CEN - 152

COMBUSTION ENGINEERING EMERGENCY PROCEDURE GUIDELINES

Prepared for the C-E OWNERS GROUP

NUCLEAR POWER SYSTEMS DIVISION
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POWER SYSTEMS
COMBUSTION ENGINEERING, INC.

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ABSTRACT

This report has been prepared in response to Item I.C.1 of NUREG-0737, Guidance for the Evaluation and Development of Procedures for Transients and Accidents. The revised Emergency Procedure Guidelines contained in this report supercede the Emergency Procedure Guidelines contained in Appendix A of CEN-128.

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DEFINITIONS OF TERMS USED IN THE EMERGENCY PROCEDURE GUIDELINES

Action.	The specific required output of a single system in response to specific inputs or conditions imposed on the system.
Safety Function	The net, total effect of one or more safety actions which have the objective of preventing or mitigating the consequences of an event in order to achieve an acceptable event termination.
Event	An unanticipated plant disturbance. The plant conditions which result in being defined as events require operator action to preclude a worsening of plant status, if left unattended, and to allow for the reinstatement of a safe, controlled operating mode.
Reactivity Control.	Provision of sufficient negative reactivity to the core to provide control of reactor power.
RCS Heat Removal.	Maintenance of sufficient heat transfer from the reactor fuel to the reactor coolant, and sufficient capability to remove heat from the reactor coolant.
RCS Inventory Control	Maintenance of sufficient reactor coolant volume.
RCS Pressure Control.	Maintenance of RCS pressure within a range.

List of Acronyms and Abbreviations

AC....Alternating current

ADV...Atmospheric dump valve

AFW...Auxiliary feedwater

AFAS..Auxiliary feedwater actuation signal

ANSI..American nuclear standards institute

ATWS..Anticipated transient without SCRAM

CVCS..Chemical volume control system

CST...Condensate storage tank

CIAS..Containment isolation actuation signal

CSAS..Containment spray actuation signal

CSS...Containment spray system

CEA...Control element assembly

CEDM..Control element drive mechanism

ESF...Engineered safety features

EFAS..Emergency feed actuation signal

EPG...Emergency Procedure Guideline

HPSI..High pressure safety injection

ICC...Inadequate core cooling

LOCA..Loss of coolant accident

LOMF..Loss of feedwater

LPSI..Low pressure safety injection

MFW...Main feedwater

MFIV..Main feedwater isolation valve

MSIS..Main steam isolation signal

MSIV..Main steam isolation valve

MSLB..Main steam line break

MSSV..Main steam safety valve

PSIA..Pounds per square inch, absolute

PSIG..Pounds per square inch, gage

PORV..Power operated relief valve

PPCS..Pressurizer pressure control system

PLCS..Pressurizer level control system

RCP...Reactor coolant pump

RCS...Reactor coolant system

RAS...Recirculation actuation signal

List of Acronyms and Abbreviations (cont'd)

SCRAM..Super critical reactor ax man

SIAS...Safety injection actuation signal

SIS....Safety injection system

SCS....Shutdown cooling system

SGTR...Steam generator tube rupture

SLB....Steam line break

SBLOCA.Small break loss of coolant accident

SMM....Subcooled margin monitor

T_c.....Reactor coolant system cold leg temperature

T_h.....Reactor coolant system hot leg temperature

T_{avg}...Average reactor coolant system temperature

T_{ref}...Reactor coolant system reference temperature

TMLP...Thermal margin/low pressure

TBCS...Turbine bypass control system

TBV....Turbine bypass valve

VCT....Volume control tank

1.0 Introduction

1.1 Purpose

The purpose of this report is to provide the C-E Emergency Procedure Guidelines System in response to Item I.C.1 of NUREG-0737, "Guidance for the Evaluation and Development of Procedures for Transients and Accidents". On April 1, 1980, CEN-128, entitled "Response of Combustion Engineering Nuclear Steam Supply System to Transients and Accidents" was submitted to the NRC. This submittal was made in response to Section 2.1.9 of NUREG-0578, "TMI-2 Lessons Learned Task Force Status Report and Short-Term Recommendations". CEN-128 contains the original package of guidelines which form the bases for the revised emergency procedure guidelines being provided in this report. Subsequently, Item I.C.1 of NUREG-0737 required that emergency procedure guidelines (EPGs) be revised to improve the technical content and to expand the scope of multiple failures addressed. The revised EPGs in this report supercede the earlier EPGs that were presented in Appendix A of CEN-128.

The operational information contained in the C-E EPG system, when combined with other balance of plant information, provides the technical input for the utilities owning C-E Nuclear Steam Supply Systems to develop detailed emergency procedures within their plant procedures system.

The format which C-E has chosen for the EPGs provides an efficient and effective vehicle for transmittal of NSSS operational information. There is no requirement intended for the utilities to duplicate the C-E format in the development of their emergency procedures.

1.2 Scope

The EPG system is to be used by the utilities in the development of their emergency procedures. Technical information, which C-E has knowledge and appropriate responsibility for, is contained in this report.

The EPG system consists of both EPGs and an Inadequate Core Cooling (ICC) package. The following guidelines are contained in this report:

- Reactor Trip Guideline
- Anticipated Transient Without SCRAM Guideline
- Loss of Coolant Accident Guideline
- Steam Generator Tube Rupture Guideline
- Loss of Feedwater Guideline
- Loss of Forced Reactor Coolant Flow Guideline
- Steam Line Break Guideline

The ICC guidance package includes a functionally oriented status and trending diagnostic and matrix of corrective responses for each critical function addressed.

1.3 Background

The need for improvement in the area of operational guidance has been recognized for some time. This is especially true since the TMI event. Considerable effort has been made in improving the technical content of operational information and in improving the framework for delivering this information. C-E report, CEN-156, entitled "Emergency Procedure Guidelines Development", details these efforts. The result of this process is the improved EPG system contained in this report. The EPG system provides an improved technical content contained in an improved framework for conveying this information.

The following features have been incorporated into the improved EPG system:

- Event oriented EPGs address multiple failures. Multiple failures include the failure of more than one steam generator tube, loss of both main and auxiliary feedwater, operator errors of both omission and commission;

- Information pertaining to the availability of systems and alternative operator actions;

- Strategy charts to clearly and simply show the strategy employed in each guideline;
- Break identification charts to aid in the diagnosis of break location and for the confirmation of that diagnosis;
- Saturation/subcooling curves as an aid to the operator;
- ICC guidance package containing a plant status and trending diagnostic and a matrix of corrective responses.

1.4 Relationship to Previous Work

Four significant topical reports provide the basis for the work presented in this report.

The small break LOCA scenario was analyzed in CEN-114. The analysis documented in CEN-114 identified the importance of the behavior of the reactor coolant pumps during an accident. A study of RCP influence was performed and is documented in CEN-115. This report, again, demonstrated the capability of the C-E NSSS to withstand a small break LOCA. The principal impact of the LOCA studies documented in reports CEN-114 and CEN-115 was that they served as a basis for revision of the C-E LOCA emergency procedure guidelines.

To provide a basis for the development of the operator guidance conerning inadequate core cooling (ICC), C-E performed a study to determine the capabilities of the instrumentation used in the detection of an ICC condition. The results of the study were used as a basis for preparing the ICC guidance package.

C-E prepared CEN-128, a report entitled "Response of Combustion Engineering Nuclear Steam Supply System to Transients and Accidents". This report was submitted to the NRC in response to Section 2.1.9 of NUREG-0587, "TMI-2 Lessons Learned Task Force Status Report and Short-Term Recommendations". CEN-128 contains the original package of guidelines which form the bases for the revised emergency procedure guidelines, which are being provided in this report.

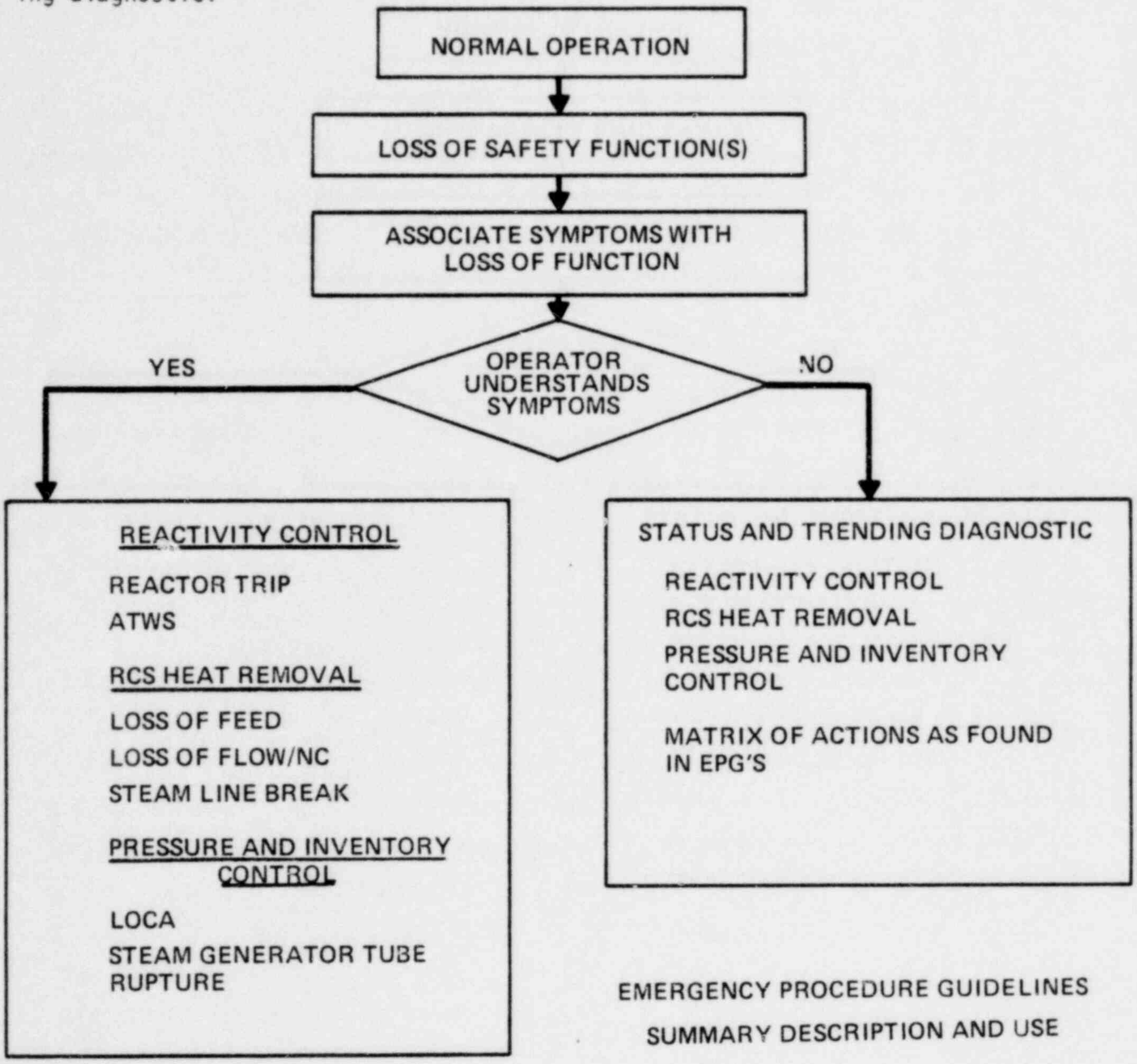
2.0 Description of Guidelines

2.1 General Description

The EPGs contained in this report provide a basis for the utilities to review and revise, if necessary, their existing plant emergency procedures. The guidelines presented are based on existing emergency and licensing information, new realistic event and analyses, and information obtained through workshops held with personnel from C-E and from C-E NSSS supplied utilities.

Regulatory Guide 1.33 and ANSI 18.7 provide guidance as to the types of procedures necessary to operate a plant. These include administrative procedures, procedures for maintenance, detailed procedures for operation of a system or component, normal plant operating procedures (e.g., plant startup, plant shutdown), and emergency procedures. Emergency procedures are written to provide a conservative course of action to the plant operator to deal with an emergency. These procedures are written to provide guidance for integrated plant operations as opposed to detailed system or equipment operating procedures. For example, an emergency procedure may call for using the residual heat removal system. The details of how to realign the valves or pumps of the residual heat removal system are contained in the system operating procedure, rather than the emergency procedure that calls for the use of this system. The guidelines presented in this report are written to serve as input to the plant emergency procedure development process. The guidelines contain a level of detail consistent with plant emergency procedures. The guidelines contained in this report are generic to C-E NSSS supplied plants.

The EPGs, when combined with the plant status and trending diagnostic included in the ICC guidance package, form a system that provides the operator two diverse paths for implementing the emergency procedures. Refer to Figure 2.1-1. The first path provided is to match symptom sets seen in the control room with symptom sets provided in the emergency procedures. If the operator has misdiagnosed events due to a similarity in symptoms, he can implement the correct emergency procedure by accessing it via the safety functions by using the plant status and trending diagnostic.



EMERGENCY PROCEDURE GUIDELINES

SUMMARY DESCRIPTION AND USE

2.2 Format and Content

A format for the guidelines was chosen (1) which provides a maximum effectiveness in the transmittal of information from the designer/analyst to the owner/operator and (2) which is compatible with the system of procedures currently in use. Each guideline contains the following sections: bases, symptoms, immediate actions, follow-up actions and precautions.

The bases section provides sufficient information for the operator to understand the intent of the procedure. This includes:

1. A walkthrough of the event addressing the full range of plant responses;
2. A discussion of the essential safety functions challenged by the event;
3. A discussion of the symptoms associated with the event;
4. A discussion of the actions taken and the functions that these actions are accomplishing.

The symptoms section contains a listing of parameters which characterize the event. This section was developed by using the results of the realistic transient analysis, as well as previous analytical and licensing results. The symptoms section includes key parameters (some of which may be non-changing) to aid in event recognition. Information has been gathered by surveying the types of indication available in the control room and determining which parameters are most closely monitored by the operator. This information has provided a basis for the choice of those symptoms listed in the symptoms section.

The immediate action section contains those actions which are required to place the plant in a stable condition. Within a given guideline, these actions are prioritized to address important functions, and are compatable with the actions called for by other events that exhibit similar symptoms.

The follow-up actions section contains those actions that confirm the diagnosis and place the plant in a condition that allows recovery to be accomplished. This could be either a return to conditions where normal operating procedures apply or a long-term shutdown condition, if necessary. The essential safety functions have been addressed in both the immediate and follow-up actions sections of the guidelines. Regardless of the cause of the emergency condition, there are certain functions that must be addressed to ensure plant safety. Each safety function is either addressed directly within a given guideline, or a reference is made to another guideline which contains the required actions for accomplishment of the safety function.

The precautions provide additional information to the operator to alert him to measures that ensure plant safety.

2.3 Operator Aids

Several features have been included in order to aid the operator in diagnosing and dealing with an accident. These are strategy charts, break identification charts and saturation/subcooling curves. The strategy charts aid in showing clearly and simply the strategy used in each guideline. Break identification charts aid in the diagnosis of break location and in the confirmation of that diagnosis. Saturation/subcooling curves aid the operator in maintaining an appropriate degree of subcooling during both the accident and subsequent plant operations.

2.4 Generic and Plant Specific Information

The guidelines have been developed generically for all C-E plants. Since there are NSSS and BOP systems which may vary from one plant to another, the use of brackets...[ ]...was incorporated in the guidelines. If a system, component, or measurement set point is plant specific, it is enclosed by a set of brackets. This will enable each utility to verify the bracketed information for their plant and adjust their procedures accordingly.

3.0 REACTIVITY CONTROL GUIDELINES

Although all the critical safety functions are addressed in each emergency procedure guideline, generally, the control of one of the safety functions is of more immediate importance than the others. It is possible to group the guidelines on this basis. The guidelines contained in the following sections are:

3.1 REACTOR TRIP GUIDELINE

3.2 ANTICIPATED TRANSIENTS WITHOUT SCRAM GUIDELINE

The actions of these two guidelines are primarily directed at the control of reactivity.

3.1 REACTOR TRIP GUIDELINE

BASES

A reactor trip is a shutdown of the reactor accomplished by the rapid insertion of the control elements. It is automatically initiated by the reactor protective system when certain continuously monitored parameters exceed predetermined setpoints, or can be initiated manually by the operator if plant conditions warrant. A malfunction in the Reactor Protective System may also result in a reactor trip signal.

Characterization of a Reactor Trip

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) Thermal margin/low pressure.
h) High containment pressure
i) Turbine Trip

[A reactor trip will also result due to an automatic or manual turbine trip at full power conditions.] A turbine trip is called for if a condition detrimental to continued turbine operation develops.

The parameters which result in a reactor trip signal being generated may be due to a plant abnormality, which when determined, may invoke the usage of another EPG concurrently with this guideline.

Safety Functions Affected

A reactor trip results in a decrease of primary system heat generation to decay heat. It is an automatic safety action performed for reactivity control and does not directly impede the ability to perform any other safety action required to place the plant in a stable condition.

Initial Trending of Key Parameters

Reactor Power

As a result of the reactor trip initiation, 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 to [5%] flow position. A rapid decrease in reactor power and startup rate will be observed.

RCS Temperature

Initially, heat removed by the steam generators will exceed the heat produced in the core (decay heat), thus RCS temperature will decrease.

Pressurizer Pressure and Level

Pressurizer pressure and level will initially decrease due to the lowering of RCS temperature. However, this effect will be subdued by operation of pressurizer heaters and charging pumps.

Steam Generator Pressure

Since steam flow is greatly reduced due to the turbine trip, steam generator pressure and temperature will increase.

Steam Generator Level

After a reactor trip, steam generator level decreases rapidly. This is due to a phenomena described as follows. Due to the increasing temperature in the steam generator, the rate of void formation is initially increased. This is followed by void collapse cuased by the increasing pressure, and leads to a sharp drop in steam generator water level. This is usually referred to as swell and shrink.

Plant operators should be cautioned not to overreact to this lowered level in the steam generators. Rapidly feeding the steam generator results in RCS temperatures being driven down below the desired no load value. Consequently, this could cause RCS pressure to fall to a point where the pressurizer is drained and/or the Safety Injection System is actuated. This complicates the recovery from a simple reactor trip considerably.

Event Strategy

Figure 3.1-1 provides a summary of the strategy employed in this guideline. Only the major decision points are indicated. A detailed discussion of the required operator actions and bases is found in the following subsections.

Bases Immediate Actions

Accompanying a reactor trip, automatic functions are initiated to safely bring the plant to a hot shutdown condition. Verification that these automatic functions occur properly forms an important part of this guideline. The immediate actions are aimed at ensuring that the reactor is safely shutdown and ensuring that the Auxiliary Feedwater System is actuated to provide feed flow for the decay heat being generated.

1. An automatic reactor trip is verified. If necessary, a manual trip is initiated. This action ensures that the proper shutdown margin is maintained, for reactivity control.

2. A full CEA insertion must be verified. If more than one CEA does not fully insert into the core and the reactor is subcritical, emergency boration must be initiated to ensure the proper shutdown margin for the decreased reactivity control If the reactor maintains criticality, the Anticipated Transients Without Scram (ATWS) Guideline must be followed. A minimum of 10 CEAs not inserted could cause the reactor to maintain criticality.

3. A turbine trip must be verified and the turbine stop valves should be verified shut to minimize the cooldown rate of the RCS to within the Technical Specification maximum allowable limit. If these actions have not occurred automatically, they should be performed manually. This action contributes to the accomplishment of the RCS Heat Removal safety function.

4. The initiation of an SIAS must be verified if pressurizer pressure decreases to [1600 psia], [or if containment pressure increases to 5 psig]. If the SIS has not been automatically actuated, it must be initiated manually. This action verifies that a safety function is being performed; RCS inventory control and RCS heat removal.

5. If pressurizer pressure decreases to [1300 psia] following an SIAS, all reactor coolant pumps must be stopped.

   A system response identified by a depressurization transient to below [1300 psia] following an SIAS (and subsequent operation of the SIS) is characteristic of a LOCA. Continued RCP operation at RCS pressures below [1300 psia] during a LOCA may result in more severe RCS conditions.

   It may not be possible to distinguish between events causing a depressurization in the early stages of the transient; specifically during the time period when the immediate actions are taken. The immediate actions required for all events are directed at placing the plant in a safe condition. To avoid the necessity of a confirmation of the initiation event during the time when the immediate actions are taken, anytime pressurizer pressure decreases to [1300 psia] following an SIAS, all RCP operation is terminated.

6. The operator should verify that the Main or Auxiliary Feedwater System is maintaining or restoring steam generator level. Feedwater flow to the steam generators provides a means for either maintaining RCS cooling or if necessary, cooling down the RCS. This action contributes to accomplishment of the RCS heat removal safety function.

7. The PLCS is verified to be automatically controlling or restoring pressurizer level. If not, charging and letdown are operated manually to ensure pressurizer level is being maintained. This action verifies that a safety function is being performed; controlling RCS inventory.

8. The PPCS is verified to be automatically controlling or restoring RCS pressure. If not, pressurizer heaters or spray are operated manually to control pressurizer pressure. This action verifies that a safety function is being performed; controlling RCS pressure.

9. The generator output breakers must be verified to be open to avoid damage to the generator when power is restored to the generator buses.

10. Station loads must be transferred to an offsite power source to provide the necessary plant electrical power to offset the loss of power from the turbine generator.

Bases Follow-up Actions

The follow-up actions are directed at bringing the plant to a stable condition following the reactor trip and ensuring that a proper heat sink for the reactor is being maintained.

1. All immediate actions are verified for their execution to check that all the critical safety functions are being attended to.

2. The diagnosis of a reactor trip should be confirmed. If misdiagnosis has been made, the proper emergency guideline can then be implemented. If a definitive diagnosis cannot be made, the plant status and trending diagnostic is referenced. This diagnostic is functionally oriented, and critical safety functions are attended to. The proper emergency guideline may then be accessed.

3. [The PORV is not expected to open on a reactor trip. However, if it does, and RCS pressure is less than 2400 psia, the PORVs should be closed. If necessary, the PORV block valves must be closed to maintain RCS inventory.]

4. Primary system heat removal is controlled by the steam generators discharging steam via the Turbine Bypass System. If condensor vacuum is lost or the turbine bypass valves are not available, the atmospheric dump valves are used to maintain steam generator pressure and RCS heat removal, this prevents the steam generator pressure from rising to the opening setpoint of the secondary safety valves. However, for radiological release considerations, use of the atmospheric dump valves is less desirable.

5. A minimum of [20^{O}F + inaccuracies] of subcooling must be established to avoid the occurrence of voiding in the RCS.

6. Turbine damage resulting from abnormal operating conditions is avoided if the turbine generator is shut down according to manufacturer's instructions.

7. The SIS is not expected to be actuated on a Reactor trip. However, if the SIS was actuated, it may be stopped if RCS inventory and pressure are adequately being controlled and heat removal capabilities are established. These conditions are indicated by the following criteria:

   a) RCS hot and cold leg temperatures are at least [20^{O}F + inaccuracies] below saturation temperature for pressurizer pressure (refer to Figure 3.1-2. Establishing[20^{O}F + inaccuracies] of subcooling prevents void formation in the core when SIS flow is terminated, and provides sufficient margin for establishing flow should the [20^{O}F + inaccuracies] subcooling deteriorate when SIS flow is secured, and

   b) pressurizer level is in the normal operating band and is responding normally to the Pressurizer Level and Pressure Control Systems . An indicated and stable pressurizer level ensures that RCS inventory control has been established, and

   c) at least one steam generator has an indicated level and is removing heat from the RCS. A steam generator having an indicated level and removing heat from the RCS ensures that primary to secondary heat removal is being maintained.

8. If [20^{o}F + inaccuracies] of subcooling cannot be maintained after the SIS has been stopped, HPSI flow must be reinitiated to ensure core heat removal and minimize the chance of voiding occurring in the RCS.

9. If all the RCPs are stopped, operation of the reactor coolant pumps should be attempted to ensure continued forced circulation of coolant through the core and to provide the capability for the normal mode of pressurizer spray. However, only one reactor coolant pump in each loop needs to be operated in an effort to minimize heat input to the RCS.

