL BREAK LOCA

PRESSURIZER PRESSURE

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 5-17

REPRESENTATIVE SMALL BREAK LOCA

PRESSURIZER LEVEL

FIGURE 5-18
REPRESENTATIVE SMALL BREAK LOCA
REACTOR VESSEL LEVEL

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 5-19

REPRESENTATIVE SMALL BREAK LOCA

SECONDARY SIDE PRESSURE

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 5-20

REPRESENTATIVE SMALL BREAK LOCA

STEAM GENERATOR WIDE RANGE LEVEL

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

Guideline Strategy and Information Flow

Figure 5-21 provides a summary of the LOCA Recovery Guideline's strategy. If a LOCA is initiated from MODE 1 or MODE 2, the operator performs the Standard Post Trip Actions and diagnoses the event prior to entering the LOCA Recovery Guideline. However, if the event is initiated from MODE 3 or MODE 4, the operator is not directed to the Standard Post Trip Actions since they may not apply. Instead, the operator ensures that the LOCA is properly diagnosed and that the specified entry conditions are met prior to entering the LOCA Recovery Guideline. Once in the LOCA Recovery Guideline, the operator would have performed the Standard Post Trip Actions and diagnosed the event. In the LOCA Recovery Guideline, the operator begins using the Safety Function Status Check to confirm that the plant is recovering. The next steps can be broken into six major recovery actions.

The six major recovery actions bring the plant to a stable condition which can be maintained indefinitely. The first major action consists of maximizing safety injection flow into the RCS and attempting to isolate the source of the leak. This step reduces the risk of core uncovery and facilitates recovery from the LOCA. The second and third major actions apply to the situation when the leak has been isolated. The second major action involves regaining control of the RCS pressure and inventory and maintaining sufficient RCS heat removal. The third major action is to perform a controlled cooldown to the SCS entry conditions. The fourth through sixth major recovery actions are applicable to the situation when the leak cannot be isolated. The fourth major action involves a rapid plant cooldown using the SGs. This step is particularly important for small breaks which require the SGs to remove the core decay heat. The fifth major recovery action is the commencement of post-LOCA Long Term Cooling (LTC). Safety injection flow is switched to simultaneous hot/cold leg injection from the normal cold leg injection. Also, the suction for the charging pumps is switched to the [refueling water tank] for boron concentration control. The sixth major action is a determination of whether SCS operation is appropriate (small breaks) or whether simultaneous hot/cold leg injection in a recirculation mode should be continued (large breaks).

A more detailed chart illustrates the recovery guideline strategy and lists the guideline steps which correspond to each strategy objective. Refer to Figure 5-24.

FIGURE 5-21A

LOSS OF COOLANT ACCIDENT STRATEGY CHART

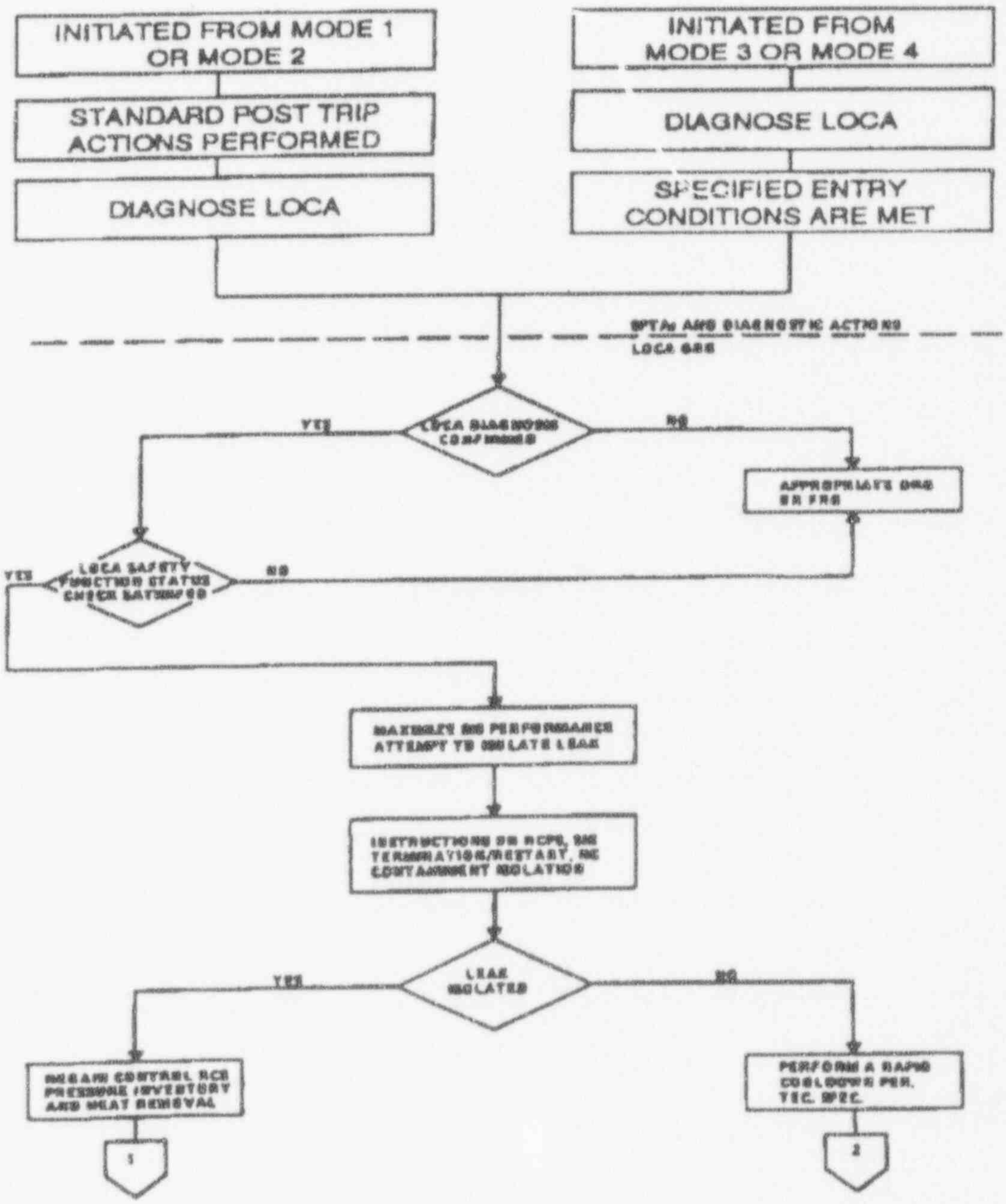
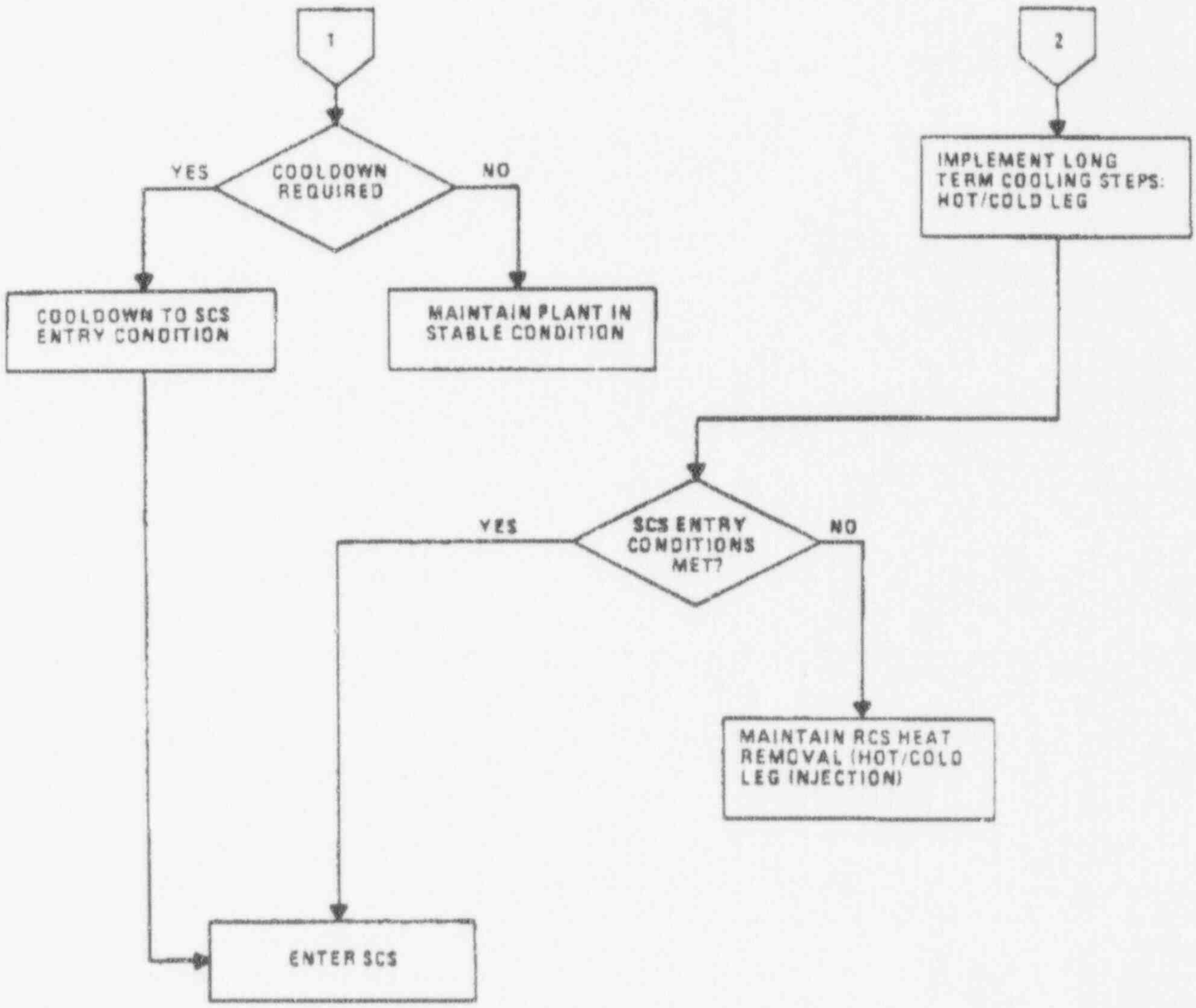


FIGURE 5-21B

LOSS OF COOLANT ACCIDENT STRATEGY CHART



Bases for Operator Actions

The operator actions are directed at placing the plant in a safe, stable condition. One of two paths is followed, depending upon whether or not the break has been isolated.

1. The diagnosis of a Loss of Coolant Accident should be confirmed by using the Break Identification Chart (Figure 5-2) and by comparing control board parameters to the acceptance criteria in the Safety Function Status Check to ensure that all safety functions are being satisfied. In particular, the operator should note the status of RCS subcooling and containment and steam plant activity. These parameters provide a means of discriminating between LOCAs/SGTRs and ESDEs. For LOCAs, the RCS reaches saturation conditions and containment activity monitors may be alarming but steam plant activity monitors should not be alarming. For a SGTR, steam plant activity monitors may be alarming but containment activity monitors should not be alarming. For ESDEs, neither steam plant or containment activity monitors should be alarming. For plants which exhibit SG tube leakage, however, steam plant or containment activity monitors may alarm during ESDEs. [Sampling both steam generators for activity will assist in confirming the diagnosis.] These actions ensure the proper guideline is being used to mitigate the effects of a LOCA.

   If the initial diagnosis of a LOCA is confirmed, then the operator continues with the actions of this guideline. However, if the Break Identification Chart indicates that a SGTR or an ESDE has occurred, then the LOCA Guideline is exited and the actions of the proper guideline are implemented. This step allows the operator to switch to the proper guideline for those events similar to LOCAs which may have occurred. LOCAs, ESDEs, and SGTRs have similar initial symptoms and could be confused early in the event.

   If a correct diagnosis cannot be made, then the operator is directed to exit this guideline and to implement the Functional Recovery Guideline. The

Functional Recovery Guideline is safety function based and will ensure that all safety functions are addressed regardless of what event(s) is occurring.

* 2. If pressurizer pressure decreases to or below the SIAS setpoint of [1825 psia], then an SIAS should be initiated automatically. If this does not occur, then the operator should manually initiate an SIAS.

* 3. A LOCA will result in the actuation of the safety injection system. Pressurizer pressure will respond during the accident according to the break size. Safety injection system (SIS) flow rate will follow pressurizer pressure according to the SIS delivery curves (see Figure 5-3). The SIS and charging flowrate should be checked (Figure 5-3 provides information which can be utilized to verify adequate SIS flow is occurring) and maximized for RCS inventory replenishment and/or core heat removal. The charging pump may have to be manually restarted if an interruption of electrical power to the charging pump bus has occurred. The following guidance will assist in ensuring maximum injection of water into the RCS:

   a. idle SI pumps should be started and system flow should be verified to be within the limits of Figure 5-3,
   b. The charging pump should be started, if necessary.

   If any SI pump that should be operating won't start, any charging pump won't start, or SIS flow is not in accordance with Figure 5-3, then the following guidance is provided:

   a. the operator should verify that electrical power is available to valves and pumps necessary for inventory control,
   b. the SIS valve lineup should be verified to be correct from control board indications,
   c. auxiliary systems necessary for SIS or charging operation should be checked.

It must be noted, however, that the maximization of charging and safety injection can result in excess RCS inventory, possible filling of the pressurizer to a solid condition, and a PTS concern upon RCS heat up, fluid expansion, and subsequent RCS pressure excursion. Operators must be aware of these concerns and terminate the SIS operation when the termination criteria are met.

* 4. Steps 4 and 5 contain guidance regarding the RCP operating strategy for a LOCA (FIGURE 5-22). A generic RCP trip strategy has been developed which results in the tripping of all four RCPs for depressurization events where RCS is not subcooled, but allows the continued operation of two RCPs (in opposite loops) for depressurization events where RCS is subcooled. For undiagnosed events, where the Functional Recovery Guideline is implemented, the RCP trip strategy is identical to that followed in the LOCA guideline. Steps 5 and 6 detail the two significant operational aspects regarding the RCP trip strategy for a LOCA. (Reference 15.22)

The first operational strategy results in the operator tripping two RCPs (in opposite loops) if pressurizer pressure decreases to less than [1300 psia] following a SIAS and RCS is subcooled. This action may occur in the Standard Post Trip Actions and, in this case, the operator would simply verify that two RCPs (in opposite loops) have been tripped. The operator trips all four RCPs if pressurizer pressure decreases to less than [1400 psia] following a SIAS and RCS is not subcooled. If the operator cannot confirm that a LOCA has occurred, and the Functional Recovery Guideline is implemented, the RCP trip strategy is identical to that followed in the LOCA guideline.

If the depressurization event can be diagnosed and is determined to be other than a LOCA (i.e., ESDE or SGTR), then only two RCPs (in opposite loops) are tripped. The other two RCPs remain operational until one or more of the RCP operating requirements (e.g., NPSH, temperatures, seal flow, oil pressures, motor amperage, vibration) are no longer satisfied, then, any pump which does not satisfy these requirements should be tripped. This gives the operator maximum flexibility in plant control because a normal plant cooldown can be performed while still ensuring a conservative approach to event recovery.

* 5. The second aspect of the RCP operating strategy concerns the verification that RCP operating limits are satisfied. The RCPs will be operating in a pressure-reduced RCS and may not satisfy NPSH requirements. The operator must continuously monitor RCP operating limits (e.g., temperatures, seal flow, oil pressures, NPSH, motor amperage, vibration) and trip any RCPs which do not satisfy RCP operating limits. Plant specific RCP operating limits should appear in this step, either directly or, by referencing the applicable operating instructions.

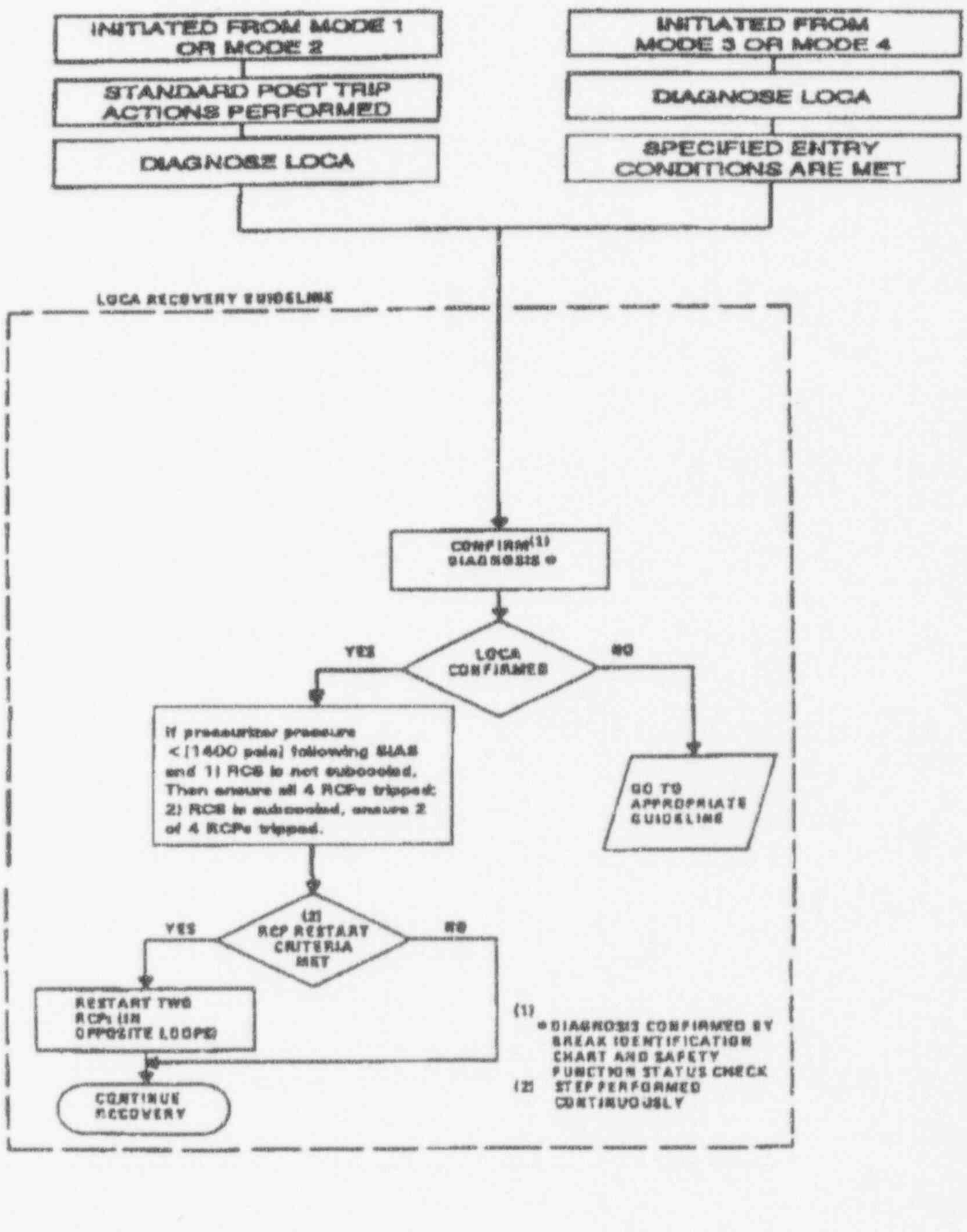
6. The operator records the time of day, since some of the follow-up actions need to be performed within a defined time window relative to the start of the accident.

7. Potential sources of leakage which can be rapidly and remotely isolated are checked and isolated, if possible, to minimize RCS inventory losses and to attempt to isolate the break. The following guidance is provided to isolate the leak:

   a. Letdown is isolated to possibly isolate the break and to preclude loss of RCS inventory to the CVCS.
   b. RCS sampling should be terminated and all sampling lines should be isolated. If necessary, this isolation should be performed manually. Isolating sampling lines minimizes the possibility of inadvertent personnel exposure, and minimizes RCS inventory losses.

FIGURE 5-22

RCP TRIP STRATEGY FOR LOCA



c. RCS to CCW leakage should be detected by the CCW radiation monitor. An increase in CCW surge tank level may also be an indication of reactor coolant to CCW in-leakage. An increased CCW heat load, possibly caused by high containment temperatures will also cause surge tank level to rise to the point where an abnormally high level increase may possibly be discerned. If RCS to CCW leakage is evident, then isolate the CCW affected RCPs and trip affected operating RCPs.

d. The rapid depressurization valves should be verified closed. If they are not closed, the operator should manually close the rapid depressurization valves. This will minimize the loss of inventory through these valves.

e. Another potential leak path is the reactor coolant gas vent valves. The operator should verify these valves are closed and if necessary, manually close the valves.

8. A LOCA outside of containment is a very low probability event but if it does occur, and appropriate actions are not taken, the consequences can be severe. In this step, the nuclear annex temperature, humidity, and radiation alarms and sump levels and subsphere sump levels are monitored for indications that RCS fluid has breached containment. If it is evident that a LOCA is occurring outside of containment, then an attempt to locate and isolate the break should be made, if possible. Plant-specific instructions for isolating the nuclear annex and its ventilation systems should be inserted here. This is provided to limit the release of fission products to the environment.

* 9. If containment pressure is greater than or equal to [2.7 psig], then the operator ensures the following:

a. The operator verifies that containment isolation occurs at the appropriate automatic setpoint. If containment isolation does not occur automatically or all containment isolation valves are not in their accident positions, then the operator should manually initiate containment isolation. The plant-specific method of manual containment isolation inserted here. The purpose of this step is to prevent direct communication between the containment atmosphere and the environment. Operators should be alert to the loss of auxiliaries to the containment (in particular component cooling water) which may occur with containment isolation. Re-establishing letdown should also be considered if it is available. This will enable the operator to better control RCS inventory during a possible RCS heatup and subsequent fluid expansion. This action can minimize the possibility of PTS.

b. The containment recirculation fan coolers must be initiated to minimize the pressure and temperature in the containment. High pressure in the containment may pose a threat to containment integrity. Furthermore, high containment temperature adversely impacts the accuracy of instruments whose transmitters are located inside containment (e.g., pressurizer level and pressure, steam generator pressure and level, RCS loop RTDs) and may impact the continued availability of equipment located in containment. The effect of temperature on hydrogen generation (by corrosion reactions) is described in the bases of step 10.

*10. The containment spray system is automatically actuated at a containment pressure of [8.5 psig] or greater. If containment pressure reaches [8.5 psig], then the operator should ensure containment spray actuation. In order to maintain containment pressure below design pressure, there exists redundant containment spray systems each capable of delivery [5000 gpm].

When containment sprays are actuated, the conditions created in the containment may generate hydrogen. Hydrogen may be generated by the reaction of boric acid (from containment spray flow) and metals in the containment. Aluminum and zinc are two metals which are reactive with boric acid. The reaction rates of boric acid and aluminum and zinc are a function of temperature. Therefore, if the containment spray system has been spraying boric acid onto zinc and aluminum surfaces in a high temperature environment, then conditions exist for the generation of hydrogen in the containment.

The operator should take action to place external hydrogen recombiners in service to minimize the hydrogen concentration. The operator should also verify the annulus ventilation system and the subsphere building ventilation system are operating. If it is not, the system should be manually started.

*11. Containment spray system operation may be terminated when containment pressure has been reduced to an acceptable level. Continued operation of the sprays after pressure has been reduced to an acceptable level increases the possibility of wetting electrical connectors which may result in electrical grounds, shorts and other malfunctions. Therefore, if containment sprays have actuated and containment pressure is reduced below [5.5 psig], then containment spray may be terminated. After terminating containment spray, the containment spray system should be realigned for automatic [or manual] operation in case containment pressure again increases to the actuation setpoint. In addition, when the containment spray system operation is terminated, the annulus ventilation system should be secured.

12. Subsequent operator actions and performance of the containment combustible gas control portion of the Safety Function Status Check will require measurement of the containment hydrogen concentration. The hydrogen monitors should be placed in service in order to enable the operator to monitor containment hydrogen concentration. [The actions required for operation of the hydrogen monitors should be performed concurrent with the following steps] (Reference 15.16.)

*13. Although hydrogen is not flammable until it achieves a concentration of at least 4%, it is prudent to reduce hydrogen to as low a concentration as possible. (i.e., less than the minimum detectable hydrogen concentration of [0.5%].) Such action minimizes the possibility of reaching the flammability limit and of forming pockets of high concentration hydrogen. Therefore, the [hydrogen recombiners] should be run until hydrogen concentration is reduced to less than [0.5%]. The recombiners take approximately [1 hour] to reach operating temperature so no decrease in measured hydrogen concentration should be expected before this time.

*14. Containment radiation levels should be monitored in order to provide the [Plant Technical Support Center] input to evaluate the environmental impact of any planned, or unplanned releases.

15. At this point in the guideline, the operator will pursue one of two strategy paths. If the LOCA has not been isolated, the operator is directed to follow the path which contains recovery actions for that condition (steps 16 through 36). If the leak or rupture has been isolated, the operator is directed to perform those steps aimed at stabilizing the plant (steps 37 through 55).

16. If the LOCA has not been isolated, then the following actions are directed toward re-establishing RCS inventory control while maintaining RCS heat removal. The goal of this section is to establish shutdown cooling, if possible, as the means of core heat removal. A rapid plant cooldown via the steam generators is beneficial for all LOCAs, particularly small breaks. For small breaks, the steam generators are the major heat sink for RCS heat removal. An aggressive cooldown (while holding the cooldown rate within Technical Specification Limitations) improves RCS heat removal by enhancing natural circulation and reflux boiling. Furthermore, an aggressive cooldown hastens the depressurization of the RCS. This results in higher safety injection flows which aid in regaining RCS inventory control. Figure 5-3 shows typical SIS flowrates as a function of RCS pressure.

For the largest breaks, the RCS depressurizes to an equilibrium pressure with the containment. In this condition, the RCS fluid is at a lower temperature than that of the steam generators. The steam generators, therefore, act as a heat source, superheating any steam in the RCS which may be flowing through the S/Gs to the break. By cooling down the steam generators, heat input to the RCS is reduced.

The turbine bypass system or the atmospheric dump valves are utilized depending on the availability of the condenser and turbine bypass system.

*17. Steam generator level should be maintained in the normal band using main, startup or emergency feedwater. This ensures that a heat sink is available for RCS heat removal and cooldown. This is especially important in the case of a small break LOCA (Reference 15.9). Maintaining steam generator in the normal band also ensures that the steam generator tubes remain covered. By maintaining level above the top of the tubes, sufficient static pressure head will be available to prevent migration of containment radioactivity through pre-existing tube defects to the secondary side of the steam generator in the long term. This minimizes the release of radioactivity to the atmosphere.

*18. The available emergency feedwater inventory should be monitored and replenished from available sources as necessary to continually provide a source for a secondary heat sink. Examples of alternate sources of condensate are nonseismic tanks, fire mains, lake water supplies, potable tanks, etc. Plant specific alternate sources of feedwater should be identified and cited in the procedure. The emergency feedwater required to either maintain the plant at hot standby or to cooldown may be determined from Figures 5-4 and 5-5.

*19. Once pressurizer level has been restored to greater than or equal to [2%], then level should be maintained [2 to 78%] by control of charging and letdown (preferentially) as necessary, and the SIS. If SIS termination criteria are met, then SI pumps may be throttled or stopped. When pressurizer level is being controlled at [2%] or greater, than charging pumps may be operated as necessary. If pressurizer level is not restored to [2%], then all available charging and SIS pumps should be operated for maximum flow.

FIGURE 5-23

POST H_2 BURN CHARACTERISTICS

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

A pressurizer level of [2 to 78%] with a saturated bubble n the pressurizer should be established if possible, as the means of RCS pressure control. If pressurizer level drops below the top of the pressurizer heaters, then pressurizer heater operation will be interlocked off for overheating protection. It may be necessary to exceed [78%] pressurizer level if the operator is attempting to restore RCS subcooling since pressurizer heaters may be unavailable and solid water operation may be necessary to restore subcooling.

20. For small break LOCAs, especially where RCS inventory and pressure are controlled, a deliberate depressurization of the RCS will be necessary to permit entry into shutdown cooling. This step directs a depressurization to SCS entry pressure, [450 psia], and provides the available depressurization success paths-depending on existing plant conditions. For large breaks, all that may be required to depressurize to or below [300 psia] is throttling of SIS flow (if SIS termination criteria are met).

*21. Throughout the cooldown and depressurization, the operator should verify that the pressurizer pressure is being maintained within the Post Accident P-T limits of Figure 5-1. If the Pressure-Temperature limits of Figure 5-1 are being violated, then the operators should take actions to restore the RCS to within the P-T limits. Depending on the situation (pressure too high or too low), the operator should perform the following actions as appropriate:

a. Stop the cooldown
b. Operate main or auxiliary spray or reactor coolant gas vent system as necessary to restore pressurizer pressure to within the P-T limits of Figure 5-1.
c. Attempt to maintain the plant in a stable pressure-temperature configuration. If low RCS subcooling exists, then the cooldown should be continued if desired, within the limits of Figure 5-1.
d. If an overpressure situation exists and is caused by SI and/or charging flow, then throttle or stop SI (refer to Step 31) or charging pumps and

manually control letdown to restore and maintain pressure within the Post Accident P-T limits of Figure 5-1.

*22. The plant conditions should be carefully assessed before any RCPs are restarted. The need for forced circulation operation should be balanced against the risk of damage to the RCP seals.

The need for operation of the RCPs should be evaluated based on:

a. the adequacy of the RCS and core heat removal under the existing natural circulating conditions,
b. the existing RCS pressure and temperatures,
c. the need for main pressurizer spray capability.

If the existing natural circulation is providing satisfactory RCS and core heat removal, a transfer to forced circulation operation may not be necessary. This would be particular true if the RCS had already been cooled and depressurized to SCS entry conditions. If the RCS pressure and temperatures are closer to hot standby conditions, it may be desirable to restart the RCPs in order to allow a normal forced circulation cooldown. Consideration should also be given to the necessity of having main pressurizer spray capability if auxiliary spray is not providing the desired depressurization rate.

The potential for RCP seal degradation should be evaluated based on:

a. how long [CCW] to the RCPs was interrupted,
b. RCP seal staging pressures and temperatures.

The possibility of seal degradation increases if the CCW has been interrupted for longer than 10 minutes. The seal staging pressures provide an indication of degraded seal stages (a low pressure drop across a stage indicates a problem). Restart of an RCP with one or more degraded seal stages should be avoided if possible.

*23. If RCP restart is to be attempted, then select two RCPs (in opposite loops) for operation, if RCP restart criteria are met. This will ensure continued forced circulation of coolant through the core, cooling of the RV head region, provide the capability for the normal mode of pressurizer spray, condense RCS steam voids, and remove non-condensible gases from the S/G tube bundle. Furthermore, this action enhances the strategy to obtain an uncomplicated cooldown whenever possible during a recovery from a LOCA. However, only one reactor coolant pump in each loop should be operated to minimize heat input to the RCS.

Determine whether RCP restart criteria are met by the following:

a. Electrical power available to the RCP bus,
b. RCP auxiliaries (In particular component cooling water) to maintain seal injection, bearing, and motor cooling should be operating in order to prevent damage to the pump and/or motor. (Note: [Following automatic or operated initiated containment isolation, reinstatement of one of the following means of RCP seal cooling ([CCW], [CVCS seal injection (SI)], [Dedicated Seal Injection System (DSIS)], should be considered to ensure adequate RCP cooling. There should be no high temperature alarms on the RCPs to be operated.
c. At least one steam generator is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow is available for removing heat from the RCS.
d. Pressurizer level is greater than [33%] and not decreasing. A pressurizer level above [33%] provides the operator with a margin for maintaining plant control during a LOCA. A level of [33%] provides a margin above the heaters to offset the possible pressurizer level decrease due to loop shrinkage and/or steam void condensation.
e. The RCS is subcooled based on representative CET temperature. A subcooled condition, taken in conjunction with (d) above, indicates that adequate inventory control has been established.

f. All plant specific RCP operating criteria should be satisfied before the RCPs are restarted to prevent damage to RCPs resulting from abnormal operating conditions.

g. Condensate that flows to the core on the cold side is depleted in boron and may collect in the RCP loop seals and cold leg. The RCPs should not be started until after single phase natural circulation has slowly moved this boron depleted coolant through the core. Twenty minutes of single phase natural circulation is considered adequate circulation and mixing time.

*24. Upon restarting two RCPs in opposite loops, pressurizer level and pressure may decrease due to loop shrinkage and/or steam void condensation. It is possible that this action will drain the pressurizer. Steam voids present in the reactor vessel will condense upon restarting RCPs. The HJTC RVLMS should be monitored for the trending of reactor vessel liquid level. This trending information may be correlated to pressurizer level decrease. RCP operation with a drained pressurizer may continue provided certain actions are taken and certain criteria are satisfied.

The following constitutes the actions to be taken, and the criteria to be satisfied, when restarting RCPs:

a. Start one RCP in each loop.

b. Ensure proper RCP operation by monitoring RCP amperage and pump NPSH. NPSH is determined by pressurizer pressure and corresponding T_c on Figure 5-1.

c. Operate charging (and SI) pumps to restore and maintain pressurizer level greater than [33%]. If SI pumps are operating, continue their operation until SIS termination criteria are met (refer to step 27). This action will ensure that pressurizer heaters remain covered.

*25. If all RCP operation is terminated and inventory and pressure are controlled, then natural circulation is monitored by heat removal via at least one steam generator. Natural circulation flow should occur within 5-15 minutes after the RCPs were tripped.

The operator has adequate instrumentation to monitor natural circulation for the single phase liquid natural circulation process. The RCS temperature instrumentation, namely loop ΔT, can be used along with the other information to confirm that the single phase natural circulation process is effective. The natural circulation process involving two phase cooling is complex and varied enough so that RCS loop ΔT may not be a meaningful indication of adequate natural circulation cooling. The guidelines are written to alert the operator to use explicit acceptance criteria for natural circulation only when RCS inventory and pressure are controlled.

The RCS temperature response during natural circulation will be slow (5-15 minutes) as compared to a normal forced flow system response time of 6-12 seconds, since the coolant loop cycle time will be significantly larger.

When single phase natural circulation flow is established in at least one loop, the RCS should indicate the following conditions:

a. Loop ΔT (T_H - T_c) less than normal full power ΔT,
b. Hot and cold leg temperatures constant or decreasing,
c. RCS is subcooled based on representative CET temperature.
d. No abnormal differences between T_H RTDs and core exit thermocouples. Hot leg RTD temperature should be consistent with the core exit thermocouples. Adequate natural circulation flow ensures that core exit thermocouple temperatures will be approximately equal to the hot leg RTDs temperature within the bounds of the instrument's inaccuracies. An abnormal difference between T_H and the CETs is greater than [10°F].

Natural circulation is governed by decay heat, component elevations, primary to secondary heat transfer, loop flow resistance, and voiding. Component elevations on C-E plant are such that satisfactory natural circulation decay heat removal is obtained by fluid density differences between the core region and the steam generator tube sheet.

As a contingency, if the criteria listed are not met, then natural circulation in the RCS is not effectively transferring heat from the core to the steam generators. Both RCS and Core Heat Removal Safety Functions may become jeopardized if any of the above criteria continue to be violated. Operators should ensure that RCS pressure and inventory, and SG steaming and feeding are being controlled properly to prevent violation of a safety function (Reference 15.11).

*26. During a LOCA, the natural circulation process can take different forms. These forms include single phase natural circulation and a more complex two phase natural circulation. The simplest form of natural circulation is a single phase liquid cooling. Single phase natural circulation is possible for most cases where RCS inventory and pressure are being controlled properly. Single phase cooling transports heat using the same flow path involved in forced circulation cooling with the liquid density difference between SG and RV driving the flow. Two phase natural circulation is more complex and can take several forms. Two phase natural circulation depends on the amount of decay heat, the amount of inventory and pressure control degradation, the RCS leak rate, and the status of the SIS and the steam generators. One form of two phase natural circulation is known as reflux. In the reflux process, steam leaves the core region and travels to the steam generator before reaching the top of the "U" tubes where it condenses and the condensate flows back to the core via the hot leg where it is once again turned to steam. Another two phase natural circulation process is similar to reflux, but differs in that the steam from the core goes past the steam generator "U" bend and is condensed in the tubes on the cold leg side and the condensate flows back to the core via the cold leg. A combination of the two processes is also possible.

The operators have adequate instrumentation to monitor natural circulation for the single phase liquid natural circulation process. The RCS temperature instrumentation, namely loop ΔT, can be used along with other information to confirm that the single phase natural circulation process is effective. The natural circulation processes involving two phase cooling are complex and varied enough so that RCS loop ΔT may not be a meaningful indication of adequate natural circulation cooling.

For cases where two phase natural circulation cooling is the core heat removal process, establishing heat removal via at least one steam generator utilizing main, startup or emergency feedwater and steam discharge through the atmospheric dump valve becomes more critical. The monitoring of representative CET temperatures, to confirm the adequacy of the heat removal process, also becomes a critical indicator of natural circulation cooling (Reference 15.9).

If RCS subcooling cannot be maintained, then the core heat removal process will be maintained utilizing two-phase natural circulation and flow through the break. If two phase natural circulation is utilized the operators must ensure that the following are observed:

a. The charging pumps and available SI pumps are operating and adequate flow per Figure 5-3,

<u>and</u>

b. steam generator feeding and steaming are properly controlled (refer to Steps 16 and 17.)

<u>and</u>

c. the representative CET temperature is maintained less than superheated. A superheated condition indicates that core uncovery has occurred and that the core heat removal process is no longer effective.

*27. If the SI pumps are operating, then they must continue to operate at full capacity until SI termination criteria are met. Termination of SI should be sequenced by stopping one pump at a time while observing the termination criteria. Throttling of SI flow is also permissible if all of the following SI termination criteria are satisfied:

a. RCS is subcooled based on representative CET temperature (Figure 5-1). Establishing subcooling ensures the fluid surrounding the core is subcooled which ensures heat transfer to the RCS inventory. Voids may exist in some parts of the RCS (e.g., reactor vessel head as determined by the HJTC RVLMS), but these are permissible as long as core heat removal is maintained.

b. Pressurizer level is greater than [33%] and not decreasing. A pressurizer level greater than [33%] and not decreasing, in conjunction with criterion a) above, is an indication that RCS inventory control has been established.

c. At least one steam generator is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow is available for removing heat from the RCS.

d. The HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles. This provides an extra margin of core coverage and, taken in conjunction with the above, serves as an additional indication that adequate RCS inventory control has been established.

If all of the SI termination criteria are met, then the operator may either stop or throttle the SI pumps. The operator may decide to throttle, rather than terminate the flow, if the SIS is to be used to control pressurizer level or plant pressure. A general assessment of the SIS performance can be made from the control room.

The operator should confirm that at least one train and preferably both trains of SI are operating and that system delivery rate is consistent with RCS pressure as shown in Figure 5-3. Injection flow rates to each cold leg should be approximately equal. Departures from this would indicate a closed flow path or some system leakage.

*28. If the criteria of step 27 cannot be maintained after the SIS pumps are throttled or stopped, then the appropriate SIS pumps should be restarted and full SIS flow restored.

*29. The operator should monitor In-containment Refueling Water Storage Tank (RWT) level. For RCS breaks inside containment, a decreasing trend in [IRWST] level should correspond to an increasing trend in Holdup Volume Tank (HVT) or Reactor Cavity sump level. This action enables the operator to trend [IRWST] level and to anticipate possible problems (LOCA is outside of containment). If a decreasing trend in [IRWST] level cannot be correlated to an increasing HVT or reactor cavity sump level, then the LOCA may be outside of containment. For LOCAs outside containment, [IRWST] level should be replenished from available sources. This will prevent the inadvertent air binding of the SI pumps.

30. During a controlled cooldown and depressurization the automatic initiation of an MSIS is undesirable, particularly when primary to secondary heat transfer via the steam generators is a necessary method of heat removal. Therefore, the MSIS setpoint must be manually reset as the cooldown progresses to ensure that automatic engineered safeguards protection for an MSIS remains available until the RCS is cooled down and depressurized.

31. During plant cooldown and depressurization, it may be necessary for the operators to vent the Safety Injection Tanks (SITs) at a pressure above the maximum SIT pressure to prevent inadvertent SIT injection. This allows the operator to maintain control of the RCS inventory. In addition, it may be desirable for the operators to have the SITs available for injection at a lower pressure during lower mode operations. Therefore, this step instructs the operator to reduce the SIT pressure to [300 psia] to prevent inadvertent injection but maintain its availability during lower mode operations.

*32. When pressurizer pressure reaches [445 psia] the safety injection tanks (SITs) must be vented, drained, or their discharge valves shut to prevent the nitrogen cover gas from being discharged into the RCS when RCS pressure is reduced below the SITs pressure during a controlled cooldown. For a large break LOCA, this step will not be applicable because SITs will have discharged as designed to maintain adequate inventory for heat removal.

*33. Low temperature overpressurization protection (LTOP) is instituted at T_c 259°F to protect against subjecting the RCS pressure boundary to low temperature brittle fracture.

34. If the SI throttle/stop criteria can be satisfied, then there is no need to initiate simultaneous hot and direct vessel injection. This step directs the operator to skip step regarding hot and direct vessel injection.

*35. If shutdown cooling system operation cannot be initiated, then simultaneous hot and direct vessel injection is used for both small break and large break LOCAs at [2-4] hours after the start of the LOCA. In this mode, the SI pump discharge lines are realigned so that the total injection flow is divided equally between the hot leg and the reactor vessel. Simultaneous injection into the hot lege and reactor vessel is used as the mechanism to prevent the precipitation of boric acid in the reactor vessel following a break that is too large to allow the RCS to refill.

Injecting to both sides of the reactor vessel ensures that fluid from the reactor vessel (where the boric acid is being concentrated) flows out of the break regardless of the break location and is replenished with a dilute solution of borated water from the other side of the reactor vessel. The action is taken no sooner than [2 hours] after LOCA since the fluid injected to the hot leg may be entrained in the steam being released from the core and hence possibly diverted from reaching the reactor vessel. After [2 hours], the core decay heat has dropped sufficiently so that there is insufficient steam velocity to entrain the fluid being injected to the hot leg. The action is taken no later than [4 hours] after the LOCA in order to ensure that the buildup of boric acid is terminated well before the potential for boric acid precipitation occurs. Even though the action is required only for large breaks, it is taken for any LOCA so that the operator need not be required to distinguish between large and small break LOCAs. Simultaneous hot and cold leg injection is not required for small breaks because the buildup of boric acid is terminated when the RCS is refilled. Once the RCS is refilled, the boric acid is dispersed throughout the RCS via natural circulation. If entry into shutdown cooling system operation is anticipated before the [4 hour] limit, and the criteria of step 36 are met, then the realignment to hot/cold leg injection is unnecessary (Reference 15.17 and see detailed plant specific long term cooling analysis).

*36. For certain sized breaks (small breaks), entry into shutdown cooling may be possible and may be initiated if certain plant conditions exist.

a. pressurizer level control should be established and verified by a level greater than [14.3%] and constant or increasing,
b. RCS is subcooled,
c. RCS pressure should be at or below the shutdown cooling system entry pressure of [450 psia]
d. RCS hot leg temperature should be at or below the shutdown cooling system entry temperature of [400°F],
e. Before the SCS is operated, RCS activity levels must be determined since the RCS fluid will now be circulated outside of the containment building. The operator must decide whether to circulate high activity RCS coolant outside containment if high activity is present and such circulation has the potential for release to the environment. If the potential for significant releases exists, it may be more desirable to continue cooling with the steam generators.

If SCS operation is determined to be appropriate, then the SIS is aligned for cold leg injection and the SCS is initiated. The [Plant Technical Support Center or Plant Operations Review Committee] may approve changes to these procedures which accommodate the LOCA conditions.

If the RCS cannot be depressurized, then voiding may be causing RCS pressure to remain high. Any time it is found that voiding inhibits RCS depressurization to SCS entry pressure, when SCS operation is desired, then an attempt at elimination of the voiding should be made.

The operator should continuously monitor for the presence of voids. Voiding in the RCS may be indicated by any of the following indications, parameter changes, or trends:

a. letdown flow greater than charging flow,
b. pressurizer level increasing significantly more than expected while operating pressurizer spray,
c. the HJTC RVLMS indicates that voiding is present in the reactor vessel,
d. HJTC unheated thermocouple temperature indicates saturated conditions in the reactor vessel upper head,

If voiding should be eliminated, then proceed as follows:

a. letdown is isolated or verified to be isolated to minimize further inventory loss,
b. the depressurization is stopped to prevent further growth of the void,
c. pressurizing and depressurizing the RCS within the limits of Figure 5-1 may condense the void. Pressurizing has the effect of filling the voided portion of the RCS with cooler fluid which will remove heat from the region. Subsequent depressurization and a repeating of this process several times will cool and condense the steam void. In the case of a void in the reactor vessel, the pressurization/ depressurization cycle will produce a fill and drain of the reactor vessel. The pressurization/depressurization cycle may be accomplished using pressurizer heaters and spray (preferred method) or the SIS/charging system (alternative method). Monitor pressurizer level and the RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.
d. if indications of unacceptable RCS voiding continue, and voiding is suspected to exist in the steam generator tubes, then cool the steam generator (by steaming or blowdown, and/or feeding) to condense the tube bundle void. This will be effective for condensing steam voids but will not have an effect on non-condensible gases trapped in the tube bundle. A buildup of non-condensible gases in the tube bundles will not hinder natural

circulation event with a large number of the tubes blocked. This is due to the small amount of heat transfer area required for the removal of decay heat. Monitor pressurizer level for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

e. if indications of unacceptable RCS voiding continue, then voiding may be caused by non-condensible gases. Operate the [pressurizer vent and/or the] reactor coolant gas vent system to clear trapped non-condensible gases. Monitor pressurizer level and/or the RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

37. This step is the lead-in for the second flow path mentioned in step 15. The LOCA has been isolated and operator actions in the subsequent Steps (33 through 55) are performed to stabilize plant conditions for long-term recovery.

*38. If the SI pumps are operating, then they must continue to operate at full capacity until SI termination criteria are met (Reference 15.9). For most LOCAs, the SI pumps will run continuously for a long period of time while RCS inventory, pressure, and heat removal control are being regained. In some cases, control of these three safety functions is not regained during the accident (i.e., largest breaks) and the SI pumps run for the duration of the recovery period. Early termination is expected only when the SIAS was spurious, or if the leak was identified and promptly isolated.

Termination of SI should be sequenced by stopping one pump at a time while observing the termination criteria. Throttling of SI flow is also permissible if all of the following criteria are satisfied:

a) RCS is subcooled based on representative CET temperature (Figure 5-1). Establishing subcooling ensures the fluid surrounding the core is subcooled. Voids may exist in some parts of the RCS (e.g., reactor vessel head as determined by the HJTC RVLMS], but these are permissible as long as core heat removal is maintained.

b) Pressurizer level is greater than [14.3%] and not decreasing. A pressurizer level greater than [14.3%] and not decreasing, in conjunction with criterion a) above, is an indication that RCS inventory control has been established.

c) At least one steam generator is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow is available for removing RCS heat.

d) The HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles. This provides an extra margin of core coverage and, taken in conjunction with the above, serves as an additional indication that adequate RCS inventory control has been established.

If all of the SI termination criteria are met, then the operator may either stop or throttle the SI pumps. The operator may decide to throttle, rather than terminate the flow, if the SIS is to be used to control pressurizer level or pressure. A general assessment of the SIS performance can be made from the control room. The operator should confirm that the charging pump is operating and that at least one train, and preferably both trains, of SI are operating and that system delivery rate is consistent with RCS pressure as shown in Figure 5-3. Injection flow rates to each reactor vessel nozzle should be approximately equal; departures from this would indicate a closed flow path or some system spillage in addition to the LOCA.

*39. If the criteria of steps 38 cannot be maintained after SIS pumps throttled or stopped, then the appropriate SIS pumps should be restarted and full SIS flow restored.

*40. Pressurizer level should be restored and maintained at [2% to 78%] by control of charging and letdown (preferentially) as necessary, and SI pumps. If SIS termination criteria are met, then SI pumps may be throttled or stopped. When pressurizer level is being controlled at [2%] or greater, then the charging pump may be operated as necessary. A pressurizer level of [2% to 78%] should be restored and maintained to avoid losing pressure control with a saturated bubble in the pressurizer. If the pressurizer level drops below the top of the pressurizer heaters, pressurizer heater operation will be interlocked off for heater protection. It may be necessary to exceed [78%] pressurizer level if the operator is attempting to restore RCS subcooling, since pressurizer heaters may be unavailable and solid water operation may be necessary to restore subcooling.

*41. For small break LOCAs, especially where RCS inventory and pressure are controlled, a deliberate depressurization of the RCS will be necessary to permit entry into shutdown cooling. This step directs a depressurization to SCS entry pressure, [450 psia], and provides the available depressurization success paths-depending on existing plant condition. For large breaks, all that may be required to depressurize to or below [450 psia] is throttling SIS flow (if SIS termination criteria are met).

*42. Throughout the cooldown and depressurization, the operator should verify that the pressurizer pressure is being maintained within the Post Accident P-T limits of Figure 5-1. If the Pressure-Temperature limits of Figure 5-1 are being violated, then the operators should take actions to restore the RCS to within the P-T limits. Depending on the situation (pressure too high or too low), the operator should perform the following actions as appropriate:

a. Stop the cooldown
b. Operate the Reactor Coolant Gas Vent System or the main or auxiliary spray as necessary to restore pressurizer pressure to within the P-T limits of Figure 5-1.
c. Attempt to maintain the plant in a stable pressure-temperature configuration. If low RCS subcooling exists, then the cooldown should be continued if desired, within the limits of Figure 5-1.
d. If an overpressure situation exists and is caused by SI and/or charging flow, then throttle or stop SI (refer to Step 38) or charging pumps and manually control letdown to restore and maintain pressure within the Post Accident P-T limits of Figure 5-1.

*43. Steam generator level should be maintained in the normal band using main, startup or emergency feedwater. This ensures that a heat sink is available for RCS heat removal and cooldown. Maintaining steam generator in the normal band also ensures that the steam generator tubes remain covered. By maintaining level above the tope of the tubes, sufficient static pressure head will be available to prevent migration of containment radioactivity through pre-existing tube defects to the secondary side of the steam generator in the long term. This minimizes the release of radioactivity to the atmosphere.

*44. The available emergency feedwater inventory should be monitored and replenished from available sources as necessary to continually provide a source for a secondary heat sink. Examples of alternate sources of emergency feedwater are nonseismic tanks, fire mains, lake water supplies, potable tanks, etc. Plant specific alternate sources of feedwater should be identified and cited in the procedure. The emergency feedwater required to either maintain the plant at hot standby or cooldown may be determined from Figure 5-4 and 5-5.

*45. The plant should be borated per Technical Specification limits for reactivity control purposes. If letdown is not available, it may not be possible to borate the RCS to the cold shutdown RCS boron concentration prior to commencing the cooldown if there is limited makeup space available in the pressurizer. If this is the case, the operator should borate the RCS to the minimum shutdown margin corresponding to Tc (per Technical Specifications). During the cooldown, as RCS shrinkage provides more space in the pressurizer, the operator should borate to maintain the minimum shutdown margin until the cold shutdown boron concentration is achieved. Note that if a 75°F/hr. cooldown rate is maintained, charging pump capacity will not be able to keep pressurizer level constant during the initial stages of the cooldown. Therefore, pressurizer level will lower and additional space will be available in the RCS for boration.

46. An orderly cooldown to an RCS hot leg temperature of ≤ [400°F] using forced or natural circulation is performed in accordance with Technical Specification. One of the following methods should be utilized to reduce RCS temperature:

a. The preferred method for cooling the RCS is by discharging steam using the turbine bypass system. This method can only be implemented if the condenser is available.
b. If the condenser or turbine bypass system is not available, an RCS cooldown should be performed by dumping steam using the atmospheric steam dump valves.

*47. The plant conditions should be carefully assessed before any RCPs are restarted. The need for forced circulation operation should be balanced against the risk of damage to the RCP seals.

The need for operation of the RCPs should be evaluated based on:

a. the adequacy of the RCS and core heat removal under the existing natural circulating conditions,
b. the existing RCS pressure and temperatures,
c. the need for main pressurizer spray capability.

If the existing natural circulation is providing satisfactory RCS and core heat removal, a transfer to forced circulation operation may not be necessary. This would be particularly true if the RCS had already been cooled and depressurized to SCS entry conditions. If the RCS pressure and temperatures are closer to hot standby conditions, it may be desirable to restart the RCPs in order to allow a normal forced circulation cooldown. Consideration should also be given to the necessity of having main pressurizer spray capability if auxiliary spray is not providing the desired depressurization rate.

The potential for RCP seal degradation should be evaluated based on:

a. how long CCW to the RCPs was interrupted,
b. RCP seal staging pressures and temperatures.

The possibility of seal degradation increases if the CCW has been interrupted for longer than 10 minutes. The seal staging pressures provide an indication of degraded seal stages (a low pressure drop across a stage indicates a problem). Restart of an RCP with one or more degraded seal stages should be avoided if possible.

*48. If all RCPs have been stopped, then operation of two RCPs (in opposite loops) should be attempted, if RCP restart criteria are met. This will ensure continued forced circulation of coolant through the core, cooling of the RV head region, provide the capability for the normal mode of pressurizer spray, condense RCS steam voids, and remove non-condensible gases from the S/G tube bundle. Furthermore, this action enhances the strategy to obtain an uncomplicated cooldown whenever possible during a recovery from a LOCA. However, only one reactor coolant pump in each loop should be operated to minimize heat input to the RCS.

Determine whether RCP restart criteria are met by the following:

a. Electrical power available to the RCP bus.
b. RCP auxiliaries (in particular component cooling water) to maintain seal injection, bearing, and motor cooling should be operating in order to prevent damage to the pump and/or motor. (Note: [Following automatic or operated initiated containment isolation, reinstatement of one of the following means of RCP seal cooling ([CCW], [CVCS seal injection (SI)], [Dedicated Seal Injection System (DSIS)], should be considered to ensure adequate RCP cooling. There should be no high temperature alarms on the RCPs to be operated.
c. At least one steam generator is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow is available for removing heat from the RCS.
d. Pressurizer level is greater than [33%] and not decreasing. A pressurizer level above [33%] provides the operator with a margin for maintaining plant control during a LOCA. A level of [33%] provides a margin above the heaters

to offset the possible pressurizer level decrease due to loop shrinkage and/or steam void condensation.

e. The RCS is subcooled based on representative CET temperature. A subcooled condition, taken in conjunction with (d) above, indicates that adequate inventory control has been established.

f. All plant specific RCP operating criteria should be satisfied before the RCPs are restarted to prevent damage to RCPs resulting from abnormal operating conditions.

g. Condensate that flows to the core on the cold side is depleted in boron and may collect in the RCP loop seals and cold leg. The RCPs should not be started until after single phase natural circulation has slowly moved this boron depleted coolant through the core. Twenty minutes of single phase natural circulation is considered adequate circulation and mixing time.

*49. Upon restarting two RCPs in opposite loops, pressurizer level and pressure may decrease due to loop shrinkage and/or steam void condensation. It is possible that this action will drain the pressurizer. Steam voids present in the reactor vessel will condense upon restarting RCPs. The HJTC RVLMS should be monitored for the trending of reactor vessel liquid level. This trending information may be correlated to pressurizer level decrease. RCP operation with a drained pressurizer may continue provided certain actions are taken and certain criteria are satisfied.

The following constitutes the actions to be taken, and the criteria to be satisfied, when restarting RCPs:

a. Start one RCP in each loop.

b. Ensure proper RCP operation by monitoring RCP amperage and pump NPSH. NPSH is determined by pressurizer pressure and corresponding T_c on Figure 5-1.

c. Operate charging (and SI) pumps, and letdown as necessary to maintain pressurizer level greater than [14.3%]. If SI pumps are operating, continue their operation until SI termination criteria are met (refer to step 38). This action will ensure that pressurizer heaters remain covered.

*50. If all RCP operation is terminated and inventory and pressure are controlled, then natural circulation is monitored by heat removal via at least one steam generator. Natural circulation flow should occur within 5-15 minutes after the RCPs were tripped.

The operator has adequate instrumentation to monitor natural circulation for the single phase liquid natural circulation process. The RCS temperature instrumentation, namely loop ΔT, can be used along with the other information to confirm that the single phase natural circulation process is effective. The natural circulation process involving two phase cooling is complex and varied enough so that RCS loop ΔT may not be a meaningful indication of adequate natural circulation cooling. The guidelines are written to alert the operator to use explicit acceptance criteria for natural circulation only when RCS inventory and pressure are controlled.

The RCS temperature response during natural circulation will be slow (5-15 minutes) as compared to a normal forced flow system response time of 6-12 seconds, since the coolant loop cycle time will be significantly larger.

When single phase natural circulation flow is established in at least one loop, the RCS should indicate the following conditions:

a. Loop ΔT (T_H - T_c) less than normal full power ΔT,
b. Hot and cold leg temperatures constant or decreasing,
c. RCS is subcooled based on representative CET temperature.
d. No abnormal differences between T_H RTDs and core exit thermocouples. Hot leg RTD temperature should be consistent with the core exit thermocouples. Adequate natural circulation flow ensures that core exit thermocouple temperatures will be approximately equal to the hot leg RTDs temperature within the bounds of the instrument's inaccuracies. An abnormal difference between T_H and the CETs is greater than [10°F].

Natural circulation is governed by decay heat, component elevations, primary to secondary heat transfer, loop flow resistance, and voiding. Component elevations on C-E plant are such that satisfactory natural circulation decay heat removal is obtained by fluid density differences between the core region and the steam generator tube sheet.

As a contingency, if the criteria listed are not met, then natural circulation in the RCS is not effectively transferring heat from the core to the steam generators. Both RCS and Core Heat Removal Safety Functions may become jeopardized if any of the above criteria continue to be violated. Operators should ensure that RCS pressure and inventory, and SG steaming and feeding, are being controlled properly to prevent violation of a safety function.

51. During a controlled cooldown and depressurization, the automatic operation of certain safeguard systems is undesirable. Therefore, the setpoints for SIAS, and MSIS must be manually reset (lowered) as the cooldown progresses to ensure that automatic engineered safeguards protection remains available until the RCS is cooled down and depressurized.

52. During plant cooldown and depressurization, it may be necessary for the operators to vent the Safety Injection Tanks (SITs) at a pressure above the maximum SIT pressure to prevent inadvertent SIT injection. This allows the operator to maintain control of the RCS inventory. In addition, it may be desirable for the operators to have the SITs available for injection at a lower pressure during lower mode operations. Therefore, this step instructs the operator to reduce the SIT pressure to [300 psia] to prevent inadvertent injection but maintain its availability during lower mode operations.

*53. If pressurizer pressure reaches [445 psia] the safety injection tanks (SITs) must be vented, drained, or their discharge valves shut to prevent the nitrogen cover gas from being discharged into the RCS when RCS pressure is reduced below the SITs pressure during a controlled cooldown.

*54. Low temperature overpressurization protection (LTOP) is initiated at T_c < [259°F] to protect against subjecting the RCS pressure boundary to low temperature brittle fracture.

*55. For certain sized breaks (small breaks), entry into shutdown cooling may be possible and may be initiated if certain plant conditions exist.

a. pressurizer level control should be established and verified by a level greater than [14.3%] and constant or increasing,
b. RCS subcooling is subcooled,
c. RCS pressure should be at or below the shutdown cooling system entry pressure of [450 psia]
d. RCS hot leg temperature should be at or below the shutdown cooling system entry temperature of [400°F],
e. Before the SCS is operated, RCS activity levels must be determined since the RCS fluid will now be circulated outside of the containment building. The operator must decide whether to circulate high activity RCS coolant outside containment if high activity is present and such circulation has the potential for release to the environment. If the potential for significant releases exists, it may be more desirable to continue cooling with the steam generators.
f. Other plant specific prerequisites for SCS operation must be considered (e.g., component cooling water, instrument air and valve control power).

If SCS operation is determined to be appropriate, then the SIS is aligned for direct vessel injection and the SCS is initiated. The [Plant Technical Support Center or Plant Operations Review Committee] may approve changes to these procedures which accommodate the LOCA conditions.

If the RCS cannot be depressurized, then voiding may be causing RCS pressure to remain high. Any time it is found that voiding inhibits RCS depressurization to SCS entry pressure, when SCS operation is desired, then an attempt at elimination of the voiding should be made.

The operator should continuously monitor for the presence of voids. Voiding in the RCS may be indicated by any of the following indications, parameter changes, or trends:

a. letdown flow greater than charging flow,
b. pressurizer level increasing significantly more than expected while operating pressurizer spray,
c. the HJTC RVLMS indicates that voiding is present in the reactor vessel,
d. HJTC unheated thermocouple temperature indicates saturated conditions in the reactor vessel upper head,

If voiding should be eliminated, then proceed as follows:

a. letdown is isolated or verified to be isolated to minimize further inventory loss,
b. the depressurization is stopped to prevent further growth of the void,
c. pressurizing and depressurizing the RCS within the limits of Figure 5-1 may condense the void. Pressurizing has the effect of filling the voided portion of the RCS with cooler fluid which will remove heat from the region. Subsequent depressurization and a repeating of this process several times will cool and condense the steam void. In the case of a void in the reactor vessel, the pressurization/ depressurization cycle will produce a fill and drain of the reactor vessel. The pressurization/depressurization cycle may be accomplished using pressurizer heaters and spray (preferred method) or the SIS/charging system (alternative method). Monitor pressurizer level and the HJTC RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.
d. if indications of unacceptable RCS voiding continue, and voiding is suspected to exist in the steam generator tubes, then cool the steam generator (by steaming or blowdown, and/or feeding) to condense the tube bundle void. This will be effective for condensing steam voids but will not have an effect on non-condensible gases trapped in the tube bundle. A buildup of non-condensible gases in the tube bundles will not hinder natural

circulation event with a large number of the tubes blocked. This is due to the small amount of heat transfer area required for the removal of decay heat. Monitor pressurizer level for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

e. if indications of unacceptable RCS voiding continue, then voiding may be caused by non-condensible gases. Operate the Reactor Coolant Gas Vent System to clear trapped non-condensible gases. Monitor pressurizer level and/or the HJTC RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

When shutdown cooling system entry conditions are met, the LOCA guideline should be exited and SCS operation initiated per plant-specific operating instructions. The [Plant Technical Support Center or Plant Operations Review Committee] may have modified the SCS procedure or added special precautions to SCS operation because of the LOCA condition.

Safety Function Status Check

The Safety Function Status Check (SFSC) is used to continually verify the status of safety functions. The safety function acceptance criteria are selected from best estimate analysis to reflect the range for each parameter which would be expected following a Loss of Coolant Event. If all SFSC acceptance criteria are being satisfied, then the adequacy of this guideline for mitigating the event in progress is confirmed and the health and safety of the public is ensured.

SAFETY FUNCTION STATUS CHECK BASES
LOSS OF COOLANT ACCIDENT

The safety functions and their respective acceptance criteria listed below are those used to confirm the adequacy of the LOCA Guideline in mitigating the event.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
1. Reactivity Control	a. Reactor Power Decreasing and b. Negative Startup Rate and c. Maximum of 1 CEA NOT fully inserted or borated per Tech. spec.	For all emergency events, the reactor must be shutdown. The criterion that no more than one CEA bottom be stuck out or the RCS borated observes typical Technical Specification requirements.
2. Maintenance of Vital Auxiliaries (AC and DC power)	a. All vital Division I [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized, or All vital Division II [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized.	One vital AC division is required to power equipment necessary to maintain control of all other safety functions. One DC Division is required as a minimum to provide monitoring and limited control of the other safety functions.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
3. RCS Inventory Control	a. _If_ LOCA is isolated, _Then_ ensure: i) charging and letdown, and SIS flow (per Figure 5-3) maintaining or restoring pressurizer level [2% to 78%] (unless SIS termination criteria met). _and_ ii) the RCS is subcooled _and_ iii) the HJTC RVLMS indicates the core is covered _or_ b. _If_ LOCA _NOT_ isolated, _Then_ ensure: i) Available charging pump is operating and the SIS pumps are injecting water into RCS per Figure 5-3 _and_ ii) the HJTC RVLMS indicates the core is covered.	If LOCA is isolated pressurizer level should be restored to the band of [2% to 78%] by control of charging and letdown and SIS flow. SIS flow may be terminated or throttled when SIS termination criteria are met. The value of [78%], was chosen as an upper limit for pressurizer level to ensure an adequate bubble is in the pressurizer following an inadvertent initiation of auxiliary spray for 20 seconds. A value of [2%], was chosen as the lower limit to ensure the operator does not drain the pressurizer. Subcooling coexisting with a pressurizer level of [2" to 78%] indicates adequate RCS inventory control via a saturated bubble in the pressurizer.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
3. RCS Inventory Control (Continued)		Representative CET Temperature is to be used during natural circulation flow conditions and T_H RTDs are to be used during forced circulation flow conditions. An HJTC RVLMS indication that the core is covered, taken in conjunction with subcooling, is an additional indication that RCS inventory control has been established. For cases where RCS inventory has badly degraded, the SIS operation provides implicit assurance that control is being regained. At RCS pressures greater than the shutoff head of the SIS, the use of the charging pump is emphasized.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
3. RCS Inventory Control (Continued)		The charging pump is emphasized because until pressure lowers, this will be the sole means of injecting water into the RCS.
4. RCS Pressure Control	a. Pressurizer heaters and spray, or charging and SIS pumps are maintaining or restoring pressurizer pressure within the P-T limits of Figure 5-1, or b. Available charging pump is operating and the SIS pump(s) are injecting water into the RCS per Figure 5-3 (unless SIS termination criteria are met).	The expected RCS pressure range of the LOCA event is very broad, therefore, the acceptance criteria are written to cover the expected range which may result from a LOCA.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
5. Core Heat Removal	T_H RTDs and representative CET temperatures less than superheated.	Super-heat condition in the RCS can only occur with core uncovery. Core uncovery results from a loss of RCS inventory which generally results from two accident scenarios: LOCA or loss of steam generators as a heat sink. LOCA results directly in a loss of inventory. Very small break LOCAs will not result in depressurization much below the SI pump shutoff head. For these small break LOCAs superheat is indicative of core uncovery occurring at high pressure. For large break LOCAs which result in rapid depressurization to less than 300 psia, superheat which is indicative of core uncovery occurs at low pressure. A loss of inventory (leading to core uncovery) can also result from a loss of S/G heat sink

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
5. Core Heat Removal (Continued)		which causes RCS pressure to rise high enough to lift the primary safety valves. Core uncovery and, therefore, superheat on the [CETs] indicate an advanced phase in the approach to inadequate core cooling and are undesirable. If at anytime superheat is approached or indicated, the operator should review the effectiveness of earlier measures and take all possible steps to restore the inventory to at least a core covered condition as indicated by saturation or subcooling on the CET, Subcooled Margin Monitor, or as an indication of core coverage on the HJTC RVLMS.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
6. RCS Heat Removal	a. At least one SG has wide level: i) within the normal level band with feedwater available to maintain level or ii) being restored by main, emergency, or startup feedwater flow.	Adequate RCS heat removal will be maintained if at least one steam generator is available for removing heat (capable of steam flow and feed flow).
7. Containment Isolation	a. No steam plant activity monitors alarming and b. i) Containment pressure less than [2.7 psig] or ii) CIAS present or manually initiated and c. i) No containment area radiation monitors alarming or ii) CIAS present or manually initiated and Annulus Vent System and Subshere Ventilation System is operating.	Steam plant activity is an indication of a SGTR and is not anticipated for a LOCA regardless of containment conditions. [2.7 psig] is the CIAS setpoint. If pressure does reach [2.7 psig], containment isolation valves should shut automatically (i.e., or CIAS should be present). If CIAS does not occur automatically, the operator should manually initiate a CIAS.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
7. Containment Isolation (Continued)		The containment should be isolated if containment area radiation monitors are alarming.
8. Containment Temperature and Pressure Control	a. i) Containment Temperature less than [236°F] <u>and</u> ii) Containment Pressure less than [8.5 psig] <u>or</u> b. At least one containment spray header delivering at least [5000 gpm].	[236°F] corresponds to the saturation temperature associated with the CSAS setpoint. [8.5 psig] is based on CSAS setpoint. Containment temperature and pressure may exceed the above limits during inside containment LOCA events. If this happens, the containment cooling systems should be operating to minimize the temperature and pressure. Each containment sprays train which will remove 100% of the design basis heat load should be specified.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
9. Containment Combustible Gas Control	a. Hydrogen concentrations less than [0.5%] or b. i) All available hydrogen recombiners energized and ii) hydrogen concentration less than 4% or c. Hydrogen mitigation system operating in accordance with plant-specific operating instructions.	The Containment Combustible Gas Control safety function is satisfied if hydrogen levels are less than the minimum detectable concentration (0.5%). If hydrogen is ≥ 0.5% then operation of the hydrogen recombiners should maintain the hydrogen concentration below the lower flammability limit of 4%. As a last resort, the hydrogen mitigation system can be operated to ensure containment integrity is maintained. The [Plant Technical Support Center or the Plant Operations Review Committee] will review containment conditions and recommend a hydrogen mitigation if conditions warrant. The safety function is satisfied if the mitigation system is operating in accordance with [plant specific operating instructions].

Event Strategy

This section contains the detailed LOCA operator actions strategy flow chart, Figure 5-24. The flow chart pictorially depicts the strategy around which the LOCA guideline is built. It is intended to assist the reader in understanding the intent of the guideline writer and for use in training. Operators should understand the major objectives of the guideline in order to facilitate their progress toward the guideline goals.

The strategy charts show the LOCA Recovery Guideline strategy in detail and list the guideline steps which correspond to each strategy objective. Some steps in the guideline may be performed at any time during the course of an event. Those steps which have an asterisk next to the step number can be performed at any time during the event.

FIGURE 5-24a

LOSS OF COOLANT ACCIDENT RECOVERY

STRATEGY CHART

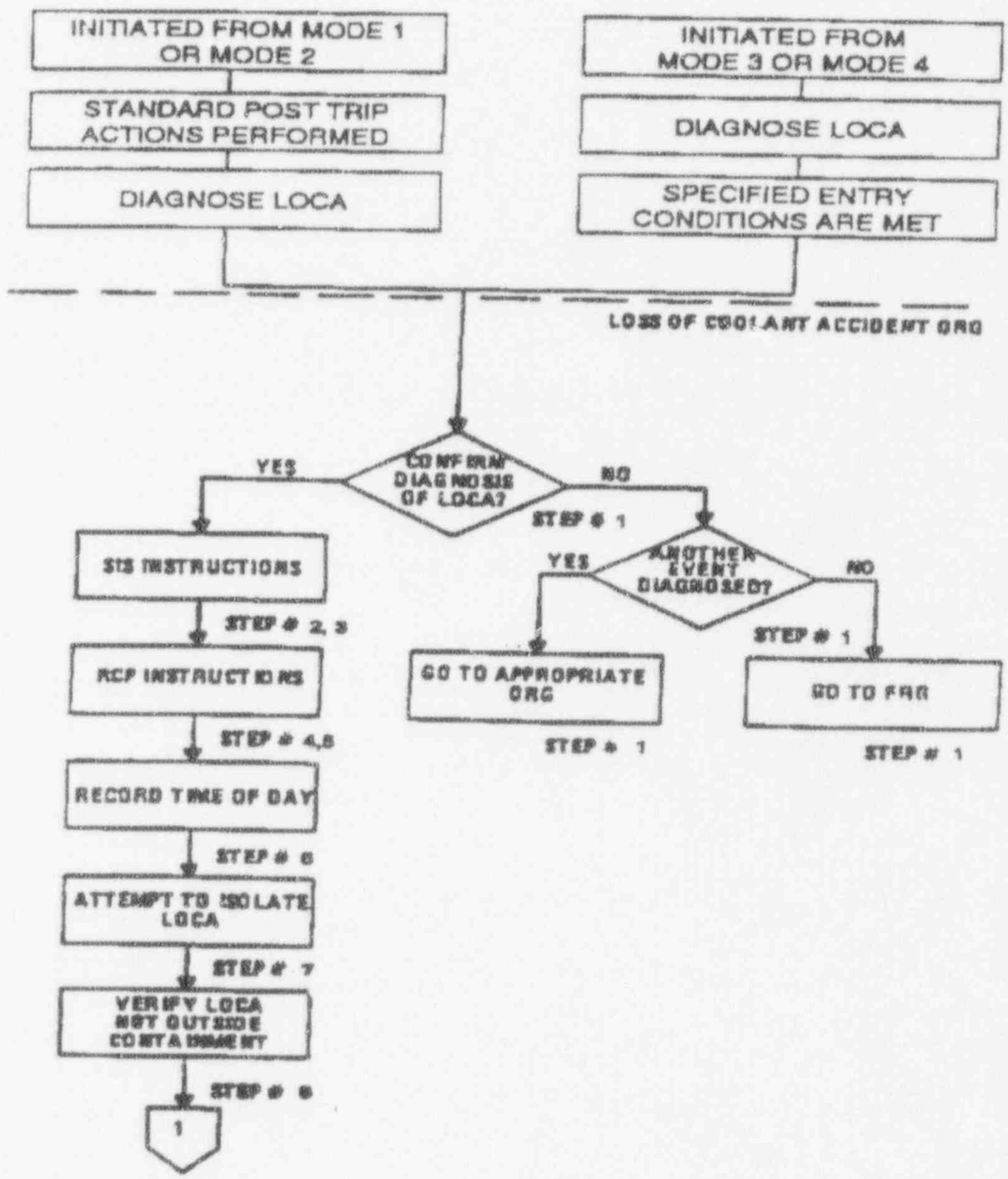


FIGURE 5-24b

LOSS OF COOLANT ACCIDENT RECOVERY

STRATEGY CHART

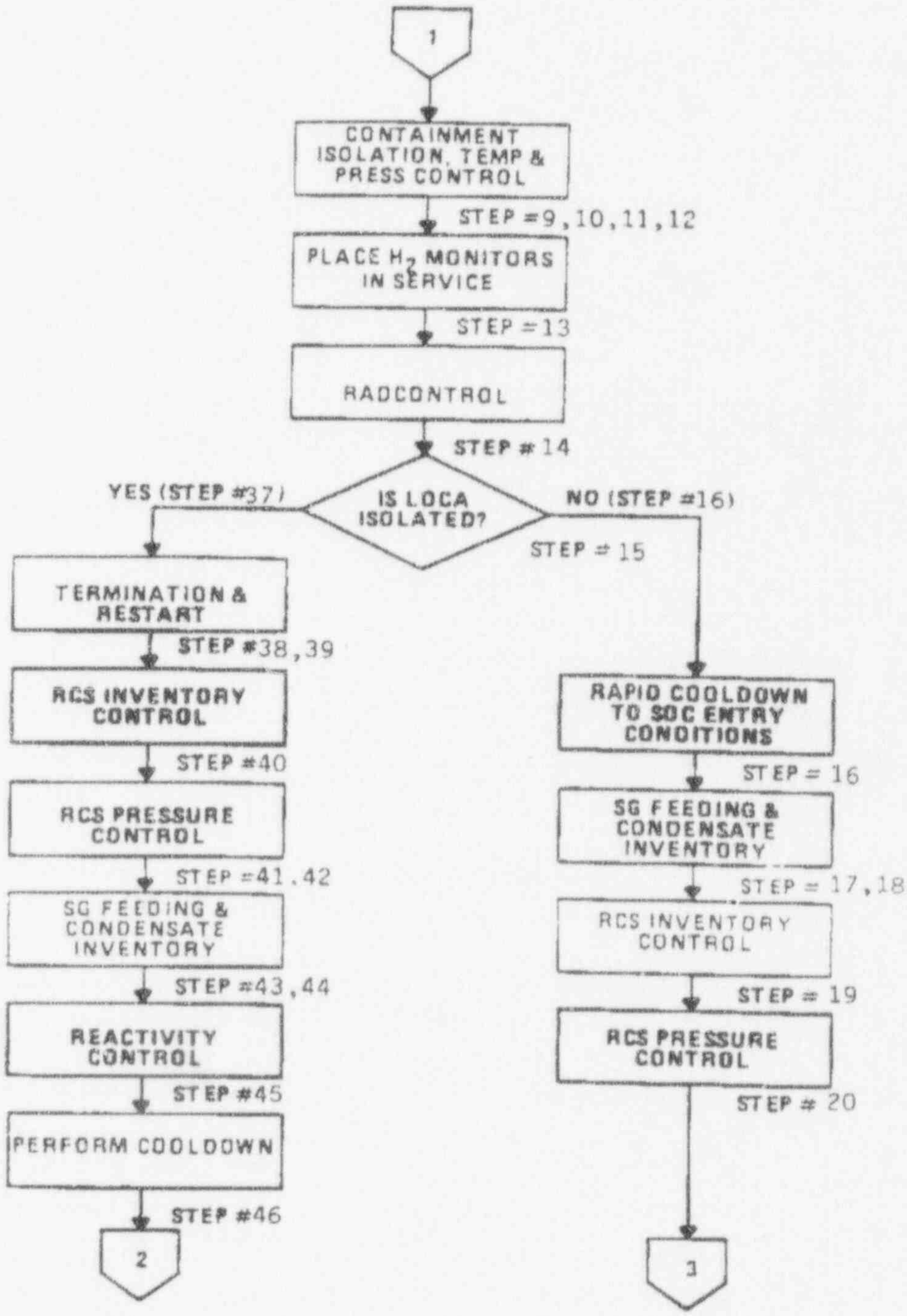


FIGURE 5-24c

LOSS OF COOLANT ACCIDENT RECOVERY

STRATEGY CHART

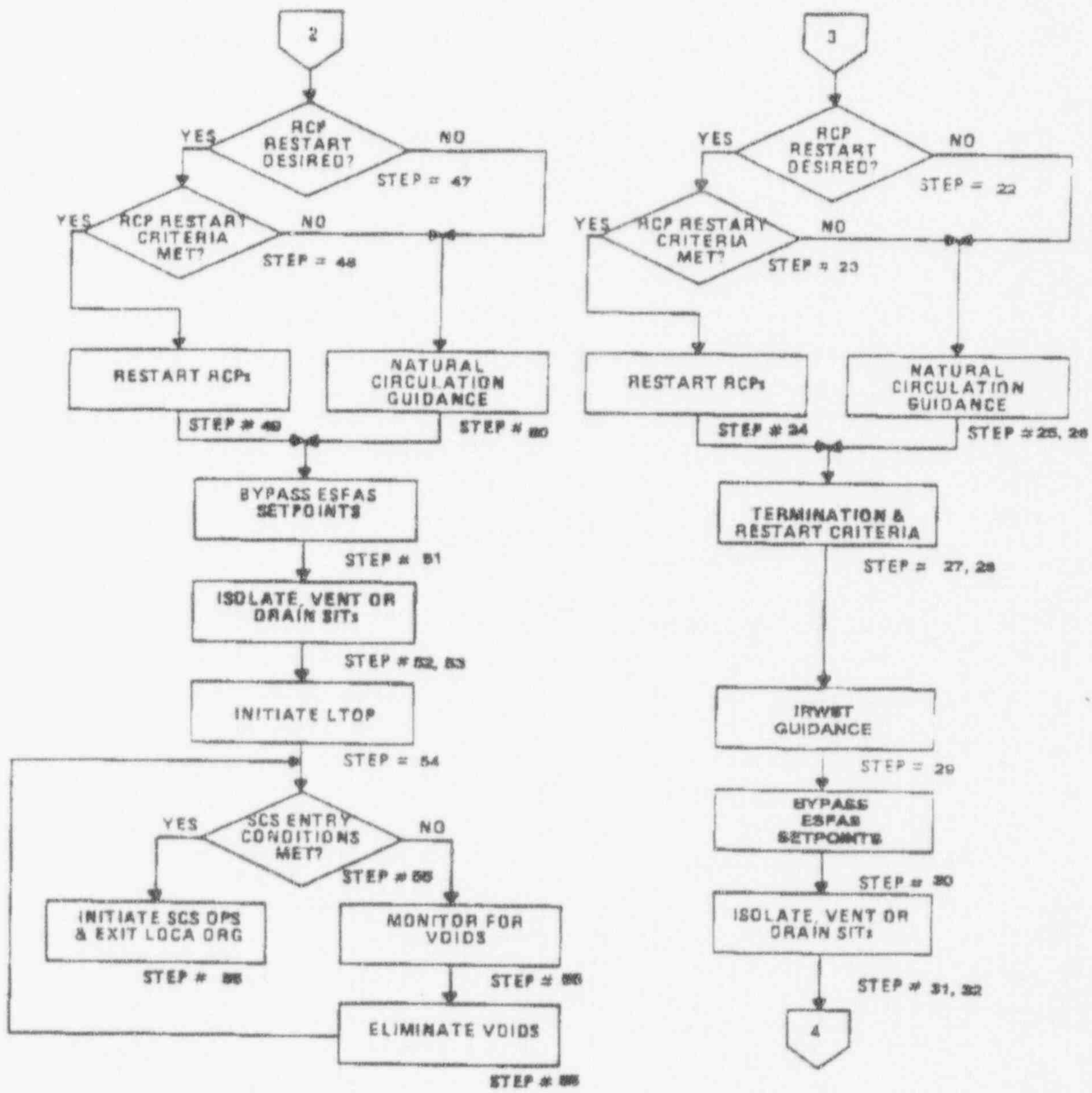
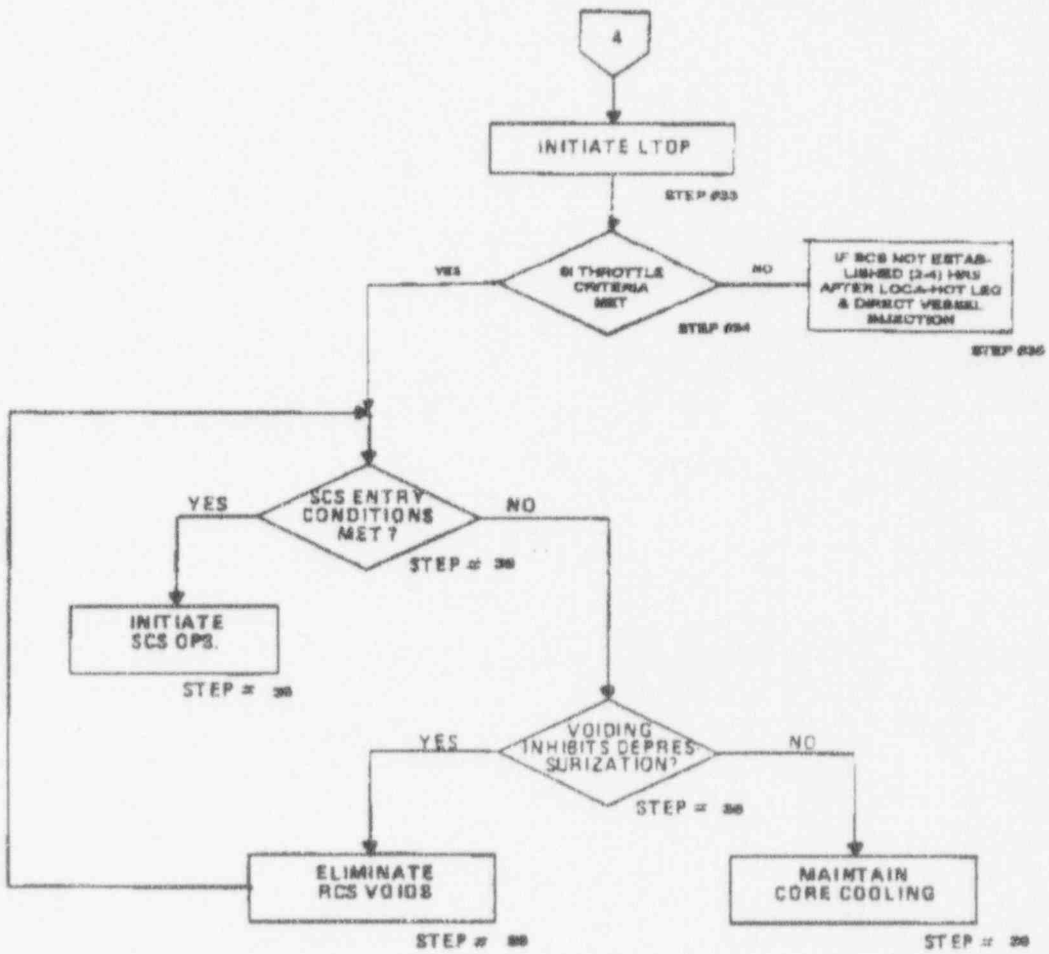


FIGURE 5-24d

LOSS OF COOLANT ACCIDENT RECOVERY

STRATEGY CHART



STEAM GENERATOR TUBE RUPTURE RECOVERY

PURPOSE

This guideline provides operator actions which must be accomplished in the event of a Steam Generator Tube Rupture (SGTR). The actions in this guideline are necessary to ensure that the plant is placed in a stable, safe condition. The goal of the guideline is to safely establish Shutdown Cooling System entry conditions while minimizing radiological releases to the environment and maintaining adequate core cooling. This guideline provides technical information to be used by utilities in developing a plant specific procedure.

ENTRY CONDITIONS

1. The Standard Post Trip Actions have been performed.

   or

   All of the following conditions exist:
   a. Event initiated from Mode 3 or Mode 4,
   b. SIAS has NOT been blocked,
   c. LTOP has NOT been initiated.

   and

2. Plant conditions indicate that a steam generator tube rupture has occurred. Any one or more of the following may be present:

   a. Condenser Vacuum Pump high activity alarm.
   b. Steam generator blowdown high activity alarm.
   c. High activity and conductivity in steam generator liquid sample.
   d. Increasing steam generator level.
   e. Main Steamline N-16 monitor alarms.
   f. Turbine Building sump activity alarms
   g. Decreasing pressurizer level
   h. Steamline area radiation monitor alarms.

EXIT CONDITIONS

1. The diagnosis of a Steam Generator Tube Rupture event is not confirmed.

or

2. Any of the Steam Generator Tube Rupture Safety Function Status Check acceptance criteria are not satisfied.

or

3. The Steam Generator Tube Rupture EOG has accomplished its purpose by satisfying All of the following:

   a. All Safety Function Status Check acceptance criteria are being satisfied.
   b. Shutdown Cooling System entry conditions have been established.
   c. An appropriate, approved procedure to implement exists or has been approved by the [Plant Technical Support Center or the Plant Operations Review Committee].

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. Confirm diagnosis of a Steam Generator Rupture by: a. verifying Safety Function Status Check acceptance criteria are satisfied, and b. referring to the Break Identification Chart (Figure 6-2), and c. sampling both steam generators for activity.	1. Rediagnose event and exit to either appropriate Optimal Recovery Guideline or to the Functional Recovery Guideline
* 2. If pressurizer pressure decreases to or below the SIAS setpoint, Then verify SIAS is actuated.	2. If pressurizer pressure decreases to or below the SIAS setpoint and a SIAS has NOT been initiated automatically, Then manually initiate a SIAS.
* 3. Ensure maximum charging and safety injection flow to the RCS, unless SI termination criteria are met, by: a. start available charging pump and idle SIS pumps and verify SIS flow in accordance with Figure 6-3.	3. If charging and safety injection flow NOT maximized, Then do the following as necessary: a. ensure electrical power to valves and pumps, b. ensure correct SIS valve lineup, c. ensure operation of necessary auxiliary systems.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
* 4. If pressurizer pressure decreases to less than [1400 psia] following an SIAS, Then ensure two of four RCPs are tripped (in opposite loops).	4. Continue RCP operation.
* 5. Verify RCP operating limits are satisfied.	5. Trip the RCP(s) which do not satisfy RCP operating limits.
6. Verify RCS hot leg temperature is less than [547°F] in order to minimize the possibility of lifting steam generator safeties after isolating a steam generator.	6. Cooldown the RCS to a hot leg temperature of less than [547°F] by (listed in order of preference): a. operation of the steam bypass system, or b. operation of the steam generator blowdown system to the condenser, or c. If the condenser or steam bypass system not available and the blowdown is insufficient, Then by operation of the atmospheric dump valve(s).

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
7. Maintain steam generator level(s) in the normal band using main, startup or emergency feedwater.	7.
8. Determine which steam generator has the tube rupture by performing the following: a. sample steam generators for activity, b. monitor main steam piping for activity (area monitors and/or Nitrogen-16 monitors), c. monitor steam generator levels,	8.
9. When RCS hot leg temperature is less than [547°F], Then isolate the steam generator with the higher activity, higher radiation levels, or increasing water level by performing the following:	9.
a. close the MSIV,	a. locally close MSIV,
b. verify closed, or close the MSIV bypass valve,	b. locally close MSIV bypass valve,
c. verify the most affected SG pressure ≤ [1150 psia] and manually close the associated ADV,	c. If the ADV can not be closed manually, then close the valve locally
d. close the main feedwater isolation valve,	d. locally close main feedwater isolation valve,

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
9. (Continued)	
e. close the emergency feedwater isolation valve(s) including the steam driven pump steam supply valve associated with the steam generator being isolated,	e. locally close EFW isolation valve(s) and steam driven pump steam supply valve.
f. isolate steam generator blowdown	f. locally isolate steam generator blowdown
g. close vents, drains, exhausts, and bleedoffs from the steam system,	g. locally isolate vents, drains, exhausts, and bleedoffs.
h. Close turbine plant sump to radwaste	
10. <u>Verify</u> the most affected steam generator is isolated by checking the following: a. activity levels, b. radiation levels, c. possible steam generator level increase.	10. <u>If</u> the wrong steam generator was isolated, <u>Then</u> unisolate that steam generator and isolate the most affected steam generator per step 9.
*11. Maintain isolated steam generator pressure less than [1150 psia] to prevent MSSV opening by: a. Manual operation of the associated ADV, b. Local operation of the associated ADV.	11.

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS	
*12.	Decrease and control RCS pressure by using main or auxiliary spray, reactor coolant gas vent system, operation of charging and letdown, or throttling of safety injection pumps (refer to step 14), in order to control pressurizer pressure within the following criteria: a. less than [1200 psia], and b. maintain RCS pressure approximately equal to but within 50 psi above isolated SG pressure.	12.	If RCS pressure can not be maintained less than [1200 psia] using main or auxiliary spray, reactor coolant gas vent system, operation of charging and letdown, or throttling of safety injection pumps, then exit this guideline and implement the Functional Recovery Guideline and Pressure Control Success Path PC-7, RCS Pressure Control via Rapid Depressurization System during a SGTR Event.
*13.	Maintain the RCS within the acceptable Post Accident Pressure-Temperature limits of Figure 6-1 by the following: a. controlling RCS heat removal via the unisolated steam generator, and b. control of RCS pressure (refer to step 12),	13.	If RCS subcooling greater than P-T limits or cooldown rate greater than [100°F/Hr], Then do the following as appropriate: a. stop the cooldown. b. depressurize the plant using the Reactor Coolant Gas Vent System or main or auxiliary spray to restore and maintain pressurizer pressure within the Post Accident P-T limits of Figure 6.1,

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*13. (Continued)	13. (Continued) c. attempt to maintain the plant in a stable pressure-temperature configuration or continue to cooldown within the limits of Figure 6-1, d. If overpressurization due to SI/charging flow, Then throttle or secure flow (refer to step 15) and manually control letdown to restore/maintain pressure within the P-T limits of Figure 6-1.
*14. Maintain the isolated steam generator level within [40% to 95%] narrow range by the following: a. periodic draining to the radioactive waste system via blowdown processing system or blowdown to the condenser b. dump steam from the affected steam generator to the condenser with approval of the [Emergency Coordinator] or the [Plant Technical Support Center or Operation Review Committee].	14. Restore the isolated steam generator level to less than [95%] narrow range by the following: a. draining to the radioactive waste system or blowdown to the condenser

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*15. If SI pumps are operating, Then they may be throttled or stopped, one pump at a time, if ALL of the following are satisfied: a. RCS is subcooled based on representative CET temperature (Figure 6-1), b. pressurizer level is greater than [14.3%] and not decreasing, c. the unisolated steam generator is available for removing heat from the RCS (ability for feed and steam flow), d. the HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles.	15. Continue SI pump operation.
*16. If criteria of step 15 cannot be maintained after SI pumps throttled or stopped, Then appropriate SI pumps must be restarted and full SI flow restored.	16.

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS	
*17.	Control charging and letdown, and SI (unless SI termination criteria met) to restore and maintain pressurizer level [2% to 78%].	17.	If RCS subcooling can NOT be maintained, Then [78%] may be exceeded to restore RCS subcooling.
*18.	If RCPs are NOT operating, Then evaluate the need and desirability of restarting RCPs. Consider the following: a. adequacy of RCS and core heat removal using natural circulation, b. existing RCS pressure and temperatures, c. the need for main pressurizer spray capability, d. the duration of CCW interruption to RCPs, e. RCP seal staging pressures and temperatures.	18.	a. If RCP operation NOT desired, Then go to step 21. or b. If at least one RCP operating in each loop, Then go to step 22.

* Step Performed Continuously

*19. Determine whether RCP restart criteria are met by ALL of the following: a. electrical power is available to the RCPs, b. RCP auxiliaries ([CCW]) to maintain seal cooling and bearing and motor cooling are operating, and there are no high temperature alarms on the selected RCPs. c. the unisolated steam generator is available for removing heat from the RCS (ability for feed and steam flow), d. pressurizer level is greater than [33%] and not decreasing, e. RCS is subcooled based on representative CET temperature (Figure 6-1), f. other criteria satisfied per RCP operating instructions. g. Natural circulation has been established per Step 21 for the preceding 20 minutes.	19. Go to step 21.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*20. If RCP restart desired and restart criteria satisfied, Then do the following: a. start one RCP in unaffected loop, b. ensure proper RCP operation by monitoring RCP amperage and NPSH, c. operate charging (and SI) pumps to maintain pressurizer level greater then [14.3%] and until SI termination criteria met. (Refer to step 15). d. start one RCP in the affected loop.	20. Go to step 21.
*21. If no RCPs are operating, Then verify natural circulation flow in at least one loop by ALL of the following: a. loop $\Delta T (T_H - T_C)$ less than normal full power ΔT, b. hot and cold leg temperatures constant or decreasing, c. RCS is subcooled based on representative CET temperature, d. no abnormal difference (greater than [10°F]) between T_H RTDs and Core Exit Thermocouples.	21. Ensure proper control of steam generator steaming and feeding (refer to steps 23 and 24), and RCS pressure and inventory (refer to steps 12 and 17).

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
22. Sample the RCS periodically for radioactivity and boron concentration. Calculate and add sufficient boron to the RCS to raise the entire RCS (including the pressurizer) to the shutdown margin required by Technical Specifications.	22.
23. Perform controlled plant cooldown, using forced or natural circulation, in accordance with Technical Specifications. Reduce RCS temperatures by the following: a. If the condenser is available, Then cooldown using the steam bypass system, or b. If the condenser or steam bypass system NOT available, Then cooldown using the unisolated steam generator atmospheric dump valve.	23.
*24. Maintain unisolated steam generator level in the normal band throughout the cooldown using main, startup or emergency feedwater.	24.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
25. Bypass or lower the automatic initiation setpoints of MSIS and SIAS as the cooldown and depressurization proceed.	25.
*26. Ensure the available emergency feedwater inventory is adequate per Figures 6-4 and 6-5.	26.
27. Cool and depressurize the isolated steam generator as the cooldown proceeds by one of the following methods: a. feed and bleed using main, startup or emergency feedwater and blowdown, b. steaming the isolated steam generator to the condenser (if available) or to atmosphere, with approval of the [Emergency Coordinator] or the [Plant Technical Support Center or Plant Operations Review Committee].	27.
*28. Sample the condensate and other connecting systems, including turbine building sumps, for activity.	28.

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS
*29.	Monitor the turbine and radwaste building ventilation radiation monitors and any other applicable radiation monitors. a. If radiation monitor readings are excessive, Then take corrective actions in accordance with TSC recommendations.	29.
*30.	When pressurizer pressure reaches [740 psia], reduce SIT pressure to [300 psi].	30.
*31.	If pressurizer pressure decreases to [445 psia], Then isolate, vent or drain the safety injection tanks (SITs).	31.
*32.	Initiate low temperature overpressurization protection (LTOP) at $T_c \leq$ [259°F].	32.

* Step Performed Continuously

INSTRUCTIONS

*33. When the following SCS entry conditions are established:
   a. pressurizer level > [14.3%] and constant or increasing,
   b. RCS is subcooled
   c. RCS pressure ≤ [450 psia]
   d. RCS T_H ≤ [400°F],

   Then exit this guideline and initiate SCS operation per operating instructions.

CONTINGENCY ACTIONS

33. If the RCS fails to depressurize, Then a void should be suspected.
   a. voiding in the RCS may be indicated by any of the following indications, parameter changes, or trends:
      i) letdown flow greater than charging flow,
      ii) pressurizer level increasing significantly more than expected while operating pressurizer spray,
      iii) the HJTC RVLMS indicates that voiding is present in the reactor vessel,
      iv) HJTC RVLMS unheated thermocouple temperature indicates saturated conditions in the reactor vessel upper head,
   b. If voiding inhibits RCS depressurization to SCS entry pressure, Then attempt to eliminate the voiding by:

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*33. (Continued)	i) verify letdown is isolated, and ii) stop the depressurization, and iii) pressurize and depressurize the RCS within the limits of Figure 6-1 by operating pressurizer heaters and spray or SI and charging pumps. Monitor pressurizer level and the HJTC RVLMS for trending of RCS inventory. c. If depressurization of the RCS to the SCS entry pressure is still not possible, Then attempt to eliminate the voiding by: i) operate the Reactor Coolant Gas Vent System to clear trapped non-condensible gases. and ii) monitor pressurizer level and/or the HJTC RVLMS for trending of RCS inventory.

* Step Performed Continuously

INSTRUCTIONS

*33. (Continued)

CONTINGENCY ACTIONS

d. If depressurization of the RCS to the SCS entry pressure is still not possible, and voiding is suspected to exist in the steam generator tubes, Then attempt to eliminate the voiding by:
   i) cool the suspected steam generator (by steaming and/or blowdown, and feeding) to condense the steam generator tube void,
   and
   ii) monitor pressurizer level for trending RCS inventory.
e. Continue attempts to establish SCS entry conditions, or exit this guideline and initiate an appropriate procedure as directed by the [Plant Technical Support Center or Plant Operations Review Committee].

* Step Performed Continuously

The Steam Generator Tube Rupture Recovery Guideline has accomplished its purpose if the most affected steam generator has been isolated and cooled, shutdown cooling system entry conditions have been established, and all SFSC acceptance criteria are being satisfied.

END

SUPPLEMENTARY INFORMATION

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. To minimize the release of radioactivity directly to the environment, use of the atmospheric steam dump valves on the affected steam generator should be minimized.

2. To reduce the release of potentially radioactive steam from turbine driven pump exhausts, the motor driven main, startup and emergency feedwater pumps should be used. If the motor driven pumps are not available, steam from the intact steam generator should be used to drive the turbine driven emergency feed pump.

3. During all phases of the cooldown, RCS temperature and pressure should be monitored to avoid exceeding a maximum cooldown rate greater than Technical Specification Limitations.

4. Automatic feedwater modulation may mask the expected steam generator level increase due to a steam generator tube rupture.

5. If the faulted steam generator has been isolated and the cooldown is proceeding via natural circulation, an inverted ΔT (i.e., T_C greater than T_H) may be observed in the idle loop. This is due to a small amount of reverse heat transfer in the isolated steam generator and will have no effect on natural circulation flow in the intact steam generator.

6. Do not place systems in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation.

7. All available indications should be used to aid in diagnosing the event since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available. (e.g., during depressurization the indicated level in the pressurizer may be higher than the actual level).

8. If the initial cooldown rate exceeds Technical Specification Limits, there may be a potential for pressurized thermal shock (PTS) of the reactor vessel. Post-Accident Pressure/Temperature Limits of Figure 6-1 should be maintained.

9. Solid water operation of the pressurizer should be avoided unless subcooling cannot be maintained in the RCS (Figure 6-1). If the RCS is solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any unfavorable rapid pressure excursions.

10. Minimize the number of cycles of pressurizer auxiliary spray whenever the temperature differential between the spray water and the pressurizer is greater than [200°F] in order to minimize the increase in the spray nozzle thermal stress accumulation factor.

11. If restarting reactor coolant pumps, consideration should be given to choosing pump combinations which will maximize pressurizer spray flow.

12. The operator should continuously monitor for the presence of RCS voiding and take steps to eliminate voiding any time voiding causes heat removal or inventory control safety functions to begin to be threatened. Void elimination should be started soon enough to ensure heat removal and inventory control are not lost.

13. When a void exists in the reactor vessel, and RCPs are not operating, the HJTC RVLMS provides an accurate indication of reactor vessel liquid inventory. When a void exists in the reactor vessel, and RCPs are operating, it is not possible to obtain an accurate reactor vessel liquid level indication due to the effect

of the RCP induced pressure head on the HJTC RVLMS. Information concerning reactor vessel liquid inventory trending may still be discerned. However, the operator is cautioned not to rely solely on the HJTC RVLMS indication when RCPs are operating.

14. It is desirable to have all electrical equipment available in order to most effectively mitigate and recover from a steam generator tube rupture event. Therefore, if any safety division AC or DC is de-energized, operators should attempt to restore power to the lost bus(es). This action is taken even though the loss of one vital AC or DC bus will not prevent the operators from performing all necessary actions in the Steam Generator Tube Rupture ORG.

15. Operators should be aware of the status of CCW supply to the RCPs and, if CCW has been isolated, should restore CCW if possible and desired.

16. The operator should take all steps possible to minimize the possibility of opening main steam safeties on the isolated SG. These steps include; ensuring RCS T_H is below [547°F], ensuring RCS pressure is below [1200 psia], and taking steps to avoid filling the isolated SG. These actions minimize the possibility of opening the main steam safety valve(s) with a resultant uncontrolled release of radioactivity to the environment.

17. When restarting RCPs, it is preferable to first start an RCP in the loop with the operating SG. Starting an RCP in the affected loop could cause a temporary reversal of T_H and T_C indications in the operating loop and minimize the rate of mixing of inventory from the isolated loop.

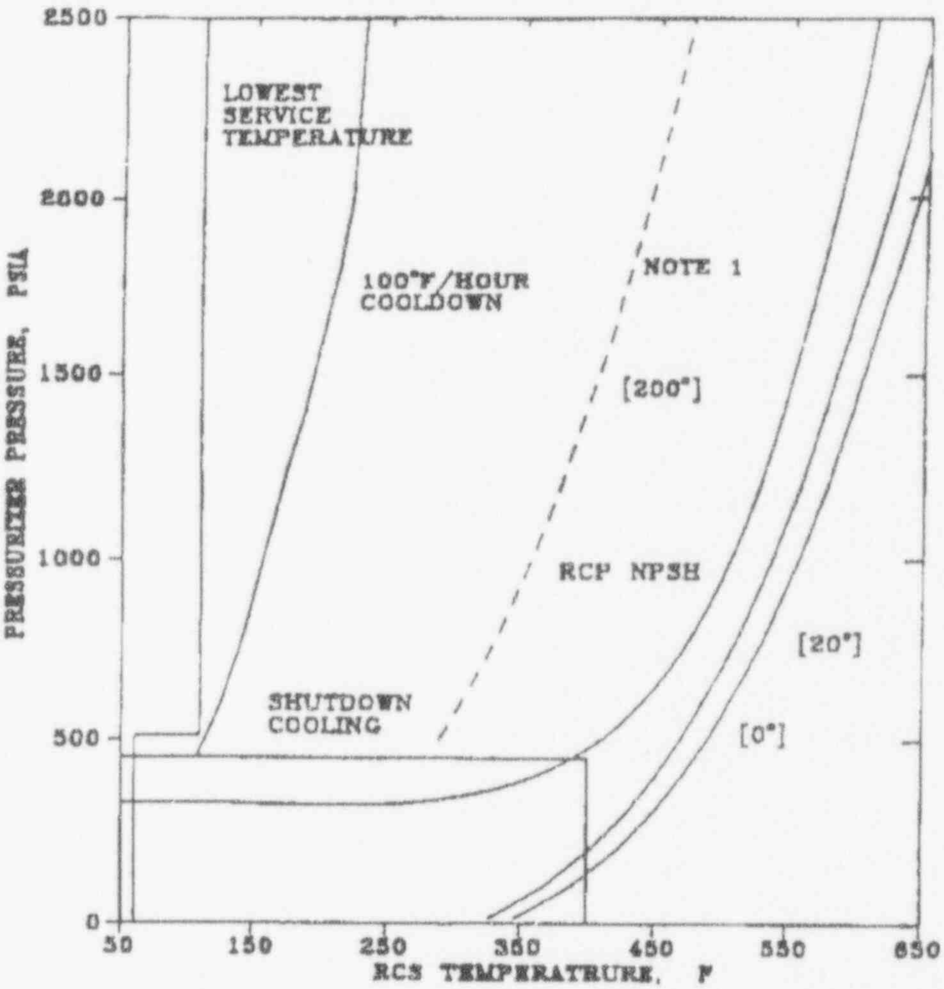
18. When indicated SG water level is excessively high (100% or greater) the possibility of valve damage and uncontrolled radioactive releases from direct water relief through the ADVs should be considered before steaming the affected steam generator.

19. If there is a conflict between isolating a SG and maintaining adequate heat removal, then maintain RCS heat removal via the least affected SG. At least one SG should always be available for heat removal, if at all possible.

20. Prior to RCP restart, verify loops with restart RCP(s) have been in natural circulation continuously for the preceding 20 minutes.

FIGURE 6-1

TYPICAL POST ACCIDENT PRESSURE-TEMPERATURE LIMITS



NOTES: (1) THIS CURVE SUPERSEDES THE 100° F/HR COOLDOWN CURVE ANYTIME THE RCS HAS EXPERIENCED AN UNCONTROLLED COOLDOWN WHICH CAUSES RCS TEMPERATURE TO GO BELOW 500° F. THIS CURVE IS AN OPERATIONAL LIMIT BASED ON ENGINEERING JUDGEMENT AND INTENDED TO MINIMIZE THE POTENTIAL OF A PRESSURIZED THERMAL SHOCK.

(2) THESE CURVES MUST BE ADJUSTED FOR INSTRUMENT INACCURACIES.

FIGURE 6-2

BREAK IDENTIFICATION CHART

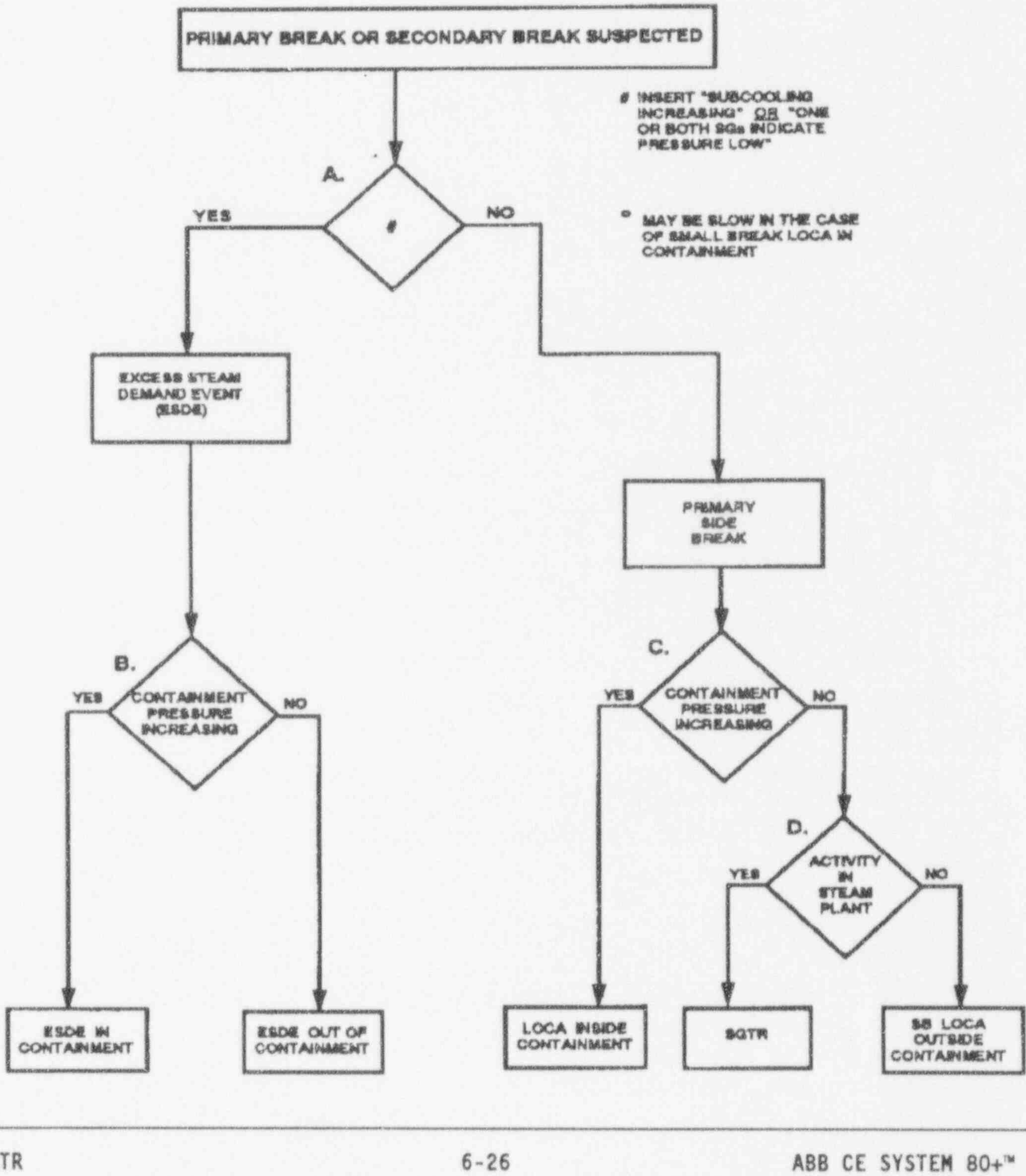
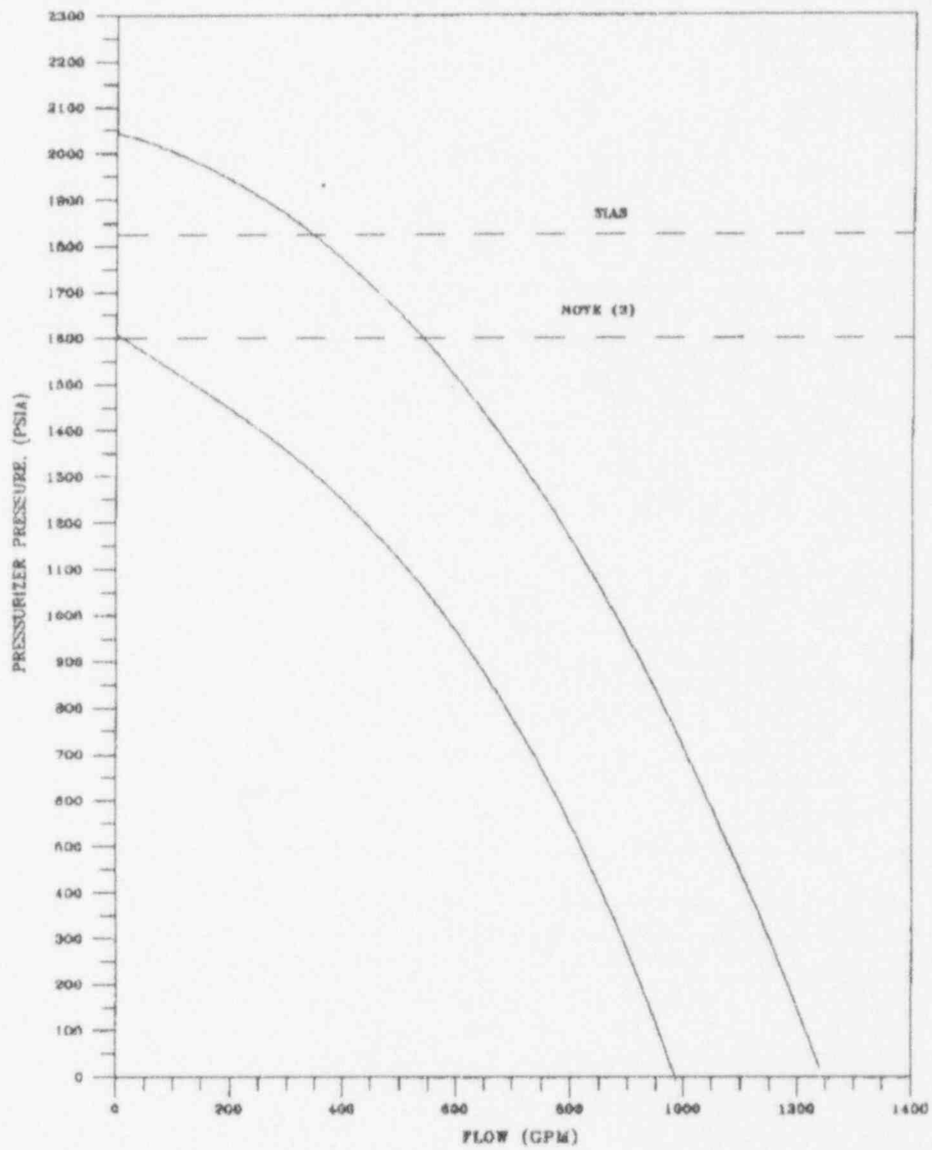


FIGURE 6-3

TYPICAL ACCEPTABLE SIS FLOW VS RCS PRESSURE[1]

INJECTION MODE[2]



NOTES: (1) SEE IMPLEMENTATION SECTION FOR DEVELOPMENT OF PLANT SPECIFIC CURVE.
(2) FOR HOT LEG AND DVI INJECTION, FULL FLOW FROM SIS PUMPS 1 AND 3 IS DIRECTED TO THE HOT LEGS.
(3) BELOW THE SIAS SETPOINT, THE SIS PUMPS WILL BE OPERATING, BUT THERE WILL BE NO INJECTION FLOW UNTIL SYSTEM PRESSURE FALLS BELOW THE SHUTOFF HEAD OF THE SIS PUMPS.
(4) THESE CURVES DO NOT ACCOUNT FOR INSTRUMENTATION INACCURACIES

FIGURE 6-4

TYPICAL FEEDWATER CAPACITY VS TIME REMAINING

UNTIL SHUTDOWN COOLING REQUIRED

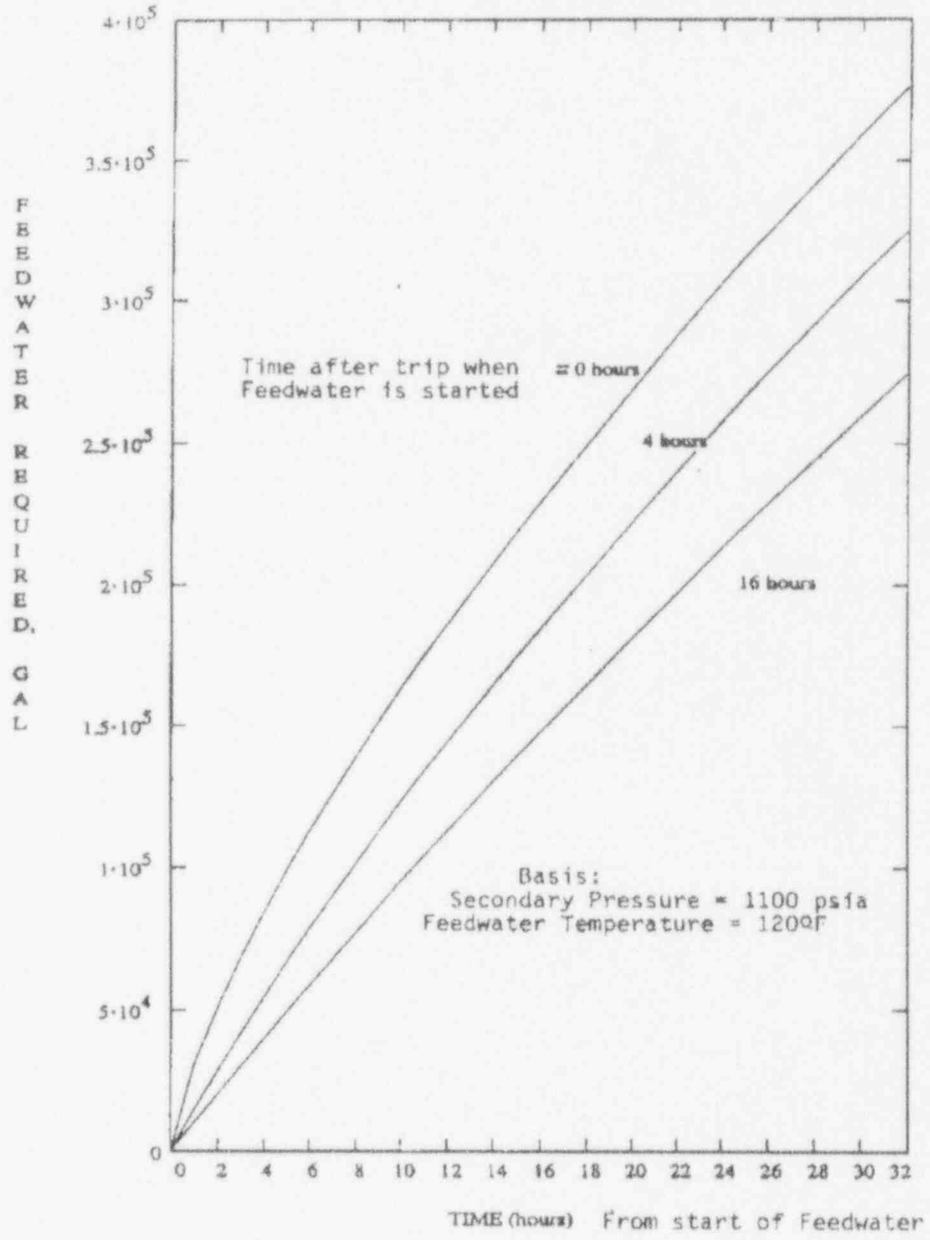
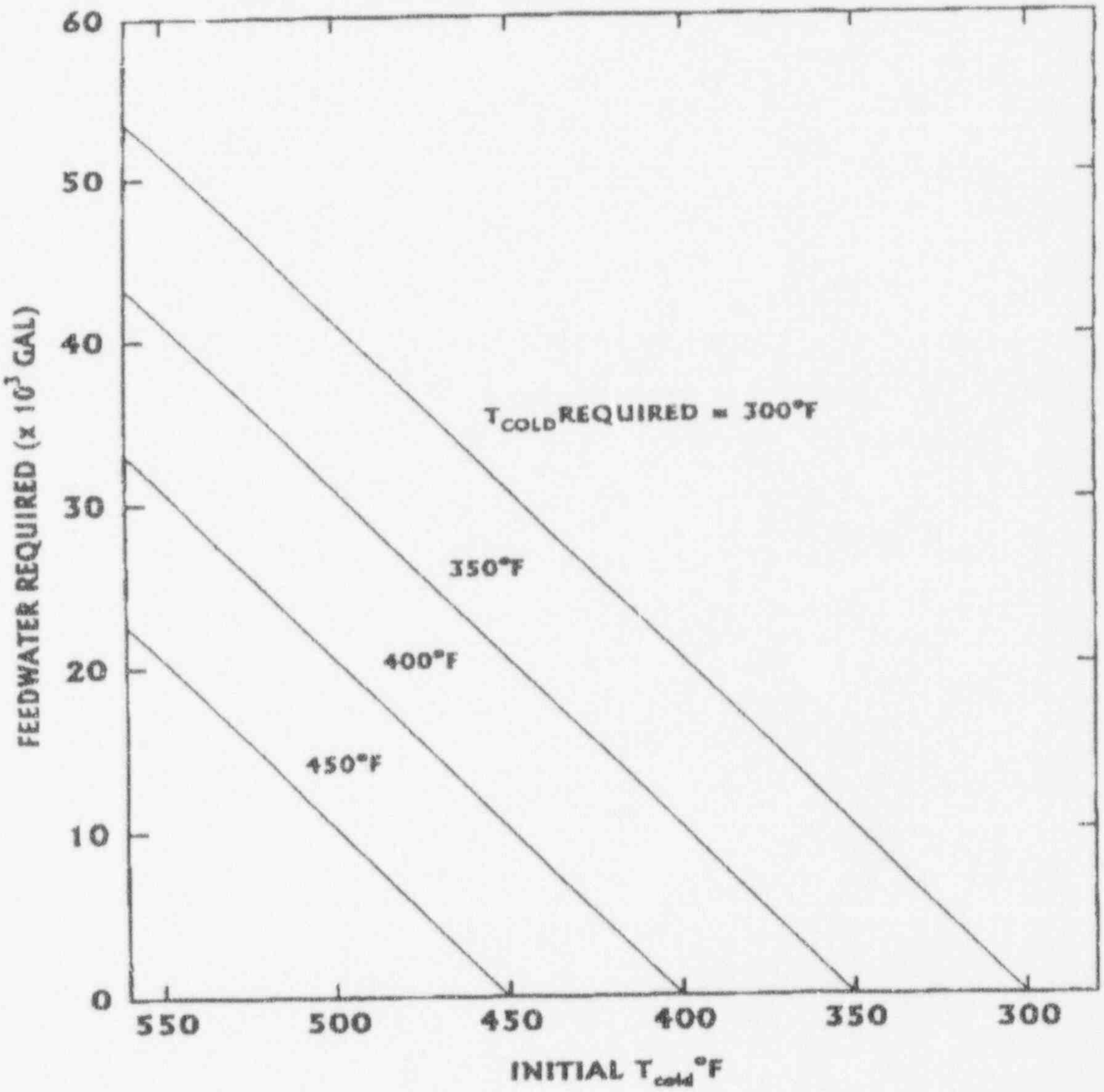


FIGURE 6-5

TYPICAL FEEDWATER REQUIRED FOR SENSIBLE HEAT REMOVAL

T_{cold} (Required) vs T_{cold} (Initial)



SAFETY FUNCTION STATUS CHECK

SAFETY FUNCTION	ACCEPTANCE CRITERIA
1. Reactivity Control	1. a. Reactor power decreasing and b. Negative Startup Rate and c. Maximum of 1 CEA not fully inserted or RCS is borated per Tech Specs.
2. Maintenance of Vital Auxiliaries (AC and DC Power)	2. All vital Division I [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized, or All vital Division II [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized.

SAFETY FUNCTION	ACCEPTANCE CRITERIA
3. RCS Inventory Control	3. a. <u>If</u> pressurizer level is [2% to 78%], <u>Then</u>: i) charging and letdown, and SI (unless SI termination criteria are met), are maintaining or restoring pressurizer level <u>and</u> ii) the RCS is subcooled <u>and</u> iii) the HJTC RVLMS indicates the core is covered <u>or</u> b. <u>If</u> pressurizer level is less than [2%], <u>Then</u>: i) available charging pump is operating and the SIS pump(s) are injecting water into the RCS per Figure 6-3, <u>and</u> ii) the HJTC RVLMS indicates the core is covered.

SAFETY FUNCTION	ACCEPTANCE CRITERIA
4. RCS Pressure Control	4. a. Pressurizer heaters and spray, the Reactor Coolant Gas Vent System, charging and letdown, or SI pumps (unless SI termination criteria met) are maintaining or restoring pressurizer pressure within the limits of Figure 6-1. or b. available charging pump is operating and the SI pump(s) are injecting water into the RCS per Figure 6-3 (unless SIS termination criteria are met).
5. Core Heat Removal	5. T_H RTD and representative Core Exit Thermocouple temperatures less than [626°F].
6. RCS Heat Removal	6. a. i) At least one steam generator has level within normal level band with feedwater available to maintain level or ii) At least one steam generator has level being restored to the normal band by feedwater flow with level increasing or iii) Total feedwater flow to either or both steam generators greater than [500 gpm],

SAFETY FUNCTION	ACCEPTANCE CRITERIA
6. RCS Heat Removal (Continued)	and
	b. RCS T_H is less than [547°F]
	and
	c. RCS temperature is controlled by the Steam Bypass System or ADVs.
7. Containment Isolation	7. a. Containment pressure less than [2.0 psig]
	and
	b. No containment area radiation monitors alarming
	and
	c. No abnormal increase in IRWST or containment sump levels.
	and
	d. No Nuclear Annex alarms
8. Containment Temperature and Pressure Control	8. a. Containment temperature less than [110°F]
	and
	b. Containment pressure less than [2.0 psig.]
9. Containment Combustible Gas Control	9. a. Containment temperature less than [110°F]
	and
	b. Containment pressure less than [2.0 psig.]

BASES

The bases section of the Steam Generator Tube Rupture (SGTR) Recovery Guideline describes the SGTR transient in relation to the actions which the operator takes during a SGTR. The purpose of the bases section is to provide the operators with information which will enable them to understand the reasons for, and the consequences of, the actions they take during a SGTR.