   If RCP operation has been terminated the possibility of RCP operation is determined if the following criteria are satisfied:

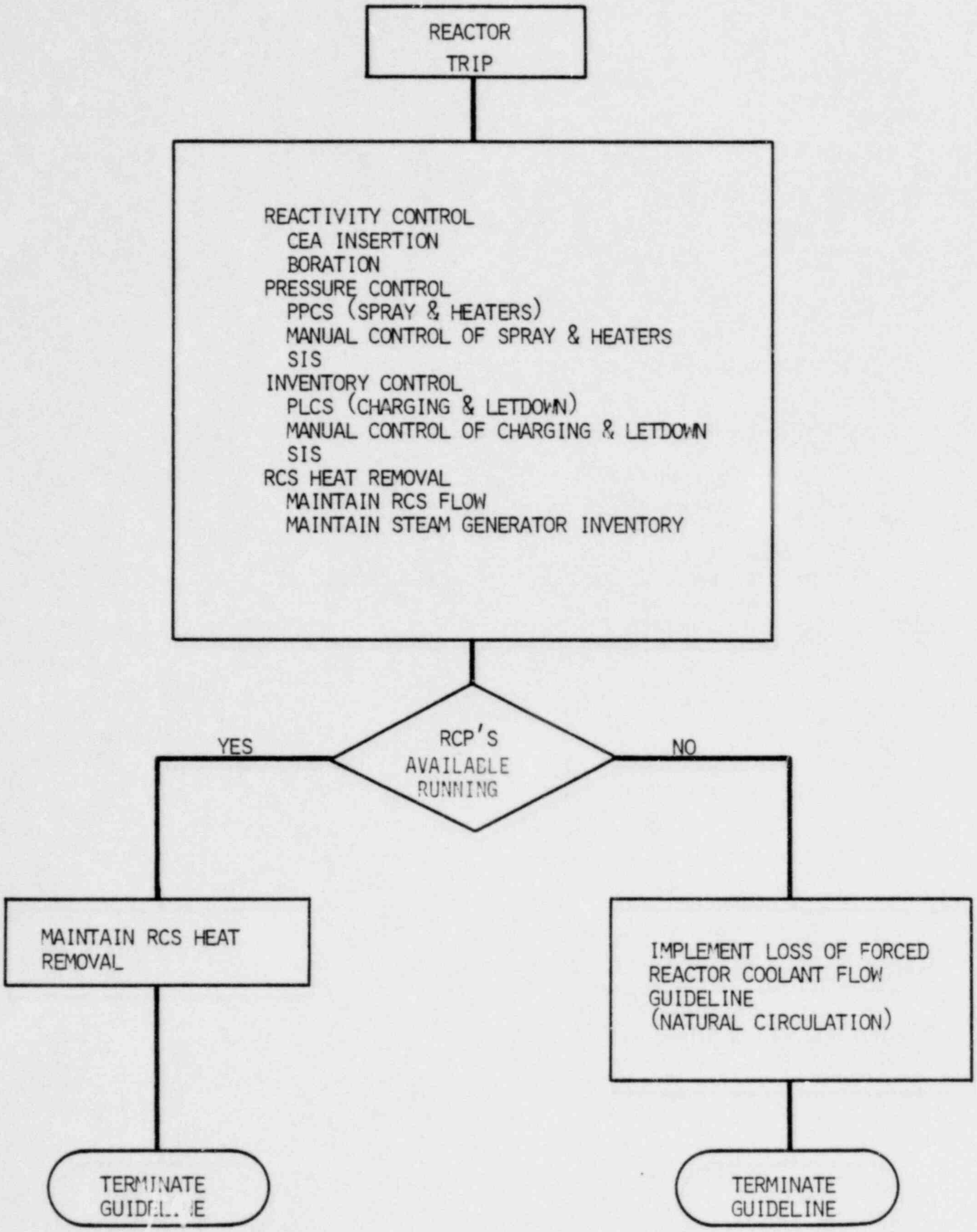
   a) A steam generator is removing heat from the RCS and thus providing a primary heat removal function.
   b) Pressurizer level and pressure are responding normally to the Pressurizer Level and Pressure Control Systems. This assures that primary inventory and pressure are being controlled.
   c) The RCS is greater than or equal to [20^{o}F + inaccuracies] subcooled. An RCS subcooled condition ensures that the RCPs can be operated without damage due to cavitation.
   d) [All plant specific RCP operating criteria are satisfied before the RCPs are restarted to prevent damage to RCPs.]

10. If the RCPs were stopped and cannot be restarted, the instructions in the Loss of Forced Reactor Coolant Flow GUideline should be implemented to establish natural circulation in the RCS.

11. At this point, the plant status should be evaluated. If necessary, a cooldown and depressurization to SDC entry conditions should be started until finally, SDC is commenced.

FIGURE 3.1-1

REACTOR TRIP STRATEGY CHART



REACTOR TRIP GUIDELINE

SYMPTOMS

1. Reactor trip alarm.

2. Control rod positions indicate zero.

3. [Negative] startup rate.

4. CEA trip circuit breaker alarms.

5. Turbine/generator trip and trouble alarms.

6. Low generator electrical output.

7. Any reactor protection system trip alarms.

8. Turbine bypass/atmospheric dump valves open.

9. Initial Trending of Key Parameters:

   a) Reactor Power - decreasing
   b) Pressurizer Pressure - decreasing
   c) RCS Temperature - decreasing
   d) Pressurizer Level - decreasing
   e) Steam Generator Pressure - increasing
   f) Steam Generator Level - decreasing

IMMEDIATE ACTIONS

1. Verify that the reactor has tripped. If necessary, manually trip the reactor.

2. Verify that the CEAs are fully inserted. If more than one CEA has not inserted fully, borate the plant in accordance with Technical Specifications. If the CEAs have not all inserted fully, and the reactor maintains critically, the actions of the ATWS Guideline should be accomplished concurrently with the actions of this guideline.

3. Verify that the turbine has tripped. If necessary, manually trip the turbine and verify that the turbine stop valves are shut.

4. If pressurizer pressure decreases to[1600 psia], [or if containment pressure increases to 5 psig], verify that an SIAS has been initiated. If not, manually initiate an SIAS.

5. If pressurizer pressure decreases to [1300 psia] following an SIAS, stop all reactor coolant pumps.

6. Verify that the Main or Auxiliary Feedwater System is maintaining or restoring normal steam generator level.

7. Verify that the PLCS is automatically maintaining or restoring pressurizer level. If not, manually operate charging and letdown to restore or maintain pressurizer level.

8. Verify that the PPCS is automatically maintaining or restoring RCS pressure. If not, manually control heaters or spray to restore pressurizer pressure.

9. Verify that the generator output breakers are open. If not, manually trip the genrator breakers.

10. Verify that station loads are transferred to an offsite power source.

FOLLOW-UP ACTIONS

1. Verify all immediate actions have been initiated.

2. Confirm the daignosis of a reactor trip event. If a misdiagnosis has been made, implement the proper emergency guideline. If a definitive diagnosis cannot be made, refer to the plant status and trending diagnostic.

3. [If RCS pressure is below 2400 psia, verify that the PORVs are closed. If necessary, isolate the PORVs or shut the PORV block valves.]

4. Operate the turbine bypass valves to maintain RCS temperature below the temperature corresponding to the minimum pressure setpoint of the steam gene[illegible] safety valves. If the bypass valves or the condenser are not available, use the atmospheric dump valves.

5. Maintain at least [20°F + inaccuracies] subcooling in the RCS (refer to Figure 3.1-2).

6. Shut down the main turbine generator [in accordance with operating instructions].

7. If the SIS is operating, it may be stopped if the following conditions are satisfied:

   a) RCS hot and cold leg temperatures are at least [20°F + inaccuracies] below saturation temperature for pressurizer pressure (refer to Figure 3.1-2), and
   b) A pressurizer level is in the normal operating band and is responding normally to the Pressurizer Level and Pressure Control Systems, and
   c) At least the steam generator has an indicated level and is removing heat from the RCS.

8. If [$20^{o}F$ + inaccuracies] of subcooling (refer to Figure 3.1-2) cannot be maintained after the SIS has been stopped, the SIS must be restarted.

9. If the RCPs were stopped, one RCP in each loop may be restarted if the following criteria are satisfied:

   a) At least one steam generator is removing heat from the RCS, and
   b) Pressurizer level and pressure are responding normally to the Pressurizer Level and Pressure Control Systems, and
   c) The RCS is at least [$20^{o}F$ + inaccuracies] subcooled (refer to Figure 3.1-2), and
   d) [Other criteria satisfied per RCP operating instructions.]

10. If the RCPs were stopped and cannot be restarted, verify that natural circulation is accomplished per the Loss of Forced Reactor Coolant Flow Guidelines.

11. Evaluate plant status. If necessary, cooldown and depressurize to SDC entry conditions and com... ..e S^C.

PRECAUTIONS

1. Pressurizer level should be 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 diagnosing the event since the accident may cause irregularities in a particular instrument reading. Critical parameters must be verified when one or more confirmatory indications are available.

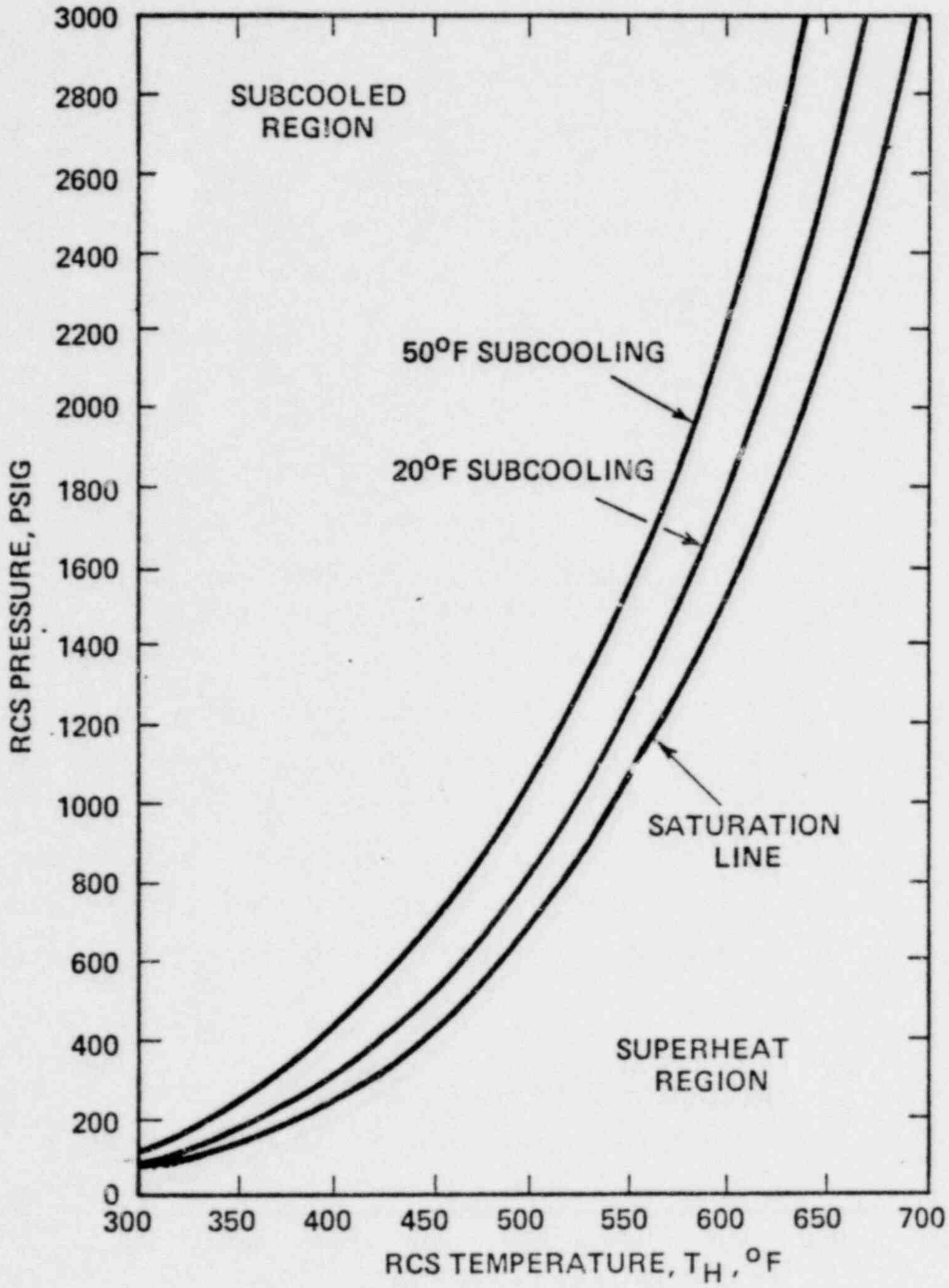
3. Evalauate condensate storage inventory. Conduct a plant cooldown and enter SDC prior to depleting condensate storage (if necessary).

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

Figure 3.1-2

SATURATION / SUBCOOLING



3.2 ANTICIPATED TRANSIENTS WITHOUT SCRAM GUIDELINE

BASES

An Anticipated Transient Without Scram (ATWS) involves a failure in the Reactor Protective System (RPS), following an emergency event, which precludes adequate insertion of negative reactivity into the core on an automatic RPS trip signal. The minimum number of CEAs which could remain withdrawn and keep the reactor critical are ten (10) CEAs, and the greater the number of CEAs which fail to be inserted, the greater the severity of the ATWS event. Some possible causes for an RPS failure include:

1) Failure in the RPS sensors.
2) Electrical failure in the RPS transmitters.
3) Electrical failure in the RPS logic.
4) Electrical failure in the RPS trip circuit relays.
5) Failure in the RPS trip circuit breakers.
6) Mechanical failure in the CEA mechanisms.
7) Machanical binding in the CEA travel ability.

This guideline addresses only failures in the RPS upon demand following an emergency condition and not those failures which may be discovered during routine maintenance. The RPS failure results in a loss of capability to quickly control core reactivity. Operator actions should be directed towards recovering reactivity control and maintaining other plant safety functions to minimize any adverse consequences until reactivity control is regained.

This guideline will be used concurrently with those guidelines required to mitigate the initiating emergency event.

Characterization of an ATWS

A malfunction of the RPS which precludes adequate insertion of negative reactivity when a reactor trip is needed may be observed following the start of an emergency event. This situation is an ATWS. An ATWS can be identified by indication on two or more safety grade instrument channels that a plant parameter has exceeded its normal reactor trip setpoint or a manual scram has been intiated and all of the CEAs have not fully dropped into the core. Primary and secondary key parameters (i.e., pressurizer pressure, steam generator pressure, etc.) may be increasing or decreasing at various rates, depending upon the initiating event which started the ATWS. Initially, taking action to mitigate the RPS failure is more important than recognizing the specific transient.

Certain RPS failures may disable the normal reactor trip alarm annunciation (e.g., RPS alarms, Supplementary Protection System alarms, Critical Functional Monitoring alarms, etc.). Thus the operator should not wait for an alarm annunciation of an abnormal parameter indication to confirm an Anticipated Transient Without SCRAM (ATWS) event before taking appropriate actions. Analysis has shown that the sooner operator actions are taken following the start of an ATWS event, the more beneficial they will be towards mitigating the consequences for such an event. There are also RPS failures which could preclude actuation of systems that receive RPS trip signals for control; for example, the Turbine Bypass System and the Main Feedwater System. Main feedwater will ramp down to [5%] flow following a trip signal. Given the nature of an RPS failure, the above systems may or may not automatically function.

One scenario for the ATWS event involves a mismatch of feedwater flow to steam generation. This is at a maximum if a total loss of feedwater initiated the ATWS. Since the secondary system can no longer remove all of the heat generated in the reactor core, the RCS temperature and pressure will increase. This may result in the pressurizer relief and/or safety valves opening. Further increases in RCS temperature cause expansion of the reactor coolant which will increase pressurizer level and may cause the plant to go solid. RCS pressure may increase high enough to allow coolant leakage and reduction in pressure through the reactor vessel flange "O" ring seal. Pressure will begin to decrease as reactor power is reduced due to the negative moderator reactivity feedback caused by the increasing RCS temperature. This negative reactivity addition is what limits the consequences of the ATWS event.

The above Loss of Feedwater (LOF), when combined with an RPS failure, is the limiting case ATWS. There are, however, a number of different scenarios based on the initiating event. If, for example, the initiating event is a steam line break, which is an excess steam demand event, the operator would be faced with plant parameters that can be completely different from the LOF event. RCS temperature and pressure would initially decrease, which would affect the other plant parameters accordingly.

Safety Function Affected

All of the safety functions may be affected by an ATWS event. A loss of reactivity control will result from the RPS failure. Because insufficient negative reactivity is added to the core initially following the initiating event, heat will continue to be added to the RCS. The RCS heat removal safety function can be affected by the continued heat addition with a mismatch in feedwater flow. If main feedwater has been tripped, the auxiliary feedwater flow may not be sufficient. The continued steaming from the steam generators may be via the turbine, the ADVs, the turbine bypass valves, and/or the steam generator safety valves. However, the ADVs and turbine bypass valves should not be used in the early stages of an ATWS to control RCS temperature and pressure if main feedwater is not available. This, of course, is the normal means for controlling RCS heat removal during an event other than an ATWS. The use of these valves will increase the rate of steam generator dry out if main feedwater is not available. The RCS pressure excursion will be more severe as the dry out occurs earlier in the transient.

If the steam generator secondary water inventory can be maintained during the event, the RCS temperature and pressure excursion can be minimized. This, of course, impacts RCS pressure and inventory control functions.

Initial Trending of Key Parameters

The description of key parameters listed below provide initial trending for the LOFW/ATWS event. These will vary according to the initiating event, and therefore, may not provide an accurate assessment of initial trending.

Reactor Power

Reactor Power will decrease at a slower rate than during a full CEA insertion due to the RPS failure. Reactor power decreases as RCS temperature increases due to the moderator temperature coefficient phenomenon.

RCS Temperature

Due to continued heat additions to the RCS, temperature will increase. The magnitude of this increase is dependent upon the initiating emergency event.

Pressurizer Pressure and Level

Pressurizer pressure and level will increase due to the increased RCS temperature. If the RCS heat removal has been affected by the intitiating emergency event, pressure could increase to the pressurizer safety valves setpoint and possibly higher.

Steam Generator Pressure

Steam generator pressure will increase due to increased RCS temperature. Pressure will increase to the steam generator safety valve setpoints and possibly higher.

Steam Generator Level

Steam generator water level will decrease due to increased steam generator pressure. Depending on the initiating emergency event, feedwater to the generators may have been affected, and will result in further reduction to steam generators water level.

Event Strategy

Figure 3.2-1 provides a summary of the strategy employed in this guideline. Only the major decision points are indicated. A detailed discussion of the required operator actions and bases is found in the following subsections.

Bases Immediate Actions

1. The actions of the Reactor Trip Guideline should be accomplished concurrently with the actions of this guideline. This will verify that all actions required when a reactor trip is necessitated have been attempted.

2. The operator attempts to manually trip the reactor using the following methods:

   a) Push manual trip buttons at main control board.
   b) Open CEA trip breakers.
   c) Deenergize control rod drive motor generators.
   d) [The plant may have other means for manually tripping the reactor, and the specific method should be inserted here.]

   The first operator action during an ATWS is directed towards inserting the CEAs into the core by all manual methods available. Since the Control Element Drive Mechanisms (CEDMs) must be energized to hold the CEAs withdrawn from the core, all methods (plant specific) of dennergizing the CEDMs should be pursued. If the CEDMs can not be deenergized or the CEAs will not drop, the CEAs should be driven into the core using the normal rod motion controls. Jogging the CEAs may free the assemblies to drop into the core. The order of the above manual methods to insert the CEAs should be prioritized based on the most rapid means to accomplish that method on a plant specific basis.

3. Maximum boration in accordance with Technical Specifications must be commenced immediately. The maximum boron concentration should be charged into the plant to add negative reactivity at the maximum rate in order to shutdown the reactor. This action contributes to maintenance of reactivity control. For any ATWS, maximum boration is also important because sufficient boron must be added to the RCS before the plant can be cooled down to cold shutdown conditions. A cold shutdown boron concentration within the RCS should be attained as soon as possible. Hence boration should be started early since only the charging system may be available due to high RCS pressure.

4. The operator should verify that the Main or Auxiliary Feedwater System is restoring or maintaining steam generator level. The main feedwater system should be used (if available). This may require that the operator override the normal post-trip ramp down function of the main feedwater system since this feature of an RPS trip signal may have been automatically initiated. If main feedwater has been lost, trip the turbine. This action conserves secondary inventory and introduces negative moderator feedback earlier in the transient and thereby reduces primary to secondary mismatch. If an adequate secondary inventory is maintained by keeping the feedwater flowrate in balance with the steam flow (which is dependent on the reactor power level), the reactor coolant system will not be subjected to a significant overpressurization. The reactor may still be at high power in this situation and incapable of being rapidly shutdown. However, continued steaming from the steam generators (possibly through the safety valves) will prevent a gross heat transfer imbalance between reactor heat generation and reactor coolant system heat removal, thus minimizing RCS temperature and pressure increases. The action of verifying that feedwater is restoring or maintaining steam generator level assures that RCS heat removal is being addressed.

5. The initiation of an SIAS must be verified if pressurizer pressure decreases to [1600 psia], [or if containment pressure increases to 5 psig]. If the SIS has not been automatically actuated, it must be initiated manually. This action verifies that safety functions are being performed; RCS heat removal and RCS inventory control. This will also provide another method of boration should RCS pressure decrease.

6. All RCPs must be stopped if pressurizer pressure decreases to below [1300 psia] following an SIAS. A system response identified by a depressurization transient to below [1300 psia] following an SIAS (and subsequent operation of the SIS) is characteristic of a LOCA. Continued RCP operation at RCS pressures below [1300 psia] during a LOCA may result in more severe CS conditions.

   It may not be possible to distinguish between events causing a depressurization in the early stages of the transient; specifically during the time period when the immediate actions are taken. The immediate actions required for all events are directed at placing the plant in a safe condition. To avoid the necessity of a confirmation of the initiation event during the time when the immediate actions are taken, anytime pressurizer pressure decreases to [1300 psia] following an SIAS, all RCP operation is terminated.

7. [Verify that the PORVs are closed if RCS pressure is below 2400 psia. If necessary, isolate the PORVs or shut the PORV block valves to maintain RCS inventory control.]

8. Verify that containment isolation has been initiated if containment pressure is greater than [5 psig],[or if pressurizer pressure decreases to 1600 psia.] If necessary, manually initiate containment isolation. This ensures that containment integrity is maintained to prevent unnecessary radioactive releases to the outside environment.

9. Verify that containment spray has been initiated if containment pressure is greater than [10 psia]. If necessary, manually initiate containment spray. This maintains containment integrity be decreasing containment pressure and temperature using the Containment Spray System.

Bases Follow-up Actions

The follow-up actions are directed at bringing the plant to a stable condition following the reactor trip and ensuring that a proper heat sink for the reactor is being maintained.

1. All immediate actions are verified for their execution to check that all the critical safety functions have been attended to.

2. The diagnosis of an ATWS event should be confirmed. If a misdiagnosis has been made, the proper emergency guideline can then be implemented. If a definative dignosis cannot be made, the plant status and trending diagnostic is referenced. This diagnostic is functionally oriented, and critical safety functions are attended to. The proper emergency guideline may then be accessed.

The following actions are taken if CEAs have been inserted:

3. The PLCS is verified to be automatically controlling pressurizer level. If not, charging and letdown are operated manually to ensure pressurizer level is being maintained. This action verifies that a safety function is being performed; controlling RCS inventory.

4. The PPCS is verified to be automatically controlling RCS pressure. If not, pressurizer heaters or spray are operated manually to ensure pressurizer pressure is being maintained. This action verifies that a safety function is being performed; controlling RCS pressure.

5. The operator should verify that the Main or Auxiliary Feedwater System is maintaining or restoring steam generator level. Feed-

water flow to the steam generators provides a means for either maintaining RCS cooling or, if necessary, cooling down the RCS. This action contributes to the accomplishment of the RCS heat removal function.

6. If RCP flow is terminated, natural circulation must be established in the RCS. This condition can be verified by referring to the Loss of Forced Reactor Coolant Flow Guideline and following its instruction concurrently with this guideline.

7. If the SIS is operating, it may be stopped if RCS inventory and pressure are adequately being controlled and heat removal capabilities are established. These conditions are indicated by the following criteria:

   a) RCS hot and cold leg temperatures are at least [20°F + inaccuracies] below saturation temperature for pressurizer pressure (refer to Figure 3.2-2). Establishing [20°F + inaccuracies] of subcooling prevents void formation in the core when SIS flow is terminated, and provides sufficient margin for establishing flow should the [20°F + inaccuracies] subcooling deteriorate when SIS flow is secured.

   b) Pressurizer level is in the normal operating band and is responding normally to the pressurizer level and pressure control systems. An indicated pressurizer level ensures that primary inventory control has been established.

   c) At least one steam generator has an indicated level and is removing heat from the RCS. A steam generator having an indicated level and removing heat from the RCS ensures that primary to secondary heat removal is being maintained.