Characterization of a SGTR Event

The Steam Generator Tube Rupture accident is a penetration of the barrier between the reactor coolant system (RCS) and the main steam system. The penetration can range from the failure of an etch pit, a small crack in a U-tube or weld joining the U-tube to the tube sheet, to a single tube doubleended rupture, to multiple ruptures in one generator, or to simultaneous ruptures in both generators. The inside diameter of a steam generator tube is [0.67 inches]. A complete severance of a tube which allows reactor coolant to flow out both ends has an equivalent flow area of approximately [0.7 square inches]. This size may be compared to 0.072 square inches, the smallest hole which is classified as a Loss of Coolant Accident. The flowrate for a Steam Generator Tube Rupture differs from the classic Loss of Coolant Accident in that the backpressure opposing flow is the steam generator pressure instead of the containment pressure.

For the double ended rupture of one steam generator tube, without operator action, a reactor trip is expected within 15 minutes after rupture. Multiple tube failures could result in a more rapid plant response. Ruptures within charging system capacity will not result in a continuously decreasing pressurizer level and pressure, since the automatic operation of the PLCS may stop the decrease. An automatic reactor trip may not occur and a controlled reactor shutdown should be performed using the appropriate non-emergency procedures.

A steam generator tube rupture is characterized by specific parameters that are indicated in the control room. Some of these indications are:

a. Radiation monitors indicating an increase in activity levels at the vacuum pump discharge, at the steam generator blowdown lines, at the turbine or nuclear annex building ventilation monitors, at the stack monitor, in the steam generator liquid sample, and/or the steamline area and/or N-16 monitor.
b. Decreasing level in the volume control tank.
c. An unaccounted for increase in the charging and/or a decrease in the letdown system flowrates.
d. Relatively constant temperature and power indications prior to reactor trip or operator intervention.
e. Steam generator water level either remaining relatively constant (indicating a small rupture) or increasing slowly (indicating a large rupture) due to the primary to secondary leakage incurred.
f. Containment temperature and pressure remaining unchanged.

Safety Functions Affected

The Steam Generator Tube Rupture accident directly affects two safety functions. One is RCS inventory control. The second safety function affected is containment isolation since the reactor coolant boundary has been broken and control of the spread of contamination is provided by secondary plant alignment and isolation. All safety functions should be monitored to assure public safety.

The general goals related to controlling RCS inventory and radionuclide containment are met by controlling leakage between the primary and secondary systems and, after isolating the leaking steam generator, by avoiding opening the leaking steam generator's main steam safety valves. Primary to secondary leakage is minimized by minimizing the pressure differential between the reactor coolant system and the steam generators. The steam generator safety valves can be lifted in two ways. Adding heat to the steam generator causes steam generator pressure to increase, which in turn causes the safety valves to lift. A second way to lift steam generator safety valves is to have RCS leakage into the steam generator with the RCS pressure greater than the steam generator safety valve setpoint. This second process has a time delay built into it. The pressure drop across the steam generator tube rupture keeps the steam generator from seeing high RCS pressure until the steam generator fills sufficiently to drive steam generator pressure up. The optimum response to control RCS inventory and radionuclide containment is to minimize RCS and steam generator pressure differential as soon as possible while lowering RCS pressure below the steam generator safety valve setpoint and to control RCS temperature to preclude lifting steam generator safety valves by heat transfer to the steam generators.

RCS inventory control is affected in the following manner. The rupture size determines when an automatic reactor trip occurs. For example, the inventory loss out a double-ended tube rupture will exceed the total maximum charging flow into the RCS. Consequently, pressurizer level and pressure decrease and a reactor trip occurs. Pressure and level fall rapidly following the trip, usually emptying the pressurizer and initiating an SIAS. If the pressurizer level decreases to less than [14.3%], all heaters are deenergized due to low pressurizer level. RCS inventory loss is controlled by minimizing the differential pressure between the RCS and the steam generators. Inventory control for the SGTR is dependent on RCS and steam generator pressure control.

Containment Isolation is the second safety function challenged by the SGTR. In addition to the loss of reactor coolant caused by a Steam Generator Tube Rupture, fission products and activated corrosion products normally suspended in the reactor coolant will be transferred from the primary to the secondary plant. Steam plant vents and exhausts provide a potential path to the environment for the radioactive products. The transfer of fission and activated corrosion products from the RCS to the affected steam generator will result in increased levels of activity in the steam generator liquid sample. A high radiation alarm could occur in the steam generator blowdown monitoring system. Activated products (mostly noble gases and nitrogen-16) will be carried into the steam plant by the main steam flow. The N-16 monitors on the steamlines may alarm if the power level is above about 25%. The non-condensible gases may eventually be exhausted to the environment by way of the stack via the condenser vacuum pump exhaust and may alarm the radiation monitoring system. As a result of gases being emitted and the build-up of activity in the affected steam generator, general area radiation levels in the turbine and possibly the Nuclear Annex Building will increase and may cause area radiation monitors to alarm. Ventilation exhaust and stack monitors may also alarm. For double ended tube ruptures at powers above 25%, the expected order of alarms is: steamline monitors, vacuum pump discharge, blowdown, ventilation and stack monitors. For small tube leaks, the first indication may be a high activity level in the steam generator liquid sample.

In this SGTR recovery guideline, containment isolation is accomplished in several stages. A step is provided which cools the RCS so that once the damaged steam generator is isolated, the RCS cannot transfer enough heat into it to cause its safety valves to open. The steps to detect and isolate the damaged steam generator are provided. The actions provided to control RCS inventory and RCS pressure minimize the release of radioactivity through the steam generator safety valves.

<u>Trending of Key Parameters</u>

<u>Reactor Power</u> (Figure 6-6)

In response to a steam generator tube rupture, reactor power initially remains constant. Ruptures exceeding the capacity of the available charging pump will result in a reactor trip on DNBR in a time dependent upon the size of the rupture.

<u>RCS Temperature</u> (Figure 6-7)

The RCS temperatures remain relatively constant until the reactor trips. Following the reactor trip, the RCS hot and cold leg temperatures will decrease to approximately the HOT STANDBY values if reactor coolant pumps are running. If all reactor coolant pumps are stopped, RCS temperatures are expected to stabilize near hot zero power values with hot leg temperature less than fifty degrees greater than cold leg temperature in the loop or loops with natural circulation flow established.

Pressurizer Pressure (Figure 6-8)

Pressurizer pressure response is dependent on the severity of the tube rupture. For small ruptures the pressure will remain relatively constant due to the ability of the PPCS to respond. For more extensive ruptures, a continual and sometimes rapid decrease in pressure will be seen, and without operator action a DNBR reactor trip will occur. If pressure continues to fall and goes below the SIAS setpoint and subsequently below the SI pump shut-off head, the SIS is expected to restore RCS pressure and inventory control.

Pressurizer Level (Figure 6-9)

Pressurizer level will remain relatively constant for small ruptures due to the ability of the PLCS to make up for inventory losses. For larger tube ruptures, a slowly decreasing level will be seen. If the ruptures are large enough to cause the level to fall below the heater cutout setpoint, the subsequent pressure decrease will cause an SIAS and inventory control is expected to be restored.

Reactor Vessel Level (Figure 6-10)

For tube ruptures which are small enough so that the PPCS and PLCS can make up the pressure and inventory decreases, no RVUH voiding is expected. The loss of primary coolant for a double-ended rupture of one tube will result in constantly decreasing pressure and level. Voids will form in the RVUH if the RCS pressure reaches the saturation pressure of the hottest RCS temperature. The void is not expected to drop below the RCS hot leg however, due to inventory replacement via the SIS.

Steam Generator Pressure (Figure 6-11)

Steam generator pressure remains relatively constant until reactor trip. The reactor trip causes a turbine trip, and the reactor trip initially causes a slight dip in S/G pressure, followed by a rapid rise in steam generator pressure due to the reduced steam demand. The steam bypass system automatically actuates to control main steam pressure.

The pressure is eventually reduced to the HOT STANDBY value (which is higher than operating steam generator pressure at full power).

Steam Generator Level (Figure 6-12)

Following the reactor trip, the level in both steam generators will shrink to the usual post trip level. Steam generator water level will be relatively unaffected for small ruptures. Large ruptures usually cause a slow increase in level in the affected steam generator if level control is in the manual mode. Otherwise S/G level will remain relatively unchanged. In general, level experiences a sharp decrease following the reactor trip and turbine trip, followed by a steady increase due to the rupture and feedwater control system until the hot zero power level is reached. If the rupture is large enough, especially after the affected steam generator has been isolated, level may increase enough in the affected steam generator to fill the steam generator unless appropriate actions are taken.

FIGURE 6-6

REPRESENTATIVE SGTR EVENT CHARACTERISTICS

REACTOR POWER

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 6-7

REPRESENTATIVE SGTR EVENT CHARACTERISTICS

RCS NARROW RANGE TEMPERATURES

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 6-8

REPRESENTATIVE SGTR EVENT CHARACTERISTICS

PRESSURIZER WIDE RANGE PRESSURE

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 6-9

REPRESENTATIVE SGTR EVENT CHARACTERISTICS

PRESSURIZER LEVEL

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 6-10

REPRESENTATIVE SGTR EVENT CHARACTERISTICS

COLLAPSED LEVEL ABOVE FUEL ALIGNMENT PLATE

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE C-11

REPRESENTATIVE SGTR EVENT CHARACTERISTICS

AFFECTED STEAM GENERATOR PRESSURE

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 6-12

REPRESENTATIVE SGTR EVENT CHARACTERISTICS

AFFECTED STEAM GENERATOR WIDE RANGE LEVEL

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

Guideline Strategy and Information Flow

Figure 6-13 provides the reader with a summary description of the SGTR Recovery Guideline strategy and information flow.

If a SGTR is initiated from MODE 1 or MODE 2, the operator performs the Standard Post Trip Actions and diagnoses the event prior to entering the SGTR Recovery Guideline. However, if the event is initiated from MODE 3 or MODE 4, the operator is not directed to the Standard Post Trip Actions since they may not apply. Instead, the operator ensures that the SGTR is properly diagnosed and that the specified entry conditions are met prior to entering the SGTR Recovery Guideline.

The first steps of this guideline require a verification that these actions have been performed and require the operator to use the SGTR Safety Function Status Check to confirm that the plant is recovering. The next steps can be broken into four major recovery actions. The four major recovery actions carry the plant to Shutdown Cooling System (SCS) entry conditions. The first major action consists of cooling the RCS using both SGs until the RCS T_H is lower than [547°F]. This initial cooldown is done prior to isolating the affected SG. This action reduces the risk of challenging the steam generator safety valves of the affected SG after it is isolated. The second major action consists of detecting and isolating the affected SG. This terminates further uncontrolled radioactive releases from the affected SG. In the third major action, the RCS pressure is reduced and then maintained approximately equal to or within 50 psi above the isolated SG pressure. This action allows the operator more control of leak flow from the RCS to the SG through the break. The fourth major action consists of cooling the plant, using either forced circulation or natural circulation in the RCS, to SCS entry conditions. This cooldown is performed using the unisolated SG. The isolated SG should also be cooled and depressurized along with the RCS.

A more detailed flow chart illustrates the SGTR Recovery Guideline strategy and lists all guideline steps. Refer to Figure 6-17.

FIGURE 6-13a

STEAM GENERATOR TUBE RUPTURE

GUIDELINE FLOWCHART

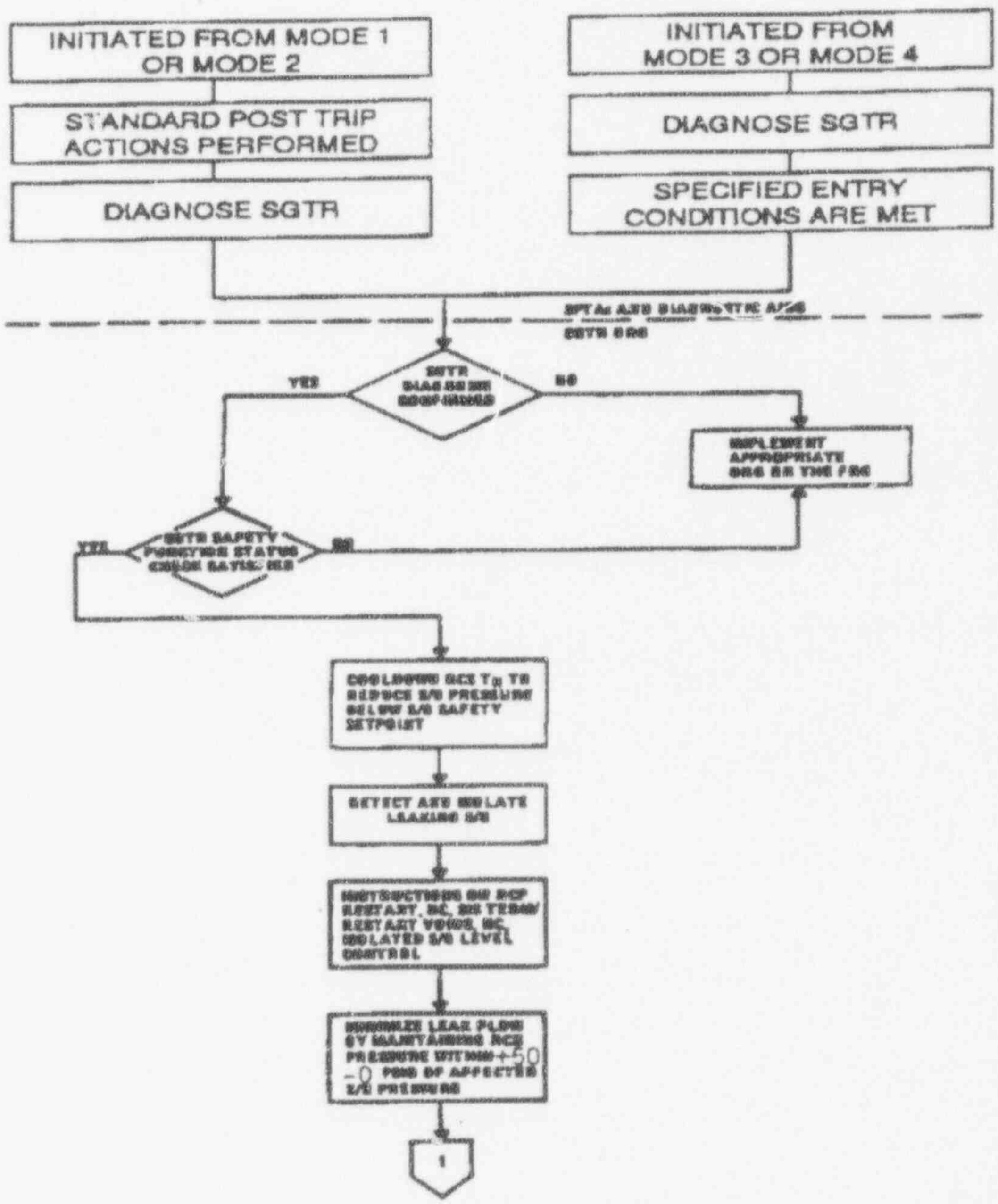
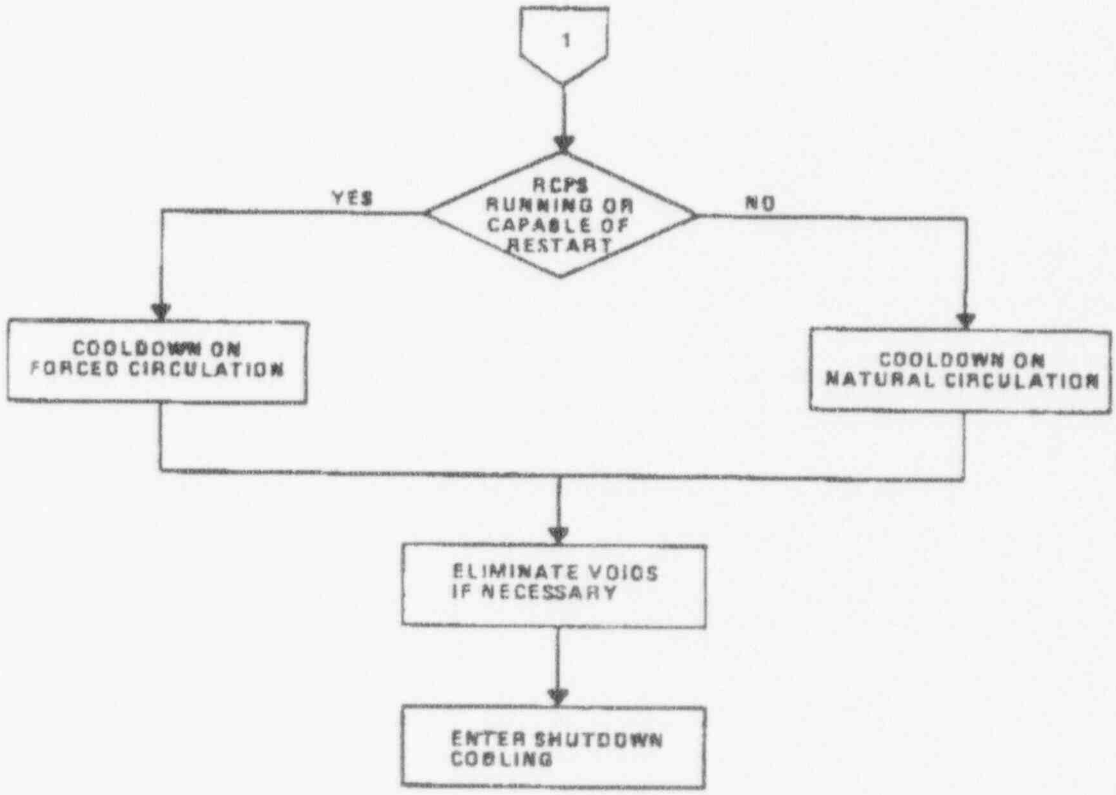


FIGURE 6-13b

STEAM GENERATOR TUBE RUPTURE

GUIDELINE FLOWCHART



BASES FOR SGTR OPERATOR ACTIONS

The operator actions are directed at recovering the plant from the SGTR, and placing it in a safe, stable condition. Actions are taken to ensure that a proper heat sink for the reactor is being maintained, and that radiation releases are minimized.

* 1. The diagnosis of a Steam Generator Tube Rupture should be confirmed using the Break Identification Chart (Figure 6-2) and by comparing control board parameters to the acceptance criteria in the Safety Function Status Check to ensure that all safety functions are being satisfied. In particular, the operator should note the status of RCS subcooling and containment and steam plant activity. These parameters provide a means of discriminating between SGTRs and LOCAs/ESDEs. For a SGTR, steam plant activity monitors may be alarming but containment activity monitors should not be alarming. For LOCAs, the RCS reaches saturation conditions and containment activity monitors may be alarming, but steam plant activity monitors should not be alarming. For ESDEs, neither steam plant nor containment activity monitors should be alarming. ESDEs which occur in plants which exhibit SG tube leakage may result in increases in steam plant or containment activity. Sampling both steam generators for activity will assist in confirming the diagnosis of a SGTR. These actions ensure that the proper guideline is being used to mitigate the effects of a SGTR.

If the initial diagnosis of a SGTR is confirmed, then the operator should continue with the actions of this guideline. However, if the initial diagnosis of a SGTR is not confirmed, and the operator determines that an ESDE or LOCA has occurred, then the SGTR ORG should be exited and the proper procedure should be implemented. This step allows the operator to switch to the proper procedure for those events which may have occurred having similar symptoms to a SGTR (LOCA, ESDE). If a diagnosis of one event cannot be made, then the Functional Recovery Guideline (FRG) should be implemented. The FRG is safety function based and will ensure that all safety functions are addressed regardless of what event(s) is occurring.

FIGURE 6-14a

RCP TRIP STRATEGY FOR SGTR

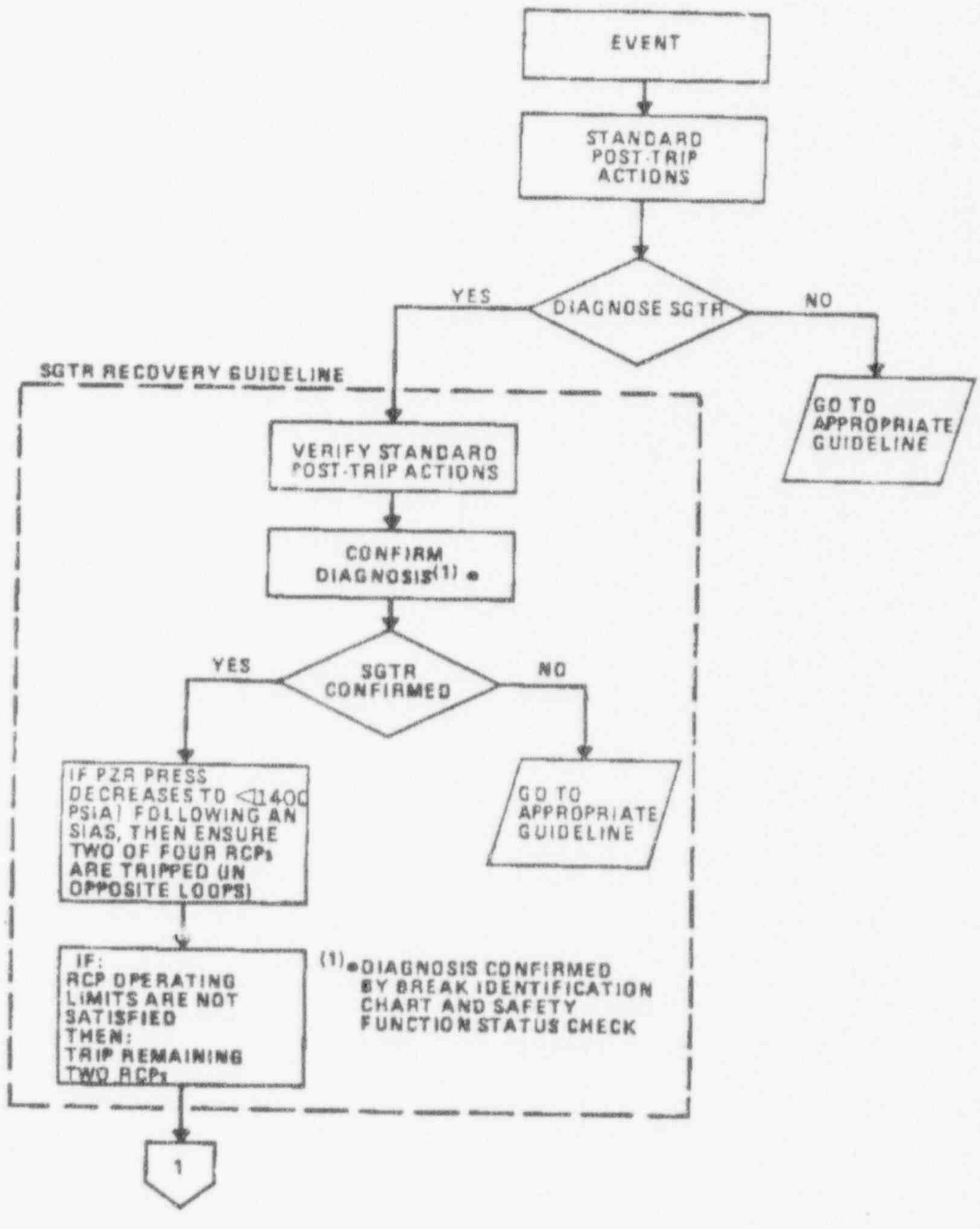
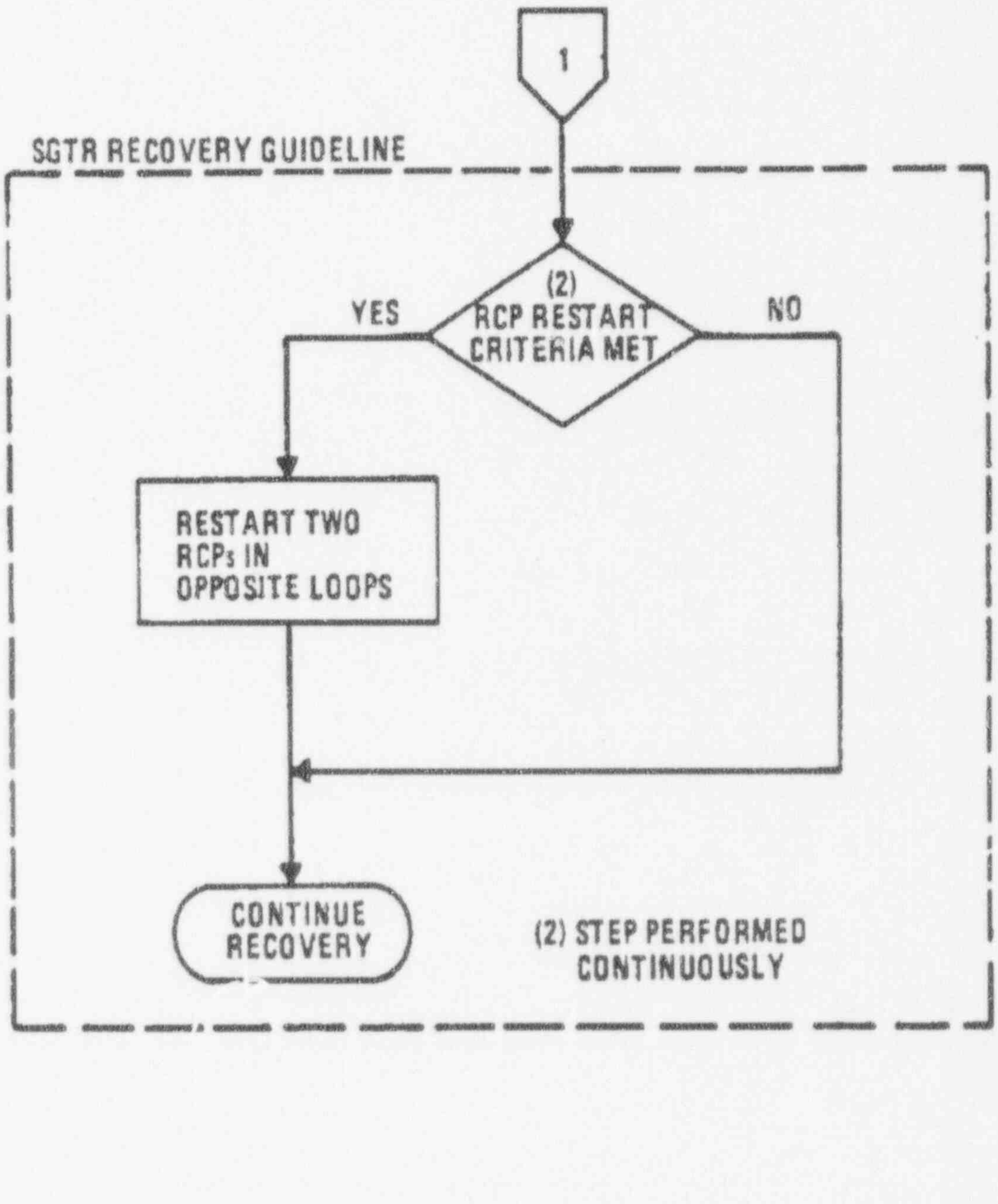


FIGURE 6-14b

RCP TRIP STRATEGY FOR SGTR



* 2. If the Steam Generator Tube Rupture is large enough to decrease pressurizer pressure to or below the SIAS setpoint of [1825 psia], then SIAS should be initiated automatically. If this does not occur, then the operator should manually initiate SIAS.

* 3. A SGTR may result in actuation of the safety injection system. If SIAS is actuated, then the available charging pump and SIS pumps should be operating and injecting water into the RCS. The SIS flowrate will vary according to pressurizer pressure. The SIS and charging flowrates should be checked and maximized (Figure 6-3 provides information which can be utilized to verify adequate SIS flow is occurring) for RCS inventory replenishment and/or core heat removal. The charging pump may have to be manually restarted if an interruption of electrical power to the charging pump bus(es) has occurred. The following guidance will assist in ensuring maximum injection of water into the RCS:

   a. idle SIS pumps should be started and system flow should be verified to be within the limits of Figure 6-3, unless SI termination criteria have been met,
   b. idle charging pump should be started.

   If any SIS pump that should be operating won't start, no charging pump will start, or SIS flow is not in accordance with Figure 6-3, then the following guidance is provided:

   a. the operator should verify that electrical power is available to valves and pumps necessary for inventory control,
   b. the SIS valve lineup should be verified correct from control board indications,
   c. auxiliary systems necessary for SIS or charging operation should be checked.

   It must be noted, however, that the maximization of charging and safety injection can result in excess RCS inventory, possible filling of the pressurizer to a solid condition, and a PTS concern upon RCS heat up, fluid expansion, and subsequent RCS pressure excursion. Operators must be aware of these concerns and terminate or throttle SIS pumps when the criteria are met.

* 4. Steps 4 and 5 contain guidance regarding the RCP operating strategy for a SGTR (Figure 6-14). A generic RCP trip strategy has been developed which results in the tripping of all four RCPs for depressurization events where RCS is not subcooled, but allows the continued operation of two RCPs (in opposite loops) for depressurization events where RCS is subcooled. For undiagnosed events, where the Functional Recovery Guideline is implemented, the RCP trip strategy is identical to that followed in the LOCA guideline. Steps 4 and 5 detail the two significant operational aspects regarding the RCP trip strategy for a SGTR.

The first operational strategy results in the operator tripping two RCPs (in opposite loops) if pressurizer pressure decreases to less than [1400 psia] following a SIAS and RCS is subcooled. This action may occur in the Standard Post Trip Actions and, in this case, the operator would simply verify that two RCPs (in opposite loops) have been tripped. The operator trips all four RCPs if pressurizer pressure decreases to less than [1400 psia] following a SIAS and RCS is not subcooled. If the operator cannot confirm that a SGTR has occurred, and the Functional Recovery Guideline is implemented, the RCP trip strategy is identical to that followed in the LOCA guideline. If the depressurization event can be diagnosed and is determined to be other than a LOCA (i.e., ESDE or SGTR), then only two RCPs (in opposite loops) are tripped. The other two RCPs remain operational until one or more of the RCP operating requirements (e.g., NPSH, temperatures, seal flow, oil pressures, motor amperage, vibration) are not longer satisfied, then, any pump which does not satisfy these requirements should be tripped. This gives the operator maximum flexibility in plant control because a normal plant cooldown can be performed while still ensuring a conservative approach to event recovery.

* 5. The second aspect of the RCP operating strategy concerns the verification that RCP operating limits are satisfied. The RCPs will be operating in a pressure-reduced RCS and may not satisfy NPSH requirements. The operator must

continuously monitor RCP operating limits (e.g., temperatures, seal flow, oil pressures, NPSH, motor amperage, vibration) and trip any RCPs which do not satisfy RCP operating limits. Plant specific RCP operating limits appear in the operating instructions.

6. The goal of this step is to verify that the RCS hot leg temperature has been decreased to less than [547°F] prior to isolating the affected SG in order to prevent lifting main steam safety valves in the affected SG. Under natural circulation flow conditions, T_H will increase approximately [15°F] as the core ΔT increases as a result of the change from two loop to one loop heat removal. The temperature in the isolated SG will be essentially T_H since it is no longer being used as a heat sink. The first bank MSSVs open at [1200 psia] which corresponds to a saturation temperature of [567°F]. Allowing a [5°F] margin and accounting for a [15°F] rise in T_H results in a value of [547°F] for isolating the affected SG. For forced flow conditions, the increase in T_H at the time the SG is isolated is negligible (1°F). Thus, this strategy will cover both forced and natural circulation conditions. If RCS hot leg temperature is not less than [547°F] the operator will manually cooldown the RCS. This action should be performed preferentially by feeding the steam generators with main, startup or emergency feedwater and dumping steam to the condenser via manual control of the Steam Bypass System. If the condenser or Steam Bypass System is not available, the next order of priority for discharging steam would be to use the steam generator blowdown system with discharge to the condenser, followed by use of the atmospheric dump valves. It is less desirable to use the atmospheric dump valves to cooldown the RCS because of the release of activity to the environment.

   This step is presented before the leaking steam generator has been identified and isolated. This step is most easily accomplished when RCPs are operating and when one or more steam generators are providing cooling. If all RCPs have been tripped and natural circulation is the heat removal process, then it is necessary to cooldown both steam generators to provide uniform RCS cooling.

Therefore, if forced circulation is available, this step can be done in parallel with steps 8 and 9, detecting and isolating the affected steam generator. If forced circulation is not available, this step should be done in parallel with step 8, but completed before going on to step 9.

Natural circulation cooldown of the RCS is not an effective method for cooling the RV head region. If natural circulation cooling provides the reduction of T_H to less than [547°F], heat transfer to the steam generator from the RCS loops will not cause lifting of the secondary safety valves. However, the energy stored in the RV head region and pressurizer has to be dealt with to bring RCS pressure close to steam generator pressure to minimize leakage into the steam generator and to preclude steam generator safety valve opening due to filling the steam generator with high RCS pressure. Controlling RCS pressure with the pressurizer and with an uncooled RV head region is addressed in a later step.

7. Steam generator levels are to be maintained in the normal band using main, startup or emergency feedwater. This ensures that an adequate heat sink for removing heat from the RCS is available while steaming both SGs.

8. The steam generator with the tube rupture should be determined by performing the following steps. These steps include:

   a. Sampling the steam generators for activity,
   b. Monitoring the main steam piping for activity using the steam pipe area monitors and the steam pipe nitrogen-16 monitors,
   c. Monitoring steam generator levels,

9. The steam generator with higher activity, higher radiation levels, or increasing water level should be isolated. Reducing RCS temperature to below the saturation temperature associated with the lowest pressure setpoint of the steam generator safety valves is one of the actions necessary to prevent opening a direct path to the environment for radionuclides after steam generator isolation. Steam generator isolation is an attempt to re-establish the

containment isolation safety function. To maintain SG pressure below the MSSV setpoint, manual operation of the ADV is used. Should the pressure in an isolated steam generator approach the lift setpoint for the associated MSSVs, it is desirable from the perspective of positive operator control that the ADV open first. This is accomplished by manually opening the ADV at [1150 psia] increasing, or locally opening the ADV at [1150 psia]. The value of [1150 psia] was chosen based on the MSSV setpoint of [1200 psia] minus an operating margin of [50 psi]. To minimize the unmonitored release of radioactivity, use of the atmospheric steam dump valves on the affected steam generator should be minimized. If both steam generators have tube ruptures, then the operators must determine which generator is most affected and isolate that generator.

The most affected steam generator is isolated as follows:

a. The main steam isolation valve is closed.
b. The main steam isolation valve bypass valve is verified closed, or closed.
c. The atmospheric steam dump valve is verified closed or closed.
d. The main feedwater isolation valve is closed.
e. The emergency feedwater isolation valves are closed, including the steam driven pump steam supply valve associated with the steam generator being isolated.
f. Steam generator blowdown is isolated.
g. Vents, drains, exhausts, and bleedoffs from the steam system are isolated. The crosstie to the auxiliary steam header is isolated. This completes the isolation of the radionuclides still in the secondary system to prevent further releases to the environment.

10. Once the steam generator has been isolated, isolation of the correct (most affected) steam generator should be verified by checking radiation indications, sampling for activity, and noting any possible increase in the isolated steam generator level. This provides feedback that the correct steam generator has been isolated. If the wrong steam generator has been isolated then it should be unisolated and the most affected steam generator should be isolated per step 9.

*11. To prevent the MSSV opening, which would create a release path from the RCS to the environment, the isolated steam generator pressure must be maintained below the MSSV setpoint. To maintain SG pressure below the MSSV setpoint, manual operation of the ADV is used. Should the pressure in an isolated steam generator approach the lift setpoint for the associated MSSVs, it is desirable from the perspective of positive operator control that the ADV open first. This is accomplished by manually opening the ADV at [1150 psia] increasing, or locally opening the ADV at [1150 psia]. The value of [1150 psia] was chosen based on the MSSV setpoint of [1200 psia] minus an operating margin of [50 psi]. The intent of the step is explicitly stated in the step so that the operator understands the goals of the step and to minimize the use of the atmospheric steam dump valves on the affected steam generator which would create an unmonitored release of radioactivity.

*12. The general goals associated with RCS pressure control are: providing subcooling to support the core heat removal process, avoiding overpressure situations for PTS and RTNDT considerations, minimizing the pressure differential between the steam generator and the RCS to minimize the leakage, and controlling RCS pressure so that it is below the steam generator safety valve setpoints. This step addresses steam generator to RCS pressure differential and RCS depressurization to below the SG safety valve setpoint.

Maintaining the RCS pressure approximately equal to but above the isolated steam generator pressure (-0, +50 psi) and below the steam generator safety valve setpoint, [1200 psia], will minimize the loss of primary fluid to the secondary side and the possibility of overfilling the isolated SG. This is accomplished by either using main spray (the preferred method), auxiliary spray, operation of reactor coolant gas vent system (RCGVS) on the pressurizer, operation of charging and letdown, or throttling of the SI pumps. This action will minimize the potential for release of radiation to the environment by minimizing RCS to steam generator leakage.

Maintaining RCS pressure approximately equal to SG pressure (-0, +50 psi) prevents backflow from the secondary system to the primary system while minimizing primary to secondary leakage.

A key point in the strategy for the SGTR event involves maintaining or restoring forced circulation. However, maintaining subcooling and adequate NPSH for RCP operation may cause the operator to hold RCS pressure above secondary pressure by the amount needed to provide adequate subcooling. This requirement takes precedence over the procedural strategy of bringing primary pressure to the point where it will be approximately equal to secondary pressure.

During the forced circulation cooldown process the lower region of the isolated steam generator may cool faster than the upper region (see Figure 6-15). The cooling of the isolated SG steam space will significantly lag in the cooldown and cause the fluid in the lower regions to be subcooled. If the tube rupture is located in this subcooled region, then the primary fluid can be at the same pressure as the secondary fluid and still be subcooled. However the continued depressurization of the primary during the cooldown will now be limited by the ability to depressurize the isolated SG (Step 27 provides guidance on isolated SG depressurization).

During natural circulation cooldown conditions the isolated steam generator will take considerably longer to cool unless there is a transfer of mass in the isolated SG. This complicates RCS pressure control during the cooldown. It is desirable to cool the RCS such that the tube bundle region of the affected SG remains subcooled. Voiding in the tube bundle region can be expected and may result in the region becoming a pressurizing source for the RCS (Step 33 provides guidance on void detection and elimination). Maintaining the presence of subcooled liquid in the affected loop will be a complicated process under natural circulation conditions. Forced circulation conditions are much more desirable and if possible should be maintained or restored. During natural circulation conditions the cooldown and depressurization of the RCS will be limited to the operator's ability to control the conditions of the isolated steam generator.

*13. Maintaining RCS pressure within the acceptable limits of Figure 6-1 helps to ensure the core is covered by subcooled fluid and minimizes the concern for pressurized thermal shock by keeping plant pressure below the [200°F] subcooling limit. This is accomplished by controlling RCS heat removal via the unisolated steam generator, and controlling RCS pressure as discussed in Step 12.

If subcooling or the cooldown limits of Figure 6-1 are being violated, then the operators should take actions to restore the RCS to within the P-T limits. Depending on the situation, the operator should perform the following actions as appropriate:

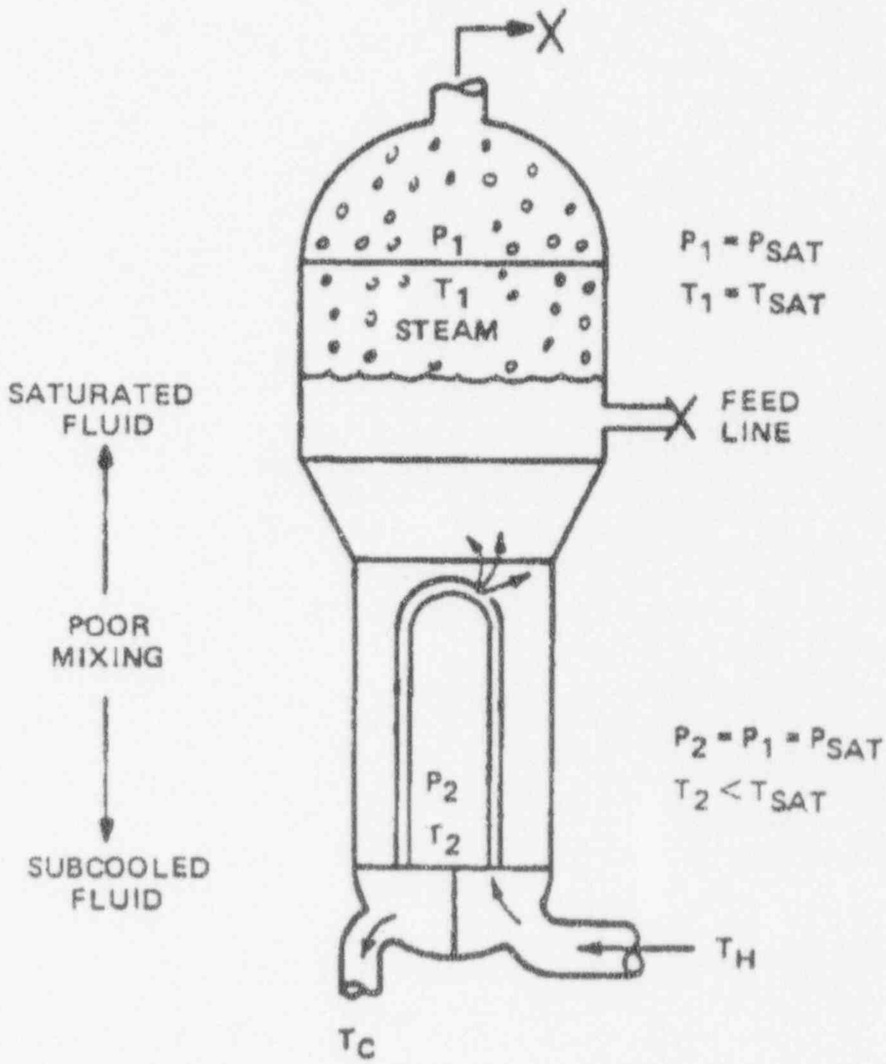
a. Stop the cooldown.
b. Operate Reactor Coolant Gas Vent System or the main or auxiliary spray as necessary to restore pressurizer pressure to within the P-T limits of Figure 6-1.
c. Attempt to maintain the plant in a stable pressure-temperature configuration. The cooldown may be continued, if desired, within the limits of Figure 6-1,
d. If an overpressure situation exists and is caused by SI and/or charging flow, then throttle or stop SI (refer to step 15) or charging pumps and manually control letdown to restore and maintain pressure within the Post Accident P-T limits of Figure 6-1.

*14. The potential exists for filling of the isolated steam generator steam space and the main steam piping up to the MSIV. This action could result in the inadvertent opening of the MSSVs and an undesirable spread of contamination and the potential for main steam piping support snubber damage.

Draining to the radioactive liquid waste system or blowdown to the condenser will reduce level and minimize the spread of contamination and the possibility of piping support snubber damage although the piping up to the MSIVs is designed for static liquid water. If the generator draining is not feasible or is insufficient, then steaming the generator to the condenser will reduce level and minimize radioactivity release. Water hammer damage should be avoided by not reopening the affected MSIV while a significant amount of water is in the main steam piping. Draining to the radioactive waste system or blowing down to the condenser or reducing RCS pressure below the isolated steam generator pressure can lower steam generator level. The off-site dose coordinator should assess the radioactive releases to the environment. The value of [95%] was chosen to prevent overfilling the steam generator by ensuring the level remains in the indicated range. The value of [40%] was chosen to ensure all tubes remain covered, which minimizes the potential of radioactive fission products reaching the steam generator steam space.

FIGURE 6-15

ISOLATED STEAM GENERATOR WITH TUBE RUPTURE



*15. If the SI pumps are operating, then they must continue to operate at full capacity until SI termination criteria are met. Termination of SI should be sequenced by stopping one pump at a time while observing the termination criteria. Throttling of SI flow is also permissible if all of the following SI termination criteria are satisfied:

a. RCS is subcooled based on representative CET temperature (Figure 6-1). Establishing subcooling ensures the fluid surrounding the core is subcooled, and provides sufficient margin for re-establishing flow should the subcooling deteriorate when SI flow is secured. Voids may exist in some parts of the RCS (e.g., reactor vessel head, as determined by the HJTC RVLMS), but these are permissible as long as core heat removal is maintained.

b. Pressurizer level is greater than [14.3%] and not decreasing. A pressurizer level greater than [14.3%] and not decreasing, in conjunction with criterion a) above, is an indication that RCS inventory control has been established. This level also ensures the heaters are covered.

c. The unisolated steam generator is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow is available for removing heat from the RCS.

d. The HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles. This provides an extra margin of core coverage and, taken in conjunction with the above, serves as an additional indication that adequate RCS inventory control has been established.

If all of the SI termination criteria are met, then the operator may either stop or throttle the SI pumps. The operator may decide to throttle, rather than terminate the flow, if the SI is to be used to control pressurizer level or plant pressure. A general assessment of the SI performance can be made from the control room. The operator should confirm that at least one train and preferably both trains of SI are operating and that system delivery rate is consistent with RCS pressure as shown in Figures 6-17 and 6-18. Injection flow rates to each Direct Vessel Injection (DVI) nozzle should be approximately equal. Departures from this would indicate a closed or misaligned flow path or some system leakage in addition to the SGTR.

*16. If the criteria of step 15 cannot be maintained after SI pumps are throttled or stopped, then the appropriate SIS pumps should be restarted (if necessary) and full SI flow restored.

*17. Pressurizer level should be restored and maintained at [2% to 78%] by control of charging and letdown (preferentially) as necessary, and SI pumps. If SI termination criteria are met, then SI pumps may be throttled or stopped. When pressurizer level is being controlled at [2%] or greater, then the charging pump may be operated as necessary. A pressurizer level of [2% to 78%] should be restored and maintained to avoid losing pressure control with a saturated bubble in the pressurizer. The top of the pressurizer heaters is at [14.3%]. If pressurizer level drops below the heaters, pressurizer heater operation will be interlocked off for heater protection. It may be necessary to exceed [78%] pressurizer level if the operator is attempting to restore RCS subcooling since pressurizer heaters may be unavailable and solid water operation may be necessary to restore subcooling. The value of [2%] was chosen based on preventing the operator from draining the pressurizer. The value of [78%] is based on the operator maintaining an operable bubble in the pressurizer.

*18. Plant conditions should be carefully assessed before any RCPs are restarted. The need for forced circulation operation should be balanced against the risk of damage to the RCP seals.

The need for operation of the RCPs should be evaluated based on:

1. the adequacy of the RCS and core heat removal under the existing natural circulation conditions,
2. the existing RCS pressure and temperatures,
3. the need for main pressurizer spray capability.

If the existing natural circulation is providing satisfactory RCS and core heat removal, a transfer to forced circulation operation may not be necessary. This would be particularly true if the RCS had already been cooled and depressurized to SCS entry conditions. If the RCS pressure and temperatures are closer to HOT STANDBY conditions, it may be desirable to restart the RCPs in order to allow a normal forced circulation cooldown. Consideration should also be given to the necessity of having main pressurizer spray capability if auxiliary spray is not providing the desired depressurization rate.

The potential for RCP seal degradation should be evaluated based on:

1. how long CCW to the RCPs was interrupted,
2. RCP seal staging pressures and temperatures.

The possibility for seal degradation increases if the CCW has been interrupted. The seal staging pressures provide an indication of degraded seal stages (a low pressure drop across a stage indicates a problem). Restart of an RCP with one or more degraded seal stages should be avoided if possible.

*19. If all RCPs have been stopped, then operation of two RCPs (in opposite loops) should be attempted if RCP restart criteria are met. This will ensure continued forced circulation of coolant through the core, cooling of the RV head region, provide the capability for the normal mode of pressurizer spray, condense RCS steam voids, and remove non-condensible gases from the SG tube bundle. Furthermore, this action enhances the strategy to obtain an uncomplicated cooldown, since a forced circulation cooldown is preferred to a natural circulation cooldown whenever possible during recovery from a SGTR. Only one reactor coolant pump in each loop should be operated to minimize heat input to the RCS.

Determine whether RCP restart criteria are met by the following:

a. Electrical power available to the RCP(s).

b. RCP auxiliaries ([in particular, Component Cooling Water]) to maintain seal cooling, bearing and motor cooling should be operating in order to prevent damage to the pump and/or motor. [Note: Following automatic or operator initiated containment isolation, reinstatement of one of the following means of RCS seal cooling ([CCW], [CVCS seal injection (SI)], [Dedicated Seal Injection System (DSIS)], should be considered to ensure adequate RCP cooling]. There should be no high temperature alarms on the RCPs to be operated.

c. The unisolated steam generator is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow is available for removing heat from the RCS.

d. Pressurizer level is greater than [33%] and not decreasing. With pressurizer level above [33%] the possibility of draining the pressurizer due to loop shrinkage and/or steam void condensation is minimized and there is a greater likelihood of keeping the pressurizer heaters covered. This will assist in maintaining positive RCS pressure control. The criterion of pressurizer level not decreasing implies that RCS inventory control has been established. The value of [33%] was determined by assuming a void in the RCS equal to one-half the volume of the reactor vessel head and determining the volume required in the pressurizer to compensate for that void collapse with draining the pressurizer (i.e., level > [2%]).

e. RCS is subcooled based on representative CET temperature. A subcooled condition in RCS taken in conjunction with d) above indicates that adequate inventory control has been established.

f. All plant specific RCP operating criteria are satisfied before the RCPs are restarted to prevent damage to RCPs resulting from abnormal operating conditions.

g. Condensate that flows to the core on the cold side is depleted in boron and may collect in the RCP loop seals and cold leg. The RCPs should not be started until after single phase natural circulation has slowly moved this boron depleted coolant through the core. Twenty minutes of single phase natural circulation is considered adequate circulation and mixing time.

*20. Upon restarting two RCPs in opposite loops, pressurizer level and pressure may decrease due to loop shrinkage and/or steam void condensation. It is possible that this action will drain the pressurizer. Steam voids present in the reactor vessel will condense upon restarting RCPs. The HJTC RVLMS should be monitored for the trending of reactor vessel liquid level. This trending information may be correlated to pressurizer level decrease. RCP operation with a drained pressurizer may continue provided certain actions are taken and certain criteria are satisfied.

The following constitute the actions to be taken and the criteria to be satisfied when restarting RCPs:

a. Start one RCP in the unaffected loop.
b. Ensure proper RCP operation by monitoring RCP amperage and pump NPSH. NPSH is determined by pressurizer pressure and corresponding Tc on Figure 6-1
c. Operate charging (and SI) pumps to maintain pressurizer level greater than [14.3%] and until SI termination criteria are met (refer to step 15). The value [14.3%] ensures the heaters remain covered.
d. Start one RCP in the affected loop.

*21. If all RCP operation is terminated and inventory and pressure are controlled, then natural circulation is monitored by heat removal via at least one steam generator. Natural circulation flow should occur within 5-15 minutes after the RCPs are tripped. Natural circulation heat removal is illustrated in Figure 6-16.

Natural circulation is governed by decay heat, component elevations, primary to secondary heat transfer, loop flow resistance, and voiding. Component elevations are such that satisfactory natural circulation decay heat removal is obtained by fluid density differences between the core region and the steam generator tubes.

The operator has adequate instrumentation to monitor natural circulation for the single phase liquid natural circulation process. The RCS temperature instrumentation, namely loop ΔT, can be used along with other information to confirm that the single phase natural circulation process is effective. The natural circulation process involving two phase cooling is complex and varied enough so that RCS loop ΔT may not be a meaningful indication of adequate natural circulation cooling. The guidelines are written to alert the operator to use explicit acceptance criteria for natural circulation only when RCS inventory and pressure are controlled.

The RCS temperature response during natural circulation will usually be slow 5-15 minutes as compared to a normal forced flow system response time of 6-12 seconds, since the coolant loop cycle time will be significantly longer.

When single phase circulation is established in at least one loop, the RCS indicates all of the following conditions:

a. Loop ΔT (T_H - T_c) less than normal full power ΔT,
b. Hot and cold leg temperatures constant or decreasing,
c. RCS is subcooled based on representative CET temperature,
d. No abnormal differences between T_H RTDs and core exit thermocouples. Hot leg RTD temperature should be consistent with the core exit thermocouples. Adequate natural circulation flow ensures that core exit thermocouple temperatures will be approximately equal to the hot leg RTD temperatures within the bounds of the instrument's inaccuracies. An abnormal difference between T_H and the CETs could be any difference greater than [10°F].

If the criteria listed in step 21 are not satisfied, then the contingency actions must be addressed. Single phase natural circulation in the RCS is not effectively transferring heat from the core to the steam generators. Both RCS Heat Removal and Core Heat Removal Safety Functions may become jeopardized if the natural circulation flow criteria continue to be violated. Operators should ensure that RCS pressure and inventory, and SG steaming and feeding, are being controlled properly in order to prevent violation of a safety function.

22. The RCS is sampled for activity and boron concentration and is borated to achieve the required shutdown margin (including the mass in the pressurizer) per Technical Specifications. The sample identifies whether reactor coolant dilution has occurred and provides the necessary information for borating to the required concentration. Activity samples will be used for dose assessments and to satisfy reporting requirements.

23. An orderly cooldown to an RCS hot leg temperature of ≤ 400°F is performed, using forced or natural circulation, in accordance with Technical Specifications. One of the following methods should be utilized to reduce RCS temperature:

    a. The preferred method for cooling the RCS is by discharging steam using the Steam Bypass System. This method can only be implemented if the condenser is available.

    <u>or</u>

    b. If the condenser or Steam Bypass System is not available, an RCS cooldown should be performed by dumping steam using the atmospheric steam dump valve of the unisolated steam generator.

    The Steam Bypass System is preferred due to the unmonitored release of radioactivity to the environment through the atmospheric dump valve.

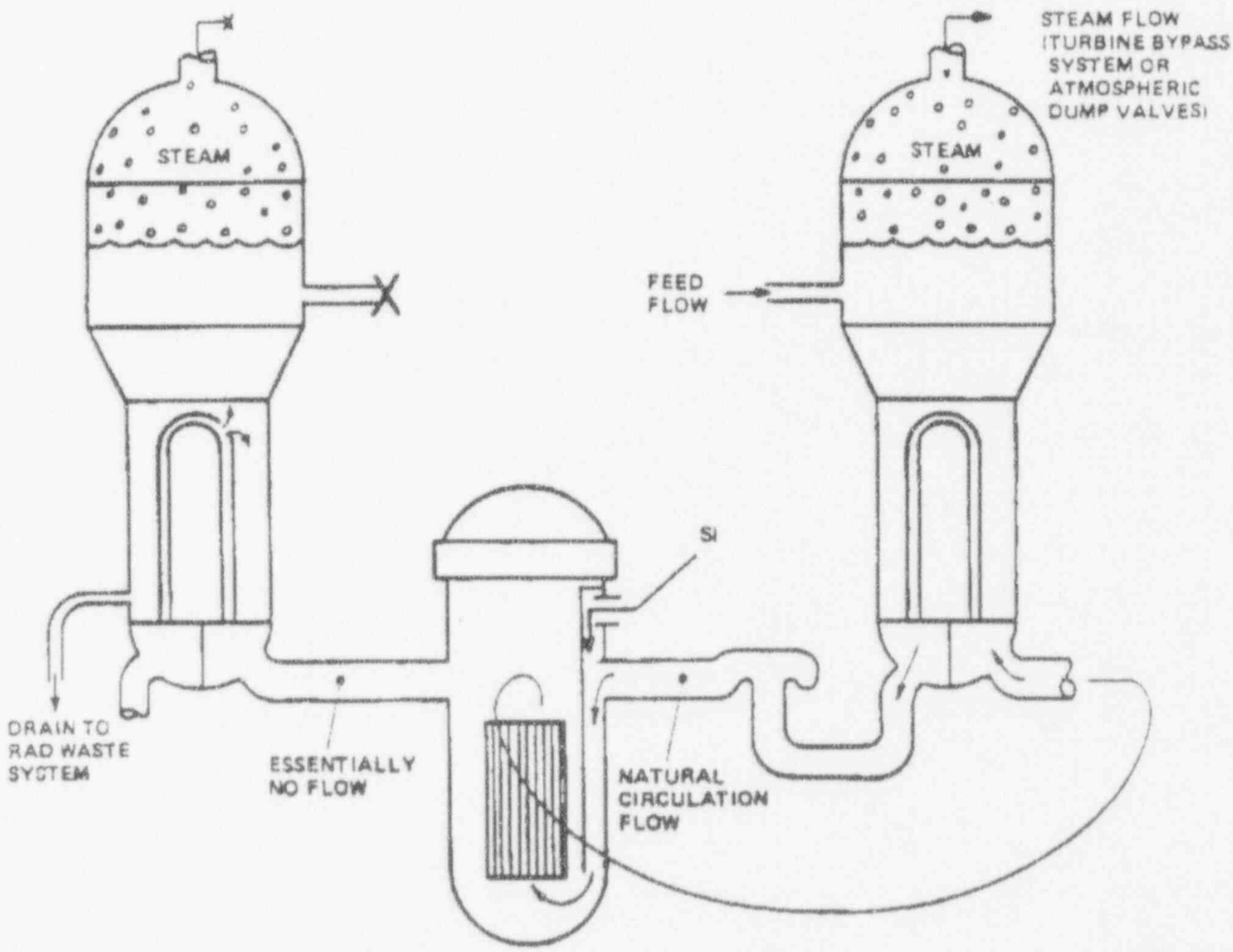
*24. The unisolated steam generator's level is to be maintained in the normal band using startup, main or emergency feedwater. This ensures that a heat sink is available for removing heat from the RCS.

25. During a controlled cooldown and depressurization, the automatic operation of certain safeguard systems is undesirable. Therefore, the setpoints of MSIS and SIAS must be manually reset (lowered) as the cooldown progresses to ensure that

automatic engineered safeguards protection remains available until the RCS is cooled down and depressurized.

*26. The available emergency feedwater inventory should be continually monitored, and replenished from available sources as necessary to provide a source for a secondary heat sink. Examples of alternate sources of emergency feedwater are nonseismic tanks, fire mains, lake water supplies, potable tanks, etc. Plant specific alternate sources of feedwater should be identified and cited in the procedure. The amount of emergency feedwater required to either maintain the plant at HOT STANDBY conditions or during a cooldown may be determined from Figures 6-4 and 6-5.

FIGURE 6-16
STEAM GENERATOR TUBE RUPTURE
(NATURAL CIRCULATION HEAT REMOVAL)



27. It is important to understand why the isolated SG needs to be cooled. Although the unaffected (or least affected) SG is being used to remove heat from the RCS, the isolated SG can still cause problems which will affect RCS depressurization during the cooldown because it will remain at a high temperature and pressure.

The pressure in an isolated SG will remain high during the cooldown due to thermal stratification of the secondary water because without boiling and recirculation flows, the secondary side fluid is not well mixed. This pressure is a concern as the SGTR strategy maintains RCS pressure approximately equal to the isolated SG's pressure to minimize the tube leak flow. Therefore, the isolated SG must be depressurized to further depressurize the RCS to SCS entry conditions.

The following methods are available for cooling and depressurizing the isolated steam generator.

a. Feed and bleed using startup, main or emergency feedwater and the blowdown system. This is a slow method which transfers feedwater through the downcomer region and out the blowdown line. Heat is transferred to the feedwater across the SG shroud from the tube bundle region. The feed rate that can be maintained will determine the effectiveness of this method. The feed rate, however, will be limited by tube leak rate in order to prevent overfilling the SG. If the tube rupture results in a leak rate comparable to or greater than the blowdown system's flow capacity, then this method would not be effective.
b. Short duration steaming of the isolated steam generator will rapidly depressurize the steam generator. Less steaming will be required if the evaporator region has been cooled by the operation of the RCPs. Steaming will result in radiological release to the atmosphere if the ADVs are used. The activity released can be minimized by steaming to the condenser, while maintaining SG water level above the top of the U-tubes. However, both methods require the approval of the [Emergency Coordinator] or the TSC since both methods may increase offsite dose.

In addition to the isolated steam generator depressurization methods listed above, there are two methods available which do not require operator action. One of these methods is simple ambient cooling which will take approximately 10 to 15 hours or longer. If steam generator level control can be maintained during this period, this may be the optimum method since no radiological releases occur after the steam generator is isolated. The other method takes into account existing small steam leaks (such as leakage past the MSIVs) which may depressurize the isolated steam generator. Even the low "normal" leakage may be sufficient to cool and depressurize the isolated steam generator. However, the operator should be aware that this may increase offsite doses.

*28. The condensate and all other connecting systems, including the turbine building sumps, should be sampled for activity that may have been transferred from the affected steam generator(s). These samples aid in determining the extent of contamination throughout the plant systems.

*29. The turbine and radwaste building ventilation systems' radiation monitors, and any other applicable radiation monitors, should be continually observed. Corrective actions, if necessary, should be taken in accordance with plant Technical Specification Limitations.

*30. If pressurizer pressure reaches [740 psia], the safety injection tanks (SITs) must be vented, drained, or their discharge valves shut to prevent the nitrogen cover gas from being discharged into the RCS when RCS pressure is reduced below the SIT's pressure during a controlled cooldown. The max SIT pressure is [640 psia] and the value of [740 psia] is 100 psi greater than the maximum SIT pressure.

*31. If the pressurizer pressure reaches [445 psia], the isolation valves on the SITs may be closed to prevent unnecessary SIT discharge. Automatic override of an SIT isolation valve closure signal occurs above [475 psia] to assure the SITs are available when needed. The value of [445 psia] was chosen to ensure some margin below the automatic override setpoint.

*32. Low temperature overpressurization protection (LTOP) is instituted at $T_c \leq$ [259°F] to protect against subjecting the RCS pressure boundary to low temperature brittle fracture.

*33. The cooldown and depressurization should continue until shutdown cooling system entry conditions are established.

a. pressurizer level control should be established and verified by a level greater than [14.3%] and constant or increasing,
b. RCS should be subcooled,
c. RCS pressure should be at or below the shutdown cooling system entry pressure of [450 psia],
d. RCS hot leg temperature should be at or below the shutdown cooling system entry temperature of [400°F],

When these criteria are established, the SGTR ORG should be exited and SCS operation initiated per operating instructions.

If the RCS cannot be depressurized, then a void should be suspected. Any time it is found that voiding inhibits RCS depressurization to SCS entry pressure, when SCS operation is desired, then an attempt at elimination of the voiding should be made.

a. The operator should monitor for the presence of voids. Voiding in the RCS may be indicated by any of the following indications, parameter changes, or trends:

i. letdown flow greater than charging flow,
ii. pressurizer level increasing significantly greater than expected while operating pressurizer spray,
iii. the HJTC RVLMS indicates that voiding is present in the reactor vessel,

iv. HJTC unheated thermocouple temperature indicates saturated conditions in the reactor vessel upper head,

b. If voiding should be eliminated, then proceed as follows:

i. Letdown is isolated or verified to be isolated to minimize further inventory loss,

ii. The depressurization is stopped to prevent further growth of the void,

iii. Pressurizing and depressurizing the RCS within the limits of Figure 6-1 may condense the void. Pressurizing has the effect of filling the voided portion of the RCS with cooler fluid which will remove heat from the region. Subsequent depressurization and a repeating of this process several times will cool and condense the steam void. In this case of a void in the reactor vessel, the pressurization/ depressurization cycle will preclude a fill and drain of the reactor vessel.

The pressurization/depressurization cycle may be accomplished using pressurizer heaters and spray (preferred method) or the SIS/charging system (alternative method). Monitor pressurizer level and the HJTC RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

c. If indications of unacceptable RCS voiding continue, then voiding may be caused by non-condensible gases. Operate the Reactor Coolant Vent Gas System to clear trapped non-condensible gases. Monitor pressurizer level and/or the HJTC RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

d. If indications of unacceptable RCS voiding continue, and voiding is suspected to exist in the (isolated) steam generator tubes, then cool the (isolated) steam generator (by steaming or blowdown, and/or feeding) to condense the tube bundle void. This will be effective for condensing steam voids but will not have an effect on non-condensible gases trapped in the tube bundle. A buildup of non-condensible gases in the tube bundles will not hinder natural circulation even with a large number of the tubes blocked. This is due to the small amount of heat transfer area required for the removal of decay heat. Monitor pressurizer level for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

When SCS entry conditions are established, the SGTR guideline should be exited and shutdown cooling initiated per plant specific operating instructions. Consideration should be given to the processing and handling of the contaminated steam generator(s) secondary side fluid. If significant voiding is present in the isolated loop, the SCS should be aligned to the subcooled loop. This activity places the plant in an operational mode where a complete cooldown and depressurization of the plant can take place.

Safety Function Status Check

The Safety Function Status Check (SFSC) is used to continually verify the status of safety functions. The safety function acceptance criteria are selected from best estimate analysis to reflect the range for each parameter which would be expected following a Steam Generator Tube Rupture Event. If all SFSC acceptance criteria are being satisfied, then the adequacy of this guideline for mitigating the event in progress is confirmed and the health and safety of the public is ensured.

The safety functions and their respective acceptance criteria listed below are those used to confirm the adequacy of the SGTR Guideline in mitigating the event.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
1. Reactivity Control	a. Reactor Power Decreasing and b. Negative Startup Rate and c. Maximum of 1 CEA not fully inserted or RCS is borated per Tech Specs.	For all emergency events, the reactor must be shutdown. Reactor power decreasing, in conjunction with negative startup rate, is a positive indication that reactivity control is established. The criterion that no more than one CEA not be fully inserted or the RCS borated observes typical Technical Specification requirements.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
2. Maintenance of Vital Auxiliaries (AC and DC power)	a. All vital Division I [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized, or All vital Division II [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized.	One Safety Division is required to power equipment necessary to maintain control of all other safety functions. One DC Division is required as a minimum to provide monitoring and limited control of the other safety functions.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
3. RCS Inventory Control	a. If pressurizer level is [2% to 78%], Then: i) charging and letdown, and SI pumps (unless SI termination criteria are met), are maintaining or restoring pressurizer level and ii) the RCS is subcooled and iii) the HJTC RVLMS indicates the core is covered or	A value of [2%] of range, was chosen as the lower limit to ensure that at least some water is in the pressurizer. The value of [78%] range, is the upper limit for pressurizer level to ensure that there is an operable steam space in the pressurizer. This level can be exceeded if solid operation is required to restore subcooling.
	b. pressurizer level is < [2%], Then: i) available charging pump is operating and the SI pump(s) are injecting water into the RCS per Figure 6-3 and	Subcooling coexisting with a pressurizer level of at least [2%] indicates adequate RCS inventory control via either solid plant operation or a saturated bubble in the pressurizer.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
3. RCS Inventory Control (Continued)	ii) the HJTC RVLMS indicates the core is covered.	Representative CET temperature is utilized during natural circulation flow conditions and T_H RTDs are utilized for forced circulation flow conditions. An HJTC RVLMS indication that the core is covered, taken in conjunction with RCS subcooling, is an additional indication that RCS inventory control has been established. For cases where RCS inventory is degraded, charging pump and SI operation provides implicit assurance that inventory control is being regained.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
4. RCS Pressure Control	a. Pressurizer heaters and spray, charging and letdown, SI pumps or the Reactor Coolant Gas Vent System are maintaining or restoring pressurizer pressure within the limits of Figure 6-1. or b. available charging pump is operating and the SI pump(s) are injecting water into the RCS per Figure 6-3 (unless SI termination criteria are met).	For the SGTR event, when pressurizer level has been restored, operation of the pressurizer heaters and sprays (automatic or manual control), or solid plant control using charging and letdown, or SI pumps, or the RCGVS should be sufficient to control RCS pressure. If none of these systems are available for pressure control, then the operator should implement the FRG. For cases where RCS pressure control is degraded, charging pump and SIS operation provides implicit assurance that inventory control is being regained.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
5. Core Heat Removal	a. T_H RTDs and representative Core Exit Thermocouple temperatures less than [626°F].	The basis for the temperature limit during the use of optimal recovery procedures other than LOCA is the indication that the event specific recovery strategy is not effective in core heat removal. For the optimal recovery guidelines other than LOCA, heat is normally removed from the RCS by the steam generators. The value of the CET temperature will be governed by steam generator conditions (i.e., pressure and temperature). In general, $T_c \cong T_{SG}$ and CET temperature will be T_c + core ΔT. For forced RCS flow conditions $T_{SG} \cong T_c \cong T_H \cong$ CET temperature.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
5. Core Heat Removal (Continued)		T_c is based on the secondary system design of [1200 psia] which has a corresponding T_{sat} = 567°F. The core ΔT during natural circulation is [59°F]. Therefore $T_{sat} + \Delta T$ = [626°F].
6. RCS Heat Removal	a.i) At least one steam generator has level within normal level band with feedwater available to maintain level or ii) At least one steam generator has level being restored to the normal band by feedwater flow with level increasing or iii) Total feedwater flow to either or both steam generators greater than [500 gpm] and	Adequate RCS heat removal will be maintained if at least one steam generator is available for removing heat (capable of steam flow and feed flow). The value of [500 gpm total feedwater flow] is sufficient feed flow to remove decay heat (approximately 2% rated thermal power) from the core. Decay heat levels may not be high enough to require 500 gpm] feed flowrate. In this case, steam generator levels in the normal band satisfies RCS heat removal.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
6. RCS Heat Removal (Continued)	b. RCS T_H is less than [547°F]. and c. RCS temperature is controlled by steam bypass system (preferred) or ADVs.	[547°F] is based on maintaining RCS temperature below the saturation temperature corresponding to the SG safety valve setpoint. The lowest lifting MSSV setpoint is [1200 psia]. The corresponding saturation temperature is [567°F]. When one steam generator is isolated, the hot leg temperature will rise in the operating loop approximately [15°F]. An additional [5°F] is added to this to account for process uncertainties. Therefore, the maximum hot leg temperature must be [567°F] minus [20°F].

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
6. RCS Heat Removal (Continued)		RCS temperatures should be controlled by operation of the steam bypass system or ADVs. The steam bypass system is preferred because of the unmonitored release of radioactivity to the environment via the ADVs. Controlled temperature response is specified to distinguish between an uncontrolled cooldown with a stuck open MSSV.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
7. Containment Isolation	a. Containment Pressure < [2.0 psig] and b. No containment area radiation monitors alarming and c. No abnormal increase in containment sump levels. and d. No Nuclear Annex alarms	[2.0 psig] is based on the containment pressure alarm. It is not expected for the SGTR event that containment pressure will increase to the alarm setpoint. No radiation is anticipated in the containment for a SGTR. During a SGTR event no increase in IRWST or reactor cavity sump levels is anticipated. During a SGTR event, no Nuclear Annex alarms are anticipated.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
8. Containment Temperature and Pressure Control	a. Containment temperature less than [110°F]. and b. Containment pressure less than [2.0 psig].	[110°F] is the containment temperature Technical Specification limit. Containment temperature is not expected to increase to [110°F] for the SGTR event. [2.0 psig] is based on the containment pressure alarm. It is not expected that the pressure will reach this value during the SGTR event.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
9. Containment Combustible Gas Control	a. Containment temperature less than [110°F] and b. Containment pressure less than [2.0 psig].	Maintaining these containment conditions provides an indirect indication that the conditions required for H_2 generatior do not exist.

Event Strategy

This section contains the SGTR operator actions strategy flow chart (Figure 6-17). The flow chart depicts the strategy around which the SGTR guideline is built. It is intended to assist the procedure writer in understanding the intent of the guideline and for use in training. Operators should understand what the major objectives of the guideline are in order to facilitate their progress toward those goals.

The strategy chart shows the recovery guideline strategy in detail and lists the guideline steps which correspond to each strategy objective. Some steps in the guideline may be performed at any time during the course of an event. These steps are indicated by an asterisk next to the step number.

FIGURE 6-17a

STRATEGY CHART FOR STEAM GENERATOR TUBE RUPTURE

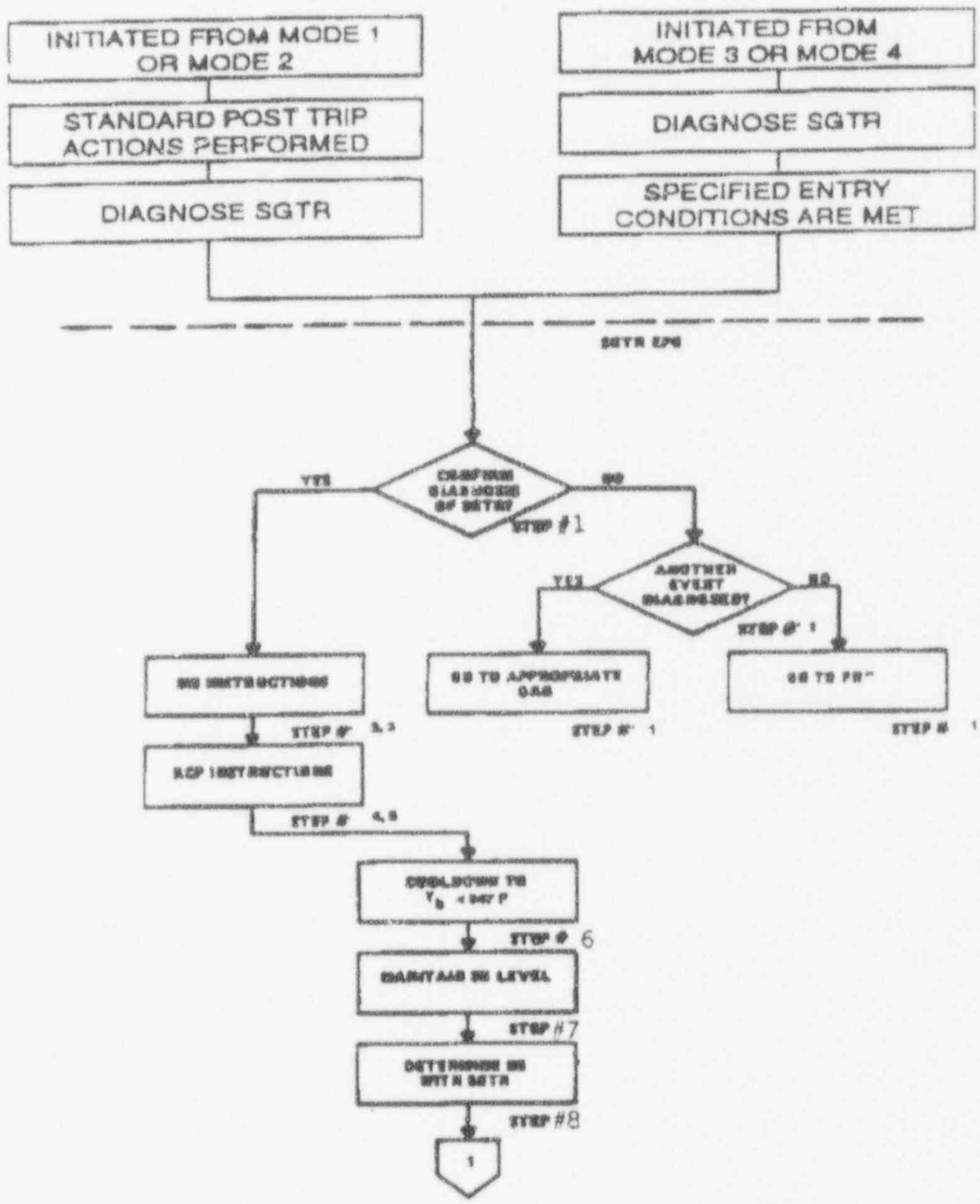


FIGURE 6-17b

STRATEGY CHART FOR STEAM GENERATOR TUBE RUPTURE

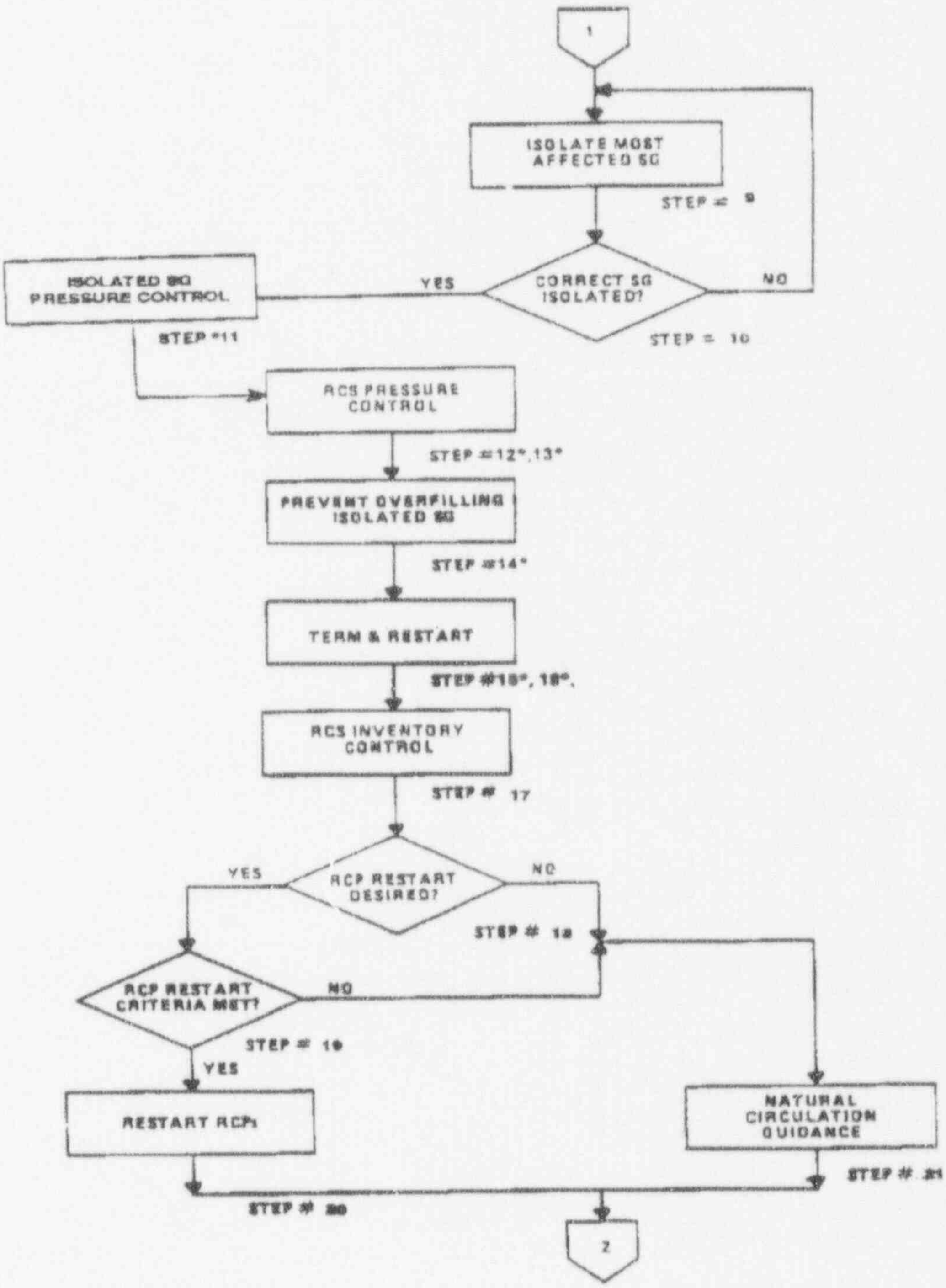


FIGURE 6-17c

STRATEGY CHART FOR STEAM GENERATOR TUBE RUPTURE

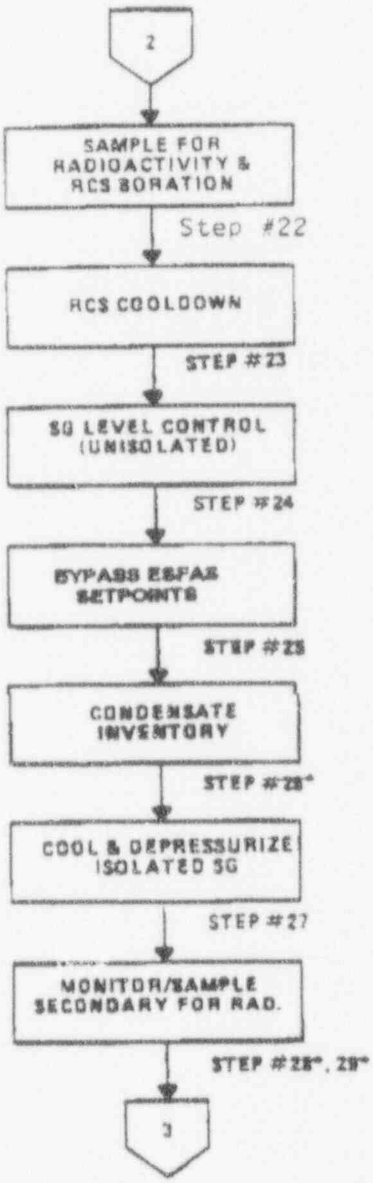
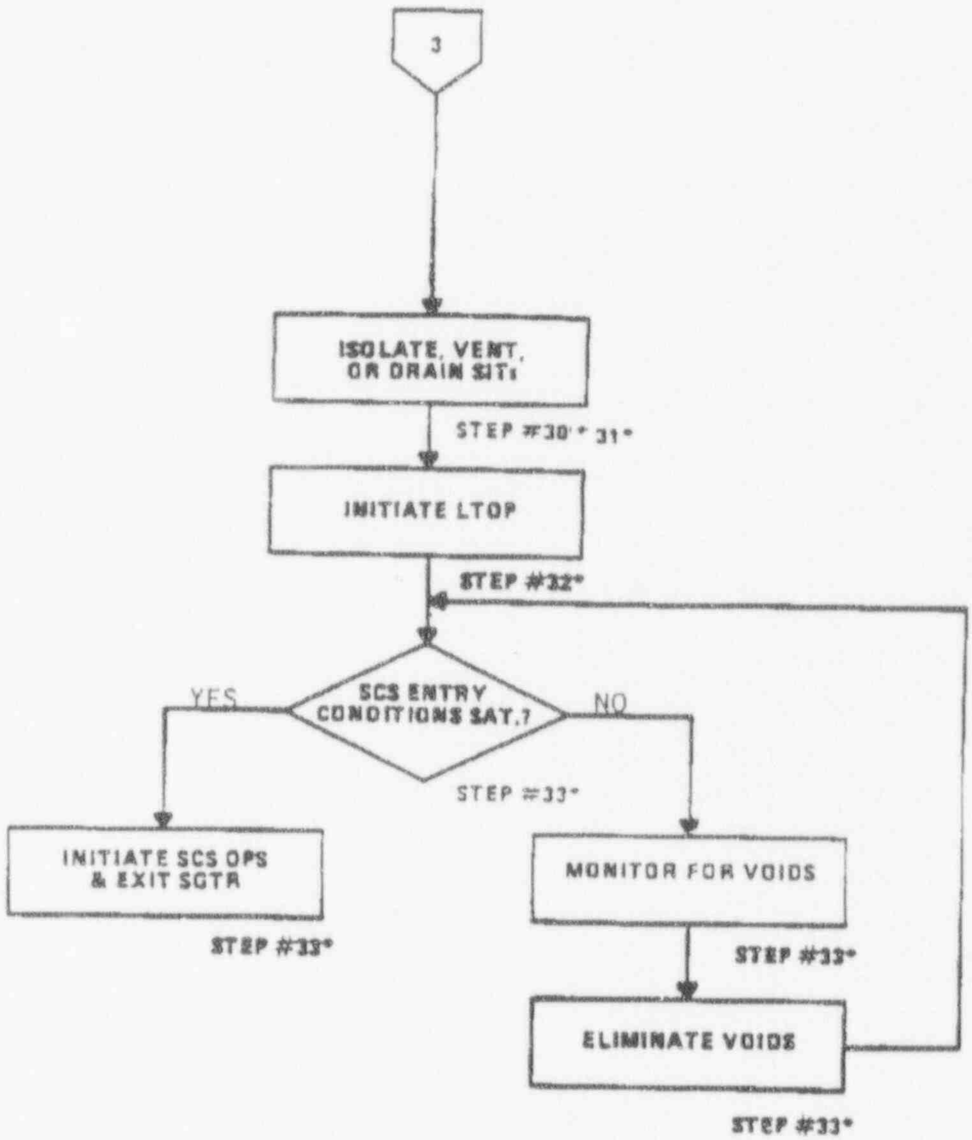


FIGURE 6-17d

STRATEGY CHART FOR STEAM GENERATOR TUBE RUPTURE



EXCESS STEAM DEMAND EVENT RECOVERY

PURPOSE

This guideline provides the operator actions which should be accomplished in the event of an Excess Steam Demand Event (ESDE). The actions in this guideline are necessary to ensure the plant is placed in a safe, stable condition. The goal of the guideline is to safely establish the plant in a condition which will allow the implementation of an appropriate existing procedure for COLD SHUTDOWN, HOT STANDBY, or HOT SHUTDOWN, if the break has been isolated. Radiological releases to the environment will be minimized and adequate core cooling will be maintained by following this guideline. This guideline provides technical information to be used by the utilities in developing a plant specific procedure.

ENTRY CONDITIONS

1. The Standard Post Trip Actions have been performed.

   or

   All of the following conditions exist:
   a. Event initiated from [Mode 3 or Mode 4]
   b. SIAS has NOT been blocked
   c. LTOP has NOT been initiated.

   and

2. Plant conditions indicate that an Excess Steam Demand Event has occurred. Any one or more of the following may be present:

   a. Loud noise indicative of a high energy steam line break.
   b. Decreasing RCS average temperature caused by the increased RCS heat removal.
   c. Increase in feedwater flow until main feedwater isolation valves are closed on MSIS.
   d. Possible increase in containment temperature, pressure, humidity, and Holdup Volume Tank level.

EXIT CONDITIONS

1. The diagnosis of an Excess Steam Demand Event is not confirmed.

<u>or</u>

2. Any of the Excess Steam Demand Event Safety Function Status Check acceptance criteria are not satisfied.

<u>or</u>

3. The Excess Steam Demand Event EOG has accomplished its purpose by satisfying <u>ALL</u> of the following:

   a. All Safety Function Status Check acceptance criteria are being satisfied.
   b. RCS conditions are being controlled and maintained in HOT STANDBY, HOT SHUTDOWN, or COLD SHUTDOWN.
   c. An appropriate, approved procedure to implement exists or has been approved, by the [Plant Technical Support Center or the Plant Operations Review Committee].

INSTRUCTIONS / CONTINGENCY ACTIONS

INSTRUCTIONS	CONTINGENCY ACTIONS
1. Confirm diagnosis of an Excess Steam Demand Event by: a. verifying Safety Function Status Check acceptance criteria are satisfied, and b. referring to the Break Identification Chart (Figure 7-2), and c. sampling both steam generators for activity.	1. Rediagnose event and exit to either appropriate Optimal Recovery Guideline or the Functional Recovery Guideline.
* 2. If pressurizer pressure decreases to or below the SIAS setpoint, Then verify an SIAS is actuated.	2. If pressurizer pressure decreases to or below the SIAS setpoint and a SIAS has NOT been initiated automatically, Then manually initiate an SIAS.
* 3. Ensure maximum safety injection and charging flow to the RCS (unless SI termination criteria met) by the following: a. start idle SI pumps and verify SI flow in accordance with Figure 7-3.	3. If safety injection and charging flow NOT maximized, Then do the following as necessary: a. ensure electrical power to valves and pumps, b. ensure correct SI valve lineup, c. ensure operation of necessary auxiliary systems.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
* 4. If pressurizer pressure decreases to less than [1400 psia] following an SIAS, Then ensure two of four RCPs are tripped (in opposite loops).	4. Continue RCP operation
* 5. Verify RCP operating limits are satisfied.	5. Trip the RCP(s) which do not satisfy RCP operating limits.
6. Determine the affected SG (or most affected SG) by comparison of the following: a. SG steam pressures, b. RCS cold leg temperatures, c. SG levels.	6.
7. If Excess Steam Demand Event stopped due to MSIS, Then go to step 10.	7.
8. Isolate the most affected steam generator by performing the following:	8.
a. close the MSIV,	a. locally close MSIV,
b. verify closed, or close the MSIV bypass valve,	b. locally close MSIV bypass valve,
c. close, or verify closed the atmospheric dump valve(s),	c. locally close ADV(s).

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
8. (Continued)	
d. close the main feedwater isolation valve,	d. locally close main feedwater isolation valve,
e. close the startup and emergency feedwater isolation valve,	e. locally close startup and emergency feedwater isolation valve
f. close vents, drains, exhausts and bleedoffs,	f. locally close vents, drains, exhausts, and bleedoffs.
g. close the Turbine Driven EFW pump steam admission valve.	g. locally close the Turbine Drive EFW pump steam admission valve.
9. Verify the correct steam generator is isolated by checking the following: a. SG steam pressures, b. RCS cold leg temperatures, c. SG levels.	9. If the wrong steam generator was isolated, Then unisolate that steam generator and isolate the most affected steam generator per step 9.
*10. Maintain unisolated steam generator level in the normal band using main, startup or emergency feedwater.	10.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*11. Stabilize RCS temperature by controlled steaming of the unisolated SG using the following (listed in preferred order): a. Steam Bypass System, or b. atmospheric dump valve(s).	11.
*12. If SI pumps are operating, Then they may be throttled or stopped, one pump at a time, if ALL of the following are satisfied: a. RCS subcooled based on Representative CET temperature (Figure 7-1), b. pressurizer level is greater than [14.3%] and not decreasing, c. at least one steam generator is available for removing heat from the RCS (ability for feed and steam flow), d. the HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles.	12. Continue SI pump operation.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*13. If criteria of step 12 cannot be maintained after SI pumps throttled or stopped, Then appropriate SI pumps must be restarted and full SI flow restored.	13.
*14. When pressurizer level is greater than or equal to [2%], Then ensure charging and letdown, and the SI (unless SI termination criteria met) are being operated to maintain pressurizer level [2% to 78%].	14. If pressurizer level less than [2%], Then continue to operate the available charging pump and all available SI pumps for maximum available flow.
*15. Maintain the RCS within the acceptable Post Accident Pressure Temperature limits of Figure 7-1 by the following: a. pressurizer heaters and main or auxiliary spray, or b. charging and letdown, or c. throttling of SI pumps.	15. If RCS subcooling greater than P-T limits or cooldown rate greater than [100°F/hr], Then do the following as appropriate: a. stop the cooldown, b. depressurize the RCS using the Reactor Coolant Gas Vent System or main or auxiliary spray to restore and maintain pressurizer pressure within the limits of Figure 7-1,

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*15. (Continued)	15. (Continued) c. attempt to maintain the plant in a stable pressure-temperature configuration or continue to cooldown within the limits of Figure 7-1, d. _If_ over-pressurization is due to SI/charging flow, _Then_ throttle or secure flow (refer to step 12) and manually control letdown to restore and maintain pressurizer pressure within the limits of Figure 7-1.
*16. _If_ containment pressure is greater than or equal to [2.7 psig], _Then_ ensure the following: a. containment isolation is actuated automatically from ESF panel _and_ b. all available containment recirculation fan coolers operating	16. a. _If_ containment isolation does not occur automatically or all containment isolation valves are not in their accident positions, _Then_ manually initiate containment isolation. [Plant specific method for manually isolating containment will be provided in plant specific EOPs].

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*17. If containment pressure is greater than or equal to [8.5 psig], Then do the following: a. ensure containment spray system actuation, and b. place the hydrogen monitors in service and continuously monitor containment hydrogen, and c. ensure Annulus vent system fans have started and pressure in the Annulus decreases to < [0"w]. and d. ensure adequate containment temperature-pressure control by at least one containment spray header delivering at least [5000 gpm], and e. take steps to have the H_2 recombiners made available and aligned for use.	17.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*18. If containment spray system is operating and containment pressure is less than [5.5 psig], Then containment spray may be terminated. Upon termination, the CSS must be aligned and reset for automatic operation or manual restart.	18. Continue containment spray system operation.
*19. If the containment hydrogen concentration is greater than or equal to 0.5%, Then operate the hydrogen recombiners.	19.
*20. If containment hydrogen concentration is less than [0.5%], Then terminate operation of hydrogen recombiners.	20.
*21. If RCPs are NOT operating, Then evaluate the need and desirability of restarting RCPs. Consider the following: a. adequacy of RCS and core heat removal using natural circulation, b. existing RCS pressure and temperatures,	21.a. If RCP operation NOT desired, Then go to step 24. or b. If at least one RCP is operating in each loop, Then go to step 25.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*21. (Continued) c. the need for main pressurizer spray capability, d. the duration of CCW interruption to RCPs, e. RCP seal staging pressures and temperatures.	
*22. Determine whether RCP restart criteria are met by ALL of the following: a. electrical power is available to the RCP(s), b. RCP auxiliaries (CCW) are operating to maintain seal cooling, bearing cooling, and motor cooling, and there are no high temperature alarms on the selected RCPs, c. the unisolated steam generator is available for removing heat from the RCS (ability for feed and steam flow), d. pressurizer level is greater than [33%] and not decreasing, e. RCS is subcooled based on Representative CET temperature (Figure 7-1),	22. Go to step 24.

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS
*22. (Continued) f. other criteria satisfied per plant specific RCP operating instructions. g. Natural circulation has been established per Step 24 for the preceding 20 minutes.		
*23. <u>If</u> RCP restart desired and restart criteria satisfied, <u>Then</u> do the following: a. start one RCP in each loop, b. ensure proper RCP operation by monitoring RCP amperage and NPSH, c. operate charging and letdown (and SI) to maintain pressurizer level [2% to 78%]. Operate SI pumps until SI termination criteria met. (Refer to step 12).	23.	<u>Go to</u> step 24

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*24. If no RCPs are operating, Then verify natural circulation flow in at least one loop by ALL of the following: a. loop ΔT (T_H - T_c) less than normal full power ΔT, b. hot and cold leg temperatures constant or decreasing. c. RCS is subcooled based on Representative CET temperature (Figure 7-1), d. no abnormal difference [greater than 10°F] between T_H RTDs and representative CET temperature.	24. Ensure proper control of steam generator feeding and steaming (refer to steps 10 and 11) and RCS inventory and pressure control (refer to steps 14 and 15).
25. Evaluate the need for a plant cooldown based on: a. plant status, b. auxiliary systems availability, c. emergency feedwater inventory (refer to Figures 7-4 and 7-5).	25.
26. If a plant cooldown is desired, Then continue with the actions of this guideline.	26. a. Maintain the plant in a stabilized condition, and b. Exit to appropriate procedure as directed by [Plant Technical Support Center or Plant Operations Review Committee].

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*27. a. Borate the RCS to maintain shutdown margin in accordance with Technical Specifications. and b. Prevent boron dilution by pressurizer outsurge by the following (listed in preferred order): i) borate to raise the entire RCS (including the mass in the pressurizer) to COLD SHUTDOWN conditions. or ii) use main or auxiliary spray to increase and maintain pressurizer boron concentration within 50 ppm of RCS boron concentration.	27.
28. Perform a controlled cooldown, using forced or natural circulation, in accordance with Technical Specifications. Reduce RCS temperatures by: a. If the condenser is available, Then cooldown using the steam bypass system,	28.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
28. (Continued) or b. If the condenser or steam bypass system NOT available, Then cooldown using the unisolated SG ADV.	
*29. Control charging and letdown, and SI (unless SI termination criteria met) to restore and maintain pressurizer level [2% to 78%].	29. If RCS subcooling can NOT be maintained, Then [78%] may be exceeded to restore RCS subcooling.
*30. Ensure RCS conditions are being maintained within the limits of Figure 7-1 during cooldown by: a. manual operation of pressurizer heaters and spray, or b. operation of charging/letdown, or c. throttling of SI pumps (refer to step 12)	30. If RCS subcooling greater than P-T limits or cooldown rate greater than [100°F/Hr.], Then do the following: a. stop the cooldown, b. depressurize the plant using Reactor Coolant Gas Vent System or main or auxiliary spray to restore and maintain pressurizer pressure within the Post Accident P-T limits of Figure 7-1, c. attempt to maintain the plant in a stable pressure-temperature configuration or continue to cooldown within the limits of Figure 7-1,

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS
	30.	(Continued) d. If overpressurization due to SI/charging flow, Then throttle or secure flow (refer to step 12) and manually control letdown to restore and maintain pressurizer pressure within the limits of Figure 7-1.
*31. Maintain unisolated SG level in the normal band throughout the cooldown using main, startup or emergency feedwater.	31.	
*32. Ensure the available emergency feedwater inventory is adequate per Figures 7-4 and 7-5.	32.	
33. Bypass or lower the automatic initiation setpoints of MSIS and SIAS as the cooldown and depressurization proceed.	33.	
*34. When pressurizer pressure reaches [740 psia], reduce SIT pressure to [300 psia].	34.	

* Step Performed Continuously

INSTRUCTIONS

*35. When pressurizer pressure reaches [445 psia], Then vent, drain, or isolate the SITs.

*36. Initiate low temperature overpressurization protection (LTOP) at $T_c \leq$ [259°F].

*37. When the following SCS entry conditions are established:
a. pressurizer level > [14.3%] and constant or increasing,
b. RCS subcooled
c. RCS pressure < [450 psia]
d. RCS $T_H \leq$ [400°F],

Then exit this guideline and initiate SCS operation per plant specific operating instructions.

CONTINGENCY ACTIONS

35.

36.

*37. If the RCS fails to depressurize, Then a void should be suspected.
a. Voiding the RCS may be indicated by any of the following indications, parameter changes, or trends:
i) letdown flow greater than charging flow,
ii) pressurizer level increasing significantly more than expected while operating pressurizer spray,
iii) the HJTC RVLMS indicates that voiding is present in the reactor vessel,
iv) HJTC unheated thermocouple temperature indicates saturated conditions in the reactor vessel upperhead,

* Step Performed Continuously

INSTRUCTIONS

CONTINGENCY ACTIONS

*37. (Continued)

b. If voiding inhibits RCS depressurization to SCS entry pressure, Then attempt to eliminate the voiding by:

i) verify letdown is isolated,

and

ii) stop the depressurization,

and

iii) pressurize and depressurize the RCS within the limits of Figure 7-1 by operating pressurizer heaters and spray or SI and charging pumps. Monitor pressurizer level and the HJTC RVLMS for trending of RCS inventory.

c. If depressurization of the RCS to the SCS entry pressure is still not possible, Then attempt to eliminate the voiding by:

i) operate the Reactor Coolant Gas Vent System to clear trapped non-condensible gases,

and

* Step Performed Continuously

INSTRUCTIONS

CONTINGENCY ACTIONS

*37. (Continued)

ii) monitor pressurizer level and/or the HJTC RVLMS for trending of RCS inventory.

d. Continue attempts to establish SCS entry condition, or exit this guideline and initiate an appropriate procedure.

The Excess Steam Demand Event Recovery Guideline has accomplished its purpose if all of the SFSC acceptance criteria being satisfied, RCS conditions are being controlled in HOT STANDBY, HOT SHUTDOWN, or COLD SHUTDOWN, and the entry conditions of an appropriate procedure are satisfied.

END

SUPPLEMENTARY INFORMATION

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions or notes or in the EOP training program.

1. Lengthy operation of the containment spray system may jeopardize the operation of equipment which would be desirable later in the event. Early consideration should be given to termination of spray operation.

2. During all phases of cooldown, monitor RCS temperature and pressure to avoid exceeding a maximum cooldown rate greater than Technical Specification Limitations.

3. Do not place systems in "manual" unless misoperation in automatic is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation.
4. All available indications should be used to aid in diagnosing the event since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available. (e.g., during rapid depressurization the indicated level in the pressurizer may be too high).

5. If the initial cooldown rate exceeds Technical Specification Limits, there may be a potential for pressurized thermal shock (PTS) of the reactor vessel. Post Accident Pressure/Temperature Limits of Figure 7-1 should be maintained.

6. Solid water operation of the pressurizer should be avoided unless subcooling cannot be maintained in the RCS (Figure 7-1). If the RCS is solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any unfavorable rapid pressure excursions.

7. Minimize the number of cycles of pressurizer auxiliary spray whenever the temperature differential between the spray water and the pressurizer is greater than 200°F in order to minimize the increase in the spray nozzle thermal stress accumulation factor.

8. When a void exists in the reactor vessel, and RCPs are not operating, the HJTC RVLMS provides an accurate indication of reactor vessel liquid inventory. When a void exists in the reactor vessel, and RCPs are operating, it is not possible to obtain an accurate reactor vessel liquid level indication due to the effect of the RCP induced pressure head on the HJTC RVLMS. The indicated level also differs for different HJTC RVLMS designs under these conditions. Information concerning reactor vessel liquid inventory trending may still be discerned. However, the operator is cautioned not to rely solely on the HJTC RVLMS indication when RCPs are operating and use other means of level indication if available.

9. The operator should continuously monitor for the presence of RCS voiding and take steps to eliminate voiding any time voiding causes the heat removal or inventory control safety functions to begin to be threatened. Void elimination should be started soon enough to ensure heat removal and inventory control are not lost.

10. Reducing containment temperature will reduce hydrogen production from corrosion due to the reaction of containment building metal (especially aluminum and zinc) and boric acid (containment spray). This is a temperature dependent reaction.

11. Any cautions provided by the hydrogen recombiner vendor concerning operation of the recombiner with a degraded containment environment should be inserted here.

12. Operation of any equipment in the containment building when containment hydrogen concentration ≥ [4%] should consider the possibility of hydrogen ignition (Reference 15.6). Consideration should be given to the following:

a. The importance to safety of equipment operation
b. The urgency of equipment operation
c. The use of alternative equipment located outside containment
d. The current hydrogen level and the anticipated time to reduce $H_2 \leq 4\%$.

13. Measured containment hydrogen typically represents a value of hydrogen in units of percent by volume of dry air. The measured hydrogen will typically indicate higher than the actual containment hydrogen for a steam/air mixture inside containment. The indicated value should, therefore, be corrected to account for any steam/air mixture inside containment.

14. If there is a conflict between maintaining adequate core cooling and complying with the pressure/temperature limits of Figure 7.1, then maintaining adequate core cooling will be given the higher priority. Subcooling has precedence over PTS considerations.

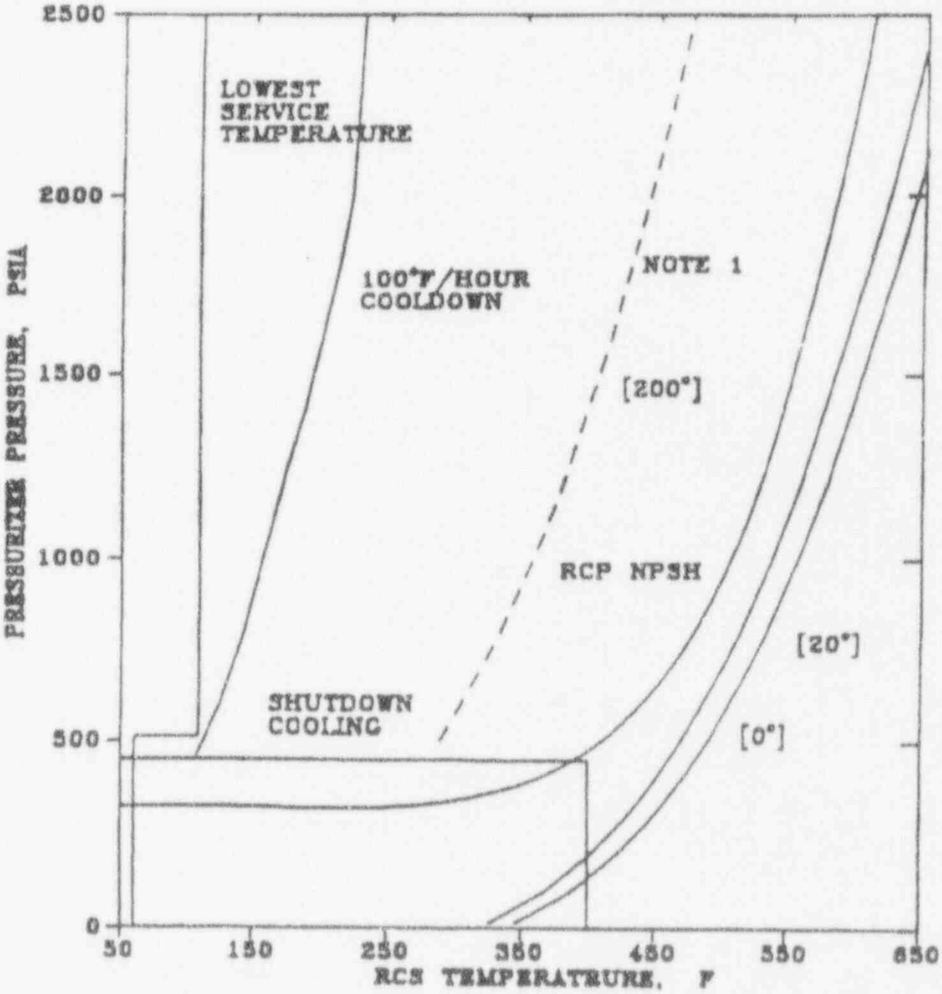
15. The loss of one AC or DC safety division bus will not prevent the operators from performing the actions of this guideline. However, it is desirable to have a complete complement of electrical equipment to mitigate and recover from an event. Therefore, the operators should attempt to restore electrical power to all AC or DC safety divisions.

16. If there is a conflict between isolating a SG and maintaining adequate heat removal, then maintain RCS heat removal via the least affected SG. At least one SG should always be available for heat removal, if at all possible.

17. Prior to RCP restart, verify loops with restart RCP(s) have been in natural circulation continuously for the preceding 20 minutes.

FIGURE 7-1

TYPICAL POST ACCIDENT PRESSURE-TEMPERATURE LIMITS



NOTES: (1) THIS CURVE SUPERSEDES THE 100° F/HR COOLDOWN CURVE ANYTIME THE RCS HAS EXPERIENCED AN UNCONTROLLED COOLDOWN WHICH CAUSES RCS TEMPERATURE TO GO BELOW 500° F. THIS CURVE IS AN OPERATIONAL LIMIT BASED ON ENGINEERING JUDGEMENT AND INTENDED TO MINIMIZE THE POTENTIAL OF A PRESSURIZED THERMAL SHOCK.

(2) THESE CURVES MUST BE ADJUSTED FOR INSTRUMENT INACCURACIES.

FIGURE 7-2

BREAK IDENTIFICATION CHART

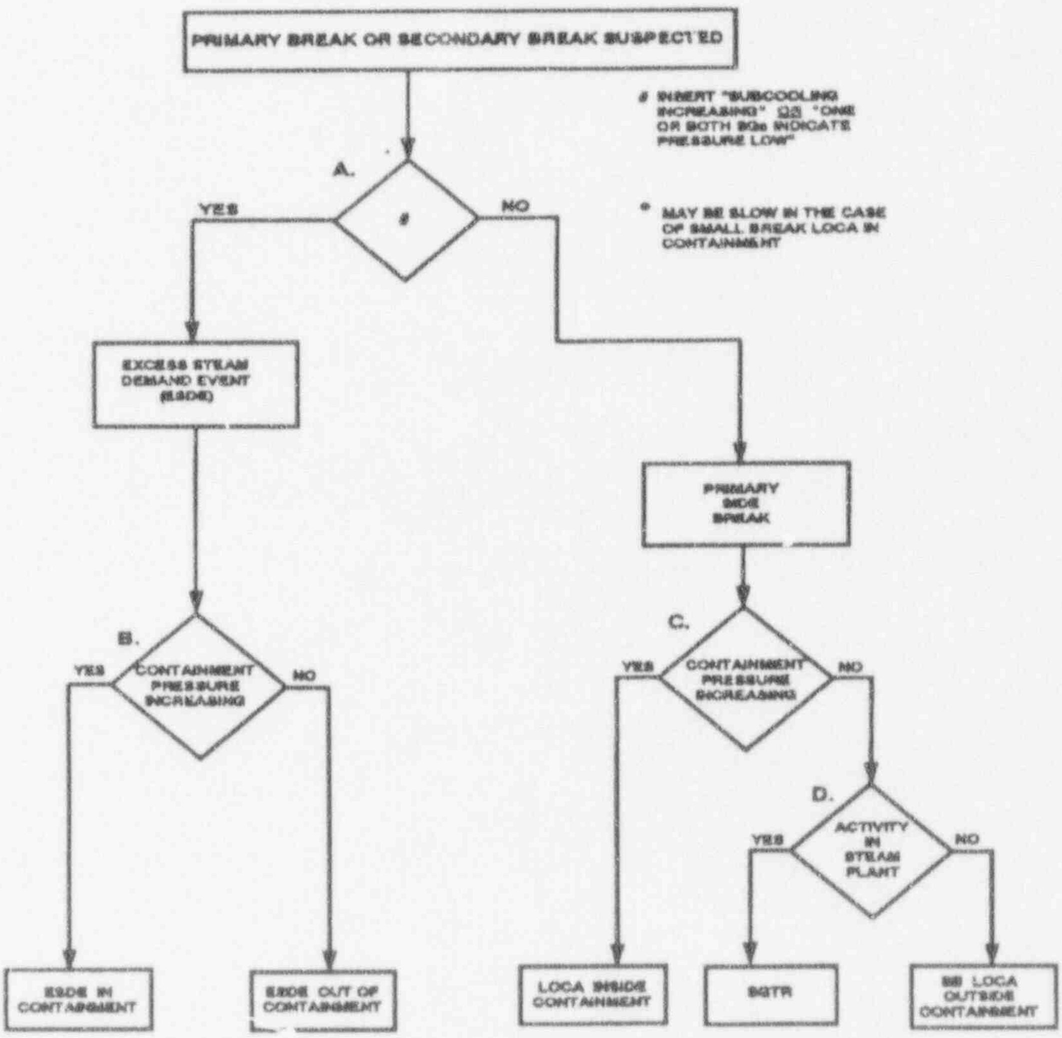
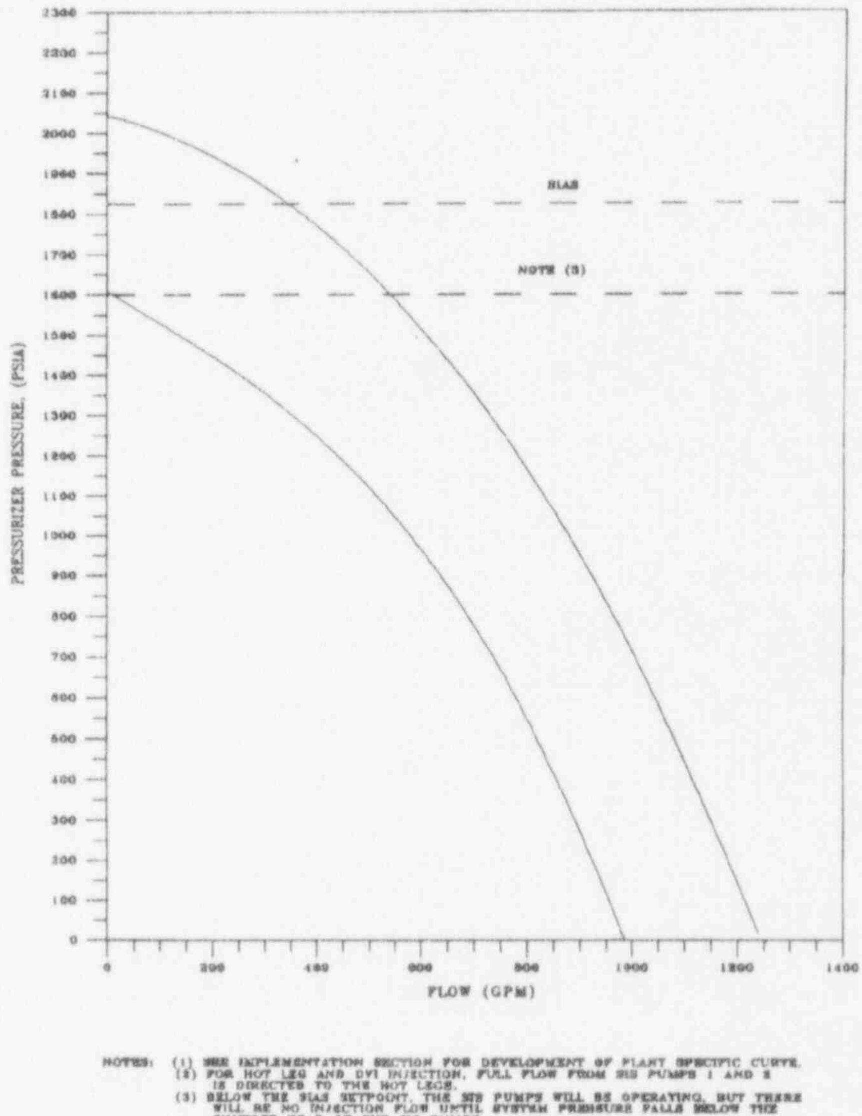


FIGURE 7-3

TYPICAL ACCEPTABLE SI FLOW VS RCS PRESSURE



NOTES: (1) SEE IMPLEMENTATION SECTION FOR DEVELOPMENT OF PLANT SPECIFIC CURVE.
(2) FOR HOT LEG AND DVI INJECTION, FULL FLOW FROM SIS PUMPS 1 AND 3 IS DIRECTED TO THE HOT LEGS.
(3) BELOW THE SIAS SETPOINT, THE SIS PUMPS WILL BE OPERATING, BUT THERE WILL BE NO INJECTION FLOW UNTIL SYSTEM PRESSURE FALLS BELOW THE SHUTOFF HEAD OF THE SIS PUMPS.
(4) THESE CURVES DO NOT ACCOUNT FOR INSTRUMENTATION INACCURACIES

FIGURE 7-4

TYPICAL FEEDWATER CAPACITY VS TIME UNTIL SHUTDOWN COOLING REQUIRED

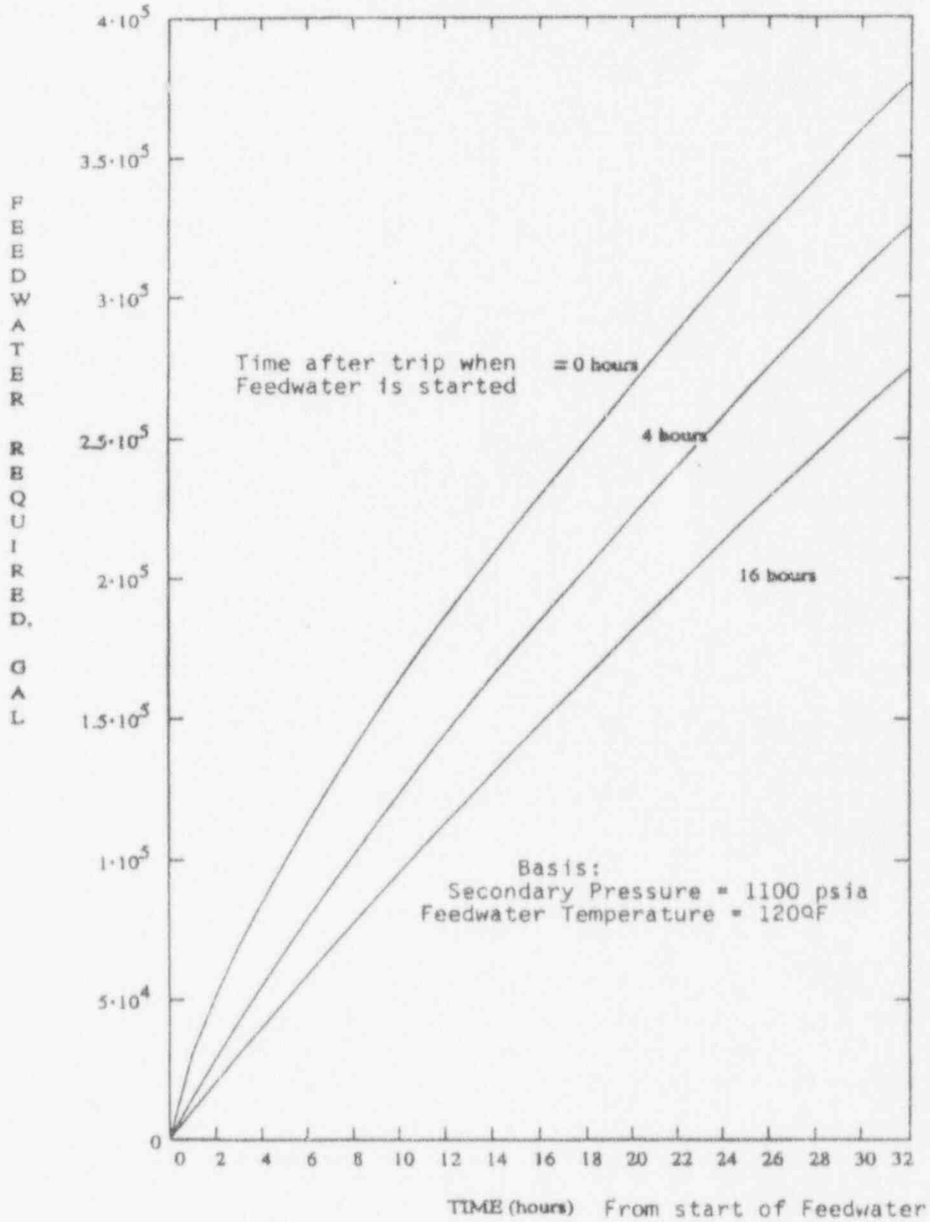
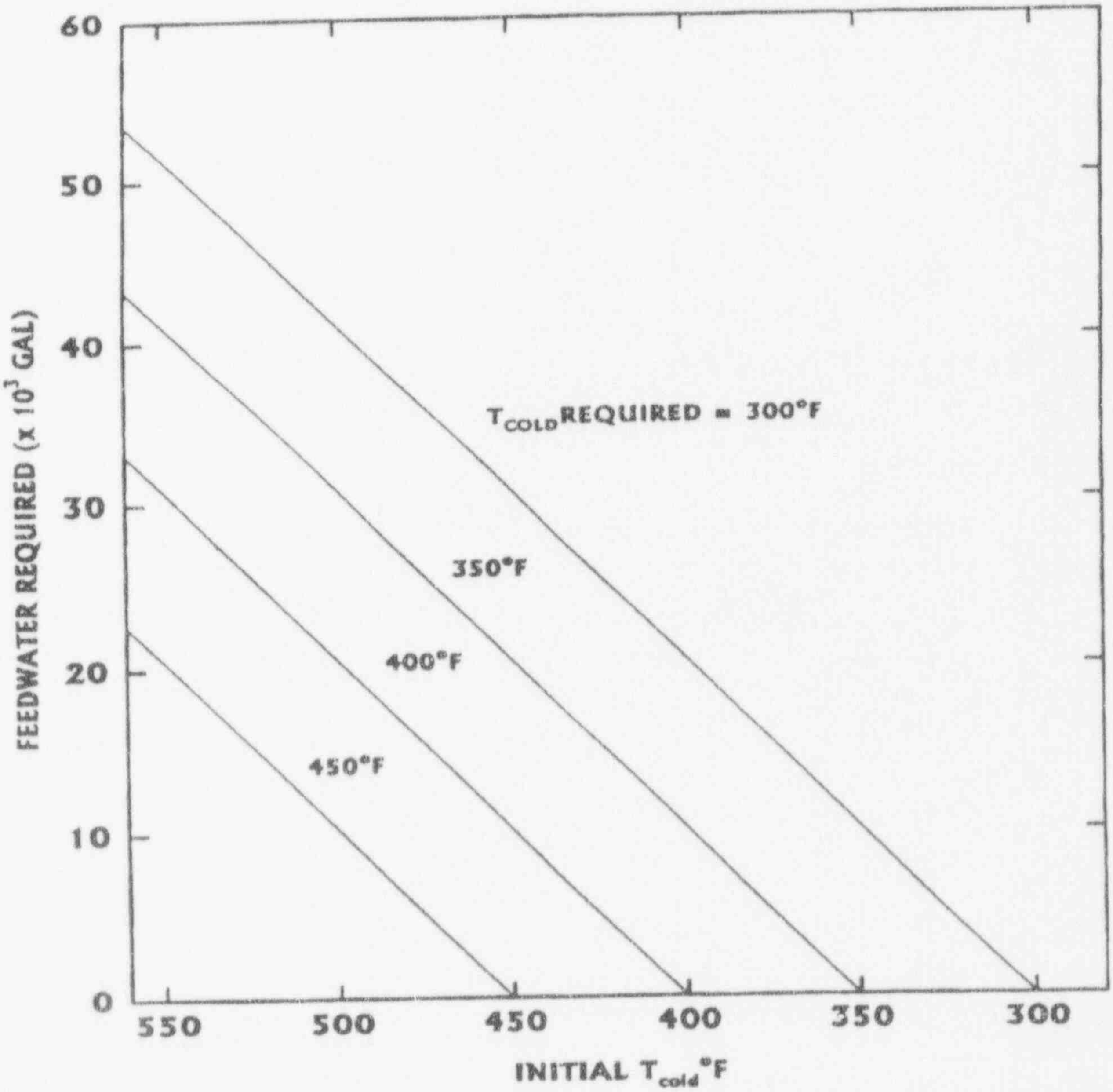


FIGURE 7-5

TYPICAL FEEDWATER REQUIRED FOR SENSIBLE HEAT REMOVAL

T_{COLD} (Required) vs T_{COLD} (Initial)



SAFETY FUNCTION STATUS CHECK

SAFETY FUNCTION	ACCEPTANCE CRITERIA
1. Reactivity Control	1. a. Reactor power decreasing and b. Negative Startup Rate and c. Maximum of one CEA NOT fully inserted or borated per Tech Specs.
2. Maintenance of Vital Auxiliaries (AC and DC Power)	2. All vital Division I [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized, or All vital Division II [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized.

2

IMAGE EVALUATION TEST TARGET (MT-3)

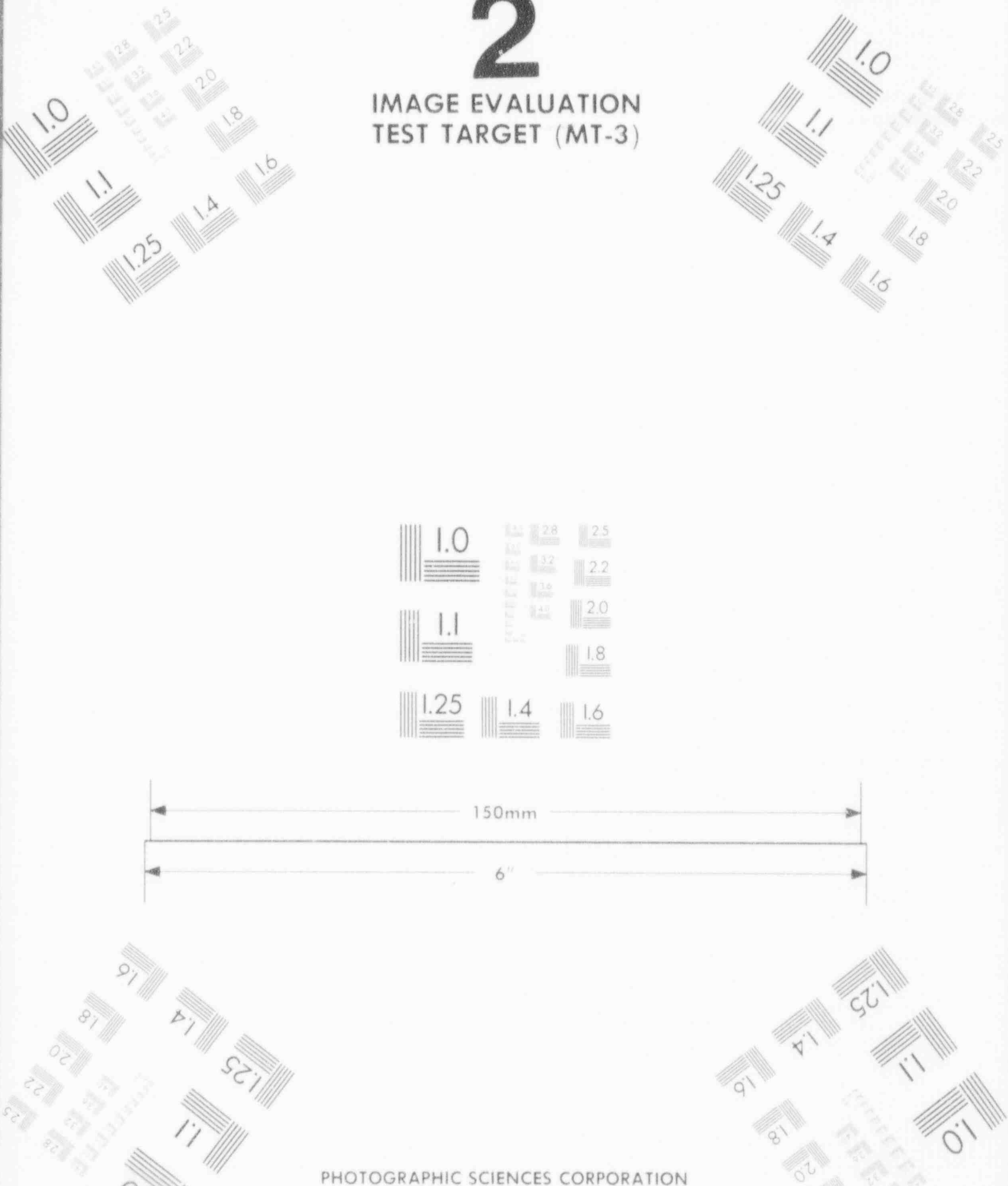


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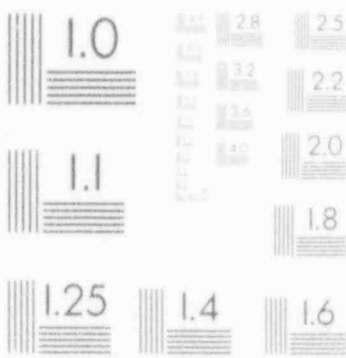
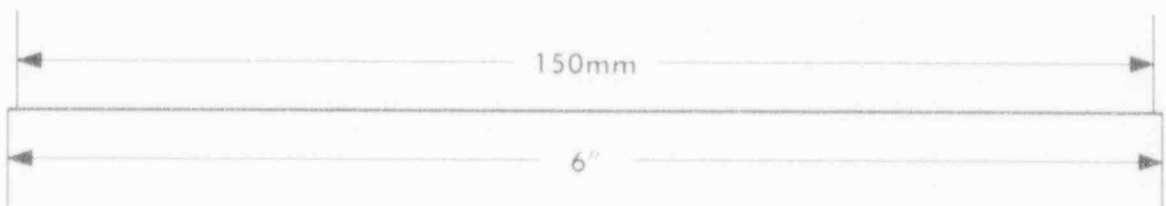
IMAGE EVALUATION TEST TARGET (MT-3)





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2

IMAGE EVALUATION
TEST TARGET (MT-3)

150mm

6"

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2

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

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SAFETY FUNCTION	ACCEPTANCE CRITERIA
3. RCS Inventory Control	3. a. <u>If</u> pressurizer level is [2% to 78%], <u>Then</u>: i, charging and letdown, and SI (unless SI termination criteria met) are maintaining or restoring pressurizer level <u>and</u> ii) the RCS is subcooled <u>and</u> iii) the HJTC RVLMS indicates the level is above the hot leg nozzles. <u>or</u> b. <u>If</u> pressurizer level is less than [2%], <u>Then</u>: i) available charging pump is operating and the SI pump(s) are injecting water into the RCS per Figure 7-3. <u>and</u> ii) the HJTC RVLMS indicates the core is covered.