8. If [20°F + inaccuracies] of subcooling can not be maintained after the SIS has been stopped, SIS flow must be reinitiated to ensure core heat removal and minimize the chance of voiding occurring in the RCS.

9. If the RCPs have been stopped, operation of the reactor coolant pumps should be attempted to ensure continued forced circulation of coolant through the core and to provide the capability for the normal mode of pressurizer spray. However, only one reactor coolant pump in each loop needs to be operated in an effort to minimize heat input to the RCS.

The possiblity of RCP operation is determined if the following criteria are satisfied:

a) A steam generator is removing heat from the RCS and thus providing a RCS heat removal function.

b) Pressurizer level and pressure are responding normally to the Pressurizer Level and Pressure Control Systems. This assures that primary inventory is being controlled.

c) The RCS is greater than or equal to [20^{o}F + inaccuracies] subcooled. An RCS subcooled condition ensures that the RCPs can be operated without damage due to cavitation.

d) All plant specific RCP operating criteria are satisfied before the RCPs are restarted to prevent damage to RCPs.

10. At this point, the plant status should be evaluated. If necessary, a cooldown and depressurization to SDC entry conditions should be started until finally, SDC is commenced.

<u>The following actions are taken if the CEAs have not been inserted</u>:

3. The operators must continue their efforts to get the CEAs inserted to ensure that a safe long-term shutdown condition can be maintained.

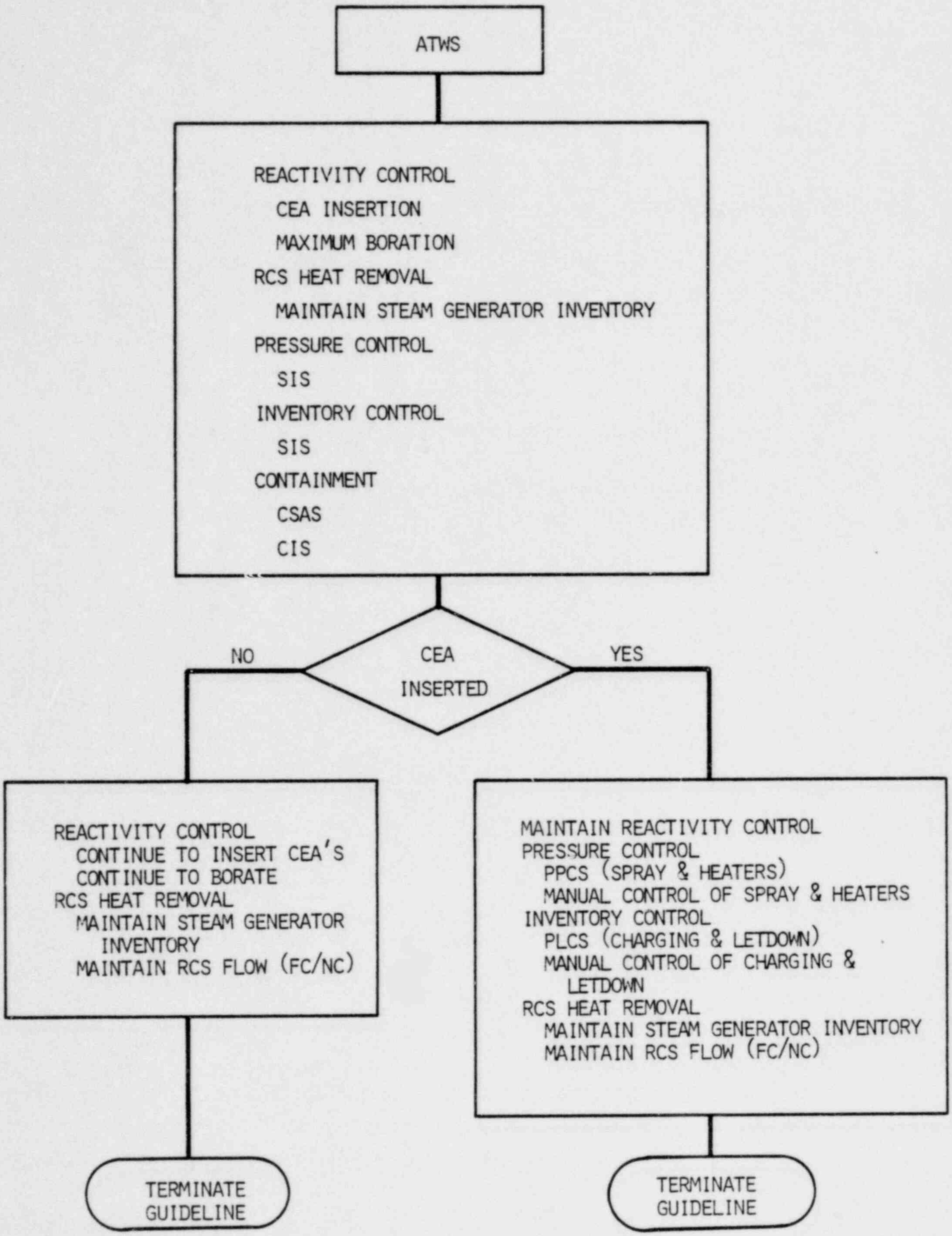
4. Continued boration is necessary to decrease reactor power and thereby minimize the RCS pressure excursion if the CEAs have not been fully inserted. Boration is also necessary to establish cold shutdown boration concentrations.

5. Only after the proper boron concentration is achieved for the required shutdown margin should the operator initiate RCS heat removal since a decrease in RCS temperature will add positive reactivity. RCS heat removal is achieved using main or auxiliary feedwater and steam discharge to the condenser or atmosphere.

6. If all RCP flow is terminated, natural circulation must be established in the RCS. This condition can be verified by referring to the Loss of Forced Reactor Coolant Flow Guideline and following its instruction concurrently with this guideline.

Figure 3.2-1

ATWS STRATEGY CHART



ANTICIPATED TRANSIENTS WITHOUT SCRAM GUIDELINE

SYMPTOMS

1. A reactor protective system setpoint has been exceeded and

   a) Reactor power greater than normal shutdown levels.
   b) Startup rate greater than normal shutdown level.
   c) CEA trip breakers are not open
   d) CEDM power undervoltage lights are not lit

2. Initial Trending of Key Parameters

   a) Reactor power - decreasing less than expected for a reactor trip.
   b) Pressurizer pressure - increasing*
   c) RCS temperature - increasing*
   d) Pressurizer level - increasing*
   e) Steam generator pressure - increasing*
   f) Steam generator level - decreasing*

*This key parameter provides initial trending for the LOF/ATWS event. The key parameters will vary according to the initiating event, and therfore, may not provide an accurate assessment of initial trending.

IMMEDIATE ACTIONS

1. Perform the actions of the Reactor Trip Guideline concurrently with the actions of this guideline.

2. Attempt to manually insert the CEAs into the core. Perform all of the following actions:

   a) Push manual trip buttons
   b) Open CEA trip breakers
   c) Deenergize control rod drive motor generators
   d) [If other methods are available to insert CEAs, insert that information here.]

3. Commence maximum boration in accordance with Technical Specifications.

4. Verify that the Main or Auxiliary Feedwater System is restoring or maintaining steam generator level.

5. If pressurizer pressure decreases to [1600 psia], [or if containment pressure increases to 5 psig], verify initiation of an SIAS. If necessary manually initiate an SIAS.

6. If pressurizer pressure decreases to [1300 psia] following an SIAS, stop all reactor coolant pumps.

7. [If RCS pressure is below 2400 psia, verify that the PORVs are closed. If necessary, isolate the PORVs or shut the PORV block valves.]

8. If containment pressure increases to [5 psig], [or if pressurizer pressure decreases to 1600 psia], verify initiation of containment isolation. If necessary, manually initiate containment isolation.

9. If containment pressure increases to [10 psig], verify initiation of containment spray. If necessary, manually initiate containment spray.

FOLLOWUP ACTIONS

1. Verify all immediate actions have been initiated.

2. Confirm the diagnosis of an ATWS event. If a misdiagnosis has been made, implement the proper emergency guideline. If a definative diagnosis cannot be made, refer to the plant status and trending diagnostic.

If CEAs have been inserted:

3. Verify that the PLCS is functioning to restore proper pressurizer level. If necessary, manually operate charging and letdown to restore and maintain normal pressurizer level.

4. Verify that the PPCS is automatically restoring RCS pressure. If necessary, manually control heaters or spray to restore pressurizer pressure.

5. Maintain RCS heat removal using main or auxiliary feedwater and steam discharge to the condenser or atmosphere.

6. If all RCPs are stopped, verify that natural circulation is accomplished per the Loss of Forced Reactor Coolant Flow Guidelines concurrently with this guideline.

7. If the SIS is operating, it may be stopped if the following conditions are satisfied:

   a) RCS hot and cold leg temperatures are at least [20^{o}F + inaccuracies] below saturation temperature for pressurizer pressure (refer to Figure 3.2-2), and

   b) Pressurizer level is in the normal operating band and is responding normally to the Pressurizer Level and Pressure Control Systems, and

c) At least one steam generator has an indicated level and is removing heat from the RCS.

8. If [$20^{o}F$ + inaccuracies] of subcooling (refer to Figure 3.2-2) cannot be maintained after the SIS has been stopped, the SIS system must be restarted.

9. If the RCPs were stopped, one RCP in each loop may be restarted if the following criteria are satisfied:

   a) At least one steam generator is removing heat from the RCS.

   b) Pressurizer level and pressure are responding normally to the Pressurizer Level and Pressure Control Systems.

   c) The RCS is at least [$20^{o}F$ + inaccuracies] subcooled (refer to Figure 3.2-2).

   d) [Other criteria satisfied per RCP operating instructions.]

10. Evaluate plant status. If necessary, cooldown and depressurize to SDC entry conditions and commence SDC.

<u>If CEAs have not been inserted:</u>

3. Continue efforts by all means available to insert all the CEAs into the core.

4. Continue maximum boration in accordance with Technical Specifications until cold shutdown boron concentration is achieved in the RCS.

5. After achieving required shutdown margin per Technical Specifications, initiate RCS heat removal using main or auxiliary feedwater and steam discharge to the condenser or atmosphere.

6. If all RCPs were stopped, verify that natural circulation is accomplished per the Loss of Forced Reactor Coolant Flow Guideline concurrent with this guideline .

PRECAUTIONS

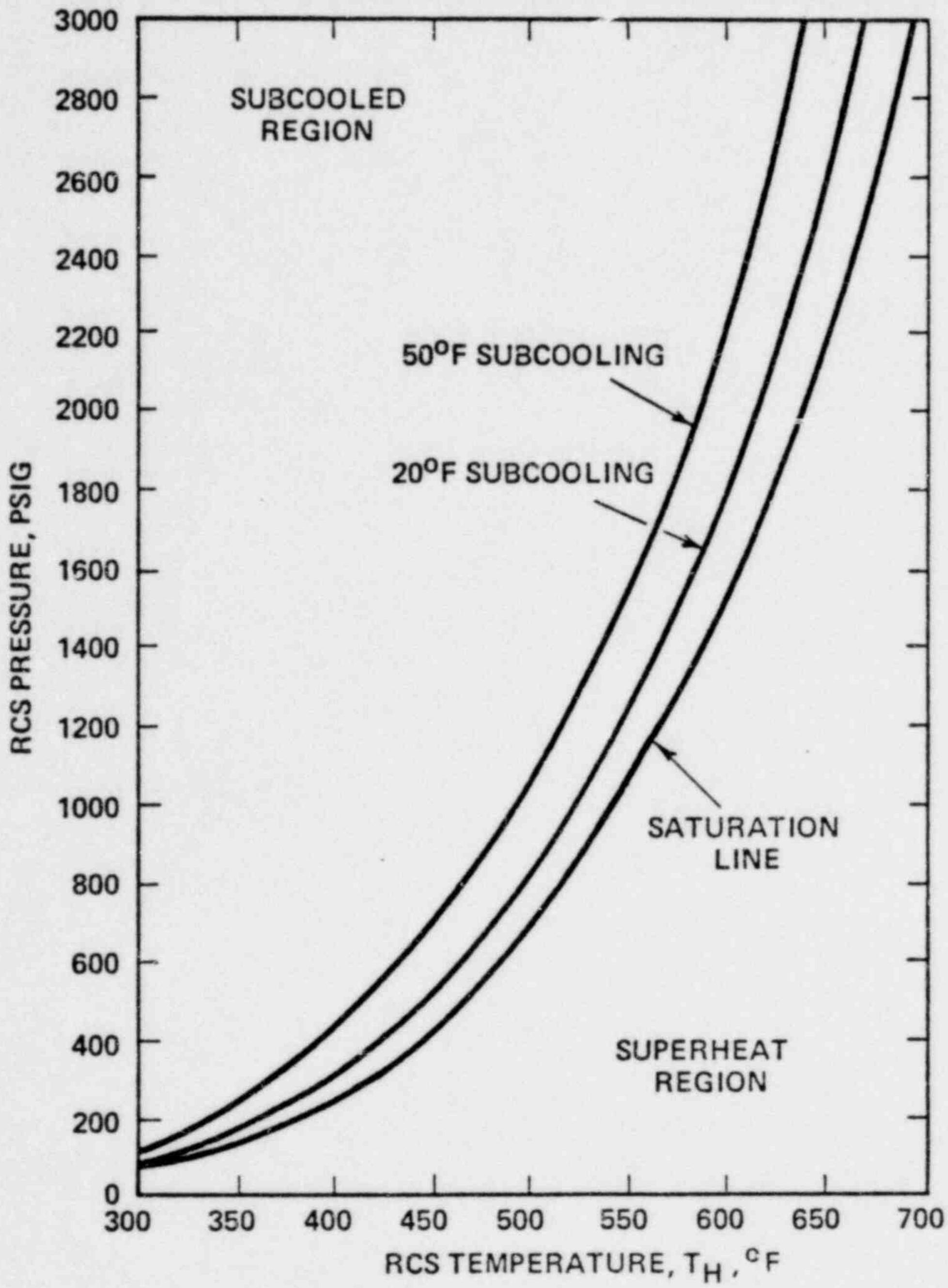
1. Do not begin manual plant cooldown to cold shutdown conditions until the boron concentration level in the RCS is verified to maintain the reactor subcritical.

2. All available indications should be used to aid in diagnosing the event since the accident may cause irregularities in a particular instrument reading. Critical parameters must be verified when one or more confirmatory indications are available.

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.

Figure 3.2-2

SATURATION / SUBCOOLING



4.0 RCS INVENTORY AND PRESSURE CONTROL GUIDELINES

Although all the critical safety functions are addressed in each emergency procedure guideline, generally, the control of one of the safety functions is of more immediate importance than the others. It is possible to group the guidelines on this basis. The guidelines contained in the following sections are:

4.1 <u>LOSS OF COOLANT ACCIDENT GUIDELINE</u>

4.2 <u>STEAM GENERATOR TUBE RUPTURE GUIDELINE</u>

The actions of these two guidelines are primarily directed at RCS inventory and pressure control.

4.1 LOSS OF COOLANT ACCIDENT GUIDELINES

BASES

The bases section to the loss of coolant accident (LOCA) emergency procedure 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 operator with information which will enable him to understand the reasons for, and the consequences of the actions he takes 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 resutls in a loss of RCS fluid at a rate that is just in excess of the maximum charging capacity of the plant.

Small and large break LOCAs differ in their effect on the RCS pressure response. RCS pressure is used to differentiate between small and large break LOCAs. However, the delineation between small and large breaks does not need to be precise since there is a range of intermediate breaks for which either response will produce satisfactory results. The guidelines take this into account with the decisions which must be made.

A LOCA is characterized by a decrease in RCS pressure and inventory and, an increase in containment temperature and pressure (for breaks inside containment). The actions taken by the operator during a LOCA are aimed at regaining control of these parameters while maintaining RCS heat removal.

Safety Functions Affected:

Depending on break size, the LOCA primarily affects RCS inventory and pressure control, and RCS heat removal capabilities. Also affected, to a lesser degree, are reactivity control and containment integrity.

RCS inventory control is lost since the break flow rate exceeds the maximum charging pump capacity of the plant. For small breaks, RCS inventory control is regained via injection from the high pressure safety injection pumps (HPSIPs) and the charging pumps. It is also 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 low pressure safety injection pumps (LPSIPs). It is maintained in the long-term through the recirculation of sump water through the RCS by the HPSIP. Note that for large breaks, the RCS may never totally refill, and pressurizer level may not be regained. Also, if the break is unisolable, injection is required, indefinitely, to make up for the loss out the break.

RCS pressure control is initially lost since the RCS depressurizes as a result of the loss of inventory out the break. For large breaks, the RCS depressurizes in 10 seconds to 3 minutes with equilibrium pressures below [300 psia] and, in the case of the largest breaks, the RCS pressure is nearly equal to containment pressure. Because of the size of the break, the operator never regains direct control of RCS pressure. 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 SIS refills the RCS and pressurizer level is regained. During the period of time the RCS is refilling, there may be significant voiding in the RCS. The presence of non-condensible gases in the RCS will result in equilibrium pressures without the RCS being completely refilled (i.e., there may be non-condensibles in the steam generator active tubes and/or the upper head of the reactor vessel). However, in this condition, adequate core cooling could be detected by indication of at least

[20^{o}F + inaccuracies] of subcooling from the hot leg temperature or core exit thermocouple instrumentation. Small break post-LOCA operator actions which are associated with pressure control are (1) decreasing RCS pressure by means of auxiliary sprays and controlling HPSIPs and charging and heat removal via steam generators in order to establish shutdown cooling entry conditions and, (2) isolating or depressurizing the SITs.

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. For a large break, the break is sufficiently large so that it is the only path that is necessary for RCS heat removal in both the short and long-term. Heat removal is maintained by once-through boiling (core heat boils the liquid in the reactor vessel and the steam flows out the break). For small breaks in the short-term, after the RCPs are tripped, core heat removal is maintained by natural circulation or by relflux boiling. Since the break is not large enough to adequately remove the heat, heat removal via the steam generator is required. This requires that the operator maintain feedwater (either main or auxiliary) to the steam generators and control steam flow from the steam generators via the turbine bypass system or the atmospheric dump valves. The percentage of required RCS heat removed by the steam generators for various break sizes is illustrated in Figures 4.1-1 and 4.1-2. In the long-term, following a small break, once RCS pressure and temperature are adequately reduced, RCS heat removal is maintained via the shutdown cooling system. [In the event that the feedwater supply to the steam generator is exhausted and the SCS is inoperable, the PORVs are opened to ensure that the flow from the SIS is sufficient for RCS heat removal purposes. The SIS will be realigned for cold leg injection only. Core flushing is from the cold legs through the core and out the PORV.]

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

Figure 4.1-1

BREAK DIAMETER vs % OF DECAY HEAT REMOVED BY STEAM GENERATORS

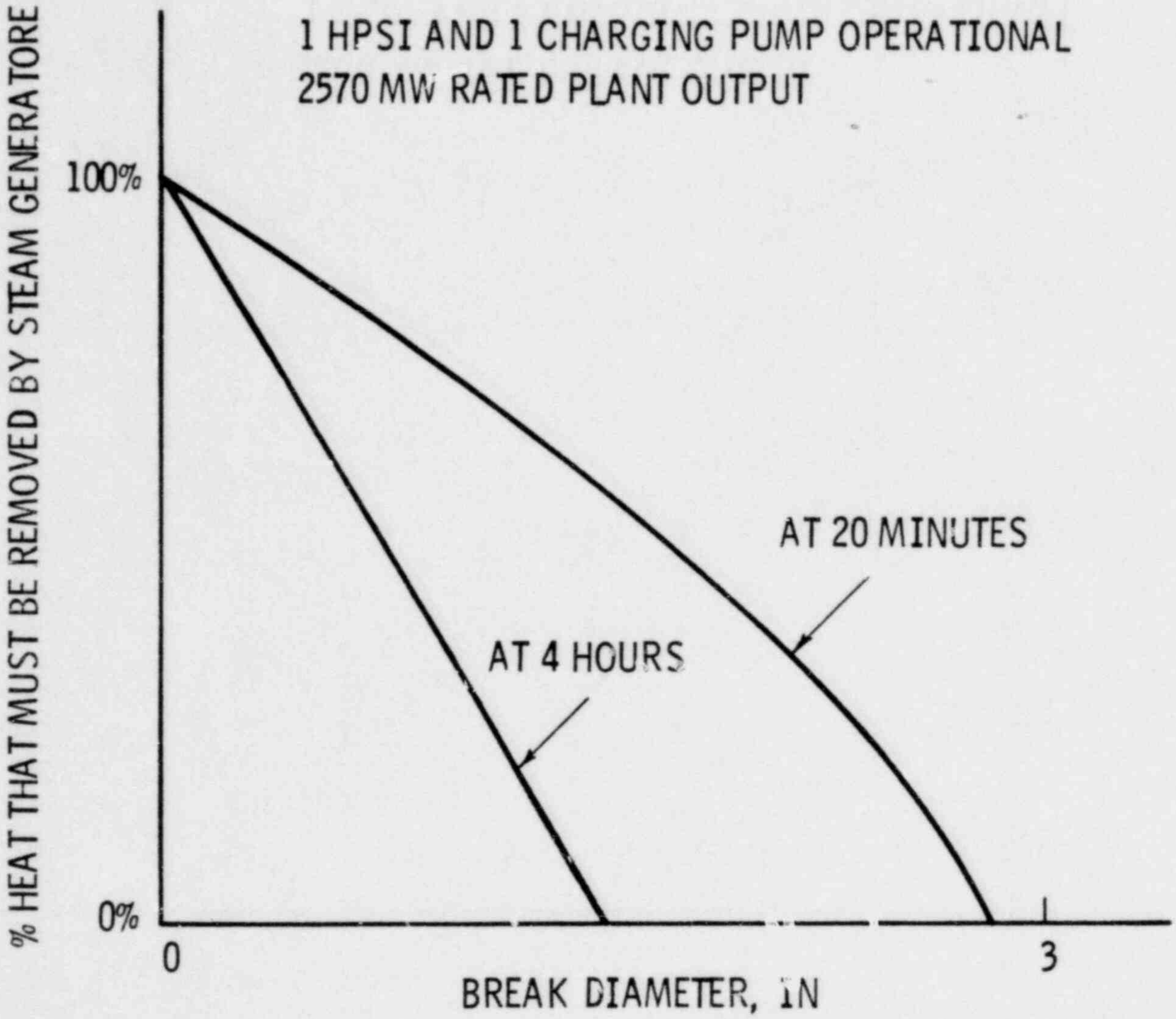
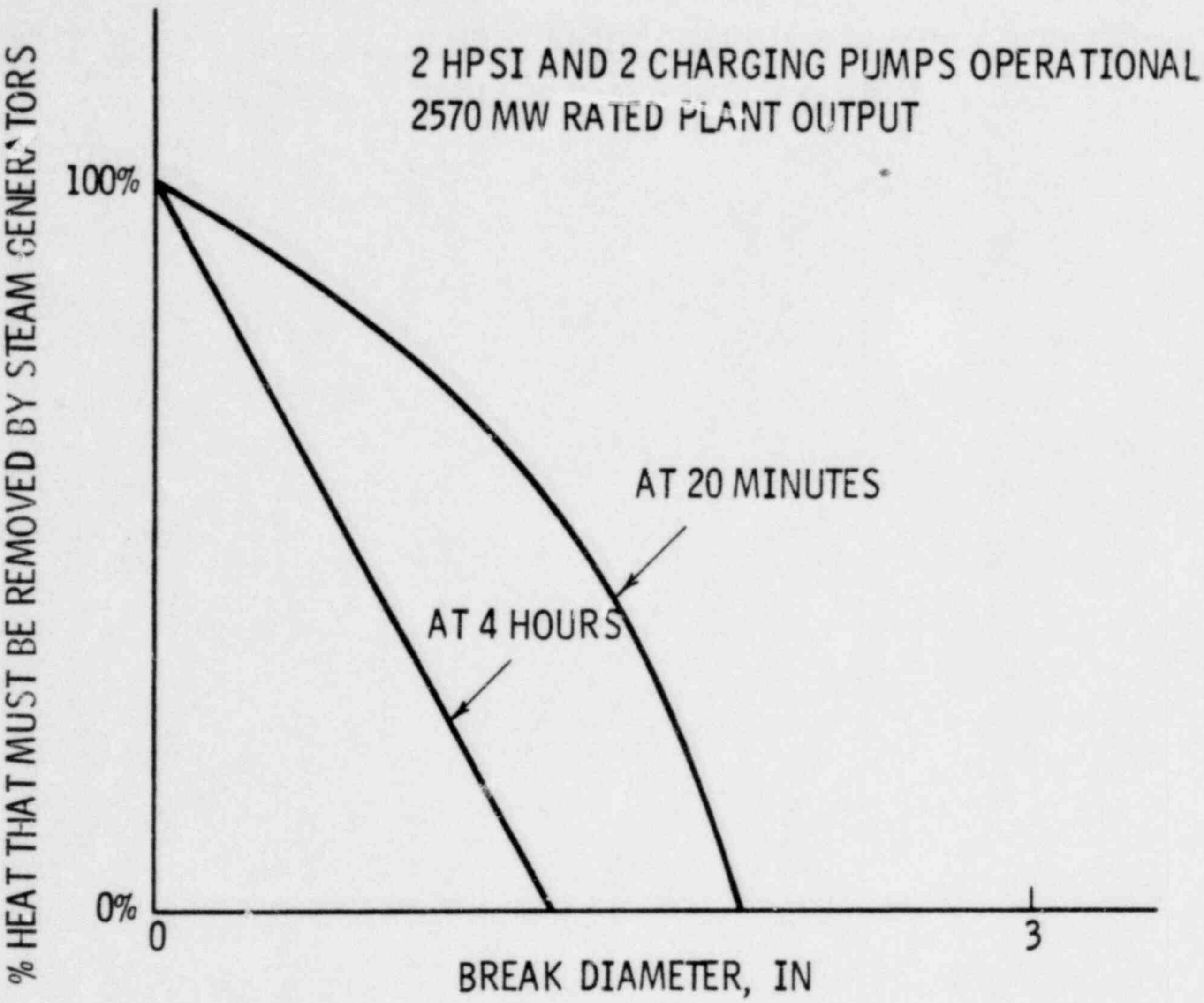


Figure 4.1-2

BREAK DIAMETER vs % OF DECAY HEAT REMOVED BY STEAM GENERATORS



If the LOCA occurs inside containment, temperature and pressure control is accomplished by action of the containment spray system. Containment isolation occurs either automatically, or manually.

Initial Trending of Key Parameters

Reactor Power

Reactor power remains constant until the reactor is tripped. For large breaks where an RCS depressurization is fast, the reactor power may be decreasing as a result of a reactor trip. For small breaks, where a reactor trip may not have occurred yet, reactor power may be constant.

Pressurizer Pressure

Pressurizer pressure decreases due to the loss of coolant.

RCS Temperature

Before the reactor trip for small break LOCAs, RCS temperature may not change. Following the reactor trip, for all size LOCAs, due to the reduction in heat input into the RCS or due to the heat removed out the break, RCS temperature decreases.

Pressurizer Level

Pressurizer level may decrease, increase, or stay constant. This irregularity in expected initial trending of pressurizer level is due to break location, and is an instrument irregularity rather than being characteristic of the system response. If the break is in the area of the pressurizer level instrumentation, readings obtained from this instrumentation may be inconsistant with true pressurizer level which is decreasing for all break sizes.

Steam Generator Pressure

Steam generator pressure may remain constant if the break is small and a reactor trip has not yet occurred. However, once the reactor trip has occurred, for all sized LOCAs, steam generator pressure may decrease.

Event Strategy

Figure 4.1-6 provides a summary of the strategy employed in this guideline. Only the major decision points are indicated. A detailed discussion of the required operator actions and bases is found in the following subsections.

Bases Immediate Actions

The immediate actions are directed at regaining control of plant safety functions; specifically, reactivity control, RCS inventory and pressure control, and ensuring containment integrity following all sized LOCAs.

1. The reactor is tripped, either automatically or manually, in order to establish short-term reactivity control. Shutting the reactor down decreases the core power to the decay heat generation rate which also aids in core heat removal by minimizing core heat production.

2. Pressurizer pressure is less than [1600 psia], [or if containment pressure increases to 5 psig], the initiation of an SIAS must be verified. If it has not been initiated, the SIAS must be manually actuated. This action verifies safety function is being performed; RCS heat removal and RCS inventory control.

3. The reactor coolant pumps (RCPs) are turned off if the pressurizer pressure falls below [1300 psia] in order to prevent the RCPs from operating during those LOCAs for which RCP operation will increase the severity of the LOCA.

   Analysis has indicated that for a break in the bottom ofthe hot leg, continued operation of the RCP can result in a larger loss of RCS fluid than if the pumps were not running. This results in a lower coolant level in the reactor vessel and, hence, may increase the severity of the LOCA. Since the operator has no way of knowing the location of the break, he is instructed to turn off the RCPs for all LOCAs if the pressure falls below [1300 psia]. The value of [1300 psia] was selected based on the following considerations.

   Following a small break, the RCS pressure reaches an equilibrium condition with the steam generators. The maximum RCS pressure during this "pressure plateau" is determined by the main steam safety valves set pressure. The value [1300 psia] is greater than the maximum equilibrium condition, including instrument uncertainty. By tripping the RCP when the pressure reaches [1300 psia], it is ensured that the pumps are tripped in a timely fashion, at a pressure above that of the pressure plateau. The RCPs are not tripped sooner for the following reason. There are some plant transients which initially exhibit some of the same characteristics as a LOCA. Continued operation of the RCPs for these transients would be beneficial. Therefore, the set point for stopping the RCPs was chosen so that the RCPs would be stopped for LOCAs which cause a depressurization to less than [1300 psia], but they would not be stopped for the non-LOCA transients which do not depressurize the RCS to less than [1300 psia].

4. To ensure that the steam generators remain available for heat removal from the RCS, a supply of steam generator feedwater, either main or auxiliary, must be verified. Feedwater should be maintaining or restoring normal steam generator level.

5. Containment isolation must be verified if containment pressure reaches [5 psig], [or if pressurizer pressure decreased to 1600 psia]. This action ensures that lines penetrating containment, that are not required for operation of the safety systems are isolated, to minimize the release of radioactive materials to the atmosphere.

6. Containment spray is verified if containment pressure reaches [10 psig]. Its operation is essential for containment heat removal and pressure reduction functions. [If the initial source of spray is the Iodine Removal System, it serves a third function of removing certain types of airborne radioactivity from the containment atmosphere.]

7. [The PORV is not expected to open on a LOCA. However, if it has, and pressurizer pressure has decreased to below 2400 psia, the PORVs should be closed. If necessary, the PORV block valves must be closed to maintain RCS inventory.]

8. Letdown is isolated to preclude loss of RCS inventory to the CVCS.

9. 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 an inadvertent personnel exposure, and minimizes RCS inventory losses.

10. All other sources of leakage which can be rapidly and remotely isolated are isolated in order to minimize RCS inventory losses and, possibly, isolate the break. This should be done rapidly, because the operator should be focusing his attention on recovering the plant from the LOCA.

Bases Follow-up Actions

The following actions which the operator takes are directed toward recovering the plant from the LOCA and placing it in a stable condition. One of two main paths are followed depending upon whether the break has been isolated.

1. All immediate actions are verified for their execution to check that all critical safety functions have been attended to.

2. The diagnosis of a loss of coolant accident should be confirmed by referring to Figure 4.1-7. If a misdiagnosis has been made, the proper emergency guideline can then be implemented. The correct diagnosis of a LOCA is important because the leading parameter changes in the event (pressurizer level or pressure) can be indicative of four different accidents. As the event progresses, the only paramater changes different from those expected for a SGTR are an increase in containment pressure temperature and radiation, and a lack of radiation alarms in the secondary side of the plant. If a definitive diagnosis cannot be made, the plant status and trending diagnostic is referred to. This diagnostic is functionally oriented, and all critical safety functions are attended to. The proper emergency guideline may then be assessed.

3. The PPCS is verified to be automatically restoring RCS pressure. If not, heaters or sprays are manually controlled to restore pressurizer pressure. The intent of this action verifies that a safety function is being performed; controlling RCS pressure.

4. The PLCS is verified to be automatically controlling pressurizer level. If not, charging and letdown are operated manually to ensure pressurizer level is being maintained. This action verifies that a safety function is being performed; controlling RCS inventory.

5. RCS cooling must be maintained during the recovery from the LOCA by continually supplying main or auxiliary feedwater to the steam generators. Steam discharge should be continued. This activity should be performed preferentially by steam discharge to the condenser via the Turbine Bypass System. If the condenser or Turbine Bypass System is not available, the next order of priority for discharging steam would be to use the atmospheric dump valves. Steam discharge is conducted in close association with the effort to mitigate the potential release of activity to the environment. Consequently, it is less desirable to use the atmospheric dump valves for radiological release considerations.

6. If all RCP operation has been terminated, natural circulation must be established in the RCS. This condition can be verified by refering to the Loss of Forced Reactor Coolant Flow Guideline and following its instruction concurrently with this guideline.

7. If an SIAS has been initiated and the SIS is operating, it must continue to operate until SIS termination criteria is met. This criteria is:

   a) RCS hot and cold leg temperatures are at least [20°F + inaccuracies] below saturation temperature for pressurizer pressure (refer to Figure 4.1-8). Establishing [20°F + inaccuracies] of subcooling prevents void formation in the core when SIS flow is terminated, and provides sufficient margin for establishing flow should the [20^{o}F + inaccuracies] subcooling deteriorate when SI flow is secured.

b) Pressurizer level is in the normal operating band, and is responding normally to the Pressurizer Level and Pressure Control Systems. A pressurizer level in the normal operating band and responding normally ensures the RCS inventory control has been reestablished.

c) At least one steam generator has an indicated level and is removing heat from the RCS. A steam generator having an indicated level and removing heat from the RCS ensures that primary to secondary heat removal is being maintained.

8. The SIS must be restarted if the [20^{o}F + inaccuracies] of subcooling cannot be maintained. This provides a sufficient margin for system operation and precludes void formation in the RCS.

9. If the RCPs have been stopped, operation of the RCPs should be attempted to ensure continued forced circulation of coolant through the core and to provide the capability for the normal mode of providing pressurizer spray. However, only one RCP in each loop needs to be operated in an effort to minimize heat input to the RCS. The possibility of RCP operation is determined if the following criteria are satisfied:

a) At least one steam generator is removing heat from the RCS and thus, providing RCS heat removal function.
b) Pressurizer level and pressure are responding normally to the Pressurizer Level and Pressure Control Systems. This assures that primary inventory is being controlled.
c) The RCS is greater than or equal to [20^{o}F + inaccuracies] subcooled. A subcooling condition in the RCS indicates that the RCPs will not be restarted and run under RCS conditions that would cause cavitation and render them unusable.

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

10. The plant status should be evaluated. If a cooldown and depressurization are necessary, this action should be performed until SCS entry conditions are established. SCS operation should be commenced per normal SCS operating instructions.

If the break has not been isolated, the following actions are aimed at reestablishing RCS inventory and pressure control while maintaining RCS heat removal.

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

4. Upon termination of all RCP operation, natural circulation must be established in the RCS. This condition can be verified by referring to the Loss of Forced Reactor Coolant Flow Guideline and following its instructions concurrently with this guideline.

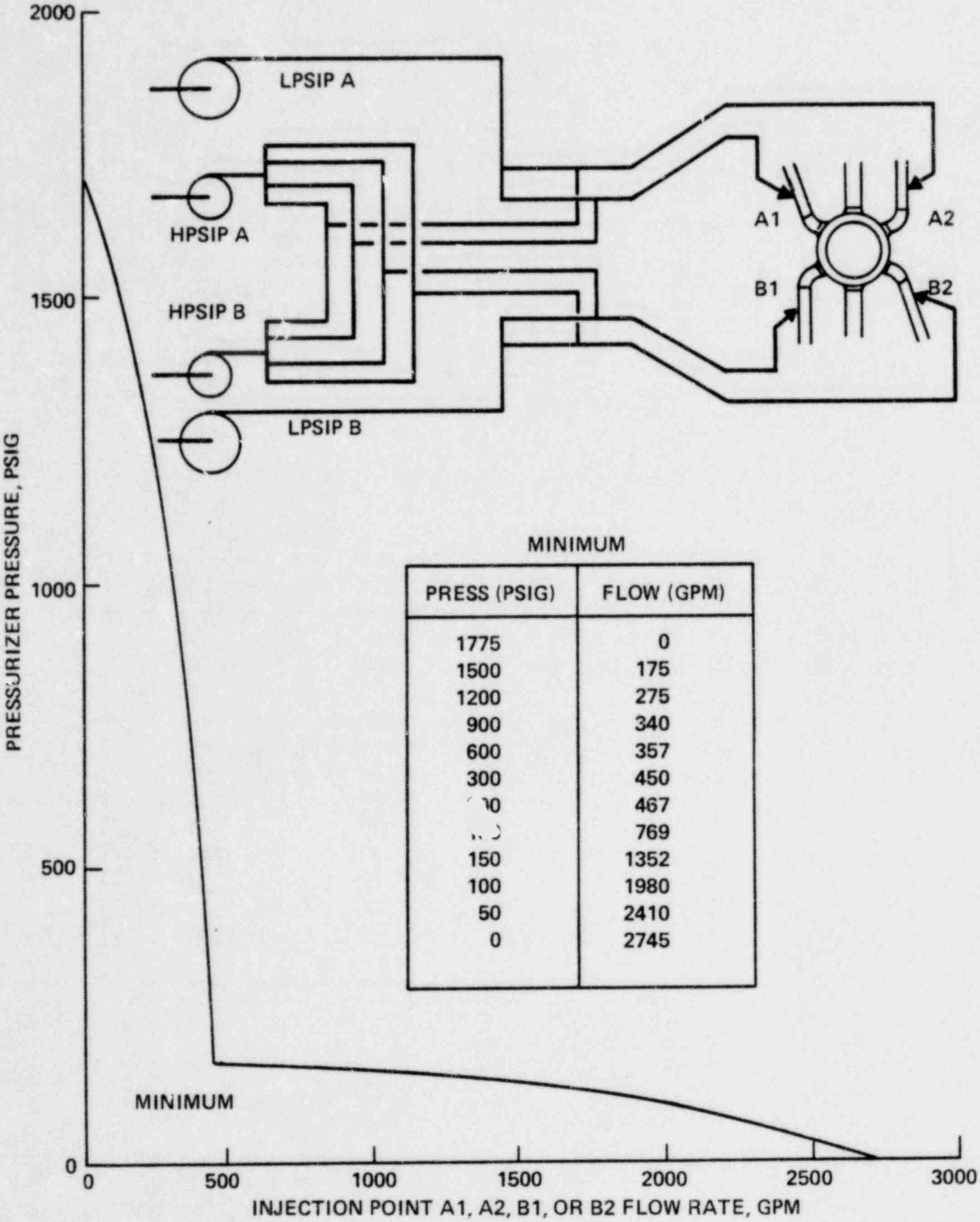
5. A rapid plant cooldown via the steam generators, commenced as soon as practicable, is beneficial for all LOCAs, particularly small breaks.

   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. Figures 4.1-3 and 4.1-4 show 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

Figure 4.1-3

TYPICAL SAFETY INJECTION DELIVERY CURVES
NO FAILURES

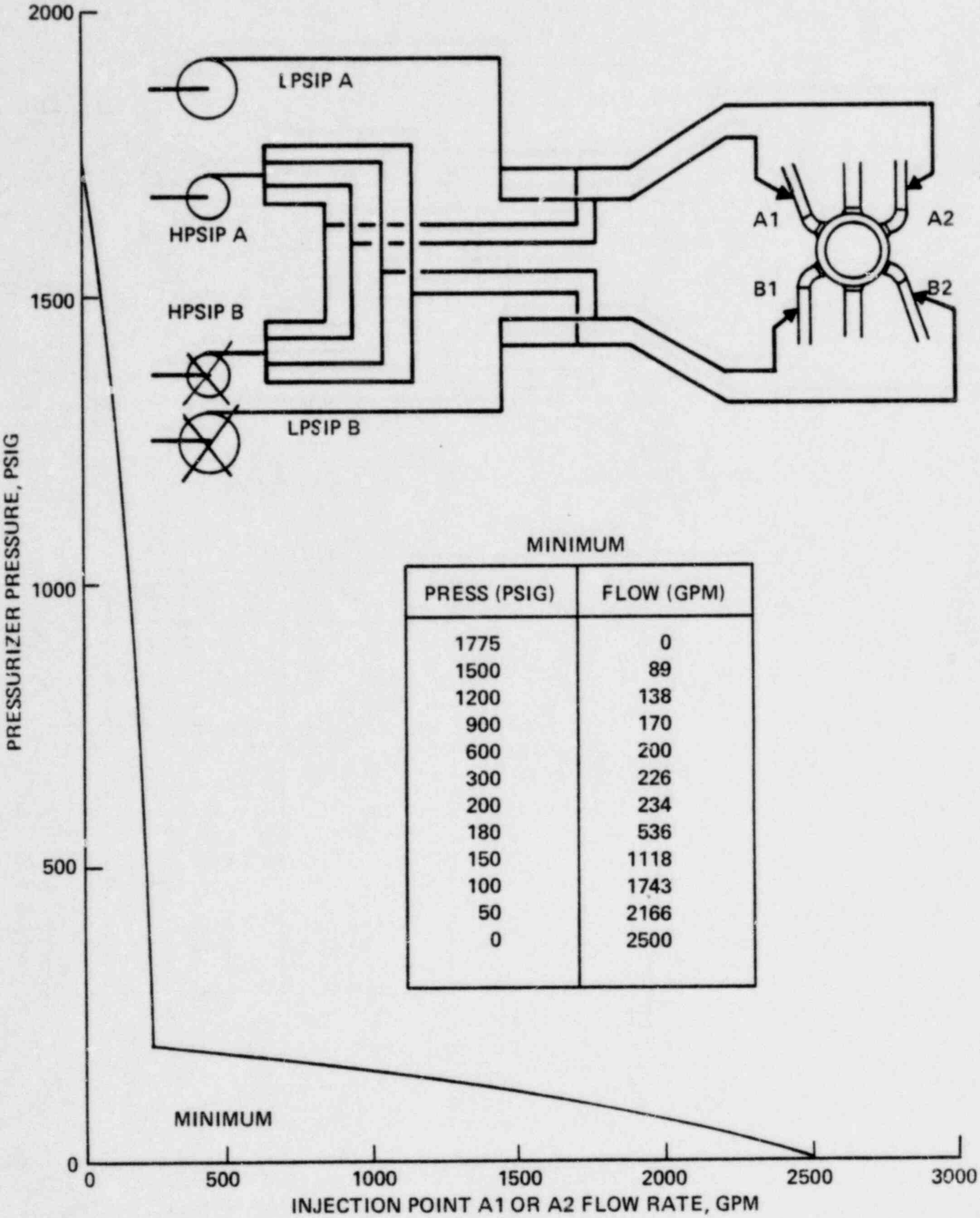


MINIMUM

PRESS (PSIG)	FLOW (GPM)
1775	0
1500	175
1200	275
900	340
600	357
300	450
[illegible]	467
[illegible]	769
150	1352
100	1980
50	2410
0	2745

Figure 4.1-4

TYPICAL SAFETY INJECTION DELIVERY
FAILURE CONDITION - LOSS OF ONE EMERGENCY GENERATOR



MINIMUM

PRESS (PSIG)	FLOW (GPM)
1775	0
1500	89
1200	138
900	170
600	200
300	226
200	234
180	536
150	1118
100	1743
50	2166
0	2500

a lower temperature than that of the steam generators. The steam generators, therefore, act as a heat sink, superheating the steam which is produced in the core and is flowing through the RCS to the break. By cooling down the steam generators, the RCS steam is superheated less and is therefore, more easily vented out the break.

The cooldown must be started no later than [one hour] after the LOCA in order to ensure that there is a sufficient supply of feedwater to cool the plant to the shutdown cooling entry temperature.

6. In order to adequately address the requirements for maintaining RCS heat removal, if there has been a loss of feedwater, the operator implements the Loss of Feedwater Guideline concurrently with the actions of this guideline.

7. Suction for the charging pumps should be realigned, within [1 hour] after the start of the loss of coolant accident (if necessary) from the concentrated boron source to the [RWT or any other plant specific suitable source]. Proper shutdown margin must be maintained.

   This realignment from a concentrated boron source to a dilute source is made in order to avoid the possibility of boric acid precipitation which may occur for large breaks. For large breaks, the reactor vessel refills only to the elevation of the hot leg nozzles. Borated water is injected into the reactor vessel via the charging and safety injection pumps and pure steam is boiled away. This may result in boric acid being concentrated in the reactor vessel. Switching suction of the charging pump to a dilute source helps limit the excessive buildup of boric acid in the reactor vessel while still allowing for sufficient long-term reactivity control.

8. For long-term cooling purposes, if the SIS is required to be operating for an extended period of time, the source of injection water [RWT] should be monitored. If possible, [RWT] inventory should be replenished.

9. If the refueling water tank level falls to [10%], initiation of recirculation should be verified. If necessary, recirculation should be initiated manually. Recirculation is actuated either automatically or manually, in order to maintain a continuous flow of safety injection fluid to the RCS (required for inventory control) and a continuous flow of containment spray water (required for containment temperature and pressure control). [If the automatic or manual initiation of the RAS does not automatically close RWT outlet valves, these must be manually closed to isolate the RWT from the SIS pumps preclude the inadvertent air binding of the safety injection pumps].

   The operator should be cautioned against prematurely initiating an RAS. A possible complication of a premature RAS is the pumps' suction being aligned to a dry sump, consequently air binding the pumps and loosing both heat removal loops. In addition, for events where high containment pressure is present, the check valves in the RWT outlet line will be forced shut and the RWT fluid will remain unavailable while the containment is pressurized.

10. After the switch to recirculation, the HPSIP flows are monitored in order to ensure that HPSIP miniflow requirements are met. If they are not met, the operator should turn off the charging pumps one at a time until the miniflow requirements are met. If they are still not met with all the charging pumps off and two HPSIPs are operating, the operator turns off the pump with the lower flow. One HPSIP should be left operating at all times.

11. Radiation which may be released to the environment should be monitored to determine the extent of any releases. Any releases should be minimized.

12. Containment spray may be terminated if containment pressure falls below [8 psig] since continuous use of the containment sprays may impact the operation of equipment inside contianment, which may be useful to recover from the LOCA. Since the containment pressure may increase again, the containment spray system should be realigned for automatic operation when it is terminated.

13. The safety injection tanks must be vented or drained, or their discharge valves shut at [1.5 to 2.5 hours] after the start of the LOCA to prevent the nitrogen cover gas from discharging into the RCS.

14. 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 HPSI pumps discharge lines are realigned so that the total injection flow is divided equally between the hot and cold legs. Simultaneous injection into the hot and cold legs 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 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 the LOCA in order to ensure that the fluid injected to the hot leg is not entrained in the steam being released from the core and swept out the break, thereby, bypassing the reactor vessel. After [2 hours], the core decay heat has dropped sufficiently so that there is insufficient boil-off 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 breaks so early in the transient. Simultaneous hot and cold leg injection is not required for small breaks because for them, 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.

15. For certain sized breaks (small breaks) entry into shutdown cooling is desired. The Shutdown Cooling System is utilized if certain plant conditions exist.

If refilling of the RCS is at all possible, the time necessary to refill the RCS and regain control of pressure and inventory depends on break size, break location, and the number of HPSI pumps and charging pumps actuated. With only one HPSI pump actuated, for a break located on the bottom of the cold leg, it may take as long as [8 hours] to refill the RCS. With all injection pumps operable, the time is about [1 hour].

At [about 8 hours] after the LOCA, if the RCS liquid level is sufficient for entry into the shutdown cooling mode (pressurizer level is stable), the HPSI pumps are maintaining system pressure (RCS hot and cold leg temperatures are at least [20°F + inaccuracies] below saturation temperature for pressurizer pressure) and the steam generators are available to reduce the RCS temperature to the shutdown cooling entry value, SCS operation may be appropriate if the SCS is available. A verification, or establishment of RCS hot leg temperature less than [400°F] should be made. Before the SDC System is operated, RCS activity levels must be determined since the RCS fluid will now be circulated outside of the containment building. The condensate inventory must be checked to ensure that the supply is sufficient to cool down the plant to SCS entry conditions. Other plant specific prerequisites for SCS operation must be considered. Once appropriate SCS operation is determined to be feasible, the plant is prepared for this mode of operation.