SAFETY FUNCTION	ACCEPTANCE CRITERIA
4. RCS Pressure Control	4. a. Pressurizer heaters and spray, or charging and letdown, or SI pumps (unless SI termination criteria met) are maintaining or restoring pressurizer pressure within the limits of Figure 7-1. or b. available charging pump is operating and the SI pump(s) are injecting water into the RCS per Figure 7-3 (unless SI termination criteria are met).
5. Core Heat Removal	5. a. T_H RTD and representative Core Exit Thermocouple temperatures less than [626°F]. and b. The RCS is subcooled.

SAFETY FUNCTION	ACCEPTANCE CRITERIA
6. RCS Heat Removal	6. a. i) The unisolated steam generator has level within the normal level band with feedwater available to maintain level or ii) The unisolated steam generator has level being restored to the normal band by feedwater flow with level increasing or iii) Total feedwater flow to the unisolated steam generators greater than [500 gpm] and b. RCS T_{ave} is less than [567°F].
7. Containment Isolation	7. a. i) Containment pressure less than [2.7 psig] or ii) CIAS present or manually initiated. and b. No containment area radiation monitors are alarming. and c. No steam plant radiation monitors are alarming and d. No nuclear annex alarms.

SAFETY FUNCTION	ACCEPTANCE CRITERIA
8. Containment Temperature and Pressure Control	8. a. i) Containment temperature less than [236°F] and ii) Containment pressure less than [8.5 psig] or b. The containment cooling system is operating: i) Annulus Fans are energized and Annulus pressure is < [0" w.g.] and ii) At least one containment spray header delivering at least [5000 gpm]
9. Containment Combustible Gas Control	9. a. Containment sprays have NOT been actuated or b. i) Annulus fans are energized and Annulus pressure is < [0" w.g.] and ii) Hydrogen concentration less than 0.5% or c. i) all available hydrogen recombiners are energized and ii) hydrogen concentration is less than 4%.

BASES

The bases section of the Excess Steam Demand Event (ESDE) Recovery Guideline describes the ESDE transient in relation to the actions which the operator takes during an ESDE. The purpose of the bases section is to provide the operators with information which will enable them to understand the reasons for, and the consequences of, the actions they take during an ESDE.

Characterization of an ESDE

An Excess Steam Demand Event (ESDE) is any event which leads to an unexpected, rapid increase in steam generator steam flow or loss of steam generator inventory that requires and/or results in a reactor trip or exceeds the control capability of the reactor regulating system, pressurizer pressure control system and/or pressurizer level control system. Some of the possible causes include:

a) Rupture or break in a main steam line.
b) Rupture or break of a main, startup or emergency feedwater line downstream of the last check valve (break upstream of the last check valve in a feedwater line is considered a loss of feedwater event).
c) Inadvertent opening of main steam system valve(s) (e.g., atmospheric dumps, steam bypass, etc.).
d) Stuck open steam generator safety valve.

The following parameters usually characterize an ESDE:

a) Increased steam flow from the steam generators.
b) Decreasing steam generator pressure and water level (initially, there may be level swell).
c) Decreasing RCS average temperature causing a decrease in pressurizer pressure and water level.

d) Reactor trip caused by the high core power, low steam generator water level, low pressurizer pressure, low steam generator pressure, or high containment pressure depending on the size and location of the break.

e) SIAS may be generated from low pressurizer pressure or high containment pressure (if ESDE within the containment).

f) A CIAS, CSAS, and MSIS may be generated on high containment pressure (if ESDE within the containment).

g) Possible increase in containment pressure, temperature, humidity, and/or Holdup Volume Tank.

h) Possible increase in containment hydrogen concentration due to corrosion of zinc and aluminum by the containment spray system.

Safety Functions Affected

An Excess Steam Demand Event, depending on the cause, will primarily affect the safety functions reactivity control, RCS heat removal, and containment temperature and pressure control (for events inside containment). However, all safety functions should be monitored to assure public safety, or to detect failures which might lead to unsafe conditions.

A significantly large ESDE usually results in excess steam flow on the secondary side which will lead to a reactor trip. This decrease in reactor heat input (due to reactor trip), combined with the increase in steam generator heat removal due to the excess steam flow, rapidly reduces RCS temperature. A reduction in RCS temperature causes an apparent inventory decrease due to volume contraction, a system pressure decrease, and possible RCS voiding. The inventory shrinkage will usually cause an SIAS if the pressurizer empties. This shrinkage will be reversed by subsequent RCS heatup (if heat removal is not established with the intact SG) and/or the safety injection system and the charging pump. If the break can be isolated, either manually or automatically, then the ESDE is essentially over. For the situation where the break cannot be isolated, the operators lose control of the affected steam generator and must isolate feedwater to that steam generator, allowing it to boil dry.

It is important to establish heat removal capability via the unaffected SG prior to the affected SG boiling dry. The unaffected SG must be used to stabilize RCS temperature and if RCPs have been tripped, it will take a few minutes to establish the thermal driving head for natural circulation in the unisolated loop.

If a significant ESDE occurs inside containment, the steam flow will result in an increase in containment pressure and temperature. There are several success paths for Containment Isolation and Containment Temperature and Pressure Control. If containment pressure reaches [2.7 psig], this will result in a CIAS. The CIAS isolates all non-essential containment penetrations. If containment pressure reaches [8.5 psig], a CSAS will be initiated. The CSAS causes containment spray to actuate and the Annulus Ventilation System (AVS) to draw a vacuum in the Annulus. The AVS will minimize uncontrolled radioactive leaking from the containment.

Some hydrogen may be generated in the containment due to the reaction of boric acid (from the spray system) with the containment metals (especially aluminum and zinc). This reaction will produce hydrogen at a rate which increases with containment temperature. If detectable hydrogen is generated (> 0.5%), the hydrogen recombiners and igniters are run to remove the hydrogen. Hydrogen generation by metal and boric acid reaction is not expected to produce enough hydrogen to exceed 4%. Therefore, if the containment hydrogen concentration exceeds 4%, the operators should exit the ESDE ORG and implement the Functional Recovery Guideline.

As steam generator pressure decreases due to the energy loss, an MSIS will occur and isolate the steam generators except for emergency feedwater to the intact steam generator. If the event is occurring downstream of the MSIVs, then the break will be isolated.

Trending of Key Parameters

Reactor Power (Figure 7-6)

In response to the reduction in moderator temperature, reactor power will initially increase until an RPS setpoint is reached by one of the following: CPC, low steam generator pressure, high containment pressure, low steam generator water level, or low pressurizer pressure. As the steam generator blowdown continues to reduce moderator temperature, there exists a possibility of a return to criticality.

RCS Temperature (Figures 7-7 and 7-8)

Prior to the reactor trip, RCS temperature will decrease because heat removed by the ESDE and the steam exceeds heat produced by the core. After the reactor has tripped, heat removal by the ESDE will exceed decay heat, causing further cooling of the RCS.

Pressurizer Pressure (Figure 7-9)

Pressurizer pressure will decrease after the ESDE due to the decrease in RCS temperature and the corresponding RCS volume contraction. Pressure may decrease to hot leg temperature saturation pressure depending on the magnitude of the RCS cooldown.

Pressurizer Level (Figure 7-10)

Pressurizer level will decrease due to lower RCS temperature after the reactor trip. For large excess steam demands the pressurizer may empty completely before inventory control can be regained.

Reactor Vessel Level (Figure 7-11)

Void formation can occur in the RVUH for ESDE or other overcooling events which are large enough to cause the pressurizer to empty. When the pressurizer empties, voids begin forming in the RVUH. The RCS pressure decreases until it equals the saturation pressure associated with the hottest point in the RCS (which is the RVUH). Saturated liquid in the RVUH will continue to flash to steam until the affected steam generator experiences dryout and RCS repressurization is established. For the most severe excess steam demand events the rate of RCS cooldown can be great enough so that RVUH voids are formed before the pressurizer empties.

Steam Generator Pressure (Figures 7-12 and 7-13)

Following an ESDE, the pressure in the affected steam generator will decrease due to the decrease in resistance caused by the break. The pressure in the unaffected steam generator will initially increase after the MSIS and then decrease as RCS temperature decreases. If the cause of the ESDE is located downstream of the MSIVs, the pressure in both steam generators will equalize after an MSIS.

Steam Generator Level (Figures 7-14 and 7-15)

Following an ESDE, the level in both the affected and unaffected steam generators will initially increase due to swell and then decrease as the feedwater level control system will not be able to keep up with steam flow. Following an MSIS the level in both steam generators will increase if the ESDE occurred downstream of the MSIV. If the ESDE occurred upstream of the MSIV, the level in the affected steam generator will continue to decrease while the level in the unaffected steam generator increases. If the event is a feedwater line break, steam generator water level decreases in the affected steam generator without an initial swell [until the feedring is uncovered] while the unaffected steam generator level will usually remain relatively constant.

FIGURE 7-6
REPRESENTATIVE MSLB OUTSIDE CONTAINMENT UPSTREAM
OF MSIV CORE POWER

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 7-7

REPRESENTATIVE MSLB OUTSIDE CONTAINMENT UPSTREAM OF MSIV

UNAFFECTED LOOP RCS WIDE RANGE TEMPERATURES

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 7-8

REPRESENTATIVE MSLB OUTSIDE CONTAINMENT UPSTREAM OF MSIV

AFFECTED LOOP RCS WIDE RANGE TEMPERATURES

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 7-9

REPRESENTATIVE MSLB OUTSIDE CONTAINMENT UPSTREAM OF MSIV

PZR WIDE RANGE PRESSURE

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 7-10

REPRESENTATIVE MSLB OUTSIDE CONTAINMENT UPSTREAM OF MSIV

PZR LEVEL

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 7-11

REPRESENTATIVE EXCESS STEAM DEMAND EVENT

REACTOR VESSEL LIQUID VOLUME vs TIME

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 7-12

REPRESENTATIVE MSLB OUTSIDE CONTAINMENT UPSTREAM OF MSIV

UNAFFECTED STEAM GENERATOR PRESSURE

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 7-13

REPRESENTATIVE MSLB OUTSIDE CONTAINMENT UPSTREAM OF MSIV

AFFECTED STEAM GENERATOR PRESSURE

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 7-14

REPRESENTATIVE MSLB OUTSIDE CONTAINMENT UPSTREAM OF MSIV

UNAFFECTED STEAM GENERATOR WIDE RANGE LEVEL

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 7-15

REPRESENTATIVE MSLB OUTSIDE CONTAINMENT UPSTREAM OF MSIV

AFFECTED STEAM GENERATOR WIDE RANGE LEVEL

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

Guideline Strategy and Information Flow

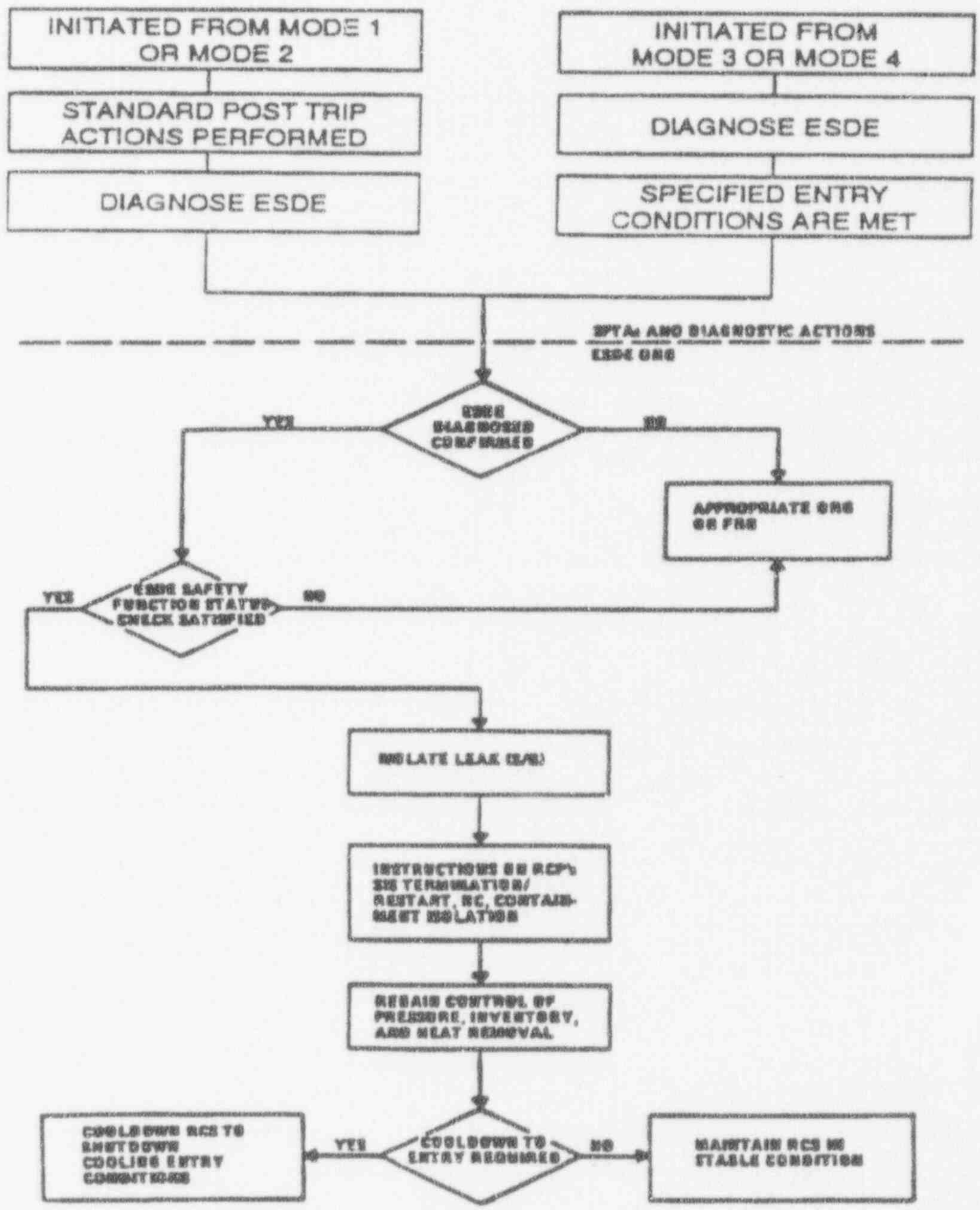
Figure 7-16 provides a summary of the ESDE Recovery Guideline's strategy. Prior to implementing the actions provided in the ESDE Recovery Guideline, the operator would have diagnosed the event. The first actions in the ESDE Recovery Guideline require a verification that these actions have taken place and require the operator to use the Safety Function Status Check to confirm that the plant is recovering. The next steps provide instructions on establishing those conditions necessary for effectively recovering from an ESDE. The strategy can be broken into five major recovery actions.

The five major recover actions carry the plant to the SCS entry conditions. The first major action consists of stopping the uncontrolled cooldown of the RCS. If the ESDE is upstream of the MSIVs, this is accomplished by isolation the affected steam generator. Feedwater is supplied only to the intact steam generator since feeding the broken steam generator will continue to depressurize the RCS. This action also reduces the risk of radioactive release from the plant. The second major action is to stabilize the RCS pressure and temperature. It may not be necessary to cool the plant down if it can be maintained in a stable condition while the break is repaired. The third action is to evaluate the necessity of a plant cooldown. The factors affecting this decision include the amount of emergency feedwater available, the status and availability of auxiliary systems and the extent of the damage and time required for repair. If the plant can be maintained at a stable condition, then the fourth action is to do just that. While the plant is in this condition it is necessary to keep evaluating and be prepared for a cooldown if conditions warrant. The fifth major action consists of cooling the plant on either forced circulation or on natural circulation in the RCS, all the way to SCS entry conditions. This cooldown is performed using the unaffected steam generator if the break is upstream of the MSIVs or both steam generators and the ADVs if the break is downstream of the MSIVs.

A more detailed chart illustrates the recovery guideline strategy and lists the guideline steps which correspond to each strategy objective. Refer to Figure 7-18.

FIGURE 7-16

EXCESS STEAM DEMAND EVENT RECOVERY STRATEGY CHART



Bases for Operator Actions

The operator actions are directed toward determining the cause of the Excess Steam Demand Event (ESDE), isolating that part of the system, and returning the plant to a safe, stable, and controlled condition.

1. The diagnosis of an Excess Steam Demand Event should be confirmed using the Break Identification Chart (Figure 7-2) and by comparing control board parameters to the acceptance criteria in the Safety Function Status Check to ensure that all safety functions are being satisfied. In particular, the operator should note the status of RCS subcooling and containment and steam plant activity. These parameters provide a means of discriminating between ESDEs and LOCAs/SGTRs. For ESDEs, neither steam plant or containment activity monitors should be alarming. ESDEs which occur in plants with existing SG tube leakage may result in increases in steam plant radiation or containment activity. For LOCAs, containment activity monitors may be alarming but steam plant activity monitors should not be alarming. For a SGTR, steam plant activity monitors may be alarming but containment activity monitors should not be alarming. Sampling both steam generators for activity will assist in confirming the diagnosis. These actions ensure the proper guideline is being used to mitigate the effects of an ESDE.

   If the initial diagnosis of an ESDE is confirmed, then the operator continues with the actions of this guideline. However, if the operator determines that a SGTR or a LOCA has occurred, then the ESDE Recovery Guideline is exited and, the actions of the proper guideline are implemented. This allows the operator to switch to the proper guideline for those events similar to ESDE which may be occurring. LOCAs, ESDEs, and SGTRs have similar initial symptoms and could be confused early in the event. If the diagnosis of one event cannot be made, then the operation is directed to exit the ESDE guideline and to implement the Functional Recovery Guideline. The Functional Recovery Guideline is safety function based and will ensure that all safety functions are addressed regardless of what event(s) is occurring.

* 2. If the Excess Steam Demand Event is large enough to decrease pressurizer pressure to or below the SIAS setpoint, then an SIAS should be initiated automatically. If this does not occur when pressure decreases below the SIAS point, then the operator should manually initiate an SIAS.

* 3. An ESDE may reduce RCS temperature by as much as [250°F] due to increased RCS heat removal. Due to the effects of the moderator temperature coefficient, this cooldown adds positive reactivity to the core and can possibly result in a return to criticality subsequent to the reactor trip. To ensure that the core remains subcritical, it is necessary to maximize RCS boration during the initial stages of severe ESDEs. The charging and safety injection systems should accomplish this automatically because significant ESDEs will result in the actuation of safety injection. If an SIAS is actuated, then all available charging and SI pump(s) should be operating and injecting water into the RCS. The SI and charging flowrates should be checked and maximized (Figure 7-3 provides information which can be utilized to verify adequate SI flow is occurring) for RCS boration and inventory replenishment. The charging pump may have to be manually restarted if an interruption of electrical power to the charging pump bus has occurred. The following guidance will assist in ensuring maximum injection of water into the RCS:

a. idle SI pumps should be started
b. system flow should be verified to be within the limits of Figure 7-3,

If any SI pump that should be operating won't start, the charging pump is not available, or SI flow is not in accordance with Figure 7-3, then the following guidance is provided:

a. the operator should verify that electrical power is available to valves and pumps necessary for inventory control
b. the SI valve lineup should be verified to be correct in the control room
c. auxiliary systems necessary for SI or charging operation should be checked.

It must be noted, however, that the maximization of charging and safety injection can result in excess RCS inventory, possible filling of the pressurizer to a solid condition, and a PTS concern upon RCS heat up, fluid expansion, and subsequent RCS pressure excursion. Operators must be aware of these concerns and terminate or throttle SI pumps when the criteria are met and establish unaffected SG heat removal to stabilize RCS temperature as the affected (isolated) SG boils dry.

* 4. Steps 4 and 5 contain guidance regarding the RCP operating strategy for a ESDE (Figure 7-17). A generic RCP trip strategy has been developed which results in the tripping of all four RCPs for depressurization events where RCS is not subcooled, but allow the continued operation of two RCPs (in opposite loops) for depressurization events where RCS is subcooled. For undiagnosed events, where the Functional Recovery Guideline is implemented, the RCP trip strategy is identical to that followed in the LOCA guideline. Steps 4 and 5 detail the two significant operational aspects regarding the RCP trip strategy for a ESDE.

The first operational strategy results in the operator tripping two RCPs (in opposite loops) if pressurizer pressure decreases to less the [1400 psia] following a SIAS and RCS is subcooled. This action may occur in the Standard Post Trip Actions and, in this case, the operator would simply verify that two RCPs (in opposite loops) have been tripped. The operator trips all four RCPs if pressurizer pressure decreases to less than [1400 psia] following a SIAS and RCS is not subcooled. If the operator cannot confirm that a ESDE has occurred, and the Functional Recovery Guideline is implemented, the RCP trip strategy is identical to that followed in the LOCA guideline. If the depressurization event can be diagnosed and is determined to be other than LOCA (i.e., ESDE or SGTR), then only two RCPs (in opposite loops) are tripped. The other two RCPs remain operational until one or more of the RCP operating requirements (e.g., NPSH, temperatures, seal flow, oil pressures, motor amperage, vibration) are no longer satisfied, then, any pump which does not satisfy these requirements should be tripped. This gives the operator maximum flexibility in plant control because a normal plant cooldown can be performed while still ensuring a conservative approach to event recovery.

* 5. The second aspect of the RCP operating strategy concerns the verification that RCP operating limits are satisfied. The RCPs may be operating in a pressure-reduced RCS and degraded containment conditions are also possible. This could result in the loss of vital RCP auxiliaries (e.g., [CCW]). The operator must continuously monitor RCP operating limits (e.g., temperatures, seal flow, oil pressures, NPSH, motor amperage, vibration) and trip any RCPs which do not satisfy RCP operating limits. Plant specific RCP operating limits should appear in the plant specific EOPs, either directly or by referencing the applicable operating instructions.

6. The most affected steam generator should be determined by comparison of steam pressures, cold leg temperature differences, and steam generator levels. If the ESDE is not isolable (e.g., a break inside containment will still be producing steam flow after the MSIVs are shut), the steam generator with the reduced loop Tc, lower steam pressure, and lower steam generator level is the affected steam generator. These differences between affected and unaffected steam generators will be more pronounced after MSIS actuation. If the ESDE is downstream of the MSIVs and the MSIS occurs, both steam generators' pressures and loop temperatures should approach approximately the same values and then start to increase following MSIV closure.

7. If the shutting of MSIVs (MSIS) stops the ESDE, then neither SG is the affected SG. The operator should go to step 10 and skip the guidance provided for isolating the most affected SG. If the MSIS does not stop the ESDE, then continue with step 8.

FIGURE 7-17a

RCP TRIP STRATEGY FOR ESDE

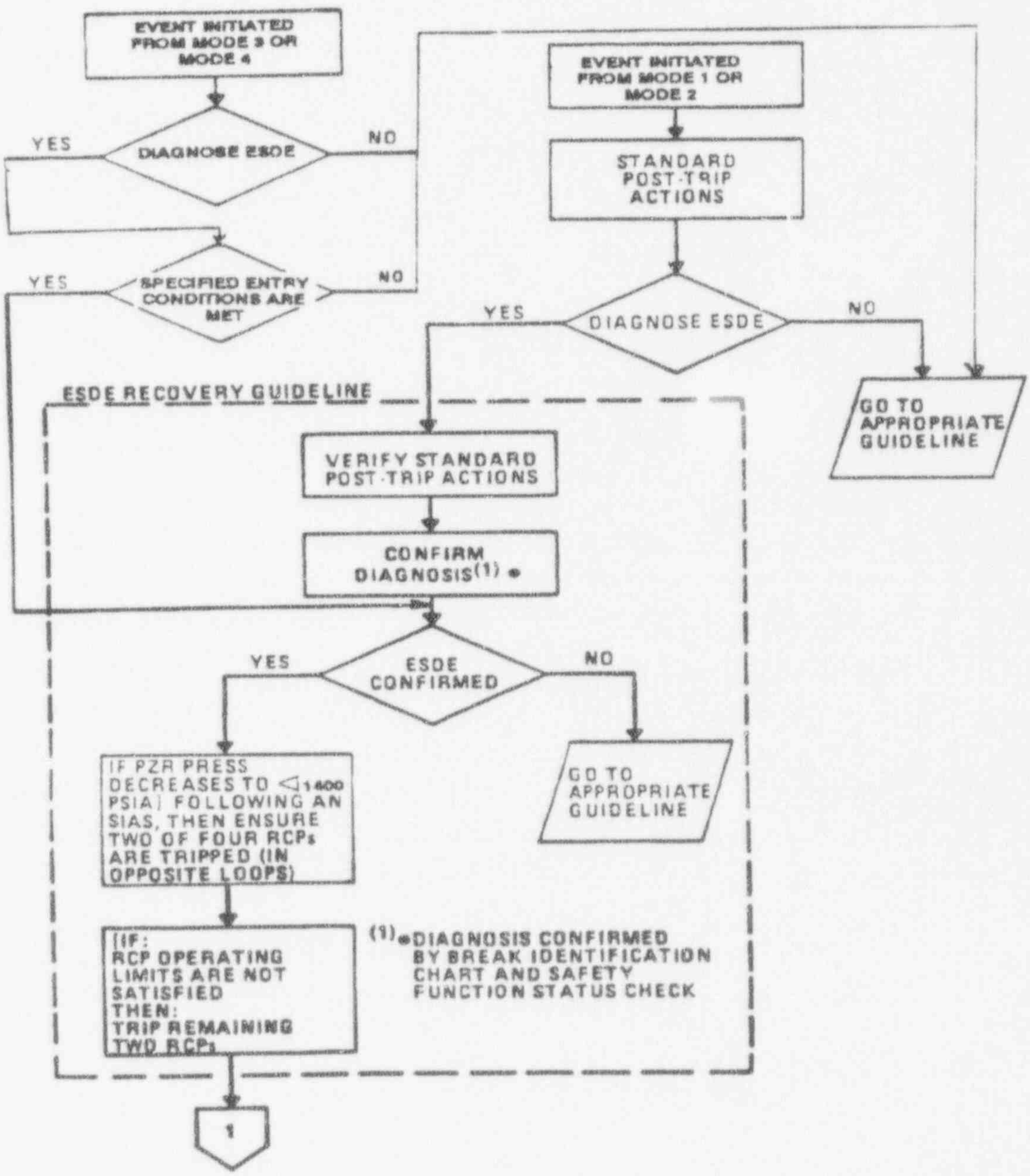
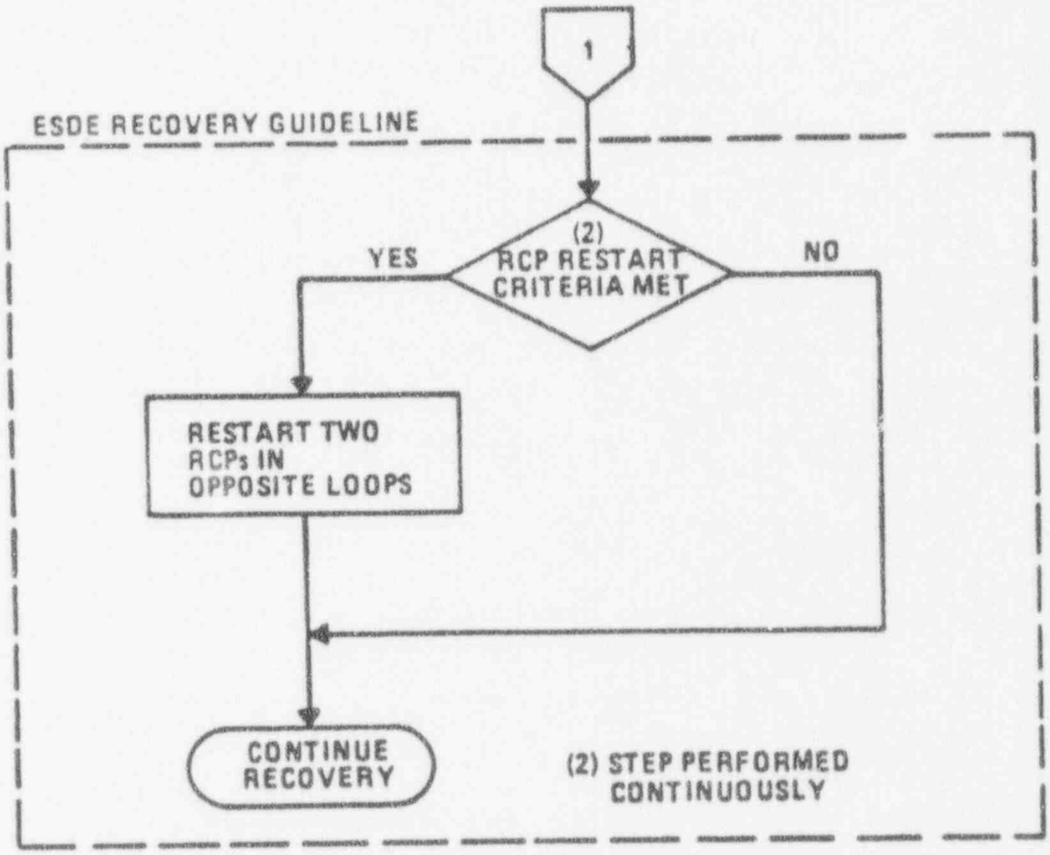


FIGURE 7-17b

ESDE RECOVERY GUIDELINE



8. The most affected steam generator should be isolated to stop the uncontrolled plant cooldown and to stabilize the plant. If both steam generators are found to be affected, then isolate the steam generator with the worse ESDE, if it can be determined, and attempt to maintain RCS heat removal capability via one steam generator. This action is designed to mitigate the uncontrolled cooldown and ready the plant for event recovery.

   The most affected steam generator is isolated as follows:

   a. The main steam isolation valve is closed.
   b. The main steam isolation valve bypass valve is verified closed, or closed.
   c. The atmospheric steam dump valve(s) is verified closed.
   d. The main feedwater isolation valve is closed.
   e. The startup and emergency feedwater isolation valves are closed.
   f. Vents, drains, exhaust, and bleedoffs are closed,
   g. The Turbine Driven Emergency Feedwater Pump Steam admission valve is closed.

9. Once the steam generator has been isolated, isolation of the correct (affected) steam generator should be verified by checking steam generator pressures, RCS cold leg temperatures, and steam generator levels. This provides feedback that the correct steam generator has been isolated. If the wrong steam generator has been isolated then it should be unisolated and the affected steam generator should be isolated per step 8.

*10. The unisolated steam generator's level (or both SGs if neither is the affected SG) is maintained or restored to the normal band using main, startup or emergency feedwater. This ensures that a heat sink is available for removing heat from the RCS.

*11. When the isolated steam generator dries out, RCS temperatures will begin to increase unless a means of controlled steaming has been established. If a method of heat removal is not established, the RCS heatup will, when taken in conjunction with the inventory added to the RCS from SI and charging pump operation, cause the plant to go solid and have the potential of creating a PTS condition. A controlled heat removal method should be established before this dry out condition occurs. The preferred method of heat removal is via the steam bypass system (if the steam bypass system and condenser are available) with the atmospheric dump valves as a backup method of heat removal. If the break is downstream of the MSIVs, then the atmospheric dump valve(s) should be used for RCS heat removal. This action establishes control of RCS and core heat removal in order to preclude heatup and repressurization of the RCS for PTS considerations.

*12. If the SI pumps are operating, then they must continue to operate at full capacity until SI termination criteria are met. Termination of SI should be sequenced by stopping one pump at a time while observing the termination criteria. Throttling of SI flow is also permissible if all of the following SI termination criteria are satisfied:

a) RCS is subcooled based on Representative CET temperature (Figure 7-1). Establishing subcooling ensures the fluid surrounding the core is subcooled. Voids may exist in some parts of the RCS (e.g., reactor vessel head as determined by the HJTC RVLMS), but these are permissible as long as core heat removal is maintained.
b) Pressurizer level is greater than [14.3%] and not decreasing. A pressurizer level greater than [14.3%] and not decreasing, in conjunction with criterion a) above, is an indication that RCS inventory control has been established.
c) The unisolated steam generator is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow is available for removing heat from the RCS.
d) The HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles. This provides an extra margin of core coverage and, taken in conjunction with the above, serves as an additional indication that adequate RCS inventory control has been established.

If all of the SI termination criteria are met, then the operator may either stop or throttle the SI pumps. The operator may decide to throttle, rather than terminate the flow, if the SI is to be used to control pressurizer level or plant pressure.

*13. If the criteria of step 12 cannot be maintained after the SI pumps are throttled or stopped, then the appropriate SI pumps should be restarted and full SI flow restored.

*14. Once pressurizer level has been restored to greater than or equal to [2%], then level should be maintained [2% to 78%] by control of charging and letdown (preferentially) as necessary, and the SI flow. If SI termination criteria are met, then SI pumps may be throttled or stopped. When pressurizer level is being controlled at [2%] or greater, then if the charging pump is available, it may be operated as necessary to maintain level. If the charging pump is not available, then SI pump(s) operation must continue to maintain level. If pressurizer level is not restored to [2%], then all available charging and SI pumps should be operated for maximum flow.

A pressurizer level of [2% to 78%] with a saturated bubble in the pressurizer should be established if possible, as the means of RCS pressure control. If pressurizer level drops below the top of the pressurizer heaters, the pressurizer heaters may burn out if they have not been interlocked off. It may be necessary to exceed [78%] pressurizer level if the operator is attempting to restore RCS subcooling since pressurizer heaters may be unavailable and solid water operation may be necessary to restore subcooling.

*15. Maintaining RCS conditions within the acceptable limits of Figure 7-1 ensures that the [100°F/Hr] cooldown rate is not exceeded, that the core is covered by subcooled fluid, and minimizes the concern for pressurized thermal shock by maintaining less than the 200°F subcooling limit is minimized. This is accomplished using pressurizer heaters and main (preferred) or auxiliary spray, operation of charging and letdown, or throttling of SI pumps to control pressurizer pressure within the limits of Figure 7-1.

If subcooling or cooldown limits are being violated, then the operators should take actions to restore the RCS to within the P-T limits. Depending on the situation, the operator should perform the following actions as appropriate:

a. Stop the cooldown.
b. Operate the Reactor Coolant Gas Vent System or main or auxiliary spray as necessary to restore pressurizer pressure to within the P-T limits of Figure 7-1.
c. Attempt to maintain the plant in a stable pressure-temperature configuration. The cooldown may be continued, if desired, within the limits of Figure 7-1.
d. If an overpressure situation exists and is caused by SI pumps and/or charging flow, then throttle or stop SI (refer to step 12) or the charging pump and manually control letdown to restore and maintain pressure within the Post Accident P-T limits of Figure 7-1.

*16. If containment pressure is greater than or equal to [2.7 psig], then the operator ensures the following:

a. The operator verifies that containment isolation occurs at the appropriate automatic setpoint. If containment isolation does not occur automatically or all containment isolation valves are not in their accident positions, then the operator should manually initiate containment isolation. The purpose of this step is to prevent direct communication between the containment atmosphere and the environment. Operators should be alert to the loss of auxiliaries to the containment ([in particular component cooling water]) which may occur with containment isolation. Re-establishing letdown should also be considered if it is available. This will enable the operator to better control RCS inventory during a possible RCS heatup and subsequent fluid expansion. This action can minimize the possibility of PTS.

b. High pressure in the containment may pose a threat to containment integrity. Furthermore, high containment temperature adversely impacts the accuracy of instruments whose transmitters are located inside containment (e.g., pressurizer level and pressure, steam generator pressure and level, RCS loop RTDs) and may impact the continued availability of equipment located in containment. The effect of temperature on hydrogen generation (by corrosion reactions) is described in the bases of step 18. To minimize the temperature in containment, the containment recirculation fan coolers should be operated if they are available.

*17. The containment spray system is automatically actuated at a containment pressure of [8.5 psig] or greater. If containment pressure reaches [8.5 psig], then the operator should ensure containment spray actuation, the annulus vent system fans have started and place the hydrogen monitors in service because conditions will now exist for the generation of hydrogen in containment. In order to maintain containment pressure below design pressure, one containment spray header delivering [5000 gpm] is sufficient to remove decay heat.

When containment sprays are actuated, the conditions created in the containment may generate detectable hydrogen concentrations. Hydrogen may be generated by the reaction of boric acid (from containment spray flow) and metals in the containment. Aluminum and zinc are two metals which are reactive with boric acid. The reaction rates of boric acid and aluminum and zinc are a function of temperature. Therefore, if the containment spray system has been spraying boric acid onto zinc and aluminum surfaces in a high temperature environment, conditions exist for the generation of hydrogen in the containment.

The appropriate personnel should be directed to make the recombiners available and aligned for use. Use of the recombiners may be required by subsequent steps in order to satisfy the combustible gas control safety function.

*18. Containment spray system operation may be terminated when containment pressure has been reduced to an acceptable level. Continued operation of the sprays after pressure has been reduced to an acceptable level increases the possibility of wetting electrical connectors which may result in electrical grounds, shorts and other malfunctions. Therefore, if containment sprays have actuated and containment pressure is reduced below [5.5 psig], then containment spray may be terminated. After terminating containment spray, the containment spray system should be realigned for automatic or manual operation in case containment pressure again increases to the actuation setpoint. The annulus vent system can also be secured at this time.

*19. Hydrogen recombiners should be energized when hydrogen is detected in containment (≥ 0.5%). This action is performed to keep the containment hydrogen concentration as low as possible throughout the event. The recombiners take approximately [1 hour] to reach operating temperature so no decrease in measured hydrogen concentration should be expected before this time.

*20. Although hydrogen is not flammable until it reaches a concentration of at least 4%, it is prudent to reduce hydrogen to as low a concentration as possible (i.e., less than the minimum detectable hydrogen concentration of 0.5%). Such action minimizes the possibility of reaching the flammability limit and of forming pockets of high concentration hydrogen. Therefore, the hydrogen recombiners should be run until hydrogen concentration is reduced to less than 0.5%.

*21. Plant conditions should be carefully assessed before any RCPs are restarted. The need for forced circulation operation should be balanced against the risk of damage to the RCP seals.

The need for operation of the RCPs should be evaluated based on:

1. the adequacy of the RCS and core heat removal under the existing natural circulation conditions,
2. the existing RCS pressure and temperatures,
3. the need for main pressurizer spray capability.

If the existing natural circulation is providing satisfactory RCS and core heat removal, a transfer for forced circulation operation may not be necessary. This would be particularly true if the RCS had already been cooled and depressurized to SCS entry conditions. If the RCS pressure and temperatures are closer to HOT STANDBY conditions, it may be desirable to restart the RCPs in order to allow a normal forced circulation cooldown. Consideration should also be given to the necessity of having main pressurizer spray capability if auxiliary spray is not providing the desired depressurization rate.

The potential for RCP seal degradation should be evaluated based on:

1. how long CCW to the RCPs was interrupted,
2. RCP seal staging pressures and temperatures.

The possibility of seal degradation increases if the CCW has been interrupted for longer than [10 minutes]. The seal staging pressures provide an indication of degraded seal stages (a low pressure drop across a stage indicates a problem). Restart of an RCP with one or more degraded seal stages should be avoided if possible.

*22. If all RCPs have been stopped, then operation of two RCPs (in opposite loops) should be attempted, if RCP restart criteria are met. This will ensure continued forced circulation of coolant through the core, cooling of the RV head region, provide the capability for the normal mode of pressurizer spray, condense RCS steam voids, and remove non-condensible gases from the SG tube bundle. Furthermore, this action enhances the strategy to obtain an uncomplicated cooldown, since a forced circulation cooldown is preferred to a natural circulation cooldown whenever possible during a recovery from an ESDE. However, only one reactor coolant pump in each loop should be operated to minimize heat input to the RCS.

Determine whether RCP restart criteria are met by the following:

a. Electrical power available to the RCP(s).

b. RCP auxiliaries (in particular component cooling water) to maintain seal injection, bearing, and motor cooling should be operating in order to prevent damage to the pump and/or motor. (Note: [Following automatic or operator initiated containment isolation, reinstatement of one of the following means of RCP seal cooling ([CCW], [CVCS seal injection (SI)], [Dedicated Seal Injection System (DSIS)], should be considered to ensure adequate RCP cooling. There should be no high temperature alarms on the RCPs to be operated.

c. The unisolated steam generator is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow is available for removing heat from the RCS.

d. Pressurizer level is greater than [33%] and not decreasing. A pressurizer level above 33% provides the operator with a margin for maintaining plant control during an ESDE.

e. The RCS is subcooled based on representative CET temperature. A subcooled condition, taken in conjunction with (b) above, indicates that adequate inventory control has been established.

f. [All plant specific RCP operating criteria should be satisfied before the RCPs are restarted to prevent damage to RCPs resulting from abnormal operating conditions].

g. Condensate that flows to the core on the cold side is depleted in boron and may collect in the RCP loop seals and cold leg. The RCPs should not be started until after single phase natural circulation has slowly moved this boron depleted coolant through the core. Twenty minutes of single phase natural circulation is considered adequate circulation and mixing time.

*23. Upon restarting two RCPs in opposite loops, pressurizer level and pressure may decrease due to loop shrinkage and/or steam void condensation. It is possible that this action will drain the pressurizer. Steam voids present in the reactor vessel will condense upon restarting RCPs. The HJTC RVLMS should be monitored for the trending of reactor vessel liquid level. This trending information may be correlated to pressurizer level decrease. RCP operation with a drained pressurizer may continue provided certain actions are taken and certain criteria are satisfied.

The following constitute the actions to be taken, and the criteria to be satisfied, when restarting RCPs:

a. Start one RCP in each loop.
b. Ensure proper RCP operation by monitoring RCP amperage and pump NPSH. NPSH is determined by pressurizer pressure and corresponding T_c on Figure 7-1.
c. Operate charging (and SI) pumps, and letdown to restore and maintain pressurizer level [2% to 78%]. If SI pumps are operating, continue their operation until SI termination criteria are met (refer to step 12). This action will ensure that pressurizer heaters remain covered but will minimize the amount of water added to the RCS.

*24. If all RCP operation is terminated and inventory and pressure are controlled, then natural circulation is monitored by heat removal via at least one steam generator. Natural circulation flow should occur within [5-15 minutes] after the RCPs were tripped.

The operator has adequate instrumentation to monitor natural circulation for the single phase liquid natural circulation process. The RCS temperature instrumentation, namely loop ΔT, can be used along with other information to confirm that the single phase natural circulation process is effective. The RCS temperature response during natural circulation will be slow [5-15 minutes] as compared to a normal forced flow system response time of 6-12 seconds, since the coolant loop cycle time will be significantly larger.

When single phase natural circulation flow is established in at least one loop, the RCS should indicate the following conditions:

a. Loop ΔT (T_H - T_c) less than normal full power ΔT,

b. Hot and cold leg temperatures constant or decreasing,

c. The RCS is subcooled based on Representative CET temperature

d. No abnormal differences between T_H RTDs and core exit thermocouples. Hot leg RTD temperature should be consistent with the core exit thermocouples. Adequate natural circulation flow ensures that core exit thermocouple temperatures will be approximately equal to the hot leg RTDs temperature within the bounds of the instrument's inaccuracies. An abnormal difference between T_H and the CETs is greater than [10°F].

Natural circulation is governed by decay heat, component elevations, primary to secondary heat transfer, loop flow resistance, and voiding. Component elevations on C-E plant are such that satisfactory natural circulation decay heat removal is obtained by fluid density differences between the core region and the steam generator tube sheet.

As a contingency, if the criteria listed are not met, then natural circulation in the RCS is not effectively transferring heat from the core to the steam generators. Both RCS and Core Heat Removal Safety Functions may become jeopardized if any of the above criteria continue to be violated. Operators should ensure that RCS pressure and inventory, and SG steaming and feeding, are being controlled properly to prevent violation of a safety function.

25. At this point in the recovery, the operators should decide if a cooldown to shutdown cooling entry conditions is necessary. One of the factors to be considered is existing plant status. If the continued availability of any systems required for maintenance of HOT STANDBY is in doubt, a cooldown should be performed before the ability to cooldown is lost. For example, if the available emergency feedwater inventory is marginally adequate (as determined by using Figures 7-4 and 7-5), a cooldown should be commenced immediately to avoid running out of emergency feedwater before the shutdown cooling system can be placed into operation. Similarly, consideration should be given to the

availability of compressed air and cooling water systems as well as the continued availability of electrical power. A cooldown may also be required before any necessary repairs can be made.

26. The following steps of the ESDE guideline provide the operator instructions for performing a cooldown to shutdown cooling entry conditions. If it is decided that a cooldown is not necessary, the plant should be maintained in a stable condition until the Plant Technical Support Center provides an appropriate procedure to implement and directs the operators to exit the ESDE ORG.

*27. The plant should be borated per Technical Specification limits for reactivity control purposes. If letdown is not available, it may not be possible to borate the RCS to the COLD SHUTDOWN RCS boron concentration prior to commencing the cooldown if there is limited makeup space available in the pressurizer. If this is the case, the operator should borate the RCS to the minimum shutdown margin corresponding to T_c (per Technical Specifications). During the cooldown, as RCS shrinkage provides more space in the pressurizer, the operator should borate to maintain the minimum shutdown margin until the cold shutdown boron concentration is achieved. Note that if a 75°F/hr. cooldown rate is maintained, charging capacity will not be able to keep pressurizer level constant during the initial stages of the cooldown. Therefore, pressurizer level will lower and additional space will be available in the RCS for boration.

28. An orderly cooldown to an SCS entry conditions, using forced or natural circulation, is performed in accordance with Technical Specifications. One of the following methods should be utilized to reduce RCS temperature:

a) The preferred method for cooling the RCS is by discharging steam using the steam bypass system. This method can only be implemented if the condenser is available.
b) If the condenser or steam bypass system is not available, an RCS cooldown should be performed by dumping steam using the atmospheric steam dump valves.

*29. Pressurizer level should be restored and maintained at [2% to 78%] by control of charging and letdown (preferentially) as necessary, and SI pumps. If SI termination criteria are met, then SI pumps may be throttled or stopped. A pressurizer level of [2% to 78%] should be restored and maintained to avoid losing pressure control with the saturated bubble in the pressurizer. If the pressurizer level drops below the top of the pressurizer heaters, pressurizer heater operation will be interlocked off for heater protection. It may be necessary to exceed [78%] pressurizer level if the operator is attempting to restore RCS subcooling, and solid water operation may be necessary to restore subcooling.

*30. The operator should control RCS conditions throughout the cooldown to ensure that pressure is being maintained within the P-T limits of Figure 7-1. The preferred method of RCS pressure control is by manual operation of pressurizer heaters and spray. If necessary, charging and letdown, or the throttling of SI pumps can be utilized to control pressurizer pressure.

If subcooling or cooldown limits of Figure 7-1 are being violated, then the operators should take actions to restore the RCS to within the P-T limits. Depending on the situation, the operator should perform the following actions as appropriate:

a. Stop the cooldown
b. Operate the Reactor Coolant Gas Vent System or the main or auxiliary spray as necessary to restore pressurizer pressure to within the P-T limits of Figure 7-1.
c. Attempt to maintain the plant in a stable pressure-temperature configuration. The cooldown may be continued, if desired, within the limits of Figure 7-1.
d. If an overpressure situation exists and is caused by SI and/or charging flow, then throttle or stop SI pump (refer to step 12) or the charging pump and manually control letdown to restore and maintain pressure within the Post Accident P-T limits of Figure 7-1.

*31. The unisolated steam generator's water level is to be maintained in the normal band using main, startup or emergency feedwater. This ensures that a heat sink is available for RCS heat removal.

*32. The emergency feedwater inventory should be monitored and replenished from available sources as necessary to continually provide a source for a secondary heat sink. Examples of alternate sources of emergency feedwater are non-seismic tanks, fire mains, lake water supplies, potable tanks, etc. Plant specific alternate sources of feedwater should be identified and cited in the plant specific procedure. The amount of emergency feedwater required to either maintain the plant at HOT STANDBY conditions or to cooldown may be determined from Figures 7-4 and 7-5.

33. During a controlled cooldown and depressurization, the automatic operation of certain safeguard systems is undesirable. Therefore, the setpoints of MSIS and SIAS should be manually reset (lowered) as the cooldown progresses to ensure that automatic engineered safeguards protection remains available until the RCS is cooled down and depressurized.

*34. If pressurizer pressure reaches [740 psia], the safety injection tanks (SITs) must be vented, drained, or their discharge valves shut to prevent the nitrogen cover gas from being discharged into the RCS when RCS pressure is reduced below the SIT's pressure during a controlled cooldown. The max SIT pressure is [640 psia] and the value of [740 psia] is 100 psi greater than the maximum SIT pressure.

*35. If the pressurizer pressure reaches [445 psia], the isolation valves on the SITs may be closed to prevent unnecessary SIT discharge. The value of [445 psia] is the SIT outlet valve interlock setpoint.

*36. Low temperature overpressurization protection (LTOP) is instituted at $T_c \geq$ [259°F] to protect against subjecting the RCS pressure boundary to low temperature brittle fracture.

*37. The cooldown and depressurization should continue until shutdown cooling system entry conditions are established.

a. pressurizer level control should be established and verified by a level greater than [14.3%] and constant or increasing,
b. the RCS is subcooled,
c. RCS pressure should be at or below the shutdown cooling system entry pressure of [450 psia],
d. RCS hot leg temperature should be at or below the shutdown cooling system entry temperature of [400°F],

When these criteria ares established, the ESDE ORG should be exited and SCS operation initiated per [operating instructions].

If the RCS cannot be depressurized to SCS entry pressure, then a void should be suspected. Any time it is found that voiding inhibits RCS depressurization to SCS entry pressure, when SCS operation is desired, then an attempt at elimination of the voiding should be made.

a. The operator should continuously monitor for the presence of voids. Voiding in the RCS may be indicated by any of the following indications, parameter changes, or trends:

i) letdown flow greater than charging flow,
ii) pressurizer level increasing significantly greater than expected while operating pressurizer spray,
iii) the HJTC RVLMS indicates that voiding is present in the reactor vessel,
iv) HJTC unheated thermocouple temperature indicates saturated conditions in the reactor vessel upper head].

b. If voiding should be eliminated, then proceed as follows:

i) Letdown is isolated or verified to be isolated to minimize further inventory loss,

ii) The depressurization is stopped to prevent further growth of the void,

iii) Pressurizing and depressurizing the RCS within the limits of Figure 7-1 may condense the void. Pressurizing has the effect of filling the voided portion of the RCS with cooler fluid which will remove heat from the region. Subsequent depressurization and a repeating of this process several times will cool and condense the steam void. In the case of a void in the reactor vessel, the pressurization/ depressurization cycle will produce a fill and drain of the reactor vessel. The pressurization/depressurization cycle may be accomplished using pressurizer heaters and spray (preferred method) or the SI/charging system (alternative method). Monitor pressurizer level and the HJTC RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

c. If indications of unacceptable RCS voiding continue, then voiding may be caused by non-condensible gases. Operate the Reactor Coolant Gas Vent System to clear trapped non-condensible gases. Monitor pressurizer level and/or the HJTC RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

When SCS entry conditions are established, the ESDE guideline should be exited and shutdown cooling initiated per plant specific operating instructions. If significant voiding is present in the loop with the isolated steam generator, the SCS should be aligned to the other loop. This step will place the plant in an operational mode where a complete cooldown and depressurization of the plant can take place.

Safety Function Status Check

The Safety Function Status Check (SFSC) is used to continually verify the status of safety functions. The safety function acceptance criteria are selected from best estimate analysis to reflect the range for each parameter which would be expected following an Excess Steam Demand Event. If all SFSC acceptance criteria are being satisfied, then the adequacy of this guideline for mitigating the event in progress is confirmed and the health and safety of the public is ensured.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
2. Maintenance of Vital Auxiliaries (AC and DC Power)	All vital Division I [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized, or All vital Division II [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized.	One division of AC power is required for equipment necessary to maintain control of all other safety functions. One division of DC power is required as a minimum to provide monitoring and limited control of the other safety function.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
3. RCS Inventory Control	a. If pressurizer level is [2% to 78%], Then: i) charging and letdown, and SI (unless SI termination criteria met) are maintaining or restoring pressurizer level and ii) the RCS is subcooled and iii) the HJTC RVLMS indicates the RCS level is above the hot leg nozzles. or b. If pressurizer level is less than [2%], Then: i) the available charging pump is operating and the SI pumps(s) are injecting water into the RCS per Figure 7-3. and	A value of [2%] was chosen as the lower limit to prevent draining the pressurizer. The value of [78%] was chosen as an upper limit for pressurizer level to ensure an operable steam bubble exists in the pressurizer, but can be exceeded if solid operation is required to restore subcooling. Subcooling coexisting with a pressurizer level of [2% to 78%] indicates adequate RCS inventory control via a saturated bubble in the pressurizer. Representative CET temperature is to be used during natural circulation flow conditions and T_H RTDs are to be used during forced circulation flow conditions.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
3. RCS Inventory Control (Continued)	ii) the HJTC RVLMS indicates the core is covered.	An HJTC RVLMS indication that the hot leg is covered, taken in conjunction with subcooling, is an additional indication that RCS inventory control has been established. For cases where RCS inventory has badly degraded, the SI operation provides implicit assurance that control is being regained. HJTC RVLMS indicating the core is covered ensures a subcooled medium for heat transfer surrounds the core.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
4. RCS Pressure Control	a. Pressurizer heaters and spray are maintaining or restoring pressurizer pressure within the limits of Figure 7-1. or b. The available charging pump is operating and the SI pump(s) are injecting water into the RCS per Figure 7-3 (unless SI termination criteria are met).	Following the initial transient, and once plant control is reestablished, operation of the pressurizer heaters and sprays should be sufficient to control the RCS pressure. While RCS pressure control is badly degraded, the SI operation provides implicit assurance that control is being regained.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
5. Core Heat Removal	a. T_H RTD and representative CET temperatures < [626°F]. and b. The RCS is subcooled.	The basis for the temperature limit during the use of optimal recovery procedures other than LOCA is the indication that the event specific recovery strategy is not effective in core heat removal. For the optimal recovery guidelines other than LOCA, heat is normally removed from the RCS by the steam generators. The value of the CET temperature will be governed by steam generator conditions (i.e., pressure and temperature). In general $T_c \cong T_{SG}$ and CET temperature will be T_c + core ΔT. Normally this core ΔT is expected to be approximately [59°F] during single phase natural circulation conditions. For forced RCS flow conditions $T_{SG} \cong T_c \cong T_H \cong$ CET temperature. The secondary system design pressure is [1200 psia].

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
5. Core Heat Removal (Continued)		The corresponding saturation temperature is [567.2°F]. By adding [59°F] to account for thermocouple inaccuracy and ΔT between T_c and CET, the value of [626°F] is reached. The subcooling is based on keeping the core covered with subcooled fluid and thus ensuring adequate core cooling.
6. RCS Heat Removal	a. i) At least one steam generator has level within normal level band with feedwater available to maintain level or ii) At least one steam generator has level being restored to the normal band by feedwater flow with level increasing or	Adequate RCS heat removal will be maintained if the unisolated steam generator is available for removing heat (capable of steam flow and feed flow). The value of [500 gpm total feedwater flow] is sufficient feed flow to remove decay heat (approximately 2% rated thermal power) from the core. Decay heat levels may not be high enough to require [500 gpm] feed flowrate. In this case, steam generator level in

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
6. RCS Heat Removal (Continued)	iii) Total feedwater flow to either or both steam generators greater than [500 gpm] and b. RCS T_{ave} is < [567°F].	the normal band satisfies RCS heat removal.
7. Containment Isolation	a. i) Containment pressure less than [2.7 psig] or ii) CIAS present or manually initiated. and b. No containment area radiation monitors alarming. and c. No steam plant radiation monitors alarming. and d. No nuclear annex alarms	[2.7 psig], is the CIAS setpoint. If pressure increases to [2.7 psig], then containment isolation valves go to their accident positions (CIAS). If this does not occur automatically, the operator must manually initiate a CIAS. During ESDEs, it is not expected that there will be radiation inside containment, in the steam plant, or in the nuclear annex. These monitors should not be alarming.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
8. Containment Temperature and Pressure Control	a. i) Containment temperature less than [236°F] and ii) Containment pressure less than [8.5 psig] or b. The containment cooling system is operating in one of the following configurations: i) At least 1 Annulus Fan is energized and Annulus pressure is less than [0" w.g.] and ii) All fan coolers in operating or iii) One containment spray header delivering at least [5000 gpm]	[236°F] corresponds to the saturation temperature for [8.5 psig]. [8.5 psig] is based CSAS setpoint. Containment temperature and pressure may exceed the above limits during inside containment ESDE events. If this happens, the containment cooling systems should be operating to minimize the temperature and pressure. At least 1 Annulus Fan should be operating to reduce Annulus pressure to less than [0" w.g.]. The fan coolers or containment sprays will remove 100% of the design basis heat load should be specified as the acceptable operating configurations.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
9. Containment Combustible Gas Control	a. Containment sprays have <u>NOT</u> been actuated <u>or</u> b.i) At least 1 Annulus fan is energized <u>and</u> ii) Annulus pressure is less than [0" w.g.] <u>and</u> iii) Hydrogen concentration less than 0.5%. <u>or</u> c.i) all available hydrogen recombiners are energized, <u>and</u> ii) hydrogen concentration is less than 4%.	Hydrogen may be generated by corrosion reactions between the spray solution and some metals inside containment. If the sprays have not been actuated, no mechanism for generating hydrogen inside containment exists, and combustible gas control will not be a concern. If containment spray has actuated, but hydrogen concentration is less than the minimum detectable concentration (0.5%), then the Containment Combustible Gas Control Safety Function is satisfied if the Annulus Ventilation System is removing air in the Annulus. For most ESDE events, even steam line breaks inside containment, no hydrogen generation is expected. If detectable hydrogen is generated (≥ 0.5%), then the hydrogen recombiners should be operated to lower this concentration of hydrogen in containment.

Event Strategy

This section contains the detailed ESDE recovery actions strategy flow chart Figure 7-19. The flow chart pictorially depicts the strategy around which the ESDE guideline is built. It is intended to assist the procedure writer in understanding the intent of the guideline and for use in training. Operators should understand the major objectives of the guideline in order to facilitate their progress toward the guideline goals.

The strategy flow chart shows the recovery guideline strategy in detail and lists the guideline steps which correspond to each strategy objective. Some steps in the guideline may be performed at any time during the course of an event. Those steps are indicated by an asterisk next to the step number.

FIGURE 7-18a

EXCESS STEAM DEMAND EVENT STRATEGY CHART

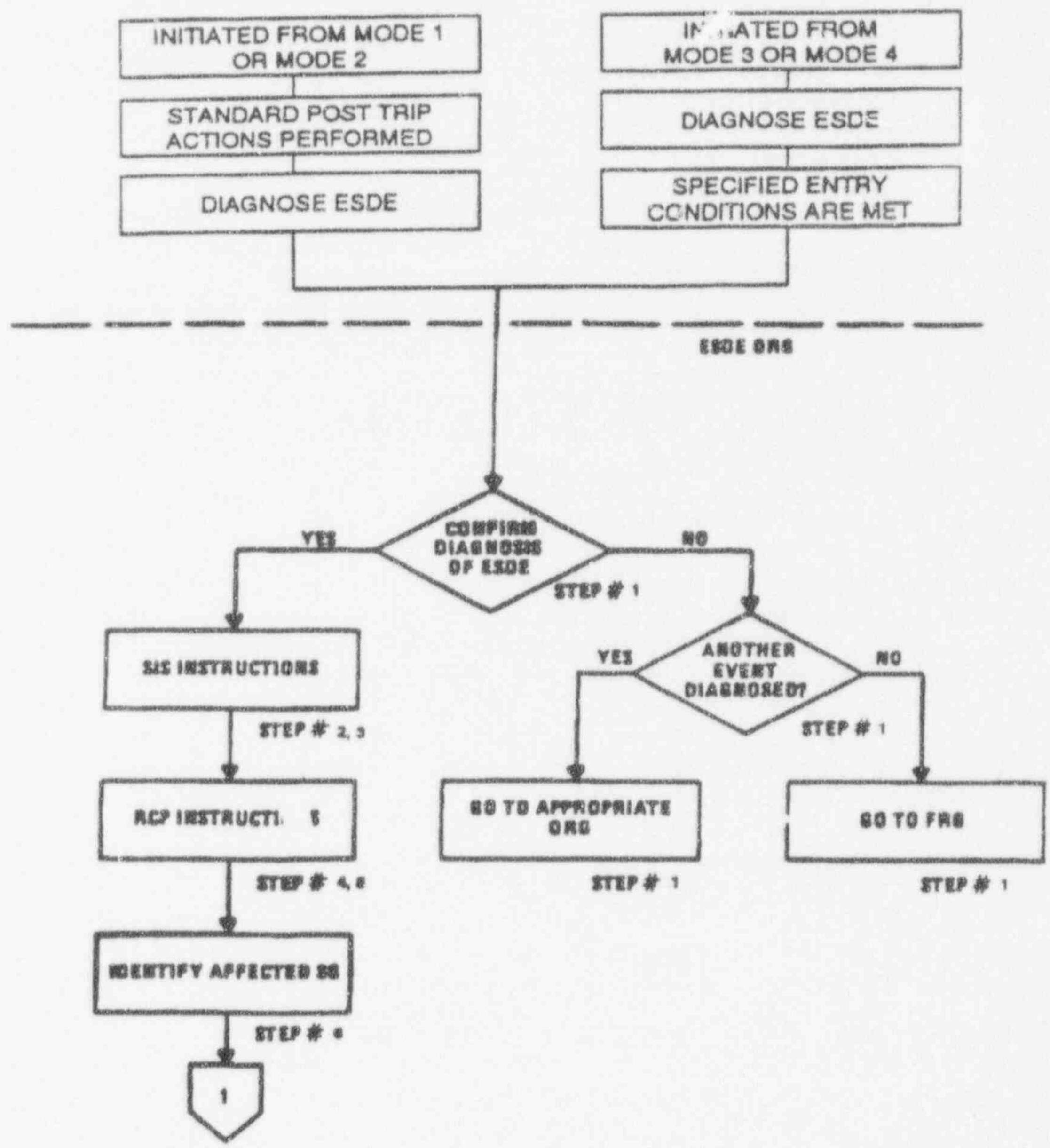


FIGURE 7-18b

EXCESS STEAM DEMAND EVENT STRATEGY CHART

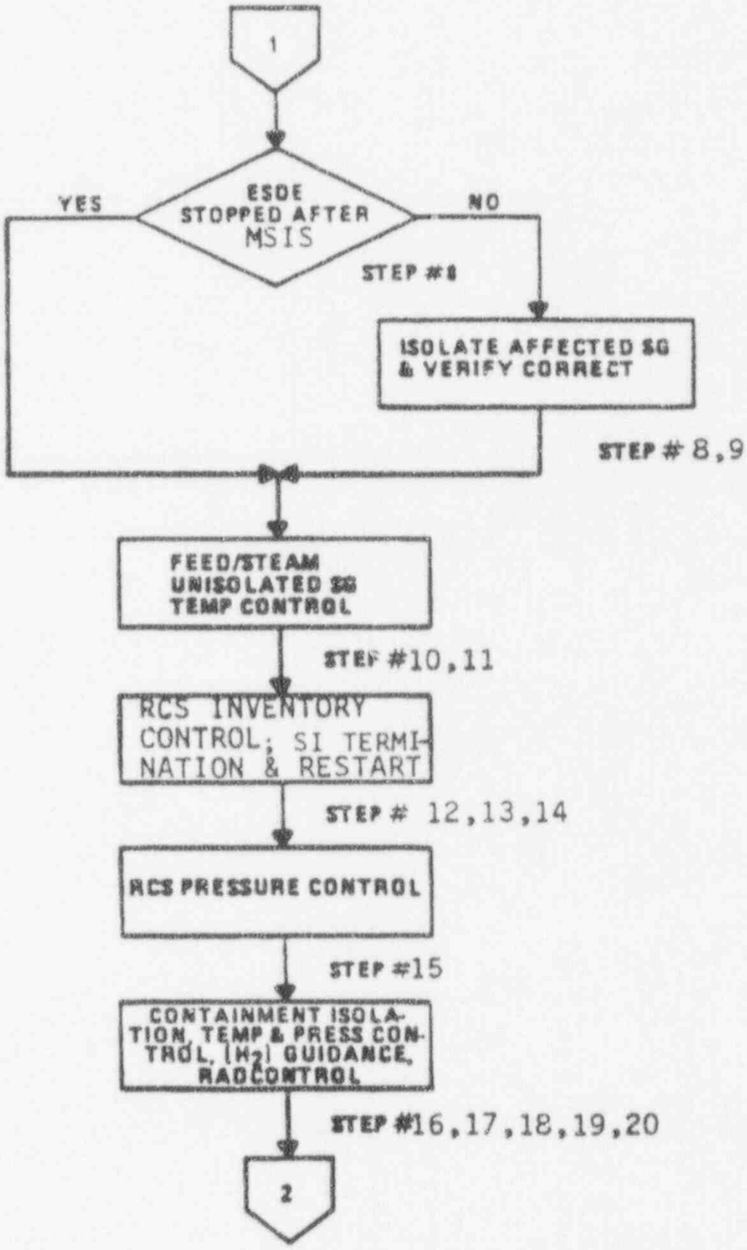


FIGURE 7-18c

EXCESS STEAM DEMAND EVENT STRATEGY CHART

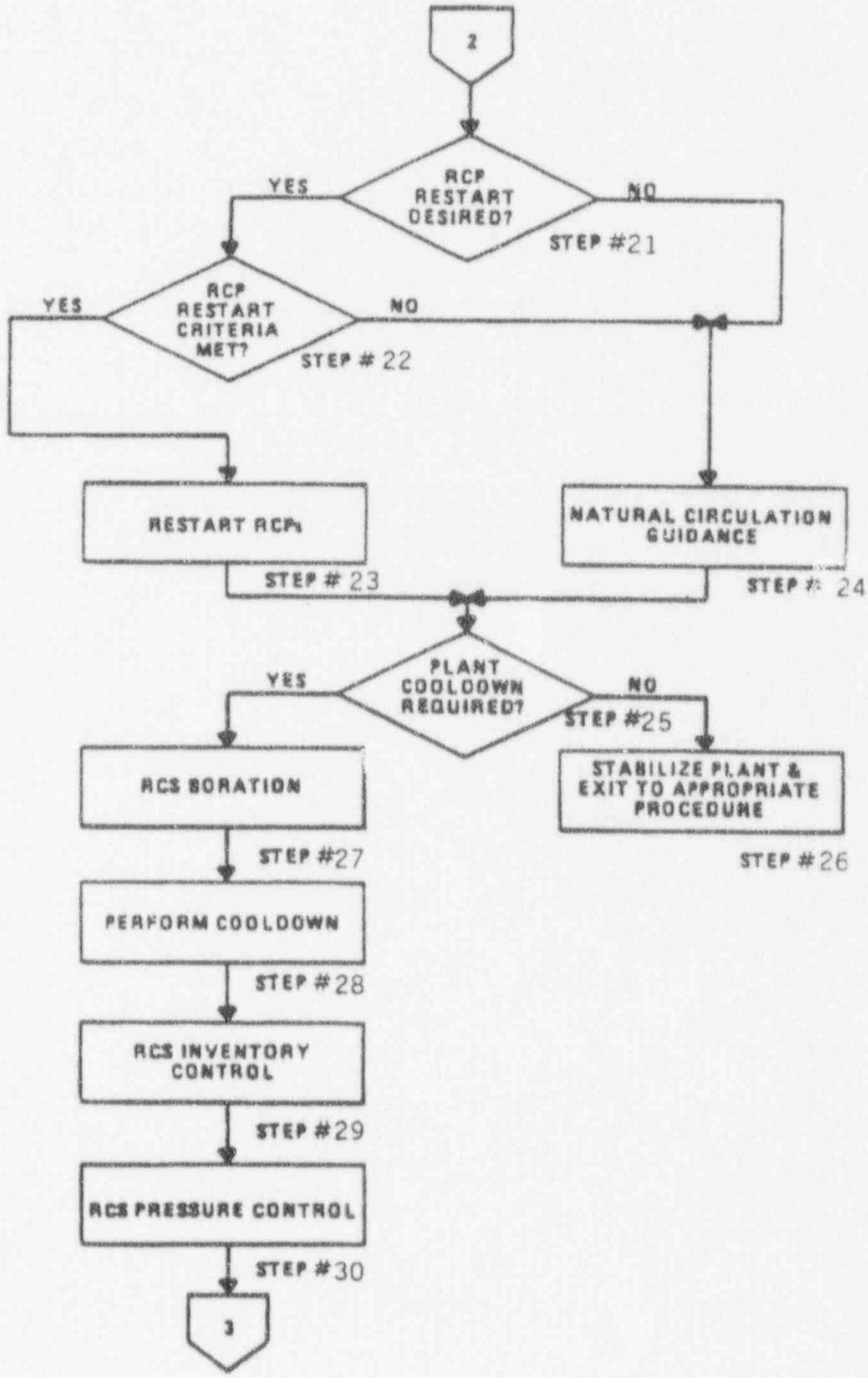
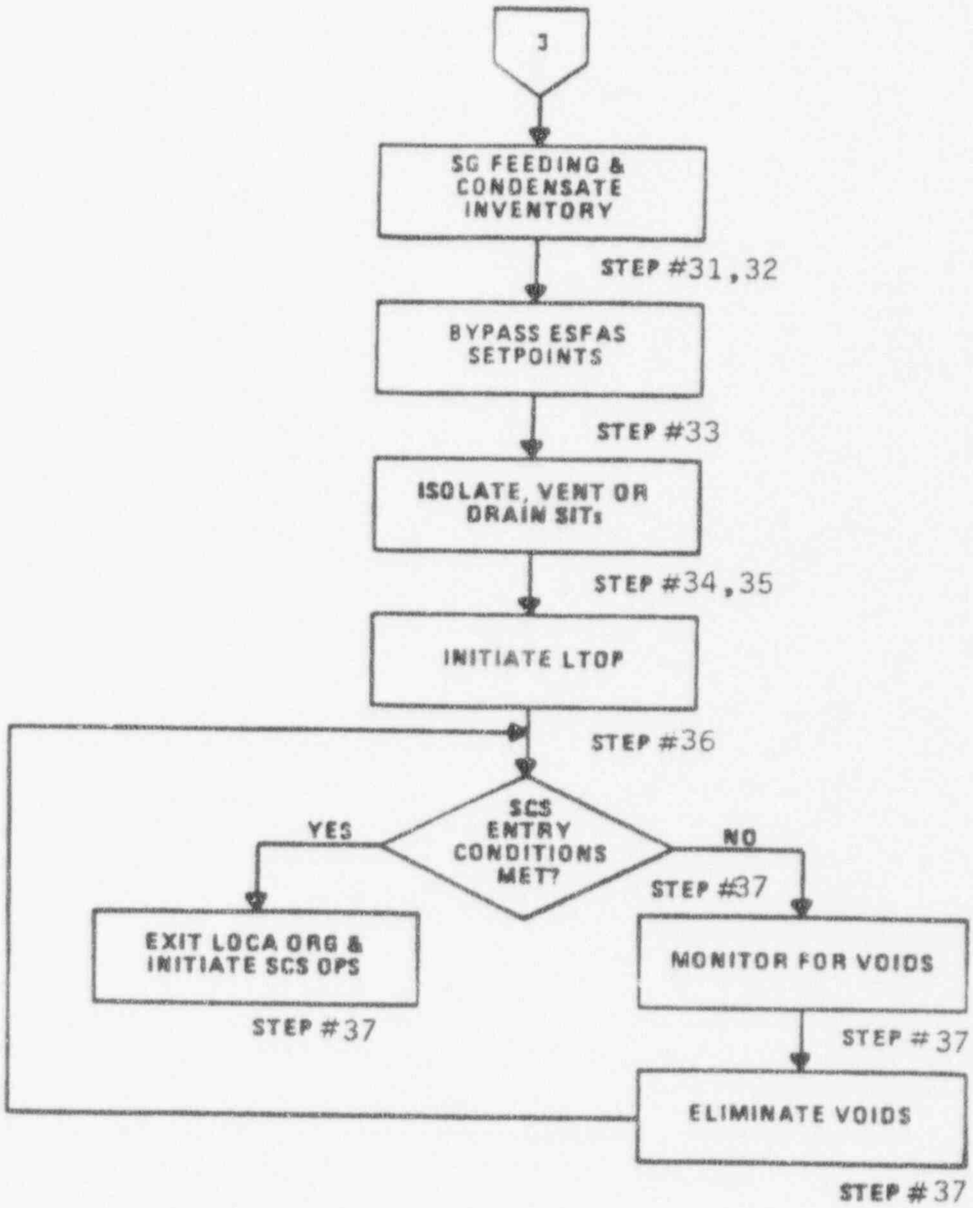


FIGURE 7-18d

EXCESS STEAM DEMAND EVENT STRATEGY CHART



LOSS OF ALL FEEDWATER RECOVERY

PURPOSE

This guideline provides operator actions which must be accomplished in the event of a Loss of All Feedwater (LOAF). The actions in this guideline are necessary to ensure the plant is placed in a stable, safe condition. The goal of this guideline is to safely establish the plant in a condition which will allow the implementation of an appropriate existing procedure for COLD SHUTDOWN, HOT STANDBY, or HOT SHUTDOWN. Radiological releases to the environment will be minimized and adequate core cooling will be maintained by following this guideline. This guideline provides technical information to be used by the utilities in developing a plant specific procedure.

Entry Conditions

1. The Standard Post Trip Actions have been performed

   or

   All of the following conditions exist:
   a. Event initiated from MODE 3 or 4
   b. SIAS has NOT been blocked
   c. LTOP has NOT been initiated

   and

2. Plant conditions indicate that a Loss of All Feedwater event has occurred. Any one, or more, of the following may be present.

   a. Decreasing steam generator water level or low level alarm.
   b. Main feedwater pump trip alarm.
   c. Low main feedwater pump or startup feedwater pump flow (possible high flow for a feedwater line break).
   d. Low main feedwater pump suction pressure.

Exit Conditions

1. The diagnosis of a Loss of All Feedwater event is not confirmed.

or

2. The feedwater line break is not isolable from the steam generator.

or

3. Any of the Loss of All Feedwater Safety Function Status Check acceptance criteria are not satisfied.

or

4. The Loss of All Feedwater EOG has accomplished its purpose by satisfying ALL of the following:

    a. All of the Safety Function Status Check acceptance criteria are being satisfied.
    b. RCS conditions are being controlled and maintained in HOT STANDBY, HOT SHUTDOWN, or COLD SHUTDOWN.
    c. An appropriate, approved procedure to implement exists or has been approved by the Plant Technical Support Center or the Plant Operations Review Committee.

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. Confirm diagnosis of Loss of All Feedwater by verifying Safety Function Status Check Acceptance criteria are satisfied.	1. Rediagnose event and exit to either the appropriate Optimal Recovery Guideline or to the Functional Recovery Guideline.
2. Trip all RCPs.	2.
3. If a feedwater line break is suspected, then islolate the break and continue with the actions of this guideline.	3. If the feedwater line break is NOT isolable from the steam generator, Then exit this guideline and implement the Excess Steam Demand Event Optimal Recovery Guideline.
* 4. Attempt to restore main, startup, and/or emergency feedwater systems to operation.	4.
* 5. If feedwater to at least one steam generator has NOT been restored, Then perform steps 6 through 8.	5. If feedwater has been restored to at least one steam generator, Then go to step 9.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
6. If main, startup or emergency feedwater has NOT been restored, Then do the following: a. isolate steam generator blowdown, secondary sampling, and any non-vital steam discharge and b. continue actions to restore main, startup or emergency feedwater.	6.
7. Depressurize the steam generator(s) in order to establish an alternate, low pressure feedwater source to at least one steam generator.	7.
* 8. Verify adequate RCS heat removal via the steam generators by: a. at least one steam generator has wide range level greater than [0%], and b. RCS T_c temperatures are stable or decreasing.	8. When at least one primary safety valve has opened following steam generator dryout, Then implement the FRG and initiate RCS and Core Heat Removal success path HR-4

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS
*9. If feedwater is restored, Then Modulate feedwater flow rate as necessary to restore and maintain SG water level in the normal level band	9.	
10. Ensure automatic or manual control of the Steam Bypass System is maintaining RCS T_{ave} < [567°F].	10.	If condenser vacuum is lost or the Steam Bypass System is not available, Then operate atmospheric dump valves to control RCS $T_{ave} \leq$ [567°F].
*11. Ensure the available emergency feedwater inventory is adequate per Figures 8-3 and 8-4.	11.	
*12. Verify charging and letdown are automatically maintaining or restoring pressurizer level [2% to 78%].	12.	Manually control charging and letdown to restore/maintain pressurizer level [2% to 78%].
*13. Ensure pressurizer heaters and spray are maintaining or restoring pressurizer pressure within the limits of Figure 8-1.	13.	If RCS subcooling greater than P-T limits or cooldown rate greater than 100°F/Hr, Then do the following as appropriate: a. stop the cooldown,

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
	13. (Continued) b. manually control the Reactor Coolant Gas Vent System or auxiliary spray to restore and maintain pressure within the limits of Figure 8-1, c. attempt to maintain the plant in a stable pressure-temperature configuration or continue to cooldown within the limits of Figure 8-1, d. <u>If</u> overpressurization due to SI/charging flow, <u>Then</u> throttle or secure flow (refer to step 18) and manually control letdown to restore and maintain pressurizer pressure within the limits of Figure 8-1.
*14. <u>Verify</u> natural circulation flow in at least one loop by <u>ALL</u> of the following: a. loop ΔT (T_H - T_c) less than normal full power ΔT,	14. <u>Ensure</u> proper control of steam generator feeding and steaming (refer to steps 9 and 10) and RCS inventory and pressure control (refer to steps 12 and 13).

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*14. (Continued)	
b. hot and cold leg temperatures constant or decreasing, c. RCS is subcooled, d. no abnormal difference [greater than 10°F] between T_H RTDs and Core Exit Thermocouples.	
*15. Evaluate the need and desirability of restarting RCPs. Consider the following: a. adequacy of RCS and core heat removal using natural circulation, b. existing RCS pressure and temperatures, c. the need for main pressurizer spray capability, d. the duration of CCW interruption to RCPs, e. RCP seal staging pressures and temperatures.	15. If RCP operation NOT desired, Then go to Step 18.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*16. <u>Determine</u> whether RCP restart criteria are met by <u>ALL</u> of the following: a. electrical power is available to the RCPs, b. RCP auxiliaries (CCW) to maintain [illegible] cooling, bearing and motor cooling are operating, and there are no high temperature alarms on the selected RCPs. c. at least one steam generator is available for removing heat from the RCS (ability for feed and steam flow), d. pressurizer level is greater than [33%] and not decreasing, e. RCS is subcooled based on representative CET temperature (Figure 8-1). f. other criteria satisfied per plant specific operating instructions. g. Natural circulation has been established per Step 14 for the preceding 20 minutes.	16. <u>If</u> RCP restart criteria <u>NOT</u> satisfied, <u>Then</u> go to step 18.

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS
*17.	If RCP restart desired and restart criteria satisfied, Then do the following: a. start one RCP in each loop, b. ensure proper RCP operation by monitoring RCP amperage and NPSH, c. operate charging pump and SI pumps until pressurizer level greater than [14.3%] and SIS termination criteria met (Refer to step 18).	17. Go to step 18.
*18.	If SI pumps are operating, Then they may be throttled or stopped one pump at a time, if All of the following are satisfied: a. RCS is subcooled based on representative CET temperature (Figure 8-1), b. pressurizer level is greater than [14.3%] and not decreasing, c. at least one SG available for RCS heat removal (ability for feed and steam flow), d. the HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles	18.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*19. If criteria of step 18 cannot be maintained after SI pumps throttled or stopped, Then SI pumps must be restarted and full SI flow restored.	19.
20. Evaluate the need for a plant cooldown based on: a. plant status, b. auxiliary systems availability, c. emergency feedwater inventory (refer to Figures 8-3 and 8-4).	20.
21. If a plant cooldown is desired, Then perform steps 22 through 27.	21.a. Maintain the plant in a stabilized condition, and b. Exit to appropriate procedure as directed by [Plant Technical Support Center or the Plant Operations Review Committee].
* 22. Borate the RCS to maintain shutdown margin in accordance with Technical Specifications.	22.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
23. Commence an orderly plant cooldown, using forced or natural circulation, in accordance with Technical Specifications. Reduce RCS temperatures by the following: a. If the condenser is available, Then cooldown using the steam bypass system, or b. If the condenser or steam bypass system NOT available, Then cooldown using the atmospheric dump valve(s).	23.
24. Bypass or lower the automatic initiation setpoints of MSIS and SIAS as the cooldown and depressurization proceed.	24.
25. When pressurizer pressure reaches [740 psia], reduce SIT pressure to [300 psia].	25.

INSTRUCTIONS	CONTINGENCY ACTIONS
26. When pressurizer pressure reaches [445 psia], Then isolate, vent or drain the safety injection tanks (SITs).	26.
27. Initiate low temperature overpressurization protection (LTOP) at T_c < [259°F].	27.
28. When the following SCS entry conditions are established: a. pressurizer level > [14.3%] and constant or increasing, b. RCS is subcooled, c. RCS pressure ≤ [450 psia], d. RCS T_H ≤ [400°F],	28. If the RCS fails to depressurize, then a void should be suspected. a. Voiding in the RCS may be indicated by any of the following indications, parameter changes, or trends: i) letdown flow greater than charging flow, ii) pressurizer level increasing significantly more than expected while operating pressurizer spray, iii) the HJTC RVLMS indicates that voiding is present in the reactor vessel, iv) HJTC unheated thermocouple temperature indicates saturated conditions in the reactor vessel upper head.

INSTRUCTIONS

CONTINGENCY ACTIONS

28. (Continued)

b. If voiding inhibits RCS depressurization to SCS entry pressure, Then attempt to eliminate the voiding by:

   i) verify letdown is isolated,

   and

   ii) stop the depressurization,

   and

   iii) pressurize and depressurize the RCS within the limits of Figure 8-1 by operating pressurizer heaters and spray or SI and charging pumps. Monitor pressurizer level and the HJTC RVLMS for trending RCS inventory.

INSTRUCTIONS | CONTINGENCY ACTIONS

28. (Continued)

c. If depressurization of the RCS to the SCS entry pressure is still not possible, and voiding is suspected to exist in the steam generator tubes, Then attempt to eliminate the voiding by:

   i) cool the suspected steam generator (by steaming and/or blowdown, and feeding) to condense the steam generator tube void,

   and

   ii) monitor pressurizer level for trending RCS inventory.

d. If depressurization of the RCS to the SCS entry pressure is still not possible, Then attempt to eliminate the voiding by:

   i) operate the Reactor Coolant Gas Vent System to clear trapped non-condensible gases.

   and

   ii) monitor pressurizer level and/or the HJTC RVLMS for trending of RCS inventory.

INSTRUCTIONS	CONTINGENCY ACTIONS
	28. (Continued)
	e. Continue attempts to establish SCS entry conditions, or exit this guideline and initiate an appropriate procedure as directed by the [Plant Technical Support Center or the Plant Operations Review Committee].

The Loss of All Feedwater Recovery Guideline has accomplished its purpose if RCS conditions are being controlled in HOT STANDBY, HOT SHUTDOWN, or COLD SHUTDOWN with all of the SFSC acceptance criteria satisfied, and the entry conditions of an appropriate, approved procedure are satisfied.

END

SUPPLEMENTARY INFORMATION

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes or in the EOP training program.

1. The operator should not add feedwater to a dry steam generator if another steam generator still contains water. Re-establish feedwater only to the steam generator that is not dry. If both steam generators become dry, refill only one steam generator to reinitiate core cooling.

2. During all phases of the cooldown, monitor RCS temperature and pressure to avoid exceeding a cooldown rate greater than Technical Specification Limitations.

3. Do not place system in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation.

4. All available indications should be used to aid in evaluating plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available (e.g., during rapid depressurization the indicated level in the pressurizer may be too high).

5. If the initial cooldown rate exceeds Technical Specification Limits, there may be a potential for pressurized thermal shock (PTS) of the reactor vessel. Post Accident Pressure/Temperature Limits of (Figure 8-1) should be maintained.

6. Solid water operation of the pressurizer should be avoided unless subcooling cannot be maintained in the RCS (Figure 8-1). If the RCS is solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any unfavorable rapid pressure excursions.

7. Minimize the number of cycles of pressurizer auxiliary spray whenever the temperature differential between the spray water and the pressurizer is greater than 200°F in order to minimize the increase in the spray nozzle thermal stress accumulation factor.

8. Natural circulation flow cannot be verified until the RCPs have stopped coasting down after being tripped.

9. During natural circulation, verification of an RCS temperature response to a plant change cannot be accomplished until approximately 5 to 15 minutes following the action due to increased loop cycle times.

10. After the required shutdown boron concentration is attained in the RCS, makeup water added to the RCS during the cooldown should be at least equal to the RCS boron concentration to prevent any dilution of RCS boron concentration.

11. Once the pressurizer cooldown has begun, pressurizer level indication decalibration will occur. The indication on the normal pressurizer level indication will begin to deviate from the true pressurizer water level. The operator should use correction curves to find the true pressurizer level. A cold calibrated pressurizer level indication is also available for lower pressurizer temperatures.

12. When a void exists in the reactor vessel and RCPs are not operating, the HJTC RVLMS provides an accurate indication of reactor vessel liquid inventory. When a void exists in the reactor vessel and RCPs are operating, it is not possible to obtain an accurate reactor vessel liquid level indication due to the effect of the RCP induced pressure head on the HJTC RVLMS. Information concerning reactor vessel liquid inventory trending may still be discerned. The operator is cautioned not to rely solely on the HJTC RVLMS indication when RCPs are operating.

13. The operator should continuously monitor for the presence of RCS voiding and take steps to eliminate voiding any time voiding causes heat removal or inventory control safety functions to begin to be threatened. Void elimination should be started soon enough to ensure heat removal and inventory control are not lost.

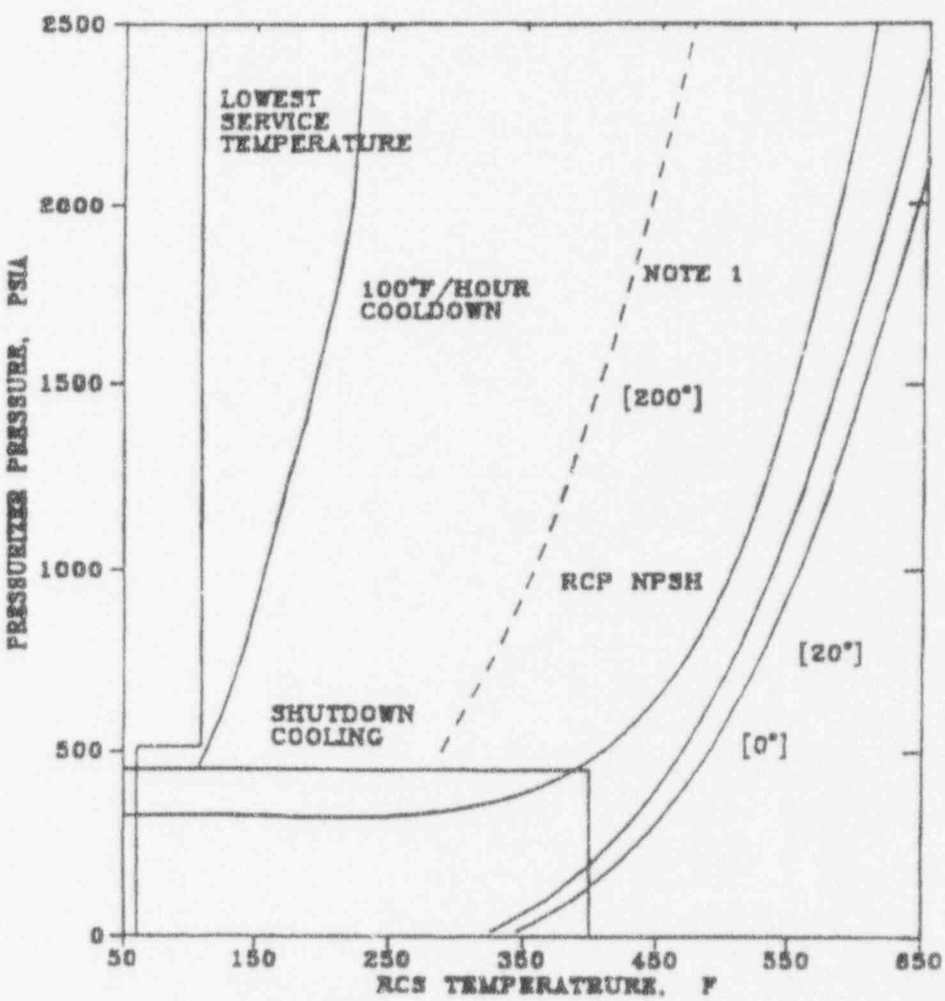
14. It is desirable to have all electrical equipment available in order to most effectively mitigate and recover from a Loss of All Feedwater event. Therefore, if any vital AC or DC bus is de-energized, operators should attempt to restore power to the vital AC or vital DC bus(es). This action is taken even though the loss of one vital AC or DC bus will not prevent the operators from performing all necessary actions in the Loss of All Feedwater ORG.

15. Prior to RCP restart, verify loops with restart RCP(s) have been in natural circulation continuously for the preceding 20 minutes.

16. The Alternate Protection System provides a redunant and diverse means of initiating a reactor trip to reduce the potential of an ATWS event. In addition, the Alternate Protection System provides a redundant and diverse emergency feedwater actuation signal to provide added assurance that an ATWS event or a Loss of Feedwater event could be mitigated if it were to occur.

FIGURE 8-1

TYPICAL POST ACCIDENT PRESSURE-TEMPERATURE LIMITS

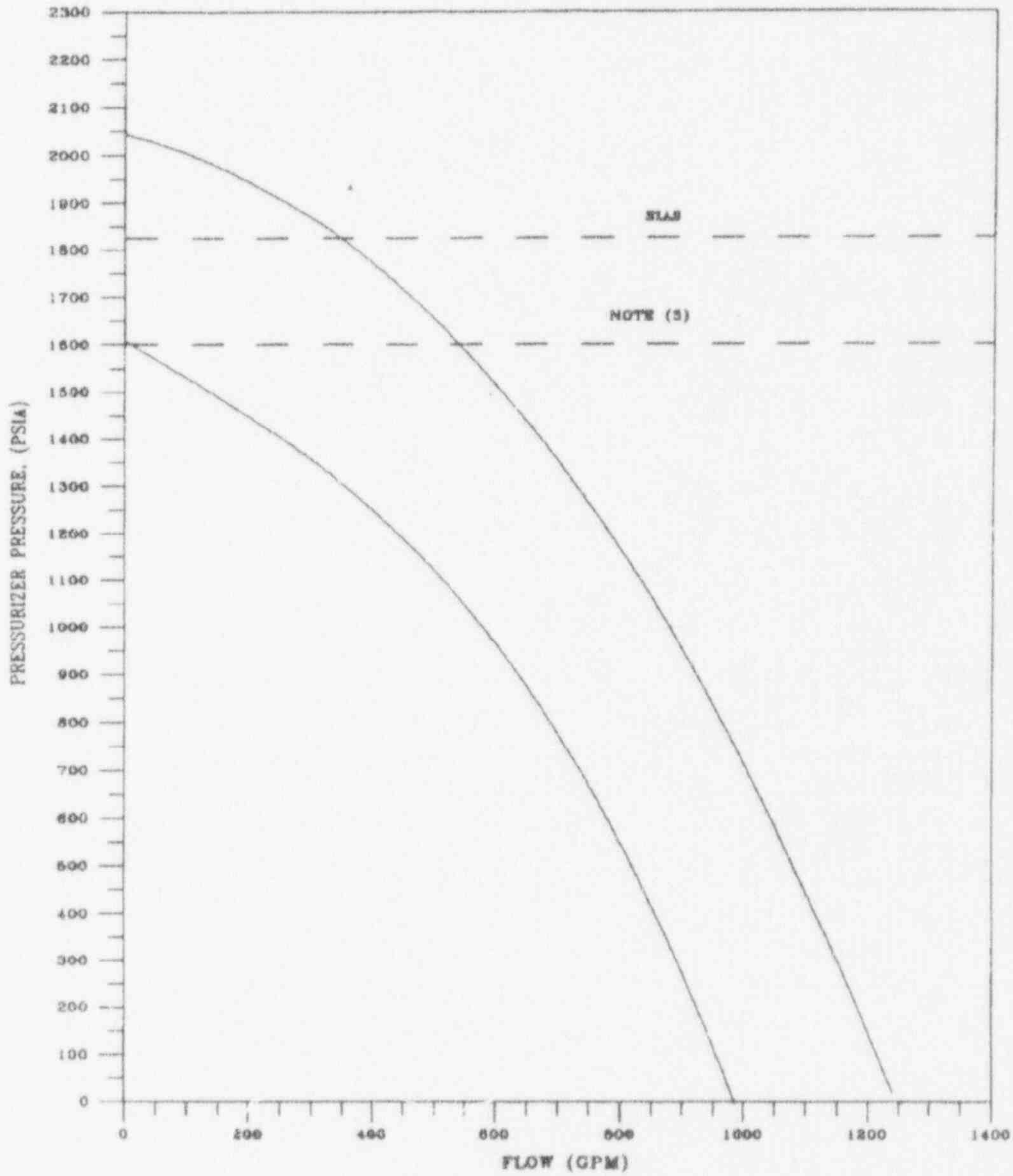


NOTES: (1) THIS CURVE SUPERSEDES THE 100° F/HR COOLDOWN CURVE ANYTIME THE RCS HAS EXPERIENCED AN UNCONTROLLED COOLDOWN WHICH CAUSES RCS TEMPERATURE TO GO BELOW 500° F. THIS CURVE IS AN OPERATIONAL LIMIT BASED ON ENGINEERING JUDGEMENT AND INTENDED TO MINIMIZE THE POTENTIAL OF A PRESSURIZED THERMAL SHOCK.

(2) THESE CURVES MUST BE ADJUSTED FOR INSTRUMENT INACCURACIES.

FIGURE 8-2

TYPICAL ACCEPTABLE SIS FLOW VS. RCS PRESSURE



NOTES:
(1) SEE IMPLEMENTATION SECTION FOR DEVELOPMENT OF PLANT SPECIFIC CURVE.
(2) FOR HOT LEG AND DVI INJECTION, FULL FLOW FROM SIS PUMPS 1 AND 3 IS DIRECTED TO THE HOT LEGS.
(3) BELOW THE SIAS SETPOINT, THE SIS PUMPS WILL BE OPERATING, BUT THERE WILL BE NO INJECTION FLOW UNTIL SYSTEM PRESSURE FALLS BELOW THE SHUTOFF HEAD OF THE SIS PUMPS.
(4) THESE CURVES DO NOT ACCOUNT FOR INSTRUMENTATION INACCURACIES

FIGURE 8-3

TYPICAL FEEDWATER CAPACITY VERSUS TIME REMAINING UNTIL SHUTDOWN COOLING REQUIRED

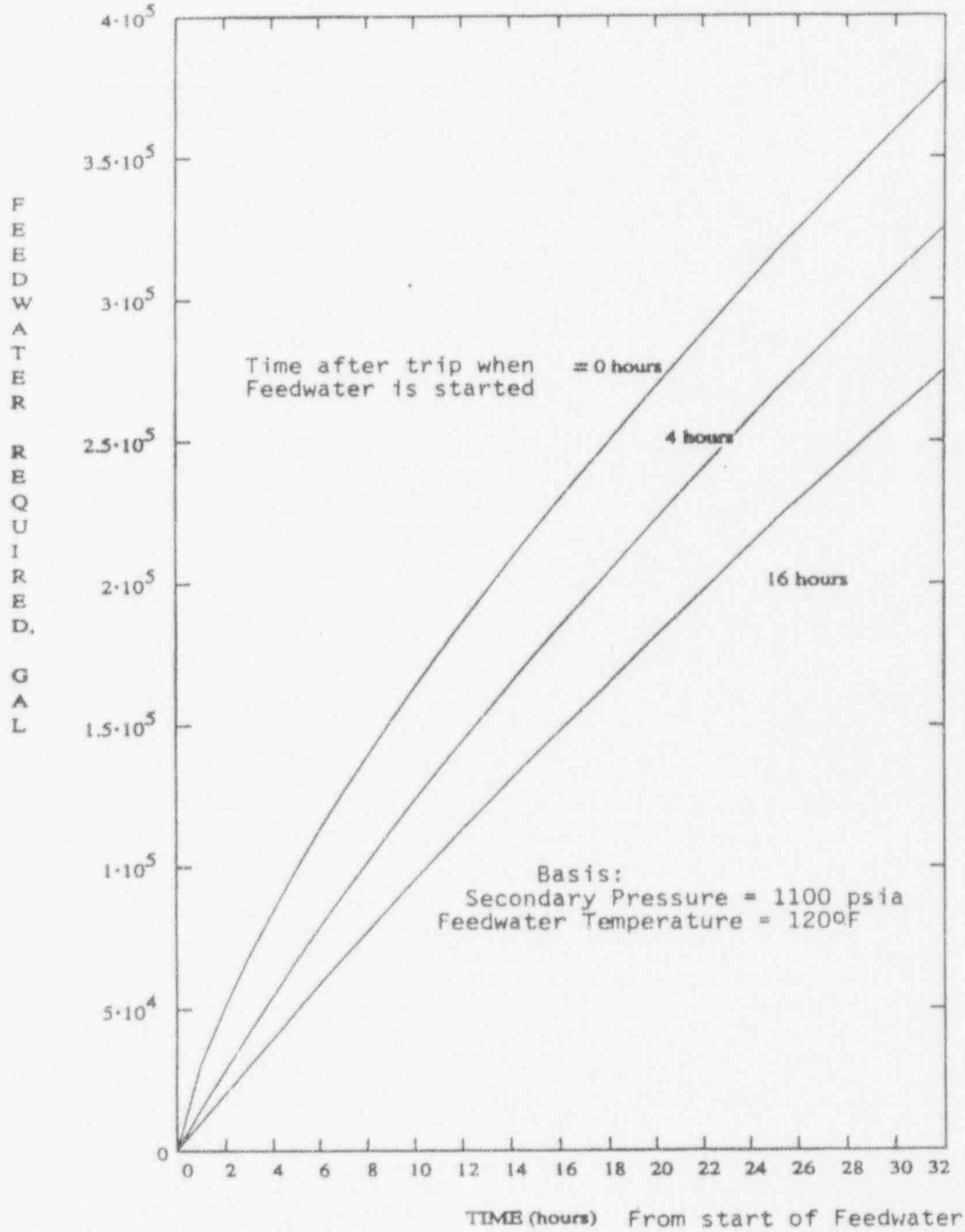
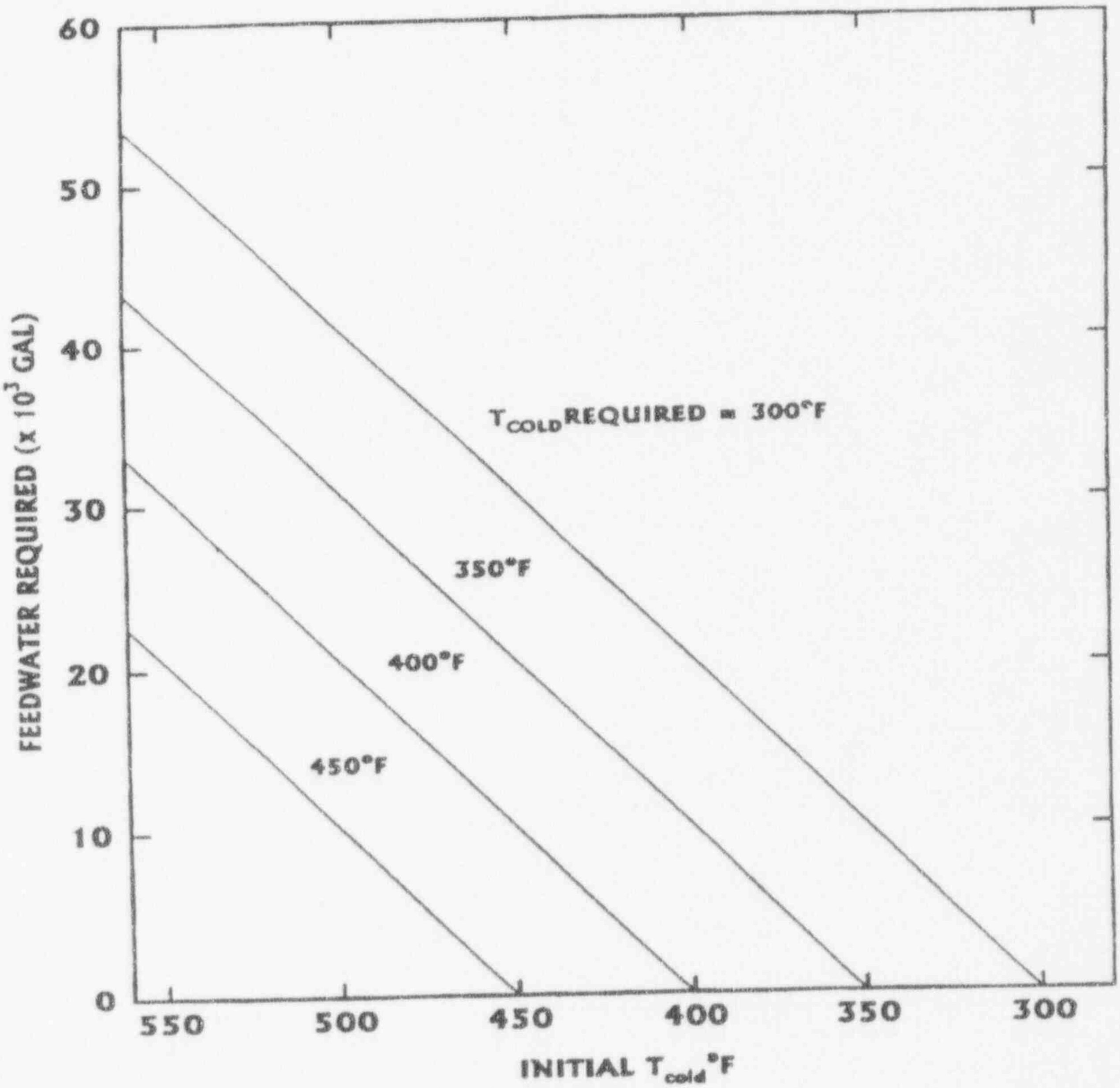


FIGURE 8-4

TYPICAL FEEDWATER REQUIRED FOR SENSIBLE HEAT REMOVAL

T_{cold} (REQUIRED) VS T_{cold} (INITIAL)



SAFETY FUNCTION STATUS CHECK

ACCEPTANCE CRITERIA	ACCEPTANCE CRITERIA
1. Reactivity Control	1. a. Reactor power decreasing and b. Negative Startup Rate] and c. Maximum of one CEA NOT fully inserted or borated per Tech Specs.
2. Maintenance of Vital Auxiliaries (AC and DC Power)	2. a. All vital Division I [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized, or All vital Division II [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized.
3. RCS Inventory Control	3. a. Charging and letdown on SIS are maintaining or restoring pressurizer level [2% to 78%] and b. The RCS is subcooled and c. The HJTC RVLMS indicates the core is covered.

SAFETY FUNCTION STATUS CHECK

ACCEPTANCE CRITERIA	ACCEPTANCE CRITERIA
4. RCS Pressure Control	4. Pressurizer heaters and spray are maintaining or restoring pressurizer pressure within the Post Accident P-T limits of Figure 8-1.
5. Core Heat Removal	5. T_H RTD and representative Core Exit Thermocouple temperatures less than [626°F].
6. RCS Heat Removal	6. A primary safety valve(s) has <u>NOT</u> lifted following steam generator dryout.
7. Containment Isolation	7. a. Containment pressure less than [2.0 psig] <u>and</u> b. No containment area radiation monitors alarming <u>and</u> c. No steam plant activity monitors alarming. <u>and</u> d. No nuclear annex alarms. <u>and</u> e. No reactor building radiation alarms.

SAFETY FUNCTION STATUS CHECK

ACCEPTANCE CRITERIA	ACCEPTANCE CRITERIA
8. Containment Temperature and Pressure Control	8. a. Containment temperature less than [110°F] and b. Containment pressure less than [2.0 psig]
9. Containment Combustible Gas Control	9. a. Containment temperature less than [110°F] and b. Containment pressure less than [2.0 psig].

BASES

The bases section of the Loss of All Feedwater (LOAF) Recovery Guideline describes the LOAF transient in relation to the actions which the operator takes during a LOAF. The purpose of the bases section is to provide the operators with information which will enable them to understand the reasons for, and the consequences of, the actions they take during a LOAF.

Characterization of a Loss of All Feedwater Event

A Loss of All Feedwater results from a loss of main, startup, and emergency feedwater to the steam generators. Some possible causes for a Loss of All Feedwater include:

a) Loss of all main feedwater pumps.
b) Malfunction of the feedwater control system which closes the main feedwater control valves.
c) Inadvertent isolation, or blockage, of the feedwater flow path.
d) Malfunction of the condensate system.
e) Feedwater line break (loss of feedwater resulting from a feedwater line break which is not isolable from the steam generator is covered under Excess Steam Demand Event).

A Loss of All Feedwater is characterized by specific parameters that may be indicated in the control room. Some of these indications are:

a) Decreasing steam generator water level. The existence of this condition may be indicated by an alarm in the control room.
b) Increasing steam generator pressure before a reactor trip, followed by a decreasing and stabilizing trend.
c) Increasing pressurizer level and pressure before a reactor trip, followed by a decreasing and stabilizing trend.
d) Reactor trip generated on low steam generator water level.

e) Emergency feedwater actuation signal (EFAS) generated on low steam generator water level.

f) Turbine/generator tripped.

g) Low main feedwater pump flow/suction pressure, resulting in a main feedwater pump trip alarm. (The main feedwater pump flow may possibly be high if there is a feedwater line break.)

h) Containment pressure may increase if a feedwater line breaks inside containment. In addition, possible increase in containment pressure, temperature, humidity, or containment sump level.

i) A feedwater line break outside containment may be indicated by noise.

j) Possible equipment operational irregularities, such as a loss of feedwater control indication, a failure of the feedwater flow control valves, or a closure of a main feedwater system isolation valve.

k) Possible steam flow vs. feedwater flow mismatch noted.

Safety Functions Affected

A Loss of All Feedwater, if not corrected, results in a loss of the steam generator's ability to remove heat from the RCS. Operator actions should be directed towards conserving the available steam generator water inventory and re-establishing feedwater flow to the steam generators so that RCS heat removal capability is maintained or restored. All safety functions should be monitored to assure public safety, or to detect changes in the plant conditions which could lead to unsafe conditions.

In addition to RCS heat removal, other safety functions may be affected in the following manner. The Loss of All Feedwater flow to the steam generators causes level in the steam generator to decrease. If the level decreases below the top of the generator tube bundle, heat transfer in the steam generator decreases and RCS temperature will begin to increase. RCS temperature also increases because cooler feedwater is no longer being added to the steam generators, thereby raising overall steam generator temperature. The rate of level decrease and RCS temperature increase is a function of reactor power. The rate of decrease is also dependent on the rate of feedwater loss or the size of the feedwater line break. As water level decreases below the reactor trip setpoint, a reactor trip (reactivity control) will occur, accompanied by a turbine trip, and rapidly decreasing RCS temperatures (to the hot zero power setpoint), pressurizer level and pressure. At high reactor powers, the reactor trip will occur within approximately 15-30 seconds after the loss of all feedwater. Following the reactor trip, the steam bypass valves will usually control steam generator pressure at the hot zero power setpoint. If the steam bypass valves are unavailable, steam pressure may be controlled by the ADVs if the operator opens them or by the steam generator main steam safety valves. RCS temperature will be controlled at a value slightly above that corresponding to steam generator saturation conditions until a substantial portion of the tube bundle in each S/G is uncovered. At this point, RCS temperature will begin to increase. If the steam generators boil dry, RCS temperature will rise rapidly. When saturation conditions in the RCS reach the setpoints for the pressurizer safeties, RCS inventory will be lost out of the safeties (loss of RCS inventory control). If RCS inventory loss continues at a high pressure, core uncovery may occur with corresponding severe consequences. The high pressure in the RCS will prevent RCS inventory replenishment via the SIS. Thus, operation of the charging pump will be the sole means of injecting water into the RCS. To avoid this situation, the operator is given explicit instructions to go to the Functional Recovery Guideline to initiate once-through-cooling upon indication that a RCS safety valve has lifted following SG dryout.

Trending of Key Parameters

Reactor Power (Figure 8-5)

When the level in one or both steam generators falls below the reactor trip setpoint, the reactor will trip. At high powers, this will occur in 15-30 seconds. The main turbine generator will trip concurrently with the reactor trip. If the operator is able to conclude that a loss of feedwater has occurred before the reactor has tripped, the reactor should be tripped immediately (even before steam generator water level drops to the low level trip setpoint) to conserve the available steam generator water inventory.

RCS Temperature (Figure 8-6)

RCS temperature may increase before the trip. After the trip, RCS temperatures should decrease to approximately the hot zero power setpoint. If steam generator water level begins to drop below the top of the heat transfer tubes, the RCS heat transfer surface is reduced and RCS temperature increases. If the steam generators are allowed to boil dry, RCS temperature will increase dramatically.

Pressurizer Pressure (Figure 8-7)

Pressurizer pressure will initially increase prior to a reactor trip due to the RCS heatup and then decrease after the trip. If the SGs are allowed to boil dry, pressurizer pressure will eventually increase in conjunction with RCS temperature and pressurizer level.

Pressurizer Level (Figure 8-8)

Coincident with RCS temperature rising prior to reactor trip, there will be an increase in pressurizer level. The level will decrease post trip as heat is removed from the RCS. If the SGs are allowed to boil dry, RCS heat removal is no longer being maintained and pressurizer level will increase in conjunction with RCS temperature increases.

Reactor Vessel Level

Voiding is not expected to occur during a Loss of All Feedwater transient since the RCS heats up and RCS inventory is not expected to be lost unless the pressurizer safety relief valves open. If RCS inventory loss continues at a high rate because of a loss of heat sink, voiding could eventually cause core uncovery because system pressure is above SI shut off head. If feedwater is restored, voiding should not occur.

Steam Generator Pressure (Figure 8-9)

Initially, the pressure in the steam generators will increase as feedwater flow to the steam generators is lost because the heat required to heat the cool feedwater now causes SG temperature to increase. Following the reactor trip, SG pressure will usually increase to the steam bypass control setpoint. If steaming continues with the steam vent path left open, and without feedwater, steam generator pressure will eventually begin to decrease as the steam generator boils dry.

Steam Generator Level (Figure 8-10)

A loss of feedwater to the steam generator will result in a decreasing steam generator level. This decrease usually causes a reactor trip. If steaming continues without feedwater, the SG tube bundle will uncover and, eventually, the steam generators will boil dry.

FIGURE 8-5

REPRESENTATIVE TOTAL LOSS OF MAIN FEEDWATER FLOW

REACTOR POWER

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 8-6

REPRESENTATIVE TOTAL LOSS OF MAIN FEEDWATER FLOW

LOOP A RCS NARROW RANGE TEMPERATURES

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 8-7

REPRESENTATIVE TOTAL LOSS OF MAIN FEEDWATER FLOW

PZR NARROW RANGE PRESSURE

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 8-8
REPRESENTATIVE TOTAL LOSS OF MAIN FEEDWATER FLOW
PZR LEVEL

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 8-9

REPRESENTATIVE TOTAL LOSS OF MAIN FEEDWATER FLOW

STEAM GENERATOR PRESSURE

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 8-10

TOTAL LOSS OF MAIN FEEDWATER FLOW

STEAM GENERATOR LEVEL

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

Guideline Strategy and Information Flow

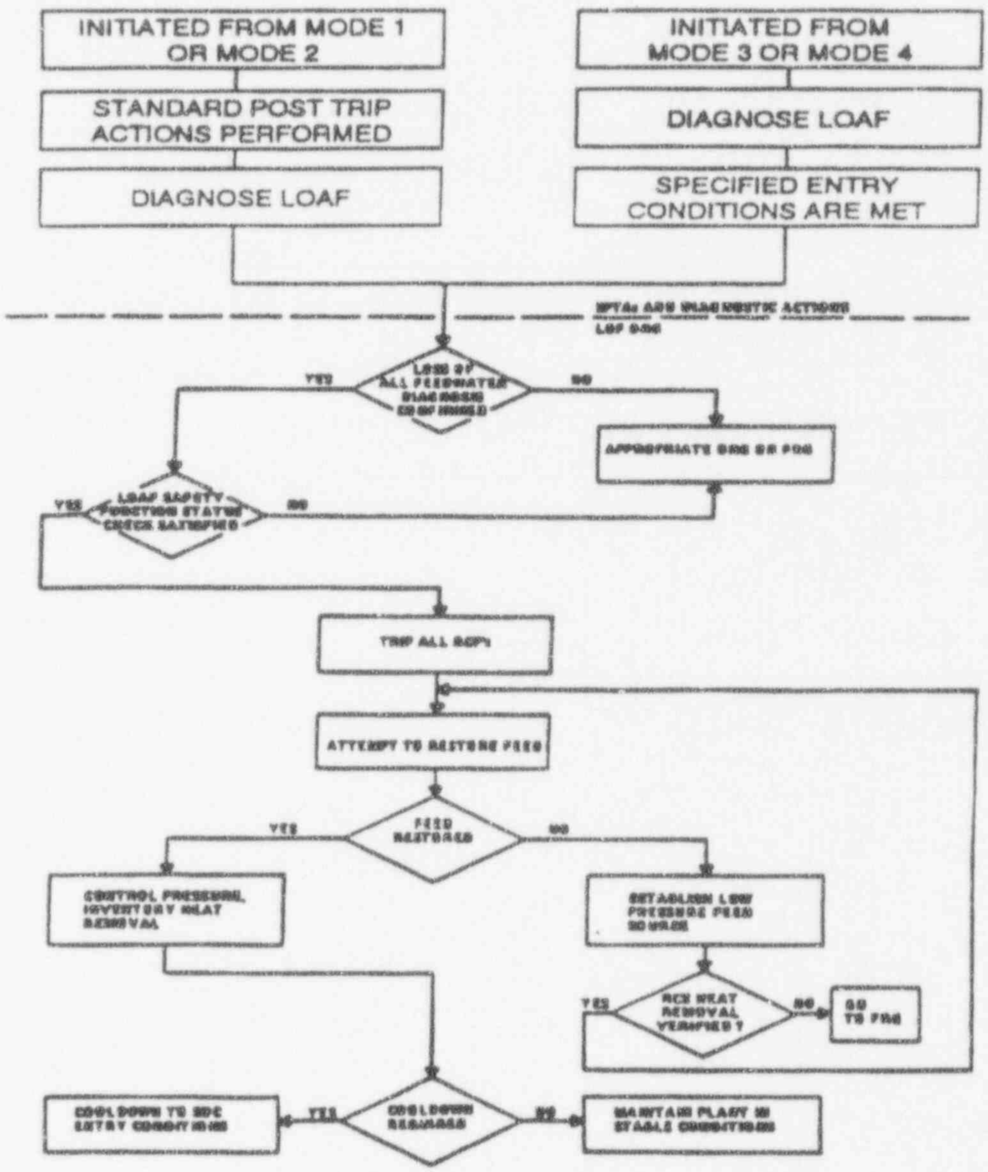
Figure 8-11 has been included to provide the reader with a summary description of the LOAF Recovery Guideline strategy and information flow. If a LOAF is initiated from MODE 1 or MODE 2, the operator performs the Standard Post Trip Actions and diagnoses the event prior to entering the LOAF Recovery Guideline. However, if the event is initiated from MODE 3 or MODE 4, the operator is not directed to the Standard Post Trip Actions since they may not apply. Instead, the operator ensures that the LOAF is properly diagnosed and that the specified entry conditions are met prior to entering the LOAF Recovery Guideline. After tripping all RCPs, guidance is provided to restore a feedwater supply to at least one steam generator.

If main, startup or emergency feedwater cannot be restored, then unnecessary steam discharges are isolated and a low pressure feedwater source is established if possible. If adequate heat removal via the SGs cannot be maintained, the operator is directed to implement the FRG and to establish once-through-cooling. If feedwater is restored to at least one steam generator, then the operator decides whether a cooldown to SCS entry conditions is necessary. Guidance to perform a cooldown is provided in this path.

A more detailed chart (Figure 8-13) illustrates the LOAF Recovery Guideline strategy and lists the guideline steps.

FIGURE 8-11

LOSS OF ALL FEEDWATER



Bases for Operator Actions

The operator actions for a Loss of All Feedwater are directed at placing the plant in a safe, stable condition. Actions are taken to ensure that an adequate heat sink is maintained and radiation releases are minimized.

* 1. The diagnosis of a LOAF event is confirmed by verifying that the Safety Function Status Check acceptance criteria are being satisfied. This action ensures that the proper procedure is being used to mitigate the effects of a LOAF. If another event is diagnosed, then the operator is directed to implement the appropriate Optimal Recovery Guideline. If diagnosis of one event is not possible, then the operator is directed to implement the Functional Recovery Guideline. The Functional Recovery Guideline is based on safety functions and will ensure that all safety functions are addressed regardless of what event(s) is occurring.

2. A Loss of All Feedwater results in a reduction of the ability of the steam generators to remove heat from the RCS. Heat input to the RCS is minimized by tripping all four RCPs. Natural circulation heat removal is adequate to remove the decay heat generated in the core.

3. If a feedwater line break is suspected, then the operator should try to isolate the feedwater line break from the steam generators by any plant-specific methods possible (e.g., closing main feedwater isolation valves, closing main feedwater regulating valves, etc.). A feedwater line break upstream of the check valves at the inlet to the steam generator should automatically be isolated from the steam generator. If a main feedwater line break has not occurred, or the break is isolated from the steam generator, then the operator is directed to continue with the actions of this guideline which address restoration of feedwater and plant control. If the feedwater line break has occurred and cannot be isolated from the steam generator, then it will continue to blowdown until the steam generator boils dry. This results in an uncontrolled cooldown of the RCS. When the operator determines that a feedwater line break is not isolable, the Excess

Steam Demand Event Recovery Guideline should be implemented for all further actions.

* 4. The operator should continue the efforts to restore main, startup and/or emergency feedwater systems operation which were begun in the SPTAs. These efforts may include restoring electrical power, operating valves, starting pumps, or restoring necessary auxiliary systems for feedwater system operation.

* 5. If feedwater flow is not restored to at least one steam generator, the operator is directed to perform steps 6 through 8. These steps are directed at eliminating non-vital steam discharge, establishing a low pressure feedwater source, and/or directing the operator to the FRG as a "last resort" heat removal method.

If feedwater flow is restored to at least one steam generator, the operator is directed to perform steps 9 through 28. These steps are directed at stabilizing the plant and recovering from a Loss of All Feedwater event.

6. The steam generator blowdown system, secondary sampling system, and any other non-vital secondary steam discharges should be isolated. Until feedwater is re-established, the steam generator water inventories must be conserved. Efforts to restore main, startup, and/or emergency feedwater systems to operation should be continued. Such attempts may include restoration of vital auxiliaries like instrument air, electrical power, and/or instrumentation. These actions may also include manual operation of valves or other equipment that is normally operated remotely.

7. If main, startup and/or emergency feedwater cannot be restored to at least one steam generator, then all plant specific sources of feedwater which could be made available to replace steam generator boil-off should be implemented. Examples of alternate low-pressure sources of feedwater are fire pumps, condensate pumps, portable pumps, etc. When developing plant procedures, alternate low-pressure sources of feedwater should be identified and their use

should be indicated in the procedures. Guidelines on steam generator depressurization should be developed for those cases when the operator is relying on low pressure sources of feedwater as a backup feedwater supply. Figure 8-12 provides an example of the type of information that must be developed on a plant specific basis. The figure provides a typical steam generator dump area required to remove heat from the steam generator for various times after shutdown. The required heat removal, compared to the available heat removal capacity (e.g., atmospheric dump valves), provides the technical basis for which guidance may be developed on steam generator depressurization to permit use of alternate low-pressure sources of feedwater.

* 8. For the Loss of All Feedwater event, as long as at least one steam generator has a wide range level greater than [0%], then adequate RCS heat removal is implicitly being maintained. An additional criterion requires the operator to monitor RCS T_c to ensure temperatures are stable or decreasing. This criterion assumes that no operator or plant initiated actions have caused a momentary, correctable reduction in RCS heat removal (e.g., ADV is closed manually). These criterion are based on ensuring that the steam generator is capable of removing heat from the RCS.

Once the steam generator has dried out or no longer is able to remove heat from the RCS, the pressure and temperatures in the RCS will increase until the primary safety valves open. Analyses have shown that once-through-cooling (FRG HR-4) must be initiated by the operator within 30 minutes following the opening of the primary safety valve to ensure that the core remains adequately cooled.

FIGURE 8-12

REQUIRED STEAM DUMP AREA VERSUS STEAM PRESSURE

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

* 9. If feedwater is restored, feedwater flow should be modulated as necessary to restore and maintain SG water level in the normal level band. Modulation of flow should be made using the feedwater regulating control valves for the particular feedwater system in use.

*10. RCS T_{ave} should be controlled by the steam bypass system at less than [567°F]. The goal is to stabilize RCS temperature and remove decay heat. If condenser vacuum is lost, the Steam Bypass System is not available, or if the MSIVs have closed, the atmospheric dump valves must be used to control steam generator pressure. This action is performed to maintain steam generator pressure below the secondary safety valve setpoints, preventing them from opening, and to allow a controlled RCS heat removal process using the steam generators.

*11. The emergency feedwater source is the emergency feedwater tank. If the emergency feedwater system is being used, the inventory in the emergency feedwater tank must be verified to be adequate. This can be determined from Figures 8-3 and 8-4. Alternate sources of emergency feedwater must be investigated. These alternate sources must be identified in plant specific procedures. Examples of alternate sources are non-seismic tanks, fire mains, lake water supplies, potable tanks, etc.

*12. The PLCS is verified to be automatically controlling or restoring pressurizer level in the band [2% to 78%]. If not, the available charging pump and letdown are operated manually to ensure pressurizer level is being maintained. This action verifies that the RCS inventory control safety function is being satisfied.