[The SIS must be realigned to discharge entirely to the cold legs.] The RCS is depressurized to [300 psia] by preferentially using auxiliary spray. [Another operational alternative for the RCS pressure reduction is to throttle the HPSI pumps and adjust charging pump flow (if the pressurized is solid) to maintain level and control pressure. Refer to Figure 4.1-5.] The shift is then made to the shutdown cooling mode and shutdown cooling is initiated per operating instructions.

Figure 4.1-5

RCS EQUILIBRIUM PRESSURE (PSIA) FOR STEAM VENT RATE

Operational Pumps	Break Diameter (in) 1	2	3	4	6	8	10	12
2HPSIP + 3 Charging	1560	1320	1020	820	425	275	155	110
2HPSIP + 2 Charging	1360	1200	980	780	420	270	155	110
2HPSIP + 1 Charging	1240	1140	940	740	400	270	150	105
2HPSIP 2LPSIP	1220	1090	860	640	330	210	200	200
1HPSIP + 1LPSIP	1200	960	610	385	200	200	200	200
2HPSIP + 3 inj valves	1220	1090	860	640	330	210	140	100
2HPSIP + 2 inj valves	1220	1040	810	590	300	195	125	85
2HPSIP + 1 inj valve	1220	1020	740	500	260	155	110	75
1HPSIP + 3 Charging	1550	1200	800	500	230	135	90	60
1HPSIP + 2 Charging	1300	1100	720	460	225	130	85	60
1HPSIP + 1 Charging	1230	990	680	440	215	125	85	60
1HPSIP	1200	960	610	385	200	120	80	55
1HPSIP + 3 inj valves	1140	860	560	340	180	105		
1HPSIP + 2 inj valves	1140	820	380	285	140	80		
1HPSIP + 1 inj valve	1060	620	300	175	85			
2LPSIP	202	202	200	200	195	190	185	175
1LPSIP	200	200	195	190	190	180	170	160
3 Charging	1200	320	180	100				
2 Charging	800	200	110	55				
1 Charging	340	110	55					

—— indicates reactor decay heat at 20 minutes

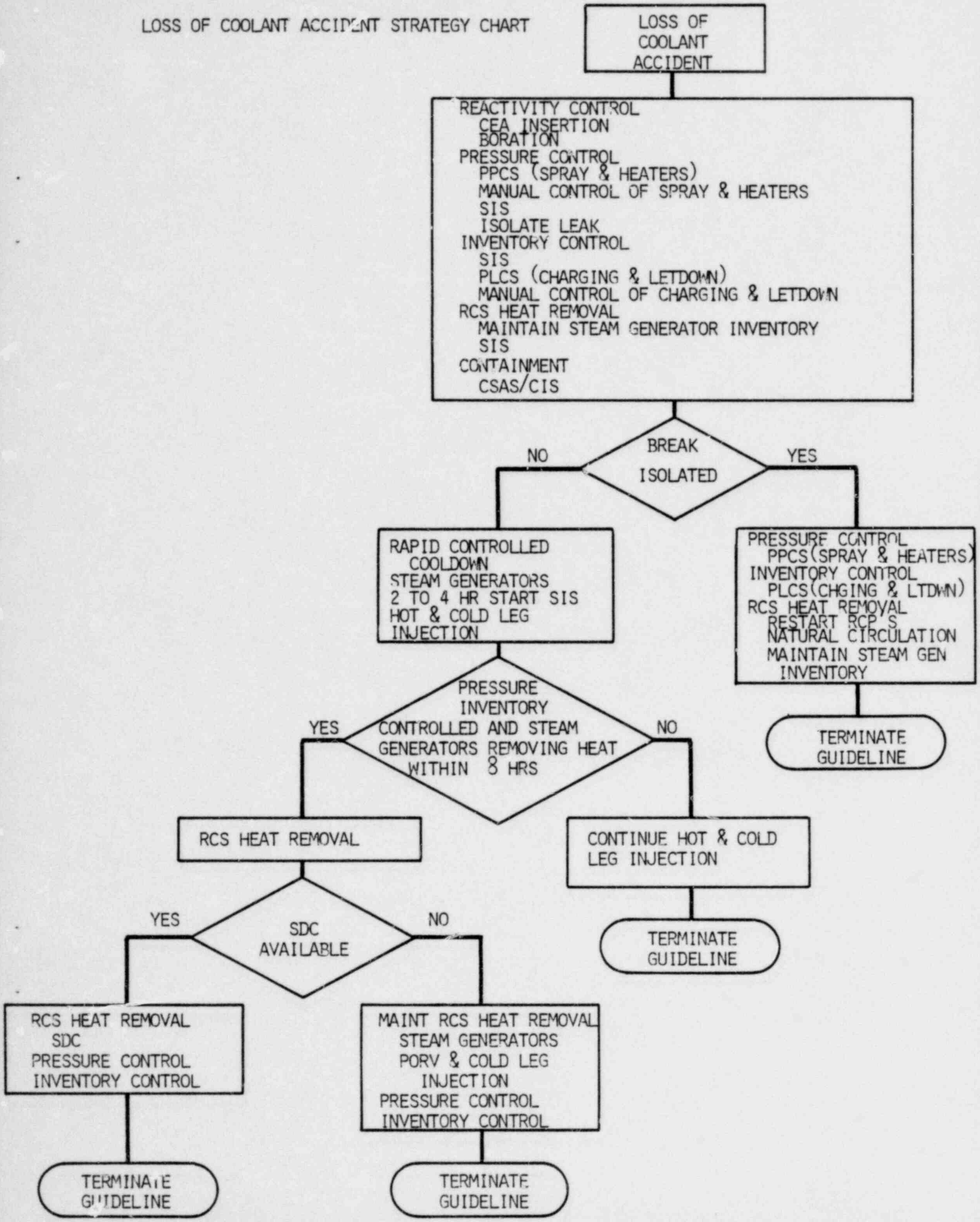
---- indicates reactor decay heat at 4 hours

If pressure and inventory control have not been established at [8 hours], (i.e., the break is larger than the sizes which would cause an RCS refill at 8 hours) the SCS is not operated. If SCS operation is not appropriate due to the above mentioned conditions, or if the system is not available, RCS heat removal must be maintained via the steam generators or by removing heat out the break. Preferentially, steam generator heat removal is maintained using main or auxiliary feedwater and steam is discharged via the condenser or atmosphere. If main and auxiliary feedwater are unavailable, alternate supplies of feedwater should be employed. Examples of alternate sources of feedwater are fire pumps, condensate pumps, temporary water transfer pumps, etc. These alternate sources of feedwater should be investigated in the plant emergency procedures. Steam discharge to the condenser or atmosphere is continued. [Lastly, the pressurizer PORV may be opened and the SIS aligned for cold leg injection for heat removal purposes.]

16. If RCS pressure and inventory control at [8 hours] has not been established, the break may be too large for absolute assurance that proper suction is available for the shutdown cooling mode; however, in this event there is assurance that the continuation of simultaneous hot and cold leg injection alone will both cool the core and flush the reactor vessel indefinitely.

Figure 4.1-6

LOSS OF COOLANT ACCIDENT STRATEGY CHART



LOSS OF COOLANT ACCIDENT GUIDELINE

SYMPTOMS

1. Pressurizer level decreasing.

2. Reactor trip alarm.

3. Safety Injection System (SIS) may have automatically actuated.

4. Possible increase in containment pressure, temperature, radiation, humidity and containment sump level.

5. Possible high quench tank level, temperature, or pressure.

6. Possible noise indicative of a high energy line break.

7. Decrease in volume control tank level.

8. Standby charging pumps energized.

9. Unbalanced charging and letdown flows.

10. Initial Trending of Key Parameters:

    a) Reactor power - constant or decreasing
    b) Pressurizer pressure - decreasing
    c) RCS temperature - constant or decreasing
    d) Pressurizer level - constant, decreasing or increasing
    e) Steam generator pressure - decreasing
    f) Steam generator level - constant or decreasing

IMMEDIATE ACTIONS

1. Verify that the reactor has tripped. If not, manually trip the reactor and carry out standard post trip actions.

2. If pressurizer pressure decreased to [1600 psia], [or if containment pressure icnreases to 5 psig], verify that an SIAS has been initiated. If not, manually initiate an SIAS.

3. If pressurizer pressure decreases to [1300 psia] following an SIAS, stop all reactor coolant pumps.

4. Verify that the Main or Auxiliary Feedwater System is maintaining or restoring normal steam generator level.

5. If containment pressure increases to [5 psig], [or if pressurizer pressure decreases to 1600 psig], verify initiation of containment isolation. If necessary, manually initiate containment isolation.

6. If containment pressure increases to [10 psig], verify initiation of containment spray. If necessary, manually initiate containment spray.

7. [If pressurizer pressure is below 2400 psia, verify the PORVs are closed. If not, manually close the PORVs or PORV block valves.]

8. Verify that the letdown line is isolated. If necessary, manually close the letdown isolation valves.

9. If sampling is in progress, terminate this activity. Verify sample lines are isolated. If necessary, manually isolate sample lines.

10. [If there are other possible sources of leakage that can be rapidly and remotely isolated, insert that information here.]

FOLLOW-UP ACTIONS

1. Verify all immediate actions have been initiated.

2. Confirm the diagnosis of a loss of coolant accident by referring to Figure 4.1-7. If a misdiagnosis has been made, implement the proper emergency guideline. If a definitive diagnosis cannot be made, refer to the plant status and trending diagnosis.

If the break has been isolated:

3. Verify that the PPCS is automatically restoring RCS pressure. If not, manually control heaters or spray to restore pressurizer pressure.

4. Verify that the PLCS is automatically maintaining or restoring pressurizer level. If necessary, manually operate charging and letdown to maintain or restore normal pressurizer level.

5. Maintain RCS cooling by supplying main or auxiliary feedwater to the steam generators and discharging steam to the condenser or atmosphere.

6. If all RCPs have been stopped, verify that natural circulation is accomplished per the Loss of Forced Reactor Coolant Flow Guidelines consurrently with this guideline.

7. If the SIS is operating, it may be stopped if the following conditions are satisfied:
   a) RCS hot and cold leg temperatures are at least [20°F + inaccuracies] below saturation temperature for pressurizer pressure (refer to Figure 4.1-8), and
   b) pressurizer level is in the normal operating band and is responding normally to the Pressurizer Level and Pressure Control Systems, and
   c) at least one steam generator has an indicated level and is removing heat from the RCS.

8. If [20^{o}F + inaccuracies] of subcooling (refer to Figure 4.1-8), and not be maintained after the SIS has been stopped, the SIS must be restarted.

9. If the RCPs were stopped, one RCP in each loop may be restarted if the following criteria are satisfied:
   a) At least one steam generator is removing heat from the RCS, and
   b) pressurizer level and pressure are responding normally to the Pressurizer Level and Pressure Control Systems, and
   c) The RCS is at least [20^{o}F + inaccuracies] subcooled (refer to Figure 4.1-8).
   d) [Other criteria satisfied per RCP operating instructions.]

10. Evaluate plant status. If necessary, cooldown and depressurize to SDC entry conditions and commence SDC per operating instructions.

<u>If the break has not been isolated</u>:

3. Record the time of day.

4. If all RCPs are stopped, verify that natural circulation is accomplished per the Loss of Forced Reactor Coolant Flow Guideline concurrently with this guideline.

5. Commence a rapid controlled plant cooldown at a rate within Technical Specification Limitations as soon as possible but no later than [1 hour] after the start of the loss of coolant via the steam generators. Continue to maintain normal steam generator level with main or auxiliary feedwater and discharge steam to the condenser or atmosphere.

6. If a loss of feedwater has occurred, the Loss of Feedwater Guideline must be accomplished concurrently with this guideline.

7. [If the charging pumps are taking suction from a concentrated boron source, realign suction to the RWT or other suitable source within [1 hour] after the start of the loss of coolant accident.]

8. Monitor the refueling water tank level. If possible, replenish as necessary.

9. If the refueling water tank level falls to [10%], verify initiation of recirculation. If necessary, manually initiate recirculation and [close RWT outlet valves to the safety injection system].

10. If the HPSI pumps are delivering less than [30 gpm] per pump during recirculation, turn off one charging pump at a time until the HPSI pumps are delivering more than [30 gpm] per pump. If the HPSI pumps are still delivering less than [30 gpm] per pump with all the charging pumps turned off, turn off the HPSI pump with the lower indicated flow.

11. Monitor radiation levels to determine environmental releases.

12. If the CSAS has been actuated and containment pressure subsequently falls below [8 psig], containment spray may be terminated. Upon termination, it must be realigned for automatic actuation.

13. After [1.5 - 2.5 hours] after the start of the loss of coolant event, [isolate, vent, or drain the safety injection tanks (SIT)].

14. At [2 - 4 hours] after the start of the loss of coolant event, align the [SIS] for hot and cold leg injection.

15. If RCS pressure and inventory control is established (i.e., pressurizer level is stable and RCS hot and cold leg temperatures are at least [20^{o}F + inaccuracies] below saturation temperature for pressurizer pressure) within [8 hours], and the steam generators are removing heat, conduct one of the following activities:

a) Cooldown the RCS to SDC entry conditions by verifying or establishing RCS hot leg temperature less than [400^{o}F]:

   (1) Determine if SDC operationis appropriate by

      i) RCS activity levels

      ii) Condensate inventory

      iii) [Other plant specific information, insert here.]

   (2) [Realign the SIS for cold leg injection.]

   (3) Depressurize the RCS to [300 psig] by:

      i) Using auxiliary spray

      ii) Decreasing SI and charging pump flow if the pressurizer is solid to maintain level and control pressure.

   (4) Initiate shutdown cooling per operating instructions.

b) Maintain RCS heat removal via alternate means (listed in order of decreasing preference):

   (1) Maintain steam generator heat removal using main or auxiliary feedwater while discharging steam to the condenser or atmosphere.

   (2) [Maintain steam generator cooling using alternate methods of feedwater while discharging steam to the condenser or atmosphere.]

   (3) [Open pressurizer PORV and align the SIS for cold leg injection.]

16. If RCS pressure and inventory control cannot be established within [8 hours], continue hot and cold leg injection.

PRECAUTIONS

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

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 diagnosing the event since the accident may cause irregularities in a particular instrument reading. Critical parameters must be verified when one or more confirmatory indications are available.

4. If there is a high radioactivity level in the reactor coolant system, circulation of this fluid through the SCS may result in high area radioactivity readings in the [auxiliary building]. The activity level of the RCS should be determined prior to initiating SCS flow.

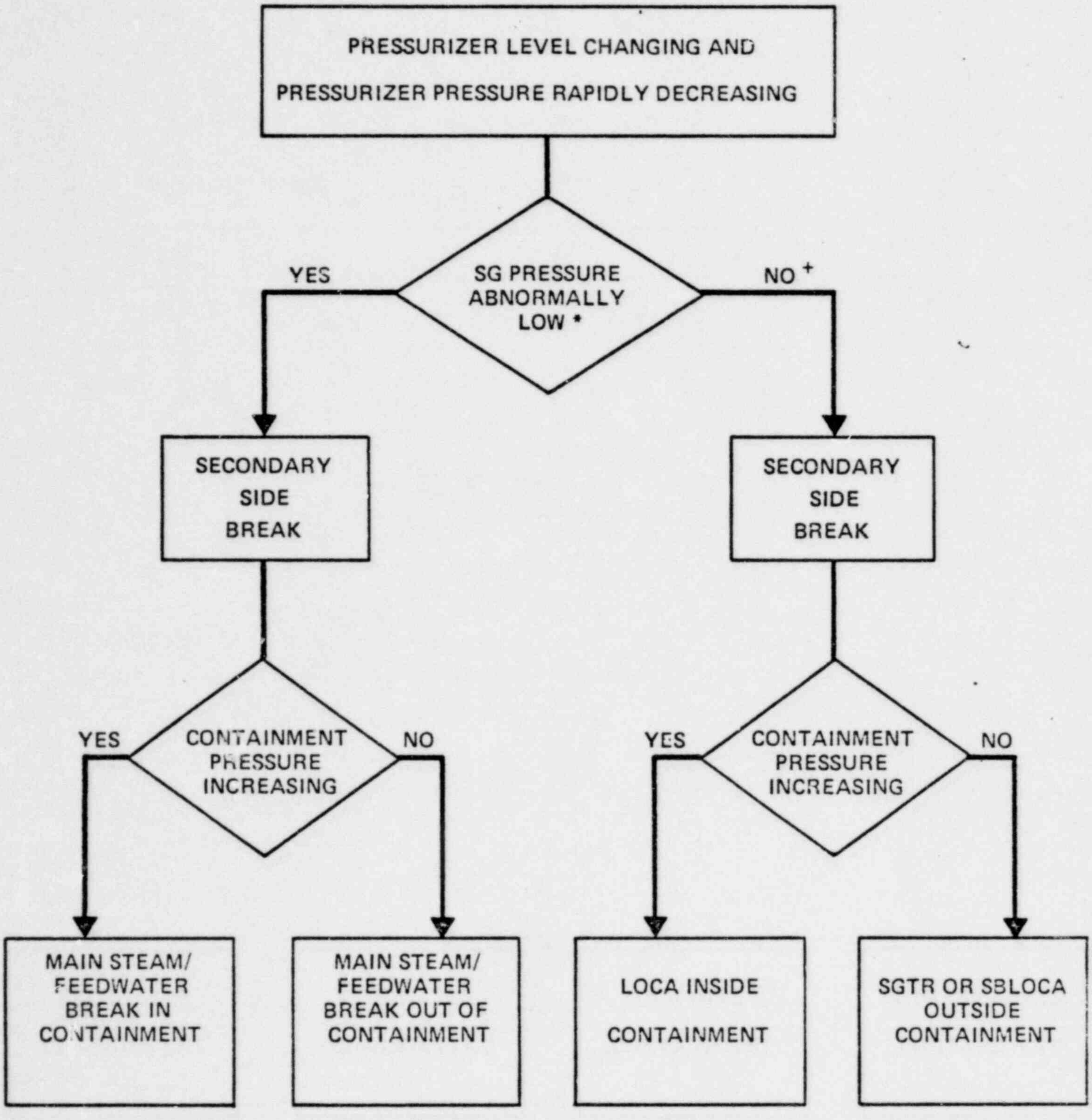
5. For small breaks in the RCS where the steam generators are important for heat removal, one steam generator must be used for this purpose even if primary to secondary leaks are detected.

6. Evaluate condensate storage inventory. Conduct a plant cooldown and enter SDC prior to depleting condensate storage.

7. The operator should be cautioned against prematurely initiating an RAS. This manual action should not be taken unless an automatic RAS is required.

Figure 4.1-7

BREAK IDENTIFICATION CHART

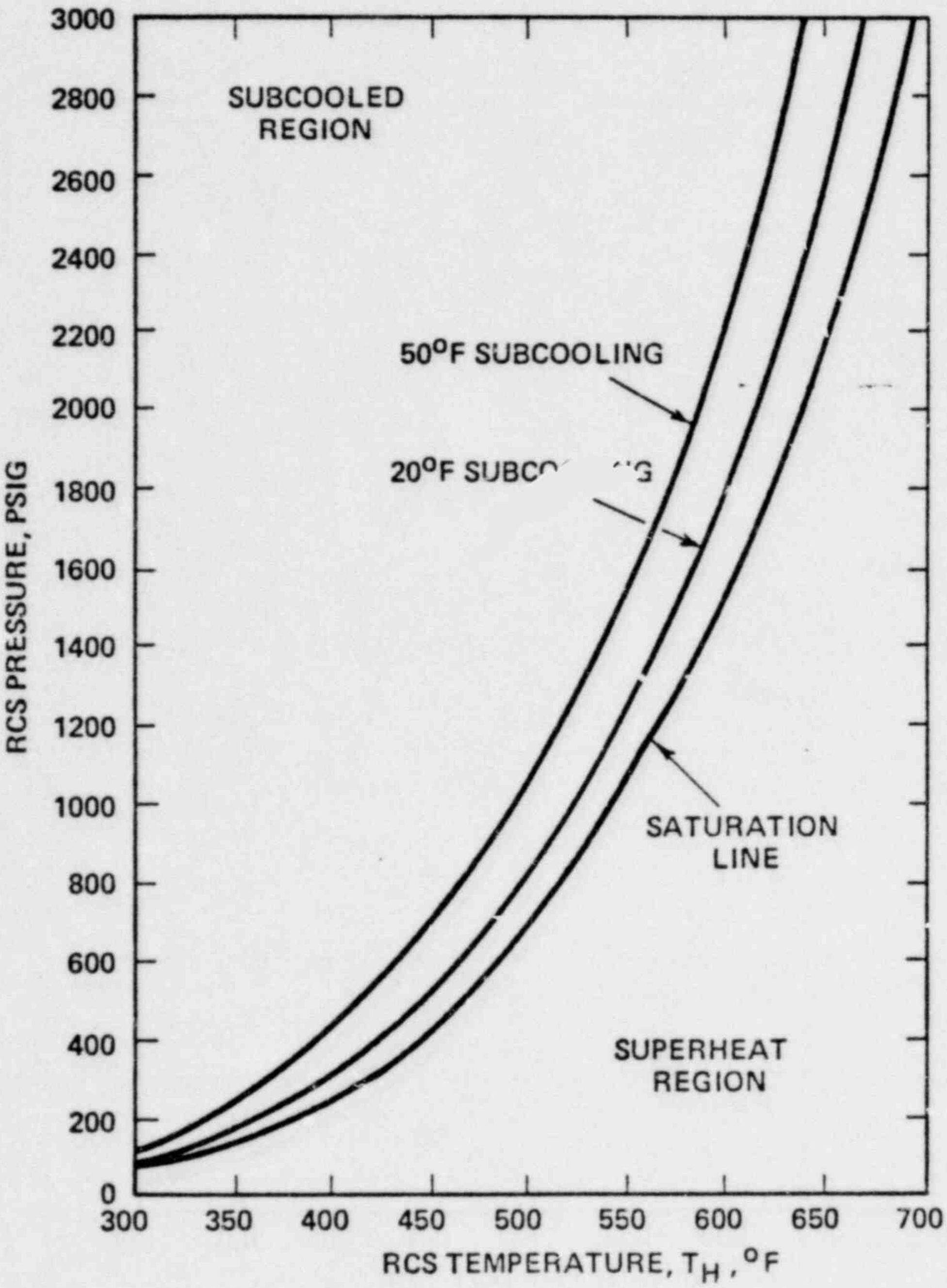


* IN ONE OR BOTH STEAM GENERATORS

\+ MAY DECREASE SLIGHTLY AFTER TRIP

Figure 4.1-8

SATURATION / SUBCOOLING



4.2 STEAM GENERATOR TUBE RUPTURE GUIDELINE

BASES

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, or a small crack in a U-tube or weld joining the U-tube to the tube sheet, to a single tube double-ended rupture. A steam generator tube inside diameter 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. The loss of coolant 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.

Characterization of a SGTR Event

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

a) Radiation monitors indicating an increase at the air ejector discharge, at the steam generator blowdown lines, at the turbine or auxiliary building ventilation monitors, at the stack monitor, and/or in the steam generator liquid sample. These monitors may alarm due to a steam generator tube rupture.

b) Decreasing level in the volume control tank.

c) An unaccounted mismatch in the charging and letdown system flowrates.

d) An unaccounted mismatch in the steam generator feed and steam flowrates. Feed flow experiences a decrease in proportion to the magnitude of the rupture. Without the steam generator blowdown system operating, for a double-ended rupture, feed flow will be approximately 50 lbm/sec lower than steam flow. Small ruptures will produce a relatively unnoticeable change in feed flow. Steam flow remains relatively constant for small and large ruptures unless the event results in a reactor trip and subsequent turbine trip when steam flow goes to zero.

e) Relatively constant temperature and power indications.

f) An increasing steam generator water level.

Safety Functions Affected

The steam generator tube rupture accident directly affects two critical safety functions. One is RCS inventory control. The second critical safety function affected is containment integrity and radiation control as contamination and radiation control are transferred from the reactor coolant boundary to the operator.

RCS inventory control is affected in the following manner. The rupture size determines whether an automatic reactor trip occurs. 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, emptying the pressurizer and initiating an SIAS. All heaters are deenergized due to low pressurizer level.

For the double ended rupture of one steam generator tube, wihtout operator action, the reactor trip is expected at approximately 6-10 minutes after rupture. Although multiple tube failures could result in a more rapid plant response, the operator actions would not change.