*13. The operator must ensure that pressurizer heaters and spray are controlling or restoring RCS pressure within the limits of Figure 8-1. If subcooling or cooldown limits of Figure 8-1 are being violated, then the operators should take actions to restore the RCS to within the P-T limits. Depending on the situation, the operator should perform the following actions as appropriate:

a. Stop the cooldown,
b. Operate [main or auxiliary] spray or the Reactor Coolant Gas Vent System as necessary to restore pressurizer pressure to within the P-T limits of Figure 8-3,
c. Attempt to maintain the plant in a stable pressure-temperature configuration. The cooldown may be continued, if desired, within the limits of Figure 8-1,
d. If an overpressure situation exists and is caused by SI and/or charging flow, then throttle or stop SI (refer to step 18) or charging pumps and manually control letdown to restore and maintain pressure within the Post Accident P-T limits of Figure 8-1.

*14. Once the RCPs are tripped, natural circulation RCS flow should develop within [5 - 15 minutes]. Natural circulation flow will be ensured by maintaining RCS pressure and inventory control and using at least one steam generator for RCS heat removal.

When single phase liquid natural circulation flow is established in at least one loop, the RCS should indicate the following conditions:

a. Loop ΔT (T_H - T_c) less than normal full power ΔT,
b. Hot and cold leg temperatures constant or decreasing,
c. RCS is subcooled based on representative CET temperature,
d. No abnormal differences between T_H RTDs and core exit thermocouples.

Hot leg RTD temperature should be consistent with the core exit thermocouples. Adequate natural circulation flow will be reflected by the core exit thermocouples temperatures being approximately equal to the hot leg RTD temperatures. An abnormal difference between T_H and the core exit thermocouples could be any difference greater than [10°F].

Natural circulation is regulated by a combination of factors. Factors which affect natural circulation include decay heat, component elevations, primary to secondary heat transfer, loop flow resistance, and voiding. The component elevations on C-E plants are such that a satisfactory natural circulation decay heat removal is obtained utilizing density differences between the bottom of the core and the top of the steam generator tube sheet. Natural circulation flow is enhanced by the density difference obtained when primary to secondary heat removal through the steam generator U-tubes is utilized.

If the natural circulation criteria of this step are not met, then natural circulation is not effectively transferring heat from the core to the steam generators. If feedwater has been regained or sufficient inventory is available in at least one SG, then ensure RCS pressure and inventory are being controlled properly. Feedwater, however, must be restored to at least one SG in order to continue the natural circulation heat removal process. Both the RCS and Core Heat Removal Safety Functions may be jeopardized if the criteria of this step continue to be violated.

*15. Plant conditions should be carefully assessed before any RCPs are restarted. The need for forced circulation operation should be balanced against the risk of damage to the RCP seals.

The need for operation of the RCPs should be evaluated based on:

1. the adequacy of the RCS and core heat removal under the existing natural circulation conditions,
2. the existing RCS pressure and temperatures,
3. the need for main pressurizer spray capability.

If the existing natural circulation is providing satisfactory RCS and core heat removal, a transfer to forced circulation operation may not be necessary. This would be particularly true if the RCS had already been cooled and depressurized to SCS entry conditions. If the RCS pressure and temperatures are closer to HOT

STANDBY conditions, it may be desirable to restart the RCPs in order to allow a normal forced circulation cooldown. Consideration should also be given to the necessity of having main pressurizer spray capability if auxiliary spray is not providing the desired depressurization rate.

The potential for RCP seal degradation should be evaluated based on:

1. how long CCW to the RCPs was interrupted,
2. RCP seal staging pressures and temperatures.

The possibility of seal degradation increases if the CCW has been interrupted for longer than [10 minutes]. The seal staging pressures provide an indication of degraded seal stages (a low pressure drop across a stage indicates a problem). Restart of an RCP with one or more degraded seal stages should be avoided if possible.

*16. If all RCPs have been stopped, then operation of two RCPs (in opposite loops) should be attempted if feedwater can be restored to at least one SG and RCP restart criteria are met. This will ensure continued forced circulation of coolant through the core and will provide the capability for the normal mode of pressurizer spray. However, only one RCP in each loop should be operated to minimize heat input to the RCS.

Determine whether RCP restart criteria are met by the following:

a. Electrical power available to the RCPs,
b. RCP auxiliaries ([in particular, Component Cooling Water]) to maintain seal cooling, bearing and motor cooling should be operating in order to prevent damage to the pump and/or motor. [Note: Following automatic or operator initiated containment isolation, reinstatement of one of the following means of RCP seal cooling ([CCW], [CVCS seal injection (SI)], [Dedicated Seal Injection System (DSIS)] should be considered to ensure adequate RCP

cooling]. There should be no high temperature alarms on the RCPs to be operated.

c. At least one steam generator has feedwater restored and is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow is available for removing heat from the RCS.

d. Pressurizer level is greater than [33%] and not decreasing. With this pressurizer level, the possibility of draining the pressurizer due to loop shrinkage and/or steam void condensation is minimized and there is a greater likelihood of keeping the pressurizer heaters covered. This will assist in maintaining positive RCS pressure control. The value of [33%] is based on the assumption that a void exists in the RCS equal to one half the reactor vessel upper head volume. [33%] ensures that the minimum pressurizer level, [2%], will exist following this void collapse. The criterion of pressurizer level not decreasing implies that RCS inventory control has been established.

e. RCS is subcooled based on representative CET temperature (Figure 8-1). This condition taken in conjunction with (d) above indicates that inventory and pressure are being controlled.

f. Condensate that flows to the core on the cold side is depleted in boron and may collect in the RCP loop seals and cold leg. The RCPs should not be started until after single phase natural circulation has slowly moved this boron depleted coolant through the core. Twenty minutes of single phase natural circulation is considered adequate circulation and mixing time.

*17. Upon restarting two RCPs in opposite loops, pressurizer level and pressure may decrease due to loop shrinkage and/or void condensation. It is possible that this action will drain the pressurizer. Steam voids, if present in the reactor vessel, will condense upon restarting RCPs. The HJTC RVLMS should be monitored for the trending of reactor vessel liquid level. This trending information may be correlated to pressurizer level decrease. RCP operation with a drained pressurizer may continue provided certain actions are taken and certain criteria are satisfied.

The following constitute the actions to be taken and the criteria to be satisfied when restarting RCPs:

a. Start one RCP in each loop.
b. Ensure proper RCP operation by monitoring RCP amperage and pump NPSH. NPSH is determined by pressurizer pressure and corresponding T_c on Figure 8-1.
c. Operate all available charging pumps and SI pumps until pressurizer level is greater than [14.3%] and (SIS termination criteria of step 18 are met).

*18. If the SI pumps are operating, then they must continue to operate until SI termination criteria are met. Termination of SI should be sequenced by stopping one pump at a time while observing the termination criteria. Throttling of SI flow is also permissible if termination criteria are met. SI termination criteria are:

a. RCS is subcooled based on representative temperature (Refer to Figure 8-1). Establishing a subcooled RCS ensures the fluid surrounding the core is subcooled and provides for reestablishing flow should the subcooled condition deteriorate when SIS flow is secured. Voids may exist in some parts of the RCS (e.g., reactor vessel head), but these are permissible as long as core heat removal is maintained.
b. Pressurizer level is greater than [14.3%] and not decreasing. A pressurizer level greater than [14.3%] and not decreasing, in conjunction with criterion a. above, is an indication that RCS inventory control has been established.
c. At least one steam generator is available for removing heat from the RCS. A steam generator having the ability for feedwater flow and steam flow is available for removing heat from the RCS.
d. The HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles. This provides an extra margin of core coverage and, taken in conjunction with the above, serves as an additional indication that adequate RCS inventory control has been established.

If the criteria are met, then the operator may either stop or throttle the SI pumps. The operator may decide to throttle rather than terminate flow if the SI pumps are to be used to control pressurizer level or plant pressure. A general assessment of the SI pump performance can be made from the control room. The operator should confirm that at least one train and preferably both SI pumps are operating and that system delivery rate is consistent with RCS pressure. Injection flow rates to each reactor vessel nozzle should be approximately equal.

*19 If the criteria of step 18 cannot be maintained after the SI pumps have been stopped, then the SI pumps must be restarted and full SI flow restored.

*20. At this point in the recovery, the operators should decide if a plant cooldown is necessary. If the continued availability of any systems required for maintenance of HOT STANDBY is in doubt, a cooldown will be required before the ability to cooldown is lost. For example, if the available emergency feedwater inventory is marginally adequate (as determined by using Figures 8-3 and 8-4), a cooldown should be commenced immediately in order to avoid running out of emergency feedwater before the shutdown cooldown system can be placed into operation. Similarly, consideration should be given to the availability of compressed air and cooling water systems as well as the continued availability of electrical power. A cooldown may also be required before any necessary repairs can be made.

21. A decision is made whether to maintain the plant in a stable condition or cooldown to shut down cooling entry conditions. If the plant is to be maintained in a stable condition, then this guideline can be exited, and an appropriate, approved procedure implemented. If a plant cooldown is to be performed, then the remaining steps of this guideline (steps 22 through 28) should be implemented.

*22. The RCS should be borated to Technical Specification concentration for the required shutdown margin prior to starting a controlled cooldown. Should letdown not be available, it may not be possible to borate the RCS to a COLD SHUTDOWN RCS boron concentration prior to commencing the cooldown. Boration will be limited to the makeup space available in the pressurizer. If this is the case, the operator should borate the RCS to the minimum shutdown margin (per Technical Specifications) corresponding to T_c. During the cooldown, RCS shrinkage will provide more space in the pressurizer for additional boration. The operator should continuously or periodically borate to maintain the minimum shutdown margin until the COLD SHUTDOWN boron concentration is achieved.

23. An RCS cooldown to shutdown cooling entry conditions is performed, using forced or natural circulation, in accordance with Technical Specifications. One of the following methods should be utilized:

a. The preferred method for cooling the RCS is by discharging steam using the steam bypass system. This method can only be implemented if the condenser is available.
b. If the condenser or steam bypass system is not available, then an RCS cooldown should be performed utilizing the atmospheric dump valves.

24. During a controlled cooldown and depressurization the automatic operation of certain safeguard systems is undesirable. The setpoints of MSIS and SIAS must be manually reset (lowered or bypassed) as the cooldown progresses. This ensures that automatic engineered safeguards actuation remains available until the RCS has been cooled down and depressurized.

*25. If pressurizer pressure reaches [740 psia], the safety injection tanks (SITs) must be vented, drained, or their discharge valves shut to prevent the nitrogen cover gas from being discharged into the RCS when RCS pressure is reduced below the SIT's pressure during a controlled cooldown. The max SIT pressure is [640 psia] and the value of [740 psia] is 100 psi greater than the maximum SIT pressure.

*26. If the pressurizer pressure reaches [445 psia], the isolation valves on the SITs may be closed to prevent unnecessary SIT discharge. [445 psia] is the SIT outlet valve interlock setpoint.

*27. Low temperature overpressure protection (LTOP) is instituted at $T_c \leq$ [259°F] to protect against subjecting the RCS pressure boundary to a low temperature brittle fracture situation.

*28. The cooldown and depressurization should continue until shutdown cooling system entry conditions are established.

a. pressurizer level control should be established and verified by a level greater than [14.3%] and constant or increasing,
b. RCS is subcooled
c. RCS pressure should be at or below the shutdown cooling system entry pressure of [450 psia],
d. RCS hot leg temperature should be at or below the shutdown cooling system entry temperature of [400°F],

When these criteria are established, the LOAF ORG should be exited and SCS operation initiated per [operating instructions].

If the RCS cannot be depressurized to SCS entry pressure then a void should be suspected.

a. The operators should continuously monitor for the presence of voids using any of the following indications, parameter changes, or trends:

i) letdown flow greater than charging flow,
ii) pressurizer level increasing significantly greater than expected while operating pressurizer spray,
iii) the HJTC RVLMS indicates that voiding is present in the reactor vessel,

iv) HJTC unheated thermocouple temperature indicates saturated conditions in the reactor vessel upper head,

b. If voiding hinders RCS depressurization to SCS entry pressure, then an attempt to eliminate voiding should be made. An attempt to eliminate the voids is performed as follows:

i) Letdown is isolated or verified to be isolated to minimize further inventory loss.

ii) The depressurization is stopped to prevent further growth of the void,

iii) The RCS is pressurized and depressurized (within the limits of Figure 8-1), to condense the void. Pressurizing will have the effect of filling the voided portion of the RCS with cooler fluid, which will remove heat from the region. Repeating the process of pressurizing and depressurizing several times will cool and condense the steam void. With a void in the reactor vessel, the pressurization/depressurization cycle will produce a fill and drain effect in the reactor vessel. This cycle may be accomplished using pressurizer heaters and spray (preferred method) or the SIS/charging system (alternative method). The monitoring of pressurizer level and the HJTC RVLMS for trending RCS inventory will assist the operator in assessing the effectiveness of void elimination.

c. If indications of unacceptable RCS voiding continue, and voiding is suspected to exist in the steam generator tubes, then attempts should be made to cool the steam generator and condense the tube bundle void. Steam generator cooling can be accomplished by steaming and/or blowdown in combination with feeding the steam generator. The steam generator cooling will be effective for condensing steam voids but will not have an effect on non-condensible gases trapped in the tube bundle. However, a buildup of non-condensible gases in the tube bundle will not hinder natural circulation, even with a large number of tubes blocked, as only a small amount of heat transfer area is required for the removal of decay heat. The monitoring of pressurizer level for RCS inventory trending will assist the operator in assessing the effectiveness of void elimination.

d. If indications of unacceptable RCS voiding continue, then voiding may be caused by non-condensible gases. Operate the Reactor Coolant Gas Vent System to clear trapped non-condensible gases. The monitoring of pressurizer level and/or the HJTC RVLMS for trending of RCS inventory will assist the operators in assessing the effectiveness of void elimination.

e. The efforts to eliminate voiding should be continued until SCS entry conditions are established or until an appropriate procedure has been approved by the [Plant Technical Support Center or the Plant Operations Review Committee].

SAFETY FUNCTION STATUS CHECK BASES
LOSS OF ALL FEEDWATER

The safety functions and their respective acceptance criteria listed below are those used to confirm the adequacy of the LOAF Guideline in mitigating the event.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
1. Reactivity Control	a. Reactor Power Decreasing and b. Negative Startup Rate and c. Maximum of one CEA NOT fully inserted or borated per Tech. Specs.	For all emergency events, the reactor must be shutdown. Reactor power decreasing, in conjunction with negative startup rate, is a positive indication that reactivity control is established. The criterion that no more than one CEA be stuck out or the RCS borated observes typical Technical Specification requirements.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
2. Maintenance of Vital Auxiliaries (AC and DC Power)	a. All vital Division I [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized, or All vital Division II [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized.	One vital AC division is required to power equipment necessary to maintain control of all other safety functions. One DC division is required as a minimum to provide monitoring and limited control of the other safety functions.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
3. RCS Inventory Control	a. Charging and letdown are maintaining or restoring pressurizer level to [2% to 78%] and b. The RCS is subcooled and c. The HJTC RVLMS indicates the core is covered.	The value of [78%] was chosen as an upper limit for pressurizer level to ensure an operable steam bubble is present in the pressurizer. A value of [2%] was chosen as the lower limit to ensure some measurable level exists in the pressurizer. Subcooling coexisting with a pressurizer level of [2% to 78%] indicates adequate RCS inventory control via a saturated bubble in the pressurizer. Representative CET Temperature is to be used during natural circulation flow conditions and T_H RTDs are to be used during forced circulation flow conditions.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
3. RCS Inventory Control (Continued)		An RVLMS indication that the core is covered, taken in conjunction with subcooling, is an additional indication that RCS inventory control has been established.
4. RCS Pressure Control	Pressurizer heaters and [main or auxiliary] spray are maintaining or restoring pressurizer pressure within the Post Accident P-T limits of Figure 8-1.	For the LOAF event, operation of the pressurizer heaters and sprays should be sufficient to control the RCS pressure within the acceptable region of the Post Accident Pressure-Temperature limits of Figure 8-1.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
5. Core Heat Removal	T_H RTDs and representative Core Exit Thermocouple temperature less than [626°F]	The basis for the temperature limit during the use of Optimal Recovery Guidelines other than LOCA is the indication that the event specific recovery strategy is not effective in core heat removal. For the optimal recovery guidelines other than LOCA, heat is normally removed from the RCS by the steam generators. The value of the T_H RTD and CET temperatures will be governed by steam generator conditions (i.e., pressure and temperature). In general, $T_c \cong T_{SG}$ and CET temperature will be T_c + core ΔT. Normally this core ΔT is expected to be approximately [59°F] during single phase natural circulation conditions. For forced RCS flow conditions $T_{SG} \cong T_c$ $T_H \cong$ CET temperature. The design secondary system pressure is [1200] psia.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
5. Core Heat Removal (Continued)		The corresponding saturation temperature is [567°F]. By adding [59°F] to account for thermocouple inaccuracy and the ΔT between T_c and CET, the value of [626°F] is reached.
6. RCS Heat Removal	A primary safety valve(s) has <u>NOT</u> lifted following steam generator dryout.	The FRG RCS and Core Heat Removal Success Path HR-4 (Once-Through-Cooling) should be implemented following steam generator dryout and after the primary safety valve(s) have opened.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
7. Containment Isolation	a. Containment Pressure < [2.0 psig] and b. No containment area radiation monitors alarming and c. No steam plant activity monitors alarming. and d. No nuclear annex alarms. e. No reactor building radiation alarms.	[2.0 psig] is based on the containment pressure alarm. It is not expected for a LOAF event that containment pressure will increase to the alarm setpoint. During a LOAF radiation should not be detected inside containment. The containment area radiation monitors should not be alarming. Steam plant activity is an indication of a SGTR and is not anticipated for a LOAF. There should be nuclear annex alarms or reactor building radiation alarms during a LOAF.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
8. Containment Temperature and Pressure Control	a. Containment temperature <[110°F] and b. Containment pressure <[2.0 psig].	Containment temperature is not expected to increase to [110°F] for a LOAF event. [2.0 psig] is based on the containment pressure alarm. It is not expected that the pressure will reach this value during a LOAF event.
9. Containment Combustible Gas Control	a. Containment temperature <[110°F] and b. Containment pressure <[2.0 psig].	Maintaining these containment conditions provides an indirect indication that the conditions required for H_2 generation in containment do not exist.

Event Strategy

This section contains the detailed LOAF operator actions strategy flow chart, Figure 8-13. The flow chart pictorially depicts the strategy around which the LOAF guideline is built. It is intended to assist the reader in understanding the intent of the guideline writer and for use in training. Operators should understand the major objectives of the guideline in order to facilitate their progress toward the guideline goals.

The strategy charts show the LOAF Recovery Guideline strategy in detail and list the guideline steps which correspond to each strategy objective. Some steps in the guideline may be performed at any time during the course of an event. Those steps which have an asterisk next to the step number can be performed at any time during the event.

FIGURE 8-13a

STRATEGY CHART FOR LOSS OF ALL FEEDWATER EVENT

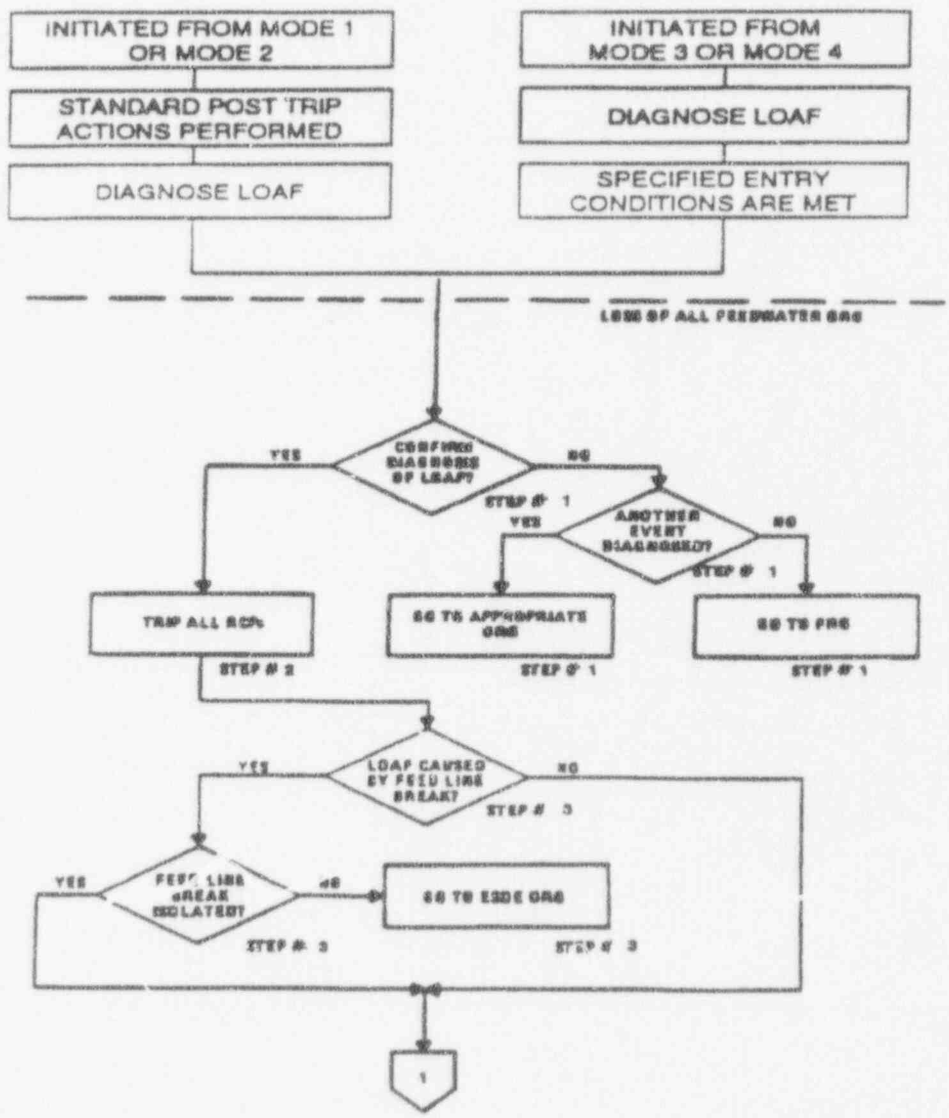


FIGURE 8-13b

STRATEGY CHART FOR LOSS OF ALL FEEDWATER EVENT

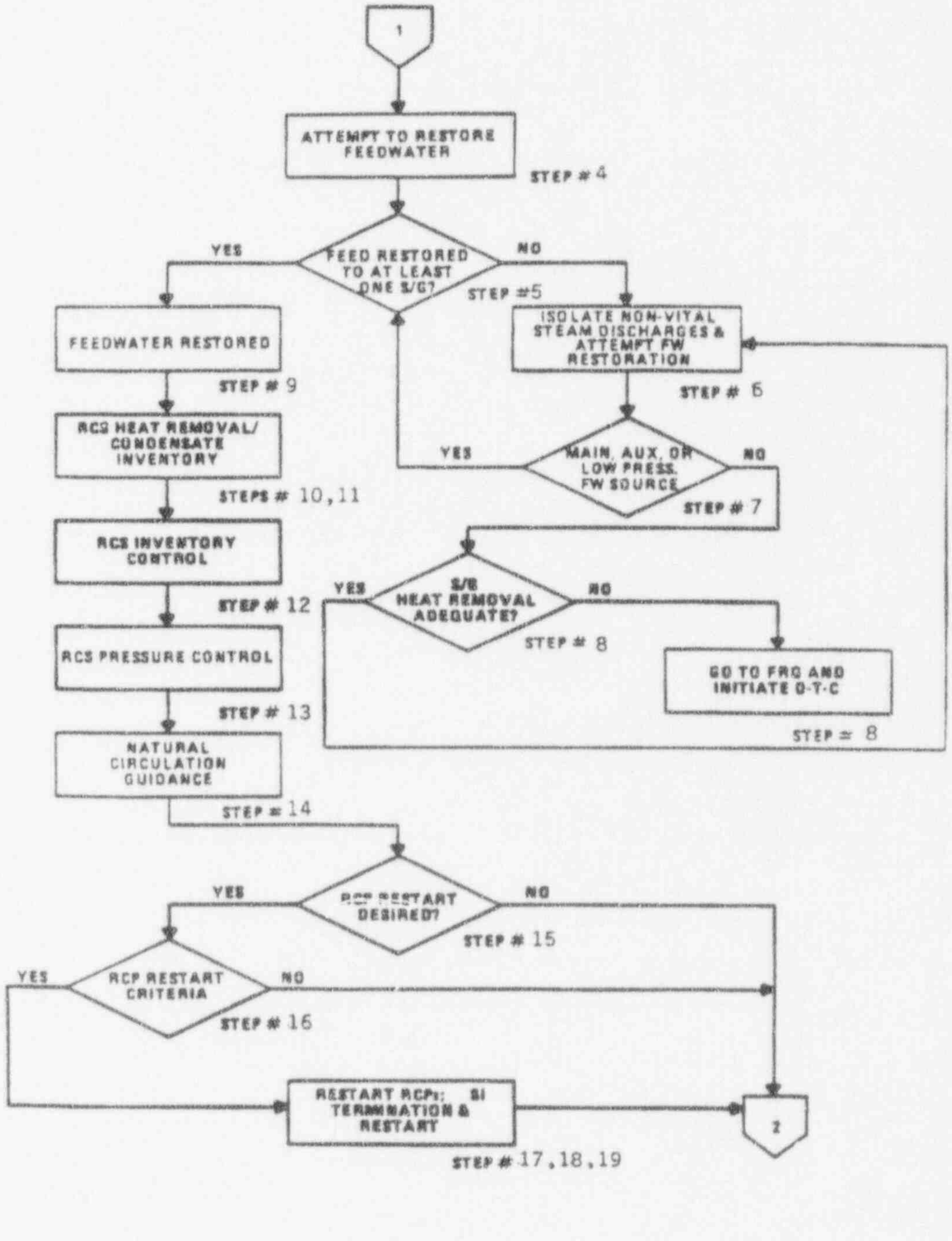
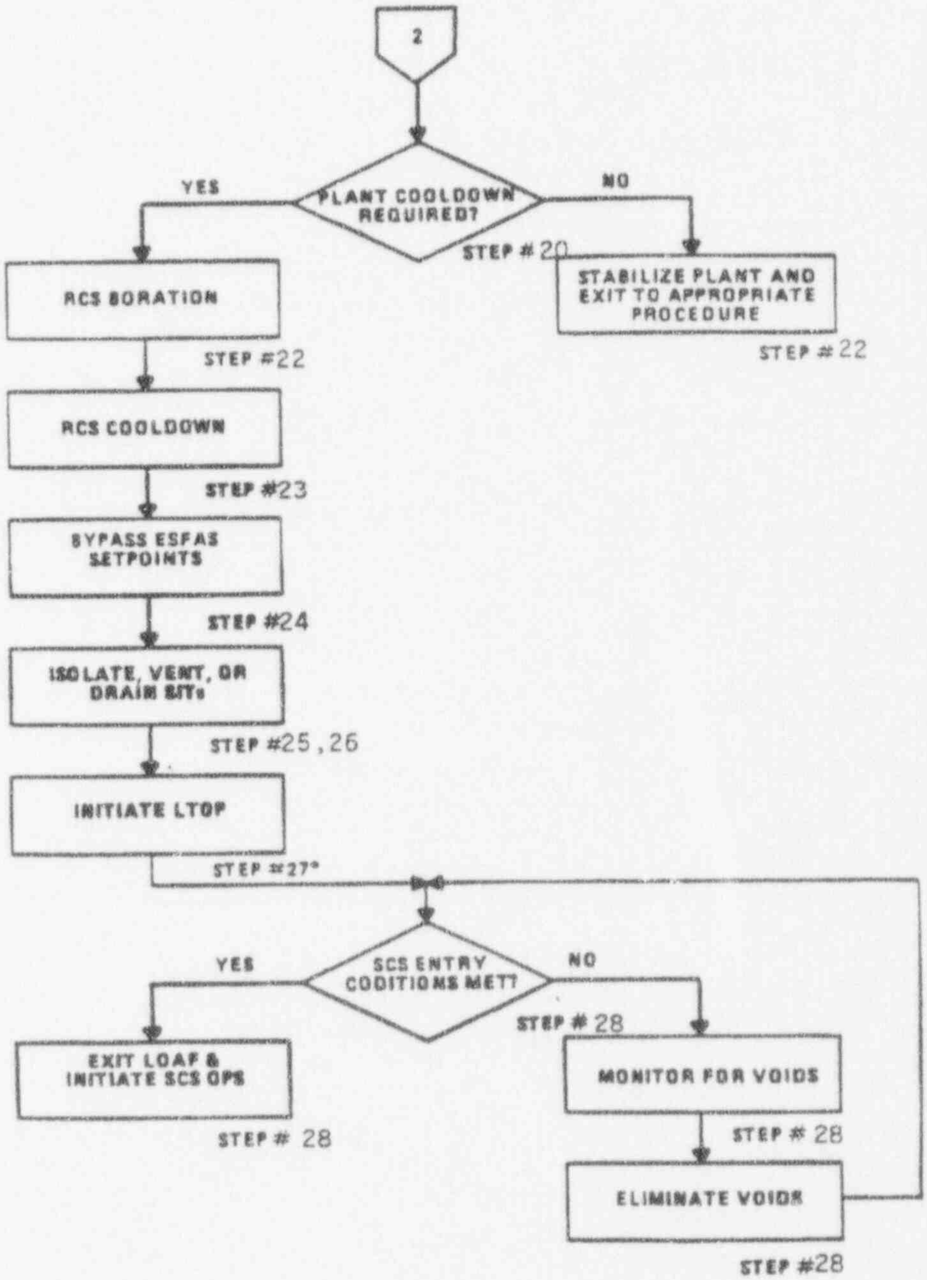


FIGURE 8-13c

STRATEGY CHART FOR LOSS OF ALL FEEDWATER EVENT



LOSS OF OFFSITE POWER RECOVERY

PURPOSE

This guideline provides the operator actions which should be accomplished in the event of a Loss of Offsite Power (LOOP). LOOP is defined as Loss of Preferred Switchyard I and Loss of Preferred Switchyard II and the Main Turbine Generator fails to "runback" and maintain the hotel loads or is not on-line. Included are the actions required to mitigate the loss of forced circulation. The actions in this guideline are necessary to ensure that the plant is placed in a stable, safe condition. The goal of this guideline is to safely establish plant conditions allowing implementation of a normal operating procedure for COLD SHUTDOWN, HOT STANDBY, or HOT SHUTDOWN. This guideline is designed to meet this objective while minimizing any radiological release to the environment and maintaining adequate core cooling. This guideline provides technical information to be used by the utilities in developing a plant specific procedure.

ENTRY CONDITIONS

1. The Standard Post Trip Actions have been performed

or

All of the following conditions exist:

a. Event initiated from MODE 3 or MODE 4
b. SIAS has NOT been blocked
c. LTOP has NOT been initiated

2.a. Plant conditions indicate that a Loss of Offsite Power has occurred. Any one or more of the following may be present:

i) Transformer alarms
ii) Breaker alarms
iii) Diesel generators automatically starting
iv) RCP trouble alarms
v) Condenser vacuum alarms
vi) Low RCS flow indications
vii) Alternate AC Source automatically starting

or

b. A station blackout event has occurred, and at least one safety division [4.16 kV] AC bus has been restored.

<u>or</u>

c. Single phase natural circulation is to be utilized for RCS heat removal although at least one [13.8 kV] bus is energized.

<u>EXIT CONDITIONS</u>

1. The diagnosis of a Loss of Offsite Power is not confirmed

<u>or</u>

2. The diagnosis indicates that in addition to the Loss of Offsite Power, a break in the primary or secondary system, or a loss of all feedwater has occurred

<u>or</u>

3. No Safety Division [4.16 kV] energized.

<u>or</u>

4. No Safety Division [125 V] DC energized.

<u>or</u>

5. Any of the Loss of Offsite Power Safety Function Status Check acceptance criteria are not satisfied

<u>or</u>

6. The Loss of Offsite Power guideline has accomplished its purpose by satisfying <u>ALL</u> of the following:
   a. at least one non-Safety Division [4.16 kV] is energized
   b. all Safety Function Status Check acceptance criteria are being satisfied.
   c. RCS conditions are being controlled and maintained in HOT STANDBY, HOT SHUTDOWN, or COLD SHUTDOWN.
   d. an appropriate procedure, which has been approved by the Plant Technical Support Center or the Plant Operations Review Committee, can be implemented.

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. Confirm diagnosis of Loss of Offsite Power (LOOP) and verify Safety Function Status Check acceptance criteria are satisfied.	1.a. If no Safety Division [4.16 kV] AC buses are energized then Verify at least one permanent non-safety bus is energized from the AAC and attempt to energize one vital AC division from the permanent non-safety bus. b. If no Safety Division [4.16 kV] AC division and no non-Safety Division [13.8/4.16 kV] AC buses are energized then Rediagnose event and exit to either appropriate Optimal Recovery Guideline or to Functional Recovery Guideline.
2. Verify Safety Division [4.16 kV] AC powered components are available by the following: a. at least one Safety Division [4.16 kV] AC has been energized and b. Safety Division loads have been properly sequenced onto their respective Safety Division [4.16 kV] AC buses.	2. If safety division loads have not been sequenced into their respective safety division AC buses, Then manually load the safety division AC buses per [plant specific operating procedures].

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
3. Ensure at least one safety Division of [125 VDC] is energized, including both the channelized and the Division load center and At least one safety Division [120 VAC] is energized, including both the channelized and the Division load center.	3. Exit this guideline and implement the Functional Recovery Guideline.
4. Ensure that all appropriate breakers on the de-energized buses [4.16kV and 13.8kV] are open [thee appropriate plant specific breaker list would be placed here when the plant specific EOPs are written].	4. Open appropriate breakers.
5. Verify RCP seal cooling.	5. If RCP seal cooling has been lost Then restore RCP seal cooling by the following: a. RCP controlled bleedoff is unisolated, b. the non-critical CCW loop is unisolated, c. establish RCP seal cooling through one of the following means ([CCW], [CVCS seal injection (SI)], [Dedicated Seal Injection System (DSIS)].

INSTRUCTIONS	CONTINGENCY ACTIONS
* 6. Ensure at least one steam generator has the following: a. level being restored or maintained in the normal band, and b. startup, main or emergency feedwater flow capability, and c. pressure control by one of the following (listed in preferred order): i) Steam Bypass System ii) atmospheric dump valves iii) main steam safety valves	6.
* 7. Ensure RCS inventory control is being maintained by the following: a. the pressurizer level control system is maintaining or restoring pressurizer level [2% to 78%] and b. RCS is subcooled based on representative CET temperature (Figure 9-1), and c. the HJTC RVLMS indicates level above the top of hot leg.	7.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
* 8. Ensure the pressurizer heaters and spray are maintaining or restoring pressurizer pressure within the limits of (Figure 9-1).	8. If RCS subcooling greater than P-T limits or cooldown rate greater than [100°F/hr], Then do the following as appropriate: a. stop the cooldown, b. depressurize the plant using Reactor Coolant Gas Vent System or auxiliary spray to restore and maintain pressurizer pressure within the Post Accident P-T limits of (Figure 9-1), c. attempt to maintain the plant in a stable pressure-temperature configuration or continue to cooldown within the limits of (Figure 9-1), d. If overpressurization due to SI/charging flow, Then throttle or secure flow (refer to step 16) and manually control letdown to restore and maintain pressurizer pressure within the limits of (Figure 9-1).

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS
* 9. Attempt to restore offsite AC power.	9.	
*10. When offsite power is available, Then restore AC power to plant distribution and station loads per plant specific operating instructions.	10.	Continue efforts to restore offsite power.
*11. If offsite power has NOT been restored, Then attempt to reenergize the permanent non-safety AC buses from the alternate AC source.	11.	
*12. If offsite power is NOT available and the alternate AC has been restored, Then restore loads to the permanent non-safety bus per plant specific operating instructions.	12.	Continue efforts to restore offsite power or the alternate AC.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*13. Evaluate the need and desirability of restarting RCPs. Consider the following: a. adequacy of RCS and core heat removal using natural circulation, b. existing RCS pressure and temperature, c. the need for main pressurizer spray capability, d. the duration of CCW interruption to RCPs, e. RCP seal staging pressures and temperatures.	13. If RCP operation is NOT desired, Then go to step 16.
*14. Determine whether RCP restart criteria are met by ALL of the following: a. electrical power is available to the RCP bus, b. RCP auxiliaries are operating to maintain seal cooling, bearing cooling, and motor cooling, and there are no high temperature alarms on the selected RCPs, c. at least one steam generator is available for removing heat from the RCS (ability for feed and steam flow),	14. If RCP restart criteria NOT met, Then go to step 16.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*14. (Continued) d. pressurizer level is greater than [33%] and not decreasing, e. RCS is subcooled based on representative CET temperature (Figure 9-1), f. other criteria satisfied per plant specific RCP operating instructions.	
*15. <u>If</u> RCP restart desired and restart criteria satisfied, <u>Then</u> do the following: a. start one RCP in each loop, b. ensure proper RCP operation by monitoring RCP amperage and NPSH, c. operate charging (and SI) until pressurizer level greater than [14.3%] (and SI termination criteria met. Refer to step 16).	15. <u>If</u> RCP will <u>NOT</u> be restarted, <u>Then</u> go to step 16.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*16. If SI pumps are operating, Then they may be throttled or stopped, one pump at a time, if ALL of the following are satisfied: a. RCS is subcooled based on representative CET temperature (Figure 9-1) b. pressurizer level is greater than [14.3%] and not decreasing, c. at least one steam generator is available for removing heat from the RCS (ability for feed and steam flow) d. the HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles.	16.
*17. If criteria of step 16 cannot be maintained after SI pumps throttled or stopped, Then SI pumps must be restarted.	17.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*18. If no RCPs are operating, Then verify natural circulation flow in at least one loop by ALL of the following: a. loop ΔT (T_H - Tc) less than normal full power ΔT, b. hot and cold leg temperatures constant or decreasing, c. RCS is subcooled based on representative CET temperature (Figure 9-1), d. no abnormal difference greater than [10°F] between T_H RTDs and representative CET temperature.	18. Ensure proper control of steam generator feeding and steaming (refer to step 6) and RCS inventory and pressure control (refer to steps 7 and 8).
*19. Evaluate the need for a plant cooldown based on: a. plant status, b. auxiliary systems availability, c. emergency feedwater inventory (refer to Figures 9-3 and 9-4). d. expected time to recover offsite power.	19.

* Step Performed Continuously

INSTRUCTIONS

20. If a plant cooldown is desired, Then continue with the actions of this guideline.

*21.a. Borate the RCS to maintain shutdown margin in accordance with Technical Specifications.

and

b. Prevent boron dilution by pressurizer outsurge by the following (listed in preferred order):

i) borate to raise the entire RCS (including the mass in the pressurizer) to COLD SHUTDOWN conditions.

or

ii) use main or auxiliary spray to increase and maintain pressurizer boron concentration within 50 ppm of RCS boron concentration.

CONTINGENCY ACTIONS

20.a. Maintain the plant in a stabilized condition,

and

b. Exit to appropriate procedure as directed by [Plant Technical Support Center or the Plant Operations Review Committee].

21.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
22. Perform a controlled cooldown in accordance with Technical Specifications. Reduce RCS temperatures utilizing: a. main, startup or emergency feedwater, and b. steam generator steaming via (listed in preferred order): i) Steam Bypass System ii) atmospheric dump valves.	22.
*23. Ensure pressurizer pressure is being maintained within the limits of Figure 9-1 during cooldown	23. If RCS subcooling greater than P-T limits or cooldown rate greater than [100°F/hr], Then do the following as appropriate: a. stop the cooldown b. depressurize the plant using Reactor Coolant Gas Vent System or main or auxiliary spray to restore and maintain pressurizer pressure within the Post Accident P-T limits of Figure 9-1.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
	23. (Continued) c. attempt to maintain the plant in a stable pressure-temperature configuration or continue to cooldown within the limits of Figure 9-1. d. If overpressurization due to SI/charging flow, Then throttle or secure flow (refer to step 16) and manually control letdown to restore and maintain pressurizer pressure within the limits of Figure 9-1.
*24. Maintain pressurizer level [2% to 78%] during cooldown by operation of: a. charging and letdown, or b. SI pumps	24.
25. Ensure the available emergency feedwater inventory is adequate per Figures 9-3 and 9-4.	25.

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS	
26.	Bypass or lower the automatic initiation setpoints of MSIS and SIAS as the cooldown and depressurization proceed.	26.	
27.	When PZR pressure reaches [740 psia], Then reduce SIT pressure to [300 psia].	27.	
*28.	When pressurizer pressure reaches [445 psia], Then isolate, vent or drain the safety injection tanks (SITs).	28.	
*29.	Initiate low temperature overpressurization protection (LTOP) at $T_c \leq$ [259°F].	29.	
*30.	When the following SCS entry conditions are established: a. pressurizer level >[14.3%] and constant or increasing, b. RCS is subcooled, c. RCS pressure $\leq$ [450 psia],	30.	If the RCS fails to depressurize, Then a void should be suspected. a. Voiding in the RCS may be indicated by any of the following indications, parameter changes, or trends: i) letdown flow greater than charging flow, ii) pressurizer level increasing significantly more than expected while operating pressurizer spray,

INSTRUCTIONS

*30. (Continued)

d. RCS $T_H \leq$ [400°F], Then exit this guideline and initiate SCS operation per plant specific operating instructions.

Then exit this guideline and initiate SCS operation per plant specific operating instructions.

CONTINGENCY ACTIONS

30. (Continued)

iii) the HJTC RVLMS indicates that voiding is present in the reactor vessel.

iv) HJTC unheated thermocouple temperature indicates saturated conditions in the reactor vessel upper head.

b. If voiding inhibits RCS depressurization to SCS entry pressure, Then attempt to eliminate the voiding by:

i) verify letdown is isolated,

and

ii) stop the depressurization,

and

iii) pressurize and depressurize the RCS within the limits of Figure 9-1 by operating pressurizer heaters and spray or SI and charging. Monitor pressurizer level and the HJTC RVLMS for trending of RCS inventory.

* Step Performed Continuously

INSTRUCTIONS

CONTINGENCY ACTIONS

30. (Continued)

c. If depressurization of the RCS to the SCS entry pressure is still not possible, and voiding is suspected to exist in the steam generator tubes, Then attempt to eliminate the voiding by:

i) cool the suspected steam generator (by steaming and/or blowdown, and feeding) to condense the steam generator tube void,

and

ii) monitor pressurizer level for trending RCS inventory.

d. If depressurization of the RCS to the SCS entry pressure is still not possible, Then attempt to eliminate the voiding by:

i) operate the Reactor Coolant Gas Vent System to clear trapped non-condensible gases,

and

ii) monitor pressurizer level and/or the HJTC RVLMS for trending of RCS inventory.

* Step Performed Continuously

30. (Continued)

e. Continue attempts to establish SCS entry conditions, or exit this guideline and initiate an appropriate procedure as directed by [Plant Technical Support Center or the Plant Operations Review Committee].

The Loss of Offsite Power Recovery Guideline has accomplished it purpose if RCS conditions are being controlled in HOT STANDBY, HOT SHUTDOWN, or COLD SHUTDOWN, all of the SFSC acceptance criteria are being satisfied, and the entry conditions of an appropriate procedure are satisfied.

END

SUPPLEMENTARY INFORMATION

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Natural circulation flow cannot be verified until the RCPs have stopped coasting down after being tripped.

2. During natural circulation, verification of an RCS temperature response to a plant change cannot be accomplished until approximately 5 to 15 minutes following the action due to increased loop cycle times.

3. If possible, interruption of the component cooling water to the reactor coolant pump seals should not exceed [10 minutes]. Extended loss of CCW flow may make inspection of the seals necessary.

4. After the required shutdown boron concentration is attained in the RCS, makeup water added to the RCS during the cooldown should be at least equal to the RCS boron concentration to prevent any dilution of RCS boron concentration.

5. Once the pressurizer cooldown has begun, pressurizer level indication decalibration will occur. The indication on the normal pressurizer level indication will begin to deviate from the true pressurizer level. The operator should use correction curves to find the true pressurizer water level. A cold calibrated pressurizer level indication is also available for lower pressurizer temperatures.

6. Minimize the number of cycles of pressurizer auxiliary spray whenever the temperature differential between the spray water and the pressurizer is greater than [200°F] in order to minimize the increase in the spray nozzle thermal stress accumulation factor.

7. If cooling down by natural circulation with an isolated steam generator, an inverted ΔT (i.e., T_c higher than T_H) might be observed in the idle loop. This is due to a small amount of reverse heat transfer in the isolated steam generator and will have no affect on natural circulation flow in the intact steam generator.

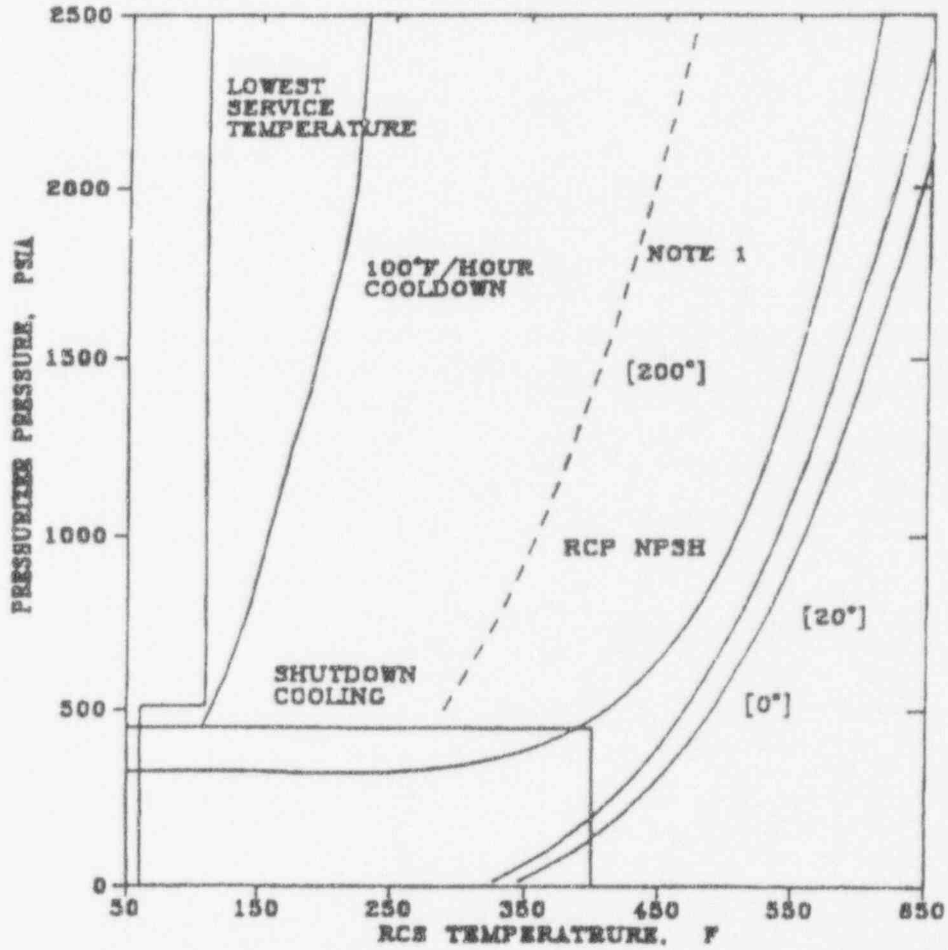
8. All available indications should be used to aid in evaluating plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings should be corroborated when one or more confirmatory indications are available.

9. When a void exists in the reactor vessel and RCPs are not operating, the HJTC RVLMS provides an accurate indication of reactor vessel liquid inventory. When a void exists in the reactor vessel and RCPs are operating, it is not possible to obtain an accurate reactor vessel liquid level indication due to the effect of the RCP induced pressure head on the HJTC RVLMS. Information concerning reactor vessel liquid inventory trending may still be discerned. The operator is cautioned not to rely solely on the HJTC RVLMS indication when RCPs are operating.

10. The operator should continuously monitor for the presence of RCS voiding and take steps to eliminate voiding any time voiding causes heat removal or inventory control safety functions to begin to be threatened. Void elimination should be started soon enough to ensure heat removal and inventory control are not lost.

FIGURE 9-1

TYPICAL POST ACCIDENT PRESSURE TEMPERATURE LIMITS

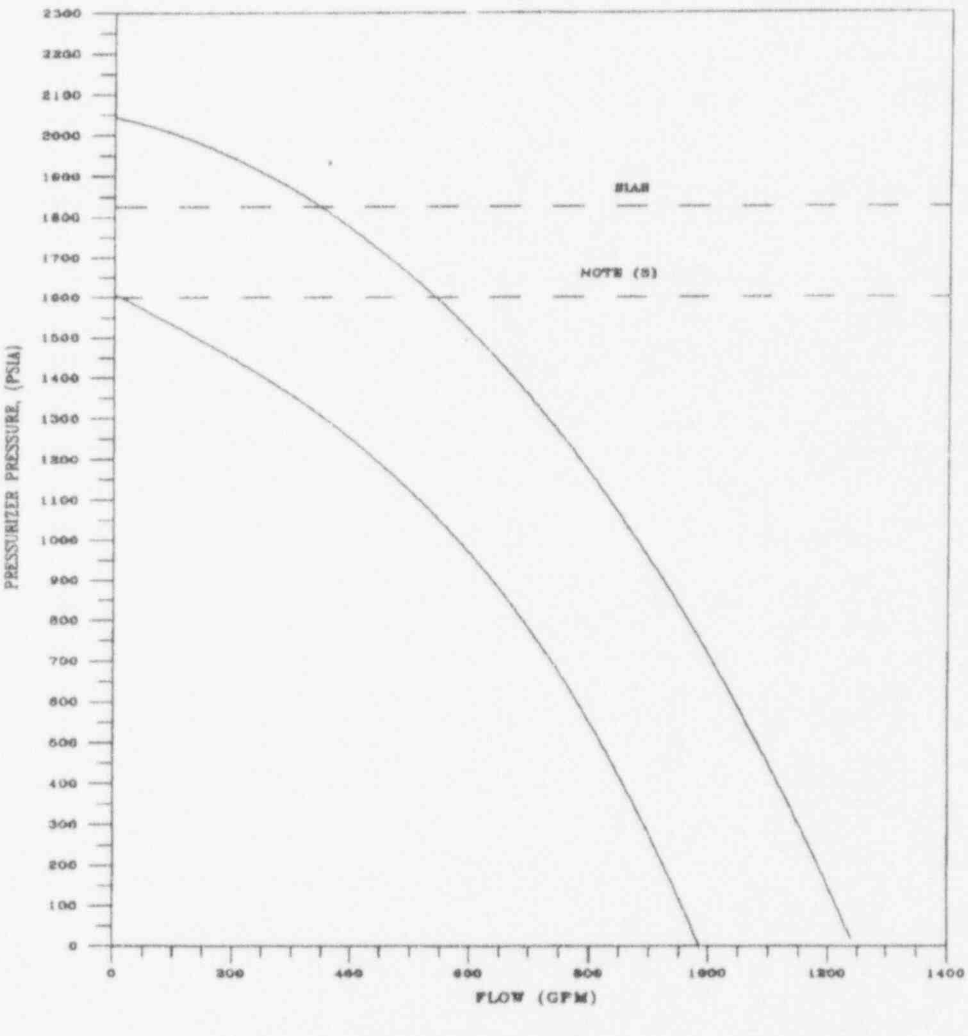


NOTES: (1) THIS CURVE SUPERSEDES THE 100° F/HR COOLDOWN CURVE ANYTIME THE RCS HAS EXPERIENCED AN UNCONTROLLED COOLDOWN WHICH CAUSES RCS TEMPERATURE TO GO BELOW 500° F. THIS CURVE IS AN OPERATIONAL LIMIT BASED ON ENGINEERING JUDGEMENT AND INTENDED TO MINIMIZE THE POTENTIAL OF A PRESSURIZED THERMAL SHOCK.

(2) THESE CURVES MUST BE ADJUSTED FOR INSTRUMENT INACCURACIES.

FIGURE 9-2

TYPICAL ACCEPTABLE SIS FLOW VS RCS PRESSURE



NOTES: (1) SEE IMPLEMENTATION SECTION FOR DEVELOPMENT OF PLANT SPECIFIC CURVE.
(2) FOR HOT LEG AND DVI INJECTION, FULL FLOW FROM SIS PUMPS 1 AND 3 IS DIRECTED TO THE HOT LEGS.
(3) BELOW THE SIAS SETPOINT, THE SIS PUMPS WILL BE OPERATING, BUT THERE WILL BE NO INJECTION FLOW UNTIL SYSTEM PRESSURE FALLS BELOW THE SHUTOFF HEAD OF THE SIS PUMPS.
(4) THESE CURVES DO NOT ACCOUNT FOR INSTRUMENTATION INACCURACIES

FIGURE 9-3

TYPICAL FEEDWATER CAPACITY VS. TIME REMAINING UNTIL SHUTDOWN COOLING REQUIRED

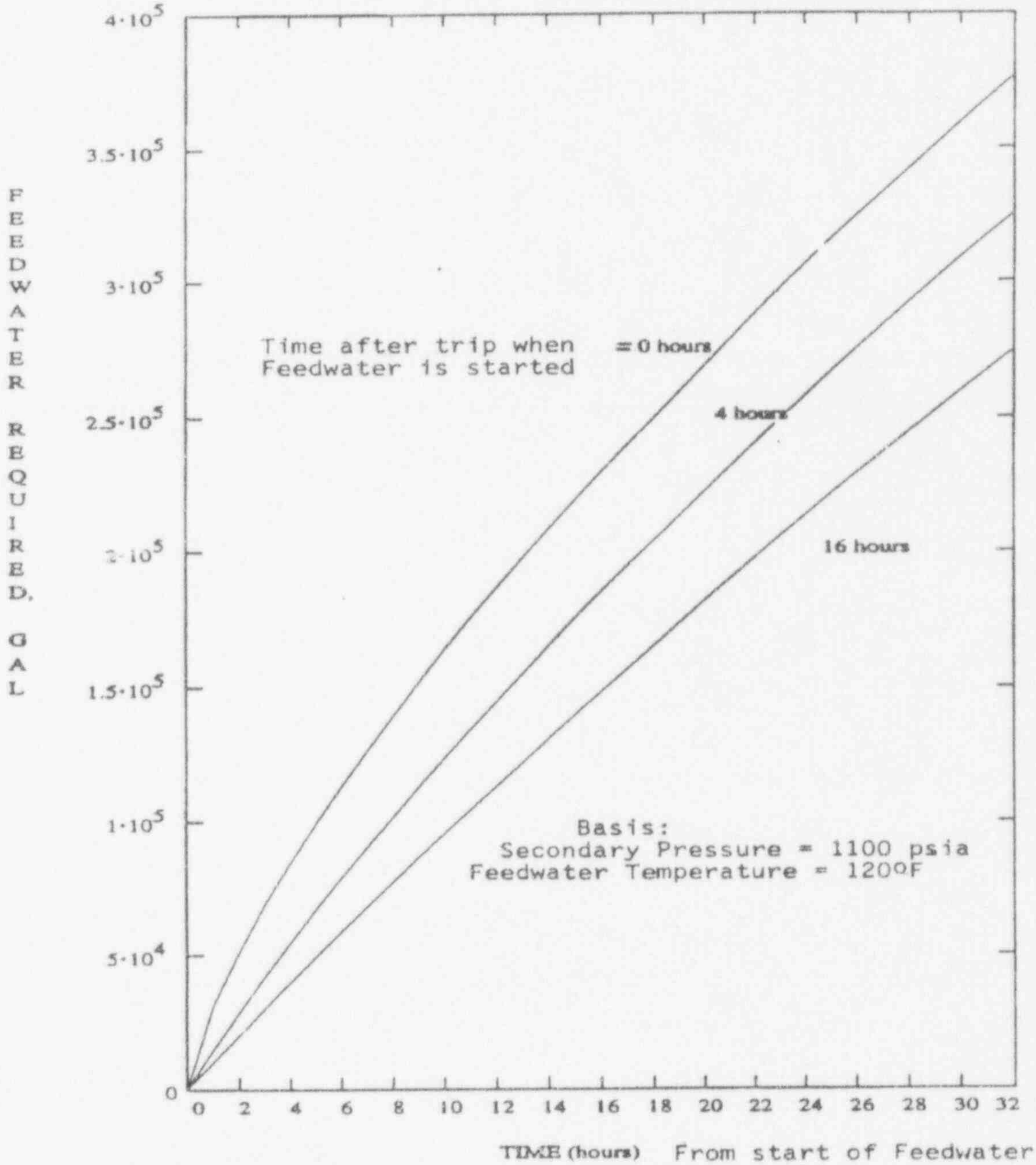
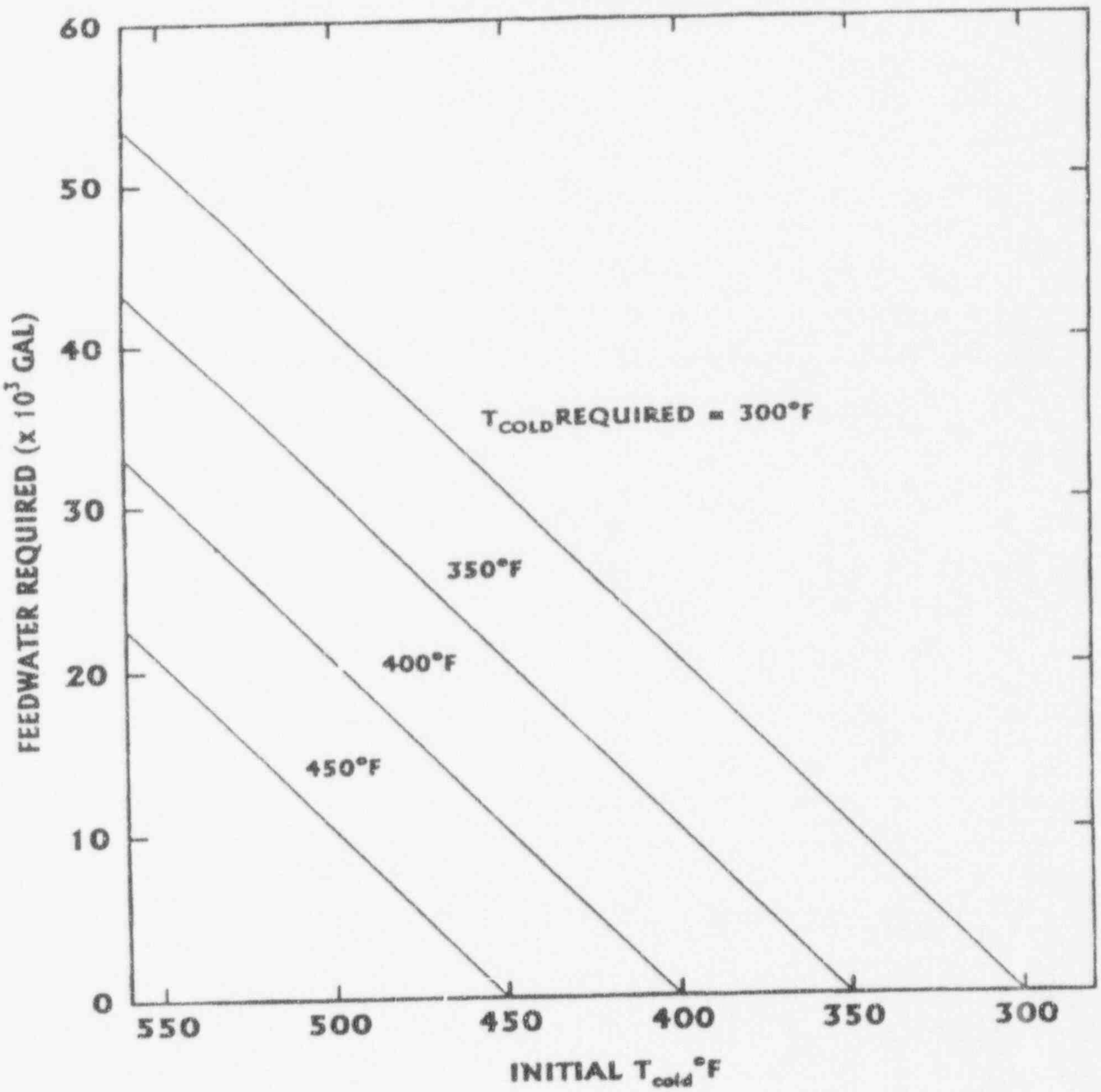


FIGURE 9-4

TYPICAL FEEDWATER REQUIRED FOR SENSIBLE HEAT REMOVAL

T_{COLD} (REQUIRED) VS. T_{COLD} (INITIAL)



SAFETY FUNCTION STATUS CHECK

SAFETY FUNCTION	ACCEPTANCE CRITERIA
1. Reactivity Control	1. a. Reactor power decreasing and b. Negative Startup Rate and c. Maximum one CEA NOT fully inserted or RCS borated per Technical Specifications.
2. Maintenance of Vital Auxiliaries (AC and DC power)	2. All vital Division I [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized, or All vital Division II [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized.
3. RCS Inventory Control	3. a. Charging and letdown are maintaining or restoring pressurizer level [2% to 78%] and b. RCS is subcooled based on representative CET temperature and c. The HJTC RVLMS indicates the core is covered.

SAFETY FUNCTION	ACCEPTANCE CRITERIA
4. RCS Pressure Control	4. Pressurizer heaters and main or auxiliary spray are maintaining or restoring pressurizer pressure within the limits of Figure 9-1.
5. Core Heat Removal	5. a. RCS is subcooled based on representative CET temperature. and b. The RCS loop ΔT in the operating steam generator is: i) less than the full power ΔT (if all RCPs are off) or ii) less than [3°F] (if any RCPs are running)
6. RCS Heat Removal	6. a. At least one steam generator has level within normal level band with feedwater available to maintain level or b. At least one steam generator has level being restored to the normal band by feedwater flow with level increasing or c. Total feedwater flow to either or both steam generators greater than [500 gpm]

SAFETY FUNCTION	ACCEPTANCE CRITERIA
7. Containment Isolation	7. a. Containment pressure less than [2.0 psig] and b. No containment area radiation monitors alarming and c. No process radiation alarms and d. No steam plant activity monitors alarming. and e. No nuclear annex radiation alarms and f. No Reactor Building radiation alarms.
8. Containment Temperature & Pressure Control	8. a. Containment temperature less than [110°F] and b. Containment pressure less than [2.0 psig].
9. Containment Combustible Gas Control	9. a. Containment temperature less than [110°F] and b. Containment pressure less than [2.0 psig].

BASES

The bases section of the Loss of Offsite Power (LOOP) Recovery Guideline describes the LOOP transient in relation to the actions which the operator takes during a LOOP. The purpose of the bases section is to provide the operators with information which will enable them to understand the reasons for, and the consequences of, the actions they take during a LOOP.

Characterization of a Loss of Offsite Power

There are many possible causes of a loss of non-Safety [13.8 kV] AC power. Some examples include: regional grid network failures, AC power distribution system failures, weather related damage, and other natural phenomena. This guideline is designed to provide guidance for a loss of offsite AC power (LOOP). A partial loss of AC (for instance, loss of one RCP bus) is covered by the Reactor Trip ORG. A total loss of AC (Safety as well as non-Safety buses) is covered by the Station Blackout ORG.

A loss of AC power is characterized by a loss of all electrical components with the exception of instrumentation, emergency DC lighting, control power for electrical breakers, DC powered solenoids for valve actuators, and turbine generator emergency lube oil pumps. A reactor and turbine trip will occur, and the diesel generators will start and energize the ESF buses.

As a result of the loss of non-Safety [13.8 kV] AC power, electrical power will be interrupted to the CEDM's, reactor coolant pumps, [main feedwater pumps], main condensate pumps, main circulating water pumps, pressurizer pressure and level control systems, feedwater control system, the steam bypass control system, and plant air compressors. Under such circumstances, the plant will experience a simultaneous reactor trip, loss of load, [loss of main feedwater flow], and loss of forced reactor coolant flow followed immediately by a turbine and generator trip. Once the diesel generators start, power will be restored or made available to many components.

RCP forced circulation and heat transfer from primary to secondary via the steam generators is the preferred method of residual heat removal whenever plant temperature and pressure are above the shutdown cooling system entry conditions. If the RCPs are unavailable, the natural circulation capability of all C-E plants provides a backup means for core cooling using the steam generators.

Safety Functions Affected

While no safety functions are directly challenged by a Loss of Offsite Power, all safety functions must be maintained while establishing and maintaining natural circulation RCS flow in HOT STANDBY conditions or during a natural circulation plant cooldown. Particularly important are reactivity control, RCS pressure control, RCS inventory control, core heat removal, and RCS heat removal. Failure to maintain any one of these safety functions could lead to an interruption of adequate natural circulation flow or core cooling. Once the maintenance of these safety functions is ensured, the operators should attempt to restore a source of non-vital AC power.

Trending of Key Parameters

The following discussion assumes that the turbine trips due to LOOP.

Reactor Power (Figure 9-5)

The loss of AC power de-energizes the CEDMs, tripping the reactor. The reactor trip causes power to decrease.

RCS Temperature (Figure 9-6)

The loss of the steam generator heat rejection capability on a turbine trip leads to a rapid increase in RCS temperature. The initial rapid increase is terminated by the opening of the main steam safety valves (MSSVs) and the insertion of the control rods. Subsequent RCS temperature responses will be influenced by heat removal via the steam generators.

Pressurizer Pressure (Figure 9-7)

Pressurizer pressure will rapidly increase, then decrease due to the changes in RCS temperature.

Pressurizer Level (Figure 9-8)

Pressurizer level will increase, then decrease following the reactor trip. This is due to RCS inventory swell and shrink response to the RCS temperature swings and the concurrent pressurizer insurge and outsurge.

Reactor Vessel Level

No reactor vessel voiding is expected to occur during a loss of offsite power event if HOT STANDBY conditions are maintained. Reactor vessel voiding may occur during a natural circulation plant cooldown, but would only be a concern if the voiding inhibited the plant depressurization.

Steam Generator Pressure (Figure 9-9)

Once the turbine control valves shut following the turbine trip, steam generator pressure increases rapidly. With the turbine control valves shut, steam demand by the turbine ceases. Pressure will continue to increase until the steam generator pressures increase to the main steam safety valve setpoint. Subsequently, the operators control the steam generator pressures by controlling the atmospheric dump valves.

Steam Generator Level (Figure 9-10)

Steam generator level will begin to decrease rapidly because of the shrinkage which occurs after the closure of the turbine stop valves following the turbine trip. If a LOOP has occurred the emergency feedwater system will then be used to maintain or restore the steam generator levels otherwise, the main feedwater system will ramp down to [5%] flow to refill the steam generators.

FIGURE 9-5
REPRESENTATIVE LOSS OF OFFSITE POWER
REACTOR POWER

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 9-6
REPRESENTATIVE LOSS OF OFFSITE POWER
LOOP RCS NARROW RANGE TEMPERATURES

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 9-7
REPRESENTATIVE LOSS OF OFFSITE POWER
PZR NARROW RANGE PRESSURE

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 9-8

REPRESENTATIVE LOSS OF OFFSITE POWER

PZR LEVEL

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 9-9

REPRESENTATIVE LOSS OF OFFSITE POWER

STEAM GENERATOR PRESSURE

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 9-10

REPRESENTATIVE LOSS OF OFFSITE POWER

STEAM GENERATOR WIDE RANGE LEVEL

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

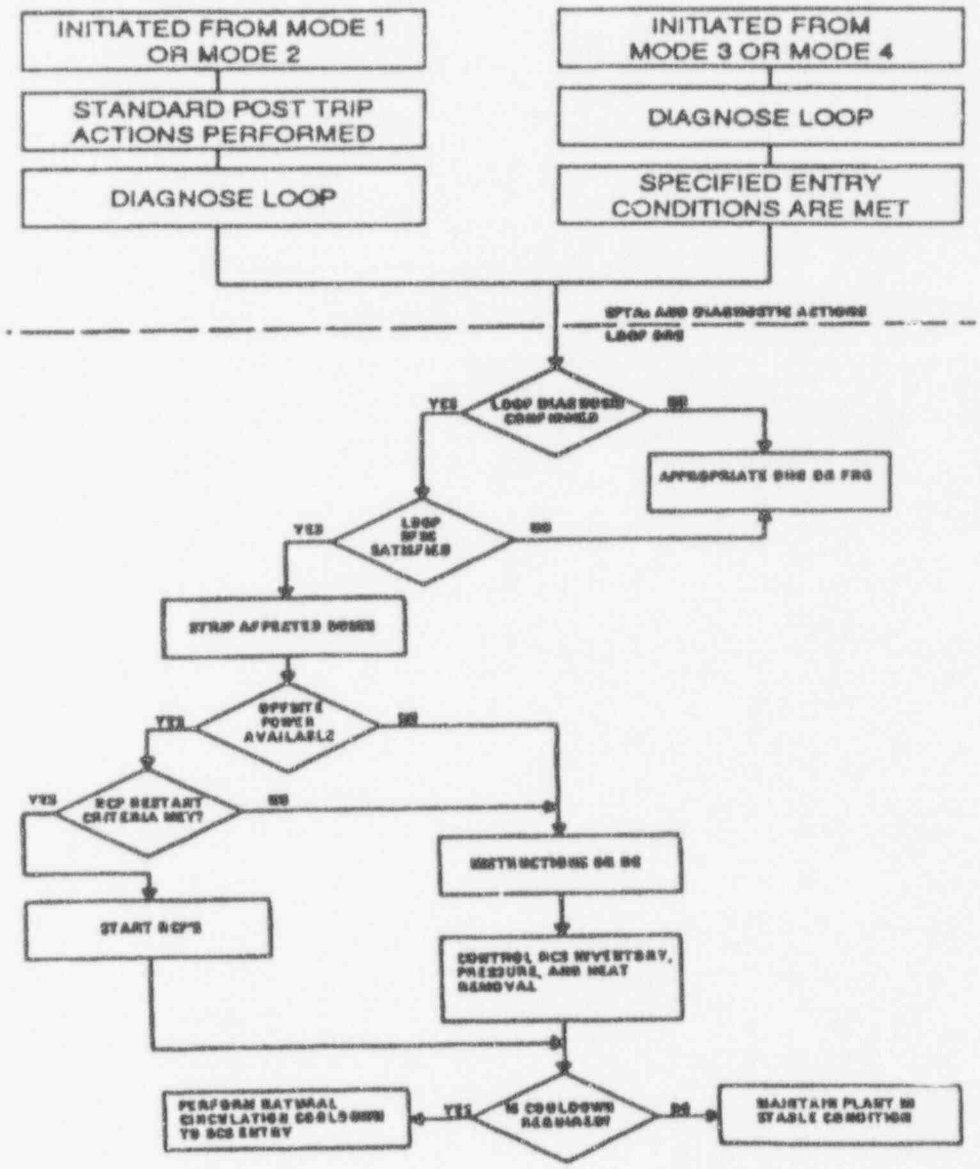
Guideline Strategy

Figure 9-11 provides a summary of the LOOP Recovery Guideline's strategy. In the LOOP Recovery Guideline, the operators begin by ensuring that the safety functions are being maintained. Next, the operators attempt to restore a source of electrical AC power to the Non-Safety [13.8 kV] buses. If power can be restored, the Non-Safety [13.8 kV] AC buses are re-energized. If the RCP restart criteria are met, pumps are restarted to restore forced circulation RCS flow. If power has not been restored, or the RCP restart criteria cannot be met, the operators maintain natural circulation RCS flow. The final block of steps allows for a cooldown and depressurization to the shutdown cooling system entry conditions.

A more detailed chart is provided in Figure 9-12. This chart illustrates the recovery guideline strategy and lists the guideline steps which correspond to each strategy objective. Those steps which are to be performed at any time during the course of the event are shown by asterisks.

FIGURE 9-11

LOSS OF OFFSITE POWER STRATEGY CHART



Bases For Operator Actions

The operator actions are directed at achieving three objectives:

a. establishing, maintaining and verifying natural circulation conditions in the RCS if all RCPs are stopped,
b. restoring the non-vital [13.8 kV] AC buses,
c. if necessary, performing a cooldown to the SCS entry conditions.

* 1. The diagnosis of a LOOP event is confirmed by verifying the Safety Function Status Check acceptance criteria are being satisfied. This action ensures that the proper procedure is being used to mitigate the effects of a LOOP. The contingency actions allow the operator to verify the alternate AC is energizing the permanent non-safety bus and to energize at least one safety bus from the permanent non-safety bus. If no safety or non-safety buses are energized, then the ORG is not the appropriate guideline to implement. If another event is diagnosed, then the operator is directed to implement the appropriate Optimal Recovery Guideline. If diagnosis of one event is not possible, then the operator is directed to implement the Functional Recovery Guideline. The Functional Recovery Guideline is based on safety functions and will ensure that all safety functions are addressed regardless of what event(s) is occurring.

2. The operators are directed to verify that at least one safety bus is energized and that all necessary loads have been properly sequenced onto their respective buses.

3. The operators are directed to verify that at least one safety division is [125 V] DC is energized, including both the channelized and the division load center. In addition, the operator is directed to verify at least one division of vital [120 VAC] distribution centers is energized including both the channelized and the Division load center. Normally these buses would be powered by the battery chargers. A total loss of vital DC indicates that more than a simple Loss of

Offsite Power has occurred, and the Functional Recovery guideline should be implemented.

4. Appropriate breakers on the de-energized bus(es) [4.16 kV and 13.8 kV] should be opened to allow for proper loading when the bus is re-energized.

5. The operators are directed to verify that RCP Seal cooling is available to all RCPs to be restarted. If seal cooling is not available, the operators must restore sealing cooling by unisolating RCP controlled bleedoff if isolated, unisolating the non-critical CCW loop if isolated, and establishing RCP seal injection. [If possible, one of the following means of seal cooling ([CCW], [CVCS seal injection (SI)], [Dedicated Seal Injection System (DSIS)] should be restored to the RCP seals to prevent overheating and possible damage to the seals.]

* 6. RCS and core heat removal are maintained by feeding and steaming at least one steam generator. The operators should control the heat removal to maintain constant RCS temperatures unless a cooldown is desired. In most cases, the NSSS will be maintained at HOT STANDBY conditions until the non-safety [13.8 kV] AC buses can be restored. If the LOOP guideline has been implemented following a station blackout event (after safety [4.16 kV] AC has been restored), the RCS may be at lower temperature and pressure. In this case, the operators should maintain the existing NSSS conditions until a decision is made to either cooldown to shutdown cooling, or return to HOT STANDBY.

   If possible, any steaming should be to the condenser (once non-safety AC is restored). Steaming to the condenser will minimize any possible radiological releases to the atmosphere and will conserve the condensate inventory.

* 7. The operators should control charging (and when available, letdown) to maintain RCS inventory control. The Charging pump may have to be manually restarted if an interruption of electrical power to the charging pump bus has occurred. Inventory control is verified by meeting all of the following criteria:

a. Pressurizer level is approximately [2% and 78%] of the pressurizer range. This range ensures that the pressurizer is not drained and that it has an operable steam bubble.
b. RCS is subcooled based on representative core exit thermocouple temperature. The RCS being subcooled, coexisting with a pressurizer level of [2% to 78%] indicates adequate RCS inventory control is being maintained.
c. The HJTC RVLMS indicates that the core is covered. An HJTC RVLMS indication that the core is covered, taken in conjunction with subcooled inventory, is an additional indication that RCS inventory control has been established.

Pressurizer level should normally be maintained at the normal shutdown reference level. If letdown is not available, pressurizer level may be allowed to vary over the full range [2% to 78%] of the pressurizer as long as care is taken not to go solid.

Level should be maintained above [14.3%] if possible to permit pressurizer heater operation. If pressurizer level drops below the top of the pressurizer heaters, then pressurizer heater burnout may occur if the heaters have not been interlocked off by their control system.

* 8. The PPCS or manual operation of pressurizer heaters and spray is verified to be maintaining or restoring RCS pressure within the limits of Figure 9-1 (Post Accident Pressure-Temperature Limits). If subcooling limits or cooldown rate limits of Figure 9-1 are being violated, then the operators should take actions to restore the RCS to within the P-T limits. Depending on the situation, the operator should perform the following actions as appropriate:

a. Stop the cooldown.
b. Operate auxiliary spray as necessary to restore pressurizer pressure to within the P-T limits of Figure 9-1.

c. Attempt to maintain the plant in a stable pressure-temperature configuration. The cooldown may be continued, if desired, within the limits of Figure 9-1.

d. If an overpressure situation exists and is caused by SI and/or charging flow, then throttle or stop SI (refer to step 16) or charging pump and manually control letdown to restore and maintain pressure within the Post Accident P-T limits of Figure 9-1.

* 9. While the operators are ensuring that all of the safety functions are being satisfied, the restoration of non-safety [13.8 kV] AC power should be continued. The actions necessary to restore power should continue until power is restored.

*10. When offsite power becomes available, electrical AC power is restored to the electrical distribution and station loads. This step provides a mechanism for restoring RCP bus power, non-safety plant loads, and backup power to the vital plant loads should the emergency diesel generators need to be secured.

*11. While the operators are ensuring that all the safety functions are being satisfied, the restoration of non-safety [4.16 kV] AC power via the combustion turbine should be continued if offsite power has not been restored. The actions should be continued until the combustion turbine is started or until offsite power is restored.

*12. When power to the permanent non-safety buses becomes available, power to the desired non-safety equipment should be restored. This step provides a mechanism for restoring power to non-safety loads and for backfeeding power to the safety buses should the diesel generators need to be secured.

*13. Plant conditions should be carefully assessed before any RCPs are restarted. The need for forced circulation operation should be balanced against the risk of damage to the RCP seals.

The need for operation of the RCPs should be evaluated based on:

1. the adequacy of the RCS and core heat removal under the existing natural circulation conditions,
2. the existing RCS pressure and temperatures,
3. the need for main pressurizer spray capability.

If the existing natural circulation is providing satisfactory RCS and core heat removal, a transfer to forced circulation operation may not be necessary. This would be particularly true if the RCS had already been cooled and depressurized to SCS entry conditions. If the RCS pressure and temperatures are closer to HOT STANDBY conditions, it may be desirable to restart the RCPs in order to allow a normal forced circulation cooldown. Consideration should also be given to the necessity of having main pressurizer spray capability if auxiliary spray is not providing the desired depressurization rate.

The potential for RCP seal degradation should be evaluated based on:

1. how long CCW to the RCPs was interrupted,
2. RCP seal staging pressures and temperatures.

The possibility of seal degradation increases if seal cooling has been interrupted for longer than [10 minutes]. The seal staging pressures provide an indication of degraded seal stages (a low pressure drop across a stage indicates a problem). Restart of an RCP with one or more degraded seal stages should be avoided if possible.

*14. With all RCPs stopped, then operation of two RCPs (in opposite loops) should be considered if the RCP restart criteria can be met. Only one reactor coolant pump in each loop needs to be operated to minimize heat input to the RCS.

Determine whether RCP restart criteria are met by the following:

a. Electrical power available to the RCP.
b. RCP auxiliaries are to maintain seal cooling, bearing cooling, and motor cooling. Following automatic or operator initiated containment isolation, reinstatement of component cooling water should be considered to ensure adequate RCP cooling. There should be no high temperature alarms on the RCPs to be operated.
c. At least one steam generator is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow is available for removing heat from the RCS.
d. Pressurizer level is greater than [33%] and not decreasing. With pressurizer level at the high end of the operating band, the possibility of draining the pressurizer due to loop shrinkage and/or steam void condensation is minimized and there is a greater likelihood of keeping the pressurizer heaters covered. This will assist in maintaining positive RCS pressure control. The criterion of pressurizer level not decreasing implies that RCS inventory control has been established.
e. RCS is subcooled. A subcooled condition in combination with (d) above indicates that inventory control has been established.
f. [All plant specific RCP operating criteria are satisfied before the RCPs are restarted to prevent damage to the RCPs resulting from abnormal operating conditions].

15 Upon restarting two RCPs in opposite loops, pressurizer level and pressure may decrease due to loop shrinkage and/or void condensation. It is possible that this action will drain the pressurizer. Steam voids present in the reactor vessel will condense upon restarting RCPs. The HJTC RVLMS should be monitored for the trending of reactor vessel liquid level. This trending information may be correlated to pressurizer level decrease.] RCP operation with a drained pressurizer may continue provided certain actions are taken and certain criteria are satisfied.

The following constitute the actions to be taken and the criteria to be satisfied when restarting RCPs:

a. Start one RCP in each loop.
b. [Ensure proper RCP operation by monitoring RCP amperage and pump NPSH. NPSH is determined by pressurizer pressure and corresponding T_c on Figure 9-1].
c. Operate all available charging (and SI) pumps until pressurizer level is greater than [33%] (and SI termination criteria are met).

16. If the SI pumps are operating, then they must continue to operate until SI termination criteria are met. Throttling of SI flow is also permissible if termination criteria are met. SI termination criteria are:

    a. RCS subcooled based on representative CET temperature (Refer to Figure 9-1). Establishing subcooling ensures the fluid surrounding the core is subcooled. Voids may exist in some parts of the RCS (e.g., reactor vessel head), but are permissible as long as core heat removal is maintained.
    b. Pressurizer level is greater than [14.3%] and not decreasing. A pressurizer level greater than [14.3%] and not decreasing, in conjunction with criterion 1. above, is an indication that RCS inventory control has been established.
    c. At least one steam generator is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow is available for removing heat from the RCS.
    d. The HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles. This provides an extra margin of core coverage and, taken in conjunction with the above, serves as an additional indication that adequate RCS inventory control has been established.

17. If the criteria of steps 16 cannot be maintained after the SI pumps are throttled or stopped, then the SI pumps must be restarted and full SI flow restored.

18. A characteristic of a loss of offsite AC power is the termination of RCP operation. Once the RCPs are tripped, natural circulation RCS flow should develop within [5 - 15 minutes]. Natural circulation flow will be ensured by maintaining RCS pressure and inventory control and using at least one steam generator for RCS heat removal.

When single phase liquid natural circulation flow is established in at least one loop, the RCS should indicate the following conditions:

a. Loop ΔT (T_H - T_c) less than normal full power ΔT,
b. Hot and cold leg temperatures constant or decreasing,
c. RCS is subcooled based on representative CET temperatures,
d. No abnormal differences between T_H RTD's and core exit thermocouples. Hot leg RTD temperatures should be consistent with the core exit thermocouples. Adequate natural circulation flow will be reflected by the core exit thermocouple temperatures being approximately equal to the hot leg RTD temperatures. An abnormal difference between T_H and the core exit thermocouples could be any difference greater than [10°F].

Natural circulation is regulated by a combination of factors. Factors which affect natural circulation include decay heat, component elevations, primary to secondary heat transfer, loop flow resistance and voiding. The component elevations on C-E plants are such that a satisfactory natural circulation decay heat removal is obtained utilizing density differences between the bottom of the core and the top of the steam generator tube sheet. Natural circulation flow is enhanced by the density difference obtained when primary to secondary heat removal through the steam generator U-tubes is utilized.

If the RCS does not indicate natural circulation is occurring, the operators should ensure that the systems available to support RCS inventory, pressure, and heat removal are being controlled properly.

If possible, any steaming should be to the condenser (once non-safety AC is restored). Steaming to the condenser will minimize any possible radiological releases to the atmosphere and will conserve the condensate inventory.

19. The ability to maintain the plant in a stable condition is based on plant status, auxiliary systems availability and condensate inventory. A major concern of this evaluation is the amount of available emergency inventory. If the available condensate inventory (Figures 9-3 and 9-4) appears to be marginally adequate to maintain the plant in a stable condition for the expected duration of time, a plant cooldown should be commenced. The cooldown is performed to avoid depleting all available emergency feedwater prior to establishing RCS heat removal capability with the shutdown cooling system. The operator should also consider the expected time to recover offsite power.

20. A decision is made whether to maintain the plant in a stable condition or cooldown to shutdown cooling entry conditions. If the plant is to be maintained in a stable condition, then this guideline can be exited, and an appropriate, approved procedure should be implemented. If a plant cooldown is to be performed, then the remaining steps of this guideline should be implemented.

21. The RCS should be borated to Technical Specification concentration for the required shutdown margin prior to starting a controlled cooldown. Should letdown not be available, it may not be possible to borate the RCS to a COLD SHUTDOWN RCS boron concentration prior to commencing the cooldown. Boration will be limited to the makeup space available in the pressurizer. If this is the case, the operator should borate the RCS to the minimum shutdown margin (per Technical Specifications) corresponding to T_c. During the cooldown, RCS shrinkage will provide more space in the pressurizer for additional boration. The operator should continuously or periodically borate to maintain the minimum shutdown margin until the COLD SHUTDOWN boron concentration is achieved.

22. An RCS cooldown is to be performed in accordance with Technical Specifications. The cooldown should be performed using one of the following methods:

   a. Feed the steam generator using main, startup or emergency feedwater.
   b. Discharge steam via the Steam Bypass System (preferred because this method maximizes the amount of emergency feedwater and condensate inventory available to support the cooldown) or via the atmospheric dump valves.

22. Throughout the cooldown and depressurization, the operator should ensure that the pressurizer pressure is being maintained within the Post Accident P-T limits of Figure 9-1. If subcooling or cooldown limits are being violated, then the operators should take actions to restore the RCS to within the P-T limits. Depending on the situation, the operator should perform the following actions as appropriate:

   a. Stop the cooldown.
   b. Operate main or auxiliary spray as necessary to restore pressurizer pressure to within the P-T limits of Figure 9-1.
   c. Attempt to maintain the plant in a stable pressure-temperature configuration. The cooldown may be continued, if desired, within the limits of Figure 9-1.
   d. If an overpressure situation exists and is caused by SI and/or charging flow, then throttle or stop SI (refer to step 16) or charging pump and manually control letdown to restore and maintain pressure within the Post Accident P-T limits of Figure 9-1.

24. Pressurizer level should be maintained in the band [2% to 78%] throughout the cooldown process. Preferably, pressurizer level should be maintained by control of charging and letdown but use of the SI pumps can provide an alternative method for maintaining pressurizer level. Maintaining RCS subcooling, in conjunction with a pressurizer level of [2% to 78%], should prevent loss of pressure control by ensuring a saturated bubble exists in the pressurizer. It should be noted that if pressurizer level drops below the top of the pressurizer

heaters [14.3%], they could burn out. However, the low level heater cutoff should actuate first to prevent.

25. Throughout the cooldown, the available emergency feedwater inventory should be monitored and replenished as required to support the cooldown. The required inventory should be determined by referencing Figures 9-3 and 9-4. [Replenishment from available sources to sustain the required inventory may require inclusion of condensate from non-seismic tanks, fire mains, ultimate cooling water supplies, potable tanks, etc.]

26. During a controlled cooldown and depressurization, the unnecessary automatic operation of certain safeguard systems is undesirable. The setpoints of SIAS and MSIS must be manually reset (lowered or bypassed) as the cooldown progresses. This ensures that automatic engineered safeguards actuation remains available until the RCS has been cooled down and depressurized.

27. If pressurizer pressure reaches [740 psia], which is [100 psi] greater than the maximum safety injection tank (SIT) pressure, then the safety injection tanks (SITs) must be vented, drained, or their discharge valves shut to prevent discharging their nitrogen cover gas into the RCS when RCS pressure is reduced below the SITs pressure during a controlled cooldown. The operators may lower the SIT pressure by venting to ensure the availability of the SITs during lower mode operations.

28. When pressurizer pressure decreases to the SIT outlet valve interlock setpoint [445 psia], the SITs should be isolated to prevent heir undesired injection into the RCS.

29. Low temperature overpressure protection (LTOP) is initiated at Tc < [259°F] to protect against subjecting the RCS pressure boundary to a low temperature brittle fracture situation.

30. The cooldown and depressurization should continue until shutdown cooling system entry conditions are established.

    a. pressurizer level control should be established and verified by a level greater than [33%] and constant or increasing,
    b. RCS should be subcooled,
    c. RCS pressure should be at or below shutdown cooling system entry pressure of [450 psia],
    d. RCS hot leg temperature should be at or below shutdown cooling entry temperature of [400°F],

    When these criteria are established, the LOOP ORG should be exited and SCS operation initiated per [operating plant specific instructions].

    If the operators cannot depressurize the RCS to the SCS conditions, then a void should be suspected. The operators should be monitoring for the presence of voids using any of the following indications, parameter changes, or trends:

    a. letdown flow greater than charging flow,
    b. pressurizer level increasing significantly greater than expected while operating pressurizer spray,
    c. the HJTC RVLMS indicates that voiding is present in the reactor vessel,
    d. HJTC unheated thermocouple temperature indicates saturated conditions in the reactor vessel upper head,

    If voiding hinders RCS depressurization to SCS entry pressure, then an attempt to eliminate voiding should be made. An attempt to eliminate the voids is performed as follows:

    a. Letdown is isolated or verified to be isolated to minimize further inventory loss.
    b. The depressurization is stopped to prevent further growth of the void.

c. The RCS is pressurized and depressurized (within the limits of Figure 9-1), to condense the void. Pressurizing will have the effect of filling the voided portion of the RCS with cooler fluid, which will remove heat from the region. Repeating the process of pressurizing and depressurizing several times will cool and condense the steam void. With a void in the reactor vessel, the pressurization/depressurization cycle will produce a fill and drain effect in the reactor vessel. This cycle may be accomplished using pressurizer heaters and spray (preferred method) or the SIS/charging system (alternative method). The monitoring of pressurizer level and the HJTC RVLMS for trending RCS inventory will assist the operator in assessing the effectiveness of void elimination.

d. If indications of unacceptable RCS voiding continue, and voiding is suspected to exist in the steam generator tubes, then attempts should be made to cool the steam generator and condense the tube bundle void. Steam generator cooling can be accomplished by steaming and/or blowdown in combination with feeding the steam generator. The steam generator cooling will be effective for condensing steam voids but will not have an effect on non-condensible gases trapped in the tube bundle. However, a buildup of non-condensible gases in the tube bundles will not hinder natural circulation, even with a large number of tubes blocked, as only a small amount of heat transfer area is required for the removal of decay heat. The monitoring of pressurizer level for RCS inventory trending will assist the operator in assessing the effectiveness of void elimination.

e. If indications of unacceptable RCS voiding continue, then voiding may be caused by non-condensible gases. Operate Reactor Coolant Gas Vent System to clear trapped noncondensible gases. The monitoring of pressurizer level and/or the HJTC RVLMS for trending of RCS inventory will assist the operators in assessing the effectiveness of void elimination.

SAFETY FUNCTION STATUS CHECKS

The Safety Function Status Check (SFSC) is used to continually verify the status of safety functions. The safety function acceptance criteria are selected from best estimate analysis to reflect the range for each parameter which would be expected following a loss of offsite power or loss of forced circulation. If all SFSC acceptance criteria are being satisfied, then the adequacy of this guideline for mitigating the event in progress is confirmed and the health and safety of the public is ensured.

SAFETY FUNCTION STATUS CHECK BASES
LOSS OF OFFSITE POWER

The safety functions and their respective acceptance criteria listed below are those used to confirm the adequacy of the LOOP Guideline in mitigating the event.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
1. Reactivity Control	a. Reactor Power Decreasing and b. Negative Startup Rate and c. Maximum of one CEA NOT fully inserted or RCS borated per Tech. spec.	For all emergency events, the reactor must be shutdown. Reactor power decreasing, in conjunction with negative startup rate, is a positive indication that reactivity control is established. The criterion that no more than one CEA be not fully inserted or the RCS borated observes typical Technical Specification requirements.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
2. Maintenance of Vital Auxiliaries (AC and DC power)	All vital Division I [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized, or All vital Division II [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized.	One vital AC bus is required to power equipment necessary to maintain control of all other safety functions. One DC division is required as a minimum to provide monitoring and limited control of the other safety functions.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
3. RCS Inventory Control	a. Charging and letdown maintaining or restoring pressurizer level [2% to 78%], and b. RCS is Subcooled based on representative CET temperature. and c. The HJTC RVLMS indicates the core is covered.	The value of [78%] was chosen as an upper limit to ensure a bubble is maintained in the pressurizer considering an initiation of auxiliary spray. A value of [2%] was chosen as the lower limit to ensure the operator can detect some level in the pressurizer. Subcooling coexisting with a pressurizer level of [2% to 78%] indicates adequate RCS inventory control via a saturated bubble in the pressurizer. Representative CET temperature is utilized during natural circulation flow conditions. T_H RTDs are utilized for forced circulation flow conditions.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
3. RCS Inventory Control (Continued)		An HJTC RVLMS indication that the core is covered, taken in conjunction with subcooling, is an additional indication that RCS inventory control has been established.
4. RCS Pressure Control	Pressurizer heaters and main or auxiliary spray are maintaining or restoring pressurizer pressure within the limits of Figure 9-1.	For the LOOP event operation of the pressurizer heaters and sprays should be sufficient to control the RCS pressure.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
5. Core Heat Removal	a. RCS is subcooled based on representative CET or temperature. and b. The RCS loop ΔT in the operating steam generator is: i) less than full power ΔT (if all RCPs are off) or ii) less than [3°F] (if any RCPs are running).	Subcooling assures adequate core cooling. Representative core exit thermocouple temperatures should be used during natural circulation flow conditions and T_H RTDs should be used during forced circulation flow conditions. Best estimate analysis demonstrates that loop ΔT will be less than full power ΔT in the steaming loop during natural circulation and less than [3°F] in the steaming loop with at least one RCP operating.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
6. RCS Heat Removal	a. At least one steam generator has level within normal level band with feedwater available to maintain level or b. At least one steam generator level being restored to the normal band by feedwater flow with level increasing or c. Total feedwater flow to either or both steam generators greater than [500 gpm]	Adequate RCS heat removal will be maintained if at least one steam generator is available for removing heat (capable of steam flow and feed flow). The value of [500 gpm total feedwater flow] is sufficient feed flow to remove decay heat (approximately 2% rated thermal power) from the core. Decay heat levels may not be high enough to require 500 gpm] feed flowrate. In this case, steam generator levels in the normal band satisfies RCS heat removal.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
7. Containment Isolation	a. Containment Pressure <[2.0 psig] and b. No containment area radiation monitors alarming and c. No process radiation alarms and d. No steam plant activity monitors alarming and e. No nuclear annex radiation alarms.	[2.0 psig] is based on the containment high pressure alarm. It is not expected for the LOOP event that containment pressure will increase to the alarm setpoint. During a LOOP it is not expected that radiation will be detected inside containment or on the process radiation monitors. The monitors should not be alarming. Steam plant activity is an indication of a SGTR and is not anticipated for a LOOP. It is also not anticipated for a LOOP that nuclear annex alarms are received.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
8. Containment Temperature and Pressure Control	a. Containment temperature <[110°F] and b. Containment pressure <[2.0 psig].	Containment temperature is not expected to increase to [110°F] for the LOOP event. [2.0 psig] is based on the containment high pressure alarm. It is not expected that the pressure will reach this value during the LOOP event.
9. Containment Combustible Gas Control	a. Containment temperature <[110°F] and b. Containment pressure <[2.0 psig].	Maintaining these containment conditions provides an indirect indication that the conditions required for H_2 generation do not exist.

Event Strategy

This section contains the detailed LOOP recovery actions strategy chart (Figure 9-12). The chart depicts the strategy around which the LOOP guideline is built. It is intended to assist the procedure writer in understanding the intent of the guideline and can also be used in operator training. Operators should understand what the major objectives of the guideline are in order to facilitate their progress toward the guideline goals.

The strategy charts show the recovery guideline strategy in detail. Steps of the guideline which may be performed at any time during the course of an event are shown by asterisks. The boxes above the dashed line indicate the lead-in steps performed by the operator prior to entering this recovery guideline.

FIGURE 9-12a

STRATEGY CHART FOR LOSS OF OFFSITE POWER

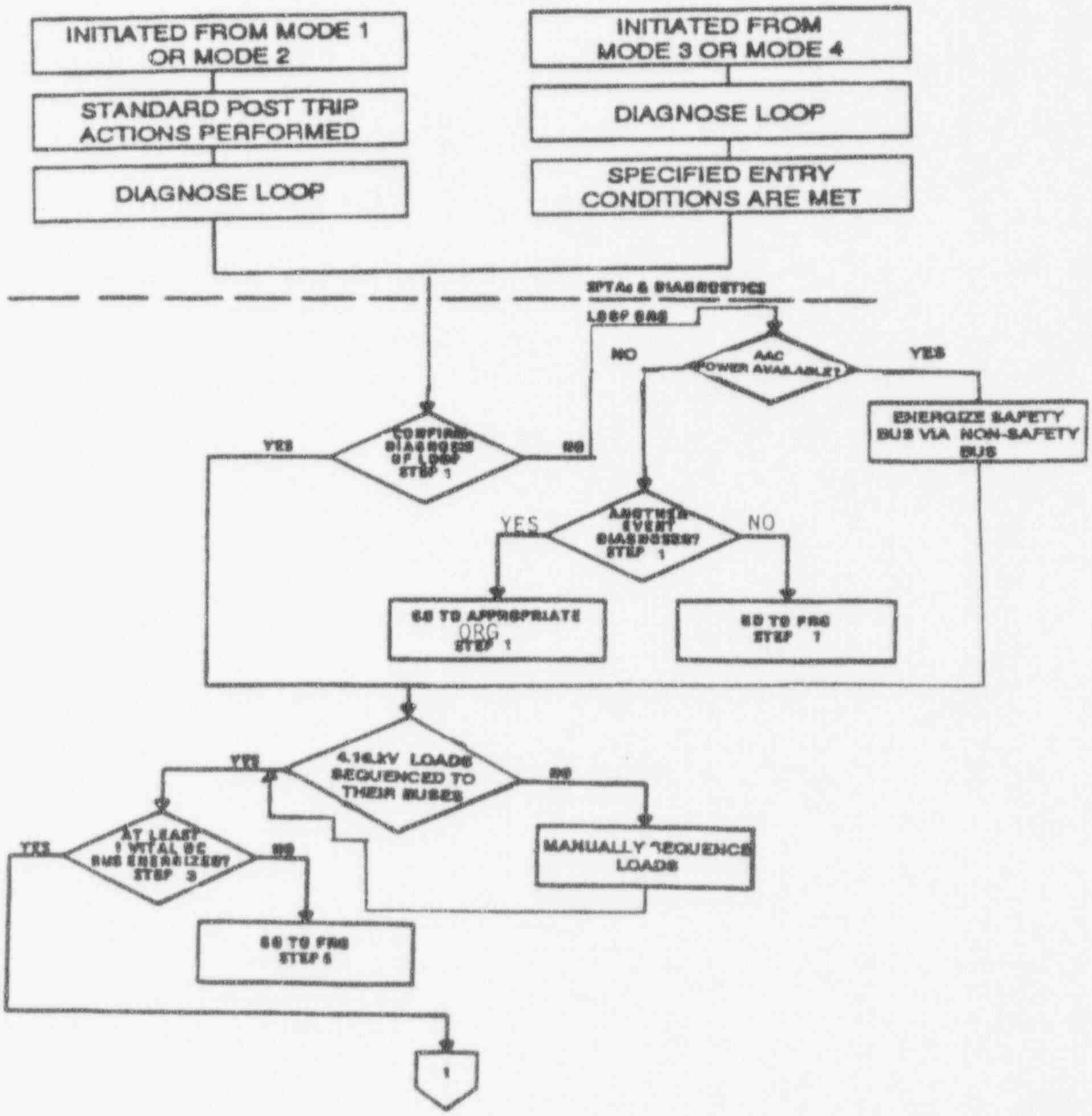


FIGURE 9-12b

STRATEGY CHART FOR LOSS OF OFFSITE POWER

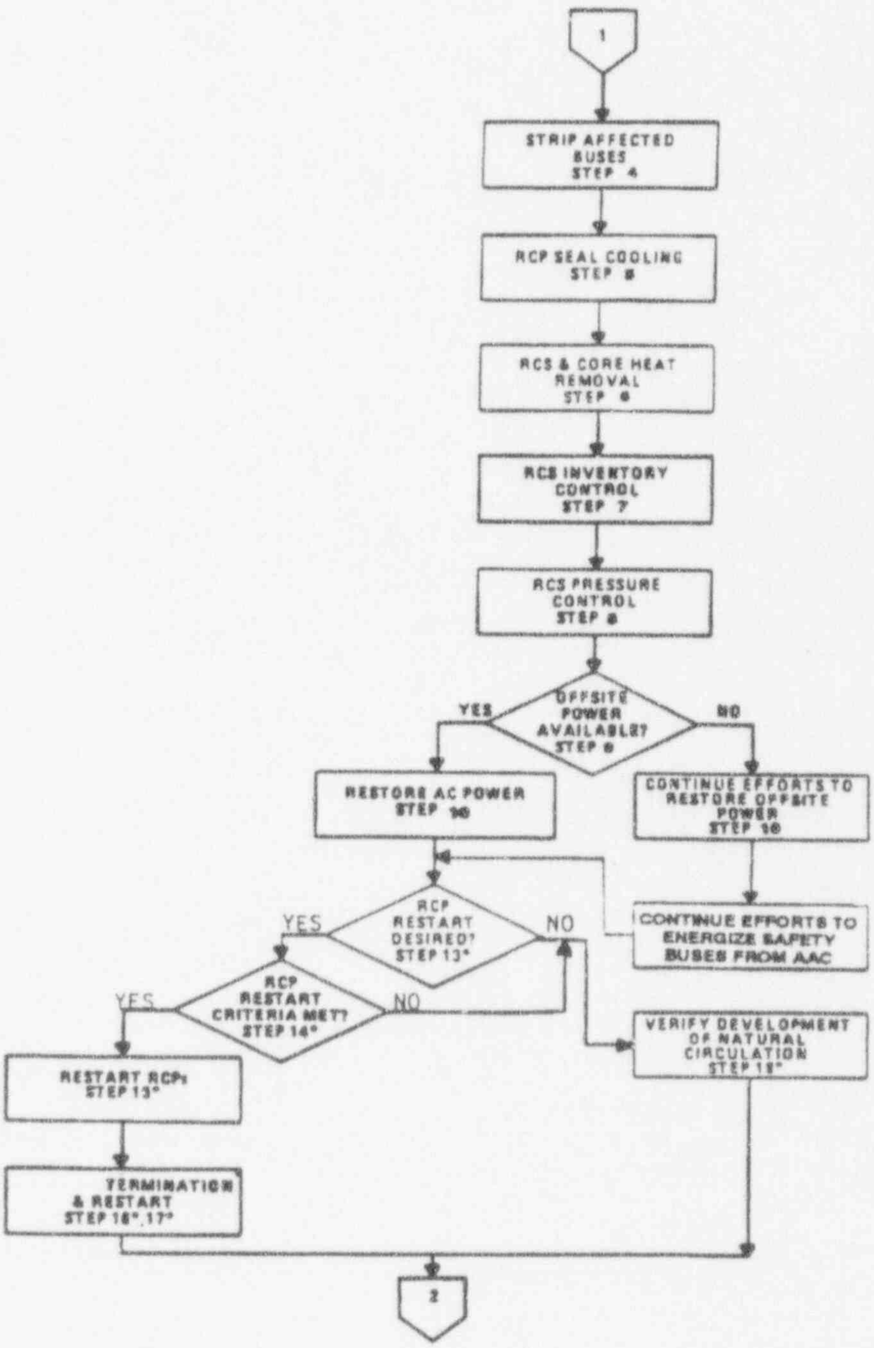
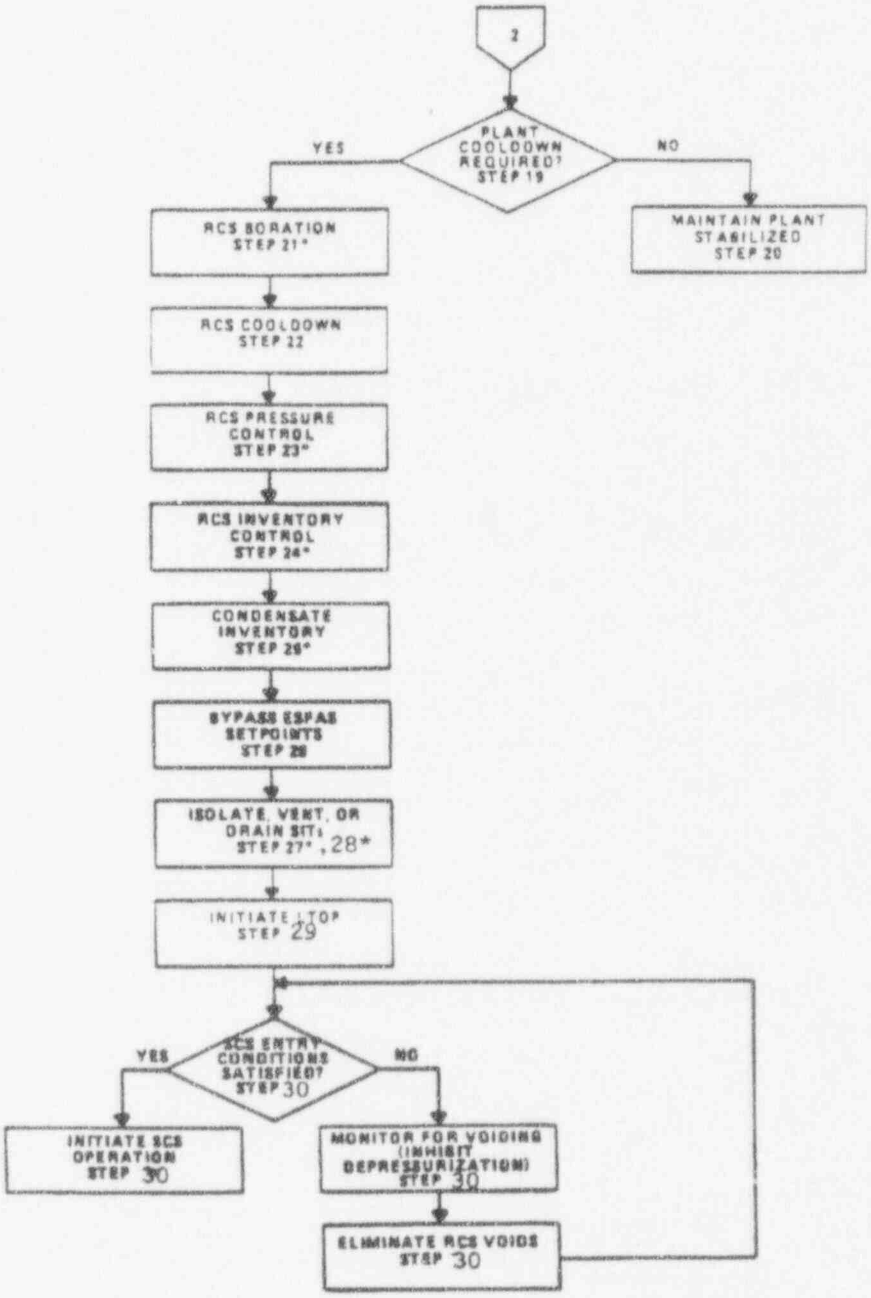


FIGURE 9-12c

STRATEGY CHART FOR LOSS OF OFFSITE POWER



STATION BLACKOUT RECOVERY

PURPOSE

This guideline provides the operator actions which should be accomplished in the event of a Station Blackout. The actions in this guideline are necessary to ensure that the plant is placed in a stable, safe condition. The goals of this guideline are to restore the availability of a full complement of vital components (and if possible, non-vital components), and to safely establish the entry conditions of a normal operating procedure for HOT STANDBY, or HOT SHUTDOWN, or a procedure provided by the Plant Technical Support Center or Plant Operations Review Committee. This guideline is designed to meet this objective while minimizing any radiological release to the environment and maintaining adequate core cooling. This guideline provides technical information to be used by the utilities in developing a plant specific procedure.

ENTRY CONDITIONS

1. The Standard Post Trip Actions have been performed.

   or

   All of the following conditions exist:
   a. Event initiated from MODE 3 or 4
   b. SIAS has NOT been blocked
   c. LTOP has NOT been initiated.

   and

2. Plant conditions indicate that a Station Blackout electrical emergency has occurred. Any one or more of the following may be present:

   a. Loss of control room lighting
   b. Extensive loss of various indications
   c. Equipment "loss of power" alarm(s)
   d. Tripped breaker indications on the [13.8] and [4.16] kV buses
   e. Extensive loss of component power available indications

EXIT CONDITIONS

1. Any of the Station Blackout Safety Function Status Check acceptance criteria are not satisfied.

or

2. The Station Blackout guideline has accomplished its purpose by satisfying ALL of the following:

   a. at least one safety division of [4.16] kV electrical AC has been restored,
   b. all Station Blackout Safety Function status check acceptance criteria are being satisfied,
   c. an appropriate procedure, which has been provided and approved by the Plant Technical Support Center or the Plant Operations Review Committee, can be implemented.

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. Confirm diagnosis of Station Blackout and verify Safety Function Status Check acceptance criteria are satisfied.	1. Rediagnose event and exit to either appropriate Optimal Recovery Guideline or to Functional Recovery Guideline.
* 2. Ensure at least one steam generator has the following: a. level being restored or maintained in the normal band and b. Emergency feed flow capability and c. pressure control by one of the following (listed in preferred order): i) atmospheric dump valves ii) main steam safety valves	2.
3. Ensure all appropriate breakers on de-energized buses [13.8] and [4.16] kV are open. [The appropriate plant specific breaker list would be placed here when the plant specific EOPs are written.]	3.

* Step Continuously Applicable

INSTRUCTIONS	CONTINGENCY ACTIONS
* 4. If AC power available from diesel generator(s) and/or alternate AC sources, then do the following (in the order indicated): a. restore power to at least one division of safety [4.16] kV AC in accordance with operating instructions, and b. (if possible) restore power to at least one permanent non-safety [4.16] kV AC bus in accordance with operating instructions, and c. Go to step 13.	4. Continue efforts to make AC power available.
* 5. Open the following DC supply breakers: [A plant specific list of breakers will be supplied in the plant specific EOPs.]	5.
6. Ensure adequate ventilation and/or supplemental cooling is provided within 30 minutes for the following rooms and cabinets. [Plant Specific list of rooms and cabinets will be provided here in the plant specific EOPs.]	6.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
7. Minimize RCS leakage by ensuring ALL of the following: a. letdown isolation valves closed, b. SCS RCS suction valves closed, c. RCP controlled bleedoff line isolation valve closed, d. RCS charging line isolation valves closed, e. RCS sample line(s) isolation valve(s) closed, f. Rapid depressurization valves closed.	7.
* 8. Verify natural circulation flow in at least one loop by ALL of the following: a. loop ΔT (T_H - T_c) less than normal full power ΔT, b. hot and cold leg temperatures constant or decreasing, c. RCS is subcooled based on representative temperature, d. No abnormal difference [greater than 10°F] between T_H RTDs and Core Exit Thermocouples.	8. Ensure proper control of steam generator feeding and steaming (refer to Step 2).

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
9. Ensure the available emergency feedwater inventory is adequate (Figures 10-3 and 10-4).	9. If emergency feedwater inventory is NOT adequate, then transfer water to the emergency feedwater tank by: [Plant Specific list of Emergency Feedwater sources will be provided in the plant specific EOPs].
*10. Maintain [1-30°F] subcooling, based on representative CET temperature, by emergency feedwater to at least one steam generator and steaming via atmospheric dump valve(s).	10. If subcooling can NOT be maintained, then continue RCS heat removal using two-phase natural circulation. Ensure the following: a. steam generator feeding and steaming are properly controlled (refer to step 2), and b. representative CET temperature is less than superheated.
*11. Verify the reactor will remain subcritical at 50°F T_c intervals, by calculating shutdown margin based on T_c 50°F less than indicated T_c and boron concentration at time of reactor trip.	11. Stop the RCS cooldown and allow 2 phase Natural Circulation to establish.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*12. Bypass or lower the automatic initiation setpoints of MSIS and SIAS as the cooldown and depressurization proceed.	12.
*13. When at least one safety division of [4.16] KV AC bus has been reenergized, Then: a. ensure that [4.16] KV, [480V], and [120/280V] AC power is being supplied to at least the minimum required safety equipment. Power should be supplied to one of the following means of RCP seal cooling (CCW, CVCS seal injection (SI), dedicated Seal Injection System (DSIS)). [A plant specific list of minimum required equipment will be provided in the plant specific EOPs]. and b. ensure that safety [125V] DC power is being supplied by the division battery chargers to: i) restore station battery capacity, and ii) power safety [125V] DC loads.	13. If no AC bus is energized, Then continue with the actions of Steps 4 through 13.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*14. If the permanent non-safety [4.16] KV bus is NOT energized, Then: a. Energize the permanent non-safety bus via i) offsite power or ii) alternate AC or iii) backfeed from energized safety division bus. b. When permanent non-safety bus is energized, Load the following equipment per plant specific operating instructions: [Plant specific equipment would be listed here in the plant specific EOPs.]	14.
15. Borate the RCS as necessary to maintain shutdown margin in accordance with Technical Specifications.	15.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*16. Ensure adequate RCS inventory control by the following: a. automatic or manual operation of safety injection pumps and/or available charging pump and letdown to control pressurizer level [2% to 78%], and b. The RCS is subcooled based on representative CET temperature (Figure 10-1), and c. the HJTC RVLMS indicates the RCS level is above the top of the hot leg nozzles.	16.

* Step Performed Continuously

INSTRUCTIONS

*17. Restore and maintain pressurizer pressure within the P-T limits of Figure 10-1 by one of the following methods:

a. automatic or manual operation of the pressurizer heaters and auxiliary spray,

or

b. manual operation of charging and/or SI.

CONTINGENCY ACTIONS

*17. If RCS subcooling greater than P-T limits or cooldown rate greater than 100°F/hr, Then do the following as appropriate:

a. stop the cooldown,

b. depressurize the plant using the Reactor Coolant Gas Vent System or auxiliary spray to restore and maintain pressurizer pressure within the Post Accident P-T limits of Figure 10-1,

c. attempt to maintain the plant in a stable pressure-temperature configuration or continue to cooldown within the limits of Figure 10-1,

d. If overpressurization due to SI/charging flow, Then throttle or secure SI (refer to Step 18) or charging flow and manually control letdown to restore and maintain pressurizer pressure within the limits of Figure 10-1.

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS
*18.	If SI pumps are operating, Then they may be throttled or stopped, one pump at a time, if ALL of following are satisfied: a. RCS is subcooled based on representative CET temperature (Figure 10-1), b. pressurizer level is greater than [14.3%] and not decreasing, c. at least one steam generator is available for removing heat from the RCS (ability for feed and steam flow), d. the HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles.	18.
*19.	If criteria of Step 18 cannot be maintained after SI pumps throttled or stopped, Then appropriate SI pumps must be restarted and full SI flow restored.	19.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
20. Ensure cooling systems (Site Service Water, Component Cooling Water) restored in accordance with applicable plant specific operating instructions.	20.
21. Ensure proper operation of the following: a. containment ventilation fan coolers, and b. control room HVAC and c. applicable building HVAC systems.	21.
*22. When the Station Blackout exit conditions are satisfied, Then exit this guideline and implement either the Loss of Offsite Power recovery guideline or an appropriate procedure as the Plant Technical Support Center or the Plant Operations Review Committee directs.	22.

* Step Performed Continuously

The Station Blackout Recovery Guideline has accomplished its purpose if RCS conditions are being controlled in HOT STANDBY or HOT SHUTDOWN, all of the SFSC acceptance criteria are being satisfied, and the entry conditions of an appropriate procedure are satisfied.

END

SUPPLEMENTARY INFORMATION

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Natural circulation flow cannot be verified until the RCPs have stopped coasting down after being tripped.

2. During natural circulation, verification of an RCS temperature response to a plant change cannot be accomplished until approximately 5 to 15 minutes following the action due to increased loop cycle times.

3. After the required shutdown boron concentration is attained in the RCS, makeup water added to the RCS during the cooldown should be at least equal to the RCS boron concentration to prevent any dilution of RCS boron concentration.

4. As the containment heats up due to the loss of containment coolers, pressurizer level indication decalibration will occur. Instrument readings must be corroborated when one or more confirmatory indications are available.

5. Minimize the number of cycles of pressurizer auxiliary spray whenever the temperature differential between the spray water and the pressurizer is greater than 200°F, in order to minimize the increase in the spray nozzle thermal stress accumulation factor.

6. If cooling down by natural circulation with an isolated steam generator, an inverted ΔT (i.e., T_c higher than T_H) may be observed in the idle loop. This is due to a small amount of reverse heat transfer in the isolated steam generator and will have no affect on natural circulation flow in the intact steam generator.

7. All available indications should be used to aid in evaluating plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings should be corroborated when one or more confirmatory indications are available.

8. When a void exists in the reactor vessel and RCPs are not operating, the HJTC RVLMS provides an accurate indication of reactor vessel liquid inventory. When a void exists in the reactor vessel and RCPs are operating, it is not possible to obtain an accurate reactor vessel liquid level indication due to the effect of the RCP induced pressure head on the HJTC RVLMS. Information concerning reactor vessel liquid inventory trending may still be discerned. The operator is cautioned not to rely solely on the HJTC RVLMS indication when RCPs are operating.

9. The operator should continuously monitor for the presence of RCS voiding and take steps to eliminate voiding any time voiding causes heat removal or inventory control safety functions to begin to be threatened. Void elimination should be started soon enough to ensure heat removal and inventory control are not lost.

10. Sustained operation of DC power equipment <u>not</u> essential to maintaining the deliberate cooldown jeopardizes the duration of battery availability. A list of the DC loads which are essential for control and monitoring of the plant should be developed on a plant specific basis with the intent of extending battery availability. Consideration should be given to those loads which are absolutely necessary.

11. Injection of borated water from the Safety Injection Tanks will not occur until pressurizer pressure is less than the nitrogen cover gas pressure.

12. A station blackout will result in the loss of numerous indications and control functions. It is important that the operators be aware of the affects of a station blackout on all indications and controls.

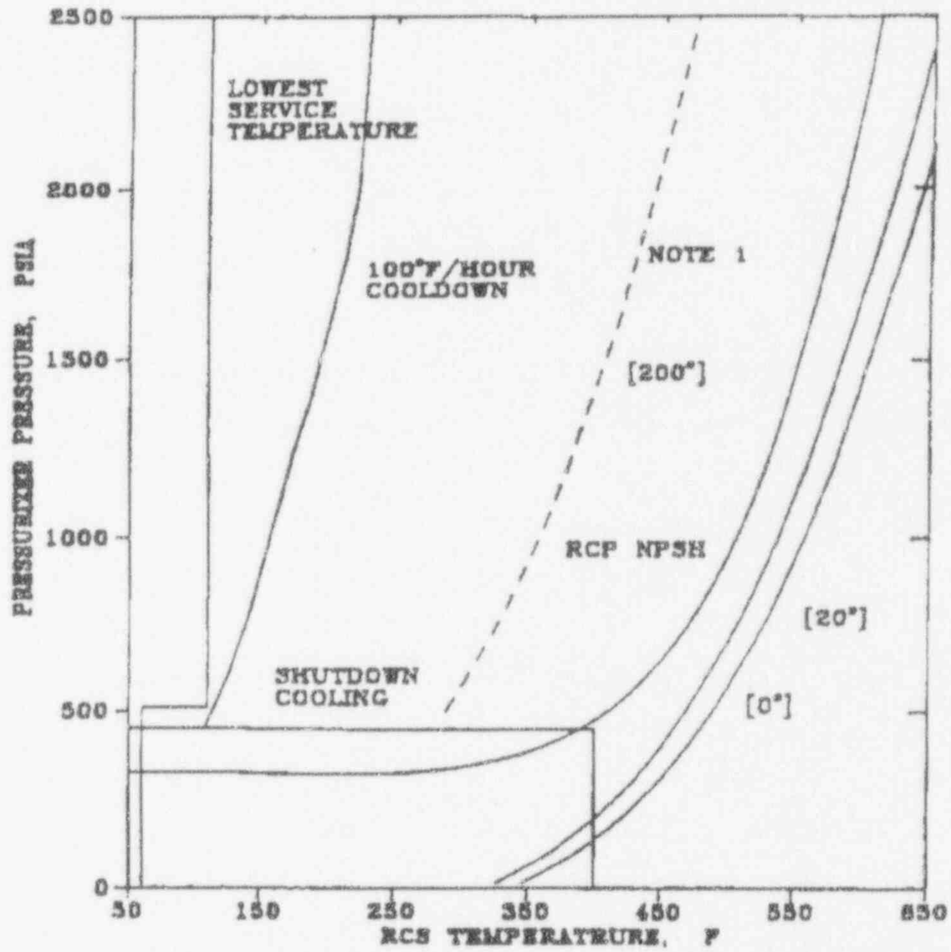
13. Plant personnel should be prepared for the possibility of inadequate lighting in access areas and equipment rooms.

14. Local operation of equipment during a station blackout may require the operator to bring the following items:

a) Portable lighting for visibility.
b) Keys to enter locations with electrically locked doors.
c) Portable communications equipment to maintain contact with the control room.
d) Gloves or valve operators necessary to reposition valves in areas of elevated temperatures.
e) [Plant specific items required for local operation of equipment].

FIGURE 10-1

TYPICAL POST ACCIDENT PRESSURE TEMPERATURE LIMITS

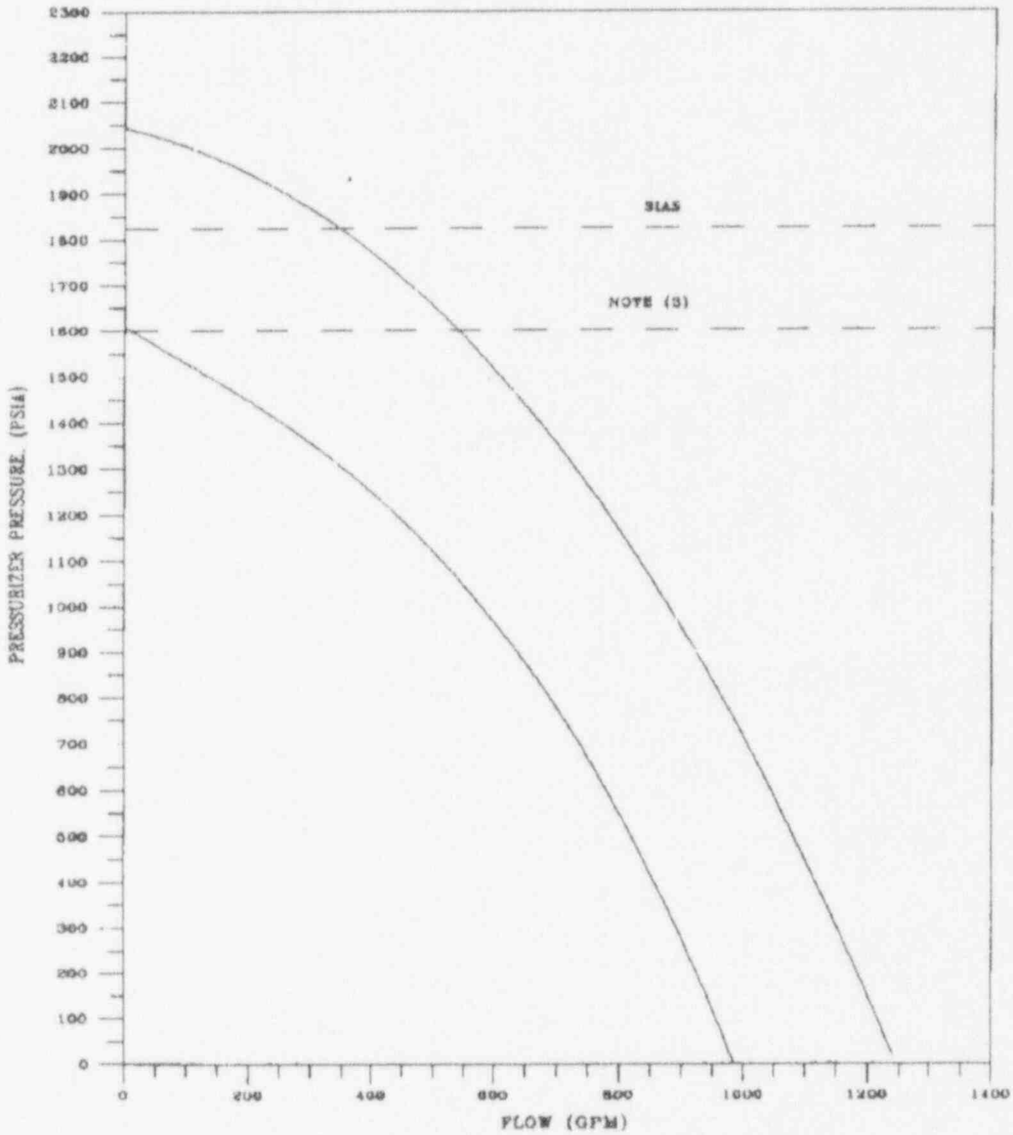


NOTES: (1) THIS CURVE SUPERSEDES THE 100° F/HR COOLDOWN CURVE ANYTIME THE RCS HAS EXPERIENCED AN UNCONTROLLED COOLDOWN WHICH CAUSES RCS TEMPERATURE TO GO BELOW 500° F. THIS CURVE IS AN OPERATIONAL LIMIT BASED ON ENGINEERING JUDGEMENT AND INTENDED TO MINIMIZE THE POTENTIAL OF A PRESSURIZED THERMAL SHOCK.

(2) THESE CURVES MUST BE ADJUSTED FOR INSTRUMENT INACCURACIES.

FIGURE 10-2

TYPICAL ACCEPTABLE SIS FLOW VS RCS PRESSURE



NOTES: (1) SEE IMPLEMENTATION SECTION FOR DEVELOPMENT OF PLANT SPECIFIC CURVE.
(2) FOR HOT LEG AND DVI INJECTION, FULL FLOW FROM SIS PUMPS 1 AND 2 IS DIRECTED TO THE HOT LEGS.
(3) BELOW THE SIAS SETPOINT, THE SIS PUMPS WILL BE OPERATING, BUT THERE WILL BE NO INJECTION FLOW UNTIL SYSTEM PRESSURE FALLS BELOW THE SHUTOFF HEAD OF THE SIS PUMPS.
(4) THESE CURVES DO NOT ACCOUNT FOR INSTRUMENTATION INACCURACIES

FIGURE 10-3

TYPICAL FEEDWATER CAPACITY VS TIME REMAINING UNIT SHUTDOWN COOLING REQUIRED

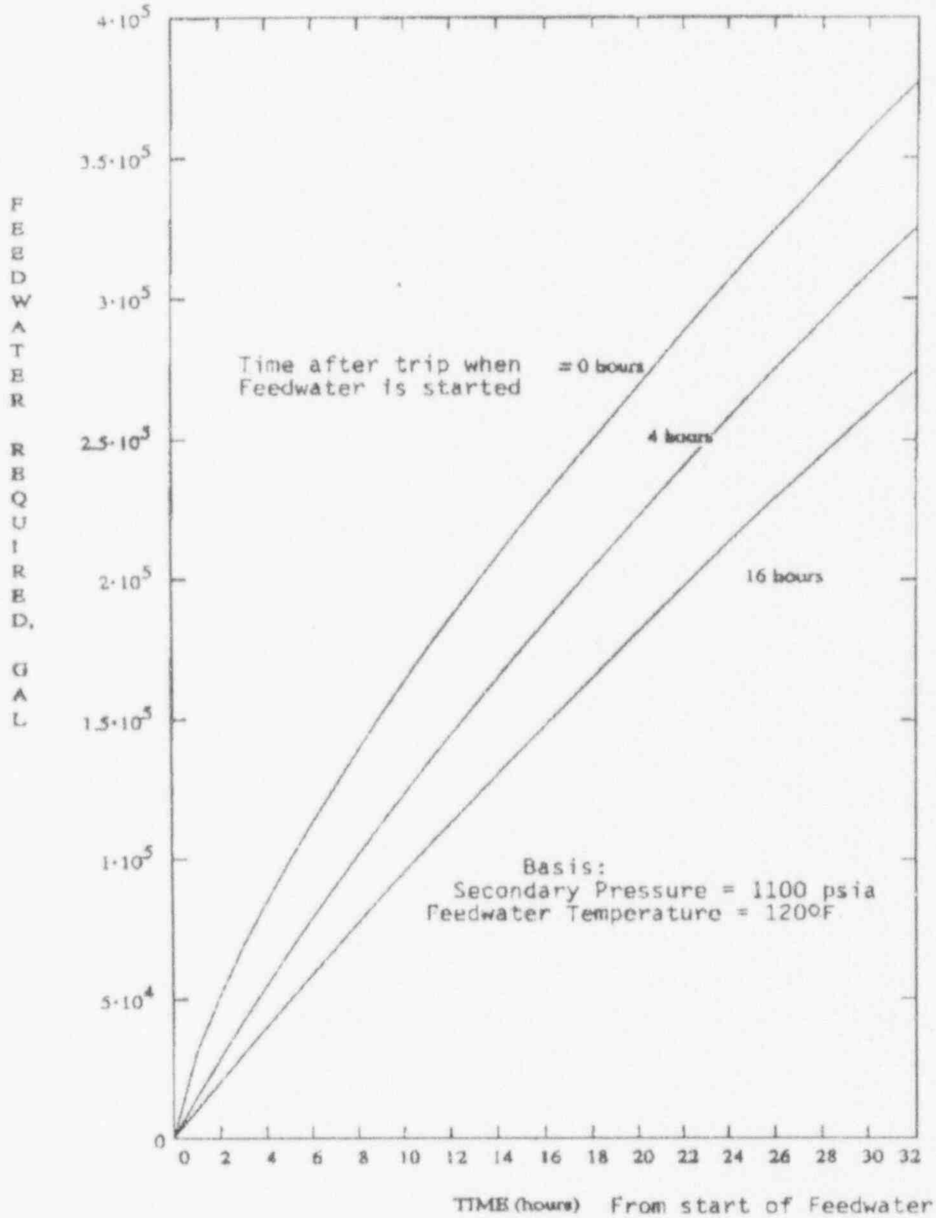
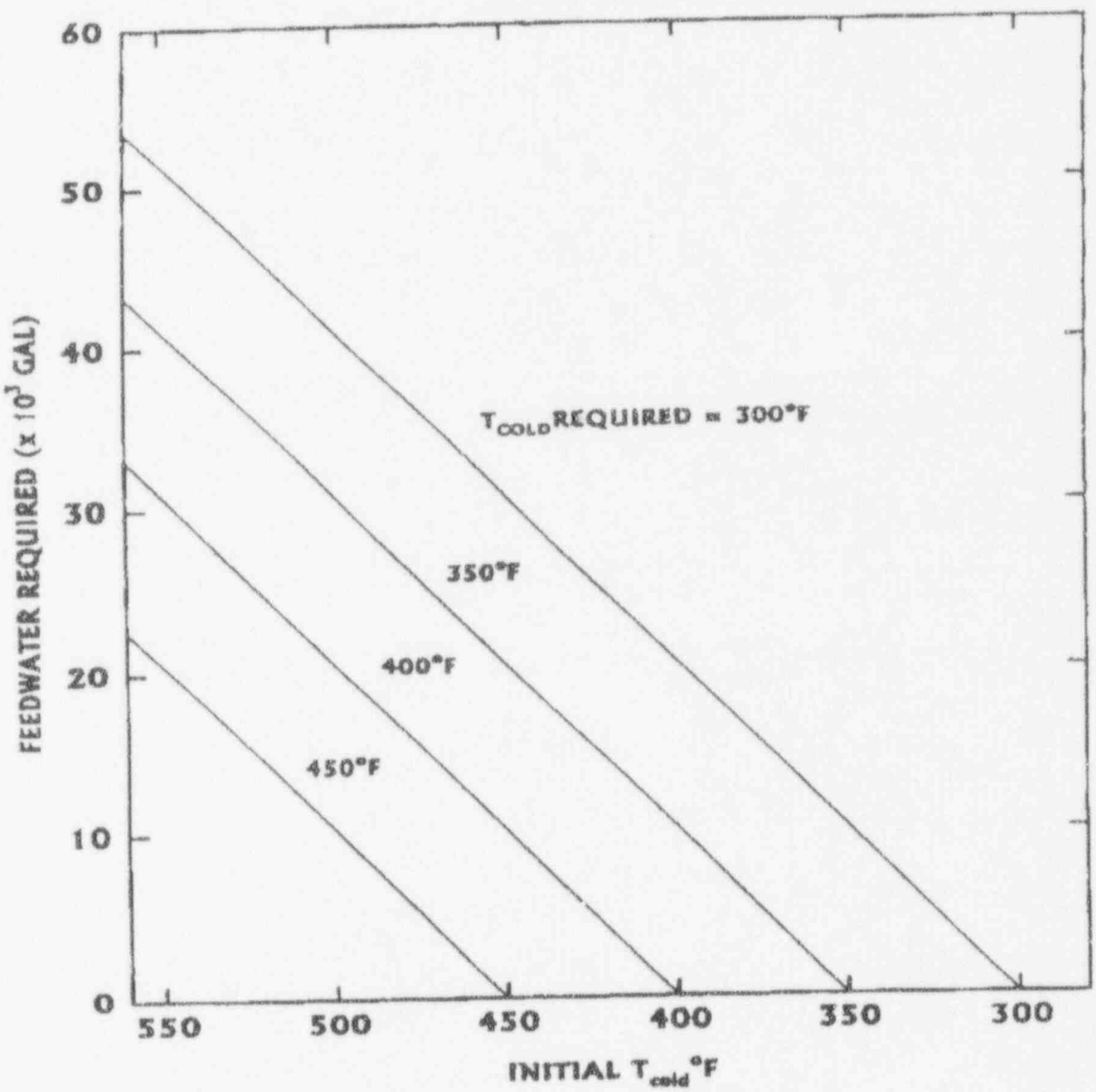


FIGURE 10-4

TYPICAL FEEDWATER REQUIRED FOR SENSIBLE HEAT REMOVAL



SAFETY FUNCTION STATUS CHECK

Safety Function	Acceptance Criteria
1. Reactivity Control	1. a. Reactor power decreasing and b. Negative Startup Rate and c. Maximum of 1 CEA not fully inserted or borated per Tech Specs.
2. Maintenance of Safety Auxiliaries (AC and DC power)	2. All vital Division I [125 V DC] and [120 V AC] Distribution Centers energized, or All vital Division II [125 V DC] and [120 V AC] Distribution Centers energized.

Safety Function	Acceptance Criteria
3. RCS Inventory Control	3. a. i) RCS is subcooled based on representative CET temperature and ii) pressurizer level is [2% to 78%] and iii) the HJTC RVLMS indicates reactor vessel level is above the top of the hot leg nozzles <u>or</u> b. i) representative CET temperature is less than superheated, and ii) the HJTC RVLMS indicates the core is covered.

Safety Function	Acceptance Criteria
4. RCS Pressure Control	4. a. Pressurizer heaters and auxiliary spray, or the charging pump and SI pumps are maintaining or restoring pressurizer pressure within the limits of Figure 10-1. or b. representative CET temperature is less than superheated.
5. Core Heat Removal	5. Representative CET temperature is less than superheated.
6. RCS Heat Removal	6. At least one steam generator has level within normal level band with feedwater available to maintain level or At least one steam generator has level being restored to the normal band by feedwater flow with level increasing or Total feedwater flow to either or both steam generators greater than [500 gpm]

Safety Function	Acceptance Criteria
7. Containment Isolation	7. a. Containment pressure less than [2.0 psig] and b. No containment area radiation monitors alarming and c. No Nuclear Annex radiation alarms and d. No steam plant activity monitors alarming. and e. No Reactor Building radiation alarms.
8. Containment Temperature & Pressure Control	8. a. Containment temperature less than [110°F] and b. Containment pressure less than [2 psig].
9. Containment Combustible Gas Control	9. a. Containment temperature less than [110°F] and b. Containment pressure less than [2 psig].

BASES

The bases section of the Station Blackout (SB) Recovery Guideline describes the SB transient in relation to the actions the operator takes during a SB. The purpose of the bases section is to provide the operators with information which will enable them to understand the reasons for, and the consequences of, the actions they take during a SB.

BACKGROUND

Regulatory Guide 1.155 was issued to provide a method acceptable to the NRC staff for complying with the Commission regulation that requires nuclear power plants to be capable of coping with a SB of at least a minimum specified duration. The guide primarily addresses three areas: (1) maintaining highly reliable AC electric power systems, (2) developing procedures and training to restore offsite and onsite emergency AC power should either one or both become unavailable, and (3) ensuring that plants can cope with a SB for some period of time based on the probability of occurrence as well as the capability for restoring AC power. Guidelines and procedures for actions to restore emergency AC when emergency AC power is unavailable should be integrated with plant specific technical guidelines and emergency operating procedures.

NUMARC 87-00 also provides guidance acceptable to the NRC for meeting the requirements of the SB rule (10 CFR 50.63). NUMARC determined that many of the concerns related to SB could be alleviated through industry initiatives to reduce overall SB risk. Among the five initiatives is Initiative 2 Procedures:

"Each utility will implement procedures at each of its site(s) for:

- (a) coping with a station blackout;
- (b) restoration of AC power following a station blackout event; and
- (c) preparing the plant for severe weather conditions (e.g, hurricanes) to reduce the likelihood and consequences of a loss of offsite power and to reduce the overall risk of a station blackout event."

NUMARC Station Blackout Initiative 2 is subdivided into three sections as follows:

2.a - Station Blackout Response Guidelines (NUMARC 87-00 Section 4.2.1)
2.b - AC Power Restoration (NUMARC 87-00 Section 4.2.2)
2.c - Severe Weather Guidelines (NUMARC 87-00 Section 4.2.3)

The SB Recovery Guideline addresses station blackout response guidelines and the restoration of AC power. It deliberately does not address actions to prepare and deal with severe weather. Severe weather actions will be taken due to conditions other than the entry conditions for emergency operating procedures.

NUMARC 87-00 Section 4.2.1 provides thirteen specific station blackout response guidelines. These NUMARC guidelines assume a single path to achieve and maintain safe shutdown conditions in a station blackout. In addition to repeated attempts at restoring AC power to a shutdown bus, the path consists of performing operations designed to stabilize the plant using available equipment.

NUMARC 87-00 Section 4.2.2 provides five specific AC power restoration guidelines. They provide guidance for operations and load dispatcher personnel concerning the proper course of action for restoring AC power in a station blackout. They also state that only plant-specific restoration strategy must consider the following issues. These issues are the maintenance of support auxiliaries to any operating diesel generators, the restoration of the battery chargers, and the prevention of inadvertent SIAS, CIAS, and/or CSAS.

NUMARC 87-00 Sections 4.2.1 and 4.2 have been significantly referenced in the development of the SBO guideline.

The SBO guideline deals with SBO coping time. While plant-specific procedures only have to deal with the minimum coping time as described in Regulatory Guide 1.155, The SBO guideline defines coping time as the time until AC power is restored or the Safety Function Status Check criteria are not met (e.g., HJTC RVLMS shows that the core is not covered or the onset of core superheating). Hence SBO guidance addresses all plant-specific minimum coping times.

Characterization of a Station Blackout

A Station Blackout event in those guidelines is an interruption of electrical power to the plant's electrical distribution system which results in a reactor trip and a concurrent loss of all station AC power. The Station Blackout has also been referred to as a loss of all AC power, or a loss of offsite power with a concurrent loss of on-site power. The definition of a station blackout in these guidelines is consistent with the definition of Station Blackout in 10 CFR 50.63.

Natural circulation and heat transfer from primary to secondary via the steam generators is the preferred method of RCS and core heat removal for this event. The natural circulation capability is the primary means of core cooling since the RCPs are unavailable to provide forced circulation and the shutdown cooling system is unavailable to provide RCS heat removal.

Safety Functions Affected

A Station Blackout affects the ability to maintain the electrical AC equipment designated as safety auxiliaries. The loss of the safety AC auxiliaries requires the operators to direct their efforts toward restoring electrical AC power and maintaining RCS heat removal capability with the systems which are not dependent on electrical AC power. All safety functions should be monitored to assure public safety and to detect changes in plant conditions which could lead to unsafe conditions.

Establishing RCS heat removal capability during a station blackout is particularly important. Methods for reactivity control, RCS pressure control, and RCS inventory control require either electrical AC power or a control of RCS heat removal such that the other safety functions can still be maintained. When electrical AC power is not available, increased emphasis on the control of heat removal is required to maintain the other safety functions. Failure to maintain any of these safety functions while electrical AC power is unavailable could lead to an interruption of adequate natural circulation flow or core cooling.

Trending of Key Parameters

Reactor Power (Figure 10-5)

Immediately following the loss of on-site and off-site AC power, a reactor and turbine trip will be initiated due to a [reactor protection system] response to the event's transient. The reactor trip causes power to decrease.

RCS Temperature (Figure 10-6)

The loss of the steam generator heat rejection capability on a turbine trip leads to a rapid increase in RCS temperature. The initial rapid increase is terminated by the opening of the main steam safety valves (MSSVs) and the insertion of the control rods. Subsequent RCS temperature responses will be controlled by heat removal via the steam generators.

RCS Pressure (Figure 10-7)

Pressurizer pressure will rapidly increase, then decrease following the reactor trip due to the changes in RCS temperature. RCS pressure will continue to decrease at a rate corresponding to the loss of RCS inventory.

Pressurizer Level (Figure 10-8)

Pressurizer level will increase, then decrease following the reactor trip. This is due to RCS inventory swell and shrink response to the RCS temperature swings and the concurrent pressurizer insurge and outsurge. Due to continued RCS inventory losses without inventory replenishment capability, pressurizer level will continue to decrease.

Reactor Vessel Level

No Reactor vessel voiding is expected to occur during a station blackout event with minimal RCS leakage. Reactor vessel voiding may occur during a sustained loss of electrical AC power as a result of RCS cooling and RCS leakage which results in a subsequent RCS depressurization.

Steam Generator Pressure (Figure 10-9)

Once the turbine stop and control valves shut following the reactor trip, steam generator pressure increases rapidly. With the turbine stop and control valves shut steam demand by the turbine ceases. Pressure will continue to increase until the steam generator's main steam safety valves (MSSVs) open. The MSSVs will cycle open and closed until steam generator pressure is controlled by the atmospheric dump valves.

Steam Generator Level (Figure 10-10)

The steam generator liquid level decreases during the transient, often below the narrow range level indication. The auxiliary feedwater flow is automatically actuated using the steam driven auxiliary feedwater pump. Level increases to approximately 30% narrow range and auxiliary feedwater is terminated automatically. This automatic action occurs within the first 5 minutes of the transient after which the operator takes control of the auxiliary feed system and attempts to maintain level in the zero power band.

FIGURE 10-5

REPRESENTATIVE STATION BLACKOUT

REACTOR POWER

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 10-6

REPRESENTATIVE STATION BLACKOUT

LOOP RCS NARROW RANGE TEMPERATURES

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 10-7
REPRESENTATIVE STATION BLACKOUT
PZR NARROW RANGE PRESSURE

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 10-8

REPRESENTATIVE STATION BLACKOUT

PZR LEVEL

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 10-9
REPRESENTATIVE STATION BLACKOUT
STEAM GENERATOR PRESSURE

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

FIGURE 10-10

REPRESENTATIVE STATION BLACKOUT

STEAM GENERATOR WIDE RANGE LEVEL

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

Guideline Strategy

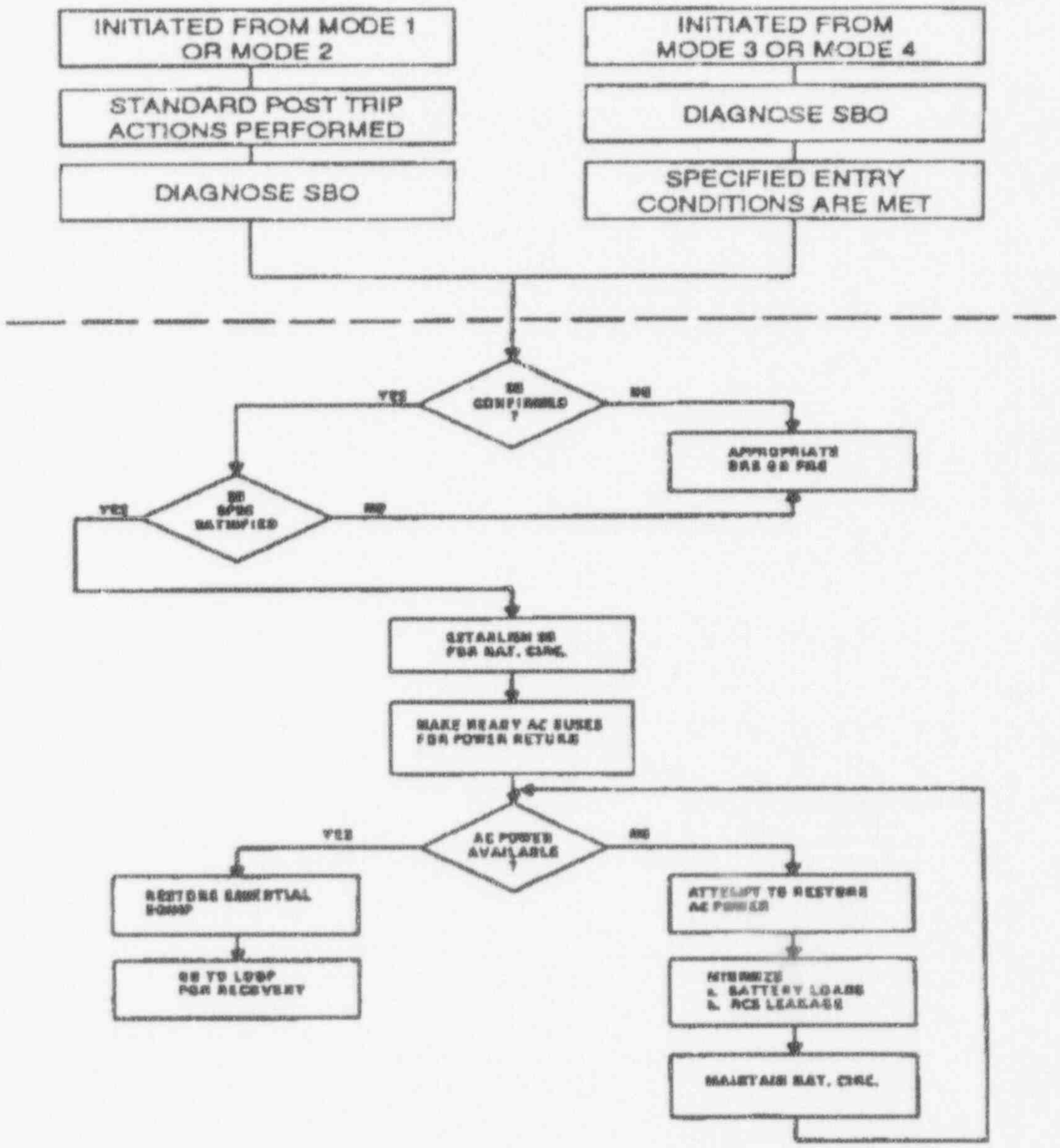
Figure 10-11 is a summary of the Station Blackout Recovery Guideline's strategy. If a SBO is initiated from MODE 1 or MODE 2, the operator performs the Standard Post Trip Actions and diagnoses the event prior to entering the SBO Recovery Guideline. However, if the event is initiated from MODE 3 or MODE 4, the operator is not directed to the Standard Post Trip Actions since they may not apply. Instead, the operator ensures that the SBO is properly diagnosed and that the specified entry conditions are met prior to entering the SBO Recovery Guideline. The Station Blackout Recovery Guideline first directs the operator to confirm the diagnosis and the status of critical safety functions using the Safety Function Status Check. The operator is then instructed to control RCS heat removal and to strip affected AC buses. The next step provides instructions to restore electrical power from either on-site emergency or off-site sources.

The strategy then directs the operator to follow one of two paths, depending on whether power is restored. One path provides for the restoration of power and safety equipment necessary for stabilization of plant conditions. The other path provides direction for the verification of natural circulation conditions and continued efforts to restore electrical power. This path provides the information operators need to perform natural circulation cooling for the purpose of extending adequate core cooling and maintaining the plant's safety functions until electrical power can be restored.

After the electrical power has been restored, direction is provided to recover the plant cooling water and ventilation systems. A determination is then made on the direction of continued operations, for which the guideline provides an exit point. Possible paths for exiting could be to the Loss of Offsite Power (LOOP) recovery guideline or an appropriate procedure as the [Plant Technical Support Center or the Plant Operations Review Committee] may direct.

FIGURE 10-11

STATION BLACKOUT STRATEGY CHART



A more detailed chart illustrates the recovery guideline strategy and lists the guideline steps which correspond to each strategy objective. Those steps which are performed at any time during the course of the event are shown by asterisks. (Refer to Figure 10-13).

Bases For Operator Actions

The operator actions are directed at achieving two objectives:

a. Establishing a source of electrical AC power and restoring, as a minimum, the plant's safety division [4.16 kV] electrical distribution within the plant specific minimum required coping time as defined in NUMARC 87-00.

b. Maintaining single phase natural circulation for as long as possible in order to simplify control of the NSSS while efforts are directed towards restoring safety division [4.16 kV] AC power. This objective is met by cooling the RCS at a rate which maintains a subcooled margin (based on a representative CET temperature). If single phase natural circulation is lost, two phase RCS heat removal is maintained with the steam generator(s) as a heat sink while trying to restore AC.

* 1. The diagnosis of a Station Blackout event is confirmed by verifying the Safety Function Status Check. The acceptance criteria evaluate the effects of the Station Blackout Guideline. If the wrong diagnosis has been made, then the operator is directed to implement the appropriate Optimal Recovery Guideline. If diagnosis of one event is not possible, then the operator is directed to implement the Functional Recovery Guideline. The Functional Recovery Guideline will ensure that all safety functions are addressed regardless of what event(s) is occurring.

* 2. RCS and Core heat removal can be maintained by using at least one steam generator for steam discharge and feeding. This is accomplished without relying on electrical AC power by ensuring the following:

a. steam generator level is being restored or maintained in the normal band to ensure effective heat removal utilizing single phase heat transfer via the SG U-tubes,

b. Emergency feedwater pump(s) (turbine driven) are capable of supplying feedwater to the steam generator(s),

c. steam generator pressure control via the preferred atmospheric dump valves (remote or local) or the MSSV(s).

3. Opening all feeder breakers and supply breakers on the de-energized [13.8] and [4.16] kV buses ensures a controlled restoration of electrical AC power in the event that the electrical source recovered has a limited load capacity or the loads are preventing the diesel generator output breaker from shutting. Opening appropriate breakers will also prevent an undesired initiation of ESF equipment if any of the PPS cabinets were de-energized to reduce battery load.

* 4. Attempts to restore electrical AC power should be directed toward restoring both the emergency diesel generator(s) or alternate AC sources. The emergency on-site diesels provide a source of electrical AC power to the safety [4.16] kV buses. This response should occur automatically. If it does not, operator actions to ensure diesel operation must be initiated. This guidance has already been provided in the SPTAs. Concurrently, alternate AC sources should be investigated and pursued as available sources to restore on-site electrical AC power. [Alternate sources can be in the form of electrical AC power from a realignment of the offsite grid, the gas turbine generator, portable AC generators, a realignment of the on-site distribution (i.e., feedback through the normal distribution paths, or receipt of electrical power from a second plant. The preferred order of the alternate sources will be plant specific.]

If electrical AC power is available, then the vital [4.16 kV] AC buses should be restored first. The vital [4.16 kV] buses will ensure pressure and inventory control can be maintained while the further restoration of electrical AC power is in progress. If electrical power is restored, the operator is directed to go to step 13.

* 5. During a station blackout event, the DC loads will be supplied by the station batteries. The battery chargers will not be available to maintain the rated battery capacity. Therefore, unnecessary loads should be stripped off the DC buses to conserve DC power.

A plant specific list of breakers to be opened should be provided in this step in the plant specific EOPs. Consideration should be given to the battery capacity, the current ratings of the safety equipment, any redundancy in the safety equipment, and the event duration. Since the DC load will be high immediately following the trip (due to the extensive automatic equipment actuation), it may be necessary to strip more loads if the vital AC buses remain de-energized to minimize the drain on the batteries. In this case, more than one list of breakers may be necessary. For a long term blackout, priority should be given to supplying DC power to only the instrumentation and equipment required to maintain the safety functions.

In developing plant-specific DC load stripping strategies, the consequences on Emergency Safeguard Feature circuit must be considered. DC load stripping can result in such signals (for example SIAS or CSAS). The restoration of AC power must address the presence of such signals.

6. Energized equipment necessary for shutdown must be protected from loss of ventilation. NUMARC 87-00 provides logic to identify equipment that will need ventilation or supplemental cooling within 30 minutes. A plant specific list of actions for rooms and cabinets requiring ventilation are to be listed in the plant specific EOPs.

   The probability of activating fire protection equipment due to elevated temperatures must be evaluated. The plant specific list of actions necessary to protect energized equipment from temperature increases must also list all steps necessary to override undesirable equipment actuation.

7. Ensuring a minimal RCS leak rate reduces the rate of depressurization attributed to RCS leakage. Minimal RCS leakage can be met by ensuring:
   a. letdown isolation valves closed,
   b. shutdown cooling RCS suction valves closed,
   c. RCP controlled bleedoff line isolation valve closed,
   d. RCS charging line isolation valve closed,

e. RCS sample line(s) isolation valves closed,
f. Rapid depressurization valves closed,

* 8. A characteristic of a station blackout is the termination of RCP operation. Once the RCPs are tripped, natural circulation RCS flow should develop within 5-15 minutes. Natural circulation flow will be ensured by maintaining RCS pressure and inventory control and using at least one steam generator for RCS heat removal.

When single phase liquid natural circulation flow is established in at least one loop, the RCS should indicate the following conditions:

a. Loop ΔT (T_H - T_c) less than normal full power ΔT,
b. Hot and cold leg temperatures constant or decreasing,
c. The RCS is subcooled based on representative temperature,
d. No abnormal differences between T_H RTDs and core exit thermocouples. Hot leg RTD temperatures should be consistent with the core exit thermocouples. Adequate natural circulation flow will be reflected by the core exit thermocouple temperatures being approximately equal to the hot leg RTD temperatures within the limits of expected instrument inaccuracies. An abnormal difference between T_H and the core exit thermocouples could be any difference greater than [10°F].

Natural circulation is a phenomenon regulated by a combination of factors. Factors which affect natural circulation include decay heat, component elevations, primary to secondary heat transfer, loop flow resistance and voiding. The component elevations on C-E plants are such that a satisfactory natural circulation decay heat removal is obtained utilizing density differences between the bottom of the core and the top of the steam generator tube sheet. These density differences are obtained when primary to secondary heat removal through the steam generator U-tubes is utilized.

If the RCS does not indicate natural circulation is occurring, the operators should ensure the systems available to support natural circulation are functioning properly. Specifically, they should verify that RCS heat removal is being controlled properly by steam generator feeding and steaming.

9. The available emergency feedwater inventory must be verified to be adequate. This can be determined from Figures 10-3 and 10-4. Alternate sources must be listed in plant specific procedures. This list should include any alternate sources required to meet the coping time established in NUMARC 87-00.

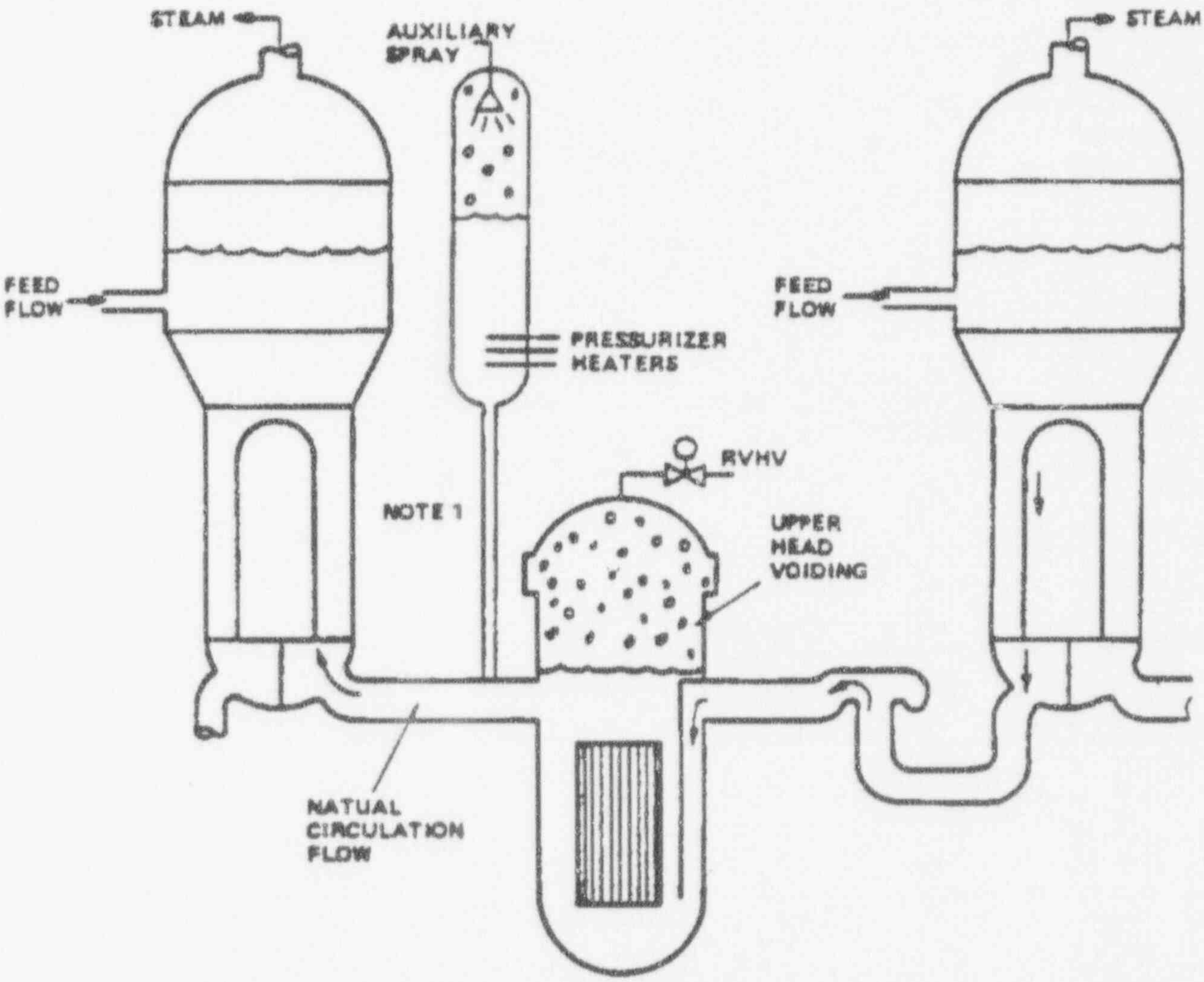
*10. The operator should maintain [1-30°F] subcooling by controlling emergency feedwater flow and steaming via the ADVs. This strategy enables the operators to maintain single phase natural circulation for as long as possible. This simplifies control of the NSSS response while efforts are directed towards restoring safety AC power. For plants with minimal RCS leakage, it should be possible to maintain HOT STANDBY conditions for [3 to 4] hours. During this time period, subcooling will slowly decrease to within the [1-30°F] range. The actions to perform a deliberate cooldown to maintain subcooling within this range will then be initiated.

RCS conditions (temperature and pressure) should be controlled by feeding at least one steam generator, utilizing the available controls of the emergency feedwater system, to restore or maintain steam generator level while discharging steam via the atmospheric dump valves. If an RCS cooldown is initiated with minimal pressurizer inventory, RCS subcooling will not be maintained. Also, if a high RCS leak rate exists, the high leak rate combined with a cooldown strategy will rapidly depressurize the plant, resulting in a loss of subcooling. Adequate core cooling can be maintained after subcooling is lost via two-phase natural circulation as described below.

During a prolonged station blackout, the natural circulation process can take different forms. These forms include single phase natural circulation and a more complex two phase natural circulation. The simplest form of natural circulation is a single phase liquid cooling. Single phase natural circulation is possible for most cases where RCS inventory and pressure are being controlled properly. Single phase cooling transports heat using the same flow path involved in forced circulation cooling with the liquid density difference between SG and RV driving the flow. Two phase natural circulation is more complex and can take several forms. Two phase natural circulation depends on the amount of decay heat, the amount of inventory and pressure control degradation, the RCS leak rate, and the status of the SIS and the steam generators. One form of two phase natural circulation is known as reflux. In the reflux process, steam leaves the core region and travels to the steam generator before reaching the top of the "U" tubes where it condenses and the condensate flows back to the core via the hot leg where it is once again turned to steam. Another two phase natural circulation process is similar to reflux but differs in that the steam from the core goes past the steam generator "U" bend and is condensed in the tubes on the cold leg side and the condensate flows back to the core via the cold leg. A combination of the two processes is also possible.

FIGURE 10-12

NATURAL CIRCULATION WITH RV HEAD VOIDING



NOTE (1): THE STEAM GENERATOR TUBES ARE AN AREA WHERE VOIDING IS POSSIBLE IF THE GENERATOR HAS BEEN ISOLATED DURING A LOFC

The operators have adequate instrumentation to monitor natural circulation for the single phase liquid natural circulation process. The RCS temperature instrumentation, namely loop ΔT, can be used along with other information to confirm that the single phase natural circulation process is effective. The natural circulation processes involving two phase cooling are complex and varied enough so that RCS loop ΔT may not be a meaningful indication of adequate natural circulation cooling.

For cases where two phase natural circulation cooling is the core heat removal process, establishing heat removal via at least one steam generator utilizing emergency feedwater and steam discharge through the atmospheric dump valve becomes more critical. The monitoring of representative CET temperature, to confirm the adequacy of the heat removal process, also becomes a critical indicator of natural circulation cooling.

Contingency actions are provided to control RCS heat removal when a forced cooldown is not possible. A forced cooldown to maintain subcooling will not be possible if:

a. The RCS cooldown rate cannot keep up with the RCS pressure losses
b. The RCS cooldown rate would have to exceed cooldown limits
c. Less than all CEAs have inserted and maintaining the reactor shutdown is in question.

If RCS subcooling cannot be maintained, then the core heat removal process will be maintained utilizing two phase natural circulation. If two phase natural circulation is utilized the operators must ensure that the following are observed:

a. steam generator feeding and steaming are properly controlled (refer to Step 3).

<u>and</u>

b. the representative CET temperature is maintained less than superheated. A superheated condition indicates that core uncovery has occurred and that the core heat removal process is no longer effective.

*11. The insertion of all the CEAs will provide more than the required shutdown margin for all C-E plants. During a station blackout until RCS pressure is reduced below SIT pressure, RCS temperature control is the only available method of controlling reactivity changes. Performing a 50°F projected shutdown margin calculation with actual plant conditions (i.e., boron concentration, actual rod worth,...) identifies whether the cooldown has the potential to challenge reactivity control. 50°F has been selected to provide the operators with sufficient lead time to stop the cooldown in advance of any problem.

*12. During a controlled cooldown and depressurization the automatic operation of certain safeguard systems is undesirable. This action also applies to a station blackout. The setpoints of MSIS and SIAS must be manually reset (lowered or bypassed) as the cooldown progresses. This ensures that automatic engineered safeguards actuation remains available (even though the components may not be availabe).

*13. When electrical power is restored, the operators should ensure that safety equipment is powered. This is done by energizing the safety buses and closing the supply breakers to the appropriate equipment. A plant specific list of the minimum required safety equipment should be provided (or referenced) in the plant specific EOPs to ensure that safety equipment is made available. This should include verifying that power is made available to one of the following means of RCP seal cooling (CCW, CVCS seal injection (SI), Dedicated Seal Injection System (DSIS).

If electrical power has not been restored, the operators are instructed to continue with the actions of steps 4 through 13. These actions will ensure that the plant is maintained in a safe condition as efforts to restore power are continued.

*14. Following the restoration of one of the safety division [4.16 kV] buses to service and the associated equipment, the operator may want to restore some non-vital equipment, such as the charging pumps, to aid in the stabilization and recovery of the plant. The permanent non-safety buses can be energized from either offsite power, the alternate AC source, or the safety division [4.16 kV] buses (listed preferentially). If any of these sources are available, the operator should energize the permanent non-safety bus. Once energized, the equipment listed (list will appear in the plant specific EOPs) should be loaded onto the bus per plant specific operating instructions. The plant specific operating instructions should ensure that the source of power to the safety division [4.16 kV] bus does not become overloaded.

15. The plant should be borated per Technical Specification limits for reactivity control purposes. A cooldown may have been performed to control RCS conditions and, prior to restoring electrical power, there is no means of restoring inventory or of borating the RCS. The RCS should be sampled for boron concentration and steps taken to ensure adequate shutdown margin.

*16. When electrical AC power has been restored, the operator is directed to ensure that the operation of the safety injection and/or available charging and letdown are maintaining RCS inventory control. The charging pump may have to be manually restarted due to the interruption of electrical power to the charging pump bus. The operators verify that adequate RCS inventory control is being maintained by all of the following criteria being satisfied:

a. SI and/or charging and letdown are operating to control pressurizer level [2% to 78%],
b. The RCS is subcooled based on representative CET temperatures (refer to Figure 10-1),
c. the HJTC RVLMS indicate reactor vessel level is above the top of the hot legs.

*17. When electrical AC power has been restored, the operators are directed to establish a method for restoring or maintaining pressurizer pressure within the Post Accident Pressure-Temperature limits of Figure 10-1. The methods available include the use of either automatic or manual operation of the pressurizer heaters and auxiliary spray, or the manual operation of the charging and/or SI. If subcooling or cooldown limits are being violated, then the operators should take actions to restore the RCS to within the P-T limits. Depending on the situation, the operator should perform the following actions as appropriate:

a. Stop the cooldown,
b. Take manual control of pressurizer pressure using RCGVS or auxiliary spray. Operate RCGVS or auxiliary spray as necessary to restore pressurizer pressure to within the P-T limits of Figure 10-1.
c. Attempt to maintain the plant in a stable pressure-temperature configuration. The cooldown may be continued, if desired, within the limits of Figure 10-1.
d. If an overpressure situation exists and is caused by SI and/or charging flow, then throttle or stop SI (refer to step 18) or charging pumps and manually control letdown to restore and maintain pressure within the Post Accident P-T limits of Figure 10-1.

18. If the SI pumps are operating, then they must continue to operate until SI termination criteria are met. Throttling of SI flow is also permissible if termination criteria are met. SI termination criteria are:
a. RCS is subcooled based on representative CET temperature (refer to Figure 10-1). Establishing subcooling ensures that the fluid surrounding the core is subcooled which ensures an adequate heat transfer medium. Voids may exist in some areas of the RCS (e.g., reactor vessel head), but are permissible as long as core heat removal is maintained.
b. Pressurizer level is greater than [14.3%] and not decreasing. A pressurizer level greater than [14.3%] and not decreasing, in conjunction with criterion (a) above, is an indication that RCS inventory control has been established.

c. At least one steam generator is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow, is available for removing RCS heat.

d. The HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles. This provides an extra margin of core coverage and, taken in conjunction with the above criteria, serves as an additional indication that adequate RCS inventory control has been established.

*19. If the criteria of step 18 cannot be maintained after the SIS pumps are throttled or stopped, then appropriate SIS pumps must be restarted and full SIS flow restored.

20. Ensuring that site service water flow through either division heat exchanger has been restored, ensures that cooling of required site components can be accomplished.

The same concerns for thermal shock of component cooling water components (see below) apply to site service water. The restoration of the site service water system must be a controlled process.

Verifying that component cooling water (CCW) flow through either division heat exchanger has been restored ensures that cooling of the required components can be accomplished.

Component Cooling Water is lost as a result of the station blackout. The restoration of cooling to the CCW heat exchanger and the CCW components must be a controlled process. Reinitiating full CCW flow with the CCW heat exchanger may cause an undesirable thermal transient to the components serviced by CCW. To avoid this, the CCW system must be restored in a controlled process.

Isolation of any loop(s) defined as non-critical CCW loop(s) is recommended as a precautionary action. The purpose of this action is to ensure protection of the RCP components cooled by CCW, specifically the RCP seals.

21. Operators should ensure the proper operation of the containment recirculation fan coolers in order to maintain containment temperature below the normal operating limit of [110°F].

The control room temperature should be maintained at [approximately 75°F] in order to limit the temperature under which the [Reactor Protective System and Engineered Safety Features Actuation System] instrumentation must operate. Once electrical power is restored to the control room [Heating/Ventilation Air Conditioning (HVAC)] system, the operators should check the control room temperature and if it is above the normal limit, ensure that the [HVAC] or the emergency air conditioning system is operating properly. Temperature control should be maintained in all safety auxiliary spaces. Once electrical power has been restored, and the [HVAC] capability is available (or can be made available), the operators should check that the temperatures are within the normal limits. In any case where the temperatures are not within normal limits, the operators should ensure that the applicable [HVAC] system is operating properly to return temperature(s) to within limits.

*22. When at least one [4.16 kV] AC safety division has been restored and all SFSC acceptance criteria are satisfied, then exit this guideline and implement either the Loss of Offsite Power (LOOP) Recovery Guideline or, if conditions warrant, another appropriate procedure (or recovery guideline) as directed by the [Plant Technical Support Center or the Plant Operations Review Committee].

Safety Function Status Checks

The Safety Function Status Check (SFSC) is used to continually verify the status of safety functions. The safety function acceptance criteria are selected from best estimate analysis to reflect the range for each parameter which would be expected following a station blackout event. If all SFSC acceptance criteria are being satisfied, then the adequacy of this guideline for mitigating the event in progress is confirmed and the health and safety of the public is ensured.

SAFETY FUNCTION STATUS CHECK BASES
STATION BLACKOUT

The safety functions and their respective acceptance criteria listed below are those used to confirm the adequacy of the SB Guideline in mitigating the event.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
1. Reactivity Control	a. Reactor Power Decreasing <u>and</u> b. Negative Startup Rate <u>and</u> c. Maximum of 1 CEA not fully inserted or borated per Tech. Specs.	For all emergency events, the reactor must be shutdown. Reactor power decreasing, in conjunction with negative startup rate, is a positive indication that reactivity control has been established. The criterion that no more than one CEA be stuck out or the RCS borated observes typical Technical Specification requirements.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
2. Maintenance of Safety Auxiliaries (AC and DC power)	All vital Division I [125 V DC] and [120 V AC] Distribution Centers energized, or All vital Division II [125 V DC] and [120 V AC] Distribution Centers energized.	A Station Blackout is the loss of offsite and onsite electrical AC sources. The criteria ensure that station batteries are available to power at least one of the redundant divisions of DC power. One DC division is required as a minimum to provide monitoring and limited control of the other safety functions.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
3. RCS Inventory	a).i) RCS is subcooled based on representative CET temperature and ii) pressurizer level [2% to 78%] and iii) The HJTC RVLMS indicates RCS level is above the top of the hot leg nozzles or b).i) representative CET temperature not superheated and ii) The HJTC RVLMS indicates the core is covered.	The value of [78%] was chosen as an upper limit to ensure an operable steam bubble in the pressurizer. A value of [2%] was chosen as the lower limit to ensure the pressurizer is not completely drained. Subcooling coexisting with a pressurizer level of [2% to 78%] indicates adequate RCS inventory control via a saturated bubble in the pressurizer. An HJTC RVLMS indication that the hot leg is covered, taken in conjunction with subcooling, is an additional indication that RCS inventory control has been established. For other cases, HJTC RVLMS indication that the core is covered and CET temperatures indicating less than superheated conditions indicates adequate core cooling during Station Blackout.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
4. RCS Pressure Control	a. Pressurizer heaters and spray, or charging and SI pumps are maintaining or restoring pressurizer pressure within the limits of Figure 10-1. or b. representative CET temperature is less then superheated.	A characteristic of a station blackout event is the inability to have positive pressure control (e.g., pressurizer heaters and spray) until power is restored. When safety AC power has been restored, the ability to control RCS pressure is re-established. Operation of PZR heaters and spray or charging and SIS pumps should be utilized to restore/maintain pressure within limits of Figure 10-1. If power is not restored then avoiding super-heated conditions satisfies this safety function.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
5. Core Heat Removal	a. Representative CET temperatures less than superheated.	When representative CET temperatures indicate superheated conditions, then core uncovery has occurred. If superheated conditions are approached the operators should review the effectiveness of earlier measures and take all possible steps to restore sufficient inventory to at least cover the core.
6. RCS Heat Removal	At least one steam generator has level within normal level band with feedwater available to maintain level or At least one steam generator has level being restored to the normal band by feedwater flow with level increasing. or Total feedwater flow to either or both steam generators greater than [500 gpm].	Once steam generator level is increasing or returned to normal band and emergency feedwater remains available to maintain that level, then RCS heat removal is being satisfied.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
7. Containment Isolation	a. Containment Pressure <[2 psig] and b. No containment area radiation monitors alarming and c. No Nuclear Annex radiation alarms and d. No steam plant activity monitors alarming. and e. No Reactor Building radiation alarms.	[2 psig] is based on the containment pressure alarm. It is not expected for the SB event that containment pressure will increase to the alarm setpoint. During a SB it is not expected that radiation will be detected inside containment or in the Nuclear Annex and Reactor Building radiation monitors. The monitors should not be alarming. Steam plant activity is an indication of a SGTR and is not anticipated for a SB.

SAFETY FUNCTION	ACCEPTANCE CRITERIA	BASES
8. Containment Temperature and Pressure Control	a. Containment temperature [<110°F] and b. Containment pressure <[2 psig].	Containment temperature is not expected to increase to [110°F] for a Station Blackout. [2 psig] is based on the containment pressure alarm. It is not expected that the pressure will reach this value during the SB event.
9. Containment Combustible Gas Control	a. Containment temperature [110°F] and b. Containment pressure <[2 psig].	Maintaining these containment conditions provides an indirect indication that the conditions required for H_2 generation do not exist.

Event Strategy

This section contains the detailed SB operator actions strategy flow chart, Figure 10-11. The flow chart pictorially depicts the strategy around which the SB guideline is built. It is intended to assist the reader in understanding the intent of the guideline writer and can be used in training. Operators should understand the major objectives of the guideline to facilitate their progress toward the guideline goals.

The strategy charts show the recovery guideline strategy in detail and list the guideline steps which correspond to each strategy objective. Some steps in the guideline may be performed at any time during the coarse of an event. These steps are shown by asterisks. The dashed boxes above the line indicate the lead-in steps performed by the operator prior to entering this recovery guideline.

FIGURE 10-13a

STATION BLACKOUT RECOVERY STRATEGY CHART

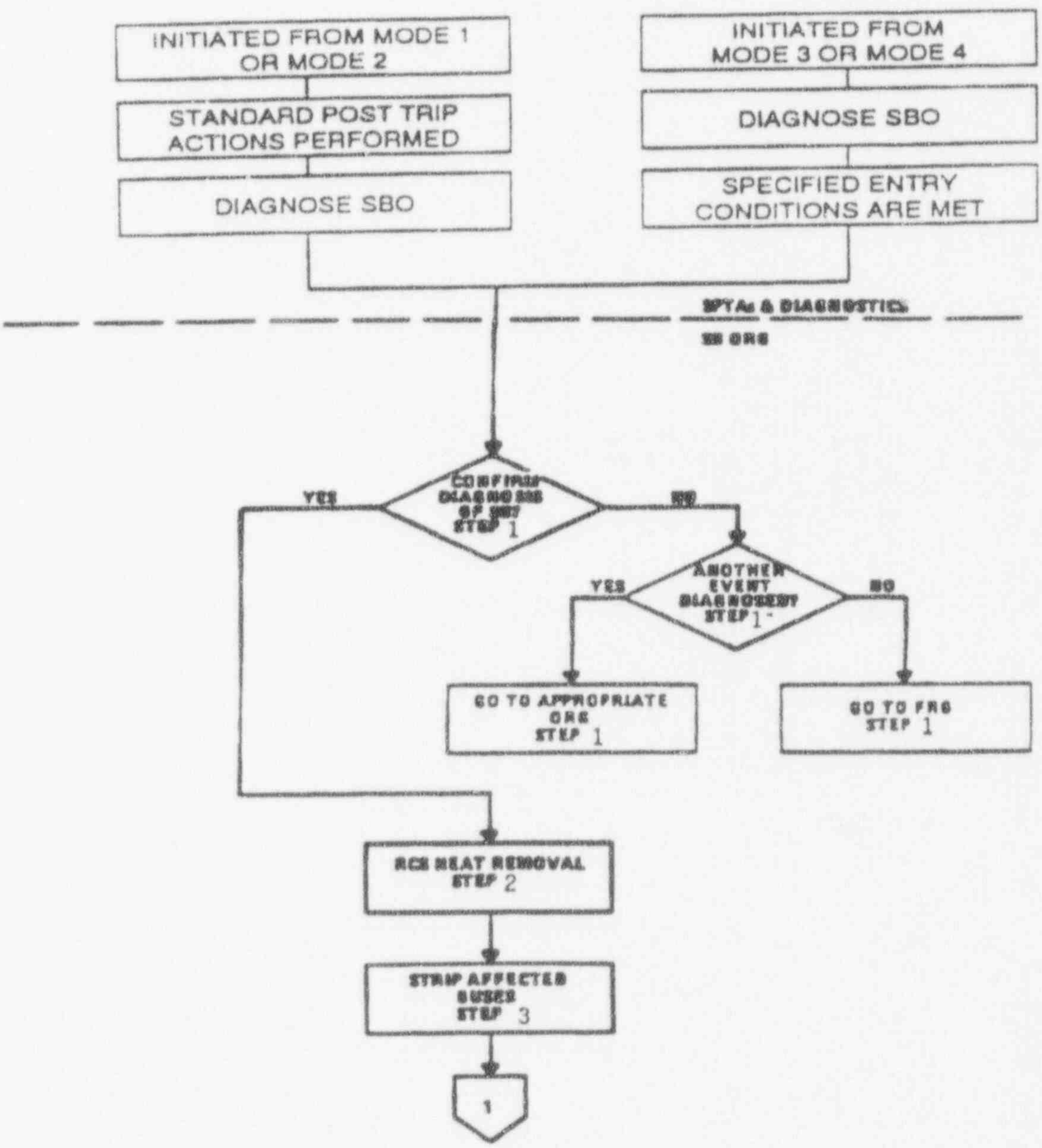
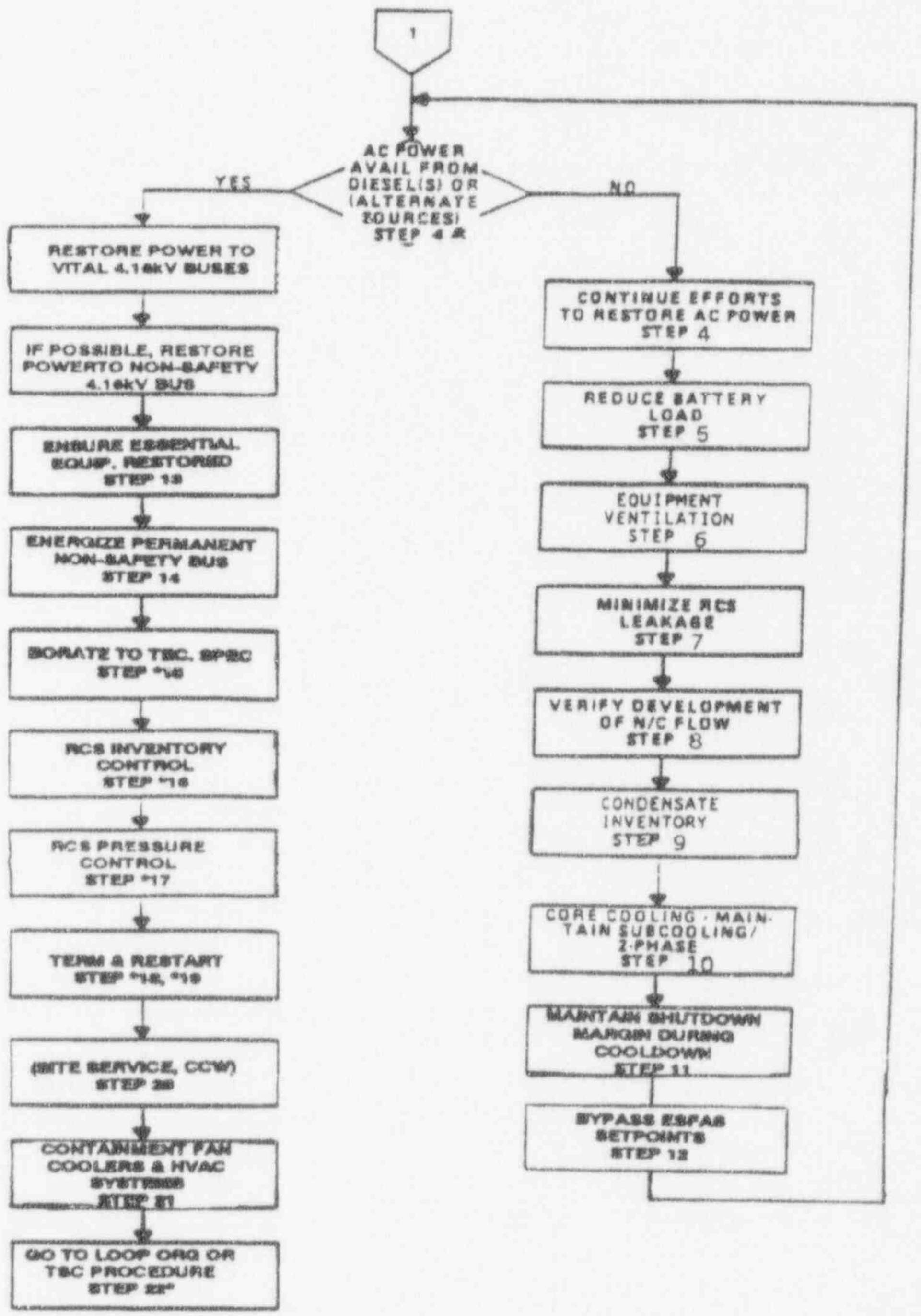


FIGURE 10-13b

STATION BLACKOUT RECOVERY STRATEGY CHART



FUNCTIONAL RECOVERY GUIDELINE

PURPOSE

This guideline provides operator actions for events in which a diagnosis is not possible, or for which emergency guidance is not available. The actions of this guideline are necessary to ensure that the plant is placed in a stable, safe condition. This guideline provides technical information to be used in developing a plant specific Functional Recovery Procedure.

ENTRY CONDITIONS

1. The Standard Post Trip Actions have been performed

   or

   All of the following conditions exist:
   a. Event initiated from Mode 3 or Mode 4,
   b. SIAS has NOT been blocked,
   c. LTOP has NOT been initiated.

   and

2. Any of the following conditions may be present:
   a. A reactor trip, and unusual concurrent symptoms, with no immediately apparent diagnosis or cause.
   b. Any condition, or pattern of symptoms, for which abnormal or emergency guidance cannot be identified.
   c. Actions taken in an Optimal Recovery Guideline are not satisfying the acceptance criteria in the Safety Function Status Check.

EXIT CONDITIONS

1. The acceptance criteria for all success paths in use are being satisfied.

   and

2. An appropriate, approved procedure to implement exists or has been approved for use.

FUNCTIONAL RECOVERY GUIDELINE ENTRY PROCEDURE

INSTRUCTIONS	CONTINGENCY ACTIONS
1. If pressurizer pressure decreases to less than [1400 psia] following an SIAS, Then do either of the following: a. If RCS is subcooled, then ensure two of the four RCPs are tripped (in opposite loops). b. If RCS is NOT subcooled, then ensure all four RCPs are tripped.	1. Continue RCP operation.
2. Determine activity levels for both steam generators from on-line sampling.	2.
3. Place the hydrogen monitors in service.	3.
4. Confirm the status of each safety function using the Safety Function Status Check by identifying success path(s) currently in use for each safety function and then checking the appropriate acceptance criteria.	4.

INSTRUCTIONS		CONTINGENCY ACTIONS
* 5.	Verify all safety functions are being satisfied, or identify those in jeopardy, by comparing control board parameters to the acceptance criteria of the Safety Function Status Check.	5.
6.	Identify plant resources or success paths, which can be used to fulfill each safety function that is not being satisfied.	6.
* 7.	If All Safety Function Status Check acceptance criteria are satisfied, Then perform appropriate OPERATOR ACTIONS for all success paths in use.	7. If any Safety Function Status Check acceptance criteria NOT satisfied, Then do the following in the order listed: a. perform OPERATOR ACTIONS for those success paths whose acceptance criteria are Not satisfied and b. perform appropriate OPERATOR ACTIONS for all success paths in use.

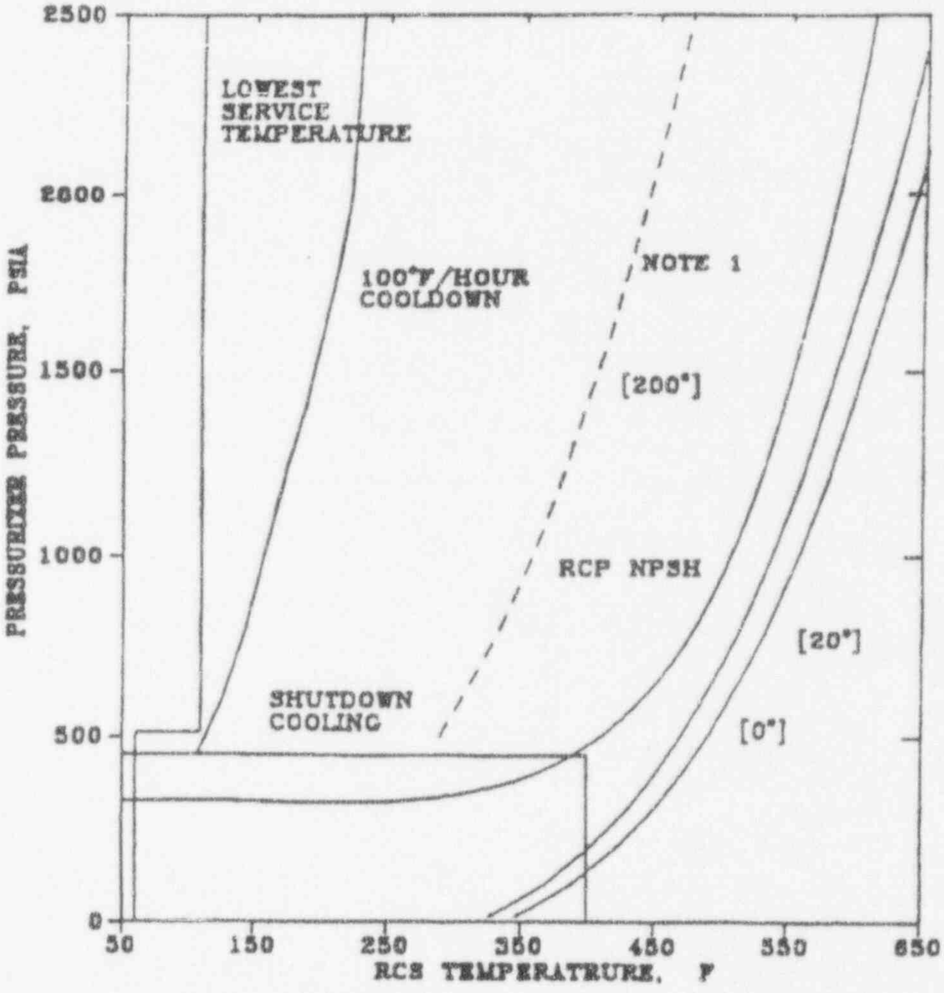
* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
* 8. Implement the Long Term Actions when the following conditions are met: a. appropriate OPERATOR ACTIONS for all success paths in use have been performed. and b. All Safety Function Status Check acceptance criteria are being satisfied.	8. Continue performing the actions of this guideline.

* Step Performed Continuously

FIGURE 11-1

TYPICAL POST ACCIDENT PRESSURE-TEMPERATURE LIMITS [2]



NOTES: (1) THIS CURVE SUPERSEDES THE 100° F/HR COOLDOWN CURVE ANYTIME THE RCS HAS EXPERIENCED AN UNCONTROLLED COOLDOWN WHICH CAUSES RCS TEMPERATURE TO GO BELOW 500° F. THIS CURVE IS AN OPERATIONAL LIMIT BASED ON ENGINEERING JUDGEMENT AND INTENDED TO MINIMIZE THE POTENTIAL OF A PRESSURIZED THERMAL SHOCK.

(2) THESE CURVES MUST BE ADJUSTED FOR INSTRUMENT INACCURACIES.

FIGURE 11-2

BREAK IDENTIFICATION CHART

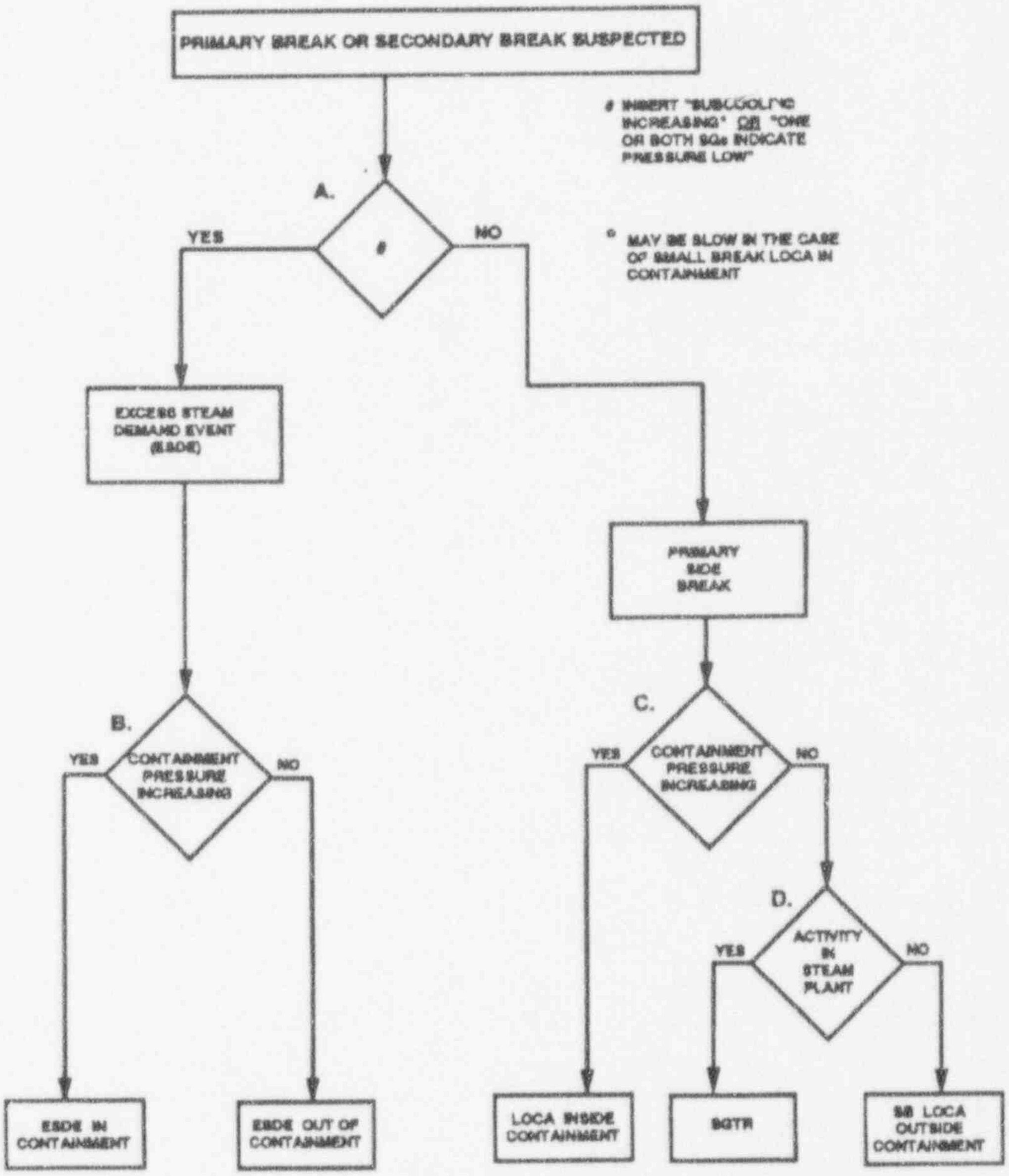
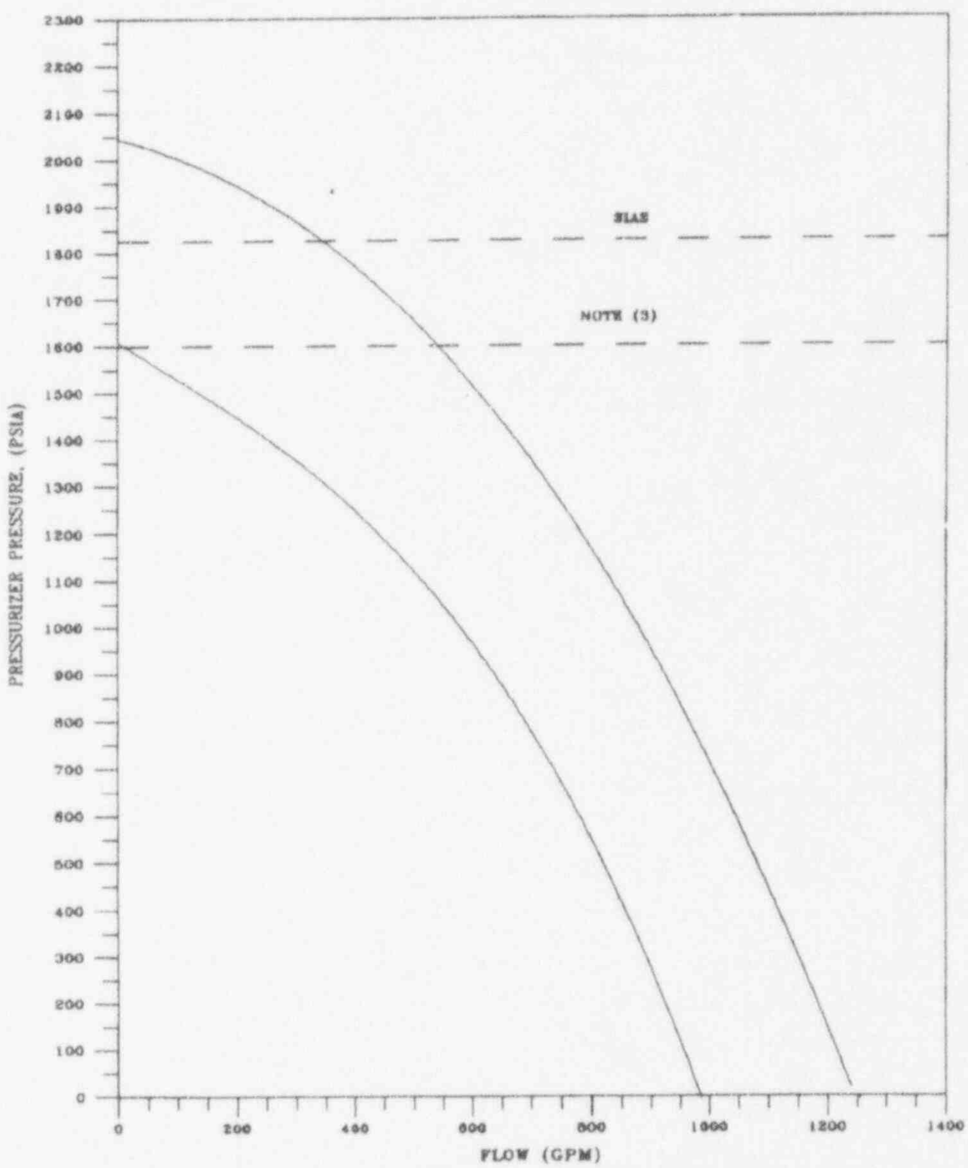


FIGURE 11-3

TYPICAL ACCEPTABLE SIS FLOW VS. RCS PRESSURE (1)

INJECTION MODE (2)



NOTES:
(1) SEE IMPLEMENTATION SECTION FOR DEVELOPMENT OF PLANT SPECIFIC CURVE.
(2) FOR HOT LEG AND DVI INJECTION, FULL FLOW FROM SIS PUMPS 1 AND 2 IS DIRECTED TO THE HOT LEGS.
(3) BELOW THE SIAS SETPOINT, THE SIS PUMPS WILL BE OPERATING, BUT THERE WILL BE NO INJECTION FLOW UNTIL SYSTEM PRESSURE FALLS BELOW THE SHUTOFF HEAD OF THE SIS PUMPS.
(4) THESE CURVES DO NOT ACCOUNT FOR INSTRUMENTATION INACCURACIES

FIGURE 11-4

TYPICAL FEEDWATER CAPACITY VS. TIME REMAINING UNTIL SHUTDOWN COOLING REQUIRED

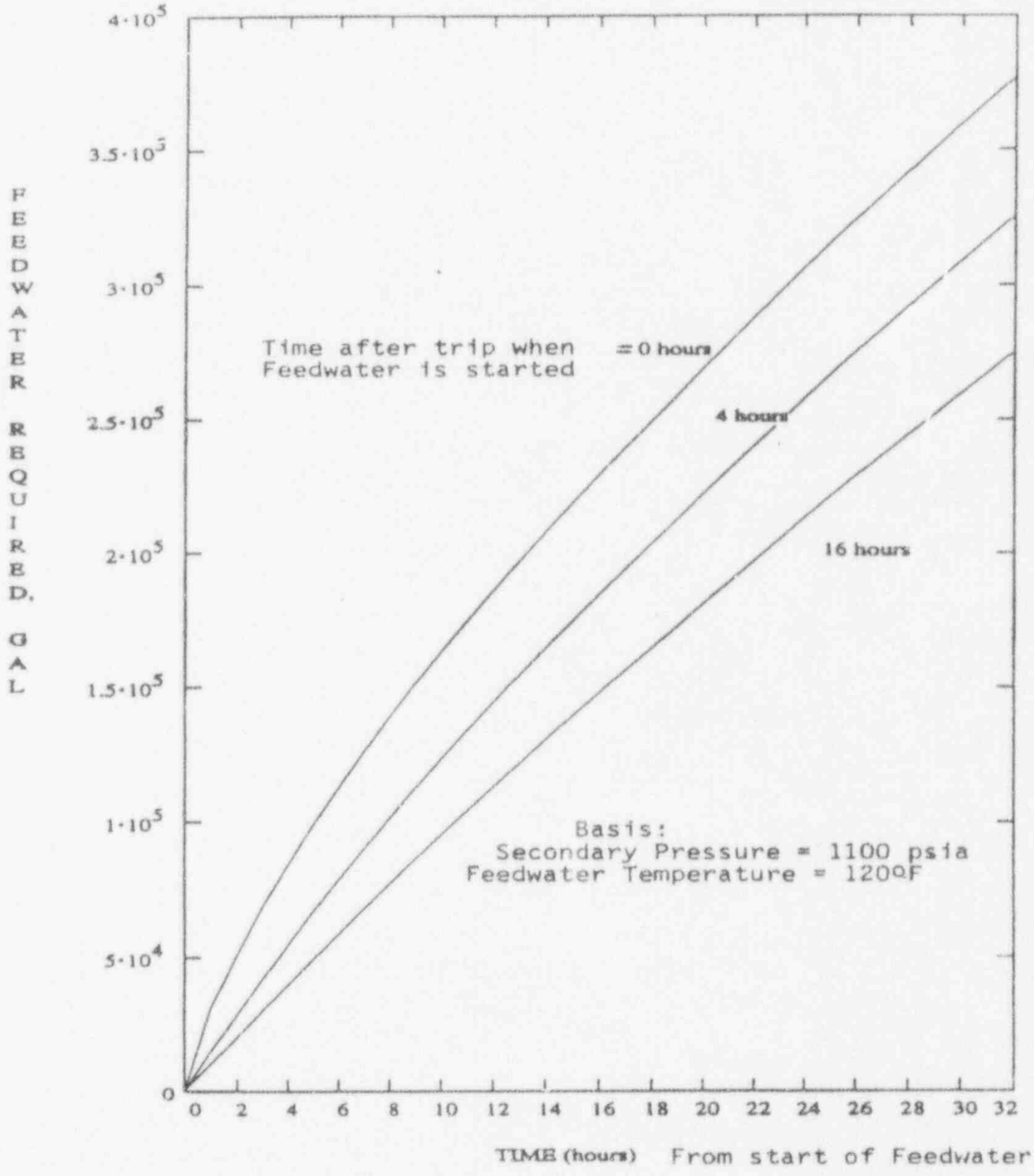
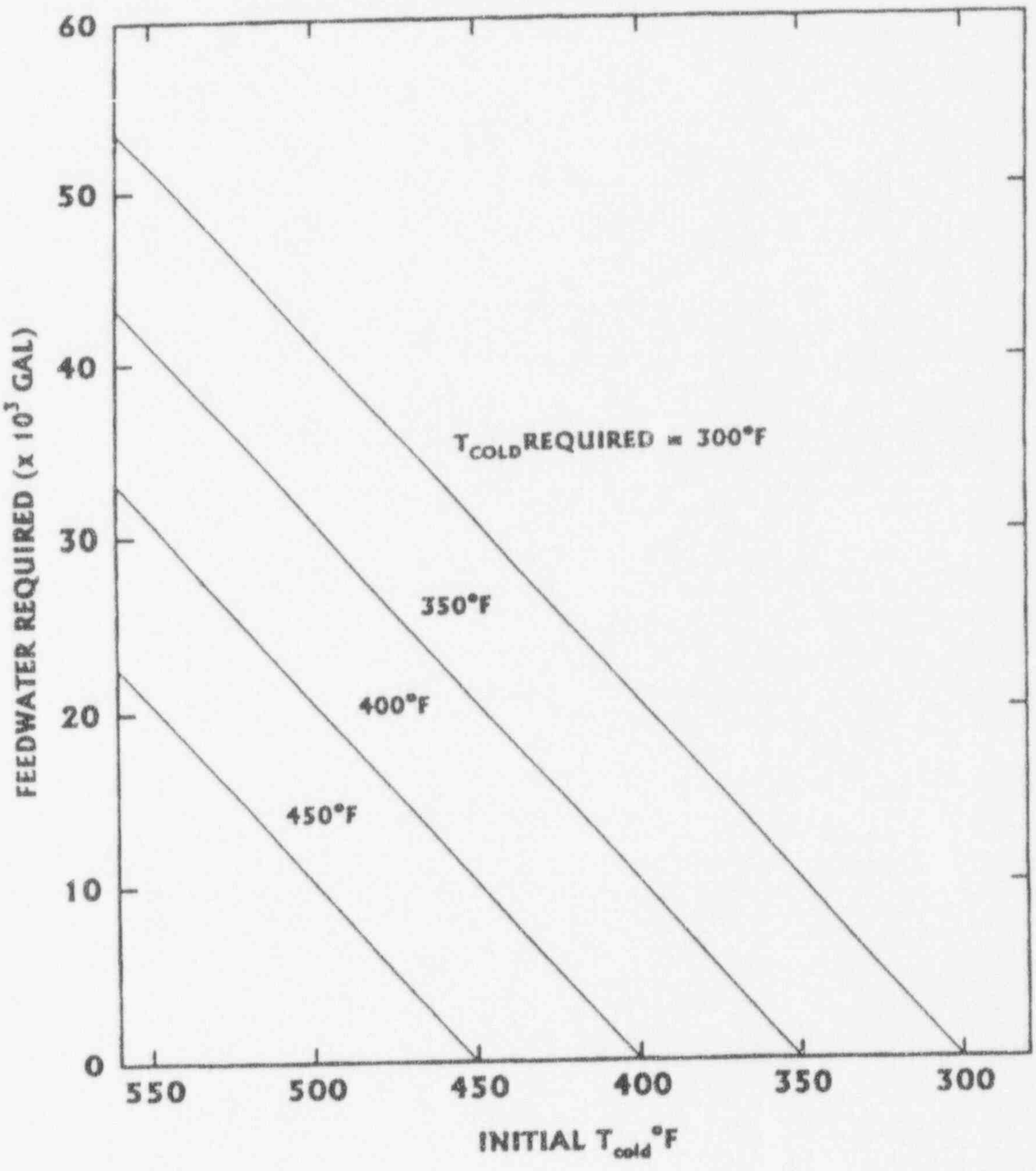


FIGURE 11-5

TYPICAL FEEDWATER REQUIRED FOR SENSIBLE HEAT REMOVAL

T_{COLD} (REQUIRED) VS. T_{COLD} (INITIAL)



Bases for Operator Actions

* 1. This step contains guidance regarding the RCP operating strategy when entering the Functional Recovery Guideline. (Figure 11-7). A generic RCP trip strategy has been developed which results in the tripping of all four RCPs for depressurization events where RCS is not subcooled, but allows the continued operation of two RCPs (in opposite loops) for depressurization events where RCS is subcooled. For undiagnosed events, where the Functional Recovery Guideline is implemented, the RCP trip strategy (Figure 11-7a) is identical to that followed in the LOCA guideline.

This operational strategy results in the operator tripping two RCPs (in opposite loops) if pressurizer pressure decreases to less than [1400 psia] following a SIAS and RCS is subcooled. This action may occur in the Standard Post Trip Actions and, in this case, the operator would simply verify that two RCPs (in opposite loops) have been tripped. The operator trips all four RCPs if pressurizer pressure decreases to less than [1400 psia] following a SIAS and RCS is not subcooled. If the operator cannot confirm that a LOCA has occurred, and the Functional Recovery Guideline is implemented, the RCP trip strategy is identical to that followed in the LOCA guideline. If the depressurization event can be diagnosed and is determined to be other than a LOCA (i.e., ESDE or SGTR), then only two RCPs (in opposite loops) are tripped. The other two RCPs remain operational until one or more of the RCP operating requirements (e.g., NPSH, temperatures, seal flow, oil pressures, motor amperage, vibration) are no longer satisfied, then, any pump which does not satisfy these requirements should be tripped. This gives the operator maximum flexibility in plant control because a normal plant cooldown can be performed while still ensuring a conservative approach to event recovery.

2. Both steam generators are sampled for activity to provide the operator with additional information for evaluating the status of the plant. The operator can use the sample results to determine whether or not RCS integrity has been breached through the steam generator. By sampling the steam generators, the

activity can be determined regardless of whether or not steam plant activity monitors are available (MSIS isolates the steam generators and may isolate the steam plant activity monitors). This information can be used in subsequent operator actions to minimize the amount of activity released to the environment.

3. The containment hydrogen monitors are placed in service in order to monitor the containment atmosphere for hydrogen gas. This will enable the operator to monitor the Containment Combustible Gas Control safety function.

4. The primary purpose of the Safety Function Status Check is to provide an assessment of all safety functions. Since the FRG may be used for a wide variety of events or combination of events, it is not possible to know in advance which success path will be the primary means of satisfying each safety function or which safety function will be most affected. Since more than one success path may be in use for each safety function, the operator should use the acceptance criteria for the highest numbered success path in use (e.g., if RCS Inventory Control success paths IC-1 (CVCS) and IC-2 (SIS) are both in use, then the acceptance criteria for IC-2 must be satisfied).

* 5. The operator is required to continually verify that all safety functions are being satisfied by comparing control board parameters to the acceptance criteria of the Safety Function Status Check. This ensures that the status of all safety functions is being monitored and that the appropriate success path acceptance criteria are being used as the plant lineup and conditions change.

If all safety functions are satisfied, then the success paths in use are adequately mitigating the effects of the event(s) which is occurring.

6. If all safety functions are not being satisfied, then the success path(s) in use is not adequately mitigating the event(s) which is occurring. For each safety function not being satisfied, the operator can identify plant resources or success paths based on plant status and equipment availability. More than one success path may be employed for each safety function in order to satisfy the

acceptance criteria of the highest numbered success path in use. Limits have been developed for each component of the success path which permit the operator to monitor the control board to decide if that success path is available. Once an available success path has been identified, the operator should refer to an operator action guideline.

* 7. If the operator determines that all Safety Function Status Check acceptance criteria are being satisfied, then the appropriate operator actions should be performed for the success path currently in use. This is done despite the fact that the acceptance criteria are being satisfied because there may be trends or conditions which may eventually place the safety function(s) in jeopardy. The operator actions associated with the success path in use contain guidance to enable those safety functions to continue to satisfy their acceptance criteria by maintaining satisfactory operation of those success paths.

In the event that any SFSC acceptance criteria are not satisfied, the operator's first priority is to perform the operator actions for the success paths of the safety functions not being satisfied. The operator actions section(s) contain specific actions to implement success paths for each safety function. Also provided are acceptance criteria for that safety function and a supplementary information section. Additional contingency guidance is provided for situations where the safety functions are not being satisfied even after implementing the available success paths (plant resources). The success path operator actions provide step-by-step operational guidance and acceptance criteria for determining the successful control of a safety function. Each operator action section contains all of the feasible actions for recovering control of a safety function. Acceptance criteria are included for determining the degree of success achieved. Additional guidance is provided which aids the operators in determining their next course of action. For instance, if control of the safety function is achieved, they may be instructed to proceed to the next safety function in jeopardy. Alternatively, if control is not achieved, they may be told to implement another success path. After the operators have performed the operator actions for the safety functions(s) not being satisfied, the appropriate operator actions for all success paths in use must be performed. The reasons for this have been discussed previously.

* 8. When operator actions for all success paths in use have been performed and all Safety Function Status Check acceptance criteria are being satisfied, the operator implements the Long Term Actions. In this section of the Functional Recovery Guideline, the operator attempts to systematically evaluate the plant status to determine what the cause of the emergency was, what course of action to take (e.g., proceed to cold shutdown), and what further emergency guidance is available. The operator continues to verify the adequate maintenance of safety functions, assesses the status of the plant and, if possible and applicable, implements an Optimal Recovery Guideline or another approved procedure.

FIGURE 11-6a

STRATEGY CHART FOR FUNCTIONAL RECOVERY GUIDELINE

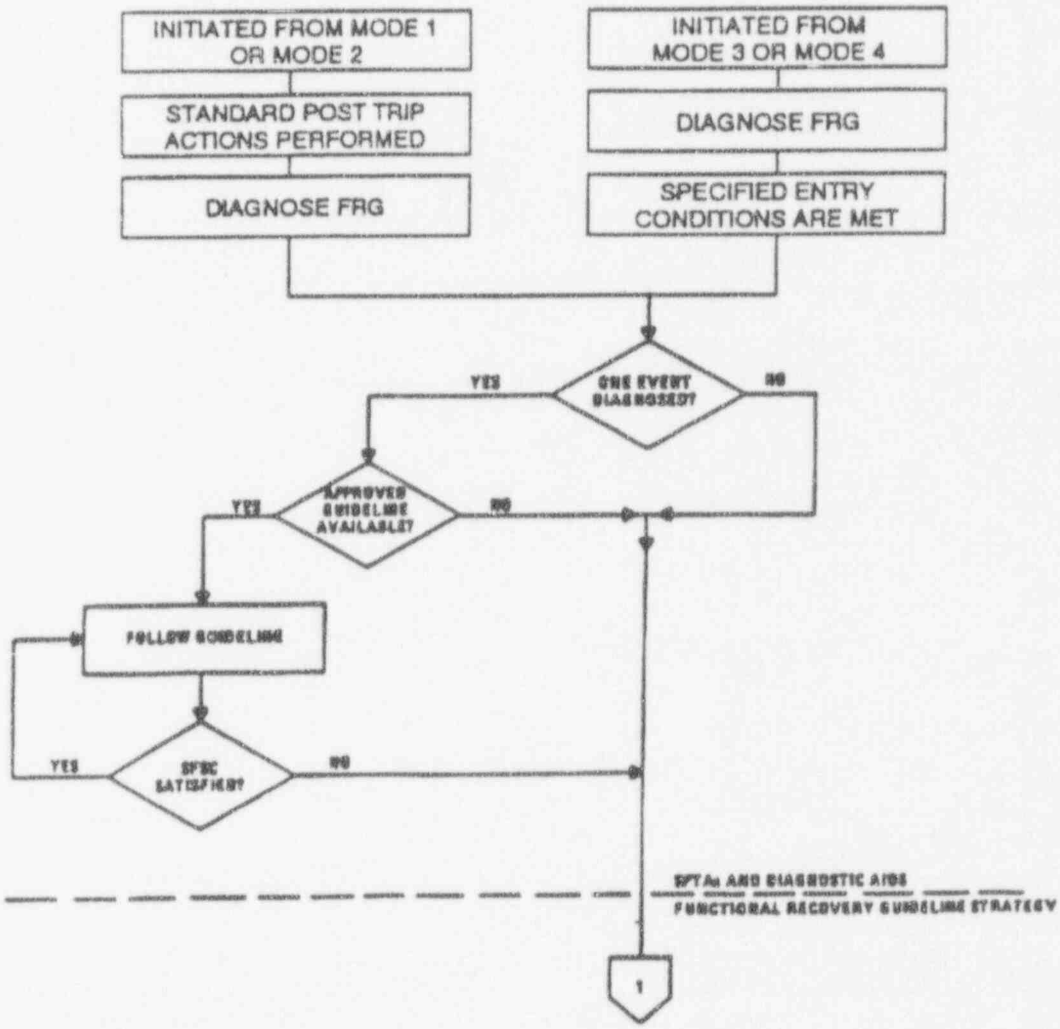


FIGURE 11-6b

STRATEGY CHART FOR FUNCTIONAL RECOVERY GUIDELINE

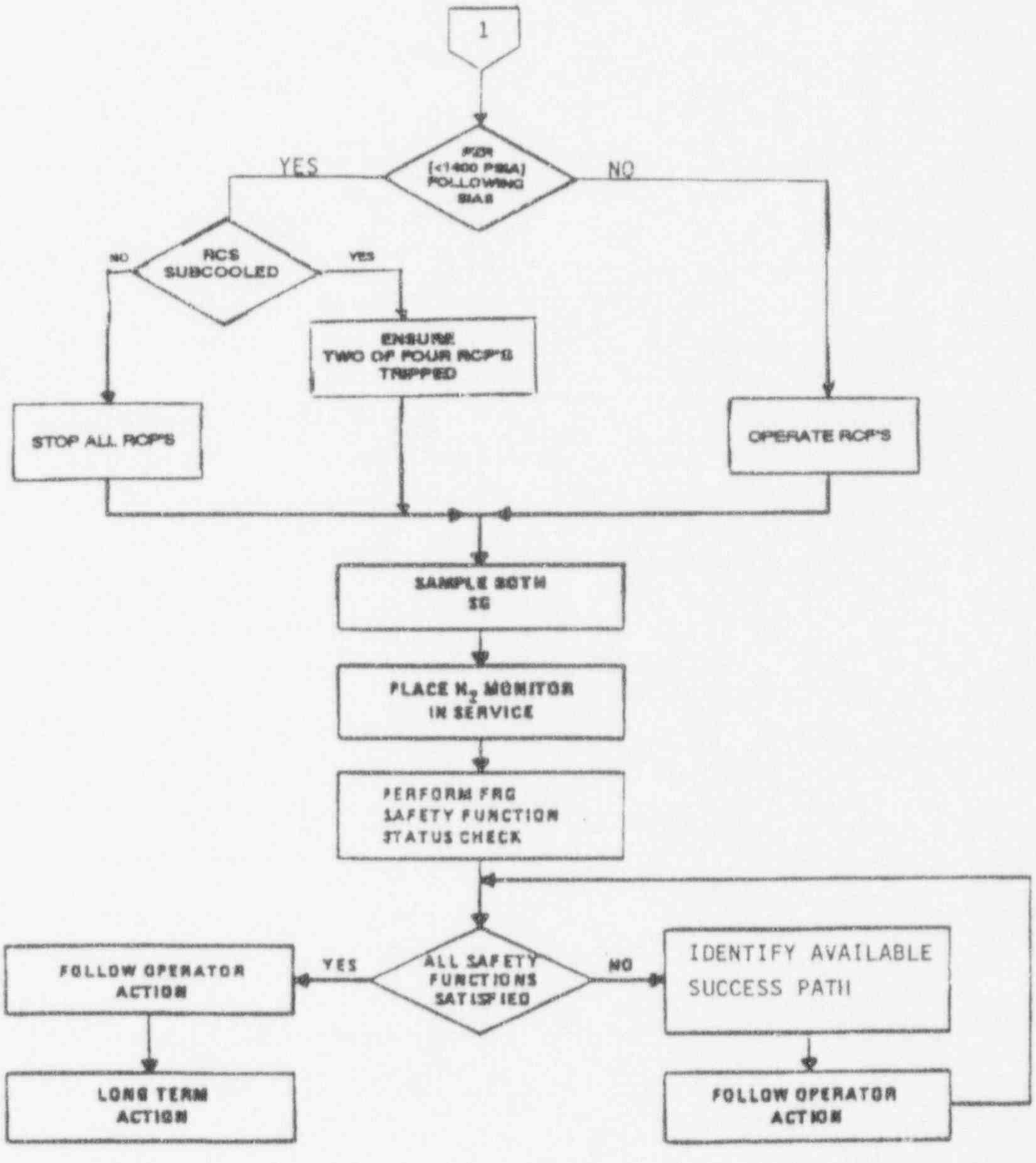
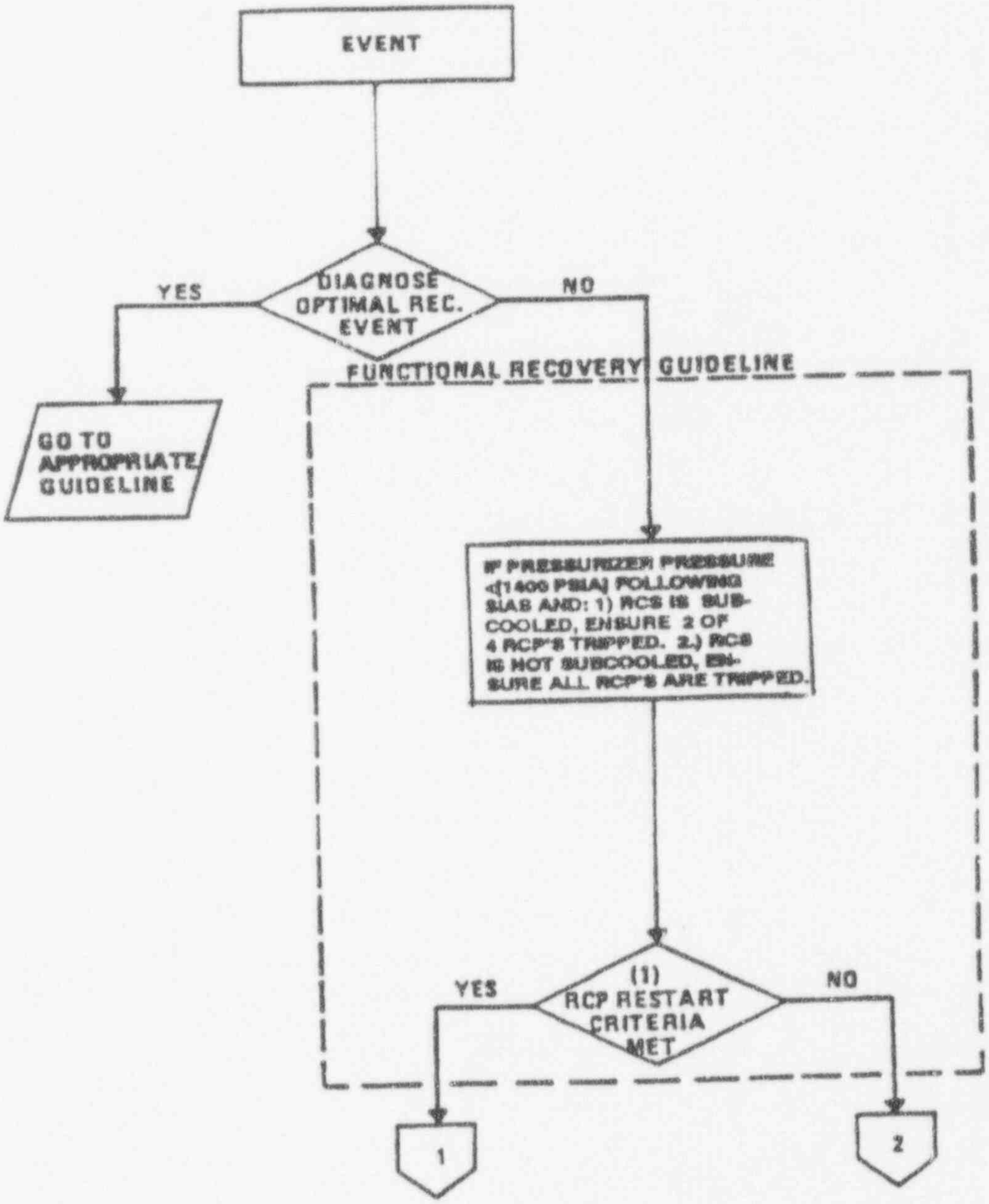


FIGURE 11-7a

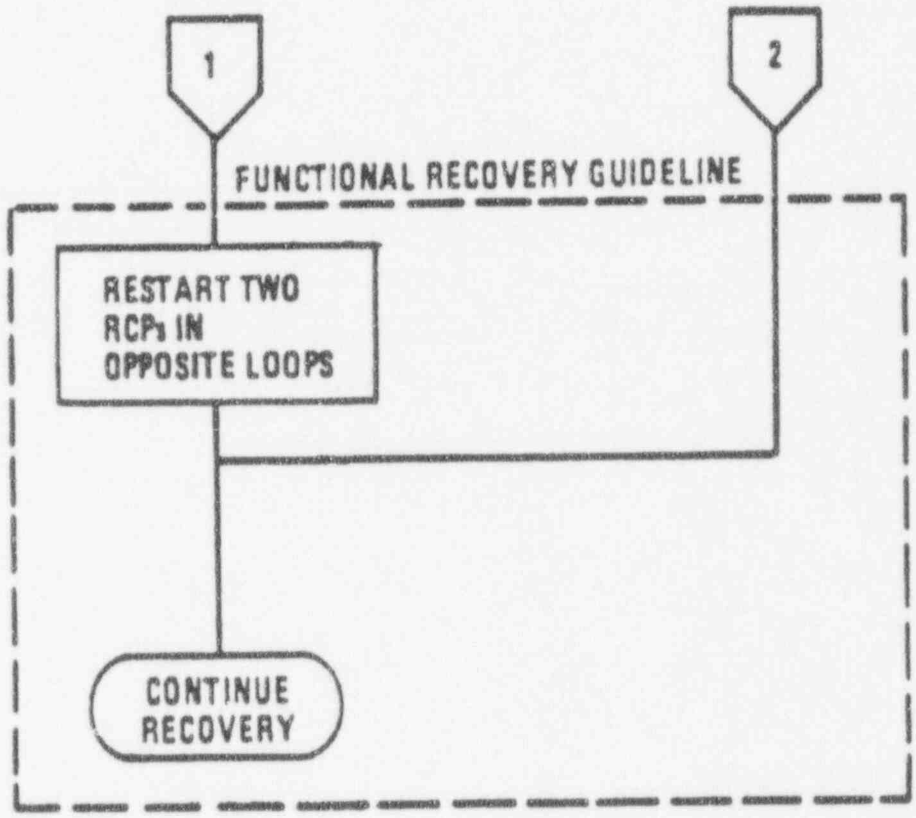
RCP TRIP STRATEGY FOR FUNCTIONAL RECOVERY GUIDELINE



(1) STEP PERFORMED CONTINUOUSLY

FIGURE 11-7b

FUNCTIONAL RECOVERY GUIDELINE



SAFETY FUNCTION STATUS CHECK

SAFETY FUNCTION

1. REACTIVITY CONTROL

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA
RC-1: CEA Insertion	a. Maximum of 1 CEA not fully inserted and reactor power decreasing or b. Reactor power less than [10^{-8}] and constant or decreasing.
RC-2: Boration Using CVCS	a. Boron addition rate greater than [40 gpm] and reactor power decreasing or b. Reactor power less than [10^{-8}] and constant or decreasing or c. Adequate shutdown margin established per Technical Specifications and reactor power constant or decreasing.

SAFETY FUNCTION

1. REACTIVITY CONTROL (Continued)

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA
RC-3: Boration Using SIS	a. Boron addition rate greater than [40 gpm] and reactor power decreasing or b. Reactor power less than [10^{-8}%] and constant or decreasing or c. Adequate shutdown margin established per Technical Specifications and reactor power constant or decreasing.
RC-4: CEA Drive Down	a. Maximum of 1 CEA not fully inserted and reactor power decreasing or b. Reactor power less than [10^{-8}%] and constant or decreasing.

SAFETY FUNCTION

2. MAINTENANCE OF VITAL AUXILIARIES (AC and DC Power)(1)

2.1 MAINTENANCE OF VITAL AC POWER

SUCCESS PATHS CURRENTLY IN USE	ACCEPTANCE CRITERIA
MVAC-1: Unit Auxiliary Transformers MVAC-2: Emergency Diesel Generator MVAC-3: Reserve Auxiliary Transformer MVAC-4: Alternate AC Source	At least one [4.16 kV AC] Safety Division energized.

SAFETY FUNCTION

2. MAINTENANCE OF VITAL AUXILIARIES (AC and DC Power)[1]

2.2 MAINTENANCE OF VITAL DC POWER

MVDC-1: Battery Chargers/Station Batteries	All [125 V] DC and [120 V] AC distribution centers energized in at least one Safety Division

[1] Maintenance of Vital Auxiliaries safety function is satisifed only if Vital AC, Vital AC I&C, and Vital DC have distribution centers in the same Safety Division energized.

SAFETY FUNCTION

3. RCS INVENTORY CONTROL

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA
IC-1: CVCS	a. Pressurizer level is [2% to 78%] *and* b. The RCS is subcooled, *and* c. The RVLMS indicates the core is covered.
IC-2: SIS	a. Available charging pump is operating and SIS pump(s) are injecting water into the RCS per Figure 11-3 (unless SIS termination criteria met, *and* b. The RVLMS indicates the core is covered.

* If the RCS is in a solid condition for pressure control, then the limit of [78%] may be exceeded.

SAFETY FUNCTION

4. RCS PRESSURE CONTROL

SUCCESSS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA
PC-1: Pressurizer Heaters and and Spray	a. Pressurizer pressure is within the Post Accident P-T limits of Figure 11-1.
PC-2: CVCS	a. Pressurizer pressure is within the Post Accident P-T limits of Figure 11-1.
PC-3: SIS	a. The available charging pump is operating and the SIS pump is injecting water into the RCS per Figure 11-3 (unless SIS termination criteria met.
PC-4: Forced Circulation with Controlled Steaming	a. Pressurizer pressure is within the Post Accident P-T limits of Figure 11-1.
PC-5: Natural Circulation with Controlled Steaming	a. Pressurizer pressure is within the Post Accident P-T limits of Figure 11-1.

SAFETY FUNCTION

4. RCS PRESSURE CONTROL (Continued)

SUCCESSS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA
PC-6: SDS	a. Pressurizer pressure is: i) less than [2360 psia] and constant or decreasing and ii) within the Post Accident P-T limits of Figure 11-1].[1]

[1] RCS Subcooling is NOT applicable when RDS valves are open

SAFETY FUNCTION

5. RCS AND CORE HEAT REMOVAL

SUCCESSS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA
HR-1: Forced Circulation, No SIS Operation	a. At least one SG has level: i) within the normal level band with feedwater available to maintain the level or ii) being restored by a feedwater flow with level increasing. and b. T_H - T_c is less than [3°F] and not increasing and c. T_{ave} is less than [567°F] and not increasing and d. The RCS is subcooled by using T_H RTD. and e. No reactor vessel voiding as indicated by the RVLMS.

SAFETY FUNCTION

5. RCS AND CORE HEAT REMOVAL (Continued)

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA
HR-2: Natural Circulation, No SIS Operation	a.i) At least one steam generator has level within normal level band with feedwater available to maintain level or ii) At least one steam generator has level being restored to the normal band by feedwater flow with level increasing or iii) Total feedwater flow to either or both steam generators greater than [500 gpm] b. T_H - T_c less than [59°F] and not increasing and c. T_{ave} is less than [567°F] and not increasing and d. The RCS is subcooled based on representative CET. and e. No abnormal difference greater than 10°F between T_H RTDs and CETs.

SAFETY FUNCTION

5. RCS AND CORE HEAT REMOVAL (Continued)

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA
HR-3: SG Heat Sink with SIS Operating	a. At least one SG has level: i) within the normal level band with feedwater available to maintain the level or ii) being restored by a feedwater flow with level increasing. and b. Representative CET temperature less than superheated and c. Available charging pump is operating and the SIS pumps are injecting water into the RCS per Figure 11-3 (unless SIS termination criteria met)

SAFETY FUNCTION

5. RCS AND CORE HEAT REMOVAL (Continued)

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA
HR-4: Once-Through-Cooling	a. Representative CET temperature less than superheated and b. Available charging pump is operating and the SIS pumps are injecting water into the RCS per Figure 11-3 (unless SIS termination criteria met) and c. Pressurizer pressure is less than [2055 psia] or decreasing.
HR-5: Shutdown Cooling System	a. Normal SCS Parameters Exist

SAFETY FUNCTION

6. CONTAINMENT ISOLATION

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA
CI-1: Automatic/Manual Isolation	a. i) No steam plant activity alarms and ii) No containment radiation alarms and iii) No nuclear annex radiation alarms and iv) No Reactor Building radiation alarms. and v) Containment pressure less than [2.7 psig] or b. Each containment penetration not required to be open has its isolation valve closed.

SAFETY FUNCTION

7. CONTAINMENT TEMPERATURE & PRESSURE CONTROL

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA
CTPC-1: Containment Fans	a. Containment temperature less than [220°F] and b. Containment pressure less than [2.0 psig].
CTPC-2: Containment Spray	a. One containment spray headers ≥ [5000 gpm] and b. Containment temperature and pressure constant or decreasing.

SAFETY FUNCTION

8. CONTAINMENT COMBUSTIBLE GAS CONTROL

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA
CCGC-1: Hydrogen Recombiners	a. Hydrogen concentration less than 0.5% or b. i) All available hydrogen recombiners are energized and ii) Hydrogen concentration is less than 4%.
CCGC-2: Hydrogen Purge System	a. Hydrogen purge system operating in accordance with plant specific operating instructions.

SAFETY FUNCTION STATUS CHECK BASES
FUNCTIONAL RECOVERY GUIDELINE

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA	BASES
1. <u>SAFETY FUNCTION: REACTIVITY CONTROL</u>		
RC-1: CEA Insertion	a. Maximum of 1 CEA not fully inserted and reactor power decreasing <u>or</u> b. Reactor power < [10^{-8}%] and constand or decreasing.	The criterion that no more bottom light not lit than 1 CEA be stuck out observes typical Tech Spec. requirements. This criterion, along with decreasing reactor power ensures that reactivity control has been established. Reactivity control can also be assured by verification of a reactor power level that is less than the maximum expected sub-critical multiplication level and constant or decreasing. Reactor shutdown can also be assured by the minimum boration rate accompanied by decreasing reactor power.
RC-2: Boration Using CVCS	a. Boron addition rate > [40 gpm] and reactor power decreasing <u>or</u> b. Reactor power < [10^{-8}%] and constant or decreasing <u>or</u> c. Adequate shutdown margin stablished per Technical Specifications and reactor power constant or decreasing.	

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA	BASES
1. SAFETY FUNCTION: REACTIVITY CONTROL (Continued)		
RC-3: Boration Using SIS	a. Boron addition rate > [40 gpm] and reactor power decreasing or b. Reactor power < [10^{-8}%] and constant or decreasing. or c. Adequate shutdown margin established per Technical Specifications and reactor power constant or decreasing.	If RCS boron samples indicate that Tech Spec shutdown margin has been established, and reactor power is constant or decreasing, then the reactivity control safety function is satisfied.
RC-4: CEA Drive Down	a. Maximum of 1 CEA NOT fully inserted and reactor power decreasing. or b. Rx power < [10^{-8}%] and constant or decreasing	

SUCCESS PATH CURRENTLY IN USE		ACCEPTANCE CRITERIA	BASES

2. SAFETY FUNCTION: MAINTENANCE OF VITAL AUXILIARIES (AC & DC POWER)

2.1 MAINTENANCE OF VITAL AC POWER

MVAC-1:	Unit Auxiliary Transformers or	All vital Division I [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized, or All vital Division II [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized.	AC power must be available to a full complement of safety related components in order to ensure that the minimum Engineered Safeguard loads can operate as designed.
MVAC-2:	Emergency Diesel Generators or		
MVAC-3:	Reserve Auxiliary Transformer or		
MVAC-4:	Alternate AC source		

SUCCESS PATH CURRENTLY IN USE		ACCEPTANCE CRITERIA	BASES

2. SAFETY FUNCTION: MAINTENANCE OF VITAL AUXILIARIES (AC & DC POWER)

2.2 MAINTENANCE OF VITAL DC POWER

MVDC-1:	Battery Chargers/Station Batteries (Continued)	All vital Division I [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized, or All vital Division II [4.16 kV AC], [125 V DC], and [120 V AC] Distribution Centers energized.	One safety division of [125 V] DC which includes at least one bus of [120 V] AC is required as a minimum to provide for monitoring and limited control of parameters/components associated with the other safety functions.

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA	BASES
3. SAFETY FUNCTION: RCS INVENTORY CONTROL		
IC-1: CVCS	a. Pressurizer level is [2% to 78%] and b. The RCS is subcooled and c. The RVLMS indicates the core is covered.	A value of [78%] was chosen as an upper limit for pressurizer level to ensure an operable steam bubble is present in the pressurizer. The value of [78%] can be exceeded if the RCS is in a solid condition for pressure control. A value of [2%] was chosen as a lower limit to ensure a measurable level in the pressurizer. Subcooling ensures the core covered with a subcooled fluid, thus ensuring adequate core cooling. An RVLMS indication that the core is covered, taken in conjunction with the other criteria, serves as an additional indication of adequate RCS inventory control.

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA	BASES

3. SAFETY FUNCTION: RCS INVENTORY CONTROL (Continued)

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA	BASES
IC-2: SIS	a. The available charging pump is operating and SIS pumps are injecting water into the RCS per Figure 11-3 (unless SIS termination criteria met). and b. The RVLMS indicates the core is covered.	When the SIS is operating, its performance adequacy is judged by its delivery flow versus RCS pressure. Once SIS flow has been changed due to stopping/throttling flow, then Figure 11-3 is no longer applicable. An RVLMS indication that the core is covered, taken in conjunction with the other criteria, serves as an additional indication of adequate RCS inventory control.

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA	BASES
4. SAFETY FUNCTION: RCS PRESSURE CONTROL		
PC-1: Pressurizer Heaters and Spray	a. Pressurizer pressure is within the Post Accident P-T limits of Figure 11-1.	Maintaining the RCS within the limits of the Post Accident P-T limits ensures that adequate core cooling is being maintained and minimizes the possibility of PTS.
PC-2: CVCS	a. Pressurizer Pressure is within the Post Accident P-T limits of Figure 11-1.	
PC-3: SIS	a. The available charging pump is operating and the SIS pumps are injecting water into the RCS per Figure 11-3 (unless SIS termination met)	When the SIS is operating, its performance adequacy is judged by observing its delivery flow versus RCS pressure.
PC-4: Forced Circulation with Controlled Steaming	a. Pressurizer pressure is within the Post Accident P-T limits of Figure 11-1.	

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA	BASES
4. <u>SAFETY FUNCTION: RCS PRESSURE CONTROL</u> (Continued)		
PC-5: Natural Circulation with Controlled Steaming	a. Pressurizer pressure is within the Post Accident P-T limits of Figure 11-1.	Once SIS flow has been throttled/stopped, then Figure 11-3 is no longer applicable.
PC-6: SDS	a. Pressurizer pressure is: i) less than [2360 psia] and constant or decreasing <u>and</u> ii) within the Post Accident P-T limits of Figure 11-1].	[2360 psia] is [10 psia] below the high pressure alarm setpoint. When the SDS valves are open, pressure in the RCS will decrease. If the SDS valves are open, then the subcooling limit is not applicable.

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA	BASES
5. SAFETY FUNCTION: RCS AND CORE HEAT REMOVAL		
HR-1: Forced Circulation, No SIS Operation	a. At least one SG has level: i) within the normal level band with feedwater available to maintain level or ii) being restored by a feedwater flow with level increasing and b. $T_H - T_c <$ [3°F] and not increasing and c. $T_{ave} <$ [567°F] and not increasing and d. The RCS is subcooled by [T_HRTD]. and e. No reactor vessel voiding as indicated by the RVLMS.	If steam generator level is below the normal band but is being restored to the normal band, then heat removal via the steam generator is adequate. Once steam generator level is returned to the normal level band and feedwater remains available to maintain that level, then the SG contribution to RCS heat removal is being satisfied. Operators use flow, SG pressure and RCS temperatures to verify the SG is intact and that level will recover.

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA	BASES

5. SAFETY FUNCTION: RCS AND CORE HEAT REMOVAL (Continued)

HR-1: Forced Circulation, No SIS Operation (Continued)

A core ΔT< [3°F] is verified by best estimate analysis to be the maximum ΔT expected for minimum forced circulation with maximum decay heat. RCS subcooling ensures a liquid state of the coolant for effective heat removal properties. [567°F] is based on maintaining RCS temperature below the saturation temperature corresponding to the main steam safety value setpoint [1200 psia]. An RVLMS indication of no reactor vessel voiding taken in conjunction with the other criteria, serves as an additional indication of adequate RCS and core heat removal.

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA	BASES
5. <u>SAFETY FUNCTION: RCS AND CORE HEAT REMOVAL</u> (Continued)		
HR-2: Natural Circulation, No SIS Operation	a. At least one SG has level: i) within the normal level band with feedwater available to maintain the level <u>or</u> ii) being restored by a feedwater flow with level increasing <u>and</u> b. $T_H - T_c$ < [59°F] and not increasing <u>and</u> c. T_{ave} < [567°F] and not increasing <u>and</u> d. The RCS is subcooled based on representative CET <u>and</u>	If steam generator level is below the normal band but is being restored to the normal band, then heat removal via the steam generator is adequate. Once steam generator level is returned to the normal level band and feedwater remains available to maintain that level then the SG contribution to RCS heat removal is being satisfied. [59°F] is based on best estimate analysis which reveals that [59°F] ΔT will not be exceeded for cooldown with maximum decay heat and one steam generator isolated with cooldown rate <75°F/hr. [567°F] is based on not lifting main steam safety valves.

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA	BASES
5. <u>SAFETY FUNCTION: RCS AND CORE HEAT REMOVAL</u> (Continued)		
HR-2: Natural Circulation, No SIS Operation (Continued)	e. No abnormal difference [>3°F] between T_HRTDs and CETs.	Subcooling is necessary to assure an adequate medium for core heat transfer.
HR-3: SG Heat Sink with SIS Operating	a. At least one SG has level: i) within the normal level band with feedwater available to maintain the level <u>or</u> ii) being restored by a feedwater flow with level increasing b. Representative CET temperature less than superheated <u>and</u>	Adequate SG performance is indicated by level in the normal band or being restored by adequate feedwater flow. When representative CET temperatures indicated superheated conditions, then core uncovery has occurred. When the SIS is operating, its performance adequacy is judged by its delivery flow versus RCS pressure. Once SIS flow has been changed due to stopping/throttling flow, then Figure 11-3 is no longer available.

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA	BASES
5. SAFETY FUNCTION: RCS AND CORE HEAT REMOVAL (Continued)		
HR-3: SG Heat Sink with SIS Operating (Continued)	c. Available charging pump is operating and the SIS pumps are injecting water into the RCS per Figure 11-3 (unless SIS termination criteria met)	
HR-4: [Once-Through-Cooling]	a. Representative CET temperature less than superheated. and b. Available charging pump operating and the SIS pumps are injecting water Figure 11-3 (unless SIS termination has occurred). and c. Pressurizer pressure is less than [2055 psia] or decreasing.	When cooling by once-through-cooling through the SDS, RCS pressure should be less than the shutoff head of the HPSI pumps ([2055 psia]). If greater than [2055 psia], then a decreasing trend is satisfactory although efforts to lower pressure below [2055 psia] should be continued.

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA	BASES
5. SAFETY FUNCTION: RCS AND CORE HEAT REMOVAL (Continued)		
HR-5: Shutdown Cooling System	a. Normal SCS Parameters Exist	
6. SAFETY FUNCTION: CONTAINMENT ISOLATION		
CI-1: Automatic/Manual Isolation	a.i) No steam plant activity alarms and ii) No containment radiation alarms and iii) No nuclear annex radiation alarms and iv) No reactor building radiation alarms and v) Containment Pressure < [2.7 psig] or	When the FRG is implemented, the operator has not been able to diagnose one event that is taking place. For this reason, acceptance criteria in the FRG are written to cover a wide range of possible events. Either specific acceptance criteria are satisfied or the operator has taken all steps possible to satisfy that safety function. In this case, containment isolation, either the containment conditions are satisfactory (no steam plant, containment radiation alarms, and

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA	BASES
6. SAFETY FUNCTION: CONTAINMENT ISOLATION (Continued)		
CI-1: Automatic/Manual Isolation (Continued)	b. Each containment penetration not required to be open has its isolation valve closed.	containment pressure < CIAS setpoint [2.7 psig] or all containment penetrations not required to be open for accident mitiagtion are closed.
7. SAFETY FUNCTION: CONTAINMENT TEMPERATURE AND PRESSURE CONTROL		
CTPC-1: Containment Fans	a. Containment temperature < [220°F] and b. Containment pressure < [2.0 psig].	For the containment fans mode success path containment temperatures should not reach [220°F]. [2.0 psig] is based on the containment pressure alarm setpoint.
CTPC-2: Containment Spray	a. One spray header delivering [5000 gpm]. and b. Containment temperature and pressure constant or decreasing.	If the containment pressure exceeds the CSAS setpoint, the containment spray pumps should be pumping spray at [5000 gpm] per spray header.

SUCCESS PATH CURRENTLY IN USE	ACCEPTANCE CRITERIA	BASES
8. <u>SAFETY FUNCTION: CONTAINMENT COMBUSTIBLE GAS CONTROL</u>		
CCGC-1: Hydrogen Recombiners	a. Hydrogen concentration less than 0.5% <u>or</u> b. i) All available hydrogen recombiners are energized <u>and</u> ii) Hydrogen concentration is less than 4%.	If the hydrogen monitors indicate that no detectible hydrogen is present, the Containment Combustible Gas Control safety function is satisfied. If the hydrogen concentration is greater than 0.5%, the hydrogen recombiners should be operated to reduce the concentration.
CCGC-2: Hydrogen Purge System	a. Hydrogen purge system operating in accordance with [plant specific operating instructions].	The recommendation to operate the hydrogen purge system will be made by the Plant Technical Support Center based on several considerations. If the hydrogen purge system is operating then it should be operated in accordance with [plant specific operating instructions].

SAFETY FUNCTION: Reactivity Control

SUCCESS PATH: CEA Insertion; RC-1

INSTRUCTIONS	CONTINGENCY ACTIONS
1. Maintain RCS temperature constant (if possible), until reactivity control is established, in order to prevent power increases following the initial transient.	1.
2. Insert CEAs into the core by one or more of the following: a. Depress all manual CEA trip buttons, b. Open all CEA trip breakers, c. De-energize all CEA drive motor generators, d. Actuate the alternate protection system reactor trips. e. Open the RTSS Trip Circuit breakers locally.	2.

RC-1

Acceptance Criteria for Success Path RC-1:

1. Reactivity Control is satisfied if:

   a. Maximum of one CEA NOT fully inserted and reactor power decreasing

   or

   b. Reactor power less than [$10^{-(8)}$%] and constant or decreasing.

2. If above criteria NOT satisfied, Then go to next appropriate Reactivity Control success path.

3. If above criteria satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for All safety functions are being satisfied, Then go to Long Term Actions after performing appropriate operator actions for all success paths in use.

RC-1

SUPPLEMENTARY INFORMATION: RC-1

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. All available indications should be used to aid in an evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available.

2. It may not be possible to control other safety functions if reactivity control is in jeopardy.

3. Changes in RCS temperature affecting reactivity must be minimized until a shutdown margin per Technical Specification Limits is achieved in order to prevent core restart.

4. After required shutdown boron concentration is attained in the RCS, makeup water added to the RCS should be at least the same boron concentration as in the RCS to prevent RCS dilution.

5. Main or auxiliary pressurizer spray should be used as necessary to equalize the pressurizer and RCS loop water boron concentration as a change is made to the RCS boron concentration. If pressurizer spray is not available, RCS boron concentration should be increased. This avoids an RCS dilution below minimum shutdown requirements caused later by a possible pressurizer outsurge.

6. Solid water operation of the pressurizer may make it difficult to control RCS pressure and therefore should be avoided unless subcooling cannot be maintained in the RCS (Figure 11-1). If the RCS is solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any rapid pressure excursions.

7. If the initial cooldown rate exceeds Technical Specification Limits, there may be a potential for pressurized thermal shock (PTS) of the reactor vessel, unless Post Accident Pressure/Temperature Limits are maintained (Figure 11-1).

RC-1

SAFETY FUNCTION: Reactivity Control

SUCCESS PATH: Boration using CVCS, RC-2

INSTRUCTIONS	CONTINGENCY ACTIONS
1. Maintain RCS temperature constant (if possible), until reactivity control is established, in order to prevent power increases following the initial transient.	1.
2. Commence maximum boration using the CVCS to achieve shutdown margin in accordance with Technical Specification Limits. Perform the following:	2.
a. Align available charging pump to take a suction from the boric acid storage tank using either gravity feed or the boric acid makeup pumps,	a. Align available charging pump to take suction from the spent fuel pool using gravity feed, or the boric acid makeup pumps.
b. Charge to the RCS using the normal charging path,	
c. Manually operate charging and letdown to maintain pressurizer level [2% to 78%].	

RC-2

Acceptance Criteria for Success Path RC-2:

1. Reactivity Control is satisfied if:

   a. Boron addition rate greater than [40 gpm] and reactor power decreasing.

   b. Reactor power less than [$10^{-(8)}$%] and constant or decreasing

   or

   c. Adequate shutdown margin established per Technical Specifications and reactor power constant or decreasing.

2. If above criteria NOT satisfied, Then go to next appropriate Reactivity Control success path.

3. If above criteria satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for All safety functions are being satisfied, Then go to Long Term Actions after performing appropriate operator actions for all success paths in use.

RC-2

SUPPLEMENTARY INFORMATION: RC-2

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Changes in RCS temperature affecting reactivity must be minimized until a shutdown margin per Technical Specification Limits is achieved in order to prevent core restart.

2. After a shutdown boron concentration is attained in the RCS, makeup water added to the RCS should be of at least the same boron concentration in the RCS in order to prevent RCS dilution.

3. Main, or auxiliary, pressurizer spray should be used as necessary to equalize the pressurizer and RCS loop water boron concentration as a change is made to the RCS boron concentration. If pressurizer spray is not available, RCS boron concentration should be increased. This avoids an RCS dilution below minimum requirements caused later by a possible pressurizer outsurge.

4. All available indications should be used to aid in an evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available.

5. It may not be possible to control other safety functions if reactivity control is in jeopardy.

RC-2

6. Solid water operation of the pressurizer may make it difficult to control RCS pressure and therefore should be avoided unless subcooling cannot be maintained in the RCS (Figure 11-1). If the RCS is solid, closely monitor any makeup or draining and any system heatup or cooldown in order to avoid rapid pressure excursions.

7. Continuously monitor RCS temperature and pressure to avoid exceeding a heat removal rate greater than Technical Specification Limitations. If the heat removal rate exceeds Technical Specification Limits, there may be a potential for pressurized thermal shock (PTS) of the reactor vessel unless Post Accident Pressure/Temperature Limits are maintained (Figure 11-1).

8. Charging from the concentrated boron source should not continue past [1 hour] after event initiation unless required for reactivity control. This is to preclude boron precipitation in the core. Suction should be shifted to the lower concentration source.

RC-2

SAFETY FUNCTION: Reactivity Control

SUCCESS PATH: Boration using SIS, RC-3

INSTRUCTIONS	CONTINGENCY ACTIONS
1. Maintain RCS temperature constant (if possible), until reactivity control is established, in order to prevent power increases following the initial transient.	1.
* 2. If pressurizer pressure ≤ SIAS setpoint or containment pressure ≥ [2.7 psig], Then verify an SIAS is actuated.	2. If pressurizer pressure ≤ SIAS setpoint or containment pressure ≥ [2.7 psig] and an SIAS has NOT been initiated automatically, Then manually initiate an SIAS.
* 3. Ensure maximum safety injection and charging flow to the RCS by the following: a. start idle SIS pumps and verify SIS flow in accordance with Figure 11-3 and b. start charging pump.	3 If safety injection and charging flow not maximized, Then do the following as necessary: a. ensure electrical power to valves and pumps, b. ensure correct SIS valve lineup, c. ensure operation of necessary auxiliary systems.

* Step Performed Continuously

RC-3

INSTRUCTIONS	CONTINGENCY ACTIONS
* 4. _If_ high RCS pressure is preventing SIS pump injection of boric acid, _Then_ attempt to cooldown/depressurize to obtain adequate SIS flow (Refer to the Pressure Control and Heat Removal success paths in use).	4.
* 5. _If_ the SIS is operating, _Then_ the SIS may be throttled or stopped, one pump at a time, if _All_ of the following are satisfied: a. Reactor power less than [$10^{-(8)}$%] and constant or decreasing, _or_ Adequate shutdown margin established per Technical Specifications and reactor power constant or decreasing, _and_ b. RCS subcooled based on Representative CET temperature (Figure 11-1), _and_	5. _Continue_ SIS operation

* Step Performed Continuously

RC-3

INSTRUCTIONS	CONTINGENCY ACTIONS
5. (Continued) c. pressurizer level greater than [14.3%] and not decreasing, and d. at least one steam generator is available for removing heat from the RCS (ability for feed and steam flow), and e. the HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles.	
* 6. If criteria of step 5 can NOT be maintained after SIS pumps throttled or stopped, Then appropriate SIS pumps must be restarted and full SIS flow restored.	6.