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.

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 will be carried into the steam plant by the main steam flow. The non-condensible gases will eventually be exhausted to the environment by way of stack via the air ejector 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 auxiliary buildings will increase and may cause area radiation monitors to alarm. Ventilation exhaust and stack monitors may also alarm. For double ended tube ruptures, the expected order of alarms is: air ejector, blowdown, ventilation and stack monitors. For small tube leaks, the first indication may be a high activity level in the steam generator liquid sample.

Initial Trending of Key Parameters

Reactor Power

In response to a steam generator tube rupture, reactor power initially remains constant. For ruptures within the capacity of the available charging pumps (small ruptures), a reactor trip does not occur, and a controlled reactor shutdown should be performed. Ruptures exceeding the capacity of the available charging pumps (large ruptures) will result in a reactor trip on thermal margin/low pressure in a time dependent on the size of the rupture.

Pressurizer Pressure and Level

Pressurizer pressure and level responses are dependent on the size of the tube rupture. Level and pressure remain relatively constant for small ruptures due to the automatic operation of the pressurizer level and pressure control system. Large ruptures result in a slowly decreasing pressurizer level due to a decreasing pressurizer level. The continued decrease in pressurizer pressure following the rupture subsequently initiates a thermal margin/low pressure reactor trip without operator action. At about the same time, pressurizer level falls below the heater cutoff level, and all heaters are deenergized. Pressurizer pressure, and level then fall rapidly, resulting in an SIAS and emptying of the pressurizer. If RCS pressure falls below the Safety Injection System pump shut-off head, they will restore the RCS pressure and inventory control.

RCS Temperature

The RCS temperatures remain constant throughout the event for small ruptures and until the reactor trips for the large ruptures. Following the reactor trip for large ruptures, the PCS hot and cold leg temperature will eventually equalize at the hot standby value.

Steam Generator Pressure

Steam generator pressure remains relatively constant for small ruptures. The reactor trip due to a large break causes a turbine trip, and the reduced steam demand rapidly raises steam generator pressure. The Turbine Bypass System automatically actuates to control main steam pressure. The pressure is eventually reduced to the hot standby value.

Steam Generator Level

Steam generator water level remains constant for small ruptures. Large ruptures cause a slow increase in level. The water level in the affected steam generator increases approximately 3% before reactor trip. A smaller increase could be expected for small ruptures. The 3% increase in level is well within normal oscillations due to the Feedwater Control System operation and may not be noted in the control room. 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.

Event Strategy

Figure 4.2-1 provides a summary of the strategy employed in this guideline. Only the major decision points are indicated. A detailed discussion of the required operator actions and bases is found in the following subsections.

Bases Immediate Actions

The immediate corrective actions taken are directed towards two main objectives; regaining pressurizer level and pressure control and reestablishing the integrity of the containment. The former is accomplished using charging or the Safety Injection System, and the latter by monitoring the Ventilation Systems' radiation monitors and taking corrective actions, if necessary.

The following immediate actions are taken if pressurizer level is being maintained by the Pressurizer Level Control System (the SGTR is within the capacity of the available charging system).

1. Reactor power is reduced at a rate that will not cause an automatic reactor trip. A controlled reactor shutdown is initiated. A controlled reactor shutdown is preferred to a trip for three reasons.

First, a ramp down in reactor power will reduce the likelihood of a turbine trip. A turbine trip has the potential to cause a loss of condenser systems and lift the secondary safety valves increasing releases to the environment. Second, a controlled power reduction will increase the availability of the reactor coolant pumps. Third, a crud burst is less likely during a controlled reactor shutdown.

The reason for performing a reduction in the steaming rate is fundamentally for radiological considerations. Reduced steaming slows the transfer of radionuclides from the steam generator to the condenser, which are then exhausted via the air ejectors and building ventilation to the environment. Reduced steaming rate also enhances the concentration of radionuclides within the affected steam generator providing earlier identification of the affected steam generator and isolation from further releases to the environment.

2. The PPCS is verified to be automatically controlling or restoring RCS pressure. If not, pressurizer heaters or spray are operated manually to control pressurizer pressure. This action verifies that a safety function is being performed; controlling RCS pressure.

3. The PLCS is verified to be automatically controlling or restoring pressurizer level. If not, charging and letdown are operated manually to ensure pressurizer level is being maintaiend. This action verifies that a safety function is being performed; controlling RCS inventory.

4. The operator should verify that the Main or Auxiliary Feedwater System is maintaining or restoring steam generator level. Feedwater flow to the steam generators provides a means for maintaining RCS heat removal or, if necessary, cooling down the RCS. This action contributes to accomplishment of the RCS heat removal safety function.

5. Steam generator blowdown is isolated. Steam generator blowdown can

transmit activity to the environment via blowdown tank vents and must be isolated until it can be redirected to a contaminated hold-up tank.

6. The [turbine] and [auxiliary] building Ventilation System monitors are observed, and corrective actions are taken, if necessary, in accordance with plant Technical Specifications. The Ventilation Systems provide a filtered path to the environment for radionuclides taken from the condenser by the air ejectors. These systems are isolated only if necessary.

The following immediate acitons are taken if pressurizer level cannot be maintained by the Pressurizer Level Control System (the SGTR is in excess of the capacity of the available charging system), or a reactor trip has occurred:

1. An automatic reactor trip is verified. If the reactor has not tripped automatically, a manual trip is initiated and standard post trip actions are carried out. Without operator action, a large rupture should result in an automatic reactor trip on thermal margin/low pressure. If an automatic trip has not occurred, a manual action assures that the reactor is tripped. Manually tripping the reactor, if this can be done before system pressure goes below the thermal margin/low pressure setpoint, prevents the unnecessary challenge of a Reactor Protective System function. Tripping the reactor reduces steam flow and a subsequent transfer of radioactivity to the environment.

2. Maximum charging flow is injected into the RCS. This action is necessary to ensure that an attempt to regain inventory control is being made. This also ensures that borated water is being added at the maximum rate to the RCS for reactivity control.

3. If pressurizer pressure is less than [1600 psia], [or if containment pressure increases to 5 psig], the initiation of an SIAS must be verified. If it has not been initiated, the SIS must be manually actuated.

This action verifies safety functions are being performed; RCS heat removal and RCS inventory control.

4. If pressurizer pressure decreases to [1300 psia] following an SIAS, all reactor coolant pumps must be stopped. A system response identified by a depressurization transient to below [1300 psia] following an SIAS (and subsequent operation of the SIS) is characteristic of a LOCA. Continued RCP operation at RCS pressures below [1300 psia) during a LOCA may result in more severe RCS conditions.

   It may not be possible to distinguish between events causing a depressurization in the early stages of the transient; specifically during the time period when the immediate actions are taken. The immediate actions required for all events are directed at placing the plant in a safe condition. To avoid the necessity of a confirmation of the initiating event during the time when the immediate actions are taken, anytime pressurizer pressure decreases to [1300 psia] following an SIAS, all RCP operation is terminated.

5. Letdown is isolated. This action verifies that RCS inventory is being managed.

6. Steam generator blowdown must be isolated. Steam generator blowdown can transmit activity to the environment via blowdown tank vents and must be isolated until it can be redirected to a contaminated hold-up tank.

7. The [turbine] and [auxiliary] building Ventilation Systems must be monitored and corrective actions must be taken, if necessary, in accordance with plant Technical Specifications. The ventilation systems provide a filtered path to the environment for radionuclides taken from the condenser by the air ejectors. These systems are isolated, if necessary.

Bases Follow-Up Actions

The follow-up actions are directed towards a plant cooldown and depressurization. The leak rate through the rupture is proportional to the square root of the differential pressure across the break and is substantially reduced by lowering the RCS pressure. Reduced leak flow rate reduces the radiological impact of the accident.

1. All immediate operator actions should be verified. This assures that the critical safety functions affected by a SGTR accident have been attended to and regaining control of the plant has been initiated.

2. The diagnosis of a SGTR event should be confirmed by referring to Figure 4.2-2. If a misdiagnosis has been made, the proper emergency guideline can be implemented. The correct diagnosis of a SGTR event is important because the leading parameter changes in the event (pressurizer level or pressure) can be indicative of four different accidents.

   There is no single indication of a steam generator tube rupture but rather a series of plant indicators that must be utilized in the determination. The attached diagnostics chart (Figure 4.2-3). illustrates how a change in pressurizer level can be indicative of four different accidents. The key indicators that are found on Figure 4.2-3, used for identifying a SGTR, are as follows:

   1. Pressurizer Pressure - decreasing, and
      Pressurizer Level - unexplained change

   2. Steam Generator Pressure - initially normal or rising, then a sharp increase following the reactor/turbine trip and a slow decrease back to hot standby pressure

3. Containment Pressure - normal
   Containment Radiation - normal
   Containment Sump Level - normal

4. Radiation Monitor Air Ejector Discharge - abnormally high or alarming

If a definitive diagnosis cannot be made, the plant status and trending diagnostic is referenced. This diagnostic is functionally oriented, and all critical safety functions are attended to. The proper emergency guideline may then be accessed.

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

   a) Monitoring and/or sampling the steam generators for activity
   b) Monitoring the main steam piping for activity
   c) If appropriate, specific plant instructions for determining which steam generator is affected should be performed

   This action ensures that radiation control can be established by the isolation of the proper steam generator.

4. If all reactor coolant pump operation is terminated, natural circulation must be established in the RCS. This condition can be verified by referring to the Loss of Forced Reactor Coolant Flow Guideline and following its instruction concurrently with this guideline.

5. The RCS should be cooled down and depressurized until the RCS hot leg temperature is less than [545^{o}F]. A reactor plant cooldown and associated pressure reduction significantly reduces the leak flowrate. This action should be performed preferentially by feeding the steam generators with main or auxiliary feedwater and dumping steam to the condenser via the turbine bypass system. If the condenser or turbine bypass system is not available, the next order of

priority for discharging steam would be to use the atmospheric dump valves. The reactor plant cooldown is conducted in close association with the effort to mitigate the potential release of activity to the environment. It is less desirable to use the atmospheric dump valves to reduce system pressure for radiological release considerations.

6. If an SIAS has been initiated and the SIS is operating, it must continue to operate until SIS termination criteria is met. This criteria is:

   a) RCS hot and cold leg temperatures are at least [20^{o}F + inaccuracies] below saturation temperature for pressurizer pressure (refer to Figure 4.2-3). Establishing [20^{o}F + inaccuracies] of subcooling prevents void formation in the core when SIS flow is terminated, and provides sufficient margin for reestablishing flow should the [20^{o}F + inaccuracies] of subcooling deteriorate when flow is secured. [For plants with high head HPSI pumps, this margin is attainable prior to the opening of the PORVs, enabling the operator to prevent an unnecessary loss of primary coolant.

   b) Pressurizer level is in the normal operating band, and is responding normally to the Pressurizer Level and Pressure Control Systems. A pressurizer level in the normal operating band and responding normally ensures inventory control has been reestablished.

   c) At least one steam generator has an indicated level and is removing heat from the RCS. A steam generator having an indicated level and removing heat from the RCS ensures that primary to secondary heat removal is being maintained.

7. The SIS must be restarted if the [20^{o}F + inaccuracies] of subcooling cannot be maintained. This provides a sufficient margin for system operation. If a subcooling margin does not exist, the RCS pressure could fall below the isolated steam generator pressure and the flow

through the rupture could reverse direction, causing the isolated steam generator water to dilute the reactor coolant boron concentration.

8. After the RCS hot leg temperature has been reduced to [545°F], 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 prevents opening a direct path to the environment for radionuclides after steam generator isolation. Steam generator isolation reestablished containment integrity.

   The affected steam generator is isolated as follows:

   a) The main steam isolation valve is closed
   b) The main steam isolation valve bypass valve is closed
   c) The main feedwater isolation valve is closed
   d) The auxiliary feedwater isolation valves are closed, including the steam driven pump steam supply valve associated with the steam generator being isolated.
   e) Vents, drains, exhausts, and bleedoffs from the steam system and turbine building sumps are isolated. This completes the isolation of the radionuclides still in the secondary system to prevent further releases to the environment.
   f) Any additional plant specific methods for isolating the steam generators should be implemented

9. Once the affected steam generator has been isolated, this action should be verified by checking radiation indications, sampling techniques, or noting an increase in the affected steam generator level. This provides feedback for the proper identification of the affected steam generator.

10. If the wrong steam generator has been isolated, confirmed by the action of the last step, it should be unisolated and the affected steam generator should be isolated.

11. If both generators are affected, for radiological considerations, the steam generator with the highest radiation indications should be isolated. This minimizes activity potentially released to the environment.

12. The RCS is sampled for activity and boron concentration and is borated for cold shutdown. The sample verifies that reactor coolant dilution has not occurred and provides the chemistry information needed for a preparation for borating to cold shutdown boration concentration. This activity confirms that the plant reactivity is in a stable condition.

13. If RCP operation has been terminated, the possibility of RCP operation is determined if all of the following criteria are satisfiedd:

   a) The unaffected steam generator is removing heat from the RCS and thus providing a primary heat removal function.
   b) Pressurizer level and pressure are responding normally to the Pressurizer Level and Pressure Control Systems. This assures that primary inventory and pressure are being controlled.
   c) The RCS is greater than or equal to [20^{o}F + inaccuracies] subcooled. A subcooling condition in the RCS indicates that the RCPs will not be restarted and run under RCS conditions that would cause cavitation and render them unusable.
   d) All plant specific RCP operating criteria should be satisfied before the RCPs are restarted.

14. Since forced circulation is preferred to natural circulation within the RCS during a cooldown and depressurization, if RCP operation has been terminated and is now possible, one RCP in each loop is restarted. An orderly cooldown is resumed by preferentially using the Main or Auxiliary Feedwater Systems in conjunction with the

Turbine Bypass System. If the condenser or Turbine Bypass System is not available, the next order of priority for steam discharge is using the atmospheric dump valves, but the usage of this method is minimized due to the radiological release considerations described earlier.

15. If RCP operation is not possible, it is preferred operationally to maintain RCS heat removal until the RCPs can be restarted before an orderly cooldown and depressurization is resumed. This operational decision depends primarily on the long-term steam generator heat removal capacity and the time period during which the RCPs are expected to be out of service. The long-term steam generator heat removal capability should be determined.

    If conditions permit, RCS heat removal should be maintained until the RCPs can be restarted. Then, an orderly forced flow cooldown and depressurization is resumed. If waiting for the RCPs to be returned to service is not operationally possible, direction on a natural circulation plant cooldown is found by referring to and accomplishing the Loss of Forced Reactor Coolant Flow Guideline concurrently with this guideline. A cooldown via natural circulation should be commenced.

16. Overfilling of the affected steam generator should be prevented by reducing the level periodically to the [Radioactive Waste System]. The potential exists for the flow of reactor coolant into the affected steam generator to fill the generator steam space and the main steam piping to the MSIV. This presents a serious and undesirable spread of contamination. Draining to the [Radiation Waste System] will minimize the spread of contamination.

17. Offsite and secondary plant radiation surveys should be conducted in an effort to detect, and thus limit, environmental radiological releases. These radiation surveys should include the monitoring of particulate iodine levels.

18. Radiation control areas should be established. These steps are taken to minimize personnel exposure to surface, radiation and airborne contamination.

19. 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. These samples aid in determining the extent of contamination throughout the plant systems.

20. The [turbine] and [auxiliary] building Ventilation Systems' radiation monitors, and any other applicable radiation monitors applicable, should be continually observed. Corrective actions, if necessary, should be taken in accordance with plant Technical Specifications.

21. When the RCS is cooled to [300^{O}F] and depressurized to [300 psia], shutdown cooling should be initiated per plant specific operating instructions. This activity places the plant in an operational mode where a complete cooldown and depressurization of the plant can take place.

Other Guidelines

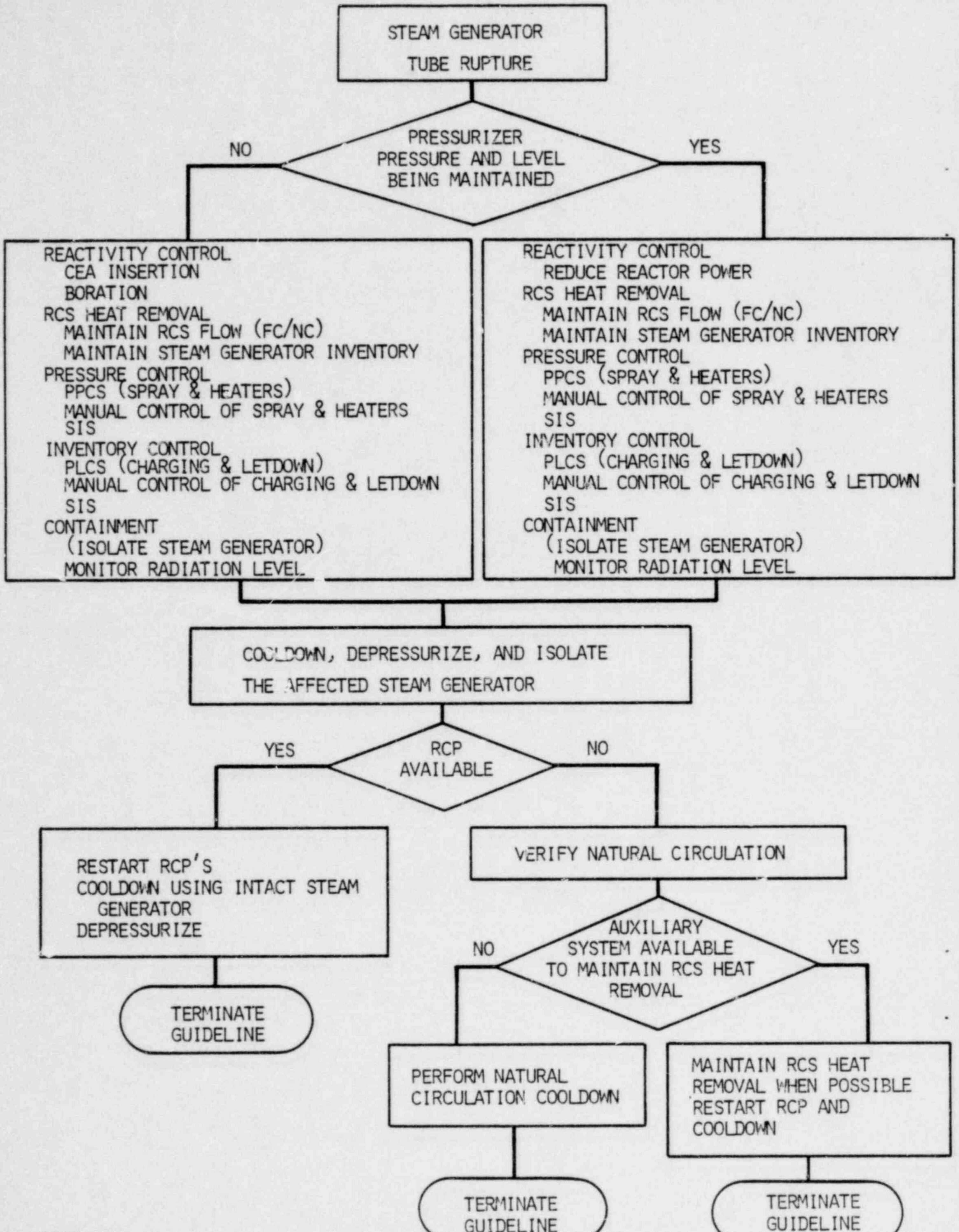
The steam generator tube rupture guideline covers a specific event. At various points in the guideline reference is made to additional guidelines whose actions are required to place the plant in a stable condition but are beyond the scope of this guideline. The additional guidelines referenced are listed below:

a) Loss of Forced Reactor Coolant Flow Guideline

If necessary, the actions of the Loss of Forced Reactor Coolant Flow Guideline should be accomplished concurrently with the actions of this guideline.

FIGURE 4.2-1

STEAM GENERATOR TUBE RUPTURE STRATEGY CHART



STEAM GENERATOR TUBE RUPTURE GUIDELINE

SYMPTOMS

1. Air ejector high activity alarm.

2. Steam generator blowdown high activity alarm.

3. Decrease in volume control tank level.

4. Standby charging pumps energized.

5. Unbalanced charging and letdown flows.

6. Possible feed versus steam flow mismatch.

7. Reactor trip alarm.

8. High activity and conductivity in steam generator liquid sample.

9. Increasing steam generator level.

10. Initial Trending of Key Parameters:

    a) Reactor power - constant
    b) Pressurizer pressure - constant or decreasing
    c) RCS temperature - constant T_{avg}
    d) Pressurizer level - constant or decreasing
    e) Steam generator pressure - constant
    f) Steam generator level - constant or increasing

IMMEDIATE ACTIONS

If pressurizer level is being maintained by the pressurizer level control system, perform the following:

1. Reduce reactor power at a rate that will not cause an automatic reactor trip.

2. Verify that the PPCS is automatically maintaining or restoring RCS pressure. If not, manually control heaters or sprays to restore pressurizer pressure.

3. Verify that the PLCS is automatically maintaining or restoring pressurizer level. If not, manually operate charging and letdown to restore or maintain pressurizer level.

4. Verify that the Main or Auxiliary Feedwater System is maintaining or restoring normal steam generator level.

5. Isolate steam generator blowdown.

6. Observe the [turbine] and [auxiliary] building Ventilation Systems' radiation monitors. If necessary, take corrective actions in accordance with plant Technical Specification Limitations.

If pressurizer level cannot be maintained by the pressurizer level control system or a reactor trip has occurred, perform the following:

1. Verify the reactor has tripped. If not, manually trip the reactor, and carry out standard post trip actions.

2. Verify that maximum charging flow is being injected into the RCS.

3. If pressurizer pressure decreases to [1600 psia], [or if containment pressure increases to 5 psig], verify that an SIAS has been initiated. If not, manually initiate an SIAS.

4. If pressurizer pressure decreases to [1300 psia] following an SIAS, stop all reactor coolant pumps.

5. Isolate letdown.

6. Isolate steam generator blowdown.

7. Observe the turbine and auxiliary building Ventilation Systems' radiation monitors. If necessary, take corrective actions in accordance with plant Technical Specification Limitations.

FOLLOW-UP ACTIONS

1. Verify that all immediate actions have been initiated.

2. Confirm the diagnosis of a SGTR event by referring to Figure 4.2-2. If a misdiagnosis ahs been made, implement the proper emergency guideline. If a definitive diagnosis cannot be made, refer to the plant status and trending diagnostic.

3. Determine which steam generator has the tube rupture by performing the following:

   a) Monitor and/or sample steam generators for activity.
   b) Monitor main steam piping for activity.
   c) [Other plant specific indications, insert here.]

4. If all RCPs are stopped, verify that natural circulation is accomplished per the Loss of Forced Reactor Coolant Flow Guidelines concurrently with this guideline.

5. Cooldown and depressurize the RCS until the RCS hot leg temperature is less than [545^{O}F] by performing one of the following. The activities are listed in order of preference:

   a) If the condenser, Turbine Bypass System, and Main or Auxiliary Feedwater System are available, commence the cooldown by using the Turbine Bypass System and main or auxiliary feedwater.

b) If the condenser or Turbine Bypass System is not available, commence a reactor plant cooldown using the atmospheric dump and main or auxiliary feedwater.

6. If the SIS is operating, it may be stopped if the following conditions are satisfied:

   a) RCS hot and cold leg temperatures are at least [20^{o}F + inaccuracies] below saturation temperature for pressurizer pressure (refer to Figure 4.2-3), and

   b) pressurizer level is in the normal operating band and is responding normally to the Pressurizer Level and Pressure Control Systems, and

   c) at least one steam generator has an indicated level and is removing heat from the RCS.

7. If [20^{o}F + inaccuracies] of subcooling (refer to Figure 4.2-3) cannot be maintained after the SIS has been stopped, the SIS must be restarted.

8. After the RCS hot leg temperature has been reduced to [545^{o}F], isolate the steam generator with higher activity, higher radiation levels or increasing water level as follows:

   a) Close the main steam isolation valve.
   b) Close the main steam isolation valve bypass valve.
   c) Close the main feedwater isolation valve.
   d) Close the auxiliary feedwater isolation valves including the steam driven pump steam supply valve associated with the steam generator being isolated.
   e) Isolate vents, drains, exhausts, and bleedoffs from the steam system and turbine building sumps.
   f) [Other plant specific information, insert here.]

9. Once the affected steam generator has been isolated, verify this action by checking radiation indications, by sampling or steam generator level increase.

10. If the wrong steam generator has been isolated, unisolate that generator and isolate the affected steam generator.

11. If both generators are affected, the steam generator with the highest radioactivity should be isolated.

12. Sample the RCS for radioactivity and boron concentration, and borate for cold shutdown.

13. If RCP operation has been terminated, one RCP in each loop may be restarted if the following criteria are satisfied:

    a) The unaffected steam generator is removing heat from the RCS.
    b) Pressurizer level and pressure are responding normally to the Pressurizer Level and Pressure Control Systems.
    c) The RCS is at least [20°F + inaccuracies] subcooled (refer to Figure 4.2-3).
    d) [Other criteria satisfied per RCP operating instructions.]

14. If RCP operation has been terminated and is now possible:

    a) Start one RCP in each loop.
    b) Resume an orderly reactor plant cooldown and depressurization by conducting one of the following activities:

        i) If the condenser, and either the Main Feedwater System or Auxiliary Feedwater System are available, cooldown by using the Turbine Bypass System.
        ii) If the condenser or Turbine Bypass System is not available, cooldown using the unaffected (or least affected) steam generator by way of the atmospheric dump on the unaffected (or least affected) steam generator, and using either the Main Feedwater System or the Auxiliary Feedwater System.

15. If RCP operation has been terminated and is currently not possible, evaluate the long-term steam generator heat removal capacity.

    a) If conditions permit, maintain RCS heat removal until the RCPs can be restarted, then resume an orderly cooldown and depressurization.

    b) If conditions do not permit waiting for the RCPs to be returned to service, perform a cooldown using natural circulation per the Loss of Forced Reactor Coolant Flow Guideline concurrently with this guideline.

16. Prevent overfilling of the affected steam generator through periodic draining to the [Radioactive Waste System].

17. Conduct offsite and secondary plant radiation surveys, including the monitoring of particualte iodine levels.

18. Establish radiation control areas.

19. Sample the condensate and other connecting systems, including turbine building sumps for activity transferred from the affected steam generator.

20. Continually observe the [turbine] and [auxiliary] building Ventilation Systems' radiation monitors and any other applicable radiation monitors. Take corrective actions if necessary in accordance with plant Technical Specifications.

21. When the RCS is cooled to [300^{o}F] and depressurized to [300 psia], initiate shutdown cooling per operating instruction.

PRECAUTIONS

1. If a controlled reactor shutdown is commenced, plant load should be reduced at a maximum rate which will not in itself cause a reactor trip; a power reduction consistent with turbine design characteristics is recommended.

2. The use of the atmospheric steam dump valves should be minimized.

3. To reduce the release of potentially radioactive steam from turbine driven pump exhausts, motor driven emergency or normal 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 auxiliary turbine driven pumps.

4. To avoid steam generator inventory from flowing into and diluting the reactor coolant, maintain reactor coolant pressure approximately equal to the affected steam generator pressure after isolation using charging pumps or safety injection flow.

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

6. To facilitate the cooldown, a Main Steam Isolation Signal (MSIS) may be avoided by bypassing the signal setpoint on each safety channel.

7. [If reactor coolant pressure control is maintained, a Safety Injection Actuation Signal (SIAS) may be avoided by bypassing the signal setpoint on each pressurizer pressure safety channel, thus facilitating cooldown and depressurization.]

8. Although it is possible in the long-term to note an increasing steam generator level, automatic feedwater modulation keeps the steam generator level approximately constant during the short-term.

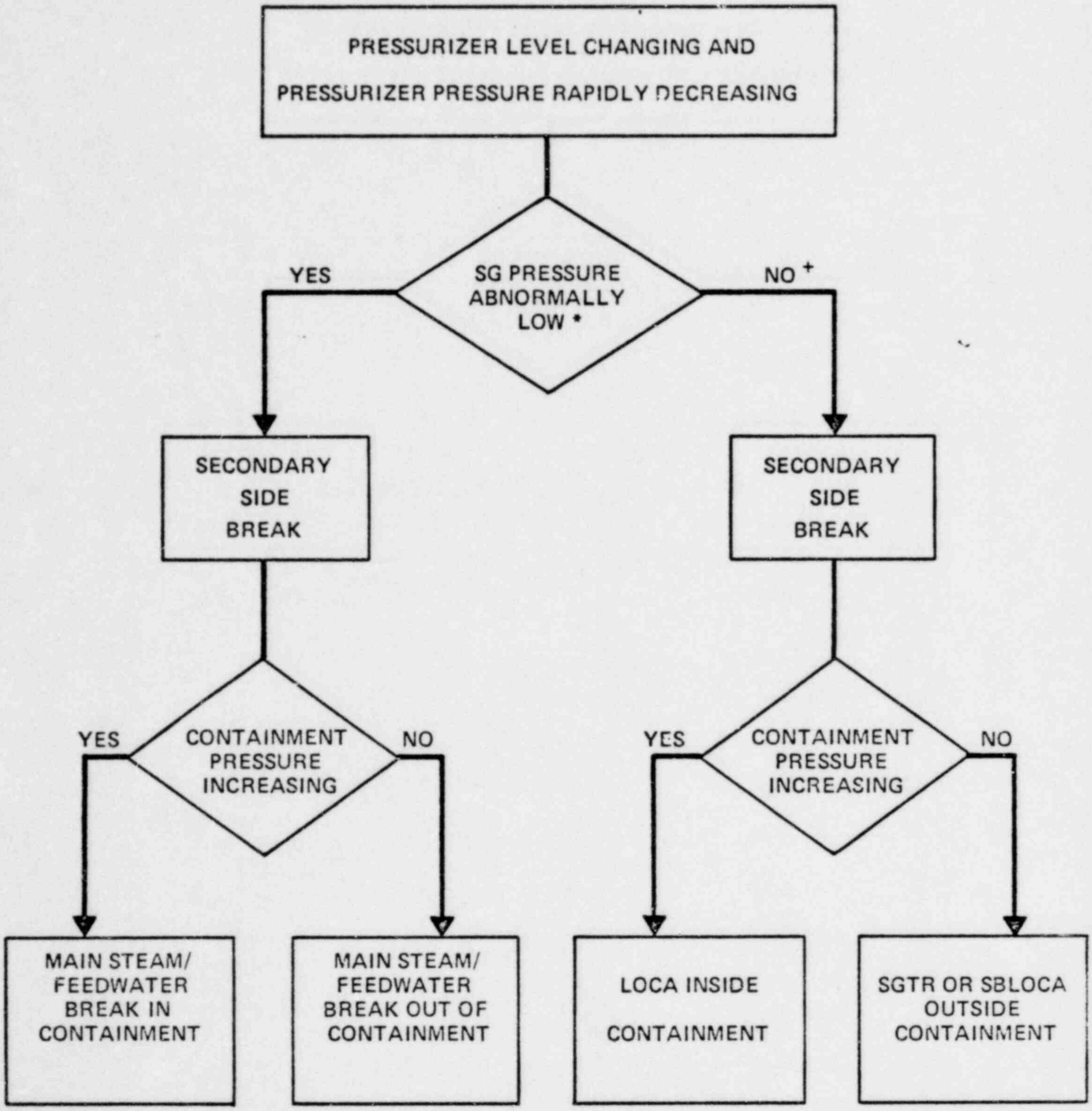
9. After the faulted steam generator has been isolated and the cooldown is proceeding via natural circulation, an inverted ΔT (i.e. T_c greater than T_h) may be observed in the idle loop. This is due to a small amount of reverse heat transfer in the isolated steam generator and will have no effect on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

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

11. All available indications should be used to aid in diagnosing the event, since the accident may cuase irregularities in a particular instrument reading. Critical parameters must be verified when one or more confirmatory indications are available.

FIGURE 4.2-2

BREAK IDENTIFICATION CHART

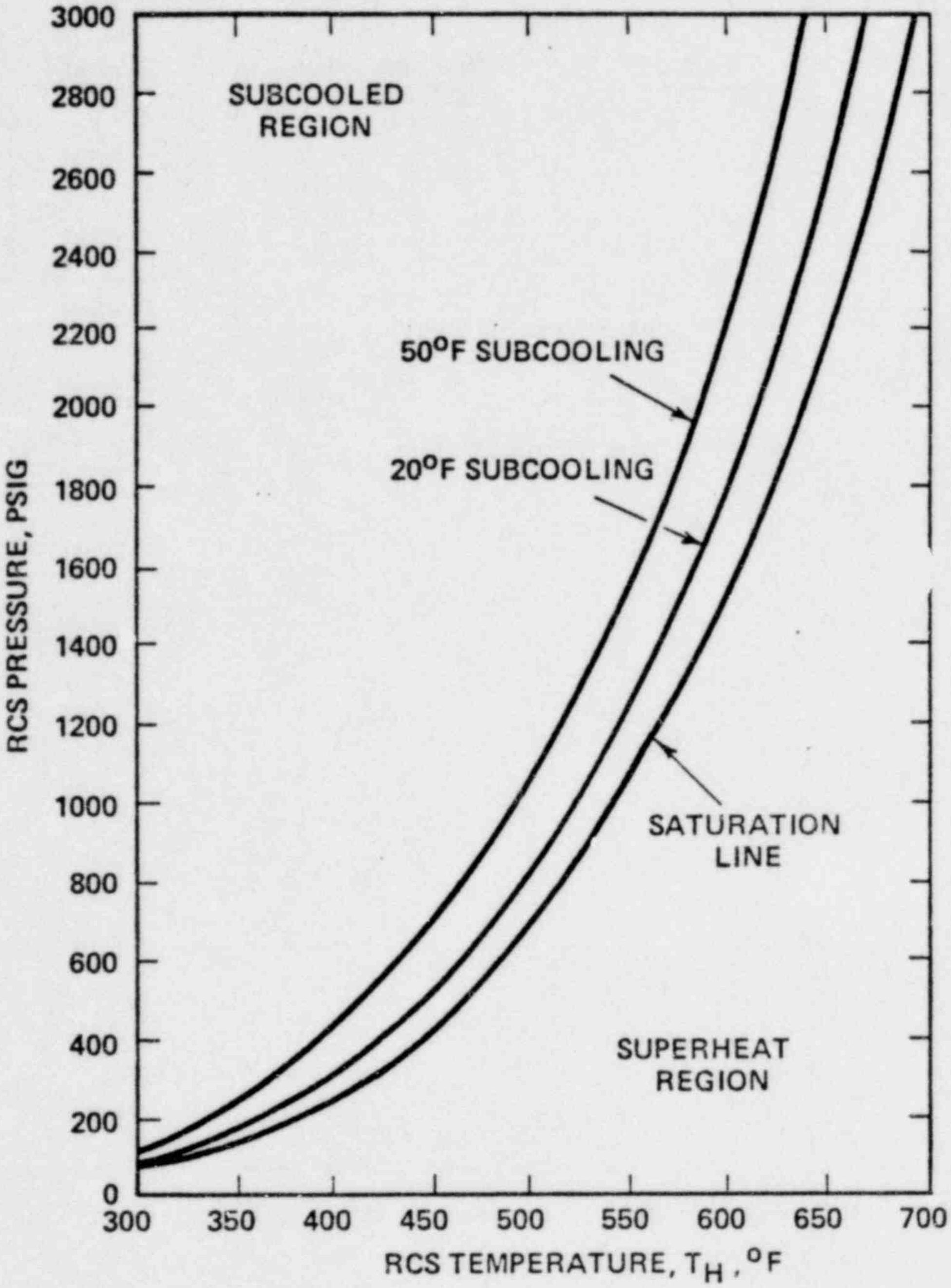


* IN ONE OR BOTH STEAM GENERATORS

\+ MAY DECREASE SLIGHTLY AFTER TRIP

FIGURE 4.2-3

SATURATION / SUBCOOLING



5.0 RCS HEAT REMOVAL GUIDELINES

Although all the critical safety functions are addressed in each emergency procedure guideline, generally, the control of one or more of the safety functions is of more immediate importance than the others. It is possible to group the guidelines on this basis. The guidelines contained in the following sections are:

5.1 <u>LOSS OF FEEDWATER GUIDELINE</u>
5.2 <u>LOSS OF FORCED REACTOR COOLANT FLOW GUIDELINE</u>
5.3 <u>STEAM LINE BREAK GUIDELINE</u>

The actions of these three guidelines are primarily directed at RCS heat removal.

5.1 LOSS OF FEEDWATER GUIDELINE

BASES

A loss of feedwater is a total loss of normal feedwater flow to the steam generators. Some possible causes for a loss of feedwater include:

a) Loss or cavitation 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.

Characterization of a Loss of Feedwater Event

A loss of feedwater is characterized by specific parameters that may be noted in the control room. Some of these indications are:

a) Decreasing steam generator water level. The existence of this condition may be noticed 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) Auxiliary Feedwater Actuation Signal (AFAS) 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) Characteristic of a feedwater line break inside containment; containment pressure may increase.
i) A feedwater line break outside containment may be indicated by noise.

j) Possible equipment operational irregularities; such as a loss of feedwater flow 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.
l) Possible increase in containment pressure, temperature, radiation, humidity, or containment sump level.

Safety Functions Affected

A loss of feedwater results in a decrease or loss of the steam generator's ability to remove heat from the RCS. Operator actions should be directed towards conserving the available steam generator secondary water inventory and re-establishing feedwater flow to the steam generators, so that the RCS heat removal capability is maintained or re-established.

The heat removal capability is affected in the following manner. The loss of feedwater flow to the steam generators greatly impedes the ability to maintain controlled cooling in the RCS. The fact that the steam generators may not be available to remove primary heat greatly increases the possibility that the RCS pressure will increase to the lifting setpoint of the secondary and/or primary safety valves. This is described by the the following scenerio. Once feedwater is lost, RCS temperature begins to increase. The RCS transfers heat to the secondary side, increasing the secondary side temperature and pressure to the secondary safety valve setpoint. Steam generator inventory is depleted through the safety valves, until the steam generators are emptied and thus RCS heat sink is lost. The RCS then heats up until the pressure corresponding to the RCS safety valve setpoint is reached. At this point, the primary safety valves lift.

Initial Trending of Key Parameters

Reactor Power

Reactor power remains constant in response to a loss of feedwater event. (A partial loss of feedwater will reduce steam generator level at a slower rate than a total loss of feedwater and in this case, only if the operator is able to conclude positively that a partial loss of feedwater has occurred should he attempt to reduce reactor power to a level within the reduced capacity of the operating feedwater supply equipment.) If steam generator water level can not be maintained or continues to drop in one or both steam generators, the reactor must be tripped.

Following a loss of feedwater, the main turbine generator will continue to operate with the decreasing secondary side steam generator water inventory until it is tripped concurrent with a reactor trip on a low steam generator water level trip signal. At full power, the reactor will be automatically tripped on low steam generator level within approximately 30 seconds of the loss of feedwater flow. If the operator is able to conclude that a loss of feedwater has occurred, he should immediately trip the reactor, even before steam generator water level drops to the low level trip setpoint in order to conserve the available steam generators water inventory and to lengthen the maximum allowable time until auxiliary feedwater must be initiated.

RCS Temperature

As the steam generator water level begins to drop below the top of the heat transfer tubes, the primary heat sink is reduced and RCS temperature increases.

Pressurizer Pressure and Level

As the RCS temperature increases, the reactor coolant expands, increasing pressurizer pressure and level.

Steam Generator Pressure

Initially, the pressure in the steam generators will increase as feedwater flow to the steam generators is terminated. Boiling occurs on the secondary side in the steam generators and the density change causes a pressure change. Because no new feedwater is entering the steam generator to absorb RCS heat, steam generator pressure will begin to decrease as the steam produced by boiling exits the steam generator.

Steam Generator Level

A loss of feedwater to the steam generator will result in a decreasing steam generator level.

Event Strategy

Figure 5.1-2 provides a summary of the strategy employed in this guideline. Only the major decision points are indicated. A detailed discussion of the required operator actions and bases is found in the following subsections.

Bases Immediate Actions

Following a loss of feedwater, the immediate operator actions should be directed towards both maintaining normal steam generator water level with all availble Main or Auxiliary Feedwater System equipment, and decreasing reactor power by tripping the reactor.

The following immediate actions are taken in response to a loss of feedwater:

1. The reactor is verified to be tripped. Tripping the reactor ensures that reactivity is being controlled. Once the reactor is tripped manually or automatically, the operator should carry out the standard post trip actions described in the Reactor Trip Guidelines concurrent with the actions of this guideline. The actions of the Reactor Trip Guideline include verifying that reactor power is decreasing, ensuring the turbine and generator are tripped, and that station loads have properly transferred to the offsite power source.

2. An AFAS is generated on low steam generator water level. The operator must verify automatic auxiliary feedwater actuation. If it has not automatically actuated, the operator should manually actuate auxiliary feedwater.

Reestablishment of feedwater flow to the steam generators provides a means for maintaining RCS heat removal and significantly reduces the potential for lifting secondary and primary safety valves or damaging the core. An increasing steam generator water level, pressure, or a cold leg temperature indication increasing at a constant or reduced rate is positive indication of feedwater addition to the steam generator(s).

Rapid introduction of feedwater to the steam generators may cause overcooling of the RCS. The operator should monitor pressurizer pressure and RCS temperature to avoid overcooling the RCS when adding feedwater. There is no need to rapidly restore steam generator water level back to the normal water level. A moderate rate of increase in steam generator water level is sufficient to provide core cooling without any unnecessary thermal or pressure transients.

Feedwater should not be reestablished (when it becomes available) to a dry steam genarator if one steam generator still contains water. The steam generator structural integrity will be maintained for at least 8 feedings to a dried steam generator. However, the repeated addition of relatively cool feedwater on hot steam generator heat transfer tubes will produce thermal stresses which may cause significant damage to the tubes and degrade steam generator performance and integrity. If both steam generators have boiled dry, feedwater flow should be reestablished to only one steam generator to provide RCS heat removal.

Bases Follow-Up Actions

The follow-up actions are directed towards determining the cause of the loss of feedwater, regaining feedwater system operation, if this is not possible, removing heat from the RCS and conducting an orderly cooldown.

1. All immediate operator actions should be verified. This assures that the critical safety functions affected by a loss of feedwater have been attended to, and regaining control of the plant has been initiated.

2. Thd diagnosis of a loss of feedwater should . confirmed. If a misdiagnosis has been made, the proper emergency guideline can then be implemented. If a definitive diagnosis cannot be made, the plant status and trending diagnostic is referenced. This diagnostic is functionally oriented, and all critical safety functions are attended to. The proper emergency guideline can then be accessed.

3. The cause of the loss of feedwater should be determined. Once the operator has verified that auxiliary feedwater has been actuated, the cause of the symptoms must be investigated. If the steam generator water level has stopped its decrease, an unisolable feedwater line break should not be suspected. Conversely, a continuing secondary pressure reduction (not caused by introduction of cool auxiliary feedwater) and continuing steam generator water level reduction is an indication of a feedwater line break.

   If a main feedwater line break is suspected, the operator should try to isolate the main feedwater line break from the steam generators by any plant-specific methods possible (i.e., closing main feedwater isolation valves, main feedwater regulating valves, etc.). A feedwater line break upstream of a check valve should automatically be isolated from the steam generator.

   If the feedwater line break is unisolable, the steam generator will continue to blowdown water until eventually the blowdown fluid changes to steam. Near this point, the event changes into an uncontrolled cooldown event. When the operator determines that a feedwater line break is unisolable, the Steam Line Break Guidelines should immediately be followed for all further actions. If no main feedwater line break has occurred or the break is isolated from the steam generator, then the operator should proceed with the follow-up actions with this guideline.

4. If all feedwater is lost (both main and auxiliary) certain activities should be performed to keep the plant in a stable condition. These activities are listed below.

a) To minimize heat input into the RCS, the number of operating RCPs should be reduced to one per loop.

b) If in operation, the Steam Generator Blowdown System, Secondary Sampling System or any other nonvital secondary discharge must be secured. Until feedwater is reestablished, the steam generator water inventories must be conserved.

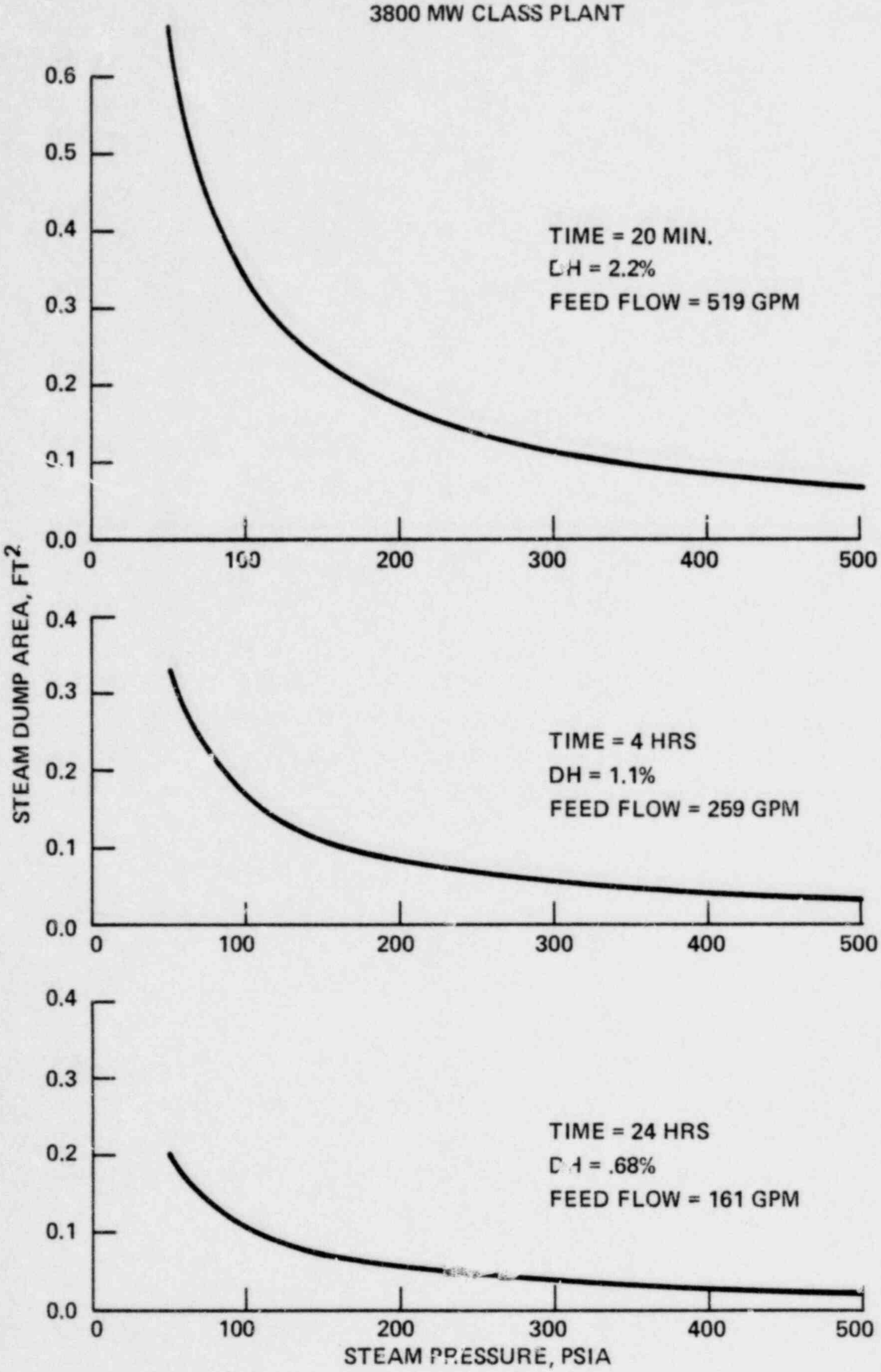
c) The operator should attempt to restore the correct operation of the Main or Auxiliary Feedwater System to provide a primary decay heat sink for a controlled reactor cooldown.

A moderate rate of increase in steam generator water level is sufficient to maintain RCS heat removal. If the refill rate is too fast, the RCS temperature can easily be driven below the desired no load value. Consequently, the RCS pressure may fall to the point where the Safety Injection System is actuated or the pressurizer is drained.

d) If both main and auxiliary feedwater can not be restored, all plant-specific sources of feedwater which could be made available to replace steam generator boil-off should be implemented. Examples of alternate sources of feedwater are fire pumps, condensate pumps, portable pumps, etc. When developing plant procedures, alternate sources of feedwater should be investigated 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 5.1-1 provides an example of the type of information that must be developed on a plant specific basis. Provided by the figure is a typical required steam generator dump area to depressurize the steam generator for various times after shutdown. The required heat removal, compared to the available heat removal capacity (i.e. atmospheric dump valves), provides the technical basis for which guidance on steam generator depressurization using alternate sources of feedwater may be developed.