* Step Performed Continuously

Acceptance Criteria for Success Path RC-3:

1. Reactivity Control is satisfied if:

   a. Boron addition rate is greater than [40 gpm] and reactor power is decreasing

   or

   b. Reactor power is less than [$10^{-(8)}$%] and constant or decreasing

   or

   c. Adequate shutdown margin established per Technical Specifications and reactor power constant or decreasing.

2. If above criteria NOT satisfied, Then go to next appropriate Reactivity Control success path.

3. If above criteria satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for All safety functions are being satisfied, Then go to Long Term Actions after performing appropriate operator actions for all success paths in use.

RC-3

SUPPLEMENTARY INFORMATION: RC-3

This section contains items which should be considered when implementing EPGs and preparing specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. All available indications should be used to aid in evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available. Hot and cold leg RTDs may be influenced by the cooler SIS injection and should be checked against each other.

2. It may not be possible to control other safety functions if reactivity control is in jeopardy.

3. Do not place system in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation.

4. Continuously monitor RCS temperature and pressure to avoid exceeding a heat removal rate greater than Technical Specification Limitations. If the heat removal rate exceeds Technical Specification Limits, there may be a potential for pressurized thermal shock (PTS) of the reactor vessel unless Post Accident Pressure/Temperature Limits are maintained (Figure 11-1).

5. Solid water operation of the pressurizer may make is difficult to control RCS pressure and therefore should be avoided unless subcooling cannot be maintained in the RCS (Figure 11-1). If the RCS is solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any unfavorable rapid pressure excursion.

6. Changes in RCS temperature affecting reactivity must be minimized until a shutdown margin per Technical Specification Limits is achieved in order to prevent core restart.

7. Main or auxiliary pressurizer spray should be used as necessary to equalize the pressurizer and RCS loop water boron concentration as a change is made to the RCS boron concentration. If pressurizer spray is not available, RCS boron concentration should be increased. This avoids an RCS dilution below minimum shutdown requirements by a possible pressurizer outsurge.

8. After shutdown boron concentration is attained in the RCS, makeup water added to the RCS should be at least the same boron concentration as the RCS to prevent RCS dilution.

RC-3

SAFETY FUNCTION: Reactivity Control

SUCCESS PATH: CEA Drive Down; RC-4

INSTRUCTIONS	CONTINGENCY ACTIONS
1. Maintain RCS temperature constant (if possible), until reactivity control is established, in order to prevent power increases following the initial transient.	1.
2. Re-energize CEA drive mechanisms and attempt to manually drive CEAs into the core using the normal rod motion controls.	2.

Acceptance Criteria for Success Path RC-4:

1. Reactivity Control is satisfied if:

   a. Maximum of one CEA NOT fully inserted and reactor power is decreasing

   or

   b. Reactor Power is less than [$10^{-(8)}$%] and constant or decreasing

2. If above criteria NOT satisfied, Then go to CONTINUING ACTIONS FOR REACTIVITY CONTROL.

3. If above criteria satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for All safety functions are being satisfied, Then go to Long Term Actions after performing appropriate operator actions for all success paths in use.

RC-4

SUPPLEMENTARY INFORMATION: RC-4

This section contains items which should be considered when implementing EPGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. All available indications should be used to aid in evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available.

2. It may not be possible to control other safety functions if reactivity control is in jeopardy.

3. Changes in RCS temperature affecting reactivity must be minimized until a shutdown margin per Technical Specification Limits is achieved in order to prevent core restart.

4. After required shutdown boron concentration is attained in the RCS, makeup water added to the RCS should be at least the same boron concentration as in the RCS to prevent RCS dilution.

5. Main or auxiliary pressurizer spray should be used as necessary to equalize the pressurizer and RCS loop water boron concentration as a change is made to the RCS boron concentration. If pressurizer spray is not available, RCS boron concentration should be increased. This avoids an RCS dilution below minimum shutdown requirements caused later by a possible pressurizer outsurge.

RC-4

6. Solid water operation of the pressurizer may make it difficult to control RCS pressure and therefore should be avoided unless subcooling cannot be maintained in the RCS (Figure 11-1). If the RCS is solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any rapid pressure excursions.

7. If the initial cooldown rate exceeds Technical Specification Limits, there may be a potential for pressurized thermal shock (PTS) of the reactor vessel, unless Post Accident Pressure/Temperature Limits are maintained (Figure 11-1).

RC-4

CONTINUING ACTIONS FOR REACTIVITY CONTROL

If the acceptance criteria are NOT met, Then reactivity control is still in jeopardy. THE OPERATOR SHOULD NOT LEAVE REACTIVITY CONTROL UNTIL THIS SAFETY FUNCTION IS FULFILLED. If necessary, the operator may pursue other urgent safety functions but must continue to attempt to establish reactivity control using the following:

a. Energize or restore other vital auxiliaries to necessary components on the reactivity control success paths.

b. Attempt manual operation of inoperative valves.

c. If high RCS pressure prevents SIS injection of boric acid, then the pressure and heat removal sections should be referenced and an attempt made to lower plant pressure to permit SIS pump injection of boric acid. Consideration should be given to the effect on RCS subcooling and core cooling which such an action will cause.

Bases for Functional Recovery of Reactivity Control

A loss of reactivity control can be characterized by the insertion of inadequate negative reactivity to shutdown the reactor. This loss may be identified by indication on two or more safety grade instrument channels that a plant parameter has exceeded its normal reactor trip setpoint. This requires a manual or an automatic reactor trip. If an automatic trip has not been initiated, then manual insertion of all of the CEAs is attempted. Specific symptoms for a loss of reactivity control depend on what actions are being taken to obtain reactivity control and include any one or a combination of the following:

a. more than 1 CEA not fully inserted,
b. reactor power not decreasing as expected,
c. startup rate indication ≥ 0 DPM,
d. boron concentration less than required per Technical Specifications,
e. RCS temperature increasing more rapidly than expected for decay heat production.

The cause of the loss of reactivity control may range from a Reactor Protection System (RPS) failure in automatically initiating a reactor trip when required, to the inability to manually insert the CEAs, or to a failure in controlling reactivity through the use of boration (possibly due to a boration equipment malfunction). Failure of the RPS to cause a reactor trip has traditionally been referred to as "Anticipated Transient Without Scram" (ATWS). Analysis has shown that the sooner operator actions are taken to restore reactivity control, the more beneficial they will be towards mitigating the consequences of such an event.

The loss of reactivity control may affect other safety functions. Because insufficient negative reactivity is added to the core following the initiating event, heat in-excess of the normal decay heat levels is being produced and added to the RCS. For example, the RCS heat removal safety function can be affected by the excess heat addition if an adequate heat sink is unavailable.

If main feedwater has been lost, emergency feedwater flow (which is generally sized for decay heat only) may not be sufficient to maintain steam generator level. Continued steaming of the steam generators via the turbine, the ADVs, the steam bypass valves, and/or the steam generator safety valves may result in steam generator dry out and subsequent loss of heat sink.

There are a large number of scenarios which may occur concurrently with a loss of reactivity control. The operator may be faced with the loss of control of one or a combination of other safety functions. The most limiting case analyzed involves an ATWS event with a continuing loss of feedwater. Since the secondary system can no longer remove all of the heat generated in the reactor core, the RCS temperature and pressure will increase. If the steam generator secondary water inventory can be restored during the event, the RCS temperature and pressure excursion can be minimized. However, if it can be avoided, the steam generator should not be steamed to control RCS temperature and pressure in the early stages of this event. Steaming will increase the rate of steam generator dry out if feedwater is not available. The resulting RCS pressure excursion will be more severe since the dry out occurs earlier in the transient. Increasing temperature and pressure may result in the pressurizer relief and/or safety valves opening. Further increases in RCS temperature can cause expansion of the reactor coolant which will increase pressurizer level and may cause the plant to go solid. RCS pressure may increase enough to allow coolant leakage through the reactor vessel flange "O" ring seal. Reactor power is reduced due to the negative moderator coefficient feedback caused by the increasing RCS temperature and significant decrease in moderator density. This negative reactivity addition is what limits the consequences of a loss of reactivity control event coincident with a loss of feedwater.

The following success paths are directed at placing the plant in a stable, safe condition following a loss of reactivity control. Reactivity control may be accomplished by any of the following methods:

RC-1: Reactivity Control via CEA Insertion
RC-2: Reactivity Control via Boration Using CVCS
RC-3: Reactivity Control via Boration Using SIS

RC-4: Reactivity Control via CEA Drive Down

The bases for the operator actions required for implementing each of the above success paths are detailed as follows:

RC-1: Reactivity Control via CEA Insertion

Inserting the control rods into the core is the preferred method of reactivity control. If the CEAs have not been inserted automatically, then methods available to manually insert the CEAs must be exercised. Reactivity control is regained in the shortest time frame possible by rapid insertion of the CEAs.

Operator Actions

1. To prevent reactor power increases following the initial transient, RCS temperature is maintained constant (if possible) until reactivity control is satisfied. Temperature is maintained constant, instead of being reduced, to prevent reactor power increases due to the negative moderator temperature coefficient.

2. An attempt is made to manually insert the CEAs into the core. This is done by performing the following:

   a. Manual trip buttons are depressed,
   b. CEA trip breakers are opened,
   c. Control rod drive motor generators are deenergized,
   d. Actuate the alternate protection system reactor trips.
   e. Open the RTSS Trip Circuit breakers locally.

   These actions are performed to deenergize the CEAs.

RC-1: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, Reactivity Control is satisfied if:

   a. Maximum of one CEA NOT fully inserted and reactor power decreasing

   or

   b. Reactor power is less than [$10^{-(8)}$%] and constant or decreasing.

   For all emergency events, the reactor must be shutdown. The Technical Specification requirement is that not more than 1 rod be not fully inserted. If more than 1 rod is not fully inserted, the RCS must be borated to compensate. Boration is also necessary to assist the CEAs if RCS cooldown has occurred. Reactivity control using boration is identified and discussed in the next two success paths, RC-2 and 3. Insertion of CEAs is adequate to keep the reactor shutdown even after some cooldown. Decreasing reactor power is a second positive indication of reactivity control. Constant or decreasing reactor power at less than [$10^{-(8)}$%] acknowledges that power will only decrease until the subcritical multiplication level is reached, then it will decrease very slowly. [$10^{-(8)}$%] is the plant specific maximum value expected for subcritical multiplication level following extended full power operation.

2. If the above criteria are not satisfied, then success path RC-1 is not successfully controlling reactivity. The operator should go to the next appropriate success path for Reactivity Control.

3. If the acceptance criteria for success path RC-1 are satisfied, then success path RC-1 is successfully controlling reactivity. Reactivity Control is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

RC-1

RC-2: Reactivity Control via Boration Using CVCS

In the case where the control rods do not insert, or where additional negative reactivity is needed to compensate for temperature effects, reactivity control can be accomplished by boron injection. Borated water can be added to the RCS using the charging and boric acid addition portions of the CVCS.

Operator Actions

1. To prevent reactor power increases following the initial transient, RCS temperature is maintained constant (if possible) until reactivity control is satisfied. Temperature is maintained constant, instead of being reduced, to prevent reactor power increases due to the negative moderator temperature coefficient.

2. Maximum boration is commenced using the CVCS to achieve shutdown margin in accordance with Technical Specification Limits. The following actions are performed.

   a. The available charging pump is aligned to take a suction from the boric acid storage tanks using either gravity feed or the boric acid makeup pumps. If the boric acid storage tanks are empty, will soon be empty, or are not available, then the operator should switch suction to the spent fuel pool using gravity drain.
   b. The charging pump is aligned to the normal charging header.
   c. Charging pumps and letdown are manually operated to maintain pressurizer level [2% to 78%].

   The charging pump may have to be manually restarted if an interruption of electrical power to the charging pump bus has occurred. The charging pumps are aligned to discharge the contents of the boric acid storage tanks (primary source of boric acid to the RCS and core). The boric acid storage tank contents may reach the suction of the charging pumps via gravity feed or via the boric acid makeup pumps.

RC-2

These sources should usually not be used past [1 hour] after event initiation (unless required for reactivity control) to prevent boron precipitation. Boron precipitation is only a concern if charging from the concentrated source has been continuous since event initiation. This is the preferred method for boron addition. An alternate source for boron is the spent fuel pool. Pressurizer level should be maintained throughout by regulating charging into the PCS (manual operation of the charging pump) and bleed off from the RCS (letdown line).

Operation of the charging system also affects RCS inventory and pressure control. When operating the charging system, the operator should maintain plant pressure and temperature within the limits of Figure 11-1.

During a cooldown, shrinkage of RCS inventory due to cooling may cause outsurge of pressurizer fluid. Since this fluid is not directly borated by charging flow, it may be at a lower boron concentration than the RCS loops and/or therefore, may dilute the loops and the reactor vessel. This same concern exists during a natural circulation cooldown with respect to the reactor vessel upper head. With no RCPs operating, there is little interaction between RCS fluid and coolant in the upper head. The boron concentration may be lower in the upper head causing loop and vessel dilution if voiding occurs. In order to avoid this loss of shutdown margin, one of the following actions should be accomplished (listed in order of preference).

a. Sufficient boron is added prior to commencing the cooldown to borate the entire RCS (including the mass in the pressurizer) to COLD SHUTDOWN boron concentration (per Technical Specifications). Therefore, even if the pressurizer (or reactor vessel upper head region) is relatively dilute and outsurges into the RCS loop, boron concentration will not drop below the COLD SHUTDOWN concentration.

RC-2

b. If letdown is available, then sufficient heaters can be energized to permit continuous auxiliary spray into the pressurizer without dropping RCS pressure. With pressurizer level held constant by letdown, the pressurizer is borated to within [50 ppm] of RCS loop concentration using auxiliary spray is shown by RCS sampling.

c. If letdown is not available, then the RCS is borated to [50 ppm] greater than the minimum shutdown margin corresponding to T_c (per Technical Specifications). As more volume becomes available in the pressurizer due to RCS cooldown shrinkage, additional boron is charged to the RCS to maintain minimum shutdown margin corresponding to T_c. The use of pressurizer spray to depressurize will also increase pressurizer boron concentration.

RC-2

RC-2: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, Reactivity Control is satisfied if:

   a. Boron addition rate is greater than [40 gpm] and reactor power is decreasing

   or

   b. Reactor power is less than [$10^{-(8)}$%] and constant or decreasing.

   or

   c. Adequate shutdown margin established per Technical Specifications and reactor power is constant or decreasing.

   For all emergency events, the reactor must be shutdown. Reactor shutdown can be assured by the minimum boration rate accompanied by decreasing reactor power. Reactivity control can also be assured by verification of a reactor power level that is less than the maximum expected sub-critical multiplication level and constant or decreasing. If RCS boron samples indicate that Technical Specification shutdown margin has been established, and reactor power is constant or decreasing, then the reactivity control safety function is satisfied.

2. If the above criteria are not satisfied, then success path RC-2 is not successfully controlling reactivity. The operator should go to the next appropriate success path for Reactivity Control.

3. If the acceptance criteria for success path RC-2 are satisfied, then success path RC-2 is successfully controlling reactivity. Reactivity Control is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

RC-3: Reactivity Control via Boration Using SIS

In the case where the control rods do not insert, or where additional negative reactivity is needed to compensate for temperature effects, reactivity control can be accomplished by boron injection. The safety injection system can be utilized to add borated water to the RCS when pressure is less than the shut-off head of the SIS pumps.

Operator Actions

1. To prevent reactor power increases following the initial transient, RCS temperature is maintained constant (if possible) until reactivity control is satisfied. Temperature is maintained constant, instead of being reduced, to prevent reactor power increases due to the negative moderator temperature coefficient.

*2. If pressurizer pressure decreases to or below the SIAS setpoint, or if containment pressure increases to or above [2.7 psig], then initiation of an SIAS must be verified. If necessary, SIAS is manually initiated.

*3. If an SIAS is actuated, then the available charging pump and the SIS pumps should be operating and injecting water into the RCS. The SIS flowrate will vary according to pressurizer pressure. The SIS and charging flowrates should be checked and maximized (Figure 11-3 provides information which can be utilized to verify adequate SIS flow is occurring) for reactivity control, RCS inventory replenishment, and/or core heat removal. The charging pump may have to be manually restarted if an interruption of electrical power to the charging pump bus has occurred. The following guidance will assist in ensuring maximum injection of water into the RCS:

a. idle SIS pumps should be started and system flow should be verified to be within the limits of Figure 11-3,
b. idle charging pumps should be started.

If any SIS pump that should be operating won't start, the charging pump will not start, or SIS flow is not in accordance with Figure 11-3, then the following guidance is provided:

a. the operator should verify that electrical power is available to valves and pumps necessary
b. the SIS valve lineup should be verified to be correct in the control room
c. auxiliary systems necessary for SIS or charging operation should be checked

It must be noted, however, that the maximization of charging and safety injection can result in excess RCS inventory, possible filling of the pressurizer to a solid condition, and a PTS concern upon RCS heat up, fluid expansion, and subsequent RCS pressure excursion. Operators must be aware of these concerns and terminate or throttle SIS pumps when the termination criteria are met.

*4. RCS pressure above the shutoff head of the SIS pumps will prevent the injection of boric acid to the RCS via the SIS. Charging pumps should still be operating and be capable of providing sufficient boric acid flow to ensure adequate reactivity control. However, if plant conditions permit, a cooldown/depressurization should be performed by referring to the pressure and heat removal success paths in use. These success paths will provide guidance to obtain the plant conditions for SIS boric acid injection, while also providing additional guidance for maintaining adequate RCS subcooling and core cooling.

RC-3

*5. If an SIAS has been initiated and the SIS is operating, then it must continue to operate at full capacity until reactor power is less than [$10^{-(8)}$%] and constant or decreasing, or the Technical Specification shutdown margin is achieved and reactor power is constant or decreasing, and SIS termination criteria are met. Early termination is expected only for steam line breaks, a spurious SIAS, or if an RCS leak is identified and promptly isolated (e.g., a stuck open PORV is blocked). Termination of SIS should be sequenced by stopping one pump at a time while observing the termination criteria. Throttling of SIS flow is also permissible if all SIS termination criteria are met.

All of the following criteria must be satisfied before SIS flow may be terminated or throttled:

a. Adequate reactivity control must be assured by satisfying one of the following:
   i) Reactor power level is less than the maximum expected sub-critical multiplication level ([$10^{-(8)}$%]) and constant or decreasing,

   <u>or</u>

   ii) RCS boron samples indicate that Technical Specification shutdown margin has been established and reactor power is constant or decreasing.

b. The RCS is subcooled based on representative CET temperature (Figure 11-1). Establishing subcooling ensures the fluid in the core is subcooled, and ensures a subcooled heat transfer medium. Voids may exist in some parts of the RCS (e.g., reactor vessel head as determined by the HJTC RVLMS), but these are permissible as long as core heat removal is maintained.

RC-3

c. Pressurizer level is greater than [14.3%], and not decreasing. A pressurizer level greater than [14.3%] and not decreasing, in conjunction with criterion b) above, is an indication that RCS inventory control has been established.

d. At least one steam generator is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow is available for removing heat from the RCS.

e. The HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles. This provides an extra margin of core coverage and, taken in conjunction with the above, serves as an additional indication that RCS inventory control has been established.

If the above criteria are met, the operator may either terminate or throttle the SIS. The operator may decide to throttle rather than to terminate flow if the SIS is to be used to control pressurizer level or plant pressure. A general assessment of the SIS performance can be made from the control room. The operator should confirm that at least one train, and preferably both trains of SIS are operating. If flow has not been throttled, system delivery rate should be consistent with RCS pressure as shown in Figure 11-3. Injection flow rates to each reactor vessel nozzle should be approximately equal. Departures from this would indicate a closed flow path or some system spillage.

*6. If the criteria of step 5 cannot be maintained after SIS flow throttled or stopped, then appropriate SIS pumps must be restarted and full SIS flow restored.

RC-3

RC-3: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, Reactivity control is satisfied if:

   a. Boron addition rate is greater than [40 gpm] and reactor power is decreasing,

   or

   b. Reactor power is less than [$10^{-(8)}$%] and constant or decreasing,

   or

   c. Adequate shutdown margin established per Technical Specifications and reactor power constant or decreasing.

   For all emergency events, the reactor must be shutdown. Reactor shutdown can be assured by the minimum boration rate accompanied by decreasing reactor power. Reactivity control can also be assured by verification of a reactor power level that is less than the maximum expected sub-critical multiplication level and constant or decreasing. If RCS boron samples indicate that Technical Specification shutdown margin has been established, and reactor power is constant or decreasing, then the reactivity control safety function is satisfied.

2. If the above criteria are not satisfied, then success path RC-3 is not successfully controlling reactivity. The operator should go to the next Reactivity Control.

3. If the acceptance criteria for success path RC-3 are satisfied, then success path RC-3 is successfully controlling reactivity. Reactivity Control is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

RC-3

RC-4: Reactivity Control via CEA Drive Down

If reactivity control has not been regained by de-energizing the CEAs or by boron addition, then attempt to re-energize the CEAs and manually drive them into the core.

Operator Actions

1. To prevent reactor power increases following the initial transient, RCS temperature is maintained constant (if possible) until reactivity control is satisfied. Temperature is maintained constant, instead of being reduced, in order to prevent reactor power increases due to the negative moderator temperature coefficient.

2. The CEA drive mechanisms may have been de-energized in success path RC-1 in an attempt to insert them. If this effort and boration have failed to establish reactivity control, then re-energize the CEA drive mechanism and attempt to drive the CEAs into the core.

RC-4: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, Reactivity Control is satisfied if:

   a. Maximum of one CEA NOT fully inserted and reactor power decreasing

   or

   b. Reactor power less than [$10^{-(8)}$%] and constant or decreasing.

   For all emergency events, the reactor must be shutdown. The Technical Specification requirement is that not more than 1 rod is not fully inserted. If more than 1 rod is not fully inserted, the RCS must be borated to compensate. Boration is also necessary to assist the CEAs if RCS cooldown has occurred. Reactivity control using boration was identified and discussed in the previous two success paths, RC-2 and 3. Insertion of CEAs is adequate to keep the reactor shutdown even after some cooldown. Decreasing reactor power is a second positive indication of reactivity control. Constant or decreasing reactor power at less than [$10^{-(8)}$%], acknowledges that power will only decrease until the subcritical multiplication level is reached, then it will decrease very slowly. [$10^{-(8)}$%] is the plant specific maximum value expected for subcritical multiplication level following extended full power operation.

2. If the above criteria are not satisfied, then success path RC-4 is not successfully controlling reactivity. The operator should go to CONTINUING ACTIONS FOR REACTIVITY CONTROL.

3. If the acceptance criteria for success path RC-4 are satisfied, then success path RC-4 is successfully controlling reactivity. Reactivity Control is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

RC-4

Continuing Actions for Reactivity Control

If Reactivity Control is not established, then the operator should continue to work to establish Reactivity Control. It may not be possible to control other safety functions while Reactivity Control is not established. However, if other safety functions urgently need attention, then the operator may attempt to satisfy them while continuing to work on Reactivity Control.

SAFETY FUNCTION: Maintenance of Vital AC Power

SUCCESS PATH: Unit Auxiliary Transformers MVAC-1

INSTRUCTIONS	CONTINGENCY ACTIONS
1. Verify that the unit auxiliary transformers (UAT) have electrical AC power available from unit main transformers, or from the main generator	1. Realign the offsite grid to provide power to the UATs.
2. If electrical AC power is available from the UATs, Then restore electrical power to at least one Safety division of [4.16 kV] in accordance with the [plant specific operating instructions].	2. If electrical AC power is not available from the UATs, Then go to the next appropriate Maintenance of Vital AC Power success path.

ACCEPTANCE CRITERIA FOR SUCCESS PATH MVAC-1:

1. Maintenance of Vital AC Power is satisfied if:

   At least one [4.16 kV AC] Safety Division energized.

2. If above criterion NOT satisfied, Then go to Maintenance of Vital AC Power success path MVAC-2.

3. If above criterion satisfied AND Maintenance of Vital DC Power satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

MVAC-1

SUPPLEMENTARY INFORMATION: MVAC-1

This section contains items which should be considered when implementing EPGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Do not place systems in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation.

2. All available indications should be used to aid in evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available.

3. If only one Safety division of [4.16 kV] has been restored, the acceptance criteria for Maintenance of Vital AC Power will be met and the operators should proceed to the next safety function in jeopardy. However, efforts to restore the second Safety division (and the non-safety divisions) should be continued in order to increase the availability of plant systems and components.

4. If PPS cabinets have been de-energized, Then ensure the appropriate breakers to ESF equipment are open in order to prevent inadvertent ESFAS actuations.

5. Maintenance of Vital Auxiliaries safety function is satisifed only if Vital AC, Vital AC I&C, and Vital DC have distribution centers in the same Safety Division energized.

MVAC-1

SAFETY FUNCTION: Maintenance of Vital AC Power

SUCCESS PATH: Emergency Diesel Generators: MVAC-2

INSTRUCTIONS	CONTINGENCY ACTIONS
1. Verify that the emergency diesel generators have been started.	1. Determine and correct the cause of the diesel failure AND start diesel generator(s)
2. Ensure emergency diesel generator(s) operating in accordance with plant specific operating instructions.	2.
3. Ensure at least one safety division of [4.16KV] is energized by associated diesel generator.	3. If diesel generators NOT capable of energizing at least one safety division of [4.16 KV], Then go to next appropriate Maintenance of Vital AC Power success path.

MVAC-2

ACCEPTANCE CRITERIA FOR SUCCESS PATH MVAC-2:

1. Maintenance of Vital AC Power is satisfied if:

   At least one [4.16 kV AC] Safety Division energized.

2. If above criterion NOT satisfied, Then go to next appropriate Maintenance of vital AC Power success path MVAC-3.

3. If above criterion satisfied AND Maintenance of Vital DC Power satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

MVAC-2

SUPPLEMENTARY INFORMATION: MVAC-2

This section contains items which should be considered when implementing EPGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Do not place systems in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation.

2. All available indications should be used to aid in evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings should be corroborated when one or more confirmatory indications are available.

3. If only one safety division of [4.16 KV] has been restored, the acceptance criteria for Maintenance of Vital AC Power will be met and the operators should proceed to the next safety function in jeopardy. However, efforts to restore the second safety division (and the non-safety divisions) should be continued in order to increase the availability of plant systems and components.

4. If PPS cabinets have been de-energized, Then ensure the appropriate breakers to ESF equipment are open in order to prevent inadvertent ESFAS actuations.

5. Maintenance of Vital Auxiliaries safety function is satisifed only if Vital AC, Vital AC I&C, and Vital DC have distribution centers in the same Safety Division energized.

SAFETY FUNCTION: Maintenance of Vital AC Power

SUCCESS PATH: Reserve Auxiliary Transformer MVAC-3

INSTRUCTIONS	CONTINGENCY ACTIONS
1. Restore electrical power to at least one [4.16 KV] safety division by performing plant specific operating instructions for the Reserve Auxiliary transformers.	1. If this mode of operation NOT available, Then go to Maintenance of Vital AC Power success path MVAC-4.

MVAC-3

ACCEPTANCE CRITERIA FOR SUCCESS PATH: MVAC-3

1. Maintenance of Vital AC Power is satisfied if:

   At least one [4.16 kV AC] Safety Division energized.

2. If above criterion NOT satisfied, Then go to Maintenance of Vital AC Power success path MVAC-4.

3. If above criterion satisfied AND Maintenance of Vital DC Power satisfied, Then go to next safety function in jeopardy

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

MVAC-3

SUPPLEMENTARY INFORMATION: MVAC-3

This section contains items which should be considered when implementing EPGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Do not place systems in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation.

2. All available indications should be used to aid in evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available.

3. If only one safety division of [4.16 KV] has been restored, the acceptance criteria for Maintenance of Vital AC Power will be met and the operators should proceed to the next safety function in jeopardy. However, efforts to restore the second safety division of [4.16 KV] (and the non-safety division) should be continued in order to increase the availability of plant systems and components.

4. _If_ PPS cabinets have been de-energized, _Then_ ensure the appropriate breakers to ESF equipment are open in order to prevent inadvertent ESFAS actuations.

5. Maintenance of Vital Auxiliaries safety function is satisifed only if Vital AC, Vital AC I&C, and Vital DC have distribution centers in the same Safety Division energized.

MVAC-3

SAFETY FUNCTION: Maintenance of Vital AC Power

SUCCESS PATH: Alternate AC (Combustion Turbine Generator) MVAC-4

INSTRUCTIONS	CONTINGENCY ACTIONS
1. Verify that AC power is available from the alternate AC Source (Combustion Turbine Generator).	1. Go to Continuing Actions for Maintenance of Vital AC Power.
2. Restore electrical power to at least one safety division [4.16 KV] by performing plant specific operating instruction for the Alternate AC Source.	2.

MVAC-4

ACCEPTANCE CRITERIA FOR SUCCESS PATH: MVAC-4

1. Maintenance of Vital AC Power is satisfied if:

   At least one [4.16 kV AC] Safety Division energized.

2. If above criterion NOT satisfied, Then go to CONTINUING ACTIONS FOR MAINTENANCE OF VITAL AC POWER.

3. If above criterion satisfied AND Maintenance of Vital DC Power satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

MVAC-4

SUPPLEMENTARY INFORMATION: MVAC-4

This section contains items which should be considered when implementing EPGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Do not place systems in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation.

2. All available indications should be used to aid in evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available.

3. If only one safety division of [4.16 KV] has been restored, the acceptance criteria for Maintenance of Vital AC Power will be met and the operators should proceed to the next safety function in jeopardy. However, efforts to restore the second safety division of [4.16 KV] (and the non-safety divisions) should be continued in order to increase the availability of plant systems and components.

4. If PPS cabinets have been de-energized, Then ensure the appropriate breakers to ESF equipment are open in order to prevent inadvertent ESFAS actuations.

5. Maintenance of Vital Auxiliaries safety function is satisifed only if Vital AC, Vital AC I&C, and Vital DC have distribution centers in the same Safety Division energized.

MVAC-4

CONTINUING ACTIONS FOR MAINTENANCE OF VITAL AC POWER

If the acceptance criteria are NOT met, Then Maintenance of vital AC Power is still in jeopardy. The operator must continue to attempt to establish a source of vital AC electrical power while pursuing other jeopardized safety functions.

The following will help stabilize the plant until vital AC power is established.

a) Ensure all appropriate breakers on de-energized buses [13.8 and 4.16 KV] are open.
b) Open the appropriate DC supply breakers: [Plant specific breakers would be listed in the plant specific EOPs]
c) Use pressure control success path PC-5 to maintain RCS subcooling between [1° and 30°F].
d) Ensure adequate ventilation and/or supplemental cooling is provided within 30 minutes for the following rooms:

   [Plant specific cabinet and building doors required to be opened would be listed in the plant specific EOPs. Other actions necessary to cope with lost ventilation would be specified in the plant specific EOPs.]

The following should be considered when attempting local operation of equipment.

a. Portable lighting
b. Keys for electrically locked doors.
c. Portable communication equipment.
d. Gloves or valve operators due to expected elevated temperatures.
e. [Plant specific items].

Bases for Maintenance of Vital AC Power

The purpose of maintaining vital AC power is to ensure the continued availability of plant systems and components required to control the plant and maintain the safety functions. If all vital AC power is lost, the operator will have to restore a source of vital AC power in order to control all of the safety functions. Vital AC power may be lost due to the failure of equipment to automatically transfer vital loads to available sources of power, if the normal source is interrupted. Typical initiating events would include a loss of offsite power (if the vital buses are normally supplied by the unit auxiliary transformers, or a turbine-generator trip (if the vital buses are supplied by the main generator), with a failure to transfer to the unit auxiliary transformers.

In most cases, vital AC power will be maintained automatically, without operator actions. Equipment failure or unavailability may result in an interruption of AC power and require operator action.

The following methods are available to maintain or to regain a source of vital AC power:

MVAC-1: Maintenance of Vital AC Power via Unit Auxiliary Transformers
MVAC-2: Maintenance of Vital AC Power via Emergency Diesel Generators
MVAC-3: Maintenance of Vital AC Power via Reserve Auxiliary Transformer
MVAC-4: Maintenance of Vital AC Power via Alternate AC (Combustion Turbine Generator)

The bases for the recovery actions required for implementing each of the methods listed above are detailed below. The preferred ordering of the success paths will be plant specific, and should be established to ensure that power is maintained or restored rapidly. Any plant specific alternate success paths not identified in these guidelines should be incorporated in the plant specific Functional Recovery Procedure. It should be noted that the Maintenance of Vital DC Power acceptance criteria must also be satisfied to satisfy the Maintenance of Vital Auxiliaries safety function.

MVAC-1: Maintenance of Vital AC Power via the Unit Auxiliary Transformers.

Utilizing offsite power via the Unit Auxiliary Transformers is the preferred method for maintaining or restoring Vital AC Power.

Operator Actions

1. Verifying that the unit auxiliary transformers (UAT) have electrical AC power available from offsite power is a prerequisite to restoring on-site power from this source. If electrical AC power is not available to the UAT from the unit main transformers or from the main generator, then realignment of the offsite grid may be necessary.

2. The feeder breakers supplying power to at least one safety division of [4.16kV] should be operated to energize the bus and provide power to the vital equipment. Plant specific instructions for operating the breakers should be referenced or provided in this step. If AC power is not available from the UAT, the operators should proceed to Vital AC Power success path MVAC-2.

MVAC-1

MVAC-1: Acceptance Criteria and Guideline Direction.

1. After implementing the above actions, Maintenance of Vital AC Power is satisfied if:

   At least one [4.16 kV AC] Safety Division energized.

   Vital AC Power supports all systems which are utilized to satisfy the other safety functions. Vital AC Power is necessary to provide electrical power for valve operation, pump and motor operation, instrument indication, and an ultimate heat sink.

2. If the above criterion is not satisfied, then success path MVAC-1 is not adequate. The operator should go to success path MVAC-2 for further guidance to restore/maintain Maintenance of Vital AC Power.

3. If the acceptance criterion for success path MVAC-1 is satisfied, then success path MVAC-1 is successfully controlling Vital AC Power. Vital AC Power is not in jeopardy so the operator should address other safety functions which may be in jeopardy. Note that the Maintenance of Vital Auxiliaries safety function is not satisfied unless Vital AC Power <u>and</u> Vital DC Power acceptance criteria are satisfied.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

MVAC-2: Maintenance of Vital AC Power via Emergency Diesel Generators

In the case where the station loads are not transferred offsite (supplied by the Unit Auxiliary Transformers), the emergency diesel generators should start automatically to provide a source of AC power. Operator actions include verifying that the diesels start, manually starting diesel generators if necessary, ensuring proper operation, and loading of the diesel generators.

Operator Actions

1. In order to ensure that a source of AC power is available, the operators should verify that the emergency diesel generators have started automatically on vital bus undervoltage, SIAS signals, or reactor trip. If the diesel generators have not started automatically, the problem should be investigated and corrected, and the operators should manually start the diesel generators.

2. The emergency diesel generators should be operated in accordance with the [plant specific operating instructions] to prevent equipment damage and to ensure continued operability.

3. At least one safety division of [4.16kV] should be energized from the diesel generators. Plant specific instructions for verifying proper operation of breakers and necessary loads to be energized should be referenced or provided in this step. If AC Power is not available from the diesel generators, the operator should proceed to Vital AC Power success path MVAC-3.

MVAC-2: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, Maintenance of Vital AC Power is satisfied if:

   At least one [4.16 kV AC] Safety Division energized.

   Vital AC Power supports all systems which are utilized to satisfy the other safety functions. Vital AC Power is necessary to provide electrical power for valve operation, pump and motor operation, instrument indication, and an ultimate heat sink.

2. If the above criterion is not satisfied, then success path MVAC-2 is not adequate. The operator should go to success path MVAC-3 for further guidance on restoring/maintaining Maintenance of Vital AC Power.

3. If the acceptance criterion for success path MVAC-2 is satisfied then success path MVAC-2 is successfully controlling Vital AC Power. Vital AC Power is not in jeopardy so the operator should address other safety functions which may be in jeopardy. Note that the Maintenance of Vital Auxiliaries safety function is not satisfied unless Vital AC Power <u>and</u> Vital DC Power acceptance criteria are satisfied.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

MVAC-3: Maintenance of Vital AC Power via Reserve Auxiliary Transformer

If offsite power is available, but none of the Unit Auxiliary Transformers are available, it may be appropriate to supply the vital AC buses by supplying offsite AC through the Reserve Auxiliary Transformer.

Operator Actions

1. Offsite AC power should be made available to at least one safety division [4.16kV] AC power through the Reserve Auxiliary Transformer. Plant specific instructions for performing this alignment should be referenced or provided.

MVAC-3: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, Maintenance of Vital AC Power is satisfied if:

   At least one [4.16 kV AC] Safety Division energized.

   Vital AC Power supports all systems which are utilized to satisfy the other safety functions. Vital AC Power is necessary to provide electrical power for valve operation, pump and motor operation, instrument indication, and an ultimate heat sink.

2. If the above criterion is not satisfied, then success path MVAC-3 is not adequate. The operator should go to success path MVAC-4 for further guidance on restoring/maintaining Maintenance of Vital AC Power.

3. If the acceptance criterion for success path MVAC-3 is satisfied then success path MVAC-3 is successfully controlling Vital AC Power. Vital AC Power is not in jeopardy so the operator should address other safety functions which may be in jeopardy. Note that the Maintenance of Vital Auxiliaries safety function is not satisfied unless Vital AC Power <u>and</u> Vital DC Power acceptance criteria are satisfied.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

MVAC-4: Maintenance of Vital AC Power via Alternate AC (Combustion Turbine Generator

For sites which have more than one unit and have the capability of supplying electrical AC power through the on-site distribution system, it may be appropriate to restore the vital AC buses from [the Second Plant].

Operator Actions

1. Verify that the Alternate AC source is available and operating to supply power. If AC Power is not available from the Alternate AC, then go to the Continuing Actions for Maintenance of Vital AC Power for further guidance.

2. Alternate AC power should be restored to at least one safety division of [4.16 kV] by operating the appropriate breakers and disconnects. Plant specific instructions for lining up Alternate AC should be referenced or provided.

MVAC-4: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, Maintenance of Vital AC Power is satisfied if:

   At least one [4.16 kV AC] Safety Division energized.

   Vital AC Power supports all systems which are utilized to satisfy the other safety functions. Vital AC Power is necessary to provide electrical power for valve operation, pump and motor operation, instrument indication, and an ultimate heat sink.

2. If the above criterion is not satisfied, then success path MVAC-4 is not adequate. The operator should go to Continuing Actions for Maintenance of Vital AC Power.

3. If the acceptance criteria for success path MVAC-4 are satisfied then success path MVAC-4 is successfully controlling Vital AC Power. Vital AC Power is not in jeopardy so the operator should address other safety functions which may be in jeopardy. Note that the Maintenance of Vital Auxiliaries safety function is not satisfied unless Vital AC Power <u>and</u> Vital DC Power acceptance criteria are satisfied.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

Continuing Actions for Maintenance of Vital AC Power

If a source of Vital AC Power is not established, then the operators should continue attempts to energize at least one safety division of [4.16 KV] AC. It may not be possible to continue to satisfy or to restore other safety functions without Vital AC power. However, the operator should attempt to satisfy other safety functions while continuing attempts to establish a source of Vital AC Power.

SAFETY FUNCTION: Maintenance of Vital DC Power

SUCCESS PATH: Battery Chargers/Station Batteries: MVDC-1

INSTRUCTIONS	CONTINGENCY ACTIONS
1. Verify that at least one safety division of [125 V] DC has electrical DC power available from the associated vital DC battery charger.	2. Ensure that at least one Safety division of [125 V] DC has electrical DC power available from the batteries.

MVDC-1

ACCEPTANCE CRITERIA FOR SUCCESS PATH: MVDC-1

1. Maintenance of Vital DC Power is satisfied if:

   All [125 V] DC and [120 V] AC distribution centers energized in at least one Safety Division for:

   i) DC control power

   and

   ii) The operation of at least one 120 volt vital AC instrument channel.

2. If above criterion NOT satisfied, Then go to CONTINUING ACTIONS FOR MAINTENANCE OF VITAL DC POWER.

3. If above criterion satisfied AND Maintenance of Vital AC Power satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

MVDC-1

2

IMAGE EVALUATION
TEST TARGET (MT-3)

150mm

6"

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P.O. BOX 338
WEBSTER, NEW YORK 14580
(716) 265-1600

2

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

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2

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

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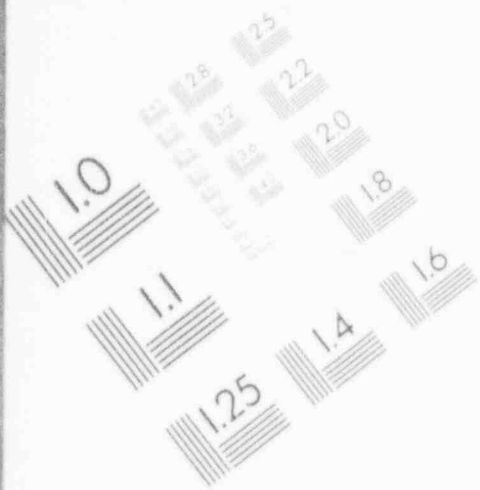
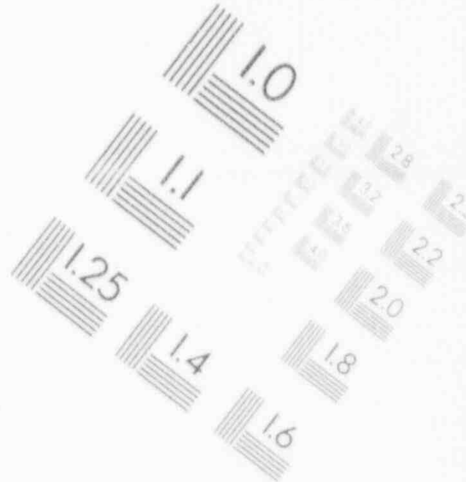
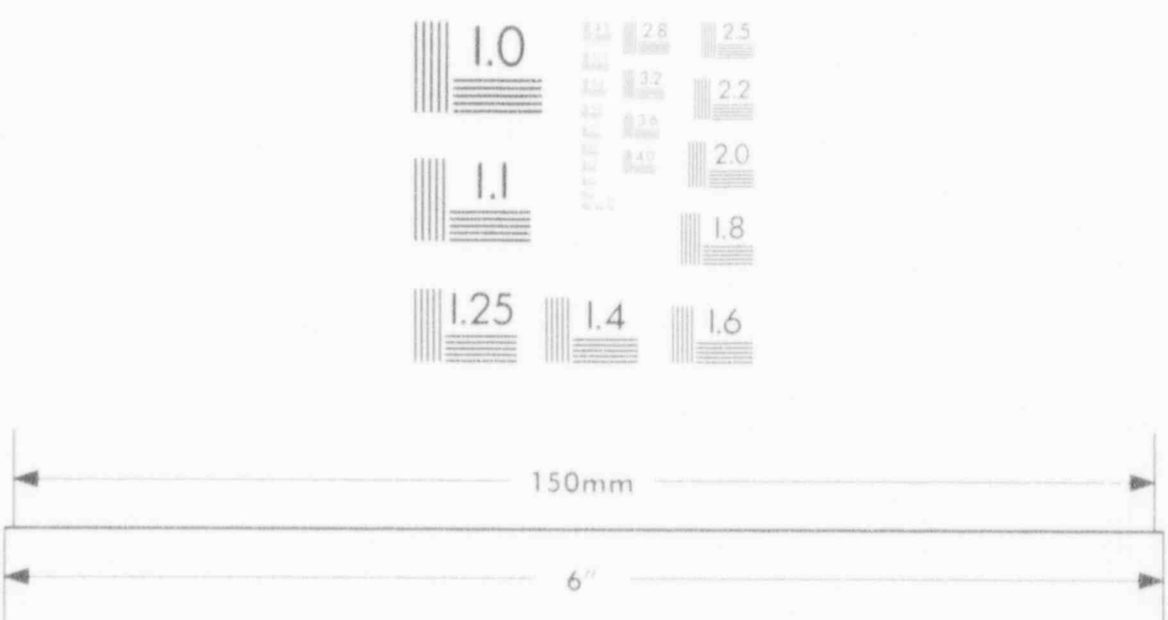
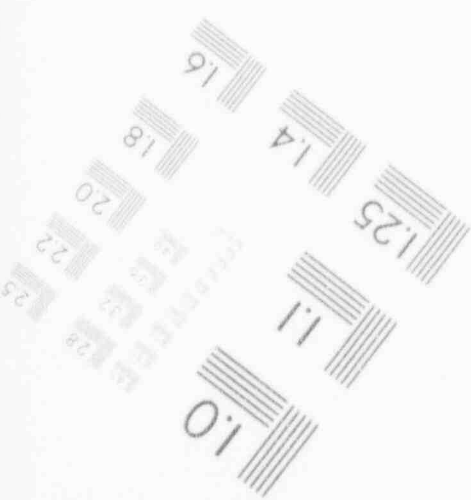
2

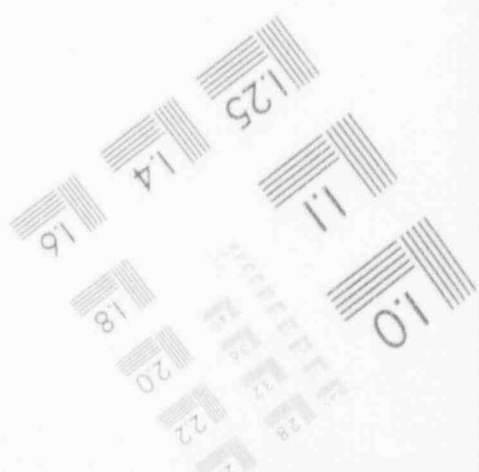
IMAGE EVALUATION TEST TARGET (MT-3)











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SUPPLEMENTARY INFORMATION: MVDC-1

This section contains items which should be considered when implementing EPGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Do not place systems in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation.

2. All available indications should be used to aid in evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available.

3. If only one safety division of [125 V] DC power has been restored, the acceptance criteria for Maintenance of Vital DC Power will be met and the operators should proceed to the next safety function in jeopardy. However, efforts to restore the second safety division (and the non-safety divisions) should be continued in order to increase the availability of plant systems and components.

4. Since the battery chargers are powered by the vital AC buses, if vital AC power is available, the vital batteries should continue to supply electric DC power to the vital station DC loads. If a prolonged loss of vital AC occurs, the sustained operation of essential DC power equipment becomes more critical. Therefore, battery current should be monitored to maximize the duration of battery availability.

MVDC-1

a. During the initial phases of a loss of vital AC, the manual and automatic use of vital station DC loads will be maximized to:

   i) realign the on-site distribution for electrical AC power;
   ii) provide electrical power to instrumentation and control equipment to monitor and control plant parameters.
   iii) provide electrical power to control DC loads required to re-establish emergency electrical AC power.

   However, the use of the batteries during this period should be coordinated to minimize peak currents and to extend the duration of battery availability. Non-essential DC loads should be removed from the DC distribution by opening the load supply breakers.

b. If the loss of vital AC power continues the use of vital station DC loads should be minimized to provide only a minimum of instrumentation and control equipment to monitor and control plant parameters.

   The use of the batteries for an electrical emergency should be reduced to a minimum. Extending the duration of the battery availability for the purpose of maintaining the safety functions is the primary objective for its continued use.

5. Maintenance of Vital Auxiliaries safety function is satisifed only if Vital AC, Vital AC I&C, and Vital DC have distribution centers in the same Safety Division energized.

MVDC-1

CONTINUING ACTIONS FOR MAINTENANCE OF VITAL DC POWER

If the acceptance criteria are NOT met, Then Maintenance of Vital DC Power is still in jeopardy. The operator must continue to attempt to establish a source of Vital DC Power while pursuing other jeopardized safety functions. Restoration of Vital AC Power may be necessary in order to make the battery chargers available.

Bases for Maintenance of Vital DC Power

The purpose of maintaining Vital DC Power is to ensure the continued availability of a plant systems and components required to control the plant and maintain the safety functions. The preferred method of energizing at least one safety Division of DC power is to utilize the battery chargers. If Vital DC Power is being supplied by the station battery, efforts to restore Vital DC Power via the battery chargers should be pursued.

The following method is provided to maintain a supply of Vital DC Power:

MVDC-1: Maintenance of Vital DC Power via Battery Chargers/Station Batteries

The bases for the recovery actions required for implementing the above are detailed below. Maintaining the continuity of Vital DC Power is desired to maintain DC control power and vital instrumentation for monitoring safety functions. It should be noted that Maintenance of Vital AC Power acceptance criteria must also be satisfied to satisfy the Maintenance of Vital Auxiliaries safety function.

MVDC-1: Maintenance of Vital DC Power via Battery Chargers/Station Batteries

The preferred method of energizing at least one Safety Division of DC power is via the battery chargers. If the battery chargers are not available, then at least one Safety Division of DC power should be energized from the station batteries. If station batteries are supplying the DC bus(es), efforts to restore Vital DC Power via the battery chargers should be pursued.

Operator Actions

1. Verifying that at least one Safety Division of [125 V] DC power is energized via the associated vital DC battery charger directs the operator to confirm that the preferred configuration of Vital DC Power exists. The operator is directed to ensure that the station battery is supplying at least one [125 V] DC bus if the battery charger(s) does not have electrical AC power, is not operating properly, or is not available.

MVDC-1

MVDC-1: Acceptance Criteria and Guideline Direction

After implementing the above actions, Maintenance of Vital DC Power is satisfied if:

All [125 V] DC and [120 V] AC distribution centers energized in at least one Safety Division for:

i) DC control power

and

ii) The operation of the associated 120 volt vital AC instrument channels.

Vital DC Power is required to ensure the continued availability of plant systems and components required to control the plant and maintain the safety functions. This is accomplished by maintaining DC control power and vital instrumentation for control and monitoring of plant parameters.

2. If the above criterion is not satisfied, then success path MVDC-1 is not adequate. The operator should go to Continuing Actions for Maintenance of Vital DC Power.

3. If the acceptance criterion for success path MVDC-1 is satisfied, then success path MVDC-1 is successfully controlling Vital DC Power. Vital DC Power is not in jeopardy so the operator should address other safety functions which may be in jeopardy. Note that the Maintenance of Vital Auxiliaries safety function is not satisfied unless Vital AC Power and Vital DC Power acceptance criteria are satisfied.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

MVDC-1

Continuing Actions for Maintenance of Vital DC Power

If a source of Vital DC Power is not established, then the operators should continue attempts to energize at least one vital DC bus. It may not be possible to continue to satisfy or restore other safety functions without Vital DC Power. However, the operator may attempt to satisfy other safety functions while continuing attempts to establish a source of Vital DC Power.

SAFETY FUNCTION: RCS Inventory Control

SUCCESS PATH: CVCS; IC-1

INSTRUCTIONS	CONTINGENCY ACTIONS
1. Verify charging and letdown are operating automatically to maintain or restore pressurizer level [2% to 78%].	1. Manually control charging and letdown to maintain or restore pressurizer level [2% to 78%].
2. Verify adequate suction source(s) exists for charging pump operation. Available sources include the VCT and boric acid storage tanks.	2. Replenish source(s) or switch charging pump suction as necessary to maintain charging capability.
3. If high pressurizer level condition appears to be caused by excessive RCS voiding, Then refer to RCS and Core Heat Removal success path HR-2 (Natural Circulation, No SI Operation) for void elimination procedure.	3.

IC-1

ACCEPTANCE CRITERIA FOR SUCCESS PATH IC-1:

1. RCS Inventory Control is satisfied if:

   a. Pressurizer level is [2% to 78%]*
      and
   b. The RCS is subcooled as indicated by representative CET,
      and
   c. The HJTC RVLMS indicates the top of the lot leg nozzle is covered.

2. If above criteria NOT satisfied, Then go to RCS Inventory Control success path IC-2 (SI).

3. If above criteria satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

* If the RCS is in a solid condition for pressure control, then the limit of [78%] may be exceeded.

IC-1

SUPPLEMENTARY INFORMATION: IC-1

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Solid water operation of the pressurizer may make it difficult to control RCS pressure, and therefore should be avoided unless subcooling cannot be maintained in the RCS (Figure 11-1). If the RCS is solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any unfavorable rapid pressure excursions.

2. All available indications should be used to aid in evaluating plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available.

3. Do not place system in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation.

4. Steam plant radiation alarms usually indicate a steam generator tube leak which may result in loss of RCS inventory.

5. Indications of high RCS inventory may be caused by the displacement of water from voided areas of the RCS. Operators must be aware of this and understand that operation of letdown and/or depressurizing in this situation may lower RCS pressure and, subsequently, increase RCS voiding.

IC-1

6. When a void exists in the reactor vessel, and RCPs are not operating, the HJTC RVLMS provides an accurate indication of reactor vessel liquid inventory. When a void exists in the reactor vessel, and RCPs are operating, it is not possible to obtain an accurate reactor vessel liquid level indication due to the effect of the RCP induced pressure head on the HJTC RVLMS. Information concerning reactor vessel liquid inventory trending may still be discerned. However, the operator is cautioned not to rely solely on the HJTC RVLMS indication when RCPs are operating.

7. The operator should continuously monitor for the presence of RCS voiding and take steps to eliminate voiding any time voiding causes the heat removal or inventory control safety functions to begin to be threatened. Void elimination should be started soon enough to ensure heat removal and inventory control are not lost.

IC-1

SAFETY FUNCTION: RCS Inventory Control

SUCCESS PATH: SI, IC-2

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. If pressurizer pressure ≤ SIAS setpoint or containment pressure ≥ [2.7 psig] Then verify SIAS actuated.	1. If pressurizer pressure ≤ SIAS setpoint or containment pressure ≥ [2.7 psig] and an SIAS has NOT been initiated automatically, Then manually initiate an SIAS.
* 2. If pressurizer pressure < [1400 psia] following an SIAS, Then do one of the following: a. If RCS is subcooled, then ensure two of four RCPs are tripped (on opposite loops). or b. If RCS is NOT subcooled, then ensure all four RCPs are tripped.	2. Continue RCP operation.
3. Verify RCP operating limits are satisfied.	3. Trip the RCP(s) which do not satisfy RCP operating limits.

* Step Performed Continuously

IC-2

INSTRUCTIONS	CONTINGENCY ACTIONS
* 4. Ensure maximum safety injection and charging flow to the RCS by the following: a. start idle SI pumps and verify SI flow in accordance with Figure 11-3, b. start idle charging pump, if available.	4. If safety injection and charging flow NOT maximized, Then do the following as necessary: a. ensure electrical power to valves and pumps, b. ensure correct SI valve lineup, c. ensure operation of necessary auxiliary systems.
5. If high RCS pressure is preventing adequate SI flow, Then attempt to cooldown/depressurize to obtain adequate SI Flow. (Refer to the Pressure Control and Heat Removal Success paths in use).	5.

* Step Performed Continuously

IC-2

INSTRUCTIONS	ACCEPTANCE CRITERIA
6. If SI pumps are operating, Then they may be throttled or stopped, one pump at a time, if ALL of the following are satisfied: a. RCS subcooled based on representative CET temperature (Figure 11-1), b. pressurizer level is greater that [14.3%] and not decreasing, c. at least one steam generator is available for removing heat from the RCS (ability for feed and steam flow), d. the HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles.	6. Continue SI pump operation.
* 7. If the criteria of step 5 cannot be maintained after SI pumps throttled or stopped, Then SI pumps must be restarted and full SI flow restored.	7.

* Step Performed Continuously

IC-2

INSTRUCTIONS	ACCEPTANCE CRITERIA
* 8. Monitor In-containment Refueling Water Storage Tank (IRWST) level and verify reactor cavity sump level or Holdup Volume Tank (HVT) increases as IRWST level decreases.	8. Maintain IRWST level by replenishment from available sources.

* Step Performed Continuously

IC-2

Acceptance Criteria for Success Path IC-2:

1. RCS Inventory Control is satisfied if:

   a. Available charging pumps is operating and the SI pump(s) are injecting water into the RCS per Figure 11-3 (unless SI termination criteria are met).

   and

   b. The HJTC RVLMS indicates the core is covered.

2. If above criteria NOT satisfied, Then go to CONTINUING ACTIONS FOR RCS INVENTORY CONTROL.

3. If above criteria satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

IC-2

SUPPLEMENTARY INFORMATION: IC-2

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Solid water operation of the pressurizer may make it difficult to control RCS pressure, and therefore should be avoided unless subcooling cannot be maintained in the RCS (Figure 11-1). If the RCS is solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any unfavorable rapid pressure excursions.

2. All available indications should be used to aid in evaluating plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available. Hot and cold leg RTDs may be influenced by cold SI injection and should be checked against each other, (e.g., during rapid depressurization the indicated level in the pressurizer may be too high).

3. Do not place system in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation.

4. Steam plant radiation alarms usually indicate a steam generator tube leak which may result in loss of RCS inventory.

CONTINUING ACTIONS FOR INVENTORY CONTROL

If the acceptance criteria are NOT met, Then RCS Inventory Control is still in jeopardy. The operator must continue to attempt to establish RCS Inventory Control while pursuing other jeopardized safety functions. Evaluate further actions using the following:

a) Rate of change of inventory and potential for damage to the RCS
b) The urgency of other jeopardized safety functions
c) The feasibility of restoring function to a success path by:
   i) Restoring the vital auxiliaries necessary to operate components or systems in the success paths
   ii) Manual operation of valves
   iii) Use of alternate components to implement a success path.
   iv) Depressurizing/cooling the RCS to increase or establish SI flow, or, in an extreme case, to allow the SITs to discharge
   v) Performing an aggressive cooldown to Shutdown Cooling System (SCS) entry conditions to allow permit use of the SCS pumps for inventory control.

If a severe accident condition has been diagnosed and a core exit temperatures are greater than [700°F] and the [Plant Technical Support Center] has not yet been activated, Then actuate the Reactor Cavity Flood system.

If a severe accident condition has been diagnosed and core exit temperatures are greater than [700°F] and the [Plant Technical Support Center] has not yet been activated and a power supply other than the station batteries is available, Then actuate the Hydrogen Mitigation System Igniters.

Bases for RCS Inventory Control

The purpose of maintaining RCS Inventory Control is to provide a medium for the removal of decay heat. To do this, RCS inventory is maintained between the minimum volume required to keep the core covered with an effective coolant medium and the maximum level desirable for operational purposes (i.e., to prevent solid plant operations with its attendant pressure control problems).

Many plant conditions may result in a loss of inventory control. A break in the primary system piping, a stuck open safety valve, or a failure in the CVCS system are some examples of possible causes of low inventory. A high inventory situation may result from excessive fluid addition from the CVCS or SI, RCS fluid expansion due to an uncontrolled heat addition, or an apparently high inventory condition may result from RCS voiding.

The methods available for RCS inventory control also affect RCS pressure control. For example, a high pressure situation may result from excessive RCS inventory. On the other hand, a high RCS pressure may hinder the achievement of RCS inventory control since the SI pumps are centrifugal pumps and limited by shutoff heads.

To achieve control of RCS inventory, the following methods are available:

IC-1: RCS Inventory Control via CVCS
IC-2: RCS Inventory Control via SI

The bases for the recovery actions required for implementing each of the methods listed above are detailed as follows:

IC-1: RCS Inventory Control via CVCS

The preferred method of RCS Inventory Control is by automatic or manual operation of charging and letdown (CVCS). The goal is to provide sufficient pressurizer inventory to maintain the core covered with an adequate cooling medium and to prevent solid plant conditions.

Operator Actions

1. Charging and letdown are verified to be maintaining or restoring pressurizer level to [2% to 78%]. If not, charging and letdown are operated manually to restore and maintain pressurizer level [2% to 78%].

   Limiting letdown while maximizing charging flow may be adequate to make up for an insufficient RCS inventory condition. Charging pump(s) may have to be manually restarted if an interruption of power to the charging pump bus(es) has occurred. Conversely, maximizing letdown and minimizing charging flow may suffice in lowering a high RCS inventory condition.

   It is necessary that the operator check that pressurizer level is within an acceptable range, that there is adequate RCS subcooling, and that there is no significant reactor vessel voiding as indicated by the HJTC RVLMS, to verify that RCS inventory is being controlled. If adequate pressurizer level is not being maintained automatically, the operator has an alternate means of control by manually operating the available charging pump and letdown to regulate inventory into and out of the RCS.

IC-1

2. Adequate suction sources to the charging pumps are verified. Available sources include the VCT, and the boric acid storage tanks. The volume of water necessary to control RCS inventory depends on the make-up rate to the RCS and the time frame over which the fluid must be introduced. The volume control tank is the primary source of fluid for RCS makeup. If necessary, for the cases where RCS inventory losses are being incurred, the contents of the boric acid storage tanks may be used as backup sources of makeup water.

3. A high pressurizer level indication may be the result of RCS voiding. If this is the case, the actions concerning letdown in Step 1 may either have minimal effect on indicated pressurizer level or result in an even higher indicated pressurizer level. (The void expands upon pressure decrease with a resulting redistribution of RCS fluid into the pressurizer). The presence of such an RCS void may be the result of depressurizing the RCS before the reactor vessel head cools below saturation temperature, inadequate RCS/Core Heat Removal or the presence of non-condensible gases. If a high pressurizer level appears to be caused by excessive RCS voiding, then the RCS and Core Heat Removal safety function success path HR-2 (Natural Circulation, No SI Operation) should be referred to if eliminating the void is necessary. The HJTC RVLMS indication may provide confirmation of this voiding, if voiding is present in the reactor vessel.

IC-1

IC-1: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, RCS Inventory Control is satisfied if:

   a. Pressurizer level is [2% to 78%]*

   and

   b. The RCS is subcooled as indicated by representative CET,

   and

   c. The HJTC RVLMS indicates the hot leg nozzle is covered.

* If the RCS is in a solid condition for pressure control, then the limit of [78%] may be exceeded.

Successful control of RCS inventory may be verified by pressurizer level being restored to [2% to 78%], RCS subcooled, and the HJTC RVLMS indicating the hot leg nozzle is covered. The basis for meeting these acceptance criteria is dependent upon whether a low or high inventory situation exists. For the low inventory situation, a value of [2%] is chosen as a lower pressurizer level limit to ensure that level is within the pressurizer level instrument indicating range. It is normally desirable to maintain pressurizer level > [14.3%] to allow for operation of pressurizer heaters. The upper limit value of [78%] was chosen as an upper limit for pressurizer level to limit refill and provide a margin to solid RCS conditions. This value accounts for uncertainties. Subcooling, pressurizer level [2% to 78%], and the HJTC RVLMS indicating the hot leg nozzle is coveraged, are indications of adequate RCS inventory control. In some cases, it may be necessary to fill the pressurizer solid in order to achieve adequate subcooling. If this is the case, then the upper limit on pressurizer level may be exceeded.

IC-1

IC-1: Acceptance Criteria and Guideline Direction, cont'd

2. If the above criteria are not satisfied, then success path IC-1 is not successfully controlling RCS Inventory. The operator should go to success path IC-2 for RCS Inventory Control.

3. If the acceptance criteria for success path IC-1 are satisfied, then success path IC-1 is successfully controlling RCS Inventory. RCS Inventory Control is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

IC-2: RCS Inventory Control via SI

If the automatic or manual operation of charging pumps and letdown is not satisfying the acceptance criteria of IC-1, then additional makeup fluid is available via the SI.

Operator Actions

* 1. If pressurizer pressure decreases to or below the SIAS setpoint, or if containment pressure increases to or above [2.7 psig], then initiation of an SIAS must be verified. If necessary, SIAS is manually initiated. This action allows the IRWST inventory to discharge into the RCS. An insufficient RCS inventory may be associated with a loss of primary coolant, a ruptured steam generator tube, a control system malfunction, or an excessive heat removal event or a combination of these events. Operation of the SI also affects RCS pressure. When operating the SI the operator must attempt to maintain or restore pressure to within the limits of Figure 11-1. If subcooling cannot be maintained, the SI is kept running for core cooling considerations regardless of pressurizer level.

* 2. A generic RCP trip strategy has been developed which results in the tripping of all four RCPs for depressurization events where RCS is not subcooled, but allows the continued operation of two RCPs (in opposite loops) for depressurization events where RCS is subcooled. For undiagnosed events, where the Functional Recovery Guideline is implemented, the RCP trip strategy is identical to that followed in the LOCA guideline. This step details the two significant operational aspects regarding the RCP trip strategy for a functional procedure.

The first operational strategy results in the operator tripping two RCPs (in opposite loops) if pressurizer pressure decreases to less than [1400 psia] following a SIAS and RCS is subcooled. This action may occur in the Standard Post Trip Actions and, in this case, the operator would simply verify that two

IC-2

RCPs (in opposite loops) have been tripped. The operator trips all four RCPs if pressurizer pressure decreases to less than [1400 psia] following a SIAS and RCS is not subcooled. If the operator cannot confirm that a LOCA has occurred, and the Functional Recovery Guideline is implemented, the RCP trip strategy is identical to that followed in the LOCA guideline. If the depressurization event can be diagnosed and is determined to be other than a LOCA (i.e., ESDE or SGTR), then only two RCPs (in opposite loops) are tripped. The other two RCPs remain operational until the RCP operating requirements (e.g., NPSH, temperatures, seal flow, oil pressures, motor amperage, vibration) are no longer satisfied, then, any pump which does not satisfy these requirements should be tripped. This gives the operator maximum flexibility in plant control because a normal plant cooldown can be performed while still ensuring a conservative approach to event recovery.

* 3. The second aspect of the RCP operating strategy concerns the verification that RCP operating limits are satisfied. The RCPs will be operating in a pressure-reduced RCS and may not satisfy NPSH requirements. The operator must continuously monitor RCP operating limits (e.g., temperatures, seal flow, oil pressures, NPSH, motor amperage, vibration) and trip any RCPs which do not satisfy RCP operating limits. Plant specific RCP operating limits should appear in this step, either directly or, by referencing the applicable operating instructions.

* 4. If an SIAS is actuated, then the available charging pump and SI pumps should be operating and injecting water into the RCS. The SI flowrate will vary according to pressurizer pressure. SI and the charging pump flowrates should be checked and maximized (Figure 11-3 provides information which can be utilized to verify adequate SI flow is occurring) for RCS inventory replenishment and/or core heat removal. [Charging pump(s) may have to be manually restarted if an interruption of power to the charging pump bus(es) has occurred]. The following guidance will assist in ensuring maximum injection of water into the RCS:

IC-2

a. idle SI pumps should be started and system flow should be verified to be within the limits of Figure 11-3,
b. the available charging pumps should be verified running.

If any SI pump that should be operating won't start, and the available charging pump will not start, or SI flow is not in accordance with Figure 11-3, then the following guidance is provided:

a. the operator should verify that electrical power is available to valves and pumps necessary for inventory control
b. the SI valve lineup should be verified to be correct in the control room
c. auxiliary systems necessary for SI or charging operation should be checked

It must be noted, however, that the maximization of charging and safety injection can result in excess RCS inventory, possible filling of the pressurizer to a solid condition, and a PTS concern upon RCS heat up, fluid expansion, and subsequent RCS pressure excursion. Operators must be aware of these concerns and terminate the SI operation when the termination criteria are met.

* 5. If high RCS pressure is causing RCS inventory or inventory trends to threaten adequate core cooling, then operators must take action to ensure that adequate core cooling is maintained. FRG success paths for Pressure Control and RCS Heat Removal that are in use should be referred for guidance to perform a cooldown/depressurization. Examples of situations which could necessitate this action include: an SIAS is actuated but SI pumps are unavailable or SI pumps are operating but RCS pressure is above the shutoff head of the SI pumps. For situations such as these, depressurizing/cooling the RCS must be performed if SI flow is required, to increase or establish SI flow, to increase or establish LPSI flow, or in an extreme case to allow the SITs to discharge.

IC-2

* 6. If the SI pumps are operating, then they must continue to operate at full capacity until SI termination criteria are met. Termination of SI should be sequenced by stopping one pump at time while observing the termination criteria. Throttling of SI flow is permissible if all of the following SI termination criteria are satisfied:

a. The RCS is at least subcooled based on representative temperature (Figure 11-1). Establishing subcooling ensures the fluid surrounding the core is subcooled. Voids may exist in some parts of the RCS (e.g., reactor vessel head as determined by the HJTC RVLMS), but these are permissible as long as core heat removal is maintained.
b. Pressurizer level is greater than [14.3%], and not decreasing. A pressurizer level greater than [14.3%] and not decreasing, in conjunction with criterion a) above is an indication that RCS inventory control has been established.
c. At least one steam generator is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow is available for removing heat from the RCS.
d. The HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles. This provides an extra margin of core coverage and, taken in conjunction with the above criteria, serves as an additional indication that RCS inventory control has been established.

If all of the SI termination criteria are met, the operator may either stop or throttle the SI pumps. The operator may decide to throttle rather than terminate the flow if the SI pumps are to be used to control pressurizer level or plant pressure. A general assessment of the SI performance can be made from the control room. The operator should confirm that at least one train, and preferably both trains, of SI is operating and that system delivery rate is consistent with RCS pressure as shown in Figure 11-3. Injection flow rates to each injection point should be approximately equal. Departures from this would indicate a closed flow path or some system spillage.

IC-2

* 7. If the criteria of step 5 cannot be maintained after SI pumps are throttled or stopped, then SI pumps should be restarted (if necessary) and full SI flow restored.

* 8. The operator should monitor In-containment Refueling Water Storage Tank (IRWST) level. For RCS breaks inside containment, a decreasing trend in [RWT] level should correspond to an increasing trend in containment sump level. This action enables the operator to trend [IRWST] level and to anticipate possible problems (IRWST LOCA is outside of containment). If a decreasing trend in [IRWST] level cannot be correlated to an increasing HTV or reactor cavity sump level, then a LOCA outside containment may be in progress. If IRWST level continues to decrease then IRWST level should be replenishment from available sources. This will prevent the inadvertent air binding of the SI pumps.

IC-2

IC-2: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, RCS Inventory Control is satisfied if:

   a. The available charging pump is operating and the SI pump(s) are injecting water into the RCS per Figure 11-3 (unless SI termination criteria are met).

   and

   b. The HJTC RVLMS indicates the core is covered.

   When the SI is operating, its performance adequacy is judged by its delivery flow versus RCS pressure. The available charging pump is specified for the additional injection flow but is not required to meet safety concern. Once SI termination criteria have been met, SI flow may be throttled or pumps turned off. The relation between SI flow and RCS pressure depicted in Figure 11-3 is no longer valid. An HJTC RVLMS indication of core coverage, taken in conjunction with adequate inventory replenishment, serves as an additional indication of adequate RCS inventory control.

2. If the above criteria are not satisfied, then success path IC-2 is not successfully controlling RCS Inventory. The operator should go to CONTINUING ACTIONS FOR RCS INVENTORY CONTROL.

3. If the acceptance criteria for success path IC-2 are satisfied, then success path IC-2 is successfully controlling RCS Inventory. RCS Inventory Control is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

CONTINUING ACTIONS FOR INVENTORY CONTROL

If RCS Inventory Control is still in jeopardy, then the operator must continue to attempt to establish RCS Inventory control while attending to other safety functions in jeopardy. The evaluation of the urgency of RCS Inventory Control should be based on rate of change of inventory and potential for damage to the RCS, the urgency of other safety functions in jeopardy, and the feasibility of restoring equipment to restore success paths. Clearly, if inventory trends are threatening core uncovery, the operator must take all possible steps to restore inventory. This may involve the manipulation of other safety functions (e.g., RCS pressure reduction to lower RCS pressure below the shutoff head of the SI pumps or even reduce pressure sufficiently to allow operation of the Shutdown Cooling pumps).

If a severe accident condition has been diagnosed (i.e. CET temperatures greater than [700°F]) and the [Plant Technical Support Center] has not yet been activated, then the operator should actuate the Reactor Cavity Flood system to help mitigate the consequences of molten core material leaving the reactor vessel. The hydrogen igniters should also be actuated, but only if there is power available from sources other than the station batteries. Battery power must be conserved and the initiation of the igniters may not be the highest priority for the mitigation of the event.

SAFETY FUNCTION: RCS Pressure Control

SUCCESS PATH: Pressurizer Heaters and Spray; PC-1

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. Verify pressurizer heaters and main or auxiliary spray are automatically maintaining pressurizer pressure within the Post Accident P-T limits of Figure 11-1.	* 1. If pressurizer pressure outside the normal band is desired or the P-T limits of Figure 11-1 are violated, Then do the following as appropriate: a. manually control pressurizer heaters and spray to restore and maintain pressurizer pressure within the Post Accident P-T limits of Figure 11-1. b. attempt to maintain the plant in a stable pressure-temperature configuration or continue to cooldown within the limits of Figure 11-1 (refer to the RCS and Core Heat Removal success path being implemented).

* Step Performed Continuously

Acceptance Criteria for Success Path PC-1:

1. RCS Pressure Control is satisfied if:

   Pressurizer pressure is within the Post Accident P-T limits of Figure 11-1.

2. If above criterion NOT satisfied, Then go to next appropriate RCS Pressure Control success path.

3. If above criterion satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

PC-1

SUPPLEMENTARY INFORMATION: PC-1

This section contains items which should be considered when implementing EPGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Continuously monitor RCS temperature and pressure to avoid exceeding a heat removal rate greater than Technical Specification Limitations. If the heat removal rate exceeds Technical Specification Limits, there may be a potential for pressurized thermal shock (PTS) of the reactor vessel unless Post Accident Pressure/Temperature Limits are maintained (Figure 11-1).

   If there is a conflict between maintaining adequate core cooling and complying with the pressure/temperature limits of Figure 11-1, then maintaining adequate core cooling will be given the higher priority. Subcooling has precedence over PTS considerations.

2. All available indications should be used to aid in evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available (e.g., during rapid depressurization the indicated level in the pressurizer may be higher than actual level).

3. Solid water operation of the pressurizer may make it difficult to control RCS pressure and, therefore, should be avoided unless subcooling cannot be maintained in the RCS (Figure 11-1). If the RCS is solid, closely monitor any makeup or draining, and any system heatup or cooldown, to avoid any unfavorable rapid pressure excursions.

PC-1

SAFETY FUNCTION: RCS Pressure Control
SUCCESS PATH: CVCS; PC-2

INSTRUCTIONS	CONTINGENCY ACTIONS
1. Verify charging and letdown are operating automatically to maintain or restore pressurizer level [2% to 78%].	1. Manually control charging and letdown to maintain or restore pressurizer level [2% to 78%].
2. Verify adequate suction source(s) exist for charging pump operation. Available sources include VCT, boric acid storage tanks, spent fuel pool, and IRWST.	2. Replenish source(s) or switch charging pump suction as necessary to maintain charging capability.
* 3. If subcooling cannot be maintained, Then attempt to take the pressurizer solid to establish RCS pressure control. Manually control charging and letdown to restore and maintain pressurizer pressure to within the Post Accident P-T limits of Figure 11-1.	3.

* Step Performed Continuously

PC-2

INSTRUCTIONS

* 4. If the P-T limits of Figure 11-1 are violated, Then do the following as appropriate:

a. attempt to maintain the plant in a stable pressure-temperature configuration or continue to cooldown within the limits of Figure 11-1.

b. If overpressurization due to excessive charging flow, Then throttle or secure charging and manually control letdown to restore and maintain pressure within the limits of Figure 11-1.

CONTINGENCY ACTIONS

4.

* Step Performed Continuously

PC-2

Acceptance Criteria for Success Path PC-2:

1. RCS Pressure Control is satisfied if:

   Pressurizer pressure is within the Post Accident P-T limits of Figure 11-1.

2. If above criterion NOT satisfied, Then go to next appropriate RCS Pressure Control success path.

3. If above criterion satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

PC-2

SUPPLEMENTARY INFORMATION: PC-2

This section contains items which should be considered when implementing EPGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Do not place systems in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation (e.g., during rapid depressurization the indicated level in the pressurizer may be higher than actual level).

2. All available indications should be used to aid in evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available.

3. Continuously monitor RCS temperature and pressure to avoid exceeding a heat removal rate greater than Technical Specification Limitations. If the heat removal rate exceeds Technical Specification Limits, there may be a potential for pressurized thermal shock (PTS) of the reactor vessel unless Post Accident Pressure/Temperature Limits are maintained (Figure 11-1).

   If there is a conflict between maintaining adequate core cooling and complying with the pressure/temperature limits of Figure 11-1, then maintaining adequate core cooling will be given the higher priority. Subcooling has precedence over PTS considerations.

4. Solid water operation of the pressurizer may make it difficult to control RCS pressure and, therefore, should be avoided unless subcooling cannot be maintained in the RCS (Figure 11-1). If the RCS is solid, closely monitor any makeup or draining, and any system heatup or cooldown, to avoid any unfavorable rapid pressure excursions. PC-2

SAFETY FUNCTION: RCS Pressure Control

SUCCESS PATH: SIS; PC-3

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. If pressurizer pressure is less than or equal to the SIAS setpoint or containment pressure ≥ [2.7 psig], Then verify an SIAS actuated.	1. If pressurizer pressure is less than or equal to the SIAS setpoint or containment pressure ≥ [2.7 psig] and an SIAS has NOT been initiated automatically, Then manually initiate an SIAS.
* 2. If pressurizer pressure decreases to less than [1400 psia] following a SIAS, then do either of the following: a. If RCS is subcooled, Then ensure two of four RCPs are tripped (in opposite loops). or b. If RCS is NOT subcooled, Then ensure all four RCPs are tripped.	2. Continue RCP operation.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
* 3. Ensure maximum safety injection and charging flow to the RCS by the following: a. start SIS pumps and verify SIS flow in accordance with Figure 11-3. and b. start charging pump.	3. If safety injection and charging flow NOT maximized, Then do the following as necessary: a. ensure electrical power to valves and pumps, b. ensure correct SIS valve lineup, c. ensure operation of necessary auxiliary systems.
* 4. If SI pumps are operating and not required for success path RC-3, Then they may be throttled or stopped, one pump at a time, if ALL of the following are satisfied: a. RCS subcooled based on representative CET temperature (Figure 11-1), b. pressurizer level is greater than [14.3%] and not decreasing, c) at least one steam generator is available for removing heat from the RCS (ability for feed and steam flow), d) the RVLMS indicates a minimum level at the top of the hot leg nozzles.	4. Continue HPSI pump operation.

* Step Performed Continuously

PC-3

INSTRUCTIONS	CONTINGENCY ACTIONS
* 5. If the criteria of step 4 cannot be maintained after SI pumps throttled or stopped, Then appropriate SI pumps must be restarted and full SIS flow restored.	5.
* 6. If subcooling cannot be maintained, Then attempt to take the pressurizer solid to establish RCS pressure control. Manually control SIS pumps (and letdown, if appropriate) to restore and maintain pressurizer pressure within the Post Accident P-T limits of Figure 11-1.	6.

* Step Performed Continuously

PC-3

INSTRUCTIONS	CONTINGENCY ACTIONS
7. If the P-T limits of Figure 11-1 are violated, Then do the following as appropriate: a. attempt to maintain the plant in a stable pressure temperature configuration or continue to cooldown within the limits of Figure 11-1. b. If overpressurization due to excessive SI flow, Then throttle or stop SI pumps (refer to step 4) and manually control letdown to restore and maintain pressure within the limits of Figure 11-1.	7.
8. Verify Holdup Volume Tank level is increasing while IRWST level is decreasing.	8. Maintain IRWST level [>10%] by replenishment from available sources as required.

PC-3

Acceptance Criteria For Success Path PC-3:

1. RCS Pressure Control is satisfied if:

   Charging pump is operating and the SIS pump(s) are injecting water into the RCS per Figure 11-3 (unless SIS termination criteria are met).

2. If above criterion NOT satisfied, Then go to next appropriate RCS Pressure Control success path.

3. If above criterion satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

SUPPLEMENTARY INFORMATION: PC-3

This section contains items which should be considered when implementing EPGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Do not place system in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation (e.g., during rapid depressurization the indicated level in the pressurizer may be higher than actual level).

2. All available indications should be used to aid in the evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available. Hot and cold leg RTDs may be influenced by the cooler SIS injection and should be checked against each other.

3. Continuously monitor RCS temperature and pressure to avoid exceeding a heat removal rate greater than Technical Specification Limitations. If the heat removal rate exceeds Technical Specification Limits, there may be a potential for pressurized thermal shock (PTS) of the reactor vessel unless Post Accident Pressure/Temperature Limits are maintained (Figure 11-1). If there is a conflict between maintaining adequate core cooling and complying with the pressure/temperature limits of Figure 11-1, then maintaining adequate core cooling will be given the higher priority. Subcooling has precedence over PTS considerations.

4. Solid water operation of the pressurizer may make it difficult to control RCS pressure and therefore should be avoided unless subcooling cannot be maintained in the RCS. If the RCS is solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any unfavorable rapid pressure excursions.

SAFETY FUNCTION: RCS Pressure Control

SUCCESS PATH: Forced Circulation with Controlled Steaming, PC-4

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. Borate the plant as necessary, while cooling down, in order to maintain shutdown margin per Technical Specification Limits (refer to RC-2 and RC-3).	1.
2. Allow pressurizer level to lower (maintaining level [2% to 78%]) while cooling down in order to aid the depressurization.	2.
3. Perform a controlled cooldown/depressurization in accordance with Technical Specifications by operation of the steam bypass control system.	3. If the condenser or steam bypass control system NOT available, Then cooldown via the atmospheric dump valve(s).
* 4. Maintain SG levels (or unisolated SG level) in the normal band using main, startup or emergency feedwater.	* 4. If main, startup and emergency feedwater are lost, Then do the following: a. stop all RCPs, b. isolate SG blowdown, secondary sampling, and any non-vital steam discharge, c. attempt to restore main, startup or emergency feedwater,

* Step Performed Continuously

PC-4

INSTRUCTIONS		CONTINGENCY ACTIONS	
* 4.	(Continued)		d. attempt to establish an alternate, low pressure feedwater source to at least one SG if necessary.
5.	Ensure the available emergency feedwater inventory is adequate per Figure 11-4 and 11-5.	5.	
* 6.	Verify adequate RCS pressure control via the steam generators by: a. at least one steam generator has wide range level > 0%, and b. RCS T_c temperatures are stable or decreasing.	* 6.	When at least one primary safety valve has opened following steam generator dryout, Then implement the FRG and initiate RCS and Core Heat Removal success path HR-4 and implement success path PC-6.
* 7.	Ensure pressurizer pressure is being maintained within the Post Accident P-T limits of Figure 11-1.	* 7.	If RCS subcooling greater than P-T limits or cooldown rate greater than [100°F/Hr], Then do the following as appropriate: a. stop the cooldown b. depressurize the plant using the Reactor Coolant Gas Vent System or main or auxiliary spray to restore and maintain pressurizer pressure within the Post Accident P-T limits of Figure 11-1.

* Step Performed Continuously

PC-4

INSTRUCTIONS

* 7. (Continued)

CONTINGENCY ACTIONS

c. attempt to maintain the plant in a stable pressure-temperature configuration or continue to cooldown within the limits of Figure 11-1.

d. If overpressurization due to SI/charging flow, Then throttle or secure flow (refer to PC-3, step 4) and manually control letdown to restore and maintain pressurizer pressure within the limits of Figure 11-1.

* Step Performed Continuously

Acceptance Criteria for Success Path PC-4:

1. RCS Pressure Control is satisfied if:

   Pressurizer pressure is within the Post Accident P-T limits of Figure 11-1.

2. If above criterion NOT satisfied, Then go to next appropriate RCS Pressure Control success path.

3. If above criterion satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

PC-4

SUPPLEMENTARY INFORMATION: PC-4

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The times should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Do not place systems in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation (e.g., during rapid depressurization the indicated level in the pressurizer may be higher than actual level).

2. All available indications should be used to aid in the evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available.

3. Continuously monitor RCS temperature and pressure to avoid exceeding a maximum heat removal rate greater than Technical Specification Limitations. If the heat removal rate exceeds Technical Specification Limits, there may be a potential for pressurized thermal shock (PTS) of the reactor vessel, unless Post-Accident Pressure/Temperature Limits are maintained (Figure 11-1).

   If there is a conflict between maintaining adequate core cooling and complying with the pressure/temperature limits of Figure 11-1, then maintaining adequate core cooling will be given the higher priority. Subcooling has precedence over PTS considerations.

4. Solid water operation of the pressurizer may make it difficult to control RCS pressure and therefore should be avoided unless subcooling cannot be maintained in the RCS (Figure 11-1). If the RCS is solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any unfavorable pressure excursion.

5. The operator should not add feedwater to a dry steam generator if another steam generator still contains water. Re-establish feedwater only to the steam generator that is not dry. If both steam generators become dry, refill only one steam generator to reinitiate core cooling.

PC-4

SAFETY FUNCTION: RCS Pressure Control

SUCCESS PATH: Natural Circulation with Controlled Steaming, PC-5

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. Verify natural circulation flow in at least one loop by ALL of the following: a. loop ΔT (T_H - T_c) less than normal full power ΔT, b. hot and cold leg temperatures constant or decreasing, c. RCS subcooled based on representative CET temperature. d. no abnormal difference [> 10°F] between T_H RTDs and CETs.	1. Ensure proper control of steam generator feeding and steaming, and RCS inventory and pressure.
* 2. Evaluate the need and desirability of restarting RCPs. Consider the following: a. adequacy of RCS and core heat removal using natural circulation, b. existing RCS pressure and temperatures, c. the need for main pressurizer spray capability, d. the duration of CCW interruption to RCPs, e. RCP seal staging pressures and temperatures.	2. If RCP operation NOT desired, Then go to step 8.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
* 3. Determine whether RCP restart criteria are met by <u>ALL</u> of the following: a. electrical power is available to the RCPs. b. RCP auxiliaries (CCW) are operating to maintain seal cooling, bearing, and motor cooling and there are no temperature alarms on the selected RCPs. c. at least one SG is available for removing heat from the RCS (ability for feed and steam flow), d. pressurizer level is greater than [33%] and not decreasing, e. RCS subcooled based on representative CET temperature (Figure 11-1), f. other criteria satisfied per RCP operating instructions. g. Conditions in step 1 satisfied continuously for preceding 20 minutes.	3. <u>If</u> RCP restart criteria <u>NOT</u> satisfied, <u>Then</u> go to step 8.

* Step Performed Continuously

PC-5

INSTRUCTIONS	CONTINGENCY ACTIONS
* 4. If RCP restart desired and restart criteria satisfied, Then do the following: a. start one RCP in each loop, b. ensure proper RCP operation by monitoring RCP amperage and NPSH, c. operate charging (and SI) pumps until pressurizer level greater than [14.3%] and SI termination criteria met (refer to step 5).	4. Go to step 8.
* 5. If HPSI pumps are operating and are not required for success path RC-3, Then they may be throttled or stopped, one pump at a time, if ALL of the following are satis-fied: a. RCS subcooled based on representative CET temperature (Figure 11-1), b. pressurizer level is greater than [14.3%] and not decreasing, c. at least one steam generator is available for removing heat from the RCS (ability for feed and steam flow).	5. Continue HPSI pump operation.

* Step Performed Continuously

PC-5

INSTRUCTIONS	CONTINGENCY ACTIONS
* 5. (Continued) d. the RVLMS indicates a minimum level at the top of the hot leg nozzle	
* 6. If the criteria of step 5 cannot be maintained after SI pumps throttled or stopped, Then SI pumps must be restarted and full SI flow restored.	6.
* 7. If at least one RCP has been restarted in a loop with SG feed and steam flow capability, Then go to PC-4, Forced Circulation with Controlled Steaming.	7. Continue with the actions of this success path.
* 8. Borate the plant as necessary while cooling down in order to maintain shutdown margin per Technical Specification limits (refer to RC-2 and RC-3).	8.
9. Allow pressurizer level to lower, maintaining level, [2% to 78%], while cooling down in order to aid the depressurization.	9.

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS	
10.	Perform a controlled cooldown/depressurization in accordance with Technical Specifications by operation of the steam bypass control system.	10.	If the condenser or steam bypass control system NOT available, Then cooldown via the atmospheric dump valve(s).
*11.	Maintain SG levels (or unisolated SG level) within the normal band using main, startup, or emergency feedwater.	*11.	If main, startup and emergency feedwater are lost, Then do the following: a. stop all RCPs, b. isolate SG blowdown, secondary sampling, and any non-vital steam discharge, c. attempt to restore main, startup, or emergency feedwater, d. attempt to establish an alternate, low pressure feedwater source to at least one SG if necessary.
*12.	Ensure the available emergency feedwater inventory is adequate per Figure 11-4 and 11-5.	12.	If emergency feedwater inventory is NOT adequate, Then transfer water to the Emergency Feedwater Tank by: [A list of plant specific alternate sources will be provided in the plant specific EOPs.]

* Step Performed Continuously

PC-5

INSTRUCTIONS	CONTINGENCY ACTIONS
*13. Verify adequate RCS pressure control via the steam generators by: a. at least one steam generator has wide range level > 0%, and b. RCS T_c temperatures are stable or decreasing.	13. When at least one primary safety valve has opened following steam generator dryout, Then implement RCS and Core Heat Removal success HR-4 and initiate success path PC-6.
*14 Verify pressurizer pressure is being maintained within the Post Accident P-T limits of Figure 11-1.	*14. If RCS subcooling greater than P-T limits or cooldown rate greater than 100°F/Hr, Then do the following as appropriate: a. stop the cooldown b. depressurize the plant using Reactor Coolant Gas Vent System or main or auxiliary spray to restore and maintain pressurizer pressure within the Post Accident P-T limits of Figure 11-1. c. attempt to maintain the plant in a stable pressure-temperature configuration or continue to cooldown within the limits of Figure 11-1.

* Step Performed Continuously

INSTRUCTIONS

CONTINGENCY ACTIONS

*14. (Continued)

d. If overpressurization due to SI/charging flow, Then throttle or secure flow (refer to PC-3; step 4) and manually control letdown to restore and maintain pressurizer pressure within the limits of Figure 11-1.

*15. If the RCS fails to depressurize, Then a void should be suspected.

a. voiding in the RCS may be indicated by any of the following indications, parameter changes, or trends:

i) letdown flow greater than charging flow,

ii) pressurizer level increasing significantly more than expected while operating pressurizer spray,

iii) the RVLMS indicates that voiding is present in the reactor vessel,

15.

* Step Performed Continuously

INSTRUCTIONS

CONTINGENCY ACTIONS

*15. (Continued)

iv) HJTC unheated thermocouple temperature indicates saturated conditions in the reactor vessel upper head.

b. _If_ voiding inhibits RCS depressurization and depressurization is desired, _Then_ attempt to eliminate the voiding by:

i) verify letdown is isolated,

and

ii) stop the depressur zation,

and

iii) pressurize and depressurize the RCS within the limits of Figure 11-1 by operating pressurizer heaters and spray or SI and charging pump. Monitor pressurizer level and the RVLMS for trending RCS inventory.

* Step Performed Continuously

PC-5

INSTRUCTIONS

CONTINGENCY ACTIONS

*15. (Continued)

c. If depressurization of the RCS is still not possible, and voiding is suspected to exist in the steam generator tubes, Then attempt to eliminate the voiding by:

   i) cool the suspected steam generator (by steaming and/or blowdown, and feeding) to condense the steam generator tube void,

   ii) monitor pressurizer level for trending RCS inventory.

d. If depressurization of the RCS is still not possible, Then attempt to eliminate the voiding by:

   i) operate the RCGVS to clear trapped non-condensible gases.

   and

   ii) monitor pressurizer level and/or the RVLMS for trending of RCS inventory.

* Step Performed Continuously

PC-5

<u>Acceptance Criteria for Success Path PC-5:</u>

1. RCS Pressure Control is satisfied if:

   Pressurizer pressure is within the Post Accident P-T limits of Figure 11-1.

2. <u>If</u> above criterion <u>NOT</u> satisfied, <u>Then</u> go to next appropriate RCS Pressure Control success path.

3. <u>If</u> above criterion satisfied, <u>Then</u> go to next safety function in jeopardy.

4. <u>If</u> acceptance criteria for <u>ALL</u> safety functions are being satisfied, <u>Then</u> go to LONG TERM ACTIONS <u>after</u> performing appropriate operator actions for all success paths in use.

PC-5

SUPPLEMENTARY INFORMATION: PC-5

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Do not place systems in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation (e.g., during rapid depressurization the indicated level in the pressurizer may be higher than actual level).

2. All available indications should be used to aid in the evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available (Reference 15.24).

3. Continuously monitor RCS temperature and pressure to avoid exceeding a heat removal rate greater than Technical Specification Limitations. If the heat removal rate exceeds Technical Specification Limits, there may be a potential for pressurized thermal shock (PTS) of the reactor vessel, unless Post-Accident Pressure/Temperature Limits are maintained (Figure 11-1).

   If there is a conflict between maintaining adequate core cooling and complying with the pressure/temperature limits of Figure 11-1, then maintaining adequate core cooling will be given the higher priority. Subcooling has precedence over PTS considerations.

PC-5

4. Solid water operation of the pressurizer may make it difficult to control RCS pressure and therefore should be avoided unless subcooling cannot be maintained in the RCS (Figure 11-1). If the RCS is solid, closely monitor any makeup or draining, and any system heatup or cooldown, to avoid any unfavorable pressure excursions.

5. Natural circulation flow should not be verified until the RCPs have stopped coasting down after being tripped.

6. Verification of temperature responses to a plant change cannot be accomplished until approximately 5 to 15 minutes following the action due to increased loop cycle times during natural circulation.

7. When RCS heat removal is conducted by natural circulation with an isolated steam generator, an inverted ΔT (i.e., T_c higher than T_H) may be observed in the idle loop. This is due to a small amount of reverse heat transfer in the isolated steam generator and will have no affect on natural circulation flow in the operating steam generator loop.

8. The operator should not add feedwater to a dry steam generator if another steam generator still contains water. Re-establish feedwater only to the steam generator that is not dry. If both steam generators become dry, refill only one steam generator to reinitiate core cooling.

9. When a void exists in the reactor vessel, and RCPs are not operating, the HJTC RVLMS provides an accurate indication of reactor vessel liquid inventory. When a void exists in the reactor vessel, and RCPs are operating, it is not possible to obtain an accurate reactor vessel liquid level indication due to the effect of the RCP induced pressure head on the HJTC RVLMS. Information concerning reactor vessel liquid inventory trending may still be discerned. However, operators are cautioned not to rely solely on the HJTC RVLMS indication when RCPs are operating.

PC-5

10. The operator should continuously monitor for the presence of RCS voiding and take steps to eliminate voiding any time voiding causes the heat removal or inventory control safety functions to begin to be threatened. Void elimination should be started soon enough to ensure heat removal and inventory control are not lost.

11. When restarting RCPs, it is preferable to first start an RCP in the loop with the operating SG. Starting an RCP in the affected loop could cause a temporary reversal of T_H and T_c indications in the operating loop and minimize the rate of mixing of inventory from the isolated loop.

PC-5

SAFETY FUNCTION: RCS Pressure Control

SUCCESS PATH: Rapid Depressurization System, PC-6

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. Verify that at least one PSV has opened.	1. If a PSV has not opened, Then go to another PC success path.
2. Verify at least two SI pumps are operating.	2. If less than 2 SI pumps are operating, Then ensure at least two SI pumps are operating before continuing with this success path.
3. Ensure all RCPs are stopped.	3.
4. Open both Rapid Depressurization paths.	4.
5. If RDS must remain open for once-through-colling (RCS and Core Heat Removal success path HR-4), Then go to RCS Pressure Control success path PC-3 (SIS).	5. If RDS paths do not need to remain open for once through cooling, Then evaluate the following criteria for closing RDS paths. a. Pressurizer pressure less than [2370 psia], and b. Pressurizer pressure is within the Post Accident P-T limits of Figure 11-1[1], c. Once-through-cooling heat removal (success path HR-4) NOT in use.

[1] RCS subcooling is NOT applicable when RDS valves are open.

Acceptance Criteria for Success Path PC-6:

1. RCS Pressure Control is satisfied if:

   a. pressurizer pressure is less than [2370 psia] and constant or decreasing,

   and

   b. pressurizer pressure is within the Post Accident P-T limits of Figure 11-1.(1)

2. If above criteria NOT satisfied, Then go to CONTINUING ACTIONS FOR RCS PRESSURE CONTROL.

3. If above criteria satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

(1) RCS subcooling is NOT applicable when RDS valves are open.

SUPPLEMENTARY INFORMATION: PC-6

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Do not place a system in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation (e.g., during rapid depressurization the indicated level in the pressurizer may be higher than level).

2. All available indications should be used to aid in evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available.

3. Solid water operation of the pressurizer may make it difficult to control RCS pressure and therefore should be avoided unless subcooling cannot be maintained in the RCS (Figure 11-1). If the RCS is solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any unfavorable pressure excursions.

4. Continuously monitor RCS temperature and pressure to avoid exceeding a heat removal rate greater than Technical Specification Limitations. If the heat removal rate exceeds Technical Specification Limits, there may be a potential for pressurized thermal shock (PTS) of the reactor vessel unless Post Accident Pressure/Temperature Limits are maintained (Figure 11-1).

   If there is a conflict between maintain adequate core cooling and complying with the pressure/temperature limits of Figure 11-1, then maintaining of adequate core cooling will be given the higher priority. Subcooling has precedence over PTS considerations.

PC-6

5. Monitor IRWST temperature since any sustained operation of the RDS will increase the temperature of the IRWST.

PC-6

SAFETY FUNCTION: RCS Pressure Control

SUCCESS PATH: Rapid Depressurization System during SGTR, PC-7

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. _If_ indications of a Steam Generator Tube Rupture are present _and_ pressure can _NOT_ be maintained less than [1200 psia] using any of the following: a. main or auxiliary sprays b. operation of charging and letdown c. throttling of safety injection d. operation of the Reactor Coolant Gas Vent System, _Then_ operate the Rapid Depressurization System to maintain pressure less than [1200 psia] and allow the affected steam generator(s) MSSVs to close or remain closed.	1.

Acceptance Criteria for Success Path PC-7:

1. RCS Pressure Control is satisfied if:

   a. pressurizer pressure is less than [1200 psia] and constant or decreasing,

   and

   b. all Main Steam Safety Valves on the affected steam generator(s) are closed

2. If above criteria NOT satisfied, Then go to CONTINUING ACTIONS FOR RCS PRESSURE CONTROL.

3. If above criteria satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

PC-7

SUPPLEMENTARY INFORMATION: PC-7

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Do not place a system in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation (e.g., during rapid depressurization the indicated level in the pressurizer may be higher than level).

2. All available indications should be used to aid in evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available.

3. Solid water operation of the pressurizer may make it difficult to control RCS pressure and therefore should be avoided unless subcooling cannot be maintained in the RCS (Figure 11-1). If the RCS is solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any unfavorable pressure excursions.

4. Continuously monitor RCS temperature and pressure to avoid exceeding a heat removal rate greater than Technical Specification Limitations. If the heat removal rate exceeds Technical Specification Limits, there may be a potential for pressurized thermal shock (PTS) of the reactor vessel unless Post Accident Pressure/Temperature Limits are maintained (Figure 11-1).

   If there is a conflict between maintaining adequate core cooling and complying with the pressure/temperature limits of Figure 11-1, then maintaining of adequate core cooling will be given the higher priority. Subcooling has precedence over PTS considerations.

PC-7

5. Monitor IRWST temperature since any sustained operation of the RDS will increase the temperature of the IRWST.

PC-7

CONTINUING ACTIONS FOR RCS PRESSURE CONTROL

If the acceptance criteria are not satisfied, then RCS Pressure Control is still in jeopardy. The operator must continue to attempt to establish RCS Pressure Control while pursuing other jeopardized safety functions. Evaluate further actions based on the following considerations:

a) Rate of change of pressure and potential for damage to the RCS.
b) The urgency of other jeopardized safety functions.
c) The feasibility of restoring function to a success path by:
   i) restoring the vital auxiliaries necessary to operate components or systems in the success paths
   ii) manual operation of valves
   iii) use of alternate components to implement a success path
   iv) depressurizing/cooling the RCS to increase or establish SIS flow.

Bases for RCS Pressure Control

The purpose of maintaining RCS Pressure Control is to maintain the RCS inventory in a subcooled condition to provide an adequate cooling medium for the core, and to prevent the loss of inventory out of a relief valve with subsequent release of radioactive liquid to the containment and possibly to the atmosphere. Controlling RCS pressure within the Post Accident P-T limits of Figure 11-1 is also desirable to minimize the potential for pressurized thermal shock.

There are many conditions that could cause a loss of pressure control. A breach in the RCS piping, a stuck open relief valve, failure of the PPCS, loss of heat sink, or the failure of CEAs to insert during a reactor trip condition are some examples of ways that RCS pressure control can be lost. Pressure Control is closely related to RCS Inventory Control, and RCS and Core Heat Removal. Changes in inventory will generally result in RCS pressure changes and excessive RCS pressure may prevent introduction of makeup water to the RCS. Similarly, the maintenance of an adequate cooling medium around the core for core heat removal is dependent on maintaining subcooling. If there is a conflict between maintaining adequate core cooling and complying with the pressure/temperature limits of Figure 11-1, then maintaining of adequate core cooling will be given the higher priority. Subcooling of 20°F has precedence over PTS considerations. Pressure control may be accomplished by any of the following methods:

- PC-1: RCS Pressure Control via Pressurizer Heaters and Spray
- PC-2: RCS Pressure Control via CVCS
- PC-3: RCS Pressure Control via SIS
- PC-4: RCS Pressure Control via Forced Circulation with Controlled Steaming
- PC-5: RCS Pressure Control via Natural Circulation with Controlled Steaming
- PC-6: RCS Pressure Control via Rapid Depressurization System
- PC-7: RCS Pressure Control via Rapid Depressurization System during SGTR.

The bases for the recovery actions required for implementing each of the methods listed above are detailed as follows:

PC-1: RCS Pressure Control via Pressurizer Heaters and Spray

The automatic operation of the Pressurizer Pressure Control System is the preferred method of RCS Pressure Control. In this mode, it is only necessary that the operator periodically check that pressure is being maintained within the Post Accident P-T limits of Figure 11-1. However, if operation outside of the normal operating range of pressure is desired or if pressure is not within the limits of Figure 11-1, the operator is directed to take manual control of pressurizer heaters and spray to restore and maintain pressurizer pressure within the required pressure band.

Operator Actions

1. The operator should verify that pressurizer heaters and main or auxiliary spray are automatically operating to maintain pressurizer pressure within the Post Accident P-T limits of Figure 11-1. This automatic control will maintain pressure in the normal band. If pressurizer pressure control outside of the normal band is desired or the P-T limits of Figure 11-1 are violated, then do the following as appropriate:
   a. Take manual control of pressurizer heaters and spray. Operate heaters and main or auxiliary spray as necessary to restore and maintain pressure within the P-T limits of Figure 11-1.
   b. If a cooldown is in progress and high RCS subcooling exists, then the cooldown should be stopped and the plant maintained in a stable pressure-temperature configuration. If a cooldown is in progress and low RCS subcooling exists, then the cooldown should be continued, if desired, within the limits of Figure 11-1. The RCS and Core Heat Removal success path being implemented should be referred to for specific guidance.

PC-1: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, RCS Pressure Control is satisfied if:

   Pressurizer pressure is within the limits of the Post Accident P-T limits of Figure 11-1.

   Observing the Post Accident P-T limits during implementation of the preferred RCS Pressure Control success path (pressurizer heaters and spray), minimizes pressurized thermal shock concerns and ensures a subcooled cooling medium for heat removal.

2. If the above criterion is not satisfied, then success path PC-1 is not successfully controlling RCS pressure. The operator should go to the next appropriate success path for RCS Pressure Control.

3. If the acceptance criterion for success path PC-1 is satisfied, then success path PC-1 is successfully controlling RCS Pressure. RCS Pressure Control is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

PC-2: RCS Pressure Control via CVCS

Pressure control using the charging system is performed as follows: raising pressurizer level above the heater cutout level will permit the use of heaters to form a steam bubble to control pressure. If there is a steam bubble in the pressurizer, then increasing pressurizer level will tend to compress the bubble and raise pressure. If the pressurizer is taken solid, then addition of further fluid will increase pressure. The pressurizer should not be taken solid unless subcooling cannot be maintained. If solid, the operator should closely monitor any makeup or draining and any system heat up or cooldown to avoid an excessive pressure excursion.

Operator Actions

1. The operator should verify that charging and letdown are operating automatically to maintain or restore pressurizer level to [2% to 78%]. If not, charging and letdown are manually operated to restore and maintain pressurizer level within [2% to 78%]. It is desirable to maintain level above the pressurizer heaters ([14.3%]) in order to permit pressure control using the heaters. Raising pressurizer level with a steam bubble in the pressurizer will tend to increase pressure. The charging pump may have to be manually restarted if an interruption of power to the charging pump bus has occurred.

2. Adequate suction sources to the charging pumps are verified. Available sources include the VCT, boric acid storage tanks, IRWST and spent fuel pool. The source(s) of water for use in controlling RCS pressure depend on the total amount of fluid necessary to add to the RCS and the time frame over which the fluid must be introduced. The volume control tank is the primary source of fluid for RCS makeup. For the case where RCS inventory losses are being incurred, the contents of the boric acid storage tanks, the In-containment refueling water storage tank, and the spent fuel pool may be used as backup sources of makeup water.

* 3. If RCS subcooling cannot be maintained (which may occur if pressurizer heaters are not available), the pressurizer is taken solid (if possible) to establish RCS pressure control. Once the pressurizer is solid, small changes in temperature or inventory have large effects on RCS pressure. Care should be exercised when manually controlling charging and letdown. RCS Pressure Control will require constant attention with a solid pressurizer to maintain pressure within the limits of Figure 11-1.

* 4. If the Pressure-Temperature limits of Figure 11-1 are being violated, then the operators should take actions to restore the RCS to within the P-T limits. Depending on the situation (pressure too high or too low), the operator should perform the following actions as appropriate:

a. If a cooldown is in progress and high RCS subcooling exists, then, the cooldown should be stopped and the plant maintained in a stable pressure-temperature configuration. If a cooldown is in progress and low RCS subcooling exists, then the cooldown should be continued, if desired, within the limits of Figure 11-1,

b. If an overpressure situation exists and is caused by charging flow, then throttle or stop the charging pump and manually control letdown to restore and maintain pressure within the P-T limits of Figure 11-1.

PC-2

PC-2: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, RCS pressure control is satisfied if:

    Pressurizer pressure is within the Post Accident P-T limits of Figure 11-1.

   Observing the Post Accident P-T limits during implementation of the RCS Pressure Control via CVCS success path minimizes pressurized thermal shock concerns and ensures a subcooled cooling medium for heat removal.

2. If the above criterion is not satisfied, then success path PC-2 is not successfully controlling RCS pressure. The operator should go to the next appropriate success path for RCS Pressure Control.

3. If the acceptance criterion for success path PC-2 is satisfied, then success path PC-2 is successfully controlling RCS Pressure. RCS Pressure Control is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

PC-3: RCS Pressure Control via SIS

If RCS Pressure Control is not obtained via pressurizer heaters and spray, or the CVCS, then the SIS may be used if pressure is low enough, to restore inventory and to control RCS pressure.

Operator Actions

* 1. If pressurizer pressure decreases to or below the SIAS setpoint, or if containment pressure increases to or above [2.7 psig], then initiation of an SIAS must be verified. If necessary, an SIAS is manually initiated. This action restores inventory so that pressure can be controlled by use of either pressurizer heaters and spray or by using the discharge head of the SIS pumps.

* 2. This step contains guidance regarding the RCP operating strategy when utilizing the Functional Recovery Guideline. A generic RCP trip strategy has been developed which results in the tripping of all four RCPs for depressurization vents where RCS is not subcooled, but allows the continued operation to two RCPs (in opposite loops) for depressurization events where RCS is subcooled. For undiagnosed events, where the Functional Recovery Guideline is implemented, the RCP trip strategy is identical to that followed in the LOCA guideline. (Reference 15.22)

This operational strategy results in the operator tripping two RCPs (in opposite loops) if pressurizer pressure decreases to less than [1400 psia] following a SIAS and RCS is subcooled. This action may occur in the Standard Post Trip Actions and, in this case, the operator would simply verify that two RCPs (in opposite loops) have been tripped. The operator trips all four RCPs if pressurizer pressure decreases to less than [1400 psia] following a SIAS and RCS is not subcooled. If the operator cannot confirm that a LOCA has occurred, and the Functional Recovery Guideline is implemented, the RCP trip strategy is identical to that following in the LOCA guideline. If the depressurization event can be diagnosed and is determined to be other than a LOCA (i.e., ESDE or SGTR), then only two RCPs (in opposite loops) are tripped. The other two RCPs remain operational until one or more of the RCP operating requirements (e.g., NPSH, temperatures, seal flow, oil pressures, motor amperage, vibration) are no longer satisfied, then, any pump which does not satisfy these requirements should be tripped. This gives the operator maximum flexibility in plant control because a normal plant cooldown can be performed while still ensuring a conservative approach to event recovery.

* 3. If an SIAS is actuated, then the charging pump and SIS pumps should be operating and injecting water into the RCS. The SIS flowrate will vary according to pressurizer pressure. SIS and charging pump flowrates should be checked and maximized (Figure 11-3 provides information which can be utilized to verify adequate SIS flow is occurring) for RCS inventory replenishment and/or core heat removal. The charging pump may have to be manually restarted if an interruption of power to the charging pump bus has occurred. The following guidance will assist in ensuring maximum injection of water into the RCS:

a. idle SIS pumps should be started and system flow should be verified to be in accordance with Figure 11-3,
b. charging pump should be started.

If any SIS pump that should be operating will not start, and the charging pump will not start, or SIS flow is not in accordance with Figure 11-3, then the following guidance is provided:

a. the operator should verify that electrical power is available to valves and pumps necessary for inventory control
b. the SIS valve lineup should be verified to be correct in the control room
c. auxiliary systems necessary for SIS or charging operation should be checked.

PC-3

It must be noted, however, that the maximization of charging and safety injection can result in excess RCS inventory, possible filling of the pressurizer to a solid condition, and a PTS concern upon RCS heat up, fluid expansion, and subsequent RCS pressure excursion. Operators must be aware of these concerns and terminate the SIS operation when the termination criteria are met.

* 4. If the SI pumps are operating, then they must continue to operate at full capacity if success path RC-3 is in use or until SI termination criteria are met. Termination of SI should be sequenced by stopping one pump at time while observing the termination criteria. Throttling of SI flow is also permissible if all of the following SI termination criteria are satisfied:

a. The RCS is subcooled based on representative CET temperature (Figure 11-1). Establishing subcooling ensures the fluid surrounding the core is subcooled, and provides sufficient margin for re-establishing flow should subcooling deteriorate when SI flow is secured. Voids may exist in some parts of the RCS (e.g., reactor vessel head as determined by the HJTC RVLMS), but these are permissible as long as core heat removal is maintained.

b. Pressurizer level is greater than [14.3%], and not decreasing. A pressurizer level greater than [14.3%] and not decreasing, in conjunction with criterion a) above is an indication that RCS inventory control has been established.

c. At least one steam generator is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow is available for removing heat from the RCS.

d. The HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles. This provides an extra margin of core coverage and, taken in conjunction with the above criteria, serves as an additional indication that RCS inventory control has been established.

PC-3

If all of the SI termination criteria are met, the operator may either stop or throttle the SI pumps. The operator may decide to throttle rather than terminate the flow if the SI pumps are to be used to control pressurizer level or plant pressure. A general assessment of the SIS performance can be made from the control room. The operator should confirm that at least one train, and preferably both trains, of SIS is operating and that system delivery rate is consistent with RCS pressure as shown in Figure 11-3. Injection flow rates to each reactor vessel nozzle should be approximately equal. Departures from this would indicate a closed flow path or some system spillage.

* 5. If the criteria of step 4 cannot be maintained after SI pumps are throttled or stopped, then the appropriate SI pumps should be restarted (if necessary) and full SIS flow restored.

* 6. If RCS subcooling cannot be maintained (which may occur if pressurizer heaters are not available), the pressurizer is taken solid (if possible) to establish RCS pressure control. Once the pressurizer is solid, small changes in temperature or inventory have large effects on RCS pressure. Care should be exercised when manually controlling the SIS, charging and letdown. RCS pressure control will require constant attention with a solid pressurizer to maintain pressure within the limits of Figure 11-1.

* 7. If the Pressure-Temperature limits of Figure 11-1 are being violated, then the operators should take actions to restore the RCS to within the P-T limits. Depending on the situation (pressure too high or too low), the operator should perform the following actions as appropriate:

PC-3

a. If a cooldown is in progress and high RCS subcooling exists, then, the cooldown should be stopped and the plant maintained in a stable pressure-temperature configuration. If a cooldown is in progress and low RCS subcooling exists, then the cooldown should be continued, if desired, within the limits of Figure 11-1,

b. If an overpressure situation exists and is caused by SI flow, then throttle or stop SI pumps (refer to step 4) and manually control letdown to restore and maintain pressure within the P-T limits of Figure 11-1.

* 8. The operator should monitor In-containment refueling water storage tank (IRWST) level. For RCS breaks inside containment, a decreasing trend in IRWST level should correspond to an increasing trend in Holdup Volume Tank level. This action enables the operator to trend IRWST level and to anticipate possible problems (if the LOCA is outside of containment). If a decreasing trend in IRWST level cannot be correlated to an increasing Holdup Volume Tank level, then a LOCA outside containment may be in progress. IRWST level should be maintained [10%] by replenishment from available sources. This will prevent the inadvertent air binding of the SIS pumps.

PC-3

PC-3: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, RCS Pressure Control is satisfied if:

   The available charging pump is operating and the SI pumps are injecting water into the RCS per Figure 11-3 (unless SIS termination criteria have been met).

   When the SIS is operating, its performance adequacy is judged by its delivery flow versus RCS pressure. Once SIS termination criteria have been met, SIS flow may be throttled or pumps turned off. Once the SI sumps are throttle/stopped, the relation between SIS flow and RCS pressure depicted in Figure 11-3 is no longer valid.

2. If the above criterion is not satisfied, then success path PC-3 is not successfully controlling RCS Pressure. The operator should go to the next appropriate success path for RCS Pressure Control.

3. If the acceptance criterion for success path PC-3 is satisfied, then success path PC-3 is successfully controlling RCS Pressure. RCS Pressure Control is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

PC-3

PC-4: RCS Pressure Control via Forced Circulation with Controlled Steaming

If pressure cannot be reduced using pressurizer sprays, then RCS pressure may be reduced by removing heat using the RCPs and steam generators (if RCPs are available). This method may be effective by removing energy from steam generators, thereby preventing steam generators from causing a steam bubble to form in the tube bundle; or by removing energy from the RCS causing a contraction in RCS fluid and lowering of pressurizer level. Lowering of pressurizer level will result in depressurization in the range of [0-300 psia] by decompression of the pressurizer steam bubble.

Operator Actions

* 1. During a controlled cooldown, the RCS is borated as necessary (success paths RC-2 and RC-3) to maintain adequate shutdown margin per Technical Specification limits.

2. RCS inventory is controlled to permit pressurizer level to lower during RCS fluid contraction. This drop in level results in pressurizer bubble decompression which in turn results in RCS depressurization. It is also possible to cool the pressurizer gradually by filling the pressurizer with cooler loop fluid by charging to the loop. The level is then allowed to drop due to cooldown contraction and then refilled with cooler loop fluid. Repeated fillings will cool the pressurizer metal and steam bubble resulting in gradual depressurization.

3. An RCS cooldown and depressurization should be performed to satisfy the acceptance criteria of success path(s) in use and/or to satisfy SCS entry conditions. This cooldown/depressurization should be performed by dumping steam to the condenser via the steam bypass control system. If the condenser or steam bypass control system is not available, steam should be discharged through the

atmospheric dump valve(s). The use of atmospheric dump valve(s) may have the potential for an unmonitored release of activity to the environment. If it is suspected that a steam generator(s) has tube leaks, then depressurization should be performed using the unaffected or least affected generator. Refer to RCS and Core Heat Removal success path HR-1 or HR-3 as applicable.

* 4. The operator should ensure that adequate steam generator inventory exists to maintain SG steaming by maintaining SG levels (or unisolated SG level) in the normal band using main, startup or emergency feedwater.

If all feedwater is lost (main, startup, and emergency), then the operator should do the following:

a. All RCPs should be stopped to minimize RCS heat input.
b. The steam generator blowdown system, secondary sampling system, or any other non-vital secondary discharge should be isolated, Until feedwater is re-established, the steam generator water inventories must be conserved.
c. Attempt to restore main, startup, or emergency feedwater systems to operation. Such attempts may include restoration of vital auxiliaries like instrument air, electrical power, and/or instrumentation. These actions may also include manual operation of valves or other equipment that is normally operated remotely.
d. All plant-specific sources of feedwater which could be made available to replace steam generator boil-off should be implemented. Examples of alternate low-pressure sources of feedwater are fire pumps, condensate pumps, potable pumps, etc. When developing plant procedures, alternate low-pressure sources of feedwater should be identified and their use should be indicated in the procedures. Guidelines on steam generator depressurization should be developed for those cases when the operator is relying on low pressure sources of feedwater as a backup feedwater supply.

PC-4

The required heat removal, compared to the available heat removal capacity(e.g., atmospheric dump valves), provides the technical basis for which guidance may be developed on steam generator depressurization to permit use of alternate low-pressure sources of feedwater.

* 5. The available emergency feedwater inventory must be verified to be adequate. This can be determined from Figures 11-4 and 11-5. Alternate sources must be identified in plant specific procedures. Examples of alternate sources of emergency feedwater are non-seismic tanks, fire mains, lake water supplies, potable tanks, etc.

* 6. Adequate steam generator inventory must exist to ensure the continued availability of this success path for RCS Pressure Control. As long as at least one steam generator has a wide range level greater than 0% wide range, then the steam generator is available for heat removal. This level is based on ensuring that some measurable level is in the steam generator. An additional criterion requires the operator to monitor RCS T_c to ensure temperatures are stable or decreasing. This criterion assumes that no operator or plant initiated actions have caused a momentary, correctable reduction in RCS heat removal (e.g., ADV is closed automatically or manually).

If both SG levels are equal to 0% WR or if RCS T_c increases (uncontrollably) 5°F or greater, then the operator should continue efforts to regain feedwater until a primary safety valve (PSV) opens following steam generator dryout. Once the PSV opens, the operator should initiate once-through-cooling (RCS and Core Heat Removal success path HR-4) and initiate RCS Pressure Control success path PC-6 ([RDS]).

PC-4

* 7. Throughout the cooldown and depressurization, the operator should ensure that the pressurizer pressure is being maintained within the Post Accident P-T limits of Figure 11-1. If subcooling or cooldown limits of Figure 11-1 are being violated, then the operators should take actions to restore the RCS to within the P-T limits. Depending on the situation, the operator should perform the following actions as appropriate:

a. Stop the cooldown.
b. Operate the Reactor Coolant Gas Vent System or main or auxiliary spray as necessary to restore pressurizer pressure to within the P-T limits of Figure 11-1.
c. Attempt to maintain the plant in a stable pressure-temperature configuration. The cooldown may be continued, if desired, within the limits of Figure 11-1.
d. If an overpressure situation exists and is caused by SI and/or charging flow, then throttle or stop SI (refer to success path PC-3; step 4) or the charging pump and manually control letdown to restore and maintain pressure within the Post Accident P-T limits of Figure 11-1.

PC-4

PC-4: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, RCS Pressure Control is satisfied If:

   Pressurizer pressure is within the Post Accident P-T limits of Figure 11-1.

   Observing the Post Accident P-T limits during implementation of the RCS pressure control via forced circulation with controlled steaming success path minimizes pressurized thermal shock concerns and ensures a subcooled cooling medium for heat removal.

2. If the above criterion is not satisfied, then success path PC-4 is not successfully controlling RCS pressure. The operator should go to the next appropriate success path for RCS Pressure Control.

3. If the acceptance criterion for success path PC-4 is satisfied, then success path PC-4 is successfully controlling RCS Pressure. RCS Pressure Control is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

PC-4

PC-5: RCS Pressure Control via Natural Circulation with Controlled Steaming

If pressure cannot be reduced using pressurizer sprays, and RCPs are not available, then RCS pressure may be reduced by removing heat via natural circulation and steam generators. This method may be effective by removing energy from steam generators, thereby preventing steam generators from causing a steam bubble to form in the tube bundle; or by removing energy from the RCS causing a contraction in RCS fluid and lowering of pressurizer level. Lowering of pressurizer level will result in depressurization in the range of [0-300 psia] by decompression of the pressurizer steam bubble. Regions of little flow (e.g., reactor vessel head, idle steam generator) will not be cooled during natural circulation and may void if RCS pressure is lowered below the saturation pressure for these hotter regions. If voiding occurs, more RCS cooling will be required in order to effect a given depressurization. In the extreme, RCS pressure may lower to the saturation pressure value corresponding to the hottest fluid in the loops and reactor vessel.

Operator Actions

* 1. Once the RCPs are tripped, natural circulation RCS flow should develop within [5 - 15 minutes]. Natural circulation flow will be ensured by maintaining RCS pressure and inventory control and using at least one steam generator for RCS heat removal.

When single phase liquid natural circulation flow is established in at least one loop, the RCS should indicate the following conditions:

a. Loop ΔT (T_H - T_c) less than normal full power ΔT,
b. Hot and cold leg temperatures constant or decreasing,
c. RCS subcooled based on representative CET temperature,
d. No abnormal difference (greater than 10°F) between T_H RTDs and core exit thermocouples.

PC5

Hot leg RTD temperature should be consistent with the core exit thermocouples. Adequate natural circulation flow will be reflected by the core exit thermocouples temperatures being approximately equal to the hot leg RTD temperatures. An abnormal difference between T_H and the core exit thermocouples could be any difference greater than 10°F.

Natural circulation is regulated by a combination of factors. Factors which affect natural circulation include decay heat, component elevations, primary to secondary heat transfer, loop flow resistance, and voiding. The component elevations on C-E plants are such that a satisfactory natural circulation decay heat removal is obtained utilizing density differences between the bottom of the core and the top of the steam generator tube sheet. Natural circulation flow is enhanced by the density difference obtained when primary to secondary heat removal through the steam generator U-tubes is utilized.

If the natural circulation criteria of this step are not met, then natural circulation is not effectively transferring heat from the core to the steam generators. If feedwater has been regained or sufficient inventory is available in at least one SG, then ensure RCS pressure and inventory are being controlled properly.

* 2. Plant conditions should be carefully assessed before any RCPs are restarted. The need for forced circulation operation should be balanced against the risk of damage to the RCP seals.

The need for operation of the RCPs should be evaluated based on:

1. the adequacy of the RCS and core heat removal under the existing natural circulation conditions,
2. the existing RCS pressure and temperatures,
3. the need for main pressurizer spray capability.

PC-5

If the existing natural circulation is providing satisfactory RCS and core heat removal, a transfer to forced circulation operaticn may not be necessary. This would be particularly true if the RCS had already been cooled and depressurized to SCS entry conditions. If the RCS pressure and temperatures are closer to hot standby conditions, it may be desirable to restart the RCPs in order to allow a normal forced circulation cooldown. Consideration should also be given to the necessity of having main pressurizer spray capability if auxiliary spray is not providing the desired depressurization rate.

The potential for RCP seal degradation should be evaluated based on:

1. how long CCW to the RCPs was interrupted,
2. RCP seal staging pressures and temperatures.

The possibility of seal degradation increases if the [CCW] has been interrupted for longer than [10 minutes]. The seal staging pressures provide an indication of degraded seal stages (a low pressure drop across a stage indicates a problem). Restart of an RCP with one or more degraded seal stages should be avoided if possible.

* 3. If all RCPs have been stopped and RCP restart criteria are met, then operation of two RCPs (in opposite loops) should be attempted if RCP restart criteria are met. This will ensure forced circulation of coolant through the core and will provide the capability for the normal mode of pressurizer spray. However, only one RCP in each loop should be operated to minimize heat input to the RCS.

Determine whether RCP restart criteria are met by the following:

a. Electrical power available to the RCP bus,

PC-5

b. RCP auxiliaries (in particular component cooling water) to maintain seal cooling, bearing, and motor cooling should be operating in order to prevent damage to the pump and/or motor. Following automatic or operator initiated containment isolation, reinstatement of component cooling water should be considered to ensure adequate RCP cooling. There should be no high temperature alarms on the RCPs to be operated.

c. At least one steam generator is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow is available for removing heat from the RCS.

d. Pressurizer level is greater than [33%] and not decreasing. With pressurizer level at this level, the possibility of draining the pressurizer due to loop shrinkage and/or steam void condensation is minimized and there is a greater likelihood of keeping the pressurizer heaters covered. This will assist in maintaining positive RCS pressure control. The criterion of pressurizer level not decreasing implies that RCS inventory control has been established.

e. RCS is subcooled based on representative CET temperature. This condition taken in conjunction with (d) above indicates that inventory and pressure are being controlled.

f. All plant specific RCP operating criteria are satisfied before the RCPs are restarted to protect the RCPs from damage resulting from abnormal operating conditions.

g. Criteria in step 1 satisfied continuously for preceding 20 minutes. This ensures that any slugs of unborated water which may have developed during two phase natural circulation have been thoroughly mixed with borated water.

PC-5

* 4. Upon restarting two RCPs in opposite loops, pressurizer level and pressure may decrease due to loop shrinkage and/or void condensation. It is possible that this action will drain the pressurizer. Steam voids, if present in the reactor vessel, will condense upon restarting RCPs. The HJTC RVLMS should be monitored for the trending of reactor vessel liquid level. This trending information may be correlated to pressurizer level decrease. RCP operation with a drained pressurizer may continue provided certain actions are taken and certain criteria are satisfied.

a. Start one RCP in each loop.
b. Ensure proper RCP operation by monitoring RCP amperage and pump NPSH. NPSH is determined by pressurizer pressure and corresponding T_c on Figure 11-1.
c. Operate the charging pump and all SI pumps until pressurizer level is greater than [14.3%] and SIS termination criteria of step 5 are met.

* 5. If the SI pumps are operating, then they must continue to operate at full capacity if success path RC-3 is in use or until SI termination criteria are met. Termination of SI should be sequenced by stopping one pump at a time while observing the termination criteria. Throttling of SI flow is also permissible if termination criteria are met. SI termination criteria are:

a. RCS is subcooled based on representative CET temperature (Refer to Figure 11-1). Establishing subcooling ensures the fluid surrounding the core is subcooled which ensures an adequate cooling medium. Voids may exist in some parts of the RCS (e.g., reactor vessel head), but these are permissible as long as core heat removal is maintained.
b. Pressurizer level is greater than [14.3%] and not decreasing. A pressurizer level greater than [14.3%] and not decreasing, in conjunction with criterion a) above, is an indication that RCS inventory control has been established.

PC-5

c. At least one steam generator is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow is available for removing heat from the RCS.

d. The HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles. This provides an extra margin of core coverage and, taken in conjunction with the above criteria, serves as an additional indication that RCS inventory control has been established.

If the criteria are met, the operator may either stop or throttle the SI pumps. The operator may decide to throttle rather than terminate flow if the SI pumps are to be used to control pressurizer level and/or plant pressure. A general assessment of the SIS performance can be made from the control room. The operator should confirm that at least one train, and preferably all SI pumps are operating and that system delivery rate is consistent with RCS pressure as shown in Figure 11-3. Injection flow rates to each reactor vessel nozzle should be approximately equal. Departures from this would indicate a closed flow path or some system spillage.

* 6. If the SI termination criteria of step 5 cannot be maintained after the SI pumps are throttled or stopped, then the SI pumps must be restarted (if necessary) and full SI flow restored.

* 7. If forced circulation has been restored by starting at least one RCP in a loop with a SG having steam and feed flow capability, then exit this guideline and go to PC-4, Forced Circulation with Controlled Steaming.

* 8. During a controlled cooldown, ensure the RCS is borated as necessary (success paths RC-2 and RC-3) to maintain adequate shutdown margin per Technical Specifications limits.

PC-5

9. RCS inventory is controlled to permit pressurizer level to lower during RCS fluid contraction. This drop in level results in pressurizer bubble decompression which in turn results in RCS depressurization. It is also possible to cool the pressurizer gradually by filling the pressurizer with cooler loop fluid by charging to the loop. The level is then allowed to drop due to cooldown contraction and then refilled with cooler loop fluid. Repeated fillings will cool the pressurizer metal and steam bubble resulting in gradual depressurization.

10. An RCS cooldown and depressurization should be performed to satisfy the acceptance criteria of success path(s) in use and/or to satisfy SCS entry conditions. This cooldown/depressurization should be performed by dumping steam to the condenser via the steam bypass control system. If the condenser or steam bypass control system is not available, steam should be discharged through the Atmospheric Dump Valve(s). The use of atmospheric dump valve(s) may have the potential for an unmonitored release of activity to the environment. If it is suspected that a steam generator(s) has tube leaks, then depressurization should be performed using the unaffected or least affected generator. Refer to RCS and Core Heat Removal success paths HR-2 or HR-3 as applicable.

*11. The operator should ensure that adequate steam generator inventory exists to maintain SG steaming. Maintain steam generator levels (or unisolated steam generator level) within the normal band using main, startup, or emergency feedwater.

If all feedwater is lost (main, startup, and emergency), then the operator should do the following:

a. All RCPs should be stopped to minimize RCS heat input.

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b. The steam generator blowdown system, secondary sampling system, or any other non-vital secondary discharge should be isolated. Until feedwater is re-established, the steam generator water inventories must be conserved.

c. Attempt to restore main, startup, or emergency feedwater systems to operation. Such attempts may include restoration of vital auxiliaries like instrument air, electrical power, and/or instrumentation. These actions may also include manual operation of valves or other equipment that is normally operated remotely.

d. All plant-specific sources of feedwater which could be made available to replace steam generator boil-off should be implemented. Examples of alternate low-pressure sources of feedwater are fire pumps, condensate pumps, portable pumps, etc. When developing plant procedures, alternate low-pressure sources of feedwater should be identified and their use should be indicated in the procedures. Guidelines on steam generator depressurization should be developed for those cases when the operator is relying on low pressure sources of feedwater as a backup feedwater supply. The required heat removal, compared to the available heat removal capacity(e.g., atmospheric dump valves), provides the technical basis for which guidance may be developed on steam generator depressurization to permit use of alternate low-pressure sources of feedwater.

*12. The available emergency feedwater inventory must be verified to be adequate. This can be determined from Figures 11-4 and 11-5. Alternate sources must be identified in plant specific procedures. Examples of alternate sources of emergency feedwater are non-seismic tanks, fire mains, lake water supplies, potable tanks, etc.

*13. Adequate steam generator inventory must exist to ensure the continued availability of this success path for RCS pressure control. As long as at least one steam generator has a wide range level greater than 0% wide range, then the steam generator is available for heat removal. This level is based on ensuring

PC-5

that some measurable level is in the steam generator. An additional criterion requires the operator to monitor RCS Tc to ensure temperatures are stable or decreasing. This criterion assumes that no operator or plant initiated actions have caused a momentary, correctable reduction in RCS heat removal (e.g., ADV is closed automatically or manually).

If both SG levels equal to 0% WR and if RCS T_c increasing (uncontrollably) 5°F or greater, then the operator should continue efforts to gain feedwater until a primary safety valve (PSV) opens following steam generator dryout. Once the PSV opens, the operator should initiate once-through-cooling (RCS and Core Heat Removal success path HR-4) and to initiate RCS Pressure Control success path PC-6 (RDS).

*14. Throughout the cooldown and depressurization, the operator should ensure that the pressurizer pressure is being maintained within the Post Accident P-T limits of Figure 11-1. If subcooling or cooldown limits of Figure 11-1 are being violated, then the operators should take actions to restore the RCS to within the P-T limits. Depending on the situation, the operator should perform the following actions as appropriate:

a. Stop the cooldown.
b. Operate Reactor Coolant Gas Vent System or the main or auxiliary spray as necessary to restore pressurizer pressure to within the P-T limits of Figure 11-1.
c. Attempt to maintain the plant in a stable pressure-temperature configuration. The cooldown may be continued, if desired, within the limits of Figure 11-1.
d. If an overpressure situation exists and is caused by SI and/or charging flow, then throttle or stop SI pumps (refer to success path PC-5; step 5) or the charging pump and manually control letdown to restore and maintain pressure within the Post Accident P-T limits of Figure 11-1.

PC-5

*15. The operator should continuously monitor for the presence of RCS voiding and take steps to eliminate voiding any time voiding inhibits RCS depressurization when depressurization is desired.

a. Voiding in the RCS may be indicated by any of the following indications, parameter changes, or trends:
   i) letdown flow greater than charging flow,
   ii) pressurizer level increasing significantly greater than expected while operating pressurizer spray,
   iii) the HJTC RVLMS indicates that voiding is present in the reactor vessel,
   iv) HJTC unheated thermocouple temperature indicates saturated conditions in the reactor vessel upper head.

b. If voiding should be eliminated, then proceed as follows:
   i) letdown is isolated or verified to be isolated to minimize further inventory loss,
   ii) the depressurization is stopped to prevent further growth of the void,
   iii) Pressurizing and depressurizing the RCS within the limits of Figure 11-1 may condense the void. Pressurizing has the effect of filling the voided portion of the RCS with cooler fluid which will remove heat from the region. Subsequent depressurization and a repeating of this process several times will cool and condense the steam void. In the case of a void in the reactor vessel, the pressurization/depressurization on cycle will produce a fill and drain of the reactor vessel. The pressurization/depressurization cycle may be accomplished using pressurizer heaters and spray (preferred method) or the SIS/charging system (alternative method). Monitor pressurizer level and the RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

PC-5

c. If indications of unacceptable RCS voiding continue, and voiding is suspected to exist in the (isolated) steam generator tubes, then cool the (isolated) steam generator (by steaming or blowdown, and/or feeding) to condense the tube bundle void. This will be effective for condensing steam voids but will not have an effect on non-condensible gases trapped in the tube bundle. A buildup of non-condensible gases in the tube bundles will not hinder natural circulation even with a large number of the tubes blocked. This is due to the small amount of heat transfer area required for the removal of decay heat. Monitor pressurizer level for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

d. If indications of unacceptable RCS voiding continue, then voiding may be caused by non-condensible gases. Operate the Reactor Coolant Gas Vent System to clear trapped non-condensible gases. Monitor pressurizer level and/or the HJTC RVLMS] for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

PC-5

PC-5: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, RCS Pressure Control is satisfied if:

   Pressurizer pressure is within the Post Accident P-T limits of Figure 11-1.

   Observing the Post Accident P-T limits during implementation of the RCS Pressure Control via Natural Circulation with Controlled Steaming success path minimizes pressurized thermal shock concerns and ensures a subcooled cooling medium for heat removal.

2. If the above criterion is not satisfied, then success path PC-5 is not successfully controlling RCS pressure. The operator should go to the next appropriate success path for RCS Pressure Control.

3. If the acceptance criterion for success path PC-5 is satisfied, then success path PC-5 is successfully controlling RCS Pressure. RCS Pressure Control is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

PC-5

PC-6: RCS Pressure Control via Rapid Depressurization System

The Rapid Depressurization System (RDS) may be used to lower RCS pressure. The operator's role is to manually open the RDS valves and determine the appropriate time to close the valves. Opening the RDS valves is expected to rapidly depressurize the RCS. This depressurization may cuase rapid pressurizer level increase and subsequent water flow through the RDS valves. this is a last-resort method of pressure reduction and should only be u sed if other means are not available.

Operator Actions

1. The operator should use this success path only after at least one Primary Safety Valve (PSV) has opened. The anlyses performed for the use of the Rapid Depressurization System (RDS) include PSV opening as an initial condition. Therefore, the consequences of opening a depressurization flowpath in cases where the PSV has not opened have not been analyzed. If the PSVs have not opened, the operator must implement a different pressure control success path.

2. Prior to opening an RDS flowpath, the operator must verify that at least two SI pumps are operating. Opening the RDS flowpaths will cause the RCS to lose inventory. In order to ensure that the core remains covered and that a medium exists to cool the core, at least two SI pumps should be operating to inject water when the RCS pressure is reduced. If less than two pumps are available, then operators must not proceed with this success path until at least one SI pump is available.

3. Implementation of this success path will likely be the result of an inability to remove heat fromt he RCS. Heat input into the RCS is minimized by tripping all RCPs. Natural circulation heat removal is adequate to remove the decay heat generated in the core.

4. Both RDS flowpaths are opened to ensure sufficient RCS depressurization.

5. If the RDS valves must remain open for once-through-cooling, then the operator should exit this success path and enter PC-3, Pressure Control via Safety Injection System. If the RDS valves do not need to remain open for once-through-cooling, then evaluate the following criteria to determine if they should be closed:

   a. Pressurizer pressure less than the high pressure alarm setpoint ([2370]),
   b. Pressurizer pressure is within the Post Accident P-T limits of Figure 11-1. When the RDS valves are open, the minimum subcooling limit is no longer applicable. The goal of this pressure control success path is to reduce pressure below some unacceptable high valve. This success path is a last-resort method of pressure reduction and therefore the loss of subcooling is acceptable.
   c. The RDS valves cannot be closed if they are open for the purpose of RCS Heat Removal via once-through-cooling (RCS Heat Removal success path HR-4). If the RDS valves are open for once-through-cooling, then they must remain open until the once-through-cooling termination criteria are met.

PC-6

PC-6: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, RCS Pressure Control is satisfied if:

   a. Pressurizer pressure is less than [2370 psia] and constant or decreasing

   and

   b. pressurizer pressure is within the Post Accident P-T limits of Figure 11-1.

   RCS pressure should decrease to less than the high pressure alarm setpoint of [2370 psia] after the PSVs open due to high pressure ([2500 psia]). If the RDS valves are manually opened at a lower RCS pressure, then pressurizer pressure should lower to the desired pressure and be constant or decreasing. Pressure should be restored to within the P-T limits of Figure 11-1 although RCS subcooling is not applicable when RDS valves are open.

2. If the above criteria are not satisfied, then success path PC-6 is not successfully controlling RCS pressure. The operator should go to Continuing Actions for RCS Pressure Control.

3. If the acceptance criteria for success path PC-6 are satisfied, then success path PC-6 is successfully controlling RCS Pressure. RCS Pressure Control is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

PC-7: RCS Pressure Control via Rapid Depressurization System during SGTR

The Rapid Depressurization System (RDS) may be used to lower RCS pressure in the event that no other systems are available to maintain RCS pressure below the main staeam safety valve setpoint during a SGTR event. The operator's role is to manually open the RDS valves and throttle the valve as necessary to control pressure in the RCS. Opening the RDS valves is expected to rapidly depressurize the RCS. This depressurization may cause rapid pressurizer level increase and subsequent water flow through the RDS valves. This is a last-resort method of pressure reduction and should only be used if other means are not available.

Operator Actions

1. If indications of a Steam Generator Tube Rupture are present and pressure can NOT be maintained less than [1200 psia] using any of the following:

   a. main or auxiliary sprays
   b. operation of charging and letdown
   c. throttling of safety injection
   d. operation of the Reactor Coolant Gas Vent System,

   Then operate the Rapid Depressurization System to maintain pressure less than [1200 psia] and allow the affected steam generator(s) MSSVs to close or remain closed. This success path should only be used when there are indications of a steam generator tube rupture as a last-resort to prevent the opening of the Main Steam Safety Valves (MSSVs) or to reduce the pressure in the RCS (and indirectly in the affected steam generator(s)) to allow the MSSVs to close after they have been opened.

PC-7: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, RCS Pressure Control is satisfied if:

   a. Pressurizer pressure is less than [1200 psia] and controlled

      and

   b. All Main Steam Safety Valves on the affected steam generator(s) are closed.

   Pressure should be restored to within the P-T limits of Figure 11-1 although RCS subcooling is not applicable when RDS valves are open.

2. If the above criteria are not satisfied, then success path PC-7 is not successfully controlling RCS pressure. The operator should go to Continuing Actions for RCS Pressure Control.

3. If the acceptance criteria for success path PC-7 are satisfied, then success path PC-7 is successfully controlling RCS Pressure. RCS Pressure Control is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

PC-7

CONTINUING ACTIONS FOR RCS PRESSURE CONTROL

If RCS Pressure Control is still in jeopardy, then the operator must continue to attempt to restore RCS Pressure Control while pursuing other safety functions in jeopardy.

SAFETY FUNCTION: RCS and Core Heat Removal

SUCCESS PATH: Forced Circulation, No SIS Operation; HR-1

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. Borate the plant as necessary while cooling down in order to maintain shutdown margin per Technical Specification limits (refer to RC-2 and RC-3).	1.
2. Allow pressurizer level to lower (maintaining level [2% to 78%]) while cooling down in order to aid the depressurization.	2.
3. Perform a controlled cooldown in accordance with Technical Specifications by operation of the steam bypass system.	3. If the condenser or steam bypass system NOT available, Then cooldown via the atmospheric dump valve(s).
* 4. Ensure pressurizer pressure is being maintained within the Post Accident P-T limits of Figure 11-1.	* 4. If RCS subcooling greater than P-T limits or cooldown rate greater than [100°F/Hr], Then do the following as appropriate: a. stop the cooldown, b. manually control pressurizer spray to restore and maintain pressurizer pressure within the limits of Figure 11-1,

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
4.	* 4. (Continued) c. attempt to maintain the plant in a stable pressure - temperature configuration or continue to cooldown within the limits of Figure 11-1, d. <u>If</u> overpressurization due to charging flow, <u>Then</u> throttle or secure flow and manually control letdown to restore and maintain pressurizer pressure within the limits of Figure 11-1.
5. <u>If</u> indications of steam generator tube leakage, <u>Then</u> go to step 6.	5. <u>If NOT</u>, <u>Then</u> go to step 15
6. <u>Verify</u> RCS hot leg temperature is less than [547°F] in order temperature to minimize the possibility of lifting SG safeties after isolating a SG.	6. <u>Cooldown</u> the RCS to a hot leg temperature of less than [547°F]. (Refer to step 3).

HR-1

INSTRUCTIONS	CONTINGENCY ACTIONS
7. Determine which SG has the tube leakage by performing the following:	7.
a. sample SGs for activity,	
b. monitor main steam piping for activity,	
c. monitor steam generator levels,	
d. monitor steam plant for activity.	
8. When RCS hot leg temperature is less than [547°F], Then isolate the steam generator with the higher activity, higher radiation levels, or increasing water level by performing the following:	8.
a. close the MSIV,	a. locally close MSIV,
b. verify closed, or close the MSIV bypass valve,	b. locally close MSIV bypass valve,
c. verify the most affected SG pressure ≤ [1150 psia] and manually close the associated ADV	c. If the ADV can not be closed manually, then close the valve locally
d. close the main feedwater isolation valve,	d. locally close main feedwater isolation valve,

HR-1

INSTRUCTIONS	CONTINGENCY ACTIONS
8. (Continued)	
e. close the emergency feedwater isolation valve(s) including the steam driven pump steam supply valve associated with the steam generator being isolated.	e. locally close EFW isolation valve(s) and steam driven pump steam supply valve,
f. isolate steam generator blowdown,	f. locally isolate SG blowdown.
g. close vents, drains, exhausts, and bleedoffs from the steam system.	g. locally isolate vents, drains, exhausts, and bleedoffs.
h. close turbine plant sump to radwaste	h. divert turbine plant sump to radwaste.
9. Verify the correct SG is isolated by checking the following:	9. If the wrong SG was isolated, Then unisolate that SG and isolate the affected SG per step 8.
a. SG samples for activity and radiation levels,	
b. possible SG level increase.	

HR-1

INSTRUCTIONS	CONTINGENCY ACTIONS
*10. Maintain isolated steam generator pressure less than [1150 psia] to prevent MSSV opening by: a. Manual operation of the associated ADV, b. Local operation of the associated ADV.	
11. <u>Decrease and control</u> RCS pressure by using main or auxiliary spray, Reactor Coolant Gas Vent System, operation of charging and letdown, or throttling of safety injection pumps in order to control pressurizer pressure within the following criteria: a. less than [1200 psia] <u>and</u> b. maintain RCS pressure approximately equal to but within 50 psi above isolated SG pressure <u>and</u> c. within the P-T limits of Figure 11-1 (refer to step 4).	11.

* Step Performed Continuously

HR-1

INSTRUCTIONS		CONTINGENCY ACTIONS
12. Maintain the isolated steam generator level within [40% to 95%] narrow range by any of the following: a. periodic draining to the radioactive waste system via blowdown processing system or blowdown to the condenser and b. dump steam from the affected steam generator to the condenser, with approval of the [Emergency Coordinator, Plant Technical Support Center, or the Plant Operations Review Committee].	12.	Restore the isolated steam generator level to less than [95%] narrow range by the following: a. draining to the radioactive waste system or blowdown to the condenser.
*13. Sample the condensate and other connecting systems, including turbine building sumps, for activity.	13.	
*14. Monitor turbine, subsphere, and nuclear annex building ventilation radiation monitors and any other applicable radiation monitors.	14.	If radiation monitor readings are excessive, Then take corrective actions in accordance with Technical Specifications.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*15. If indications of excessive steam demand, Then go to step 16.	15. If NOT, Then go to step 21.
16. Determine the affected SG (or most affected SG) by comparison of the following: a. SG steam pressures, b. RCS cold leg temperatures, c. SG levels.	16.
17. If excessive steam demand stopped due to MSIS, Then go to step 21.	17. Go to step 18.
18. Isolate the most affected steam generator by performing the following:	18.
a. close the MSIV,	a. locally close MSIV,
b. verify closed, or close the MSIV bypass valve,	b. locally close MSIV bypass valve,
c. close, or verify closed the atmospheric dump valve(s),	c. locally close ADV(s),
d. close the main feedwater isolation valve,	d. locally close main feedwater isolation valve,
e. close the emergency feedwater isolation valve	e. locally close emergency feedwater isolation valve,
f. close vents, drains, exhausts and bleedoffs from the steam system.	f. locally close vents, drains, exhausts, and bleedoffs.

* Step Performed Continuously

HR-1

INSTRUCTIONS		CONTINGENCY ACTIONS
19. Verify the correct SG is isolated by checking the following: a. SG steam pressures, b. RCS cold leg temperatures c. SG levels.	19.	If the wrong SG was isolated, Then unisolate that SG and isolate the most affected SG per step 18.
20. Stabilize RCS temperature by controlled steaming of the unisolated SG using the following (listed in preferred order): a. Steam bypass system or b. atmospheric dump valve(s).	20.	
*21. Ensure the available emergency feedwater inventory is adequate per Figures 11-4 and 11-5.	21.	
*22. Maintain SG levels (or unisolated SG level) in the normal band using main, startup or emergency feedwater.	22.	If all feedwater is lost, Then do the following: a. stop all RCPs, b. isolate SG blowdown, secondary sampling, and any non-vital steam discharge, c. attempt to restore one or more feedwater systems, d. attempt to establish an alternate, low pressure feedwater source to at least one SG.

* Step Performed Continuously

HR-1

INSTRUCTIONS	CONTINGENCY ACTIONS
*23. Verify adequate RCS heat removal via the SGs by: a. at least one SG has wide range level [> 0%], and b. RCS T_c temperatures are stable or decreasing.	23. a. When at least one primary safety valve has opened following a SG dryout, Then go to RCS and Core Heat Removal success path HR-4 and initiate once-through-cooling.
*24. If main, startup or emergency feedwater is restored, Then modulate feedwater flow rate as necessary to restore and maintain SG water level in the normal band.	24.

* Step Performed Continuously

ACCEPTANCE CRITERIA FOR SUCCESS PATH HR-1:

1. RCS and Core Heat Removal is satisfied if:

   a. At least one SG (or the unisolated SG) has level:
      i) within the normal level band with feedwater available to maintain level.

      or

      ii) being restored by main, startup or emergency feedwater flow and SG level is increasing

      and

   b. $T_H - T_c < [3°F]$ and not increasing

      and

   c. $T_{ave} < [562°F]$ and not increasing

      and

   d. RCS subcooled by T_H RTDs

      and

   e. No reactor vessel voiding as indicated by the HJTC RVLMS.

2. If above criteria NOT satisfied, Then go to next appropriate RCS and Core Heat Removal success path.

3. If above criteria satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

SUPPLEMENTARY INFORMATION: HR-1

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Do not place system in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation.

2. All available indications should be used to aid in the evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available. For example, during rapid depressurization the indicated level in the pressurizer may be higher than the actual level.

3. Continuously monitor RCS temperature and pressure to avoid exceeding a heat removal rate greater than Technical Specification Limitations. If the heat removal rate exceeds Technical Specification Limits, there may be a potential for pressurized thermal shock (PTS) of the reactor vessel, unless Post Accident Pressure/Temperature Limits are maintained (Figure 11-1).

4. If there is a conflict between maintaining adequate core cooling and complying with the pressure/temperature limits of Figure 11-1, then maintaining of adequate core cooling will be given the higher priority. Subcooling has precedence over PTS considerations.

HR-1

5. Solid water operation of the pressurizer may make it difficult to control RCS pressure and therefore should be avoided unless subcooling cannot be maintained in the RCS (Figure 11-1). If the RCS is solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any unfavorable pressure excursions.

6. The operator should not add feedwater to a dry steam generator if another steam generator still contains water. Re-establish feedwater only to the steam generator that is not dry. If both steam generators become dry, then refill only one steam generator to reinitiate core cooling.

7. If there is a conflict between isolating a SG (e.g., due to indications of steam generator tube leakage or excessive steam demand) and maintaining adequate heat removal, then maintain RCS heat removal via the least affected SG. At least one SG should always be available for heat removal if at all possible.

8. The Alternate Protection System provides a redundant and diverse emergency feedwater actuation signal to provide added assurance that an ATWS event or a Loss of Feedwater event could be mitigated if it were to occur.

HR-1

SAFETY FUNCTION: RCS and Core Heat Removal

SUCCESS PATH: Natural Circulation, No SIS Operation; HR-2

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. Verify natural circulation flow in at least one loop by ALL of the following: a. loop ΔT (T_H - T_c) less than normal full power ΔT, b. hot and cold leg temperatures constant or decreasing, c. RCS subcooled based on representative CET temperature, d. no abnormal difference [>10°F] between T_H RTDs and CETs.	1. Ensure proper control of steam generator feeding and steaming, and RCS inventory and pressure.
*2. Evaluate the need and desirability of restarting RCPs. Consider the following: a. adequacy of RCS and core heat removal using natural circulation, b. existing RCS pressure and temperatures, c. the need for main pressuizer spray capability, d. the duration of CCW interruption to RCPs, e. RCP seal staging pressures and temperatures.	2. If RCP operation NOT desired, Then go to step 8.

* Step Performed Continuously

HR-2

INSTRUCTIONS

* 3. Determine whether RCP restart criteria are met by ALL of the following:
   a. electrical power is available to the RCPs,
   b. RCP auxiliaries ([CCW]) to maintain seal cooling, bearing and motor cooling are operating, and there are no high temperature alarms on the selected RCPs,
   c. at least one steam generator is available for removing heat from the RCS (ability for feed and steam flow),
   d. pressurizer level is greater than [33%] and not decreasing,
   e. RCS subcooled based on representative CET temperature (Figure 11-1),
   f. other criteria satisfied per RCP operating instructions.
   g. Natural circulation has been verified by step 1 for the preceeding 20 minutes.

CONTINGENCY ACTIONS

3. If RCP restart criteria NOT satisfied, Then go to step 8.

* Step Performed Continuously

HR-2

INSTRUCTIONS	CONTINGENCY ACTIONS
* 4. If RCP restart desired and restart criteria satisfied, Then do the following: a. start one RCP in each loop, b. ensure proper RCP operation by monitoring RCP amperage and NPSH, c. operate charging and SI pumps until pressurizer level greater than [14.3%].	4. Go to step 8.
* 5. If SI pumps are operating, Then they may be throttled or stopped, one pump at a time, if ALL of the following are satisfied: a. RCS subcooled based on representative CET temperature (Figure 11-1), b. pressurizer level is greater than [14.3%] and not decreasing, c. at least one steam generator is available for removing heat from the RCS (ability for feed and steam flow), d. the HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles.	5. Continue SI pump operation.

* Step Performed Continuously

HR-2

INSTRUCTIONS		CONTINGENCY ACTIONS	
* 6.	If criteria of step 5 cannot be maintained after SI pumps throttled or stopped, Then SI pumps must be restarted and full SI flow restored.	6.	
* 7.	If at least one RCP has been restarted in a loop with a SG having feed and steam flow capability, Then go to HR-1, Forced Circulation, No SIS Operation.	7.	Continue with the actions of this success path.
* 8.	Borate the plant as necessary while cooling down in order to maintain shutdown margin per Technical Specification limits (refer to RC-2 and RC-3).	8.	
9.	Allow pressurizer level to lower (maintaining level [2% to 78%]) while cooling down in order to aid the depressurization.	9.	
10.	Perform a controlled cooldown in accordance with Technical Specifications by operation of the steam bypass system.	10.	If the condenser or steam bypass system NOT available, Then cooldown via the atmospheric dump valve(s).

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*11 Ensure pressurizer pressure is being maintained with the Post Accident P-T limits of Figure 11-1.	*11. If RCS subcooling greater than P-T limits or cooldown rate greater than [100°F/Hr], Then do the following as appropriate: a. stop the cooldown, b. manually control pressurizer spray to restore and maintain pressurizer pressure within the limits of Figure 11-1, c. attempt to maintain the plant in a stable pressure-temperature configuration or continue to cooldown within the limits of Figure 11-1, d. If overpressurization due to charging flow, Then throttle or secure flow and manually control letdown to restore and maintain pressurizer pressure within the limits of Figure 11-1.
*12. If indications of steam generator tube leakage, Then go to step 13.	12. If NOT, Then go to step 22.
13. Verify RCS hot leg temperature is less than [547°F] in order to minimize the possibility of lifting SG safeties after isolating a SG.	13. Cooldown the RCS to a hot leg temperature of less than [547°F]. (refer to step 10).

* Step Performed Continuously

HR-2

INSTRUCTIONS	CONTINGENCY ACTIONS
14. <u>Determine</u> which SG has the tube leakage by performing the following:	14.
a. sample SGs for activity,	
b. monitor main steam piping for activity	
c. monitor steam generator levels,	
d. monitor steam plant for activity.	
15. <u>When</u> RCS hot leg temperature is less than [547°F], <u>Then</u> isolate the steam generator with the higher activity, higher radiation levels, or increasing water level by performing the following:	15.
a. close the MSIV,	a. locally close MSIV,
b. verify close, or close the MSIV bypass valve,	b. locally close MSIV bypass valve,
c. verify the most affected SG pressure ≤ [1150 psia] and manually close the associated ADV,	c. <u>If</u> the ADV can not be closed manually, <u>then</u> close the valve locally
d. close the main feedwater isolation valve,	d. locally close main feedwater isolation valve,

* Step Performed Continuously

HR-2

INSTRUCTIONS		CONTINGENCY ACTIONS
15.	(Continued)	
	e. close the emergency feedwater isolation valve(s) including the steam driven pump steam supply valve associated with the steam generator being isolated,	e. locally close EFW isolation valve(s) and steam driven pump steam supply valve,
	f. isolate steam generator blowdown,	f. locally isolate SG blowdown.
	g. close vents, drains, exhausts, and bleedoffs from the steam system	g. locally isolate vents, drains, exhausts, and bleedoffs.
	h. verify turbine plant sump diverted to radwaste	h. divert turbine plant sump to radwaste
16.	Verify the correct SG is isolated by checking the following: a. SG samples for activity and radiation levels, b. possible SG level increase.	16. If the wrong SG was isolated Then unisolate that SG and isolate the affected SG per step 15.
*17.	Maintain isolated steam generator pressure less than [1150 psia] to prevent MSSV opening by: a. Manual operation of the associated ADV, b. Local operation of the associated ADV.	

* Step Performed Continuously

HR-2

INSTRUCTIONS	CONTINGENCY ACTIONS
18. Decrease and control RCS pressure by using main or auxiliary spray, Reactor Coolant Gas Vent System, operation of charging and letdown, or throttling of safety injection pumps in order to control pressurizer pressure within the following criteria: a. less than [1200 psia] and b. maintain RCS pressure approximately equal to but within 50 psi above isolated SG pressure and c. within the P-T limits of Figure 11-1 (refer to step 11).	18.
*19. Maintain the isolated steam generator level within [40% to 95%] narrow range by any of the following: a. periodic draining to the radioactive waste system. and	19. Restore the isolated steam generator level to less than [95%] narrow range by the following: a. draining to the radioactive waste system or blowdown to the condenser.

* Step Performed Continuously

HR-2

INSTRUCTIONS		CONTINGENCY ACTIONS
*19. (Continued) b. dump steam from the affected steam generator to the condenser, with approval of the [Emergency Coordinator, Plant Technical Support Center or the Plant Operations Review Committee].		
*20. Sample the condensate and other connecting systems, including turbine building sumps, for activity.	20.	
*21. Monitor turbine, subsphere and nuclear annex building ventilation radiation monitors and any other applicable radiation monitors.	21.	If radiation monitor readings are excessive, Then take corrective actions in accordance with Technical Specifications.
22. If indications of excessive steam demand, Then go to step 23.	22.	If NOT, Then go to step 28.
23. Determine the affected SG (or most affected SG) by comparison of the following: a. SG steam pressures, b. RCS cold leg temperatures, c. SG levels.	23.	

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
24. If excessive steam demand stopped due to MSIS, Then go to step 28.	24. Go to step 25.
25. Isolate the most affected steam generator by performing the following:	25.
a. close the MSIV,	a. locally close MSIV,
b. verify closed, or close the MSIV bypass valve,	b. locally close MSIV bypass valve,
c. close, or verify closed the atmospheric dump valve(s),	c. locally close ADV(s),
d. close the main feedwater isolation valve,	d. locally close main feedwater isolation valve,
e. close the emergency feedwater isolation valve,	e. locally close emergency feedwater isolation valve,
f. close vents, drains, exhausts and bleedoffs from the steam system.	f. locally close vents, drains, exhausts, and bleedoffs.
26. Verify the correct SG is isolated by checking the following: a. SG steam pressures, b. RCS cold leg temperatures, c. SG levels.	26. If the wrong SG was isolated, Then unisolate that SG and isolate the most affected SG per step 25.

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS	
27.	Stabilize RCS temperature by controlled steaming of the unisolated SG using the following (listed in preferred order): a. steam bypass system or b. atmospheric dump valve(s).	27.	
*28.	Ensure the available emergency feedwater inventory is adequate per Figures 11-4 and 11-5.	28.	
*29.	Maintain SG levels (or unisolated SG level) in the normal band using main, startup or emergency feedwater.	*29.	If all feedwater is lost, Then do the following: a. stop all RCPs, b. isolate SG blowdown, secondary sampling, and any non-vital steam discharge, c. attempt to restore one or more feedwater systems, d. attempt to establish an alternate, low pressure feedwater source to at least one SG.

* Step Performed Continuously

HR-2

INSTRUCTIONS		CONTINGENCY ACTIONS
*30.	Verify adequate RCS heat removal via the SGs by: a. at least one SG has wide range level [> 0%], and b. RCS T_c temperatures are stable or decreasing.	30. a. When at least one primary safety valve has opened following a SG dryout, Then go to RCS and Core Heat Removal success path HR-4 and initiate once-through-cooling.
*31.	If main, startup or emergency feedwater is restored, Then modulate flowrate as necessary to restore and maintain SG water level in the normal band.	31.
*32.	If the RCS fails to depressurize, Then a void should be suspected. a. voiding in the RCS may be indicated by any of the following indications, parameter changes, or trends: i) letdown flow greater than charging flow, ii) pressurizer level increasing significantly more than expected while operating pressurizer spray, iii) the HJTC RVLMS indicates that voiding is present in the reactor vessel,	32.

* Step Performed Continuously

HR-2

INSTRUCTIONS

32. (Continued)

iv) HJTC unheated thermocouple temperature indicates saturated conditions in the reactor vessel upper head,

b. If voiding inhibits RCS depressurization and depressurization is desired, Then attempt to eliminate the voiding by:

i) verify letdown is isolated,

and

ii) stop the depressurization,

and

iii) pressurize and depressurize the RCS within the limits of Figure 11-1 by operating pressurizer heaters and spray or SI and charging pumps. Monitor pressurizer level and the HJTC RVLMS for trending RCS inventory.

CONTINGENCY ACTIONS

32.

* Step Performed Continuously

INSTRUCTIONS

32. (Continued)

c. If depressurization of the RCS is still not possible, and voiding is suspected to exist in the steam generator tubes, Then attempt to eliminate the voiding by:

i) cool the suspected steam generator (by steaming and/or blowdown, and feeding) to condense the steam generator tube void,

and

ii) monitor pressurizer level for trending RCS inventory.

d. If depressurization of the RCS is still not possible, Then attempt to eliminate the voiding by:

i) operate the Reactor Coolant Gas Vent System to clear trapped non-condensible gases,

and

ii) monitor pressurizer level and/or the HJTC RVLMS for trending of RCS inventory.

CONTINGENCY ACTIONS

32.

* Step Performed Continuously

ACCEPTANCE CRITERIA FOR SUCCESS PATH HR-2:

1. RCS and Core Heat Removal is satisfied if:

   a. At least one SG (or the unisolated SG) has level:
      i) within the normal level band with feedwater available to maintain level.

      or

      ii) being restored by main, startup or emergency feedwater flow and SG level is increasing

      and

   b. $T_H - T_c <$ [59°F] and not increasing

      and

   c. $T_{ave} <$ [567°F] and not increasing

      and

   d. RCS subcooled by representative CET temperature.

      and

   e. No abnormal difference [>10°F] between T_H RTDs and CETs.

2. If above criteria NOT satisfied, Then go to next appropriate RCS and Core Heat Removal success path.

3. If above criteria satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

HR-2

SUPPLEMENTARY INFORMATION: HR-2

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Natural circulation flow should not be verified until the RCPs have stopped coasting down after being tripped.

2. Verification of temperature responses to a plant change cannot be accomplished until approximately 5 to 15 minutes following the action due to increased loop cycle times during natural circulation.

3. Continuously monitor RCS temperature and pressure to avoid exceeding a heat removal rate greater than Technical Specification Limitations. If the heat removal rate exceeds Technical Specification Limits, there may be a potential for pressurized thermal shock (PTS) of the reactor vessel, unless Post-Accident Pressure/Temperature Limits are maintained (Figure 11-1).

4. If there is a conflict between maintaining adequate core cooling and complying with the pressure/temperature limits of Figure 11-1, then maintaining of adequate core cooling will be given the higher priority. Subcooling has precedence over PTS considerations.

5. If cooling down by natural circulation with an isolated steam generator, and an inverted ΔT (i.e., T_c higher than T_H) may be observed in the idle loop. This is due to a small amount of reverse heat transfer in the isolated steam generator and will have no affect on natural circulation flow in the operating steam generator loop.

6. All available indications should be used to aid in the evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available. For example, during rapid depressurization the indicated level in the pressurizer may be higher than the actual level.

7. Solid water operation of the pressurizer may make it difficult to control RCS pressure and therefore should be avoided unless subcooling cannot be maintained in the RCS (Figure 11-1). If the RCS is solid, closely monitor any makeup or drainage and any system heatup or cooldown to avoid any unfavorable pressure excursions.

8. When a void exists in the reactor vessel, and RCPs are not operating, the HJTC RVLMS provides an accurate indication of reactor vessel liquid inventory. When a void exists in the reactor vessel, and RCPs are operating, it is not possible to obtain an accurate reactor vessel liquid level indication due to the effect of the RCP induced pressure head on the HJTC RVLMS. Information concerning reactor vessel liquid inventory trending may still be discerned. However, operators are cautioned not to rely solely on the HJTC RVLMS indication when RCPs are operating.

9. The operator should continuously monitor for the presence of RCS voiding and take steps to eliminate voiding any time voiding causes the heat removal or inventory control safety functions to begin to be threatened. Void elimination should be started soon enough to ensure heat removal and inventory control are not lost.

HR-2

10. If there is a conflict between isolating a SG (e.g., due to indications of steam generator tube leakage or excessive steam demand) and maintaining adequate heat removal, then maintain RCS heat removal via the least affected SG. At least one SG should always be available for heat removal, if at all possible.

11. Prior to RCP restart, verify loops with restart RCP(s) have been in natural circulation continuously for the preceding 20 minutes.

12. The Alternate Protection System provides a redundant and diverse emergency feedwater actuation signal to provide added assurance that an ATWS event or a Loss of Feedwater event could be mitigated if it were to occur.

HR-2

SAFETY FUNCTION: RCS and Core Heat Removal

SUCCESS PATH: SG Heat Sink with SIS Operating; HR-3

	INSTRUCTIONS		CONTINGENCY ACTIONS
* 1.	If pressurizer pressure ≤ the SIAS setpoint or containment pressure ≥ [2.7 psig], Then verify an SIAS actuated.	1.	If pressurizer pressure ≤ the SIAS setpoint or containment pressure ≥ [2.7 psig] and an SIAS has NOT been initiated automatically, Then manually initiate an SIAS.
* 2.	If pressurizer pressure < [1400 psia] following an SIAS, Then do either of the following: a. If RCS is subcooled Then ensure two of four RCPs are tripped (in opposite loops). or b. If RCS is NOT subcooled then ensure all four RCPs are tripped.	2.	Continue RCP operation.
3.	Verify RCP operating limits are satisfied.	3.	Trip the RCPs which do not satisfy RCP operating limits.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
* 4. Ensure maximum safety injection and charging flow to the RCS by the following: a. start idle SI pumps and verify SIS flow in accordance with Figure 11-3, and b. start available charging pump.	4. If safety injection and charging flow NOT maximized, Then do the following as necessary: a. ensure electrical power to valves and pumps, b. ensure correct SIS valve lineup, c. ensure operation of necessary auxiliary systems.
5. If high RCS pressure is preventing adequate SIS flow, Then attempt to cooldown/depressurize to obtain adequate SIS flow (refer to step 10 and the Pressure Control success path in use).	5.
* 6. If all RCPs are stopped, Then verify natural circulation flow in at least one loop by ALL of the following a. loop ΔT (T_H - T_c) less than normal full power ΔT, b. hot and cold leg temperatures constant or decreasing, c. RCS subcooled based on representative CET temperature, d. no abnormal difference greater than 10°F between T_H RTDs and Core Exit Thermocouples.	6. Ensure proper control of steam generator feeding and steaming, and RCS inventory and pressure.

* Step Performed Continuously

HR-3

INSTRUCTIONS	CONTINGENCY ACTIONS
* 7. If single-phase natural circulation can NOT be maintained, Then (break flow and) two-phase natural circulation can maintain the heat removal process. The operator should ensure the following: a. available charging pump is operating and SI pumps are injecting water into the RCS per Figure 11-3, and b. SG steaming and feeding are properly controlled, and c. representative CET temperature is less than superheated.	7.
* 8. Borate the plant as necessary while cooling down in order to maintain shutdown margin per Technical Specification limits (refer to RC-2 and RC-3).	8.
9. Allow pressurizer level to lower (maintaining level [2% to 78%]) while cooling down in order to aid the depressurization.	9.

* Step Performed Continuously

INSTRUCTIONS		CONTINGENCY ACTIONS	
10.	Perform a controlled cooldown in accordance with Technical Specifications by operation of the steam bypass system.	10.	If the condenser or steam bypass system NOT available, Then cooldown via the atmospheric dump valve(s).
*11.	Ensure pressurizer pressure is being maintained within the Post Accident P-T limits of Figure 11-1.	11.	If RCS subcooling greater than P-T limits or cooldown rate greater than [100°F/Hr], Then do the following as appropriate: a. stop the cooldown, b. manually control pressurizer heaters and spray to restore and maintain pressurizer pressure within the limits of Figure 11-1, c. attempt to maintain the plant in a stable pressure-temperature configuration or continue to cooldown within the limits of Figure 11-1, d. If overpressurization due to SI or charging flow, Then throttle or secure flow (refer to step 32) and manually control letdown to restore and maintain pressurizer pressure within the limits of Figure 11-1.

* Step Performed Continuously

HR-3

INSTRUCTIONS		CONTINGENCY ACTIONS
12.	If indications of steam generator tube leakage, Then go to step 13.	12. If NOT, Then go to step 22
13.	Verify RCS hot leg temperature is less than [547°F] in order to minimize the possibility of lifting SG safeties after isolating a SG.	13. Cooldown the RCS to a hot leg temperature of less than [547°F] (refer to step 10).
14.	Determine which SG has the tube leakage by performing the following: a. sample SGs for activity, b. monitor main steam piping for activity, c. monitor steam generator levels, d. monitor main steam plant for activity.	14.
15.	When RCS hot leg temperature is less than [547°F], Then isolate the steam generator with the higher activity, higher radiation levels, or increasing water level by performing the following: a. close the MSIV, b. verify closed, or close the MSIV bypass valve,	15. a. locally close MSIV, b. locally close MSIV bypass valve,

* Step Performed Continuously

HR-3

INSTRUCTIONS	CONTINGENCY ACTIONS
15. (Continued)	
c. verify the most affected SG pressur~ ≤ [1150 psia] and manu `ose the associated ADV,	c. If the ADV can not be closed manually, then close the valve locally
d. close the main feedwater isolation valve	d. locally close main feedwater isolation valve,
e. close the emergen~ feedwater isolation valve(,uding the steam driven pump steam supply valve associated with the steam generator being isolated.	e. locally close EFW isolation valve(s) and steam driven pump steam supply valve.
f. isolate steam generator blowdown,	f. locally isolate SG blowdown,
g. close vents, drains, exhausts, and bleedoffs from the steam system.	g. locally isolate vents, drains, exhausts, and bleedoffs.
h. verify turbine plant sump diverted to radwaste.	h. divert turbine plant sump to radwaste.
16. Verify the correct SG is isolated by checking the following: a. SG samples for activity and radiation levels, b. possible SG level increase.	16. If the wrong SG was isolated, Then unisolate that SG and isolate the affected SG per step 14.

* Step Performed Continuously

HR-3

INSTRUCTIONS	CONTINGENCY ACTIONS
*17. Maintain isolated steam generator pressure less than [1150 psia] to prevent MSSV opening by: a. Manual operation of the associated ADV, b. Local operation of the associated ADV.	17.
18. Decrease and control RCS pressure by using main or auxiliary spray, Reactor Coolant Gas Vent System, operation of charging and letdown, or throttling of safety injection pumps (refer to step 32) in order to control pressurizer pressure within the following criteria: a. less than [1200 psia] and b. maintain RCS pressure approximately equal to but within 50 psi above isolated SG pressure and c. within the P-T limits of Figure 11-1 (refer to step 10).	18.

* Step Performed Continuously

HR-3

INSTRUCTIONS		CONTINGENCY ACTIONS
19. Maintain the isolated steam generator level [40% to 95%] narrow range by any of the following: a. periodic draining to the liquid waste management system. b. dump steam from the affected steam generator to the condenser with the approval of the Emergency Coordinator, Plant Technical Support Center, or the Operations Review Committee].	19.	Restore the isolated steam generator level to the indicated range by the following: a. draining to the liquid waste management system or blowdown to the condenser
*20. Sample the condensate and other connecting systems, including turbine building sumps, for activity.	20.	
*21. Monitor subsphere, turbine, and annex building ventilation radiation monitors and any other applicable radiation monitors.	21.	If radiation monitor readings are excessive, Then take corrective actions in accordance with Technical Specifications.
22. If indications of excessive steam demand, Then go to step 24.	22.	If NOT, Then go to step 29.

* Step Performed Continuously

HR-3

INSTRUCTIONS	CONTINGENCY ACTIONS
23. Determine the affected SG (or most affected SG) by comparison of the following: a. SG steam pressures, b. RCS cold leg temperatures, c. SG levels.	23.
24. If excessive steam dem;nd stopped due to MSIS, Then go to step 28.	24. Go to step 25.
25. Isolate the most affected steam generator by performing the following:	25.
a. close the MSIV,	a. locally close MSIV,
b. verify closed, or close the MSIV bypass valve,	b. locally close MSIV bypass valve,
c. close, or verify closed the atmospheric dump valve(s)	c. locally close ADV(s),
d. close the main feedwater isolation valve	d. locally close main feedwater isolation valve,
e. close the emergency feedwater isolation valve,	e. locally close emergency feedwater isolation valve
f. close vents, drains, exhausts and bleedoffs,	f. locally close vents, drains, exhausts, and bleedoffs.

* Step Performed Continuously

HR-3

INSTRUCTIONS		CONTINGENCY ACTIONS	
26.	Verify the correct SG is isolated by checking the following: a. SG steam pressures, b. RCS cold leg temperatures c. SG levels.	26.	If the wrong SG was isolated, Then unisolate that SG and isolate the most affected SG per step 25.
27.	Stabilize RCS temperature by controlled steaming of the unisolated SG using the following: (listed in preferred order): a. steam bypass system or b. atmospheric dump valve(s).	27.	
28.	Ensure the available emergency feedwater inventory is adequate per Figures 11-4 and 11-5.	28.	
29.	Maintain SG levels (or unisolated SG level) in the normal band using main, startup or emergency feedwater.	29.	If main, startup and emergency feedwater are lost, Then do the following: a. trip all RCPs b. isolate SG blowdown, secondary sampling, and any non-vital steam discharge, c. attempt to restore main, start-up and/or emergency feedwater d. attempt to establish an alternate, low pressure feedwater source to at least one SG.

* Step Performed Continuously

HR-3

INSTRUCTIONS		CONTINGENCY ACTIONS	
*30.	Verify adequate RCS heat removal via the SGs by: a. at least one SG has wide range level > 0%, and b. RCS T_c temperatures are stable or decreasing.	30.	When at least one primary safety valve has opened following SG dryout, Then go to RCS and Core Heat Removal success path HR-4 and initiate one-through-cooling.
*31.	If main, startup or emergency feedwater is restored, Then modulate feedwater flow rate as necessary to restore and maintain SG water level in the normal band.	31.	
*32.	If SI pumps are operating, Then they may be throttled or stopped, one pump at a time, if ALL of the following are satisfied: a. RCS subcooled based on representative CET temperature (Figure 11-1), b. pressurizer level is greater than [14.3%] and not decreasing, c. at least one steam generator is available for removing heat from the RCS (ability for feed and steam flow),	32.	Continue SI pump operation.

* Step Performed Continuously

HR-3

INSTRUCTIONS	CONTINGENCY ACTIONS
32. (Continued) d. the HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles.	
*33. _If_ the criteria of step 32 cannot be maintained after SI pumps throttled or stopped, _Then_ appropriate SI pumps must be restarted and full SI flow restored.	33.
*34. _Evaluate_ the need and desirability of restarting RCPs. Consider the following: a. adequacy of RCS and core heat removal using natural circulation, b. existing RCS pressure and temperatures, c. the need for main pressurizer spray capability, d. the duration of CCW interruption to RCPs, e. RCP seal staging pressures and temperatures.	34. _If_ RCP operation _NOT_ desired, _Then_ go to step 37.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
*35. Determine whether RCP restart criteria are met by ALL of the following: a. electrical power is available to the RCP(s), b. RCP auxiliaries (CCW) to maintain seal cooling, bearing, and motor cooling are operating, and there are no high temperature alarms on the selected RCPs, c. at least one steam generator is available for removing heat from the RCS (ability for feed and steam flow), d. pressurizer level is greater than [33%] and not decreasing, e. RCS subcooled based on representative CET temperature (Figure 11-1), f. [other criteria satisfied per RCP operating instructions]. g. Natural circulation has been established in accordance with step 6 for the proceeding 20 minutes.	35. If RCP restart criteria NOT satisfied, Then go to step 37.

* Step Performed Continuously

HR-3

INSTRUCTIONS		CONTINGENCY ACTIONS	
*36.	If RCP restart desired and restart criteria satisfied, Then do the following: a. start one RCP in each loop, b. ensure proper RCP operation by monitoring RCP amperage and NPSH, c. operate charging and SI pumps until pressurizer level greater than [14.3%] and SI termination criteria met (refer to step 32).	36.	Go to step 37.
37.	Monitor In-containment Refueling Water Storage Tank (IRWST) level and verify reactor cavity sump level or Holdup volume Tank (HVT) increases as IRWST level decreases.	37.	Maintain IRWST level by replenishment from available sources as necessary.
*38.	If the RCS fails to depressurize, Then a void should be suspected. a. voiding in the RCS may be indicated by any of the following indications, parameter changes, or trends: i) letdown flow greater than charging flow,	38.	

* Step Performed Continuously

INSTRUCTIONS

CONTINGENCY ACTIONS

38. (Continued)

ii) pressurizer level increasing significantly more than expected while operating pressurizer spray,

iii) the HJTC RVLMS indicates that voiding is present in the reactor vessel,

iv) HJTC unheated thermocouple temperature indicates saturated conditions in the reactor vessel upper head,

b. If voiding inhibits RCS depressurization when depressurization desired, Then attempt to eliminate the voiding by:

i) verify letdown is isolated,

and

ii) stop the depressurization,

and

* Step Performed Continuously

INSTRUCTIONS

CONTINGENCY ACTIONS

38. (Continued)

iii) pressurize and depressurize the RCS within the limits of Figure 11-1 by operating pressurizer heaters and spray or SI and charging pumps. Monitor pressurizer level and the HJTC RVLMS for trending RCS inventory.

c. _If_ depressurization of the RCS is still not possible, _and_ voiding is suspected to exist in the steam generator tubes, _Then_ attempt to eliminate the voiding by:

i) cool the suspected steam generator (by steaming and/or blowdown, and feeding) to condense the steam generator tube void,

and

ii) monitor pressurizer level for trending RCS inventory.

* Step Performed Continuously

HR-3

INSTRUCTIONS	CONTINGENCY ACTIONS
38. (Continued) d. <u>If</u> depressurization of the RCS is still not possible, <u>Then</u> attempt to eliminate the voiding by: i) operate the Reactor Coolant Gas Vent System to clear trapped non-condensible gases, <u>and</u> ii) monitor pressurizer level and/or the HJTC RVLMS for trending of RCS inventory.	
39. If SI throttle/stop criteria of step 32 and <u>NOT</u> met, <u>Then</u> at [2-4 hours] after start of event, <u>establish</u> simultaneous hot leg and direct vessel injection (unless SCS operation can be established before the [4 hour] time limit.	39.

* Step Performed Continuously

ACCEPTANCE CRITERIA FOR SUCCESS PATH HR-3:

1. RCS and Core Heat Removal is satisfied if:

   a. At least one SG (or the unisolated SG) has level:

      i) within the normal level band with feedwater available to maintain level

      or

      ii) being restored by main, startup or emergency feedwater with level increasing

      and

   b. Representative CET temperature less than superheated.

      and

   c. The available charging pump is operating and the SI pumps are injecting water into the RCS per Figure 11-3 (unless SIS termination criteria met).

2. If above criteria NOT satisfied, Then go to next appropriate RCS and Core Heat Removal success path.

3. If above criteria satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

HR-3

SUPPLEMENTARY INFORMATION: HR-3:

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Do not place system in "manual unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation.

2. All available indications should be used to aid in evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available (e.g., during rapid depressurization the indicated level in the pressurizer may be too high). Hot and cold leg RTDs may be influenced by the cold SIS injection and should be checked against each other.

3. Solid water operation of the pressurizer may make it difficult to control RCS pressure and therefore should be avoided unless subcooling cannot be maintained in the RCS. If the RCS is solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any unfavorable pressure excursions.

4. If there is a conflict between maintaining adequate core cooling and complying with the pressure/temperature limits of Figure 11-1, then maintaining of adequate core cooling will be given the higher priority. Subcooling has precedence over PTS considerations.

HR-3

5. When a void exists in the reactor vessel, and RCPs are not operating, the HJTC RVLMS provides an accurate indication of reactor vessel liquid inventory. When a void exists in the reactor vessel, and RCPs are operating, it is not possible to obtain an accurate reactor vessel liquid level indication due to the effect of the RCP induced pressure head on the HJTC RVLMS. Information concerning reactor vessel liquid inventory trending can still be discerned. However, operators are cautioned not to rely solely on the HJTC RVLMS indication when RCPs are operating.

6. The operator should continuously monitor for the presence of RCS voiding and take steps to eliminate voiding any time voiding causes the heat removal or inventory control safety functions to begin to be threatened. Void elimination should be started soon enough to ensure heat removal and inventory control are not lost.

7. If there is a conflict between isolating a SG (e.g., due to indications of steam generator tube leakage or excessive steam demand and maintaining adequate heat removal, then maintain RCS heat removal via the least affected SG. At least one SG should always be available for heat removal, if at all possible.

8. Prior to RCP restart, verify loops with restart RCP(s) have been in natural circulation continuously for the preceding 20 minutes.

9. The Alternate Protection System provides a redundant and diverse emergency feedwater actuation signal to provide added assurance that an ATWS event or a Loss of Feedwater event could be mitigated if it were to occur.

HR-3

SAFETY FUNCTION: RCS and Core Heat Removal

SUCCESS PATH: Once-Through-Cooling; HR-4

INSTRUCTIONS	CONTINGENCY ACTIONS
1. Establish RCS heat removal via once-through-cooling by the following:	1.
a. verify all RCPs stopped,	a. stop all RCPs,
b. verify SI pumps aligned for DVI,	b. align SI pumps for DVI
c. verify the available charging pump and SI pumps operating,	c. start available charging and SI pumps.
d. open both RDS gate valves,	
e. verify SIS flow in accordance with Figure 11-3.	
* 2. If SI pumps are operating and are NOT required for success path RC-3, Then they may be throttled or stopped, one pump at a time, if ALL of the following are satisfied:	2. Continue SI pump operation.
a. RCS is subcooled based on representative CET temperature (Figure 11-1),	
b. pressurizer level is greater than [14.3%] and not decreasing,	
c. another heat removal success path is available,	

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
* 2. (Continued) d. the HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles.	
* 3. <u>If</u> the criteria of step 2 cannot be maintained after SI pumps throttled or stopped, <u>Then</u> appropriate SI pumps must be restarted and full SIS flow restored.	3.
4. <u>Establish</u> cooling to the IRWST as required per applicable procedure.	4.
5. <u>Monitor</u> In-containment Water Storage Tank (IRWST) level and <u>verify</u> reactor cavity sump level or Holdup Volume Tank Level increases as IRWST level decreases.	5. <u>Maintain</u> IRWST level by replenishment from available sources as necessary.

* Step Performed Continuously

INSTRUCTIONS	CONTINGENCY ACTIONS
* 6. If the following criteria are satisfied, Then once-through-cooling may be terminated by closing both RDS bleed valves: a. representative CET temperature is less than or equal to saturation and not increasing, and b. another heat removal success path is available, and c. the HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles.	6.
*7. If once-through-cooling has been terminated, Then a. Close the Rapid Depressurization gate valves b. implement heat removal success path HR-2, HR-3, or HR-5 as appropriate. c. Secure cooling to the IRWST when no longer required.	7. Continue with the actions of this success path.

* Step Performed Continuously

HR-4

ACCEPTANCE CRITERIA FOR SUCCESS PATH HR-4:

1. RCS and Core Heat Removal is satisfied if:

   a. Representative CET temperature is less than superheated

   and

   b. Available charging pump is operating and the SIS pumps are injecting water into the RCS per Figure 11-3 (unless SI termination criteria met,

   and

   c. Pressurizer pressure is less than [2055 psia] or decreasing.

2. If above criteria NOT satisfied, Then re-evaluate the availability of success paths HR-1,2, and 3 and refer to CONTINUING ACTIONS FOR RCS AND CORE HEAT REMOVAL.

3. If above criteria satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

HR-4

SUPPLEMENTARY INFORMATION: HR-4

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Do not place system in "manual" unless misoperation in "automatic" is apparent. Systems placed in "manual' must be checked frequently to ensure proper operation (e.g., during rapid depressurization the indicated level in the pressurizer may be too high).

2. All available indications should be used to aid in evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available. Hot and cold leg RTDs may be influenced by the cold SIS injection and should be checked against each other.

3. Solid water operation of the pressurizer may make it difficult to control RCS pressure and therefore should be avoided unless subcooling cannot be maintained in the RCS. If the RCS is solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any unfavorable pressure excursions.

SAFETY FUNCTION: RCS and Core Heat Removal

SUCCESS PATH: Shutdown Cooling System; HR-5

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. When pressurizer pressure reaches [445 psia], Then isolate, vent or drain the safety injection tanks (SITs).	1.
* 2. Initiate low temperature over-pressurization protection (LTOP) at $T_c \leq$ [259°F].	2.
* 3. When the following criteria are met, Then initiate shutdown cooling system (SCS) operation per plant specific instructions: a. pressurizer level > [14.3%] and constant or increasing, b. RCS subcooled, c. pressurizer pressure ≤ [450 psia], d. RCS $T_H \leq$ [400°F], e. RCS activity levels within plant specific limits.	3. If the RCS fails to depressurize, then a void should be suspected. b. voiding in the RCS may be indicated by any of the following indications, parameter changes, or trends: i) letdown flow greater than charging flow, ii) pressurizer level increasing significantly more than expected which operating pressurizer spray, 3.a. iii) the HJTC RVLMS indicates that voiding is present in the reactor vessel,

* Step Performed Continuously

HR-5

INSTRUCTIONS	CONTINGENCY ACTIONS
3. (continued)	iv) HJTC unheated thermocouple temperature indicates saturated conditions in the reactor vessel upper head,
	b. <u>If</u> voiding inhibits RCS depressurization to SCS entry pressure, <u>them</u> attempt to eliminate the voiding by: i) verify letdown is isolated, <u>and</u> ii) stop the depressurization, <u>and</u> iii) pressurize and depressurize the RCS within the limits of Figure 11-1 by operating pressurizer heaters and spray or SI and charging pumps. Monitor pressurizer level and the HJTC RVLMS for trending RCS inventory.

HR-5

INSTRUCTIONS

3. (Continued)

CONTINGENCY ACTIONS

c. If depressurization of the RCS to the SCS entry pressure is still not possible, and voiding is suspected to exist in the steam generator tubes, Then attempt to eliminate the voiding by:
   i) cool the suspected steam generator (by steaming and/or blowdown, and feeding) to condense the steam generator tube void,
   and
   ii) monitor pressurizer level for trending RCS inventory.

d. If depressurization of the RCS to the SCS entry pressure is still not possible, Then attempt to eliminate the voiding by:
   i) operate the RCGVS to clear trapped non-condensible gases,
   and
   ii) monitor pressurizer level and/or the HJTC RVLMS for trending of RCS inventory.

HR-5

ACCEPTANCE CRITERIA FOR SUCCESS PATH HR-5:

1. RCS and Core Heat Removal is satisfied if:

   Normal Shutdown Cooling System parameters exist.

2. If above criteria NOT satisfied, Then re-evaluate feasibility of SCS operation and consider implementing success paths HR-1, 2, 3, or 4. Refer to CONTINUING ACTIONS FOR RCS AND CORE HEAT REMOVAL.

3. If above criterion satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

HR-5

SUPPLEMENTARY INFORMATION: HR-5:

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Do not place system in "manual unless misoperation in "automatic" is apparent. Systems placed in "manual" must be checked frequently to ensure proper operation.

2. All available indications should be used to aid in evaluation of plant conditions since the accident may cause irregularities in a particular instrument reading. Instrument readings must be corroborated when one or more confirmatory indications are available (e.g., during rapid depressurization the indicated level in the pressurizer may be too high). Hot and cold leg RTDs may be influenced by the cold SI injection and should be checked against each other.

3. Solid water operation of the pressurizer may make it difficult to control RCS pressure and therefore should be avoided unless of subcooling cannot be maintained in the RCS. If the RCS is solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any unfavorable pressure excursions.

4. When a void exists in the reactor vessel, and RCPs are not operating, the HJTC RVLMS provides an accurate indication of reactor vessel liquid inventory. When a void exists in the reactor vessel, and RCPs are operating, it is not possible to obtain an accurate reactor vessel liquid level indication HR-5 due to the effect of the RCP induced pressure head on the HJTC RVLMS. Information concerning reactor vessel liquid inventory trending may still be discerned. However, operators are cautioned not to rely solely on the HJTC RVLMS indication when RCPs are operating.

5. The operator should continuously monitor for the presence of RCS voiding and take steps to eliminate voiding any time voiding causes the heat removal or inventory control safety functions to begin to be threatened. Void elimination should be started soon enough to ensure heat removal and inventory control are not lost.

HR-5

CONTINUING ACTIONS FOR RCS AND CORE HEAT REMOVAL

1. If the RCS and Core Heat Removal safety function is still in jeopardy, then the operator must pursue the RCS and Core Heat Removal safety function and other jeopardized safety functions simultaneously. If the SI pumps are delivering flow to the RCS per Figure 11-3, then the operator should evaluate the need and feasibility of transferring additional heat through the steam generators by:

   a. restoring the vital auxiliaries necessary to feed one or both steam generators
   b. using alternate means to feed the SGs
   c. alternate means of operating atmospheric dump valves or steam bypass valves or other steam outlets.

2. If the SI pumps are not delivering adequate flow to the RCS, then the operator should evaluate ways of implementing one of the RCS and core heat removal success paths by considering:

   a. restoring necessary vital auxiliaries (control air, electrical, diesel generator, etc.) to regain needed components or subsystems
   b. manual operation of failed remotely operated valves
   c. alternate sources of water for SG or RCS makeup
   d. alternate means of steam discharge from the steam generators
   e. depressurizing/cooling the RCS to increase or establish SI flow.

Bases for RCS and Core Heat Removal

The purpose of the RCS and Core Heat Removal safety function is to remove the decay heat generated in the core and transfer it to the RCS fluid, where it can be transferred to the secondary system or to some other heat sink.

To achieve control of RCS and Core Heat Removal, and to continually provide a heat sink for residual heat removal, the following methods are available-

HR-1: RCS and Core Heat Removal via Forced Circulation, No SI Operation
HR-2: RCS and Core Heat Removal via Natural Circulation, No SI Operation
HR-3: RCS and Core Heat Removal via SG Heat Sink with SI Operating
HR-4: RCS and Core Heat Removal via Once-Through-Cooling
HR-5: RCS and Core Heat Removal via Shutdown Cooling System

The bases for the operator actions required to implement the above success paths are detailed as follows:

HR-1: RCS and Core Heat Removal via Forced Circulation, No SIS Operation

Reactor coolant pump forced circulation is the preferred method for RCS heat removal. The reactor coolant absorbs the core heat and transfers this heat to the steam generators providing for the RCS and Core Heat Removal safety function. This requires that at least one steam generator be available to act as a heat sink. The heat is transferred to the secondary system fluid supplied by the main, startup or emergency feedwater systems.

Operator Actions

* 1. During a controlled cooldown, the RCS is borated as necessary (success paths RC-2 and RC-3) to maintain adequate shutdown margin per Technical Specification limits.

2. RCS inventory is controlled to permit pressurizer level to lower during RCS fluid contraction. This drop in level results in pressurizer bubble decompression which in turn results in RCS depressurization. It is also possible to cool the pressurizer gradually by filling the pressurizer with cooler loop fluid by charging to the loop. The level is then allowed to drop (maintaining [2% to 78%]) due to cooldown contraction and then refilled with cooler loop fluid. Repeated fillings will cool the pressurizer metal and steam bubble resulting in gradual depressurization.

3. An RCS cooldown should be performed to satisfy the acceptance criteria of success paths in use and/or to satisfy SCS entry conditions. This cooldown should be performed by dumping steam to the condenser via the steam bypass system. If the condenser or steam bypass system is not available, steam should be discharged through the atmospheric dump valve(s). The use of atmospheric dump valve(s) may have the potential for an unmonitored release of activity to the environment. If it is suspected that a steam generator(s) has tube leaks, then the cooldown should be performed using the unaffected or least affected generator. Refer to steps 5 through 14.

* 4. Throughout the cooldown and depressurization, the operator should ensure that the pressurizer pressure is being maintained within the Post Accident P-T limits of Figure 11-1. If subcooling or cooldown limits of Figure 11-1 are being violated, then the operators should take actions to restore the RCS to within the P-T limits. Depending on the situation, the operator should perform the following actions as appropriate:

   a. Stop the cooldown.
   b. Operate main or auxiliary spray as necessary to restore pressurizer pressure to within the P-T limits of Figure 11-1.
   c. Attempt to maintain the plant in a stable pressure-temperature configuration. The cooldown may be continued, if desired, within the limits of Figure 11-1.
   d. If an overpressure situation exists and is caused by charging flow, then throttle or stop the available charging pump and manually control letdown to restore and maintain pressure within the Post Accident P-T limits of Figure 11-1.

* 5. If indications of steam generator tube leakage exist (e.g., condenser air ejector radiation alarm, blowdown radiation alarm, high activity in a steam generator liquid sample, etc.), then the operator should go to step 6 for further guidance. If no indications of steam generator tube leakage exist, then the operator should go to step 15 for further guidance.

HR-1

6. The goal of this step is to verify that the RCS hot leg temperature has been decreased to less than [547°F] so that RCS to steam heat generator heat transfer is not sufficient to cause secondary safety valves to lift. If RCS hot leg temperature is not less than [547°F] the operator will manually cooldown the RCS. As discussed in step 3, this action should be performed preferentially by dumping steam to the condenser via manual control of the steam bypass system. If the condenser or steam bypass system is not available, the next order of priority for discharging steam would be to use the atmospheric dump valves. It is less desirable to use the atmospheric dump valves to cooldown the RCS because of the unmonitored release of activity to the environment.

   This step is presented before the leaking steam generator has been identified and isolated. This step is most easily accomplished when RCPs are operating and when one or more steam generators are providing cooling. Since forced circulation is available this step can be done in parallel with steps 7 and 8, detecting and isolating the affected steam generator.

7. The steam generator with the tube leakage should be determined by performing the following steps. These steps include:

   a. Sampling the steam generators for activity,
   b. Monitoring the main steam piping for activity,
   c. Monitoring steam generator levels,
   d. Monitor steam plant for activity.

HR-1

8. The steam generator with higher activity, higher radiation levels, or increasing water level should be isolated. Reducing RCS temperature to below the saturation temperature associated with the lowest pressure setpoint of the steam generator safety valves is one of the actions necessary to prevent opening a direct path to the environment for radionuclides after steam generator isolation. Steam generator isolation is an attempt to re-establish the containment isolation safety function. If both steam generators have tube ruptures, then the operators must determine which generator is most affected and isolate that generator.

   The most affected steam generator is isolated as follows:

   a. The main steam isolation valve is closed.
   b. The main steam isolation valve bypass valve is verified closed, or closed.
   c. The atmospheric steam dump valve is verified closed or closed.
   d. The main feedwater isolation valve is closed.
   e. The emergency feedwater isolation valves are closed, including the steam driven pump steam supply valve associated with the steam generator being isolated.
   f. Steam generator blowdown is isolated.
   g. Vents, drains, exhausts, and bleedoffs from the steam system are isolated. The crosstie to the auxiliary steam header is isolated. This completes the isolation of the radionuclides still in the secondary system to prevent further releases to the environment.

9. Once the steam generator has been isolated, isolation of the correct (most affected) steam generator should be verified by checking radiation indications, sampling for activity, and noting any possible increase in the isolated steam generator level. This provides feedback that the correct steam generator has been isolated. If the wrong steam generator has been isolated then it should be unisolated and the most affected steam generator should be isolated per step 9.

HR-1

*10. To prevent the MSSV opening, which would create a release path from the RCS to the environment, the isolated steam generator pressure must be maintained below the MSSV setpoint. To maintain SG pressure below the MSSV setpoint, manual operation of the ADV is used. Should the pressure in an isolated steam generator approach the lift setpoint for the associated MSSVs, it is desirable from the perspective of positive operator control that the ADV open first. This is accomplished by manually opening the ADV at [1150 psia] increasing, or locally opening the ADV at [1150 psia]. The value of [1150 psia] was chosen based on the MSSV setpoint of [1200 psia] minus an operating margin of [50 psi]. The intent of the step is explicitly stated in the step so that the operator understands the goals of the step and to minimize the use of the atmospheric steam dump valves on the affected steam generator which would create an unmonitored release of radioactivity.

11. The general goals associated with RCS pressure control are: providing subcooling to support the core heat removal process, avoiding overpressure situations for PTS and RT_{NDT} considerations, minimizing the pressure differential between the steam generator and the RCS to minimize the leakage, and controlling RCS pressure so that it is below the steam generator safety valve setpoints. This step addresses steam generator to RCS pressure differential and RCS depressurization to below the SG safety valve setpoint.

Maintaining the RCS pressure approximately equal to but above the isolated steam generator pressure (-0, +50 psi) and below the steam generator safety valve setpoint, [1200 psia], will minimize the loss of primary fluid to the secondary side and the possibility of overfilling the isolated SG. This is accomplished by either using main spray (the preferred method), auxiliary spray, the Reactor Coolant Gas Vent System or operation of charging and letdown. This action will minimize the potential for release of radiation to the environment by minimizing RCS to steam generator leakage.

HR-1

Maintaining RCS pressure approximately equal to SG pressure (-0, +50 psi) prevents backflow of secondary water into the primary system while minimizing primary to secondary leakage.

A key point in this strategy involves maintaining or restoring forced circulation. However, maintaining subcooling and adequate NPSH for RCP operation may cause the operator to hold RCS pressure above secondary pressure by the amount needed to provide adequate subcooling. This requirement takes precedence over the procedural strategy of bringing primary pressure to the point where it will be approximately equal to secondary pressure.

During the forced circulation cooldown process the lower region of the isolated steam generator may cool faster than the upper region. The cooling of the isolated SG steam space will significantly lag in the cooldown and cause the fluid in the lower regions to be subcooled. If the tube rupture is located in this subcooled region, then the primary fluid can be at the same pressure as the secondary fluid and still be subcooled. However the continued depressurization of the primary during the cooldown will now be limited by the ability to depressurize the isolated SG.

Maintaining RCS pressure within the acceptable limits of Figure 11-1 helps to ensure the core is covered by subcooled fluid and minimizes the concern for pressurized thermal shock by keeping plant pressure below the [200°F] subcooling limit. This is accomplished by controlling RCS heat removal via the unisolated steam generator, and controlling RCS pressure as discussed in Step 4.

*12. The potential exists for filling of the isolated steam generator steam space and the main steam piping up to the MSIV. This action could result in the inadvertent opening of the MSSVs and an undesirable spread of contamination and the potential for main steam piping support snubber damage.

HR-1

Draining to the radioactive liquid waste system or blowdown to the condenser will reduce level and minimize the spread of contamination and the possibility of piping support snubber damage although the piping up to the MSIVs is designed for static liquid water. If the generator draining is not feasible or is insufficient, then steaming the generator to the condenser will reduce level and minimize radioactivity release. Water hammer damage should be avoided by not reopening the affected MSIV while a significant amount of water is in the main steam piping. Draining to the radioactive waste system or blowing down to the condenser or reducing RCS pressure below the isolated steam generator pressure can lower steam generator level. The off-site dose coordinator should assess the radioactive releases to the environment. The value of [95%] was chosen to prevent overfilling the steam generator by ensuring the level remains in the indicated range. The value of [40%] was chosen to ensure all tubes remain covered, which minimizes the potential of radioactive fission products reaching the steam generator steam space.

*13. The condensate and all other connecting systems, including the turbine building sumps, should be sampled for activity that may have been transferred from the affected steam generator(s). These samples aid in determining the extent of contamination throughout the plant systems.

*14. The turbine subsphere and annex building ventilation systems' radiation monitors, and any other applicable radiation monitors, should be continually observed. Corrective actions, if necessary, should be taken in accordance with plant Technical Specification Limitations.

*15. If indications of excessive steam demand exist (e.g., excessive cooldown rate, excessive SG depressurization, etc.), then the operator should go to step 16 for further guidance. If no indications of excessive steam demand exist, then the operator should go to step 21 for further guidance.

HR-1

16. The most affected steam generator should be determined by comparison of steam pressures, cold leg temperature differences, and steam generator levels. If the excessive steam demand is not isolable (e.g., a break inside containment will still be producing steam flow after the MSIVs are shut, the steam generator with the reduced loop T_c, lower steam pressure, and lower steam generator level is the affected steam generator. These differences between affected and unaffected steam generators will be more pronounced after MSIS actuation. If the ESDE is downstream of the MSIVs and the MSIS occurs, both steam generators' pressures and loop temperatures should approach approximately the same values and then start to increase following MSIV closure.

17. If the shutting of the MSIVs (MSIS) stops the excessive steam demand, then neither SG is the affected SG. The operator should go to step 21 and skip the guidance for isolating the most affected SG. If the MSIS does not stop the excessive steam demand, then continue with step 18.

18. The most affected steam generator should be isolated to stop the uncontrolled plant cooldown and to stabilize the plant. If both steam generators are found to be affected, then isolate the most affected steam generator, if it can be determined, and attempt to maintain RCS heat removal capability via one steam generator. This action is designed to mitigate the uncontrolled cooldown and ready the plant for event recovery.

    The most affected steam generator is isolated as follows:

    a. The main steam isolation valve is closed.
    b. The main steam isolation valve bypass valve is verified closed, or closed.
    c. The atmospheric steam dump valve(s) is verified closed, or closed.
    d. The main feedwater isolation valve is closed.
    e. The emergency feedwater isolation valve is closed.
    f. Vents, drains, exhaust, and bleedoffs are closed,

HR-1

19. Once the steam generator has been isolated, isolation of the correct (affected) steam generator should be verified by checking steam generator pressures, RCS cold leg temperatures, and steam generator levels. This provides feedback that the correct steam generator has been isolated. If the wrong steam generator has been isolated then it should be unisolated and the most affected steam generator should be isolated per step 18.

20. When the isolated steam generator dries out, RCS temperatures will begin to increase unless a means of controlled steaming can be established. If a method of heat removal is not established, the RCS heatup will, when taken in conjunction with the inventory added to the RCS from SIS and charging pump operation, cause the plant to go solid and have the potential of being a PTS condition. A controlled heat removal method should be established before this dry out condition occurs. The preferred method of heat removal is via the steam bypass system (if the SBS and condenser are available) with the atmospheric dump valves as a backup method of heat removal. If the break is downstream of the MSIVs, then the atmospheric dump valve(s) should be used for RCS heat removal.

*21. The available emergency feedwater inventory should be monitored and replenished from available sources as necessary to continually provide a source for a secondary heat sink. Examples of alternate sources of emergency feedwater are non-seismic tanks, fire mains, lake water supplies, portable tanks, etc. Plant specific alternate sources of feedwater should be identified and cited in the procedure. The amount of condensate required to either maintain the plant at HOT STANDBY conditions or to cooldown may be determined from Figures 11-4 and 11-5.

*22. Both SG levels should be maintained in the normal band using main startup or emergency feedwater. If one SG was isolated (due to SG tube leakage or excessive steam demand), then the unisolated SG level should be maintained in the normal band to ensure continued SG heat removal capability.

HR-1

If all sources of feedwater are lost, the operator should perform the following actions:

a. A loss of all feedwater results in a reduction of the ability of the steam generators to remove heat from the RCS. Heat into the RCS is minimized by tripping all four RCPs. Natural circulation heat removal is adequate to remove the decay heat generated in the core.
b. The steam generator blowdown system, secondary sampling system, and any other non-vital secondary steam discharges should be isolated. Until feedwater is re-established, the steam generator water inventories must be conserved.
c. The operator should attempt to restore main, startup and/or emergency feedwater system operation. These efforts may include restoring electrical power, operating valves, starting pumps, or restoring necessary auxiliary systems for feedwater system operation.
d. If main, startup or auxiliary feedwater cannot be restored to at least one steam generator, then all plant-specific sources of feedwater which could be made available to replace steam generator boil-off should be implemented. Examples of alternate low-pressure sources of feedwater are fire pumps, condensate pumps, etc. When developing plant procedures, alternate low-pressure sources of feedwater should be identified and their use should be indicated in the procedures. Guidelines on steam generator depressurization should be developed for those cases when the operator is relying on low pressure sources of feedwater as a backup feedwater supply. The required heat removal, compared to the available heat removal capacity (e.g., atmospheric dump valves), provides the technical basis for which guidance may be developed on steam generator depressurization to permit use of alternate low-pressure sources of feedwater.

HR-1

*23. As long as at least one steam generator has indicated wide range level (greater than 0%, then adequate RCS heat removal is implicitly being maintained. An additional criterion requires the operator to monitor RCS T_c to ensure temperatures are stable or decreasing. This criterion assumes that no operator or plant initiated actions have caused a momentary, correctable reduction in RCS heat removal (e.g., ADV is closed automatically).

If both SG levels are indicating 0% WR, then the operator is instructed to go to RCS and Core Heat Removal success path HR-4 to initiate once-through-cooling, once the primary safety valve opens.

*24. If main, startup or emergency feedwater is restored, steam generator water level should be restored to the normal band.

HR-1

HR-1: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, RCS and Core Heat Removal is satisfied if:

   a. At least one SG (or the unisolated SG) has level:
      i) within the normal level band with feedwater available to maintain level

      or

      ii) being restored by main, startup or emergency feedwater flow with level increasing,

      and

   b. $T_H - T_c$ < [3°F] and not increasing

      and

   c. T_{ave} < [562°F] and not increasing,

      and

   d. RCS subcooled by T_H RTD

      and

   e. No reactor vessel voiding as indicated by HJTC RVLMS.

At least one steam generator with adequate level or adequate feed flow, a core ΔT <[3°F], T_{ave} < [562°F], adequate RCS subcooling, and no reactor vessel voiding, comprise the indications that heat is being properly removed from the core and the RCS. Operators use feed flow, steam flow and RCS temperature response to verify the SG is being effective as a heat removal mechanism and that the level will recover if it went below the indication range. ΔT < [3°F] is verified by best estimate analysis to be the maximum ΔT expected for minimum forced circulation with maximum decay heat. RCS subcooling ensures a liquid state of the coolant for effective heat removal properties. With RCPs operating, and the above criteria satisfied, there should be no reactor vessel voiding.

HR-1

2. If the above criteria are not satisfied, then success path HR-1 is not successfully controlling RCS and Core Heat Removal. The operator should go to the next appropriate success path for RCS and Core Heat Removal.

3. If the acceptance criteria for success path HR-1 are satisfied, then success path HR-1 is successfully controlling RCS and Core Heat Removal. RCS and Core Heat Removal is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement LONG TERM ACTIONS.

HR-2: RCS and Core Heat Removal via Natural Circulation, No SIS Operation

In the absence of forced reactor coolant flow, adequate core cooling can still be maintained by natural circulation. This RCS flow is induced by a temperature differential between the steam generators and the core. This method also requires that at least one steam generator be available to act as a heat sink. Heat is transferred to the secondary system water supplied by the main or auxiliary feedwater systems.

Operator Actions

* 1. If all RCPs are stopped, natural circulation RCS flow should develop within [5 - 15 minutes]. Natural circulation flow will be ensured by maintaining RCS pressure and inventory control and using at least one steam generator for RCS heat removal.

When single phase liquid natural circulation flow is established in at least one loop, the RCS should indicate the following conditions:

a. Loop ΔT (T_H - T_c) less than normal full power ΔT,
b. Hot and cold leg temperatures constant or decreasing,
c. RCS subcooled based on representative CET temperature,
d. No abnormal differences between T_H RTDs and core exit thermocouples. Hot leg temperature should be consistent with the representative core exit thermocouple temperature. Adequate natural circulation flow will be reflected by the core exit thermocouples temperatures being approximately equal to the hot leg RTD temperatures. An abnormal difference between T_H and the core exit thermocouples could be any difference greater than [10°F].

Natural circulation is regulated by a combination of factors. Factors which affect natural circulation include decay heat, component elevations, primary to secondary heat transfer, loop flow resistance, and voiding. The component elevations on C-E plants are such that a satisfactory natural circulation decay heat removal is obtained utilizing density differences between the bottom of the core and the top of the steam generator tube sheet. Natural circulation flow is enhanced by the density difference obtained when primary to secondary heat removal through the steam generator U-tubes is utilized.

If the natural circulation criteria of this step are not met, then natural circulation is not effectively transferring heat from the core to the steam generators. If sufficient inventory is available in at least one SG, then ensure RCS pressure and inventory are being controlled properly. At least one SG must be available in order to continue the natural circulation heat removal process. Both the RCS and Core Heat Removal Safety Functions may be jeopardized if the criteria of this step continue to be violated.

* 2. Plant conditions should be carefully assessed before any RCPs are restarted. The need for forced circulation operation should be balanced against the risk of damage to the RCP seals.

The need for operation of the RCPs should be evaluated based on:

1. the adequacy of the RCS and core heat removal under the existing natural circulation conditions,
2. the existing RCS pressure and temperatures,
3. the need for main pressurizer spray capability.

HR-2

If the existing natural circulation is providing satisfactory RCS and core heat removal, a transfer to forced circulation operation may not be necessary. This would be particularly true if the RCS had already been cooled and depressurized to SCS entry conditions. If the RCS pressure and temperatures are closer to HOT STANDBY conditions, it may be desirable to restart the RCPs in order to allow a normal forced circulation cooldown. Consideration should also be given to the necessity of having main pressurizer spray capability if auxiliary spray is not providing the desired depressurization rate.

The potential for RCP seal degradation should be evaluated based on:

1. how long CCW to the RCPs was interrupted,
2. RCP seal staging pressures and temperatures.

The possibility of seal degradation increases if the CCW has been interrupted for longer than [10 minutes]. The seal staging pressures provide an indication of degraded seal stages (a low pressure drop across a stage indicates a problem). Restart of an RCP with one or more degraded seal stages should be avoided if possible.

* 3. If all RCPs have been stopped, then operation of two RCPs (in opposite loops) should be attempted if RCP restart criteria are met. This will ensure continued forced circulation of coolant through the core and will provide the capability for the normal mode of pressurizer spray. However, only one RCP in each loop should be operated to minimize heat input to the RCS.

HR-2

Determine whether RCP restart criteria are met by the following:

a. Electrical power available to the RCPs,
b. RCP auxiliaries (In particular component cooling water) to maintain seal injection, bearing, and motor cooling should be operating in order to prevent damage to the pump and/or motor. (Note: [Following automatic or operated initiated containment isolation, reinstatement of one of the following means of RCP seal cooling ([CCW], [CVCS seal injection (SI)], [Dedicated Seal Injection System (DSIS)], should be considered to ensure adequate RCP cooling. There should be no high temperature alarms on the RCPs to be operated.
c. At least one steam generator has feedwater restored and is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow is available for removing heat from the RCS.
d. Pressurizer level is greater than [33%] and not decreasing. With pressurizer level at the high end of the operating band, the possibility of draining the pressurizer due to loop shrinkage and/or steam void condensation is minimized and there is a greater likelihood of keeping the pressurizer heaters covered. This will assist in maintaining positive RCS pressure control. The criterion of pressurizer level not decreasing implies that RCS inventory control has been established.
e. RCS subcooling taken in conjunction with (d) above indicates that inventory and pressure are being controlled.
f. All plant specific RCP operating criteria are satisfied before the RCPs are restarted to protect the RCPs from damage resulting from abnormal operating conditions.
g. Condensate that flows to the core on the cold side is depleted in boron and may collect in the RCP loop seals and cold leg. The RCPs should not be started until after single phase natural circulation has slowly moved this boron depleted coolant through the core. Twenty minutes of single phase natural circulation is considered adequate circulation and mixing time.

HR-2

* 4. Upon restarting two RCPs in opposite loops, pressurizer level and pressure may decrease due to loop shrinkage and/or void condensation. It is possible that this action will drain the pressurizer. Steam voids, if present in the reactor vessel, will condense upon restarting RCPs. The HJTC RVLMS should be monitored for the trending of reactor vessel liquid level. This trending information may be correlated to pressurizer level decrease. RCP operation with a drained pressurizer may continue provided certain actions are taken and certain criteria are satisfied.

The following constitute the actions to be taken and the criteria to be satisfied when restarting RCPs:

a. Start one RCP in each loop.
b. Ensure proper RCP operation by monitoring RCP amperage and pump NPSH. NPSH is determined by pressurizer pressure and corresponding T_c on Figure 11-1.
c. Operate the available charging (and SI pump) until pressurizer level is greater than [14.3%] and (SI termination criteria are met).

* 5. If the SI pumps are operating, then they must continue to operate until SI termination criteria are met. Termination of SI should be sequenced by stopping one pump at a time while observing the termination criteria. Throttling of SI flow is also permissible if termination criteria are met. SI termination criteria are:

a. RCS is subcooled based on representative CET temperature (Refer to Figure 11-1). Establishing subcooling ensures the fluid surrounding the core is subcooled. Voids may exist in some parts of the RCS (e.g., reactor vessel head), but these are permissible as long as core heat removal is maintained.

HR-2

b. Pressurizer level is greater than [14.3%] and not decreasing. A pressurizer level greater than [14.3%] and not decreasing, in conjunction with criterion a) above, is an indication that RCS inventory control has been established.

c. At least one steam generator is available for removing heat from the RCS. A steam generator having the ability for feedwater flow and steam flow is available for removing heat from the RCS.

d. The HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles. This provides an extra margin of core coverage and, taken in conjunction with the above, serves as an additional indication that adequate RCS inventory control has been established.

If the criteria are met, then the operator may either stop or throttle the SI pumps. The operator may decide to throttle rather than terminate flow if the SI pumps are to be used to control pressurizer level or plant pressure. A general assessment of the SI pump performance can be made from the control room. The operator should confirm that at least one train and preferably both SI pumps are operating and that system delivery rate is consistent with RCS pressure as shown in Figure 11-3. Injection flow rates to each injection point should be approximately equal.

* 6. If the criteria of step 5 cannot be maintained after the SI pumps have been stopped, then the SI pumps must be restarted and full SI flow restored.

* 7. If at least one RCP is restarted in a loop with heat removal capability (SG with feed and steam flow capability), then the operator should go to success path HR-1 (Forced Circulation, No SIS Operation). If all RCPs are stopped, then continue with the actions of this success path.

* 8. During a controlled cooldown, the RCS is borated as necessary (success paths RC-2 and RC-3) to maintain adequate shutdown margin per Technical Specification limits.

HR-2

9. RCS inventory is controlled to permit pressurizer level to lower during RCS fluid contraction. This drop in level results in pressurizer bubble decompression which in turn results in RCS depressurization. It is also possible to cool the pressurizer gradually by filling the pressurizer with cooler loop fluid by charging to the loop. The level is then allowed to drop (maintaining [2% to 78%]) due to cooldown contraction and then refilled with cooler loop fluid. Repeated fillings will cool the pressurizer metal and steam bubble resulting in gradual depressurization.

10. An RCS cooldown should be performed to satisfy the acceptance criteria of success paths in use and/or to satisfy SCS entry conditions. This cooldown should be performed by dumping steam to the condenser via the steam bypass system. If the condenser or steam bypass system is not available, steam should be discharged through the atmospheric dump valve(s). The use of atmospheric dump valve(s) may have the potential for an unmonitored release of activity to the environment. If it is suspected that a steam generator(s) has tube leaks, then the cooldown should be performed using the unaffected or least affected generator. Refer to steps 12 through 21.

*11. Throughout the cooldown and depressurization, the operator should ensure that the pressurizer pressure is being maintained within the Post Accident P-T limits of Figure 11-1. If subcooling or cooldown limits of Figure 11-1 are being violated, then the operators should take actions to restore the RCS to within the P-T limits. Depending on the situation, the operator should perform the following actions as appropriate:

   a. Stop the cooldown.
   b. Operate main or auxiliary spray as necessary to restore pressurizer pressure to within the P-T limits of Figure 11-1.

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c. Attempt to maintain the plant in a stable pressure-temperature configuration. The cooldown may be continued, if desired, within the limits of Figure 11-1.

d. If an overpressure situation exists and is caused by charging flow, then throttle or stop the charging pump and manually control letdown to restore and maintain pressure within the Post Accident P-T limits of Figure 11-1.

*12. If indications of steam generator tube leakage exist (e.g., condenser air ejector radiation alarm, blowdown radiation alarm, high activity in a steam generator liquid sample, etc.), then the operator should go to step 13 for further guidance. If no indications of steam generator tube leakage exist, then the operator should go to step 22 for further guidance.

13. The goal of this step is to verify that the RCS hot leg temperature has been decreased to less than [547°F] so that RCS to steam heat generator heat transfer is not sufficient to cause secondary safety valves to lift. If RCS hot leg temperature is not less than [547°F] the operator will manually cooldown the RCS. As discussed in step 10, this action should be performed preferentially by dumping steam to the condenser via manual control of the steam bypass system. If the condenser or steam bypass system is not available, the next order of priority for discharging steam would be to use the atmospheric dump valves. It is less desirable to use the atmospheric dump valves to cooldown the RCS because of the unmonitored release of activity to the environment.

Natural circulation cooldown of the RCS is not effective for cooling the RV head region. If natural circulation cooling provides the reduction of T_H to less than [547°F], heat transfer to the steam generator from the RCS loops will not cause lifting the secondary safety valves. However, the energy stored in the RV head region and pressurizer has to be dealt with to bring RCS pressure close to steam generator pressure to minimize leakage into the steam generator and to preclude steam generator safety valve opening due to filling the steam generator with high RCS pressure.

HR-2

14. The steam generator with the tube leakage should be determined by performing the following steps. These steps include:

    a. Sampling the steam generators for activity,
    b. Monitoring the main steam piping for activity,
    c. Monitoring steam generator levels,
    d. Monitor the main steam plant for activity.

15. The steam generator with higher activity, higher radiation levels, or increasing water level should be isolated. Reducing RCS temperature to below the saturation temperature associated with the lowest pressure setpoint of the steam generator safety valves is one of the actions necessary to prevent opening a direct path to the environment for radionuclides after steam generator isolation. Steam generator isolation is an attempt to re-establish the containment isolation safety function. If both steam generators have tube ruptures, then the operators must determine which generator is most affected and isolate that generator.

    The most affected steam generator is isolated as follows:

    a. The main steam isolation valve is closed.
    b. The main steam isolation valve bypass valve is verified closed, or closed.
    c. The atmospheric steam dump valve is verified closed or closed.
    d. The main feedwater isolation valve is closed.
    e. The emergency feedwater isolation valves are closed, including the steam driven pump steam supply valve associated with the steam generator being isolated.
    f. Steam generator blowdown is isolated.
    g. Vents, drains, exhausts, and bleedoffs from the steam system are isolated. The crosstie to the auxiliary steam header is isolated. This completes the isolation of the radionuclides still in the secondary system to prevent further releases to the environment.

HR-2

16. Once the steam generator has been isolated, isolation of the correct (most affected) steam generator should be verified by checking radiation indications, sampling for activity, and noting any possible increase in the isolated steam generator level. This provides feedback that the correct steam generator has been isolated. If the wrong steam generator has been isolated then it should be unisolated and the most affected steam generator should be isolated per step 9.

*17. To prevent the MSSV opening, which would create a release path from the RCS to the environment, the isolated steam generator pressure must be maintained below the MSSV setpoint. To maintain SG pressure below the MSSV setpoint, manual operation of the ADV is used. Should the pressure in an isolated steam generator approach the lift setpoint for the associated MSSVs, it is desirable from the perspective of positive operator control that the ADV open first. This is accomplished by manually opening the ADV at [1150 psia] increasing, or locally opening the ADV at [1150 psia]. The value of [1150 psia] was chosen based on the MSSV setpoint of [1200 psia] minus an operating margin of [50 psi]. The intent of the step is explicitly stated in the step so that the operator understands the goals of the step and to minimize the use of the atmospheric steam dump valves on the affected steam generator which would create an unmonitored release of radioactivity.

18. The general goals associated with RCS pressure control are: providing subcooling to support the core heat removal process, avoiding overpressure situations for PTS and RT_{NDT} considerations, minimizing the pressure differential between the steam generator and the RCS to minimize the leakage, and controlling RCS pressure so that it is below the steam generator safety valve setpoints. This step addresses steam generator to RCS pressure differential and RCS depressurization to below the SG safety valve setpoint.

HR-2

Maintaining the RCS pressure approximately equal to but above the isolated steam generator pressure (-0, +50 psi) and below the steam generator safety valve setpoint, [1200 psia], will minimize the loss of primary fluid to the secondary side and the possibility of overfilling the isolated SG. This is accomplished by either using main spray (the preferred method), auxiliary spray, operation of Reactor Coolant Gas Vent System (RCGVS) on the pressurizer, operation of charging and letdown, or throttling of the SI pumps. This action will minimize the potential for release of radiation to the environment by minimizing RCS to steam generator leakage.

Maintaining RCS pressure approximately equal to SG pressure (-0, +50 psi) prevents backflow from the secondary system to the primary system while minimizing primary to secondary leakage.

A key point in the strategy for the SGTR event involves maintaining or restoring forced circulation. However, maintaining subcooling and adequate NPSH for RCP operation may cause the operator to hold RCS pressure above secondary pressure by the amount needed to provide adequate subcooling. This requirement takes precedence over the procedural strategy of bringing primary pressure to the point where it will be approximately equal to secondary pressure.

During the forced circulation cooldown process the lower region of the isolated steam generator may cool faster than the upper region. The cooling of the isolated SG steam space will significantly lag in the cooldown and cause the fluid in the lower regions to be subcooled. If the tube rupture is located in this subcooled region, then the primary fluid can be at the same pressure as the secondary fluid and still be subcooled. However the continued depressurization of the primary during the cooldown will now be limited by the ability to depressurize the isolated SG.

HR-2

During natural circulation cooldown conditions the isolated steam generator will take considerably longer to cool unless there is a transfer of mass in the isolated SG. This complicates RCS pressure control during the cooldown. It is desirable to cool the RCS such that the tube bundle region of the affected SG remains subcooled. Voiding in the tube bundle region can be expected and may result in the region becoming a pressurizing source for the RCS. Maintaining the presence of subcooled liquid in the affected loop will be a complicated process under natural circulation conditions. Forced circulation conditions are much more desirable and if possible should be maintained or restored. During natural circulation conditions the cooldown and depressurization of the RCS will be limited to the operator's ability to control the conditions of the isolated steam generator.

Maintaining RCS pressure within the acceptable limits of Figure 11-1 helps to ensure the core is covered by subcooled fluid and minimizes the concern for pressurized thermal shock by keeping plant pressure below the [200°F] subcooling limit. This is accomplished by controlling RCS heat removal via the unisolated steam generator, and controlling RCS pressure as discussed in Step 11.

*19. The potential exists for filling of the isolated steam generator steam space and the main steam piping up to the MSIV. This action could result in the inadvertent opening of the MSSVs and an undesirable spread of contamination and the potential for main steam piping support snubber damage.

Draining to the radioactive liquid waste system or blowdown to the condenser will reduce level and minimize the spread of contamination and the possibility of piping support snubber damage although the piping up to the MSIVs is designed for static liquid water. If the generator draining is not feasible or is insufficient, then steaming the generator to the condenser will reduce level and minimize radioactivity release. Water hammer damage should be avoided by not reopening the affected MSIV while a significant amount of water is in the main

HR-2

steam piping. Draining to the radioactive waste system or blowing down to the condenser or reducing RCS pressure below the isolated steam generator pressure can lower steam generator level. The off-site dose coordinator should assess the radioactive releases to the environment. The value of [95%] was chosen to prevent overfilling the steam generator by ensuring the level remains in the indicated range. The value of [40%] was chosen to ensure all tubes remain covered, which minimizes the potential of radioactive fission products reaching the steam generator steam space.

*20. The condensate and all other connecting systems, including the turbine building sumps, should be sampled for activity that may have been transferred from the affected steam generator(s). These samples aid in determining the extent of contamination throughout the plant systems.

*21. The turbine, subsphere and annex building ventilation systems' radiation monitors, and any other applicable radiation monitors, should be continually observed. Corrective actions, if necessary, should be taken in accordance with plant Technical Specification Limitations.

22. If indications of excessive steam demand exist (e.g., excessive cooldown rate, excessive SG depressurization, etc.), then the operator should go to step 23 for further guidance. If no indications of excessive steam demand exist, then the operator should go to step 28 for further guidance.

HR-2

23. The most affected steam generator should be determined by comparison of steam pressures, cold leg temperature differences, and steam generator levels. If the excessive steam demand is not isolable (e.g., a break inside containment will still be producing steam flow after the MSIVs are shut, the steam generator with the reduced loop T_c, lower steam pressure, and lower steam generator level is the affected steam generator. These differences between affected and unaffected steam generators will be more pronounced after MSIS actuation. If the excessive steam demand is downstream of the MSIVs and the MSIS occurs, both steam generators' pressures and loop temperatures should approach approximately the same values and then start to increase following MSIV closure.

24. If the shutting of the MSIVs (MSIS) stops the excessive steam demand, then neither SG is the affected SG. The operator should go to step 28 and skip the guidance for isolating the most affected SG. If the MSIS does not stop the excessive steam demand, then continue with step 25.

25. The most affected steam generator should be isolated to stop the uncontrolled plant cooldown and to stabilize the plant. If both steam generators are found to be affected, then isolate the most affected steam generator, if it can be determined, and attempt to maintain RCS heat removal capability via one steam generator. This action is designed to mitigate the uncontrolled cooldown and ready the plant for event recovery.

    The most affected steam generator is isolated as follows:

    a. The main steam isolation valve is closed.
    b. The main steam isolation valve bypass valve is verified closed, or closed.
    c. The atmospheric steam dump valve(s) is verified closed, or closed.
    d. The main feedwater isolation valve is closed.
    e. The emergency feedwater isolation valve is closed.
    f. Vents, drains, exhaust, and bleedoffs are closed,

HR-2

26. Once the steam generator has been isolated, isolation of the correct (affected) steam generator should be verified by checking steam generator pressures, RCS cold leg temperatures, and steam generator levels. This provides feedback that the correct steam generator has been isolated. If the wrong steam generator has been isolated then it should be unisolated and the affected steam generator should be isolated per step 25.

27. When the isolated steam generator dries out, RCS temperatures will begin to increase unless a means of controlled steaming can be established. If a method of heat removal is not established, the RCS heatup will, when taken in conjunction with the inventory added to the RCS from SIS and charging pump operation, cause the plant to go solid and have the potential of being a PTS condition. A controlled heat removal method should be established before this dry out condition occurs. The preferred method of heat removal is via the steam bypass system (if the SBS and condenser are available) with the atmospheric dump valves as a backup method of heat removal. If the break is downstream of the MSIVs, then the atmospheric dump valve(s) should be used for RCS heat removal.

*28. The available condensate inventory should be monitored and replenished from available sources as necessary to continually provide a source for a secondary heat sink. Examples of alternate sources of condensate are non-seismic tanks, fire mains, lake water supplies, portable tanks, etc. Plant specific alternate sources of feedwater should be identified and cited in the procedure. The amount of condensate required to either maintain the plant at HOT STANDBY conditions or to cooldown may be determined from Figures 11-4 and 11-5.

*29. Both SG levels should be maintained in the normal band using main, startup or emergency feedwater. If one SG was isolated (due to SG tube leakage or excessive steam demand), then the unisolated SG level should be maintained in the normal band to ensure continued SG heat removal capability.

HR-2

If all sources of feedwater are lost, the operator should perform the following actions:

a. A loss of all feedwater results in a reduction of the ability of the steam generators to remove heat from the RCS. Heat into the RCS is minimized by tripping all four RCPs. Natural circulation heat removal is adequate to remove the decay heat generated in the core.

b. The steam generator blowdown system, secondary sampling system, and any other non-vital secondary steam discharges should be isolated. Until feedwater is re-established, the steam generator water inventories must be conserved.

c. The operator should attempt to restore main, startup and/or emergency feedwater system operation. These efforts may include restoring electrical power, operating valves, starting pumps, or restoring necessary auxiliary systems for feedwater system operation.

d. If main, startup or auxiliary feedwater cannot be restored to at least one steam generator, then all plant-specific sources of feedwater which could be made available to replace steam generator boil-off should be implemented. Examples of alternate low-pressure sources of feedwater are fire pumps, condensate pumps, etc. When developing plant procedures, alternate low-pressure sources of feedwater should be identified and their use should be indicated in the procedures. Guidelines on steam generator depressurization should be developed for those cases when the operator is relying on low pressure sources of feedwater as a backup feedwater supply. The required heat removal, compared to the available heat removal capacity (e.g., atmospheric dump valves), provides the technical basis for which guidance may be developed on steam generator depressurization to permit use of alternate low-pressure sources of feedwater.

HR-2

*30. As long as at least one steam generator has an indication of wide range level greater than 0%, then adequate RCS heat removal is implicitly being maintained. An additional criterion requires the operator to monitor RCS T_c to ensure temperatures are stable or decreasing. This criterion assumes that no operator or plant initiated actions have caused a momentary, correctable reduction in RCS heat removal (e.g., ADV is closed).

If both SG levels are less than or equal to 0% WR then the operator is instructed to go to RCS and Core Heat Removal success path HR-4 to initiate once-through-cooling.

*31. If main, startup or emergency feedwater is restored, steam generator water level should be restored to the normal band.

*32. If the RCS cannot be depressurized, then a void should be suspected. Any time it is found that voiding inhibits RCS depressurization when depressurization is desired, then an attempt at elimination of the voiding should be made.

The operator should monitor for the presence of voids. Voiding in the RCS may be indicated by any of the following indications, parameter changes, or trends:

a. letdown flow greater than charging flow,
b. pressurizer level increasing significantly greater than expected while operating pressurizer spray,
c. the HJTC RVLMS indicates that voiding is present in the reactor vessel,
d. HJTC unheated thermocouple temperature indicates saturated conditions in the reactor vessel upper head,

If voiding should be eliminated, then proceed as follows:

a. Letdown is isolated or verified to be isolated to minimize further inventory loss,
b. The depressurization is stopped to prevent further growth of the void,
c. Pressurizing and depressurizing the RCS within the limits of Figure 11-1 may condense the void. Pressurizing has the effect of filling the voided portion of the RCS with cooler fluid which will remove heat from the region. Subsequent depressurization and a repeating of this process several times will cool and condense the steam void. In this case of a void in the reactor vessel, the pressurization/depressurization cycle will preclude a fill and drain of the reactor vessel. The pressurization/depressurization cycle may be accomplished using pressurizer heaters and spray (preferred method) or the SIS/charging system (alternative method). Monitor pressurizer level and the HJTC RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.
d. If indications of unacceptable RCS voiding continue, and voiding is suspected to exist in the (isolated) steam generator tubes, then cool the (isolated) steam generator (by steaming or blowdown, and/or feeding) to condense the tube bundle void. This will be effective for condensing steam voids but will not have an effect on non-condensible gases trapped in the tube bundle. A buildup of non-condensible gases in the tube bundles will not hinder natural circulation even with a large number of the tube blocked. This is due to the small amount of heat transfer area required for the removal of decay heat. Monitor pressurizer level for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.
e. If indications of unacceptable RCS voiding continue, then voiding may be caused by non-condensible gases. Operate the Reactor Coolant Gas Vent System to clear trapped non-condensible gases. Monitor pressurizer level and/or the HJTC RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

HR-2

HR-2: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, RCS and Core Heat Removal is satisfied if:

   a. At least one SG (or the unisolated SG) has level:
      i) within the normal level band with feedwater available to maintain level

      or

      ii) being restored by main, startup or emergency feedwater with level increasing.

      and

   b. $T_H - T_c$ <[59°F] and not increasing

      and

   c. T_{ave} <[562°F] and not increasing

      and

   d. RCS subcooled by representative CET temperature

      and

   e. No abnormal difference [>10°F] between T_H RTDs and CETs.

   Best estimate analysis reveals that loop differential temperature for natural circulation will be less than [59°F] ($T_H - T_c$) in the operating loop for the full range of decay heat. Proper loop ΔT accompanied by average operating loop temperature below the saturation temperature corresponding to the lowest SG safety setpoint ([567°F]) and indications that at least one SG is removing heat are adequate confirmation of RCS and Core Heat Removal. Subcooling assures a subcooled heat transfer medium for the core.

2. If the above criteria are not satisfied, then success path HR-2 is not successfully controlling RCS and Core Heat Removal. The operator should go to the next appropriate success path for RCS and Core Heat Removal.

3. If the acceptance criteria for success path HR-2 are satisfied, then success path HR-2 is successfully controlling RCS and Core Heat Removal. RCS and Core Heat Removal is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement LONG TERM ACTIONS.

HR-2

HR-3: RCS and Core Heat Removal via SG Heat Sink with SIS Operating

In some instances, RCS and Core Heat Removal may be satisfied by a combination of steam generator heat removal and heat removal by venting energy out of an RCS opening such as a break or a stuck open RCGVS or RDS valve.

* 1. If pressurizer pressure decreases to or below the SIAS setpoint, or if containment pressure increases to or above [2.7 psig], then initiation of an SIAS must be verified. If necessary, an SIAS is manually initiated. This action restores inventory so that pressure can be controlled by use of either pressurizer heaters and spray or by using the discharge head of the SIS pumps.

* 2. A generic RCP trip strategy has been developed which results in the tripping of all four RCPs for depressurization events where RCS is not subcooled, but allows the continued operation of two RCPs (in opposite loops) for depressurization events where RCS is subcooled. For undiagnosed events, where the Functional Recovery Guideline is implemented, the RCP trip strategy is identical to that followed in the LOCA guideline. This step and step 3 detail the two significant operational aspects regarding the RCP trip strategy for a functional procedure.

The first operational strategy results in the operator tripping two RCPs (in opposite loops) if pressurizer pressure decreases to less than [1400 psia] following a SIAS and RCS is subcooled. This action may occur in the Standard Post Trip Actions and, in this case, the operator would simply verify that two RCPs (in opposite loops) have been tripped. The operator trips all four RCPs if pressurizer pressure decreases to less than [1400 psia] following a SIAS and RCS is not subcooled. If the operator cannot confirm that a LOCA has occurred, and the Functional Recovery Guideline is implemented, the RCP trip strategy is identical to that followed in the LOCA guideline. If the depressurization event can be diagnosed and is determined to be other than a LOCA (i.e., ESDE or SGTR), then only two RCPs (in opposite loops) are tripped. The other two RCPs remain operational until one or more of the RCP operating requirements (e.g., NPSH, temperatures, seal flow, oil pressures, motor amperage, vibration) are no longer satisfied, then, any pump which does not satisfy these requirements should be tripped. This gives the operator maximum flexibility in plant control because a normal plant cooldown can be performed while still ensuring a conservative approach to event recovery.

* 3. The second aspect of the RCP operating strategy concerns the verification that RCP operating limits are satisfied. The RCPs will be operating in a pressure-reduced RCS and may not satisfy NPSH requirements. The operator must continuously monitor RCP operating limits (e.g., temperatures, seal flow, oil pressures, NPSH, motor amperage, vibration) and trip any RCPs which do not satisfy RCP operating limits. Plant specific RCP operating limits should appear in this step, either directly or, by referencing the applicable operating instructions.

* 4. If an SIAS is actuated, then the available charging pump and SI pumps should be operating and injecting water into the RCS. The SIS flowrate will vary according to pressurizer pressure. SIS and charging pump flowrates should be checked and maximized (Figure 11-3 provides information which can be utilized to verify adequate SIS flow is occurring) for RCS inventory replenishment and/or core heat removal. Charging pump may have to be manually restarted if an interruption of power to the charging pump bus has occurred. The following guidance will assist in ensuring maximum injection of water into the RCS:

   a. idle SI pumps should be started and system flow should be verified to be within the limits of Figure 11-3,
   b. the available charging pump should be verified running.

   If any SI pump that should be operating won't start, any charging pump will not start, or SIS flow is not in accordance with Figure 11-3, then the following guidance is provided:

HR-3

a. the operator should verify that electrical power is available to valves and pumps necessary for inventory control

b. the SIS valve lineup should be verified to be correct in the control room

c. auxiliary systems necessary for SIS or charging operation should be checked

It must be noted, however, that the maximization of charging and safety injection can result in excess RCS inventory, possible filling of the pressurizer to a solid condition, and a PTS concern upon RCS heat up, fluid expansion, and subsequent RCS pressure excursion. Operators must be aware of these concerns and terminate the SIS operation when the termination criteria are met.

* 5. If high RCS pressure is causing SIS flow or the trending of SIS flow to threaten adequate core cooling, then operators must take action to ensure that adequate core cooling is maintained. Step 9 of this success path and the FRG success path for Pressure Control that is in use should be referred to for guidance to perform a cooldown/depressurization. Examples of situations which could necessitate this action include: an SIAS is actuated but SI pumps are unavailable or SI pumps are operating but RCS pressure is above the shutoff head of the SI pumps. For situations such as these, depressurizing/cooling the RCS must be performed if SIS flow is required, to increase or establish SI flow.

* 6. If all RCPs are tripped, natural circulation RCS flow should develop within [5 - 15 minutes]. Natural circulation flow will be ensured by maintaining RCS pressure and inventory control and using at least one steam generator for RCS heat removal.

When single phase liquid natural circulation flow is established in at least one loop, the RCS should indicate the following conditions:

HR-3

a. Loop ΔT (T_H - T_c) less than normal full power ΔT,

b. Hot and cold leg temperatures constant or decreasing,

c. RCS subcooled based on representative CET temperature

d. No abnormal differences between T_H RTDs and core exit thermocouples. Hot leg RTD temperature should be consistent with the representative core exit thermocouple temperature. Adequate natural circulation flow will be reflected by the core exit thermocouples temperatures being approximately equal to the hot leg RTD temperatures. An abnormal difference between T_H and the core exit thermocouples could be any difference greater than [10°F].

Natural circulation is regulated by a combination of factors. Factors which affect natural circulation include decay heat, component elevations, primary to secondary heat transfer, loop flow resistance, and voiding. The component elevations on C-E plants are such that a satisfactory natural circulation decay heat removal is obtained utilizing density differences between the bottom of the core and the top of the steam generator tube sheet. Natural circulation flow is enhanced by the density difference obtained when primary to secondary heat removal through the steam generator U-tubes is utilized.

If the criteria listed above are not satisfied, then single phase natural circulation in the RCS is not effectively transferring heat from the core to the steam generators. Both RCS Heat Removal and Core Heat Removal Safety Functions may become jeopardized if the natural circulation flow criteria continue to be violated. Operators should ensure that RCS pressure and inventory, and SG steaming and feeding, are being controlled properly in order to prevent violation of this safety function.

HR-3

* 7. When a break in the RCS pressure boundary has occurred, the natural circulation process can take different forms. These forms include single phase natural circulation and a more complex two phase natural circulation. The simplest form of natural circulation is a single phase liquid cooling. Single phase natural circulation is possible for most cases where RCS inventory and pressure are being controlled properly. Single phase cooling transports heat using the same flow path involved in forced circulation cooling with the liquid density difference between SG and RV driving the flow. Two phase natural circulation is more complex and can take several forms. Two phase natural circulation depends on the amount of decay heat, the amount of inventory and pressure control degradation, the RCS leak rate, and the status of the SIS and the steam generators. One form of two phase natural circulation is known as reflux. In the reflux process, steam leaves the core region and travels to the steam generator before reaching the top of the "U" tubes where it condenses and the condensate flows back to the core via the hot leg where it is once again turned to steam. Another two phase natural circulation process is similar to reflux, but differs in that the steam from the core goes past the steam generator "U" bend and is condensed in the tubes on the cold leg side and the condensate flows back to the core via the cold leg. A combination of the two processes is also possible.

The operators have adequate instrumentation to monitor natural circulation for the single phase liquid natural circulation process. The RCS temperature instrumentation, namely loop ΔT, can be used along with other information to confirm that the single phase natural circulation process is effective. The natural circulation processes involving two phase cooling are complex and varied enough so that RCS loop ΔT may not be a meaningful indication of adequate natural circulation cooling.

HR-3

For cases where two phase natural circulation cooling is the core heat removal process, establishing heat removal via at least one steam generator utilizing main, startup or emergency feedwater and steam discharge through the atmospheric dump valve becomes more critical. The monitoring of representative CET temperatures to confirm the adequacy of the heat removal process, also becomes a critical indicator of natural circulation cooling.

If RCS subcooling cannot be maintained, then the core heat removal process can be maintained utilizing two-phase natural circulation and flow through the break. If two phase natural circulation is utilized the operators must ensure that the following are observed:

a. The available charging pump is operating and adequate SIS flow per Figure 11-3,

and

b. steam generator feeding and steaming are properly controlled

and

c. the representative CET temperature is maintained less than superheated. A superheated condition indicates that core uncovery has occurred and that the core heat removal process is no longer effective.

* 8. During a controlled cooldown, the RCS is borated as necessary (success paths RC-2 and RC-3) to maintain adequate shutdown margin per Technical Specification limits.

9. RCS inventory is controlled to permit pressurizer level to lower during RCS fluid contraction. This drop in level results in pressurizer bubble decompression which in turn results in RCS depressurization. It is also possible to cool the pressurizer gradually by filling the pressurizer with cooler loop fluid by charging to the loop. The level is then allowed to drop (maintaining [2% to 78%) due to cooldown contraction and then refilled with cooler loop fluid. Repeated fillings will cool the pressurizer metal and steam bubble resulting in gradual depressurization. HR-3

10. An RCS cooldown should be performed to satisfy the acceptance criteria of success paths in use and/or to satisfy SCS entry conditions. This cooldown should be performed by dumping steam to the condenser via the steam bypass system. If the condenser or steam bypass system is not available, steam should be discharged through the atmospheric dump valve(s). The use of atmospheric dump valve(s) may have the potential for an unmonitored release of activity to the environment. If it is suspected that a steam generator(s) has tube leaks, then the cooldown should be performed using the unaffected or least affected generator. Refer to steps 18 through 25.

*11. Throughout the cooldown and depressurization, the operator should ensure that pressurizer pressure is being maintained within the Post Accident P-T limits of Figure 11-1. If subcooling or cooldown limits of Figure 11-1 are being violated, then the operators should take actions to restore the RCS to within the P-T limits. Depending on the situation, the operator should perform the following actions as appropriate:

a. Stop the cooldown.
b. Operate main or auxiliary spray as necessary to restore pressurizer pressure to within the P-T limits of Figure 11-1.
c. Attempt to maintain the plant in a stable pressure-temperature configuration. The cooldown may be continued, if desired, within the limits of Figure 11-1.
d. If an overpressure situation exists and is caused by SI or charging flow, then throttle or stop (refer to step 32) pumps and manually control letdown to restore and maintain pressure within the Post Accident P-T limits of Figure 11-1.

HR-3

*12. If indications of steam generator tube leakage exist (e.g., condenser air ejector radiation alarm, blowdown radiation alarm, high activity in a steam generator liquid sample, etc.), then the operator should go to step 13 for further guidance. If no indications of steam generator tube leakage exist, then the operator should go to step 22 for further guidance.

13. The goal of this step is to verify that the RCS hot leg temperature has been decreased to less than [547°F] so that RCS to steam generator heat transfer is not sufficient to cause secondary safety valves to lift. If RCS hot leg temperature is not less than [547°F] the operator will manually cooldown the RCS. This action should be performed preferentially by dumping steam to the condenser via manual control of the steam bypass system. If the condenser or steam bypass system is not available, the next order of priority for discharging steam would be to use the atmospheric dump valves. It is less desirable to use the atmospheric dump valves to cooldown the RCS because of the unmonitored release of activity to the environment.

Natural circulation cooldown of the RCS is not effective for cooling the RV head region. If natural circulation cooling provides the reduction of T_H to less than [547°F], heat transfer to the steam generator from the RCS loops will not cause lifting the secondary safety valves. However, the energy stored in the RV head region and pressurizer has to be dealt with to bring RCS pressure close to steam generator pressure to minimize leakage into the steam generator and to preclude steam generator safety valve opening due to filling the steam generator with high RCS pressure.

14. The steam generator with the tube leakage should be determined by performing the following steps. These steps include:

a. Sampling the steam generators for activity,
b. Monitoring the main steam piping for activity,
c. Monitoring steam generator levels,
d. Monitoring the main steam plant for activity.

HR-3

15. The steam generator with higher activity, higher radiation levels, or increasing water level should be isolated. Reducing RCS temperature to below the saturation temperature associated with the lowest pressure setpoint of the steam generator safety valves is one of the actions necessary to prevent opening a direct path to the environment for radionuclides after steam generator isolation. Steam generator isolation is an attempt to re-establish the containment isolation safety function. If both steam generators have tube ruptures, then the operators must determine which generator is most affected and isolate that generator.

The most affected steam generator is isolated as follows:

a. The main steam isolation valve is closed.
b. The main steam isolation valve bypass valve is verified closed, or closed.
c. The atmospheric steam dump valve is verified closed or closed.
d. The main feedwater isolation valve is closed.
e. The emergency feedwater isolation valves are closed, including the steam driven pump steam supply valve associated with the steam generator being isolated.
f. Steam generator blowdown is isolated.
g. Vents, drains, exhausts, and bleedoffs from the steam system are isolated. The crosstie to the auxiliary steam header is isolated. This completes the isolation of the radionuclides still in the secondary system to prevent further releases to the environment.

16. Once the steam generator has been isolated, isolation of the correct (most affected) steam generator should be verified by checking radiation indications, sampling for activity, and noting any possible increase in the isolated steam generator level. This provides feedback that the correct steam generator has been isolated. If the wrong steam generator has been isolated then it should be unisolated and the most affected steam generator should be isolated per step 9.

HR-3

*17. To prevent the MSSV opening, which would create a release path from the RCS to the environment, the isolated steam generator pressure must be maintained below the MSSV setpoint. To maintain SG pressure below the MSSV setpoint, manual operation of the ADV is used. Should the pressure in an isolated steam generator approach the lift setpoint for the associated MSSVs, it is desirable from the perspective of positive operator control that the ADV open first. This is accomplished by manually opening the ADV at [1150 psia] increasing, or locally opening the ADV at [1150 psia]. The value of [1150 psia] was chosen based on the MSSV setpoint of [1200 psia] minus an operating margin of [50 psi]. The intent of the step is explicitly stated in the step so that the operator understands the goals of the step and to minimize the use of the atmospheric steam dump valves on the affected steam generator which would create an unmonitored release of radioactivity.

18. The general goals associated with RCS pressure control are: providing subcooling to support the core heat removal process, avoiding overpressure situations for PTS and RT_{NDT} considerations, minimizing the pressure differential between the steam generator and the RCS to minimize the leakage, and controlling RCS pressure so that it is below the steam generator safety valve setpoints. This step addresses steam generator to RCS pressure differential and RCS depressurization to below the SG safety valve setpoint.

Maintaining the RCS pressure approximately equal to but above the isolated steam generator pressure (-0, +50 psi) and below the steam generator safety valve setpoint, [1200 psia], will minimize the loss of primary fluid to the secondary side and the possibility of overfilling the isolated SG. This is accomplished by either using main spray (the preferred method), auxiliary spray, operation of reactor coolant gas vent system (RCGVS) on the pressurizer, operation of charging and letdown, or throttling of the SI pumps. This action will minimize the potential for release of radiation to the environment by minimizing RCS to steam generator leakage.

HR-3

Maintaining RCS pressure approximately equal to SG pressure (-0, +50 psi) prevents backflow from the secondary system to the primary system while minimizing primary to secondary leakage.

A key point in the strategy for the SGTR event involves maintaining or restoring forced circulation. However, maintaining subcooling and adequate NPSH for RCP operation may cause the operator to hold RCS pressure above secondary pressure by the amount needed to provide adequate subcooling. This requirement takes precedence over the procedural strategy of bringing primary pressure to the point where it will be approximately equal to secondary pressure.

During the forced circulation cooldown process the lower region of the isolated steam generator may cool faster than the upper region (see Figure 6-15). The cooling of the isolated SG steam space will significantly lag in the cooldown and cause the fluid in the lower regions to be subcooled. If the tube rupture is located in this subcooled region, then the primary fluid can be at the same pressure as the secondary fluid and still be subcooled. However the continued depressurization of the primary during the cooldown will now be limited by the ability to depressurize the isolated SG (Step 27 provides guidance on isolated SG depressurization).

During natural circulation cooldown conditions the isolated steam generator will take considerably longer to cool unless there is a transfer of mass in the isolated SG. This complicates RCS pressure control during the cooldown. It is desirable to cool the RCS such that the tube bundle region of the affected SG remains subcooled. Voiding in the tube bundle region can be expected and may result in the region becoming a pressurizing source for the RCS. Maintaining the presence of subcooled liquid in the affected loop will be a complicated process under natural circulation conditions. Forced circulation conditions are much more desirable and if possible should be maintained or restored. During natural circulation conditions the cooldown and depressurization of the RCS will be limited to the operator's ability to control the conditions of the isolated steam generator. HR-3

Maintaining RCS pressure within the acceptable limits of Figure 11-1 helps to ensure the core is covered by subcooled fluid and minimizes the concern for pressurized thermal shock by keeping plant pressure below the [200°F] subcooling limit. This is accomplished by controlling RCS heat removal via the unisolated steam generator, and controlling RCS pressure as discussed in Step 11.

*19. The potential exists for filling of the isolated steam generator steam space and the main steam piping up to the MSIV. This action could result in the inadvertent opening of the MSSVs and an undesirable spread of contamination and the potential for main steam piping support snubber damage.

Draining to the radioactive liquid waste system or blowdown to the condenser will reduce level and minimize the spread of contamination and the possibility of piping support snubber damage although the piping up to the MSIVs is designed for static liquid water. If the generator draining is not feasible or is insufficient, then steaming the generator to the condenser will reduce level and minimize radioactivity release. Water hammer damage should be avoided by not reopening the affected MSIV while a significant amount of water is in the main steam piping. Draining to the radioactive waste system or blowing down to the condenser or reducing RCS pressure below the isolated steam generator pressure can lower steam generator level. The off-site dose coordinator should assess the radioactive releases to the environment. The value of [95%] was chosen to prevent overfilling the steam generator by ensuring the level remains in the indicated range. The value of [40%] was chosen to ensure all tubes remain covered, which minimizes the potential of radioactive fission products reaching the steam generator steam space.

*20. The condensate and all other connecting systems, including the turbine building sumps, should be sampled for activity that may have been transferred from the affected steam generator(s). These samples aid in determining the extent of contamination throughout the plant systems.

HR-3

*21. The turbine subsphere and annex building ventilation systems' radiation monitors, and any other applicable radiation monitors, should be continually observed. Corrective actions, if necessary, should be taken in accordance with plant Technical Specification Limitations.

*22. If indications of excessive steam demand exist (e.g., excessive cooldown rate, excessive SG depressurization, etc.), then the operator should go to step 23 for further guidance. If no indications of excessive steam demand exist, then the operator should go to step 28 for further guidance.

23. The most affected steam generator should be determined by comparison of steam pressures, cold leg temperature differences, and steam generator levels. If the excessive steam demand is not isolable (e.g., a break inside containment will still be producing steam flow after the MSIVs are shut, the steam generator with the reduced loop T_c, lower steam pressure, and lower steam generator level is the affected steam generator. These differences between affected and unaffected steam generators will be more pronounced after MSIS actuation. If the excessive steam demand is downstream of the MSIVs and the MSIS occurs, both steam generators' pressures and loop temperatures should approach approximately the same values and then start to increase following MSIV closure.

24. If the shutting of the MSIVs (MSIS) stops the excessive steam demand, then neither SG is the affected SG. The operator should go to step 28 and skip the guidance for isolating the most affected SG. If the MSIS does not stop the excessive steam demand, then continue with the guidance of step 25.

25. The most affected steam generator should be isolated to stop the uncontrolled plant cooldown and to stabilize the plant. If both steam generators are found to be affected, then isolate the most affected steam generator, if it can be determined, and attempt to maintain RCS heat removal capability via one steam generator. This action is designed to mitigate the uncontrolled cooldown and ready the plant for event recovery.

HR-3

The most affected steam generator is isolated as follows:

a. The main steam isolation valve is closed.
b. The main steam isolation valve bypass valve is verified closed, or closed.
c. The atmospheric steam dump valve(s) is verified closed, or closed.
d. The main feedwater isolation valve is closed.
e. The emergency feedwater isolation valve is closed.
f. Vents, drains, exhaust, and bleedoffs are closed,

26. Once the steam generator has been isolated, isolation of the correct (affected) steam generator should be verified by checking steam generator pressures, RCS cold leg temperatures, and steam generator levels. This provides feedback that the correct steam generator has been isolated. If the wrong steam generator has been isolated then it should be unisolated and the affected steam generator should be isolated per step 25.

27. When the isolated steam generator dries out, RCS temperatures will begin to increase unless a means of controlled steaming can be established. If a method of heat removal is not established, the RCS heatup will, when taken in conjunction with the inventory added to the RCS from SIS and charging pump operation, cause the plant to go solid and have the potential of being a PTS condition. A controlled heat removal method should be established before this dry out condition occurs. The preferred method of heat removal is via the steam bypass system (if the SBS and condenser are available) with the atmospheric dump valves as a backup method of heat removal. If the break is downstream of the MSIVs, then the atmospheric dump valve(s) should be used for RCS heat removal.

HR-3

*28. The available condensate inventory should be monitored and replenished from available sources as necessary to continually provide a source for a secondary heat sink. Examples of alternate sources of condensate are non-seismic tanks, fire mains, lake water supplies, portable tanks, etc. Plant specific alternate sources of feedwater should be identified and cited in the procedure. The amount of condensate required to either maintain the plant at hot standby conditions or to cooldown may be determined from Figures 11-4 and 11-5.

*29. Both SG levels should be maintained in the normal band using main, startup or emergency feedwater. If one SG was isolated (due to SG tube leakage or excessive steam demand), then the unisolated SG level should be maintained in the normal band to ensure continued SG heat removal capability.

If all sources of feedwater are lost, the operator should perform the following actions:

a. A loss of all feedwater results in a reduction of the ability of the steam generators to remove heat from the RCS. Heat input to the RCS is minimized by tripping all four RCPs. Natural circulation heat removal is adequate to remove the decay heat generated in the core.

b. The steam generator blowdown system, secondary sampling system, and any other non-vital secondary steam discharges should be isolated. Until feedwater is re-established, the steam generator water inventories must be conserved.

c. The operator should attempt to restore main, startup and/or emergency feedwater system operation. These efforts may include restoring electrical power, operating valves, starting pumps, or restoring necessary auxiliary systems for feedwater system operation.

HR-3

d. If main, startup or emergency feedwater cannot be restored to at least one steam generator, then all plant-specific sources of feedwater which could be made available to replace steam generator boil-off should be implemented. Examples of alternate low-pressure sources of feedwater are fire pumps, condensate pumps, etc. When developing plant procedures, alternate low-pressure sources of feedwater should be identified and their use should be indicated in the procedures. Guidelines on steam generator depressurization should be developed for those cases when the operator is relying on low pressure sources of feedwater as a backup feedwater supply. The required heat removal, compared to the available heat removal capacity (e.g., atmospheric dump valves), provides the technical basis for which guidance may be developed on steam generator depressurization to permit use of alternate low-pressure sources of feedwater].

*30. As long as at least one steam generator has an indication of wide range level greater than 0%, then adequate RCS heat removal is implicitly being maintained. An additional criterion requires the operator to monitor RCS T_c to ensure temperatures are stable or decreasing. This criterion assumes that no operator or plant initiated actions have caused a momentary, correctable reduction in RCS heat removal (e.g., ADV is closed).

If both SG levels are less than or equal to 0% WR then the operator is instructed to go to RCS and Core Heat Removal success path HR-4 to initiate once-through-cooling.

*31. If main, startup or emergency feedwater is restored, steam generator water level should be restored to the normal band.

HR-3

*32. If the SI pumps are operating, then they must continue to operate at full capacity until SI termination criteria are met. Termination of SI should be sequenced by stopping one pump at a time while observing the termination criteria. Throttling of SI is also permissible if all of the following SI termination criteria are satisfied:

a. The RCS is subcooled based on representative CET temperature (Figure 11-1). Establishing subcooling ensures the fluid surrounding the core is subcooled. Voids may exist in some parts of the RCS (e.g., reactor vessel head as determined by the HJTC RVLMS), but these are permissible as long as core heat removal is maintained.
b. Pressurizer level is greater than [14.3%], and not decreasing. A pressurizer level greater than [14.3%] and not decreasing, in conjunction with criterion a) above is an indication that RCS inventory control has been established.
c. At least one steam generator is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow is available for removing heat from the RCS.
d. The HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles. This provides an extra margin of core coverage and, taken in conjunction with the above criteria, serves as an additional indication that RCS inventory control has been established.

If all of the SI termination criteria are met, the operator may either stop or throttle the SI pumps. The operator may decide to throttle rather than terminate the flow if the SI pumps are to be used to control pressurizer level or plant pressure. A general assessment of the SIS performance can be made from the control room. The operator should confirm that at least one train, and preferably both trains, of SIS is operating and that system delivery rate is consistent with RCS pressure as shown in Figure 11-3. Injection flow rates to each cold leg should be approximately equal. Departures from this would indicate a closed flow path or some system spillage.

HR-3

*33. If the criteria of step 32 cannot be maintained after SI pumps are throttled or stopped, then the appropriate SI pumps should be restarted (if necessary) and full SIS flow restored.

*34. Plant conditions should be carefully assessed before any RCPs are restarted. The need for forced circulation operation should be balanced against the risk of damage to the RCP seals.

The need for operation of the RCPs should be evaluated based on:

1. the adequacy of the RCS and core heat removal under the existing natural circulation conditions,
2. the existing RCS pressure and temperatures,
3. the need for main pressurizer spray capability.

If the existing natural circulation is providing satisfactory RCS and core heat removal, a transfer to forced circulation operation may not be necessary. This would be particularly true if the RCS had already been cooled and depressurized to SCS entry conditions. If the RCS pressure and temperatures are closer to HOT STANDBY conditions, it may be desirable to restart the RCPs in order to allow a normal forced circulation cooldown. Consideration should also be given to the necessity of having main pressurizer spray capability if auxiliary spray is not providing the desired depressurization rate.

The potential for RCP seal degradation should be evaluated based on:

1. how long CCW to the RCPs was interrupted,
2. RCP seal staging pressures and temperatures.

HR-3

The possibility of seal degradation increases if the CCW has been interrupted for longer than [10 minutes]. The seal staging pressures provide an indication of degraded seal stages (a low pressure drop across a stage indicates a problem). Restart of an RCP with one or more degraded seal stages should be avoided if possible.

*35. If all RCPs have been stopped, then operation of two RCPs (in opposite loops) should be attempted if feedwater can be restored to at least one SG and RCP restart criteria are met. This will ensure continued forced circulation of coolant through the core and will provide the capability for the normal mode of pressurizer spray. However, only one RCP in each loop should be operated to minimize heat input to the RCS.

Determine whether RCP restart criteria are met by the following:

a. Electrical power available to the RCP,
b. RCP auxiliaries (In particular component cooling water) to maintain seal injection, bearing, and motor cooling should be operating in order to prevent damage to the pump and/or motor. (Note: [Following automatic or operated initiated containment isolation, reinstatement of one of the following means of RCP seal cooling ([CCW], [CVCS seal injection (SI)], [Dedicated Seal Injection System (DSIS)], should be considered to ensure adequate RCP cooling. There should be no high temperature alarms on the RCPs to be operated.
c. At least one steam generator has feedwater restored and is available for removing heat from the RCS. A steam generator having the ability for feed flow and steam flow is available for removing heat from the RCS.

HR-3

d. Pressurizer level is greater than [33%] and not decreasing. With pressurizer level within the operating band, the possibility of draining the pressurizer due to loop shrinkage and/or steam void condensation is minimized and there is a greater likelihood of keeping the pressurizer heaters covered. This will assist in maintaining positive RCS pressure control. The criterion of pressurizer level not decreasing implies that RCS inventory control has been established.

e. RCS is subcooled. A subcooled condition taken in conjunction with (d) above indicates that inventory and pressure are being controlled.

f. [All plant specific RCP operating criteria are satisfied before the RCPs are restarted to protect the RCPs from damage resulting from abnormal operating conditions].

g. Condensate that flows to the core on the cold side is depleted in boron and may collect in the RCP loop seals and cold leg. The RCPs should not be started until after single phase natural circulation has slowly moved this boron depleted coolant through the core. Twenty minutes of single phase natural circulation is considered adequate circulation and mixing time.

*36. Upon restarting two RCPs in opposite loops, pressurizer level and pressure may decrease due to loop shrinkage and/or void condensation. It is possible that this action will drain the pressurizer. Steam voids, if present in the reactor vessel, will condense upon restarting RCPs. The HJTC RVLMS should be monitored for the trending of reactor vessel liquid level. This trending information may be correlated to pressurizer level decrease. RCP operation with a drained pressurizer may continue provided certain actions are taken and certain criteria are satisfied.

The following constitute the actions to be taken and the criteria to be satisfied when restarting RCPs:

a. Start one RCP in each loop.

HR-3

b. Ensure proper RCP operation by monitoring RCP amperage and pump NPSH. NPSH is determined by pressurizer pressure and corresponding T_c on Figure 11-1.

c. Operate all available charging (and SI) pumps until pressurizer level is greater than [14.3%] and (SI termination criteria are met).

*37. The operator should monitor In-containment Refueling Water Storage Tank (IRWST) level. For RCS breaks inside containment, a decreasing trend in IRWST level should correspond to an increasing trend in Holdup Volum Tank level. This action enables the operator to trend IRWST level and to anticipate possible problems (break is outside of containment). If a decreasing IRWST level cannot be correlated to an increasing HVT or reactor cavity sump level, then the break may be outside containment. If IRWST level continues to decrease, then IRWST level should be maintained by replenishment from available sources. This will prevent the inadvertent air binding of the SI pumps.

*38. If the RCS cannot be depressurized, then a void should be suspected. Any time it is found that voiding inhibits RCS depressurization when depressurization is desired, then an attempt at elimination of the voiding should be made.

The operator should monitor for the presence of voids. Voiding in the RCS may be indicated by any of the following indications, parameter changes, or trends:

a. letdown flow greater than charging flow,

b. pressurizer level increasing significantly greater than expected while operating pressurizer spray,

c. the HJTC RVLMS indicates that voiding is present in the reactor vessel,

d. HJTC unheated thermocouple temperature indicates saturated conditions in the reactor vessel upper head.

HR-3

If voiding should be eliminated, then proceed as follows:

a. Letdown is isolated or verified to be isolated to minimize further inventory loss,
b. The depressurization is stopped to prevent further growth of the void,
c. Pressurizing and depressurizing the RCS within the limits of Figure 11-1 may condense the void. Pressurizing has the effect of filling the voided portion of the RCS with cooler fluid which will remove heat from the region. Subsequent depressurization and a repeating of this process several times will cool and condense the steam void. In this case of a void in the reactor vessel, the pressurization/depressurization cycle will preclude a fill and drain of the reactor vessel.

The pressurization/depressurization cycle may be accomplished using pressurizer heaters and spray (preferred method! or the SI/charging system (alternative method). Monitor pressurizer level and the HJTC RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

d. If indications of unacceptable RCS voiding continue, and voiding is suspected to exist in the (isolated) steam generator tubes, then cool the (isolated) steam generator (by steaming or blowdown, and/or feeding) to condense the tube bundle void. This will be effective for condensing steam voids but will not have an effect on non-condensible gases trapped in the tube bundle. A buildup of non-condensible gases in the tube bundles will not hinder natural circulation even with a large number of the tubes blocked. This is due to the small amount of heat transfer area required for the removal of decay heat. Monitor pressurizer level for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

HR-3

e. If indications of unacceptable RCS voiding continue, then voiding may be caused by non-condensible gases. Operate the Reactor Coolant Gas Vent System to clear trapped non-condensible gases. Monitor pressurizer level and/or the HJTC RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

39. If shutdown cooling system operation cannot be initiated, then simultaneous hot and cold leg injection is used for both small break and large break LOCAs at [2-4] hours after the start of the LOCA. In this mode, the SI pump discharge lines are realigned so that total injection flow is divided equally between the hot leg and reactor vessel nozzle. Simultaneous injection into the hot leg reactor vessel is used as the mechanism to prevent the precipitation of boric acid in the reactor vessel following a break that is too large to allow the RCS to refill.

Injecting to both sides of the reactor vessel ensures that fluid from the reactor vessel (where the boric acid is being concentrated) flows out of the break regardless of the break location and is replenished with a dilute solution of borated water from the other side of the reactor vessel. The action is taken no sooner than [2 hours] after LOCA since the fluid injected to the hot leg may be entrained in the steam being released from the core and hence possibly diverted from reaching the reactor vessel. After [2 hours], the core decay heat has dropped sufficiently so that there is insufficient steam velocity to entrain the fluid being injected to the hot leg. The action is taken no later than [4 hours] after the LOCA in order to ensure that the buildup of boric acid is terminated well before the potential for boric acid precipitation occurs. Even

HR-3

though the action is required only for large breaks, it is taken for any LOCA so that the operator need not be required to distinguish between large and ssmall break LOCAs. Simultaneous hot leg injection and DVI is not required for small breaks because the buildup of boric acid is terminated when the RCS is refilled. Once the RCS if refilled, the boric acid is dispersed throughout the RCS via natural circulation. If entry into shutdown cooling system operation is anticipated before the [4 hour] limit, and the criteria of step 39 are met, then the realignment to hot leg/DVI is unnecessary.

HR-3

HR-3: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, RCS and Core Heat Removal is satisfied if:

   a. At least one SG (or the unisolated SG) has level:

      i) within the normal level band with feedwater available to maintain level

      or

      ii) being restored by main, startup or emergency feedwater flow with level increasing,

   and

   b. Representative CET temperature is less than superheated,

   and

   c. The available charging pump operating and the SI pumps are injecting water into the RCS per Figure 11-3 (unless SI termination criteria are met).

   When the SI is operating, it should be delivering flow which corresponds to RCS pressure. If delivery flow is equal to or greater than that of Figure 11-3, then SI performance is adequate. Once SI termination criteria have been met, SI flow may be throttled or pumps turned off. The relation between SI flow and RCS pressure depicted in Figure 11-3 is no longer valid. Superheated conditions are indicative of core uncovery and is not an indication of adequate heat removal. Actions must be taken to establish a core covered condition. At least one steam generator level in the normal band or being restored is indication of the ability to remove heat through the steam generator(s).

2. If the above criteria are not satisfied, then success path HR-3 is not successfully controlling RCS and Core Heat Removal. The operator should go to the another appropriate success path for RCS and Core Heat Removal or continue within this success path until the criteria to establish once-through-cooling (HR-4) is met.

HR-3

3. If the acceptance criteria for success path HR-3 are satisfied, then success path HR-3 is successfully controlling RCS and Core Heat Removal. RCS and Core Heat Removal is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement LONG TERM ACTIONS.

HR-3

HR-4: RCS and Core Heat Removal via Once Through Cooling

If adequate heat removal capability via the steam generators is not available, heat can be removed from the RCS by flushing SI flow through the core and discharging into the containment through a pressure boundary opening such as a PORV or RDS valve (or a break in the RCS if there is one).

Operator Actions

1. Once-through-cooling is established as a last-resort method of core cooling if steam generator heat removal is no longer adequate. The operator establishes once-through-cooling by performing the following actions:

   a. All RCPs are stopped because opening of the RDS will result in the RCS being in a saturated condition which is not desirable for RCP operation.
   b. SI pumps are aligned for direct vessel injection to ensure flow through the core. (The plant may have been lined up for hot and direct vessel injection).
   c. The available charging and SI pumps are operated for maximum inventory flow into the RCS, and thus, through the core.
   d. Both RDS gate valves are opened to ensure sufficient RCS depressurization and an adequately sized opening for sufficient flow through the core.
   e. SI flow should be checked against pressurizer pressure to verify that the maximum available SI flow is being injected into the RCS (Figure 11-3).

* 2. If the SI pumps are operating and are not required for success path RC-3, then they must continue to operate at full capacity until SI termination criteria are met. Termination of SI should be sequenced by stopping one pump at a time while observing the termination criteria. Throttling of SI flow is also permissible if all of the following SI termination criteria are satisfied:

a. RCS is subcooled based on representative CET temperature (Figure 11-1). Establishing subcooling ensures the fluid surrounding the core is subcooled. Voids may exist in some parts of the RCS (e.g., reactor vessel head as determined by the HJTC RVLMS), but these are permissible as long as core heat removal is maintained.

b. Pressurizer level is greater than [14.3%] and not decreasing. A pressurizer level greater than [14.3%] and not decreasing, in conjunction with criterion a) above, is an indication that RCS inventory control has been established.

c. A method of removing heat from the RCS is available. A steam generator having the ability for feed flow and steam flow is available for removing heat from the RCS or the SCS can be lined up for operation.

d. The HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles. This provides an extra margin of core coverage and. taken in conjunction with the above, serves as an additional indication that adequate RCS inventory control has been established.

If all of the SI termination criteria are met, then the operator may either stop or throttle the SI pumps. The operator may decide to throttle, rather than terminate the flow, if the SI is to be used to control pressurizer level or plant pressure. A general assessment of the SI performance can be made from the control room. The operator should confirm that at least one train and preferably both trains of SI are operating and that system delivery rate is consistent with RCS pressure as shown in Figure 11-3. Injection flow rates to each cold leg should be approximately equal. Departures from this would indicate a closed flow path or some system leakage.

* 3. If the criteria of step 2 cannot be maintained after SI pumps are throttled or stopped, then the appropriate SI pumps should be restarted (if necessary) and full SI flow restored.

HR-4

4. Establishing cooling to the IRWST will establish a heat removal path from the containment to the ultimate heat sink. This will maintain once-through-cooling as a long term heat removal success path.

5. The operator should monitor In-containment Refueling Water Storage Tank (IRWST) level. For RCS breaks inside containment, a decreasing trend in IRWST level should correspond to an increasing trend in containment sump level. This action enables the operator to trend IRWST level and to anticipate possible problems (break is outside of containment). If a decreasing IRWST level cannot be correlated to and increasing HVT or reactor cavity, sump level, then the break may be outside containment. If IRWST level continues to decrease then IRWST level should be maintained by replenishment from available sources. This will prevent the inadvertent air binding of the SI pumps.

* 6. When adequate RCS and Core Heat Removal is re-established via at least one steam generator or the SCS, then once-through-cooling should be terminated. This will re-establish a normal mode of RCS heat removal, and minimize radioactive releases to the containment which will minimize the potential for releases to the environment.

Both RDS flowpaths should be closed (terminating once-through-cooling) when the following criteria are satisfied:

a. Representative CET temperature less than or equal to saturation and not increasing

<u>and</u>

b. At least one steam generator has wide range level greater than [15%] with feed and steam flow capability or the SCS can be lined up. This criterion ensures that adequate heat removal can be established when the once-through-cooling path is terminated,

<u>and</u>

HR-4

c. The HJTC RVLMS indicates a minimum level at the top of the hot leg nozzles. This provides an extra margin of core coverage and, taken in conjunction with the above criteria, serves as an additional indication of adequate heat removal.

If all of the above criteria are satisfied but one or both RDVs bleed valves will not close, then the appropriate RDV gate valves should be closed to terminate once-through-cooling.

* 7. If once-through-cooling has been terminated in step 6, then the RDV gate valves should be closed. Success path HR-2 (Natural Circulation, No SI Operation), success path HR-3 (SG Heat Sink with SI Operating) or success path HR-5 (Shutdown Cooling System) should be implemented as appropriate. If once-through-cooling is still in progress, then continue with the actions of this success path.

HR-4

HR-4: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, RCS and Core Heat Removal is satisfied if:

   a. Representative CET temperature is less than superheated

      and

   b. The available charging pump is operating and SI pumps are injecting water into the RCS per Figure 11-3 (unless SI termination criteria are met).

      and

   c. Pressurizer pressure is less than [2055 psia] or decreasing.

   SIS performance is judged by comparing delivery flow to RCS pressure. If flow is equal to or greater than that shown on Figure 11-3, SI performance is adequate. Once SI termination criteria have been met, SI flow may be throttled or pumps turned off. The relation between SI flow and RCS pressure depicted in Figure 11-3 is no longer valid. Superheated conditions are indicative of core uncovery and is not an indication of adequate heat removal. Actions must be taken to establish a core covered condition. Pressurizer pressure less than the SI pump shutoff head ([2055 psia]) or decreasing is indicative of conditions where the SI can deliver flow to the RCS.

2. If the above criteria are not satisfied, then the availability of success paths HR-1, 2, and 3 should be re-evaluated and the operator should refer to Continuing Actions for RCS and Core Heat Removal.

3. If the acceptance criteria for success path HR-4 are satisfied, then success path HR-4 is successfully controlling RCS and Core Heat Removal. RCS and Core Heat Removal is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria re satisfied, then the operator should implement LONG TERM ACTIONS.

HR-4

HR-5: RCS and Core Heat Removal via the Shutdown Cooling System

If the RCS is cooled to at least [400°F] and depressurized to at least [450 psia], then it may be possible to use the SCS for RCS heat removal.

Operator Actions

* 1. If pressurizer pressure reaches [445 psia] the safety injection tanks (SITs) must be vented, drained, or their discharge valves shut to prevent the nitrogen cover gas from being discharged into the RCS when RCS pressure is reduced below the SITs pressure during a controlled cooldown.

* 2. Low temperature over-pressurization protection (LTOP) is instituted at $T_c \leq$ [259°F] to protect against subjecting the RCS pressure boundary to low temperature brittle fracture.

* 3. The operator should determine if SCS operation criteria are met. Criteria include; RCS T_H of $\leq$ [400°F] and pressurizer pressure $\leq$ [450 psia], pressurizer level (greater than [14.3%] and constant or increasing and the pressurizer and/or SI pumps maintaining system pressure such that RCS hot and cold leg temperatures are at below saturation temperatures for pressurizer pressure. Before the SCS is operated, RCS activity levels must be determined since the RCS fluid will be circulated outside of the containment building. A determination must be made whether to circulate high activity RCS coolant outside containment if high activity is present and such an operation has the potential for release to the environment. If the potential for significant releases exists, it may be more desirable to continue cooling with the steam generators.

  If the RCS cannot be depressurized, then voiding may be causing RCS pressure to remain high. Any time it is found that voiding inhibits RCS depressurization to SCS entry pressure, when SCS operation is desired, then an attempt at elimination of the voiding should be made. HR-5

The operator should continuously monitor for the presence of voids. Voiding in the RCS may be indicated by any of the following indications, parameter changes, or trends:

a. letdown flow greater than charging flow,
b. pressurizer level increasing significantly more than expected while operating pressurizer spray,
c. the HJTC RVLMS indicates that voiding is present in the reactor vessel,
d. HJTC unheated thermocouple temperature indicates saturated conditions in the reactor vessel upper head.

If voiding should be eliminated, then proceed as follows:

a. letdown is isolated or verified to be isolated to minimize further inventory loss,
b. the depressurization is stopped to prevent further growth of the void,
c. pressurizing and depressurizing the RCS within the limits of Figure 11-1 may condense the void. Pressurizing has the effect of filling the voided portion of the RCS with cooler fluid which will remove heat from the region. Subsequent depressurization and a repeating of this process several times will cool and condense the steam void. In the case of a void in the reactor vessel, the pressurization/depressurization cycle will produce a fill and drain of the reactor vessel. The pressurization/depressurization cycle may be accomplished using pressurizer heaters and spray (preferred method) or the SI/charging system (alternative method). Monitor pressurizer level and the HJTC RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

HR-5

d. if indications of unacceptable RCS voiding continue, and voiding is suspected to exist in the steam generator tubes, then cool the steam generator (by steaming or blowdown, and/or feeding) to condense the tube bundle void. This will be effective for condensing steam voids but will not have an effect on non-condensible gases trapped in the tube bundle. A buildup of non-condensible gases in the tube bundles will not hinder natural circulation event with a large number of the tubes blocked. This is due to the small amount of heat transfer area required for the removal of decay heat. Monitor pressurizer level for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

e. if indications of unacceptable RCS voiding continue, then voiding may be caused by non-condensible gases. [Operate the Reactor Coolant Gas Vent System to clear trapped non-condensible gases. Monitor pressurizer level and/or the HJTC RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

HR-5

HR-5: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, RCS and Core Heat Removal is satisfied if:

   Normal Shutdown Cooling System Parameters Exist

   Examples of SCS parameters being monitored include: heat exchanger ~Ts, cooling water flow, pump discharge pressure, etc.

2. If the above criterion is not satisfied, then re-evaluate the feasibility of SCS operation and the availability of success paths HR-1, 2, 3, and 4. The operator should refer to Continuing Actions for RCS and Core Heat Removal.

3. If the acceptance criterion for success path HR-5 is satisfied, then success path HR-5 is successfully controlling RCS and Core Heat Removal. RCS and Core Heat Removal is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement LONG TERM ACTIONS.

CONTINUING ACTIONS FOR RCS AND CORE HEAT REMOVAL

If the RCS and Core Heat Removal safety function is still in jeopardy, then the operator must pursue RCS and Core Heat Removal and other jeopardized functions simultaneously. If the SI pumps are delivering flow to the RCS per Figure 11-3, then the operator should evaluate the need and feasibility of transferring additional heat through the steam generators by:

a. restoring the vital auxiliaries necessary to feed one or both steam generators
b. using alternate means (e.g., fire water pump, non-grade A condensate, etc.) to feed the SG's
c. alternate means of operating steam dumps or steam bypass valves or other steam outlets.

If the SI pumps are not delivering adequate flow to the RCS, then the operator should evaluate ways of implementing one of the RCS and core heat removal success paths by considering:

a. restoring necessary vital auxiliaries (control air, electrical, diesel generator, etc.) to regain needed components or subsystems
b. manual operation of failed remotely operable valves
c. alternate success of water for SG or RCS makeup
d. alternate means of steam discharge from the steam generators.
e. cooling/depressurizing the RCS to increase or establish SI flow.

SAFETY FUNCTION: Containment Isolation

SUCCESS PATH: Automatic/Manual Isolation; CI-1

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. If containment pressure is greater than or equal to [2.7 psig] or pressurizer pressure is less than or equal to the SIAS setpoint, Then verify containment isolation is actuated automatically.	1. If containment isolation does NOT occur automatically or all containment isolation valves are NOT in their accident positions, Then manually initiate containment isolation.
* 2. If activity is detected in the steam plant, Then identify and isolate the leaking steam generator. (Refer to HR-1, 2, or 3 as appropriate for guidance on identifying and isolating the SG and maintaining adequate RCS heat removal).	2.

* Step Performed Continuously

ACCEPTANCE CRITERIA FOR SUCCESS PATH CI-1:

1. Containment Isolation is satisfied if:

   a. i) No steam plant activity or alarms

   and

   ii) No containment radiation alarms

   and

   iii) No Nuclear Annex radiation alarms

   and

   iv) No reactor building radiation alarms

   and

   v) Containment pressure less than [2.7 psig]

   or

   b. Each containment penetration not required to be open has an isolation valve closed.

2. If above criteria NOT satisfied, Then go to CONTINUING ACTIONS FOR CONTAINMENT ISOLATION.

3. If above criteria satisfied, Then go to next safety function in jeopardy.

4. If acceptance for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

SUPPLEMENTARY INFORMATION: CI-1

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. The closing of some containment isolation valves may cause the isolation of vital auxiliaries (i.e., instrument air for valve opening/closing, component cooling water to the RCPs or SCS, sampling, nitrogen supply, letdown, blowdown) which could lead to equipment damage.

2. Local radioactivity levels should be determined before attempting any local manual valve closure. Appropriate precautions should be taken if high radiation levels exist.

CI-1

CONTINUING ACTIONS FOR CONTAINMENT ISOLATION

If the acceptance criteria are NOT met, Then containment isolation is still in jeopardy. The operator must continue to attempt to establish Containment Isolation while pursuing other jeopardized safety functions. Evaluate further actions using the following:

a. The urgency of other safety functions in jeopardy.
b. The risk to plant personnel and the public of leaving certain containment penetrations unisolated.
c. The feasibility of isolating the containment penetration(s) by alternate methods.

CI-1: Containment Isolation via Automatic/Manual Isolation

Containment isolation is necessitated when a risk to plant personnel and/or the public exists from leaving containment penetrations unisolated. This may include the potential release of radionuclides from a steam generator with leaking tubes.

Operator Actions

* 1. If containment pressure is greater than or equal to [2.7 psig] or if pressurizer pressure is less than or equal to the SIAS setpoint, then the operator verifies that containment isolation occurs automatically. If containment isolation does not occur automatically or all containment isolation valves are not in their accident positions, then the operator should manually initiate containment isolation. The purpose of this step is to prevent direct communication between the containment atmosphere and the environment. Operators should be alert to the loss of auxiliaries to the containment (in particular, component cooling water) which may occur with containment isolation. Re-establishing letdown should also be considered if it is available. This will enable the operator to better control RCS inventory during a possible RCS heatup and subsequent fluid expansion. This action can minimize the possibility of PTS.

* 2. Activity detected in the steam plant usually means that at least one steam generator has tube leaks. The operator should attempt to identify the affected (or most affected SG, if both SGs have leaks) by sampling and other plant specific means. If the steam generator is not required to remove heat from the RCS (i.e., the other steam generator is available or some other heat removal path is available), that steam generator (or the most contaminated steam generator, if both are leaking) should be isolated. The operator should refer to HR-1, 2, or 3 and perform the applicable operator actions concurrently with the actions of this Containment Isolation success path.

* Step Performed Continuously CI-1

CI-1: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, Containment Isolation is satisfied if:

   a. i) No steam plant activity or alarms

      and

      ii) No containment radiation alarms

      and

      iii) No Nuclear Annex radiation alarms

      and

      iv) No reactor building radiation alarms

      and

      v) Containment pressure less than [2.7 psig]

      or

   b. Each containment penetration not required to be open has an isolation valve closed.

   Activity in the steam plant is usually a symptom requiring steam generator isolation. Containment penetrations required for essential services, such as cooling water to the RCPs or SIS operation, need not be isolated when containment isolation is called for. The operator must be alert to the possibility that any unisolated penetration may be a potential path for release of fission products.

2. If the above criteria are not satisfied, then success path CI-1 is not successfully controlling containment isolation. The operator should go to CONTINUING ACTIONS FOR CONTAINMENT ISOLATION.

3. If the acceptance criteria for success path CI-1 are satisfied, then success path CI-1 is successfully controlling containment isolation. Containment Isolation is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

CI-1

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

CONTINUING ACTIONS FOR CONTAINMENT ISOLATION

If the Containment Isolation safety function is still in jeopardy, then the operator must attempt to satisfy Containment Isolation while pursuing other safety functions in jeopardy based on the urgency of other safety functions in jeopardy, and the feasibility of restoring equipment to restore success paths.

SAFETY FUNCTION: Containment Temperature and Pressure Control

SUCCESS PATH: Containment Fans; CTPC-1

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. Verify containment fan cooler units are operating.	1. Manually start all available containment fan coolers.
* 2. Ensure containment fan coolers are operating in accordance with plant specific operating instructions.	2.

* Step Performed Continuously

CTPC-1

ACCEPTANCE CRITERIA FOR SUCCESS PATH CTPC-1:

1. Containment Temperature and Pressure Control is satisfied if:

   a. Containment pressure is less than [8.5 psig]

2. If above criteria NOT satisfied, Then go to next appropriate Containment Temperature and Pressure Control success path.

3. If above criteria satisfied, Then go to next safety function in jeopardy.

4. If acceptance for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

CTPC-1

SUPPLEMENTARY INFORMATION: CTPC-1

This sections contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. If the containment fan coolers are not available, the operator should continue efforts to restore the fan coolers to operation.

SAFETY FUNCTION: Containment Temperature and Pressure Control

SUCCESS PATH: Containment Spray, CTPC-2

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. If containment pressure is greater than or equal to [8.5 psig], Then do the following:	1.
a. verify containment spray and	a. manually actuate containment spray
b. verify at least one containment spray header delivering at least [5000 gpm].	
* 2. If containment spray system is operating and containment pressure is less than [5.5 psig], Then containment spray may be terminated. Upon termination, the CSS must be aligned and reset for automatic operation or manual restart.	2. Continue containment spray system operation.

* Step Performed Continuously

CTPC-2

ACCEPTANCE CRITERIA FOR SUCCESS PATH CTPC-2:

1. Containment Temperature and Pressure Control is satisfied if:

   a. At least one containment spray header delivering at least [5000 gpm],

   and

   b. Containment temperature and pressure constant or decreasing.

2. If above criteria NOT satisfied, Then go to CONTINUING ACTIONS FOR CONTAINMENT TEMPERATURE AND PRESSURE CONTROL.

3. If above criteria satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

CTPC-2

SUPPLEMENTARY INFORMATION: CTPC-2

This sections contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Operation of the CSS may be desirable in the event of an iodine buildup in containment.

2. The Shutdown Cooling Pumps and the Containment Spray Pumps are functionally interchangeable. Therefore, if containment spray or shutdown cooling is required but not available due to pump malfunction, the backup pump(s) may be aligned, if not already being used for their intended function, and operated as an alternate success path.

CONTINUING ACTIONS FOR CONTAINMENT TEMPERATURE AND PRESSURE CONTROL

If the Containment Temperature and Pressure Control safety function is NOT satisfied, Then the operator must continue to attempt to establish Containment Temperature and Pressure Control while pursuing other jeopardized safety functions. Evaluate further actions based on the following:

a. Rate of change of containment temperature and pressure, and potential for damage to the containment.

b. The urgency of other jeopardized safety functions.

c. The feasibility of restoring function to a success path by:

i) restoring the vital auxiliaries necessary to operate components or systems in the success paths

ii) manual operation of valves

iii) use of alternate components to implement a success path.

Bases for Containment Temperature and Pressure Control

The purpose of the Containment Temperature and Pressure control safety function is to prevent damage to the containment building which provides a barrier to fission product release to the general public.

To establish Containment Temperature and Pressure Control, the following three methods are available:

CTPC-1: Containment Temperature and Pressure Control via Containment Fans

CTPC-2: Containment Temperature and Pressure Control via Containment Spray

The bases for the operator actions required for implementing each of the methods listed are detailed as follows:

CTPC-1: CONTAINMENT TEMPERATURE AND PRESSURE CONTROL VIA CONTAINMENT FANS

For those events which permit continued operation of the containment fan coolers (i.e., power available to fans and cooling water available), Containment Temperature and Pressure Control should be maintained by operation of the fan coolers.

Operator Actions

* 1. The operator should verify containment fan coolers are operating. If all containment fan coolers are not operating, then the operator should manually start all available containment fan coolers.

* 2. The operator should ensure that the containment fan coolers are operating per plant specific operating instructions. Adequate cooling water supplied to the cooling system, pump amperage, and air flow rates are examples of parameters to be checked. This step can preclude possible system faults which can degrade the ability to control containment temperature and pressure.

CTPC-1: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, Containment Temperature and Pressure Control is satisfied if:

   a. Containment pressure is less than [8.5 psig].

The operation of containment cooling fans is the preferred method of controlling containment temperature and pressure. Operation of additional containment cooling and air recirculation systems (e.g., CEDM coolers, reactor cavity coolers, dome air circulators, etc.) can also be utilized to aid in Containment Temperature and Pressure Control.

2. If the above criteria are not satisfied, then success path CTPC-1 is not successfully controlling Containment Temperature and Pressure. The operator should go to the next appropriate success path for Containment Temperature and Pressure Control.

3. If the acceptance criteria for success path CTPC-1 are satisfied, then success path CTPC-1 is successfully controlling containment temperature and pressure. Containment Temperature and Pressure Control is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

CTPC-2: CONTAINMENT TEMPERATURE AND PRESSURE CONTROL VIA CONTAINMENT SPRAY

The containment spray system removes heat from the containment by spraying water droplets throughout the containment atmosphere. This condenses steam and cools the air, subsequently reducing containment pressure.

Operator Actions

* 1. The containment spray system is automatically actuated at a containment pressure greater than or equal to [8.5 psig]. If containment pressure reaches [8.5 psig], then the operator should:

   a. verify that containment sprays have been automatically actuated. If this has not occurred automatically, the operator should take necessary steps to manually actuate containment spray

   and

   b. maintain containment pressure below design pressure. Verify at least one containment spray header with ≥ [5000 gpm] flow.

   Additional guideance regarding the use of containment sprays during a severe accident, particularly when a significant concentration of hydrogen exists in containment and containment pressure is elevated, is provided in the Severe Accident Management Guidance (Appendix A) to this document.

* 2. Containment spray system operation may be terminated when containment pressure has been reduced to an acceptable level. Continued operation of the sprays after pressure has been reduced to an acceptable level increases the possibility of wetting electrical connectors which may result in electrical grounds, shorts and other malfunctions. Therefore, if containment sprays have actuated and containment pressure is reduced below [5.5 psig], then containment spray may be terminated. After terminating containment spray, the containment spray system should be realigned for automatic or manual operation in case containment pressure again increases to the actuation setpoint.

CTPC-2

CTPC-2: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, Containment Temperature and Pressure Control is satisfied if:

   a. At least one containment spray header delivering at least [5000 gpm]

   and

   b. Containment temperature and pressure constant or decreasing.

2. If the above criteria are not satisfied, then success path CTPC-2 is not successfully controlling containment temperature and pressure. The operator should go to CONTINUING ACTIONS FOR CONTAINMENT TEMPERATURE AND PRESSURE CONTROL.

3. If the acceptance criteria for success path CTPC-2 are satisfied, then success path CTPC-2 is successfully controlling containment temperature and pressure. Containment Temperature and Pressure Control is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

CONTINUING ACTIONS FOR CONTAINMENT TEMPERATURE AND PRESSURE CONTROL

If the Containment Temperature and Pressure Control safety function is still in jeopardy, then the operator must continue to attempt to establish Containment Temperature and Pressure Control while pursuing other jeopardized safety functions. Actions should be based on the results of evaluating the possible risks to plant personnel and the public, the urgency of other safety functions in jeopardy, the rate of change of containment temperature and pressure, and the feasibility of restoring equipment to restore success paths.

SAFETY FUNCTION: Containment Combustible Gas Control

SUCCESS PATH: Passive/Hydrogen Recombiners: CCGC-1

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. Ensure containment hydrogen monitors operating in accordance with plant-specific operating instructions.	1.
2. Ensure hydrogen recombiners are available and aligned for use.	2.
3. Ensure all available containment air recirculation systems are operating: a. pressurizer compartment Fan b. CEDM cooling system, c. reactor vessel cavity fan, d. normal containment coolers	3.
* 4. Verify containment hydrogen concentration is less than 0.5%.	*4. Operate hydrogen recombiners until containment hydrogen concentration is less than 0.5%.

* Step Performed Continuously

CCGC-1

ACCEPTANCE CRITERIA FOR SUCCESS PATH: CCGC-1

1. Containment Combustible Gas Control is satisfied if:

   a. Hydrogen concentration is less than 0.5%

   or

   b. i) All available hydrogen recombiners are energized

   and

   ii) Hydrogen concentration is less than 4%

2. If above criteria NOT satisfied, Then go to Containment Combustible Gas Control success path CCGC-2 (Hydrogen Purge System).

3. If above criteria satisfied, Then go to next safety function in jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

SUPPLEMENTARY INFORMATION: CCGC-1

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Operation of any electrical equipment in the containment building when containment hydrogen concentration $\geq$ 4% should consider the possibility of hydrogen ignition. Consideration should be given to the following:

    a. The importance to safety of equipment operation
    b. The urgency of equipment operation
    c. The use of alternative equipment located outside containment
    d. The current hydrogen level and the anticipated time to reduce $H_2 \leq$ 4%.

2. The containment fan coolers should be operating to aid in the Combustible Gas Control function by: 1) mixing the containment atmosphere, which reduces the possibility of local hydrogen pockets forming, and, 2) reducing the containment temperature, which decreases the amount of hydrogen generated by the corrosion of aluminum and zinc materials.

3. Any cautions provided by the hydrogen recombiner vendor concerning operation of the recombiners with a degraded containment environment would be inserted here in the plant specific EOPs.

4. Measured containment hydrogen typically represents a value of hydrogen in units of percent by volume of dry air. The measured hydrogen will typically indicate higher than the actual containment hydrogen for a steam/air mixture inside containment. The indicated value should, therefore, be corrected to account for any steam/air mixture inside containment.

CCGC-1

SAFETY FUNCTION: Containment Combustible Gas Control

SUCCESS PATH: Hydrogen Purge System; CCGC-2

INSTRUCTIONS	CONTINGENCY ACTIONS
* 1. <u>Ensure</u> containment hydrogen monitors operating in accordance with plant-specific operating instructions.	1.
2. <u>Ensure</u> all available containment air recirculation systems are operating: a. Pressurizer compartment fan b. CEDM cooling system, c. reactor vessel cavity cooling system, d. normal containment coolers.	2.
* 3. Monitor containment radiation level and provide input to Plant Technical Support Center for evaluating the impact of potential environmental releases.	3. <u>If</u> containment radiation levels are high, <u>Then</u> operate the Containment Spray System.

* Step Performed Continuously

CCGC-2

INSTRUCTIONS	CONTINGENCY ACTIONS
* 4. *If* the Plant Technical Support Center has reviewed and recommended purge system operation, *Then* operate the hydrogen purge system in accordance with plant specific operating instruction.	4.
* 5. *When* Plant Technical Support Center has reviewed and recommended termination of hydrogen purge, *Then* terminate operation of the hydrogen system.	5.

* Step Performed Continuously

CCGC-2

ACCEPTANCE CRITERIA FOR SUCCESS PATH: CCGC-2:

1. Containment Combustible Gas Control is satisfied if:

   The hydrogen purge system is operating in accordance with plant-specific operating instructions.

2. If above criterion NOT satisfied, Then go to CONTINUING ACTIONS FOR CONTAINMENT COMBUSTIBLE GAS CONTROL.

3. If above criterion satisfied, Then go to next safety function in Jeopardy.

4. If acceptance criteria for ALL safety functions are being satisfied, Then go to LONG TERM ACTIONS after performing appropriate operator actions for all success paths in use.

SUPPLEMENTARY INFORMATION: CCGC-2

This section contains items which should be considered when implementing EOGs and preparing plant specific EOPs. The items should be implemented as precautions, cautions, notes, or in the EOP training program.

1. Operation of any electrical equipment in the containment building when containment hydrogen concentration $\geq$ 4% should consider the possibility of hydrogen ignition. Consideration should be given to the following:

   a. The importance to safety of equipment operation
   b. The urgency of equipment operation
   c. The use of alternative equipment located outside containment
   d. The current hydrogen level and the anticipated time to reduce $H_2 \leq 4\%$.

2. The containment fan coolers should be operating to aid in the Combustible Gas Control function by: 1) mixing the containment atmosphere, which reduces the possibility of local hydrogen pockets forming, and, 2) reducing the containment temperature, which decreases the amount of hydrogen generated by the corrosion of aluminum and zinc materials.

3. Any cautions provided by the hydrogen recombiner vendor concerning operation of the recombiners with a degraded containment environment would be inserted here in the plant specific EOPs.

4. Measured containment hydrogen typically represents a value of hydrogen in units of percent by volume of dry air. The measured hydrogen will typically indicate higher than the actual containment hydrogen for a steam/air mixture inside containment. The indicated value should, therefore, be corrected to account for any steam/air mixture inside containment.

CCGC-2

CONTINUING ACTIONS FOR CONTAINMENT COMBUSTIBLE GAS CONTROL

If the Containment Combustible Gas Control safety function is NOT satisfied, then the operator must attempt to satisfy other jeopardized safety functions and continue pursuing this safety function based on these considerations:

a. Rate of change of containment hydrogen concentration, and potential for hydrogen burn
b. The urgency of other jeopardized safety functions
c. The feasibility of restoring function to a success path by restoring vital auxiliaries necessary to operate systems or components in the success paths.

Bases for Containment Combustible Gas Control

The purpose of the Containment Combustible Gas Control safety function is to prevent the hydrogen concentration in the containment atmosphere from increasing to the flammable concentration. A hydrogen burn inside containment could cause damage to the containment building which provides a barrier to fission product release to the general public.

Three significant sources of hydrogen exist. These are:

1) Metal-water reactions involving zirconium or stainless steel in the RCS,
2) Radiolysis of the RCS water by fission product decay,
3) Corrosion of aluminum and zinc in the containment by the containment spray solution.

The first two sources are only a concern during inside containment LOCA events, since these are the events which produce the high temperatures required for the metal-water reaction and provide a path for the hydrogen from the RCS into the containment atmosphere. The third source is only a concern during LOCA or steam line break events inside containment, since these are the events which actuate the containment sprays and produce the high containment temperatures required for the corrosion reactions to generate significant amounts of hydrogen.

Containment Combustible Gas Control may become a concern due to hydrogen generated during LOCA events. The ultimate goal of the Containment Combustible Gas Control safety function is to prevent a hydrogen burn from causing containment pressure to reach or exceed containment design pressure. Preferentially, this is accomplished by operation of the hydrogen recombiners. If recombiner operation is not possible or sufficient, then hydrogen purge may be performed if deemed necessary by the [Plant Technical Support Center or the Plant Operations Review Committee]. These actions are performed to prevent or minimize the release of fission products to the environment. To establish Containment Combustible Gas Control, the following methods are available:

CCGC-1: Containment Combustible Gas Control via Passive/Hydrogen Recombiners

CCGC-2: Containment Combustible Gas Control via Hydrogen Purge System

The bases for the operator actions required for implementing each of the methods are detailed as follows:

CCGC-1: Containment Combustible Gas Control via Passive/Hydrogen Recombiner

In the Passive mode of Containment Combustible Gas Control, the operators merely monitor containment hydrogen concentration. If hydrogen concentration remains below 0.5%, then this safety function is satisfied. If necessary, the containment hydrogen concentration can be reduced by combining hydrogen and oxygen to form water. The hydrogen recombiners do this by raising the temperature of the air passing through them to the point where the recombination reaction takes place. Electric heating elements are used to heat the incoming mixture, flow through the units is provided by natural circulation.

The relatively low flow rates through the recombiners result in a gradual decrease in the hydrogen concentration. Since the recombination rate (cubic feet of hydrogen removed per hour) depends on the hydrogen concentration in the atmosphere, use of the recombiners will result in an exponential decrease in the hydrogen concentration. Typically, one recombiner will remove hydrogen at a rate that is comparable with long term hydrogen generation rate following a large break (LOCA).

Operator Actions

* 1. The containment hydrogen monitors should have been placed in service when the Functional Recovery Guideline was implemented. The operator should ensure that the hydrogen monitors are being operated per plant-specific operating instructions. This will ensure the continued capability of monitoring containment hydrogen concentration and enable the operator to evaluate the effectiveness of actions taken.

2. The operators should direct the appropriate personnel to make the hydrogen recombiners available and aligned for control of the containment hydrogen concentration. Operation of the hydrogen recombiners may be required by subsequent steps.

3. Operation of the containment air recirculation systems will reduce the possibility of local pockets of hydrogen accumulating, by ensuring that the containment atmosphere is well-mixed.

* 4. Containment hydrogen concentration should be verified to be less than 0.5% and hydrogen recombiners should be energized when hydrogen is detected in containment ≥ 0.5%. This action is performed to keep the containment hydrogen concentration as low as possible throughout the event. The recombiners take approximately [1 hour] to reach operating temperature so no decrease in measured hydrogen concentration should be expected before this time. Although hydrogen is not flammable until it achieves a concentration of at least 4%, it is prudent to reduce hydrogen to as low a concentration as possible. (i.e., less than the minimum detectable hydrogen concentration of 0.5%.) Such action minimizes the possibility of reaching the flammability limit and of forming pockets of high concentration hydrogen. Therefore, the hydrogen recombiners should be run until hydrogen concentration is reduced to less than 0.5%.

CCGC-1: Acceptance Criteria and Guideline Direction

1. After implementing the above actions Containment Combustible Gas Control is satisfied if:

   a. Hydrogen concentration is less than 0.5%

   or

   b. i) All available hydrogen recombiners are energized

   and

   ii) Hydrogen concentration is less than 4%.

2. If the above criteria are not satisfied, then success path CCGC-1 is not successfully controlling containment hydrogen. The operator should go Containment Combustible Gas Control success path CCGC-2 (Hydrogen Purge System).

3. If the acceptance criteria for success path CCGC-1 are satisfied, then success path CCGC-1 is successfully controlling containment hydrogen. Containment Combustible Gas Control is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

CCGC-1

CCGC-2: Containment Combustible Gas Control via Hydrogen Purge System

The containment hydrogen concentration can be reduced by purging the containment atmosphere with fresh air. The hydrogen purge system accomplishes this by providing controlled intakes and exhausts to the containment atmosphere.

The hydrogen removal rate (cubic feet of hydrogen removed per hour) depends on the purge system flow rate, the containment free volume, and the containment hydrogen concentration. Higher purge rates will result in higher removal rates.

Operator Actions

* 1. The containment hydrogen monitors should have been placed in service when the Functional Recovery Guideline was implemented. The operator should ensure that the hydrogen monitors are being operated per plant-specific operating instructions. This will ensure the continued capability of monitoring containment hydrogen concentration and enable the operator to evaluate the effectiveness of actions taken.

2. Operation of the containment air recirculation systems will reduce the possibility of local pockets of hydrogen accumulating, by ensuring that the containment atmosphere is well mixed.

* 3. Containment radiation levels should be monitored in order to provide the Plant Technical Support Center input to evaluate the environment of any planned, or unplanned releases. Removal of iodine from the containment atmosphere using the Containment Spray System may be desirable in order to minimize the activity released to the environment in the event of a hydrogen purge.

* 4. The Plant Technical Support Center should obtain information concerning containment conditions, evaluate this information, and if necessary, make the recommendations to operate the hydrogen purge system.

CCGC-2

The following factors should be considered in the evaluation:

a. Containment Hydrogen Concentration
   The Plant Technical Support Center should consider the current hydrogen concentration relative to the flammability concentration to determine if combustion is imminent.
b. Containment Pressure
   The containment pressure prior to a hydrogen burn directly affects the containment pressure following the burn.
c. Expected Effects of a Hydrogen Burn

If a hydrogen burn is not expected to threaten containment integrity, then radioactive releases to the environment could be minimized or avoided if the burn were allowed to occur rather than purging. In contrast, if a hydrogen burn is expected to result in containment pressure exceeding its design value, a continuous, unisolable release to the environment could occur. Figure 11-16 is available to the Plant Technical Support Center to assist in evaluating the expected effects of a hydrogen burn. Existing containment pressure and containment concentration are determined and, using Figure 11-16, the expected post-burn containment pressure can also be determined. If the post-burn pressure is expected to be less than containment design pressure 60 psig, then a hydrogen purge may not be necessary. Containment conditions must still be monitored and evaluated to ensure that expected post-burn pressure will remain below design pressure. Conditions to monitor include: rate of increase of hydrogen concentration, hydrogen recombiner availability/capability, and rate of increase of containment pressure.

CCGC-2

FIGURE 11-16

POST H_2 BURN CHARACTERISTICS

(TO BE DEVELOPED DURING DETAILED ENGINEERING)

If the expected post-burn pressure would exceed containment design pressure, then a hydrogen purge may be necessary to ensure continued containment integrity.

d. Containment Atmosphere Radiation Levels
This factor effects the offsite dose that a hydrogen purge would produce. The Plant Technical Support Center should consider whether the offsite doses will be within acceptable limits.

e. Rate of Change of Hydrogen Concentration

The rate of change of hydrogen concentration is an important factor to consider in the evaluation of whether or not to purge. If hydrogen concentration is increasing rapidly and expected post-burn containment pressure would exceed design pressure, then a hydrogen purge may be required to be performed expeditiously to maintain containment integrity in the event of a hydrogen burn. Conversely, if hydrogen concentration is decreasing and expected post-burn containment pressure would slightly exceed design pressure (e.g., 65 psig), then it may be prudent to allow hydrogen concentration to decrease to an acceptable level instead of purging.

f. Hydrogen Recombiner Availability/Capability

This factor is related to factor (e.) discussed above. If hydrogen recombiners are not available (not operable), then purging will be the sole means of hydrogen control available. Recombiner capability relates to whether or not hydrogen recombiners are lowering containment hydrogen concentration, maintaining constant hydrogen levels, or incapable of keeping up with the hydrogen generation rate.

CCGC-2

g. Rate of Change of Containment Pressure

Existing containment pressure and existing containment hydrogen concentration are used to determine expected post-burn containment pressure. The rate of change of hydrogen concentration has been discussed. The discussion of the rate of change of containment pressure is similar. If containment pressure is increasing and expected post-burn pressure is above design pressure, then efforts to make available all containment temperature/pressure control equipment should be made and a hydrogen purge may be necessary depending on factors d, e, and f. Conversely, if expected post-burn pressure would exceed design pressure but containment temperature/pressure control equipment are now lowering containment pressure, then a hydrogen purge may not be necessary. Again, this decision would be made by also considering factors d, e, and f.

h. Plant-Specific Requirements for a Containment Hydrogen Purge

Any plant-specific requirements to purge the containment of hydrogen have to be considered, and modified if necessary, when determining the necessity and feasibility of performing a hydrogen purge.

* 5. The recommendation to stop the containment hydrogen purge should be made by the Plant Technical Support Center. The factors presented in Step 4 should be evaluated and the purge terminated as soon as conditions warrant in order to minimize radiation releases to the environment.

CCGC-2

CCGC-2: Acceptance Criteria and Guideline Direction

1. After implementing the above actions, Containment Combustible Gas Control is satisfied if:

   The hydrogen purge system is operating in accordance with plant-specific operating instructions.

2. If the above criterion is not satisfied, then success path CCGC-2 is not successfully controlling containment hydrogen. The operator should go to CONTINUING ACTIONS FOR CONTAINMENT COMBUSTIBLE GAS CONTROL.

3. If the acceptance criterion for success path CCGC-2 is satisfied, then success path CCGC-2 is successfully controlling containment hydrogen. Containment Combustible Gas Control is not in jeopardy so the operator should address other safety functions which may be in jeopardy.

4. If the operator actions for all success paths in use have been performed and all safety function acceptance criteria are satisfied, then the operator should implement the LONG TERM ACTIONS.

LONG TERM ACTIONS

Since the FRG may be implemented in the course of a variety of different events, which may or may not be diagnosed, the long term actions strategy must be flexible. Since the detailed course of actions to be taken will depend on the nature of the events(s), considerable reliance on the Technical Support Center for guidance is used in the Long Term Actions. The basic strategy is as follows:

- Continuously perform the FRG Safety Function Status Check and ensure acceptance criteria remain satisfied.
- Determine if a plant cooldown is urgent.
- Maintain the ability to perform a plant cooldown.
- If necessary, cooldown and implement shutdown cooling.
- Continuously attempt to diagnose the event.

* 1. Compare plant indications against the acceptance criteria of the FRG Safety Function Status Check for the success paths currently in use for each safety function.

* 2. Determine plant status. This entails the identification of the following:

a. RCS conditions (inventory, temperature, pressure, radioactivity levels, etc.)
b. Success paths in use for fulfilling each safety function.
c. Adequacy of core cooling.
d. Plant area radiation levels.
e. Rates of radioactivity release to the environment.

* Step Performed Continuously

* 3. If a specific event (e.g., LOCA, SGTR, LOAF, etc.) can be identified, Then further guidance for casualty management may be found in an Optimal Recovery Guideline (ORG).

4. Continue implementing a success path unless another equivalent path as been verified ready for implementation.

* 5. Determine whether a cooldown to COLD SHUTDOWN is necessary. Consider the following:

   a. Rate of release of radioactivity to the environment. If a high rate of release to the environment exits, Then a cooldown should be initiated. If possible, dump steam to the condenser rather than to the atmosphere.
   b. Available emergency feedwater and condensate inventory and ability to replenish inventory. If the available inventory approaches the inventory requirement for a cooldown (determined using Figures 11-4 and 11-5), And the inventory is decreasing (due to insufficient makeup capability), Then a cooldown must be initiated.
   c. Continued availability of vital auxiliaries required for a cooldown. If a loss of vital auxiliaries may be anticipate, Then a cooldown should be initiated. Consider:
      i) electric power supplies
      ii) compressed air supplies
      iii) other plant specific auxiliaries would be listed here in the plant specific EOPs.
   d. Ability to make required repairs. If a cooldown is necessary to make repairs, Then a cooldown should be initiated. If the plant can be maintained in a stable condition, and a cooldown is not required immediately (considering (a), (b) and (c), above), Then the operator or Technical Support Center may decide to delay the initiation of the cooldown.

* Step Performed Continuously

* 6. Determine whether a cooldown is feasible. Consider the following:

a. Failed equipment or conditions which may prevent or inhibit a cooldown (e.g., loss of all pressurizer sprays, inability to dump steam). If repairs to required equipment are not feasible, Then if possible, bring the plant to conditions allowing the repairs.

b. Available emergency feedwater and condensate inventory. If insufficient inventory is available (determined using Figures 11-4 and 11-5), Then attempt to increase the inventory or obtain additional sources of feedwater.

c. RCS voiding. If voiding inhibits RCS depressurization to SCS entry pressure, Then an attempt to eliminate the voiding should be made.

Voiding in the RCS may be indicated by any of the following indications, parameter changes, or trends:

i) letdown flow greater than charging flow,

ii) pressurizer level increasing significantly greater than expected while operating pressurizer spray,

iii) the RVLMS indicates that voiding is present in the reactor vessel,

* 7. If voiding should be eliminated, Then proceed as follows:

a. verify letdown is isolated,

b. stop the depressurization,

c. pressurize and depressurize the RCS within the limits of Figure 11-1 by operating pressurizer heaters and spray (preferred method) or SI and charging pump (alternative method). Monitor pressurizer level and the RVLMS for trending of RCS inventory.

d. if indication of unacceptable RCS voiding continue, and voiding is suspected to exist in the (isolated) steam generator tubes, then cool the (isolated) steam generator (by steaming or blowdown, and/or feeding) to condense the steam generator tube bundle void. Monitor pressurizer level for trending of RCS inventory.

* Step Performed Continuously

8. If a cooldown is to be performed, Then guidance from the Technical Support Center may be required. Standard cooldown methods may require modification due to the nature of the event. If a cooldown s not required, Then continue to maintain the safety functions until guidance is provided by the Technical Support Center or an approved procedure can be implemented.

* 9. If the following criteria re mt, Then shutdown cooling may be initiated per SCS operating instructions:

a. RCS T_H is cooled down to at least [400°F]
b. The RCS is depressurized to at least [450 psia]
c. The RCS is subcooled
d. Pressurizer level is greater than [14.3%] and not decreasing
e. RCS activity level within appropriate limits

* Step Performed Continuously

BASES FOR LONG TERM ACTIONS

* 1. This step ensures that safety functions are continuously monitored and appropriate actions are taken to continue to satisfy SFSC acceptance criteria. This will held to ensure the health and safety of the public.

* 2. Determining the plant status is necessary in order to make sound judgements concerning the subsequent actions to be taken. Evaluating a detailed plant status will also provide some diagnostic information. The possibility of making repairs to equipment, and what repairs are necessary, should also be considered.

* 3. Using the information determined in Step 2, a diagnosis may be possible. If a multiple failure event can be diagnosed, guidance from more than one ORG may be utilized by the [Plant Technical Support Center] to develop an event specific procedure.

4. Redundant means of satisfying safety functions are available to the operator (success paths). Before implementing an alternate success path, however, the usability of that success path must be ensured.

* 5. Plant conditions may require that a cooldown be initiated immediately. The rate of radiological releases to the environment should be considered in order to minimize the offsite dose due to the event. This is accomplished by: a) minimizing the rate of release (e.g., by dumping steam to the condenser rather than to the atmosphere), and b) by minimizing the duration of the releases by entering shutdown cooling as soon as possible.

Consideration of the emergency feedwater inventory and the continuing availability of vital auxiliaries should be made in order to ensure that a cooldown can be completed. The initiation of a cooldown should not be delayed if the ability to cooldown is in jeopardy. A cooldown should be initiated in time to ensure that the shutdown cooling system can be placed into operation before the emergency feedwater inventory is depleted or the ability to control valves and/or other equipment is lost (e.g., due to a loss of electrical power or compressed air supplies).

A cooldown may also be required in order to make repairs to the plant. If the need to cooldown is not urgent, a delay in the cooldown initiation and/or a slower cooldown rate may be appropriate.

* 6. Whether or not a cooldown is immediately required, the ability to cooldown should be verified and maintained, since a cooldown may become necessary.

If a cooldown is prevented by equipment problems, and repairs are not feasible, the Plant Technical Support Center should provide guidance on an alternate cooldown method. If the emergency feedwater inventory is insufficient for a cooldown, alternate sources of feedwater should be obtained. Examples of alternate sources are nonseismic tanks, fire mains, lake water supplies, potable tanks, etc. Plant specific alternate sources of feedwater should be identified and cited in the plant specific procedure.

Any time it is found that voiding is causing the RCS to remain pressurized above the SCS entry pressure, when SCS operation is desired, then an attempt at elimination of the voiding should be made. The operator should monitor for the presence of voids. Voiding in the RCS may be indicated by any of the following indications, parameter changes, or trends:

a. letdown flow greater than charging flow,
b. pressurizer level increasing significantly greater than expected while operating pressurizer spray,
c. the RVLMS indicates that voiding is present in the reactor vessel.

* 7. If voiding should be eliminated, then proceed as follows:

a. Letdown is isolated or verified to be isolated to minimize further inventory loss,

b. The depressurization is stopped to prevent further growth of the void,

c. Pressurizing and depressurizing the RCS within the limits of Figure 11-1 may condense the void. Pressurizing has the effect of filling the voided portion of the RCS with cooler fluid which will remove heat from the region. Subsequent depressurization and a repeating of this process several times will cool and condense the steam void. In this case of a void in the reactor vessel, the pressurization/depressurization on cycle will preclude a fill and drain of the reactor vessel. The pressurization/depressurization cycle may be accomplished using pressurizer heaters and spray (preferred method) or the SIS/charging system (alternative method). Monitor pressurizer level and the RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

d. If indications of unacceptable RCS voiding continue, and voiding is suspected to exist in the (isolated) steam generator tubes, then cool the (isolated) steam generator (by steaming or blowdown, and/or feeding) to condense the tube bundle void. This will be effective for condensing steam voids but will not have an effect on non-condensible gases trapped in the tube bundle. A buildup of non-condensible gases in the tube bundle will not hinder natural circulation even with a large number of the tubes blocked. This is due to the small amount of heat transfer area required for the removal of decay heat. Monitor pressurizer level for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

e. If indications of unacceptable RCS voiding continue, then voiding may be caused by non-condensible gases. Operate the Reactor Coolant Gas Vent System to clear trapped non-condensible gases. Monitor pressurizer level and/or the RVLMS for trending of RCS inventory. This will assist the operator in assessing the effectiveness of void elimination.

8. If a cooldown is to be performed, the method to be followed should be carefully considered. The plant condition and the availability of systems and equipment may influence the cooldown method. The [Plant Technical Support Center] should

provide detailed guidance to the operator for any deviation from a normal cooldown.

If a cooldown is not required, the operator should continue to maintain the Safety Function Status Check acceptance criteria. [The Plant Technical Support Center] should evaluate the plant status and determine the course of actions to be followed.

* 9. If the plant has been cooled and depressurized to the shutdown cooling system entry conditions, the SCS should be placed in operation. In addition to the SCS pressure and temperature requirements, the NPSH requirements of the SCS pumps must be ensured. This is done by:

a) verifying that the RCS is subcooled,
b) pressurizer level is at least [14.3%] and not decreasing.

Consideration should also be given to the RCS activity levels, since the SCS will circulate RCS coolant outside containment. The circulation of highly contaminated coolant outside containment may result in the potential for radiological releases. It may also result in high radiation levels in areas requiring access for repair work.

APPENDIX A
SEVERE ACCIDENT MANAGEMENT GUIDANCE

1.0 INTRODUCTION

The purpose of this appendix is to capture and summarize the philosophy, and the key elements of the Accident Management Guidance (AMG) for System 80+. As the AMG process is still evolving in the nuclear industry, the document is not intended to be prescriptive in nature. Instead, the guidance provides the basis to allow for the Combined Operating License (COL) holder to flexibly incorporate into its plant specific Emergency Operating Procedures (EOPs) and interface these actions between the plant operating staff and members of the plant Technical Support Center (TSC).

2.0 INTERFACE WITH EPGs

ABB-CE provides a comprehensive Emergency Operations Guidelines (EOGs) package for System 80+ plant operators to cope with a wide spectrum of anticipated and abnormal plant transients. The ABB-CE guidelines provide a two-tiered approach to accident management. These include (1) accident specific guidelines for those transients that can be diagnosed and reside within the design basis plant envelope and (2) a functional recovery guideline when the transient cannot be identified, when multiple events are occurring, or when less than the minimal design basis plant equipment is available. The Functional Recovery Guidelines (FRGs) in the existing EOG package generally provides the initial entry into severe accident management.

Instead of defining detailed equipment oriented steps, the FRGs are process driven. When the operator feels the need to enter the FRGs, the FRGs guide the operator to ensure that a number of key safety functions are met. These safety functions include, but are not limited to:

1. Reactivity Control
2. RCS inventory Control
3. RCS heat Removal
4. Containment integrity

In the FRGs, the operator is guided to restore RCS inventory sources, and heat removal paths without a pre-determined knowledge of the detailed transient. Severe Accident management, the subject of this Accident Management Guidance, typically begins when both the guidance in the Accident Specific and Functional Recovery portions, particularly that related to inventory control and RCS heat removal, are unsuccessful in preventing and arresting a core damage scenario. In these scenarios, significant core uncovery and consequent core damage are expected.

In controlling the ensuing severe accident, it is the responsibility of the operator to carry out the plant recovery actions stipulated in the FRG (e.g. turning on or off pumps), while the TSC provides added mitigation guidance. The FRGs, which still remain operative, will continue to guide the operator to maintain all remaining safety functions and will therefore be conceptually similar to the TSC guidance. However, because of the complications associated with significant core damage, some actions may no longer be useful and other FRG actions may be detrimental to plant safety. As a result of the very low probability of these beyond design basis events and the heavy burden already placed on the operator to correctly and expeditiously respond to a wide range of plant transients, the control of unique severe accident mitigation guidance will primarily be the responsibility of the TSC.

With the above general organization to responding to a severe accident, the following must be addressed:

1. What are the indicators of a Severe Accident that can be used to transition accident management from the control room to the TSC?

2. What, if any, severe accident guidance should be provided to the operator so that he may respond to a rapidly evolving severe accident situation prior to transfer of accident management to the TSC?

3. Which if any EOG / FRG guidelines, would be modified once a severe accident realm is entered?

3.0 POTENTIAL SEVERE ACCIDENT EOG/AMG TRANSITION CRITERIA

Prior to entering the severe accident AMGs the operator will likely have entered into the FRGs and would have failed or is shortly expected to fail (without expectation of recovery) the RCS inventory control safety function. Thus, a sustained core uncovery would occur.

The diagnosis of an anticipated core uncovery leading to significant core damage can be made by the operator based on "in vessel" instrumentation and the status (or anticipated status) of key safety equipment. A sustained core uncovery would be anticipated when:

(1) The RVLMS indicates a very low and continuosly decreasing water level in the upper plenum

and,

(2) Safety Injection (SI) is:

(a) inoperable due to mechanical, electrical or other support system failures
(b) limited due to water resource limitations (such as SI injection following a diagnosed ISLOCA or SGTR with containment bypass)

or

(c) unavailable due to system limitations (RCS pressure greater than SI shutoff head and all FW either lost or in the process of being depleted without the possibility of alternate RCS depressurization).

If impending core uncovery is not diagnosed, the presence of an uncovered core condition can be established by:

(1) No liquid measurement in the upper plenum, as noted by the lowest RVLMS sensors

and,

(2) Core exit temperature indicative of superheat. Superheat can be inferred directly from temperature measurements only (either the CET, RVLMS HJTC or the RTD) by readings above [700°F]

or,

By inferred superheat ($T_{measured} - T_{saturation}$) greater than [50°F] using temperature measurements in conjunction with the RCS pressure

and,

(3) Safety Injection either inadequate or unavailable.

Typically Severe Accident Management Guidance will be required when a sustained core uncovery is expected and high levels of fuel oxidation is anticipated. This will occur when inventory control is expected to be lost for a long (or indefinite) time period. Under these circumstances, the Inventory Control Safety Function in the FRG has failed to be satisfied and the operator is pursuing "Continuing Actions for Inventory Control".

4.0 CONDITIONS AND TIMING ASSOCIATED WITH TRANSITION CRITERIA

The ultimate location of the accident management guidelines and their importance to operator driven actions is typically based on the timing of the severe accident scenario relative to the assembly of a functional TSC. In order to judge the ability of a TSC to cope with unfolding severe accidents, the relative timings and containment conditions associated with a wide spectrum of severe accidents were established based on System 80+ severe accident analyses presented in CESSAR DC Section 19.11.5.

A summary of information of interest to severe accident management is presented in Table 4-1. The table illustrates several points of interest. First, most scenarios will not challenge the core (experience a sustained core uncovery) within the first hour of the accident initiation. The one accident that was an exception to this rule was the Large LOCA without SI. Accordingly, the time to Reactor Vessel (RV) lower head failure is typically over two hours (again, with the exception of the large LOCA). For all transients with the exception of the small break LOCA, the hydrogen availability in containment is insufficient to require active combustion control prior to vessel breach (VB). Since the technical support centers are expected to be manned and functional within [one] hour, in general sufficient time will be available to control severe accident management strategy from the TSC. Both the TSC and operating staff will be trained on responding to severe accidents. However, since many actions may be required in the time frame immediately following the formation of the TSC, the operating staff should have some identified actions that may be required of them in this time frame. In the unlikely event that the deployment of the TSC is delayed, selected actions should also be included as considerations within the FRGs. These actions can be flagged within the "Continuing Actions for Inventory Control" Section of the EOGs for consideration once entry into a severe accident scenario has been confirmed (see criteria of section 3).

TABLE 4-1. SUMMARY OF KEY EVENT TIMING

SYSTEM 80+™

SCENARIO	TIME TO A SUSTAINED CORE UNCOVERY (SECONDS)	TIME TO CORE RELOCATION (SECONDS)	MAX. CONTAINMENT HYDROGEN CONCENTRATION PRIOR TO VESSEL BREACH VOLUME-PER CENT
LARGE LOCA W/O SI	1836	6100	4.3
ISLOCA W/SI	7700	13881	0.0
SMALL LOCA W/SI	3840	12316	8.2
SGTR W MSSV STUCK OPEN	3927	9072	0.0
TOTAL LOSS OF FW	4456	8100	<2%
STATION BLACKOUT*	6938	12581	<2%

* NO BATTERY SUPPORT

1. BASED ON CODE PREDICTIONS PRESCRIBED IN SECTION 19.11.5.
2. HYDROGEN NOT RELEASED INSIDE CONTAINMENT

5.0 SEVERE ACCIDENT MANAGEMENT GUIDANCE

Once a severe accident condition has been diagnosed, the operator will have made an assessment that actions taken within the EOGs (including the FRGs) are not accomplishing one or more safety functions, or will have an uncertain probability of arresting the transient with limited core damage. Hence the ensuing transient has the potential for considerable clad oxidation, hydrogen generation, high RCS temperatures and significant fission product releases. Thus, in addition to continuing to re-establish lost resources (i.e. SI, or feedwater), the operator and/or the TSC must deal with the expanded severe accident issues of combustion control, and fission product retention. In the context of the AMGs this requires:

1. Guidance on the operation of System 80+ Severe Accident Management mitigative features
2. Identification of EOG operator actions that may conflict or be modified in some way by the presence of high radiation areas and significant accumulation of hydrogen.
3. Identification of the use of available equipment for the primary purpose of fission product retention.

5.1 Guidance on the Operation of System 80+ Severe Accident Mitigative Features

System 80+™ includes several advanced features for coping with the highly unlikely severe core damage event. These systems include:

1. RCS Safety Depressurization System (SDS)
2. Cavity Flooding System (CFS)
3. Hydrogen Mitigation System (HMS) Igniters
4. External Connection for Internal Containment Spray
5. High Pressure Qualified Hydrogen Purge Vent

The application of these systems and the interface with the EOGs are summarized in Table 5-2.

TABLE 5-1:

SUMMARY OF AMG ACTIONS REGARDING SYSTEM 80+ MITIGATIVE EQUIPMENT

SYSTEM	DESCRIPTION	PURPOSE	ANTICIPATED APPLICATION	EOG INTERFACE
Safety Depressurization System	Motor operated pressurizer valves designed to rapidly depressurize the RCS	Applicability of SDS is primarily to allow Once Through Core Cooling (OTCC) following a total loss of feedwater. The system may also be used when SI is unavailable to depressurize the RCS prior to VB.	For severe accident operation, the operator is directed to initiate the SDS at PSV lift. This maximizes time to VB. Action occurs prior to core uncovery	Operation of SDS is included in EOGs
Cavity Flooding System	Motor operated valves designed to flood the reactor cavity with a minimum of 5 feet of water prior to VB	The pre-flooding of the reactor cavity is expected to enhance debris fragmentation and overall debris coolability	CFS actuation must occur at least 40 minutes prior to VB. It is likely this action will be directed by the TSC staff	A note should be added to the FRGs that if a severe accident condition is diagnosed and core exit temperatures are greater than [700°F] and the TSC is not yet in place the CFS should be actuated. Otherwise, take direction from TSC staff.

TABLE 5-1:

SUMMARY OF AMG ACTIONS REGARDING SYSTEM 80+ MITIGATIVE EQUIPMENT

SYSTEM	DESCRIPTION	PURPOSE	ANTICIPATED APPLICATION	EOG INTERFACE
Hydrogen Mitigation System (Igniters)	Approximately 80 distributed glow plug igniters intended to limit hydrogen accumulation by burning hydrogen concentrations at the lower flammability limit.	Operation of igniters will control hydrogen concentration in the containment following a severe accident	The HMS igniters should be actuated prior to accumulation of 4 volume percent of hydrogen in the containment. The earliest expected time for actuation of the HMS occurs at 0.5 hours following a large LOCA without SI. For most severe accident transients, HMS actuation up to 1 hour after a sustained core uncovery will properly control hydrogen. For battery depletion transients, the igniters are not expected to be needed for more than [8] hours into the event.	A note should be added to the FRGs that if a severe accident condition is diagnosed and core exit temperatures are greater than [700°F] and the TSC is not yet in place the HMS igniters should be actuated. Otherwise, take direction from TSC staff. The operators must not be encouraged to energize igniters early in a station blackout sequence. Therefore, the following caution should also be added, if the only power source to the igniters is via batteries, do not energize without igniters without permission from the TSC.

TABLE 5-1:

SUMMARY OF AMG ACTIONS REGARDING SYSTEM 80+ MITIGATIVE EQUIPMENT

SYSTEM	DESCRIPTION	PURPOSE	ANTICIPATED APPLICATION	EOG INTERFACE
External Spray Systems	System 80+ is equipped with a external flange and high pressure pump to deliver water to the containment in the event all internal containment spray systems are unavailable.	Containment spray is essential for RCS pressure control. Delayed external spray will allow pressure control of a post severe accident containment.	Actuation of the external spray system is not expected until about 24 hours following the initiation of the transient.	None. Directing the use of the external spray system and its implementation is the responsibility of the TSC.
Containment Venting	Pressure qualified hydrogen recombiner lines that purge into the annulus are available for containment venting. Used in conjunction with the annulus ventilation and filtering system the containment pressure can be controlled by a partially filtered vented release	This represents an optional pressure control strategy. Pressure control in this manner will release fission products to the environment.	Use of hydrogen venting is not expected for the System 80+ design. If it is used, venting will not be allowed for at least 24 hours following a severe accident.	None. Directing the use of the hydrogen purge vent for containment pressure control is the responsibility of the TSC.

5.2 SEVERE ACCIDENT MANAGEMENT CONFLICTS

During a severe accident, a limited number of the design basis assumptions underlying the EOGs will be violated. These typically related to the early availability of combustible gases and larger potential for fission product releases. Consequently, the appropriateness of delayed restorative operator actions must be re-evaluated. A review of the EOGs indicates a limited number of areas where the operating staff should be cautioned about taking certain actions that would otherwise be acceptable within the EOGs. Two items are of particular note. These are:

1. Restoration of Sprays following a Prolonged Core Uncovery

   and,

2. Return to operation of RCPs following a prolonged core uncovery

5.2.1 Restoration of Sprays

Sprays are essential in System 80+ for containment pressure control. However, in a hydrogen environment, the unavailability of sprays may allow sufficient steam buildup to inert a large combustible hydrogen mixture. Thus, in the process of depressurizing the containment the operator may also induce a large hydrogen burn. The presence of a severely degraded core (with high levels of core-wide oxidation and hydrogen production) must be considered prior to restoring containment sprays to a fully functional state.

Once a severe accident environment has been identified, the procedure for restoring sprays will be guided by the TSC. In this environment, spray restoration should be performed as follows:

1. Prior to spray restoration activate the HMS igniters. This allows the possibility for a number of smaller incomplete burns while the steam concentration is high. Furthermore, the potential for any detonative containment response is minimized.

2. When restoring sprays activate one train at a time. As with the above procedure, operation of one train, or a throttled train, will allow smaller incomplete burns as the atmosphere becomes de-inerted.

A more quantitative guidance can also be established which limits the spray operation based on the measured containment global hydrogen concentration. However, the ability of the operator to "control" the decompression / burn process is likely only at the lower hydrogen concentrations. Actions such as restoration of the sprays following a severe core damage event will not be expected for several hours after event initiation and therefore this action should fall into the responsibility of the TSC. Since this transfer of responsibility for an otherwise common action only is required for coping with a severe accident a caution should likely be included in the FRG.

A caution should therefore be made to the EOG, that restart of the containment spray system following the identification of a severe accident condition, only be performed with permission of the TSC.

5.2.2 Restoration of RCP operation

Following a diagnosis of a severely damaged core, restoration of the RCPs to an operating state will not be recommended unless the steam generator have adequate water supply and tubes are well covered. If SG tubes are uncovered, there is a potential that otherwise relatively stagnant steam trapped in the core region could be circulated through the steam generator with sufficient velocity to allow effective heat transfer and fail some of the weaker steam generator tubes. This can potentially cause a breach of an important fission product boundary and increase the radiation exposure to the public. The availability of a full (or nearly full) steam generator secondary side, will ensure SG tube integrity. To caution the operator of this possibility operator training should include a discussion regarding restricting pump restart when a degraded core condition has been diagnosed. Since this action is expected to be not allowed by existing EOG RCP restart criteria no specific guidance is required within the EOG.

5.2.3 Guidance on Protection of Fission Product Barriers

The entry into severe accident space results in added threats to various fission product barriers and associated additional severe accident mitigating actions. These threats typically arise later in the degraded core sequence and are generally considered within the responsibility of the TSC for their implementation. In certain instances, similar actions will also be identified for the operator within the FRGs. Actions considered new to the severe accident mitigation include:

1. Filling of SG secondary side to prevent a thermally induced SGTR, or to scrub releases following a SGTR.

2. Depressurization of a SG to effect early closure of a cycling MSSV following a SGTR with significant core damage.

3. Use of the spray system for containment fission product scrubbing, even in the absence of CCW heat removal

4. Use of the annulus ventilation and filtering system to control fission product releases following intact and vented severe accident sequences.

Item 1 is generally included within the existing FRGs, however, the primary focus of these actions in that context was to established RCS heat removal and prepare the plant for entry into shutdown cooling. In this context, these actions are valuable even if the RCS is no longer intact.

SG isolation (item 2) is required within the existing EOGs. Hence this action will likely be performed by the plant operator in the normal course of events.

The spray system has two roles. Its primary role is to preserve containment integrity by ensuring containment heat removal. Its secondary function is that of scrubbing airborne fission products. In the rare instance that its heat removal capability is compromised, or in circumstances where the containment pressure is low due to a pre-existing containment breach, the spray system can also function in the capacity of a fission product scrubbing device. This feature is not directly addressed within the EOGs but must be included in the AMGs. Use of sprays for the purpose of fission product control is the responsibility of the TSC and will typically be required later in the severe accident sequence.

System 80+™ is equipped with a Class 1E designed annulus ventilation and filter system. The initial purpose of this system was to control fission product releases following design basis accidents. As a result of improved analysis methods, this system is no longer required as a design basis system. However, its availability in a post severe accident environment can have a significant impact on fission product releases to the public. Operation of the Annulus Ventilation and Filter System is expected for all intact containment sequences and for those severe accident sequences where containment venting is used as an accident management strategy.

6.0 SUMMARY

The key actions associated with Severe Accident mitigation have been identified along with the interface between the TSC and the operating staff. In general, severe accident management guidance will be the responsibility of the TSC. However, to ensure a smooth transition of responsibility from the operating staff to the TSC, selected cautions and/or actions can be added to the FRGs. These cautions will allow the operator to take timely action for those rare events that unfold quickly, and provide a mechanism for operators to accept guidance from the TSC which might otherwise be in conflict with the EOGs. By minimizing these interface cautions the burden of operator training on severe accident issues can be restricted.

It was also noted that the AMG guidance provided herein is based on our current knowledge of severe accident management issues. This area continues to evolve. While the general guidance provided is expected to retain its applicability, the guidance is considered to be sufficiently flexible to allow the COL holder to implement plant specific TSC guidelines and Emergency Operating Procedures which reflect the state-of-the-art at the time of plant operation.

APPENDIX B

LOWER MODE OPERATIONAL GUIDANCE

1.0 INTRODUCTION

This Appendix provides the basis for the Combined Operating License (COL) applicant to develop plant specific procedures for responding to events initiated from the shutdown modes. It is based upon the evaluations in CESSAR-DC Appendix 19.8A on shutdown risk. Insights and guidance developed from those evaluations were presented in Appendix 19.8A. This information is collected and summarized in this Appendix as Lower Mode Operational Guidance (LMOG).

2.0 INTERFACE BETWEEN LMOG AND EOGs

The Emergency Operations Guidelines (EOGs) provide guidance for responding to events initiated from Modes 1 through 4. Two levels are provided. Optimal Recovery Guidelines (ORGs) apply when a specific event is identified and for which specific recovery sequences have been formulated. Functional Recovery Guidelines (FRGs) apply when a specific recovery sequence cannot be identified or when it becomes ineffective.

The EOGs may be entered from the critical Modes 1 and 2. They may also be entered from shutdown Modes 3 and 4 when SIAS has not been blocked and LTOP has not been initiated. The EOGs are typically exited when the safety functions are satisfied and after shutdown cooling has been initiated.

This LMOG may be entered from a shutdown mode following an event initiated from shutdown. It would not typically be entered directly from the EOGs because exit from the EOGs requires that LTOP has been initiated and that would imply that shutdown cooling has been established. An exception might be a situation where following an event initiated from a higher mode all success paths have been accomplished, but the event has resulted in some deficiency in components or systems for shutdown cooling that can be mitigated by the guidance in this Appendix.

3.0 CONTENT OF LMOG APPENDIX

The content of this Appendix is generally consistent with the intent of the Safety Functions that are typically dominant during shutdown events. They are:

1. Reactivity Control - events that reduce boron concentration or cause CEA withdrawal.
2. RCS Inventory Control - events that drain the RCS or that cause loss of control of RCS inventory (such as during midloop operations).
3. RCS Heat Removal - events that cause loss of the shutdown cooling system capability.
4. Containment Integrity - events that cause radiological release directly out of an open containment, as during an outage, or indirectly through systems that interface with the RCS.

The particular events that challenge these safety functions may be somewhat different in detail than events initiated from the critical power modes. In the shutdown risk evaluations reported in CESSAR-DC Appendix 19.8A the shutdown specific topics are identified. A summary of the procedural guidance from Appendix 19.8A is given here in Table B-1. It lists seven topics for which procedural guidance related to shutdown operations is provided. For each topic, Table B-1 lists significant aspects that are addressed and also lists the relevant sections of Appendix 19.8A where there is additional information. These topics are expanded in the following sections of this LMOG.

4.0 LOSS OF DECAY HEAT REMOVAL GUIDANCE

Four classes of initiators for loss of Decay Heat Removal (DHR) are identified:

I. Failure in the suction side
II. Failure in the discharge line
III. Failed pump
IV. Loss of AC Power

Table B-2 lists failure modes for these initiators and identifies instrumentation indicators and alarms that are used to evaluate and mitigate the failure.

Figure B-1 shows a diagnostic chart to identify specific initial plant configurations at the time of loss of DHR and a specific Termination Point, numbered 1 through 11. The Termination Points are coordinated in Table B-3 to information and guidance for recovery that is specific to each of the eleven initial plant configurations.

5.0 REDUCED INVENTORY OPERATIONAL GUIDANCE

5.1.0 OBJECTIVE

This section provides guidance to develop reduced inventory procedures. It contains information based on analysis and review of reduced inventory operations.

5.2.0 INITIAL CONDITIONS

5.2.1 The earliest time to enter reduced inventory operation is 4 days for shutdown from full power.

5.2.2 The reactor is subcritical, [K_{eff} < .99] for greater than (96 hrs).

5.2.3 RCS core exit temperature [< 150°F].

5.2.4 RCS level > El. [117'-0"].

5.2.5 Technical specification surveillance requirements for reduced inventory are met.

5.2.6 Maintenance activities are not being performed on the shutdown cooling system or the operable containment spray pump.

5.3.0 PRECAUTIONS

5.3.1 Reduced inventory operations duration should be minimized to reduce risk of core uncovery due to the loss of decay heat removal.

5.3.2 Perturbations affecting RCS level should be minimized during reduced inventory operations to minimize the possibility of loss of decay heat removal capabilities.

5.3.3 Isolation (closure of a containment isolation valve) in the non-operating SCS loop can reduce the possibility of an inadvertent draindown to the RCS.

5.3.4 Operations directly affecting the reactor vessel pressure boundary, i.e. In-core Instrumentation Seal Table evolutions, shall be prohibited during mid-loop operations.

5.4.0 <u>OPERATIONAL GUIDANCE</u>

5.4.1 Verify RCS vent path established per Technical Specification (3.10.3).

5.4.2 Verify that the shutdown cooling/containment spray cross connection isolation valves are administratively closed.

5.4.3 Perform the RCS drain procedure to lower RCS level to the desired reduced inventory elevation identified below:

Scheduled Maintenance Activity	RCS Elevation
S/G cold leg nozzle dams	[ ]
S/G hot leg nozzle dams RCP seal housing removal	[ ]
DVI nozzle 2A or 2B valve maintenance	[ ]

5.4.4 Monitor the following RCS/SCS system parameters during reduced inventory operations.

RCS core exit temperature	[List instruments]
SCS system flow rate	[ ]

RCS boron concentration	[ ]
SCS system temperature	[ ]
RCS pressure	[ ]
RCS level	[ ]

NOTE

Decay heat production decreases steadily with time after shutdown. Shutdown cooling system flow rate should be throttled to match heat removal requirements to reduce the possibility of vortexing.

5.4.5 Adjust SCS flow rate to match decay heat removal requirements. Minimum flow must be maintained > (3000 gpm).

5.4.6 Perform the scheduled maintenance activities while in the reduced inventory mode.

NOTE

Should reduced inventory maintenance require the installation of S/G nozzle dams, the cold leg dams shall be installed first, prior to the hot leg dams and removed last, after hot leg nozzle dam removal.

5.4.7 After the completion of the desired maintenance activities, restore RCS level to greater than elevation [117'-0"] per the applicable RCS make-up procedure.

5.5.0 ABNORMAL OPERATING CONDITIONS

5.5.1 Loss of shutdown cooling flow.

NOTE

There are a number of potential initiators that lead to the loss of shutdown cooling flow. The more probable initiators and the immediate actions to restore decay heat removal are discussed below.

A. Pump failure, i.e., bearing failure, motor failure, shaft breakage, etc.

Actions

1. Verify RCS level > minimum RCS level

2. Align the alternate SCS division, if required, for decay heat removal.

3. Start alternate division SCS system pump and verify decay heat removal capability.

4. Align the containment spray pump in the failed division for operation; hold system in standby.

5. Determine cause of SCS pump failure and determine most reliable means (division) of heat decay removal. Realign plant systems, if required, to support decay heat removal operation. If technical specification surveillance requirements/LCOs cannot be met, actions should be taken to raise RCS level to > elevation [117'-0"] as soon as possible.

B. SCS flow degradation due to vortexing

1. Secure the operating SCS pump.

2. Restore RCS level using one or more of the systems identified below. The methods of level restoration are specified in the order of preference:

   a. Operable safety injection system
   b. Alternate SCS via IRWST (requires manual valve realignment)
   c. Operable containment spray pump
   d. Charging pump alignment to the BAST or designated alternate borated water source (verify boron concentration and level before use)
   e. Safety injection tanks (verify level before use)

3. Start alternate division SCS system pump and verify decay heat removal capability.

4. Vent (if necessary) and verify containment spray pump operability as backup to SCS pump.

5. Vent failed loop SCS system pump.

6. Determine most reliable means (division) of decay heat removal. Realign plant systems, if required, to support decay heat removal operation. If technical specification surveillance requirements/LCOs cannot be met, actions should be taken to raise RCS level to > elevation [117'-0"]- as soon as possible.

C. Inadvertent SCS pump suction isolation valve closure

   1. Align, if necessary, and start the alternate SCS division pump to restore decay heat removal.

2. Realign the failed division flow path. If the SCS pump cannot be aligned, align the failed division containment spray pump.

3. Determine most reliable means (division) of decay heat removal. Realign plant systems, if required, to support decay heat removal operation. If technical specification surveillance requirements/LOCs cannot be met, actions should be taken to raise RCS level to > elevation [117'-0"] as soon as possible.

D. Loss of offsite power/station blackout

1. Align, if necessary, and start the alternate division SCS pump if power is available to the alternate pump.

2. If no power is available, restore power immediately.

3. Verify diesel generator operation and align/start the applicable division SCS pump to restore decay heat removal.

4. Start and align the combustion turbine, if available, to the Class 1E buss, only if emergency diesel generator is not available.

5. Determine most reliable means (division) of decay heat removal. Realign plant systems, if required, to support decay heat removal operation. If technical specification surveillance requirements/LOCs cannot be met, actions should be taken to raise RCS level to > elevation [117'-0"] as soon as possible.

5.5.2 Loss of coolant inventory

1. Stop/isolate leak.

2. Secure the operating SCS pump if vortexing is indicated.

NOTE

In the event of decay heat removal interruption due to the loss of forced shutdown cooling flow, alternate methods of decay heat removal, i.e., S/Gs (if available) should be considered.

3. Restore RCS inventory as described in Section 5.5.1.B.2.a through e.

4. Restore SCS flow after inventory recovery and associated venting operations are completed.

6.0 PROCEDURAL GUIDANCE ITEMS FOR SPECIFIC SHUTDOWN EVENTS

6.1 LOCA

The operator should assure that the Technical Specification LCO's pertaining to shutdown are satisfied. In particular verify the operability requirements for automatic SIS actuation in Modes 1 through 4 and the operability requirements for SIS, SCS, and CS in all modes where applicable. Assurance that these LCOs are satisfied along with an understanding of their bases assures appropriate plant and operator response.

6.2 LOSS OF DHR WITH UPPER INTERNALS IN PLACE

In Mode 6 with the upper internals in place, natural circulation between the refueling cavity and the core is restricted. Figure B-2 shows the coolant temperature vs. time after loss of DHR. With an initial coolant temperature of 135°F, the core outlet could reach the boiling temperature in 35 minutes. Recovery of DHR is outlined on Sheet 10 of Table B-3.

6.3 BORON DILUTION EVENTS

Various flow paths for borated water into the RCS are listed in Table B-4. Guidance to avoid dilution is given in the Resolution column. A particular example involves the introduction of a water slug into the RCS during startup or refueling operations. In that example, a loss of offsite power has occurred and the charging pump is returned on line, powered by an emergency power source (AAC for System 80$^+$ design). If the plant were in startup mode - i.e., deboration in progress - the charging pumps could continue to operate causing a "slug" of unborated water to collect in the lower plenum of the reactor vessel. If it is then assumed that offsite power is restored and the RCP's are restarted, then a water slug of deborated water can be injected into the core.

This scenario is avoided by not automatically restarting the charging pumps and by not using the charging pump prior to RCP restart. If inventory is needed, the operator should use the SIS and the Safety Depressurization System.

6.4 CAVITY SEAL FAILURE

Should a cavity seal fail while a spent fuel assembly is being transported, the time available to secure the fuel is dependent on the drain down time. The time to drain down the nine (9) feet of water over the top of an active fuel assembly being transferred with the refueling machine is approximately eighty (80) minutes. To preclude uncovering the fuel assembly, the assembly must be lowered below the reactor pressure vessel flange level in this time.

Loss of water depth in the refueling cavity is determined by the refueling cavity level alarm that is set two (2) inches below the nominal water level. The level monitoring system provides an indication of the water level down to the reactor pressure vessel flange elevation.

The fuel assembly may be either lowered into the reactor vessel or the end of the refueling cavity containing the transfer system upender and core support barrel (CSB) storage stand. Both of these locations provide sufficient water depth below the pool seal elevation to maintain water coverage over the fuel assembly. These two (2) areas are separated by a section of the refueling cavity that is at the elevation of the reactor pressure vessel flange. The raised section is about eleven feet long.

The refueling machine transit time over this area is less than thirty (30) seconds. The refueling machine can lower the fuel assembly below the reactor pressure vessel flange in approximately three (3) minutes in the slow speed range of the hoist. Therefore the eighty (80) minute drain down time (assuming no water makeup capability) is adequate to ensure the fuel assembly being transferred can be kept underwater in the event the pool seal develops the maximum credible leak.

TABLE B-1

SUMMARY OF PROCEDURAL GUIDANCE RELATED TO SHUTDOWN OPERATIONS

TOPIC	PROCEDURAL GUIDANCE	CESSAR-DC APPENDIX 19.8A SECTION
Unplanned Draining of the Reactor Coolant	<u>Prevention</u> Administratively Control Major Potential Draindown Paths Identified for Shutdown Modes	2.12.1, 2.12.2.1(3), 2.12.3, 2.12.3.2.1, 2.12.4
	<u>Identification</u> Monitor Instrumentation for RCS Level, Inventory and Temperature Controls a. Refueling pool level. b. Containment and subsphere sump levels. c. Level indicators and alarms: EDT, RDT, IRWST, HVT, VCT. d. RCS operational leakage (Tech. Spec. Surveillance). e. RCS level indicators and alarms. 1) Pressurizer level instrumentation 2) Wide range, dP based refueling water level instrumentation 3) Narrow range, dP based refueling water level instrumentation 4) Heated junction thermocouple probes (provided as inadequate core cooling instrumentation) 5) Heated junction thermocouple probes (clustered thermocouples provided for reduced inventory measurement)	2.3.3.1, 2.12.4, 2.8 Table 2.8-1

TABLE B-1 (Continued)

SUMMARY OF PROCEDURAL GUIDANCE RELATED TO SHUTDOWN OPERATIONS

TOPIC	PROCEDURAL GUIDANCE	CESSAR-DC APPENDIX 19.8A SECTION
Unplanned Draining of the Reactor Coolant (Continued)	Identification (Continued) f. Pressurizer Pressure g. RCS temperature 1) Core Exit Thermocouples 2) Resistance Temperature Detectors (when SCS flow is lost, the RTDs are used for trending only) 3) Shutdown Cooling a) SG Parameters b) Shutdown Cooling System	
	MITIGATION (Immediate Operator Action) Identify leakage path. Isolate leakage path. Make up losses. a. Safety Injection b. SCS via IRWST c. Containment spray from IRWST via SCS lines d. Charging pumps e. BAST f. Safety Injection Tanks	2.3.3.4, 2.12.3, 2.12.4, 2.12.2.3(2) Appendix B
Heavy Loads 1) Drop of transported equipment. 2) Drop of fuel bundle 3) Refueling pool seal integrity. 4) Loads over ICI table.	Restrictions specified for: a. Lift Height b. Travel Directions c. Systems Lineup (Specified in CESSAR DC, Chapter 9 and Plant Designer's "Heavy Load Guides")	2.11.3

TABLE B-1 (Continued)

SUMMARY OF PROCEDURAL GUIDANCE RELATED TO SHUTDOWN OPERATIONS

TOPIC	PROCEDURAL GUIDANCE	CESSAR-DC APPENDIX 19.8A SECTION
Outage Maintenance	Strategy for Shutdown Operations	2.4.3.2.2
	a. Define operating and operational divisions. b. Limit maintenance activities to components and systems not included in a).	Appendix B
Fire Protection	Administratively require fire protection systems to remain operable in shutdown modes.	2.7.3.2, and 2.7.3.3
	Procedurally Control: a. Combustible materials b. Housekeeping c. Hot work	
	Pre-Fire Plan a. Outline fire fighting strategies b. Monitor status of fire barriers	2.7.3.2
RCS Cooling Using Feed and Bleed (other systems not available)	RCS Pressurized	
	1. Start SI pump.	2.4.3.1.3.1 1
	2. Reduce pressure through Safety Depressurization System (SDS) venting to IRWST. (Maintain subcooled temperatures in RCS). 3. Secure operating RCPs (if applicable) 4. Cycle SI feed and SDS bleed to reduce RCS pressure and temperature.	2.4.3.1.3.2.1

TABLE B-1 (Continued)

SUMMARY OF PROCEDURAL GUIDANCE RELATED TO SHUTDOWN OPERATIONS

TOPIC	PROCEDURAL GUIDANCE	CESSAR-DC APPENDIX 19.8A SECTION
	RCS Pressurized (Continued) 5. When depressurized, open SDS and Run SI continuously. 6. Align SDC heat exchanger for IRWST cooling. 7. Restore Normal SDC systems. RCS Depressurized 1. Start SI 2. Open SDS 3. Secure RCP's (if RCS not vented) 4. Align SDC heat exchanger for IRWST Cooling. 5. Restore normal SDC Systems	
SG Tube Rupture	Include in Emergency Procedure Guides a requirement to maintain a positive primary to secondary pressure differential.	Table 2.6-1 Section C(a)
Lockout of main feedwater pumps in shutdown modes with RTCBs closed.	Administratively lockout main feedwater pumps if subcritical.	4.1.1 and 4.1.2

TABLE B-2

SCS INSTRUMENTATION

INITIATOR	ITEM	RESULT	INDICATORS/ALARMS	
I - FAILURE IN THE SUCTION LINE				
Inadvertent signal closes motor operated valve	SI-651, 653, 655 OR SI-652, 654, 666	Loss of Cooling Flow	Low Flow Alarm Fluctuating Discharge Pressure Current Fluctuations Low Suction Pressure Position indication on valve operators	FI-302 & FI-305
Operator error in closing SCS suction isolation valve	SI-106 & SI-107	Loss of Cooling Flow	Low Flow Alarm Fluctuating Discharge Pressure Current Fluctuations Low Suction Pressure Position indication on valve operators	FI-302 & FI-305 P-302 & P-305 I-306 & I-307 P-300 & P-301
Low RCS level resulting in vortex formation and air entrainment		Pumps will cavitate resulting in Loss of Cooling Flow	Low Flow Alarm Fluctuating Discharge Pressure Current Fluctuations Low Suction Pressure RCS level	
II - FAILURE IN THE DISCHARGE LINE				
Inadvertent signal closes motor operated valve	SI-310 & 312, 601 OR SI-311 & 313, 600	System resistance increases causing the pump to operate near shutoff	Low Flow Alarm Fluctuating Discharge Pressure Current Fluctuations Low Suction Pressure RCS level	FI-302 & FI-305 P-302 & P-305 P-300 & P-301 I-306 & I-307

TABLE B-2 (Continued)

SCS INSTRUMENTATION

INITIATOR	ITEM	RESULT	INDICATORS/ALARMS	
Operator error in closing scs discharge isolation valve	SI-579, 578	System resistance increases causing the pump to operate near shutoff	Low Flow Alarm Fluctuating Discharge Pressure Current Fluctuations Low Suction Pressure RCS level	FI-302 & FI-305 P-302 & P-305 P-300 & P-301 I-306 & I-307
Inadvertent signal opens motor operated valve	SI-690, 691	System resistance decreases causing increase in pump flow. Also, flow split may cause rcs to heat up as less flow will be delivered.	High flow indication low discharge pressure suction pressure decreases increased power consumption position indication on valve operators	FI-302 & FI-305 P-302 & P-305 P-300 & P-301 I-306 & I-307
Valves in the IRWST test path not closed following completion of sc full flow test	SI-315,693 & 301 OR SI-304,686 & 300	Pumps will drain the rcs inventory into the IRWST through the test path then lose suction as the fluid in the hot leg drops	Liquid level instr for midloop operation Rapid decrease in RCS pressure Rapid decrease in RCS level Liquid level alarms in the IRWST Temp indication in the IRWST AFTER LEVEL DECREASES BELOW MIDLOOP Low flow alarm Normal Discharge Pressure Current fluctuations Low Suction Pressure	SEE SECTION 2.3 L-350, L-351 T-350, T-351 FI-302 & FI-305 P-302 & P-305 I-306 & I-307 P-300 & P-301

TABLE B-2 (Continued)

SCS INSTRUMENTATION

INITIATOR	ITEM	RESULT	INDICATORS/ALARMS	
SCS active train is used to fill refueling pool	SI-450 & 458 SI-454 & 455	The SCS has been designed to support epri requirement 4.3.1.2 For refueling pool (RFP) fill. If the RFP is filled using the train performing SC, then the RCS inventory could be transferred to the RFP.	No detection until rcs inventory decreases Decreases below the midloop. Low Flow Alarm Normal Discharge Pressure Current Fluctuations Low Suction Pressure	 FI-302 & FI-305 P-302 & P-305 P-300 & P-301 I-306 & I-307
Inadvertent cross connect to the Containment Spray System	SI-341, 343	Loss of Coolant flow	Low RCS level	
III - FAILED PUMP Shaft failure		Loss of Coolant flow	Low Flow Arm No Discharge Pressure No Suction Pressure	FI-302 & FI-305 P-305 & P-306 P-300 & P-301
IV - LOSS OF AC POWER				

TABLE B-3

RESTORATION OF DHR FROM

TERMINATION POINT 1*

Plant Configuration	Modes 4, 5 or 6
Initiators	Loss of power
Applicable Technical Specifications	LCO 3.8.1 - 3.8.8
Procedural Requirements	See Table b-1
Recovery From Initiators	Each Division has 3 power sources: 1) Normal-Permanent Non-safety Bus (PNS-Bus) 2) Alternate Reserve Transformer 3) Emergency Diesel Generator The power to the safety bus from the PNS-Bus has 3 sources of power: 1) Unit Auxiliary Transformer, Switchyard Interface I 2) Alternate Reserve Transformer, Switchyard Interface II 3) Combustion Turbine

* See Figure B-1 for identification of termination points.

TABLE B-3 (Continued)

RESTORATION OF DHR FROM

TERMINATION POINT 2*

(This Termination Point has been deleted, but the numbering of the remaining points was retained for continuity and consistency)

* See Figure B-1 for identification of termination points.

TABLE B-3 (Continued)

RESTORATION OF DHR FROM

TERMINATION POINT 3*

Plant Configuration	Mode 4. IRWST full.
Initiators	Group I - III (Table B-2) (for RCS pressure less then [450] psia) Group IV RCS line break.
Applicable Technical Specifications	LCO 3.4.6 Two RCS loops or two SCS trains or any combination of these to be operable. One RCS loop or SCS train to be in operation. LCO 3.5.1 Four SIT's operable when pressurizer pressure is greater than [900 psia]. LCO 3.5.3 Two SIS trains operable. LCO 3.5.4 IRWST operable. LCO 3.6.6 Two CSS trains operable.
Alternative Support Equipment/Systems	None required.
Recovery From Initiators	DHR will be provided by sources other than the SCS when the RCS pressure is above [450] psia. During these conditions, the ECCS will be operable. The SIS will be available by automatic actuation down to RCS pressures of 400 psia (SIAS cutout pressure) and manual actuation at any time. The CSS is operable throughout Mode 4. Below [450] psia Group I - IV initiators can be mitigated per CESSAR-DC Appendix 19.8A Section 2.4.3.1.

* See Figure B-1 for identification of termination points.

TABLE B-3 (Continued)

RESTORATION OF DHR FROM

TERMINATION POINT 4*

Plant Configuration	Mode 5 RCS in reduced inventory. Nozzle dams installed. IRWST full.
Initiators	Group I-IV. RCS line break.
Applicable Technical Specifications	LCO 3.4.8 Two SCS trains operable. One SCS train operating. LCO 3.4.11 LTOP operable. LCO 3.5.3 Two SI pumps operable. LCO 3.8.2 AC Power (Shutdown) LCO 3.10.3 Midloop vent operable. LCO 3.10.4 One CS pump operable. LCO 3.10.6 AC Power Availability LCO 3.10.7 DC Distribution Center
Procedural Requirements	Maintain shutdown cooling (SC) flow rate near the minimum required for DHR.
Alternative Support Equipment/Systems	Pumps... Charging pump. Boric Acid Make-up pump. Tanks... Safety Injection Tanks (SIT) Boric Acid Storage Tank (BAST)
Recovery From Initiators	Regain inventory control... SC, CS or SI pumps can be used to inject IRWST water into the RCS to regain water level. If these pumps are not functional inventory control can be established using a charging pump or boric acid make-up pump by injecting BAST water into the RCS. Regain DHR capability... DHR can be regained by using the redundant SCS train once level is recovered. If the redundant SC pump is not functional DHR can be established using the CS pump. If the CS pump is not functional, DHR can be established by feed and bleed using SI pumps and opening the SDS valves.
Time To Boil	Approximately 10-15 minutes.

* See Figure B-1 for identification of termination points.

TABLE B-3 (Continued)

RESTORATION OF DHR FROM TERMINATION POINT 5*

Plant Configuration	Mode 5. RCS in reduced inventory. Nozzle dams not installed. RCS closed (mid loop vent or RCP seals). IRWST full.
Initiators	Group I-IV. RCS line break.
Applicable Technical Specifications	LCO 3.4.8 Two SCS trains operable. One SCS train operating. LCO 3.4.11 LTOP operable. LCO 3.5.3 Two SI pumps operable. LCO 3.8.2 AC Power (Shutdown) LCO 3.10.3 Midloop vent operable. LCO 3.10.4 One CS pump operable. LCO 3.10.6 AC Power Availability LCO 3.10.7 DC Distribution Center
Procedural Requirements	Maintain shutdown cooling (SC) flow rate near the minimum required for DHR.
Alternative Support Equipment/Systems	Pumps... Charging pump. Boric Acid Make-up pump. Tanks... Safety Injection Tanks (SIT) Boric Acid Storage Tank (BAST) Steam Generators
Recovery From Initiators	Regain inventory control... SC, CS or SI pumps can be used to inject IRWST water into the RCS to regain water level. If these pumps are not functional inventory control can be established using charging pump or boric acid make-up pump by injecting BAST water into the RCS. Regain DHR capability... DHR can be regained by using the redundant SCS train. If the redundant SC pump is not operable DHR can be regained using the CS pump. If the CS pump is not functional DHR can be established initially by reflux boiling, then by feed and bleed using SI pumps and opening the SDS valves.

* See Figure B-1 for identification of termination points.

TABLE B-3 (Continued)

RESTORATION OF DHR FROM
TERMINATION POINT 6*

Plant Configuration	Mode 5. RCS in reduced inventory. Nozzle dams not installed. RCS open (manway) IRWST full.
Initiators	Group I-IV. RCS line break.
Applicable Technical Specifications	LCO 3.4.8 Two SCS trains operable. One SCS train operating. LCO 3.4.11 LTOP operable. LCO 3.8.2 AC Power (Shutdown) LCO 3.10.3 Midloop vent operable. LCO 3.10.4 One CS pump operable. LCO 3.10.6 AC Power Availability LCO 3.10.7 DC Distribution Center
Procedural Requirements	Maintain shutdown cooling (SC) flow rate near the minimum required for DHR.
Alternative Support Equipment/Systems	Pumps... Charging pump. Boric Acid Make-up pump. Tanks... Safety Injection Tanks (SIT) Boric Acid Storage Tank (BAST) Steam Generators
Recovery From Initiators	Regain inventory control... SC, CS, SC or SI pumps can be used to inject IRWST water into the RCS to regain water level. If these pumps are not functional inventory control can be established using charging pump or boric acid make-up pump by injecting BAST water into the RCS. SITs can also be used. Regain DHR capability... DHR can be regained by using the redundant SCS train. If the redundant SC pump is not operable DHR can be regained using the CS pump. IF the CS pump is not functional, DHR can be established by reflux boiling, or feed and bleed using CS or SI pumps and utilizing the open pressurizer manway.

* See Figure B-1 for identification of termination points.

TABLE B-3 (Continued)

RESTORATION OF DHR FROM TERMINATION POINT 7*

Plant Configuration	Mode 5. RCS not in reduced inventory. Nozzle dams installed. IRWST full.
Initiators	Group I-IV. RCS line break.
Applicable Technical Specifications	LCO 3.4.8 Two SCS trains operable. One SCS train operating. LCO 3.4.11 LTOP operable. LCO 3.8.2 AC Power (Shutdown) LCO 3.10.3 Midloop vent operable. LCO 3.10.4 One CS pump operable. LCO 3.10.6 AC Power Availability LCO 3.10.7 DC Distribution Center
Procedural Requirements	One CS pump available. Midloop vent operable.
Alternative Support Equipment/Systems	Pumps... CS pump. SI pump. Charging pump. Boric Acid Make-up pump. Tanks... Safety Injection Tanks (SIT) Boric Acid Storage Tank (BAST)
Recovery From Initiators	Regain DHR capability... DHR can be regained by using the redundant SCS train. If the redundant SC pump is not functional DHR can be regained using the CS pump. If the CS pump is not functional, DHR can be established by feed and bleed using SI pumps and utilizing the open pressurizer manway.

* See Figure B-1 for identification of termination points.

TABLE B-3 (Continued)

RESTORATION OF DHR FROM TERMINATION POINT 8*

Plant Configuration	Mode 5. RCS water level above reduced inventory. Nozzle dams not installed. IRWST full.
Initiators	Group I-IV. RCS line break.
Applicable Technical Specifications	LCO 3.4.8 Two SCS trains operable. One SCS train operating. LCO 3.4.11 LTOP operable. LCO 3.5.3 Two SI Pumps operable.
Procedural Requirements	One CS pump available.
Alternative Support Equipment/Systems	Pumps... CS pump. SI pump. Charging pump. Boric Acid Make-up pump. Tanks... Safety Injection Tanks (SIT) Boric Acid Storage Tank (BAST) Steam Generators
Recovery From Initiators	Regain DHR capability... DHR can be regained by using the redundant SCS train. If the redundant SC pump is not functional, DHR can be regained using the CS pump. If the CS pump is not functional, DHR can be established by reflux boiling, or feed and bleed using SI pumps and opening the SDS valves.

* See Figure B-1 for identification of termination points.

TABLE B-3 (Continued)

RESTORATION OF DHR FROM
TERMINATION POINT 9*

Plant Configuration	Mode 6 Refueling pool empty IRWST Full
Initiators	Group I-IV LOCA
Applicable Technical Specifications	LCO 3.9.5 Two SCS trains operable. One SCS train operating. LCO 3.5.3 Two SI pumps operable.
Alternative Support Equipment/Systems	One CS pump available.
Recovery From Initiators	Regain DHR capability... DHR can be regained using the redundant SCS train. If the SCS pump is not functional, DHR can be regained using the CS pump and SCS heat exchanger. If the CS pump is not functional, DHR can be established using feed and bleed since the IRWST is not fully drained.

* See Figure B-1 for identification of termination points.

TABLE B-3 (Continued)

RESTORATION OF DHR FROM
TERMINATION POINT 10*

Plant Configuration	Mode 6. Refueling pool filled. Reactor vessel head off. Upper internals in place. IRWST empty.
Initiators	Group I-IV RCS line break.
Applicable Technical Specifications	LCO 3.9.4 For high water level, one SCS train operable and in operation. LCO 3.9.5 For low water level, two SCS trains operable and one in operation.
Procedural Requirements	One CS pump available.
Alternative Support Equipment/Systems	Instrumentation... Refueling Pool water level indication in addition to high and low level alarm. Pumps... Charging pumps. Boric acid make-up pumps. Tanks... Boric Acid Storage Tank (BAST)
Recovery From Initiators	Regain DHR capability... DHR can be regained by using the redundant SCS train. If the redundant SCS pump is not functional, DHR can be established by either passive or active means as described in CESSAR-DC Appendix 19.8A Section 2.10.3. If DHR has been defeated due to an inter-system LOCA, DHR can be regained by matching boil-off using the charging pumps or boric acid make-up pumps injecting BAST water. See Figure B-2

* See Figure B-1 for identification of termination points.

TABLE B-3 (Continued)

RESTORATION OF DHR FROM TERMINATION POINT 11*

Plant Configuration	Mode 6. Refueling pool filled. Reactor vessel head off. Upper internals removed. IRWST empty.
Initiators	Group I-IV RCS line break.
Applicable Technical Specifications	LCO 3.9.4 For high water level, one SCS train operable and in operation. LCO 3.9.5 For low water level, two SCS trains operable and one in operation. LCO 3.9.4 Two SCS pumps operable.
Procedural Requirements	One CS pump available.
Alternative Support Equipment/Systems	Instrumentation... Refueling Pool water level indication in addition to high and low level alarm. Pumps... Charging pumps. Boric acid make-up pumps. Tanks... Boric Acid Storage Tank (BAST)
Recovery From Initiators	Regain DHR capability... DHR can be regained by using the redundant SCS train. If the redundant SCS pump is not functional, DHR can be established by feed and bleed. If DHR has been defeated due to an inter-system LOCA, DHR can be regained by matching boil-off using the charging pumps or boric acid make-up pumps injecting BAST water.

* See Figure B-1 for identification of termination points.

TABLE B-4

POSSIBLE FLOW PATHS OF NON-BORATED WATER

SYSTEM	FLOW PATH	RESOLUTION
A. SAFETY INJECTION SYSTEM		
1. STANDBY	a. RCS leakage through 1st isolation check valve (SI-217,-227,-237,-247) REF: PFS-91-044	a. Results in a diluted slug of water (assumed 0 ppm boron) with a volume of 30 cu. Ft. Per dvi line (120 cu. Ft. Total)
	b. Leakage through SIS Hot Leg injection isolation valve (si-522,-532) dilutes sis hot leg injection line	b. Results in a diluted slug of water. Hot Leg injection is only used 2 to 4 hours post loca, when shutdown margin is large. Slug will mix with highly borated water before entering core.
	c. Inadvertent refill of sis sections with non-borated water post-maintenance	c. The operator must avoid using non-borated sources of water to refill the SIS. (No practical sources exist in the System 80+™ design)
2. SIS OPERATION	NONE	SIS pumps take suction from borated IRWST

TABLE B-4 (Continued)

POSSIBLE FLOW PATHS OF NON-BORATED WATER

SYSTEM	FLOW PATH	RESOLUTION
B. SHUTDOWN COOLING SYSTEM		
1. STANDBY (ISOLATED)	a. Leakage of RCS fluid through 1st Isolation Valve (SI-651,-652)	a. - Leakage is into a borated SCS, will not result in a slug of pure water - Operator should warm up SCS and check Boron Concentraion before injecting into RCS
	b. Leakage of component cooling water through a ruptured schx tube	b. - Leakage is into a borated SCS - Dilution would be bounded by check valves and normally closed gate and globe valves - Maximum dp is 150 psig, pressure would quickly stabilize before significant dilution results - Approximate dilution of 1 gallon - Operator checks boron concentration upon SCS heatup, will detect dilution and correct before injection
	c. Inadvertent refill of SCS sections with non-borated water post-maintenance	c. Operator verifies that no non-borated sources of water are used to refill the SCS. (no practical sources exist in the System 80+™ Design)

TABLE B-4 (Continued)

POSSIBLE FLOW PATHS OF NON-BORATED WATER

SYSTEM	FLOW PATH	RESOLUTION
2. SCS OPERATION (NON-ISOLATED)	a. Leakage of ccw through ruptured schx tube	a. - If CCWS pressure > SCS pressure, CCW inflow will mix with flow from hot leg, boron conc. >0 ppm - Pressure from operating SCS pump is likely to create a dP such that CCW inflow is precluded - Loss of CCW inventory into SCS will eventually be detected by CCW surge tank low level alarms - Possible volume of leakage and resulting boron conc. Is small compared to the CESSAR-DC Chapter 15 analysis, inadvert. Boron dilution event - This event is not coincident with the charging pump event of CESSAR-DC Chapter 15, Section 15.4.6
	b. Injection of pure water through CVCS purification line into SCS	b. Only source of non-borated water in CVCS is the RMWST...Design of CVCS prevents this situation (i.E., Multiple failures are necessary for this to occur)
C. REACTOR COOLANT SYSTEM STEAM GENERATORS	a. Steam Generator Tube Rupture resulting in secondary flow to RCS	a. Procedures will require that a positive dP exist between primary and secondary sides of S.G. REF: RAI 440.109
	b. Leakage of secondary fluid through ruptured tube during hydrostatic test with fuel in core, dP of 800 psig (after major steam generator maintenance)	b. Operator will detect pressure change and correct before starting RCPs Very unlikely that fuel will be in core during this test

TABLE B-4 (Continued)

POSSIBLE FLOW PATHS OF NON-BORATED WATER

SYSTEM	FLOW PATH	RESOLUTION
D. CHEMICAL AND VOLUME CONTROL SYSTEM (CVCS)	a. Upon startup from mode 6, power is lost...RCPs and charging pumps shut off, diesels power up and charging pumps continue to provide flow to vessel (pure water). RCPs start once offsite power is restored and pump slug of diluted water into core REF: NRC INFO. NOTICE 91-54	a. Charging pumps are powered off AAC source (Gas Turbine), pumps must be manually aligned to AAC bus by operator. Avoid using charging pump prior to restart of RCPs. See also Section 6.3 of this LMOG.
	b. Unable to borate VCT due to nitrogen gas binding of BAMPs	b. BASTs are not pressurized by any gas, vented to GWMS..precludes gas binding of BAMPs
	c. Injection of pure water into RCS from the RMWST	c. Design of CVCS prevents this situation (I.E., Multiple failures are necessary for this to occur) however, considered in the CESSAR-DC Chapter 15 analysis.

FIGURE B-1

PLANT STATES AND TERMINATION POINTS
FOR RESTORATION OF DHR

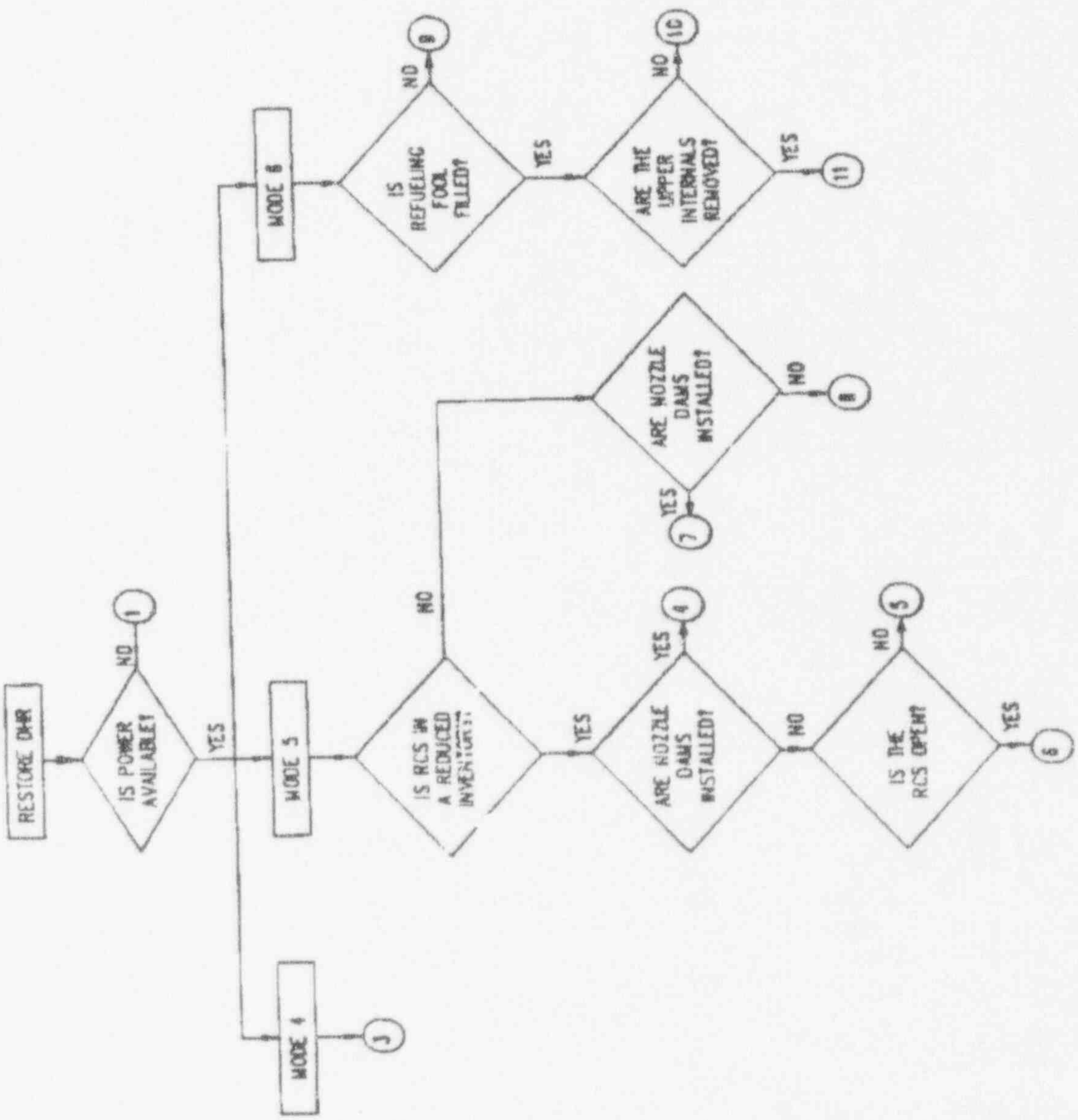

FIGURE B-2

RESULTS OF MODE 6
NATURAL CIRCULATION ANALYSIS OF SYSTEM 80+™
TEMPERATURE VS. TIME