Figure 5.1-1

REQUIRED STEAM DUMP AREA vs STEAM PRESSURE
3800 MW CLASS PLANT



e) [As a last resort, cooling of the core is attempted by core flushing. The SIS is aligned for cold leg injection and the PORVs are opened. Core flushing is from the cold legs through the core and out the PORVs.]

f) If other methods are available for RCS heat removal purposes they should be appraised and if possible implemented. Examples are drain valves, pressurizer vents, etc. These should be indicated in the procedures.

5. Steam generator pressure should be controlled by the Turbine Bypass System. If condensor vacuum is lost,the Turbine 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 prevents the secondary safety valves from opening, and is necessary for maintaining RCS heat removal.

6. The PPCS is verified to be automatically controlling or restoring RCS pressure. If not, pressurizer heaters or spray are operated manually to control pressurizer pressure. This action verifies that a safety function is being performed; controlling RCS pressure.

7. The PLCS is verified to be automatically controlling or restoring pressurizer level. If not, charging the letdown are operated manually to ensure pressurizer level is being maintained. This action verifies that a safety function is being performed; controlling the RCS inventory.

8. The initiation of an SIAS must be verified if pressurizer pressure decreases to [1600 psia], [or if containment pressure increases to 5 psig]. If the SIS has not been automatically actuated, it must be initiated manually. This action verifies safety functions are being performed; RCS heat removal and RCS inventory control.

9. If pressurizer pressure decreases to below [1300 psia] following an SIAS, all RCPs must be stopped. A system response identified by a depressurization transient to below [1300 psia] following an SIAS (and subsequent operation of the SIS) is characteristic of a LOCA. Continued RCP operation at RCS pressures below [1300 psia] during a LOCA may result in more severe RCS conditions.

   It may not be possible to distinguish between events causing a depressurization in the early stages of the transient; specifically during the time period when the immediate actions are taken. The immediate actions required for all events are directed at placing the plant in a safe condition. To avoid the necessity of confirmation of the initiating event during the time when the immediate actions are taken, anytime pressurizer pressure decreases to [1300 psia] following an SIAS, all RCP operation is terminated.

10. If all RCPs were stopped and cannot be restarted, the instructions in the Loss of Forced Reactor Coolant Flow Guideline should be implemented to establish natural circulation flow in the RCS.

11. If an SIAS has been initiated and the SIS is operating, it must continue to operate until SIS termination criteria is met. This criteria is:

    a) RCS hot and cold leg temperatures are at least [20°F + inaccuracies] below saturation temperature for pressurizer pressure (refer to Figure 5.1-4). Establishing [20°F +inaccuracies] of subcooling prevents void formation in the core when SIS flow is terminated, and provides sufficient margin for establishing flow should the [20°F + inaccuracies] subcooling deteriorate when SIS flow is secured.

    b) Pressurizer level is in the normal operating band, and is responding normally to the Pressurizer Level and Pressure Control Systems. A pressurizer level in the normal operating band and responding normally ensures that RCS inventory control has been reestablished.

c) At least one steam generator has an indicated level and is removing heat from the RCS. A steam genarator having an indicated level and removing heat from the RCS ensures that primary to secondary heat removal is being maintained.

12. The SIS must be restarted if the [20°F + inaccuracies] of subcooling cannot be maintained. This provides a sufficient margin for system operation and prevents void formation.

13. If RCP operation has been terminated, restarting of the reactor coolant pumps should be attempted to ensure continued forced circulation of coolant through the core and to provide the capability for the normal mode of pressurizer spray. However, only one reactor coolant pump in each loop needs to be operated in an effort to minimize heat input to the RCS.

The possibility of RCP operation is determined if the following criteria are satisfied:

a) At least one steam generator is removing heat from the RCS and thus providing an RCS heat removal function.

b) Pressurizer level and pressure are responding normally to the Pressurizer Level and Pressure Control Systems. This assures that RCS inventory and pressure are being controlled.

c) The RCS is greater than or equal to [20°F + inaccuracies] subcooled. An RCS subcooled condition ensures that the RCPs can be operated without damage due to cavitation.

d) [All plant specific RCP operating criteria is satisfied before the RCPs are restarted to protect the RCPs from damage.]

14. The auxiliary feedwater source is the condensate storage tank. If the Auxiliary Feedwater System is being used, the inventory in the condensate storage tank must be continually replenished. Alternate sources of condensate must be investigated. These alternate sources must be included

in plant procedures. Examples of alternate sources of condensate are non-seismic tanks, fire mains, lake water supplies, portable tanks, etc.

15. RCS cooling must be maintained during the loss of feedwater event. Furthermore, the extent of the component malfunctions may require the plant to be cooled down from hot standby conditions to facilitate repair and maintenance. To keep plant conditions stable, one of the following activities must be performed. The activities are used in decreasing order of preferred implementation.

    a) If a cooldown is necessary and RCS heat is being removed by the steam generators using auxiliary feedwater, a forced cooldown is preferred and shutdown cooling is entered prior to depleting condensate storage capacity.

    b) Steam should be continually discharged to dissipate RCS heat. Auxiliary feedwater flow should be used for this purpose until main feedwater flow is available.

       The reactor coolant pumps, if operating, will provide forced reactor coolant circulation for this cooldown function. Natural circulation, established in accordance with the Loss of Forced Reactor Coolant Flow Guidelines, will provide core cooling if forced reactor coolant circulation is not available.

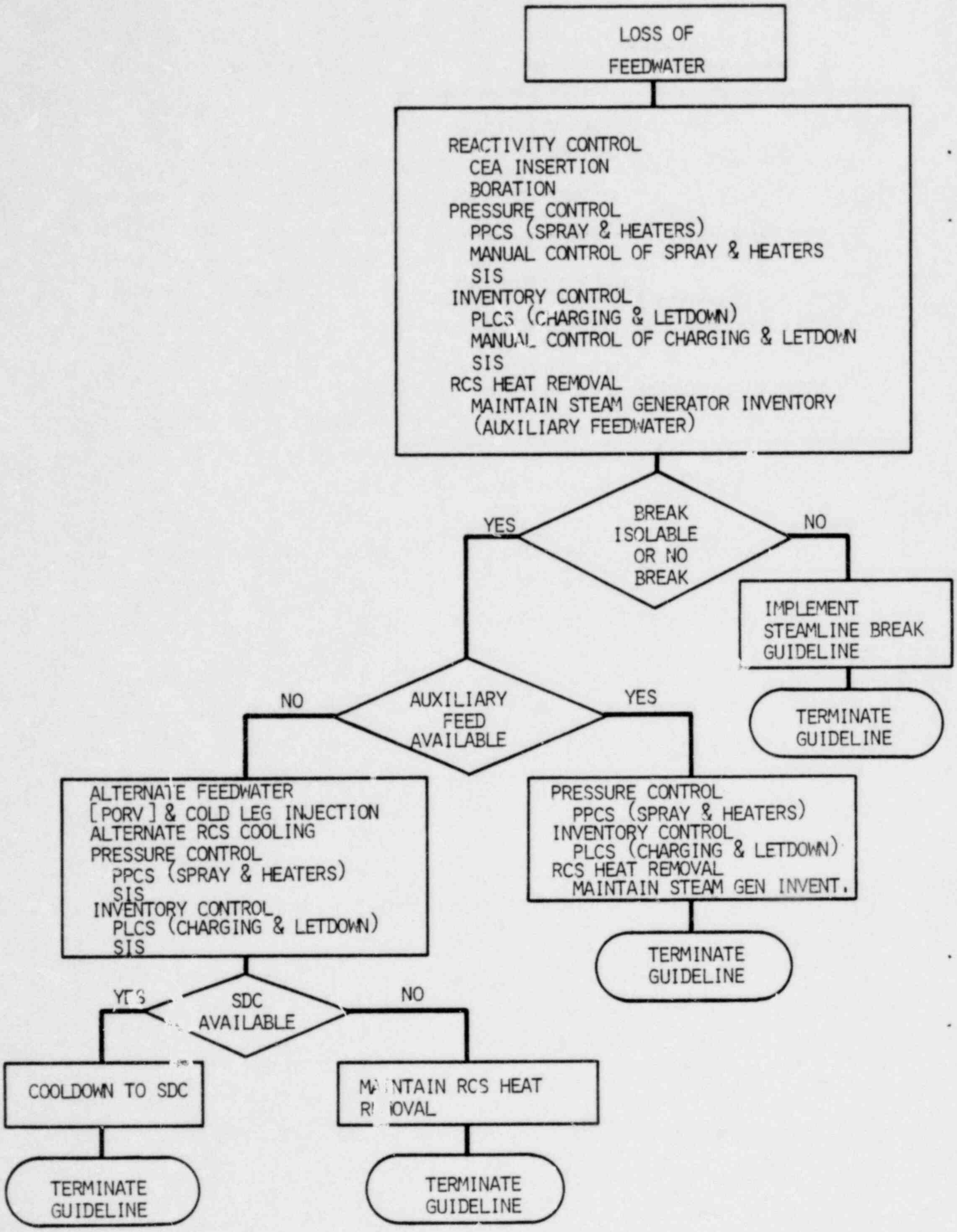
    c) If main or auxiliary feedwater is not available, RCS cooling must be maintained with any suitable source of feedwater.

    d) RCS cooling must be maintained using all plant specific alternative methods available.

16. Shutdown cooling should be initiated if the shutdown cooling entry criteria can be met. SDC initiation and operation will establish a plant status where the regaining of main feedwater can be attempted.

Figure 5.1-2

LOSS OF FEEDWATER STRATEGY CHART



LOSS OF FEEDWATER GUIDELINE

SYMPTOMS

1. Decreasing steam generator water level/alarm.

2. Main feedwater pump trip alarm.

3. Low main feedwater pump flow (possible high flow for a feedwater line break).

4. Low main feedwater pump suction pressure.

5. Reactor trip alarm.

6. Turbine generator trip alarm.

7. Possible increase in containment pressure (feedwater line break inside containment).

8. Possible noise indicative of feedwater line break outside containment.

9. Possible loss of feedwater flow control indication, or failure of feedwater flow control valves.

10. Possible closure of a Main Feedwater System isolation valve.

11. Possible steam flow vs. feedwater flow mismatch.

12. Possible increase in containment pressure, temperature, radiation humidity or containment sump level.

13. Initial Trending of Key Parameters:

    a) Reactor power- constant, then decreasing
    b) Pressurizer pressure - initially increasing, decreasing, then stabilizing
    c) RCS temperature - initially increasing, then decreasing
    d) Pressurizer level- slightly increasing, then decreasing
    e) Steam generator pressure - slightly increasing,then decreasing
    f) Steam generator level - decreasing

IMMEDIATE ACTIONS

1. Verify the reactor has tripped. If not, manually trip the reactor and carry out standard post trip actions.

2. Verify actuation of the Auxiliary Feedwater System. If necessary, manually actuate the Auxiliary Feedwater System.

FOLLOW-UP ACTIONS

1. Verify all immediate actions have been initiated.

2. Confirm the diagnosis of a loss of feedwater event by referring to Figure 5.1-3. If a misdiagnosis has been made, implement the proper emergency guideline. If a definitive diagnosis cannot be made, refer to the plant status and trending diagnostic.

3. Determine whether the cause of the loss of main feedwater is a result of a main feedwater line break or a Main Feedwater System abnormality by monitoring steam generator pressure and level. If a main feedwater line break is suspected, isolate the break.

    a) If the main feedwater line break is unisolable, the Steam Line Break Guideline should be accomplished concurrently with the Loss of Feedwater Guideline.

    b) If the main feedwater line break is isolable, proceed with the follow-up actions within this guideline.

4. If all feedwater (main and auxiliary) is lost, conduct the following activities:

    a) Reduce the number of operating RCPs to one per loop to minimize heat input into the RCS.
    b) Secure steam generator blowdown, secondary sampling and any nonvital steam discharge.

FOLLOW-UP ACTIONS (continued)

c) Take actions to regain Main or Auxiliary Feedwater System operation.

d) If other sources of water are available for steam generator heat removal, insert that information here .

e) Open the PORVs and actuate the HPSI pumps aligned to cold legs .

f) If other methods are available for heat removal from the RCS, insert that information here .

5. Verify turbine bypass valves are controlling steam generator pressure at [900 psig]. If condenser vacuum is lost, the Turbine Bypass System is unavailable, or if the MSIVs are closed, the atmospheric dump valves must be used to control steam generator pressure.

6. Verify that the PPCS is automatically controlling or restoring RCS pressure. If not, manually control pressurizer heaters or spray to control pressurizer pressure.

7. Verify that the PLCS is automatically restoring pressurizer level. If not, manually operate charging and letdown to restore or maintain normal pressurizer level.

8. If pressurizer pressure decreases to [1600 psia], [or if containment pressure increases to 5 psig], verify that an SIAS has been initiated. If not, manually initiate an SIAS.

9. If pressurizer pressure decreases to [1300 psia] following an SIAS, stop all reactor coolant pumps.

10. If all RCPs have been stopped, verify that natural circulation is accomplished per the Loss of Forced Reactor Coolant Flow Guidelines concurrently with this guideline.

FOLLOW-UP ACTIONS (continued)

11. If the SIS is operating, it may be stopped if the following conditions are satisfied:

    a) RCS hot and cold leg temperatures are at least [20°F + inaccuracies] below saturation temperatue for pressurizer pressure (refer to Figure 5.1-4), and
    b) pressurizer level is in the normal operating band and is responding normally to the Pressurizer Level and Pressure Control Systems, and
    c) at least one steam generator has an indicated level and is removing heat from the RCS.

12. [If 20°F + inaccuracies] of subcooling (refer to Figure 5.1-4) cannot be maintained after the SIS has been stopped, the SIS system must be restarted.

13. If the RCPs were stopped, one RCP in each loop may be restarted if the following criteria are satisfied:
    a) At least one steam generator is removing heat from the RCS.
    b) Pressurizer level and pressure are responding normally to the Pressurizer Level and Pressure Control Systems.
    c) The RCS is at least [20°F + inaccuracies] subcooled (refer to Figure 5.1-4.)
    d) [Other critieria satisfied per RCP operating instructions].

14. If the Auxiliary Feedwater System is being used, ensure that the condensate storage tank is being continually replenished.

15. Maintain RCS cooling by conducting one of the following activities. The activities are listed in order of decreasing preference:

    a) Conduct an RCS cooldown using forced circulation and operate the SCS prior to depleting the condensate storage water supply .
    b) Conduct a natural circulation cooldown per the Loss of Forced Reactor Coolant Flow Guidelines concurrently with the actions of this guideline.

c) Maintain steam generator cooling by supplying main or auxiliary feedwater to the steam generators and discharging steam to the condenser or atmosphere.

d) [Maintain cooling to the steam generator using alternate sources of feedwater and discharging steam to the condenser or atmosphere].

e) [Maintain RCS cooling using alternate methods].

16. If an RCS cooldown is accomplished, when RCS temperature is cooled to [300°F] and depressurized to [300 psig], initiate shutdown cooling.

PRECAUTIONS

1. The operator should not add feedwater to a dry steam generator if another steam generator still contains water. Reestablish 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.

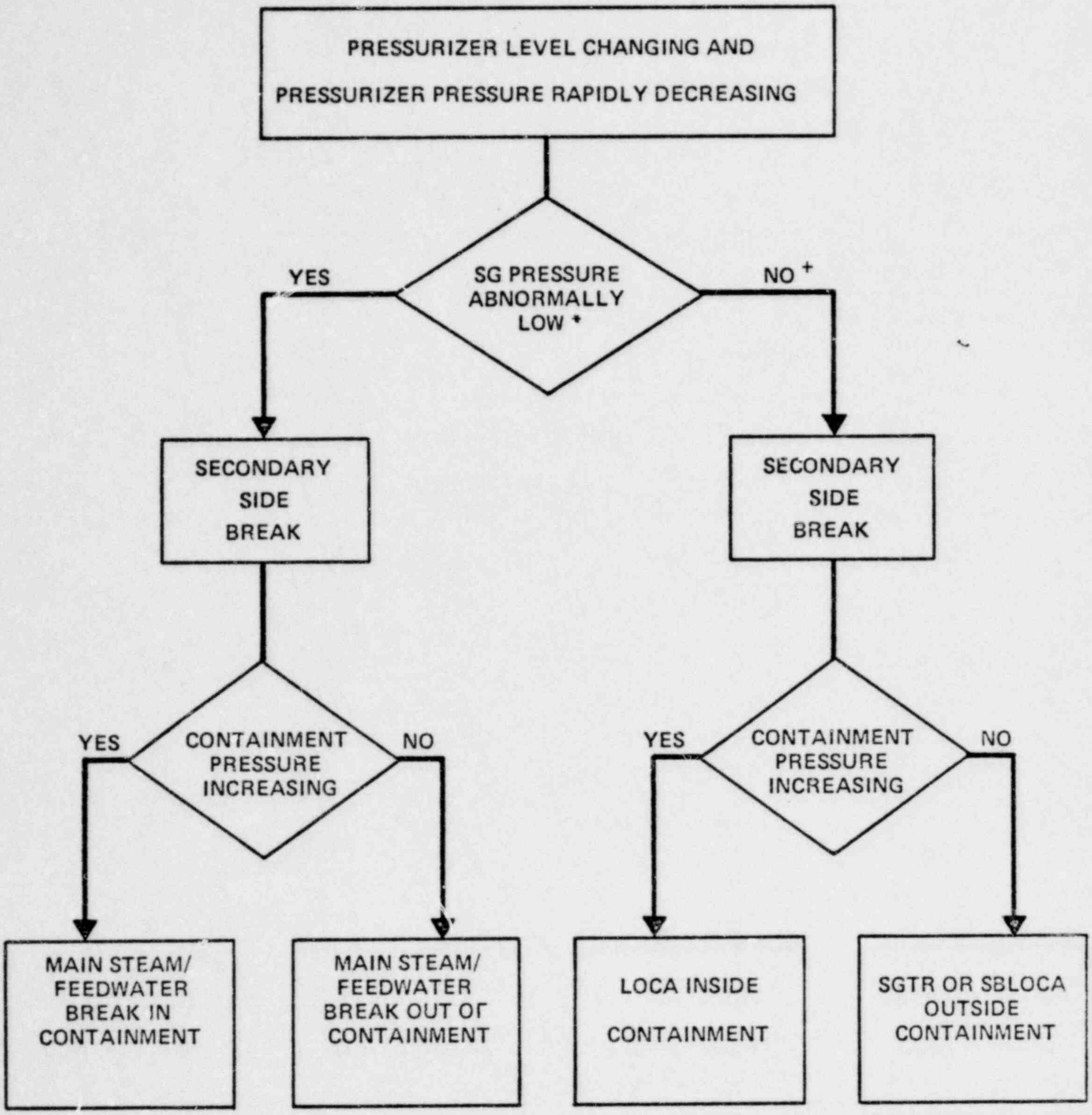
2. During all phases of the cooldown, monitor RCS temperature and pressure to avoid exceeding a cooldown rate greater than Technical Specification Limitations.

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 diagnosing the event since the accident may cause irregularities in a particular instrument reading. Critical parameters must be verified when one or more confirmatory indications are available.

Figure 5.1-3

BREAK IDENTIFICATION CHART

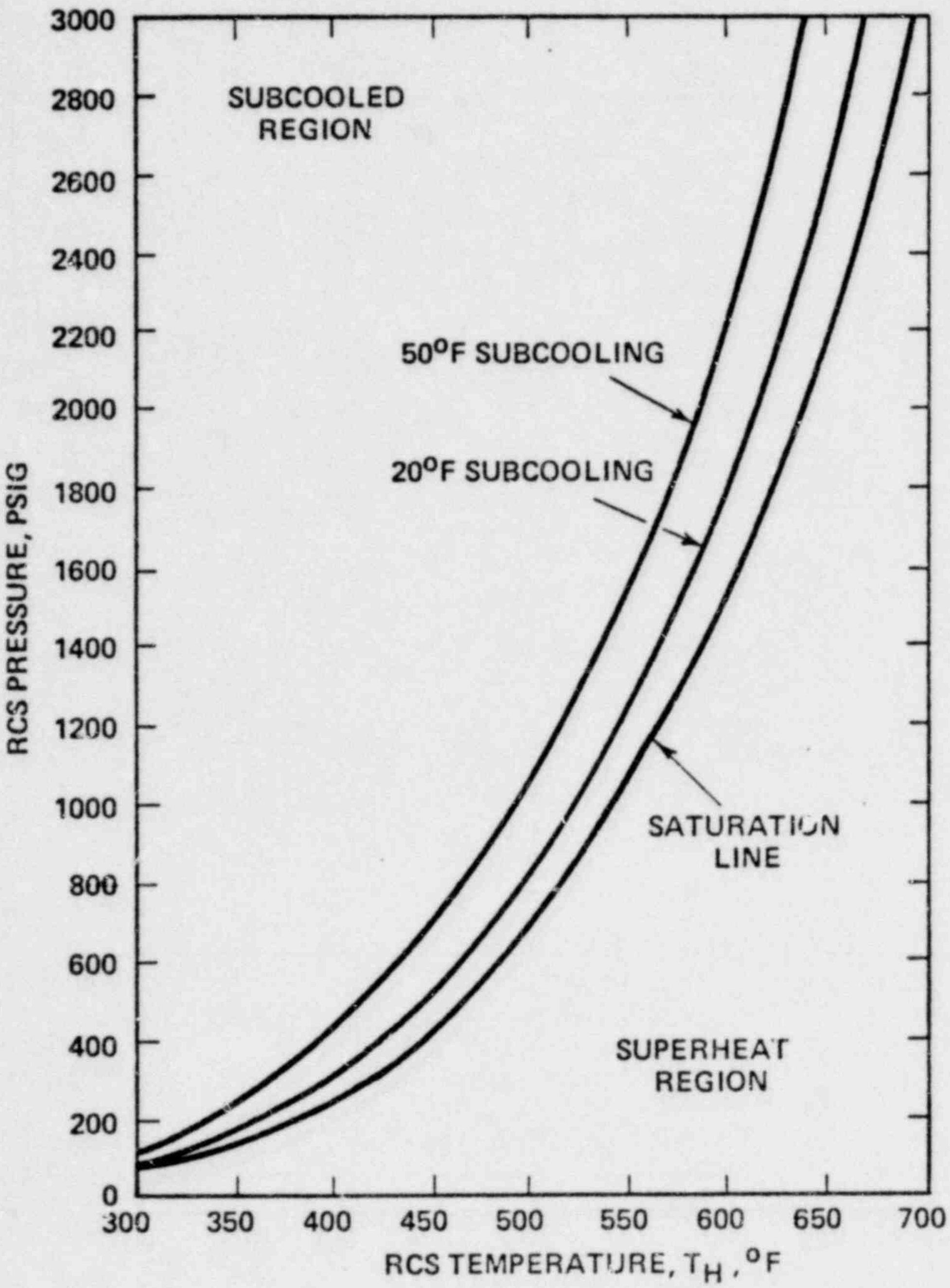


* IN ONE OR BOTH STEAM GENERATORS

+ MAY DECREASE SLIGHTLY AFTER TRIP

Figure 5.1-4

SATURATION / SUBCOOLING



5.2 LOSS OF FORCED REACTOR COOLANT FLOW GUIDELINE

BASES

A loss of forced reactor coolant flow will result from a loss of one or more reactor coolant pumps (RCPs). A RCP failure could result from any number of mechanical failures in the pump or motor, from a loss of electrical power, or from a manual trip for pump protection purposes.

RCP forced circulation and heat transfer from primary to secondary via the steam generators is the preferred method of residual heat removal whenever plant temperatures and pressures 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.

Characterization of a Loss of Forced Reactor Coolant Flow

A loss of RCP flow can be characterized by reactor turbine and generator trips accompanied by low steam generator ΔPs or RCP ΔPs in the affected loops. Depending on the type of failure, there will also be RCP trouble alarms or abnormal RCP motor currents. The RCS primary loop flow meters will indicate low RCS flow.

Safety Functions Affected

Four safety functions must be managed while establishing and maintaining natural circulation core cooling in hot standby conditions or during a natural circulation plant cooldown. These include reactivity control, RCS pressure control, RCS inventory control, and RCS heat removal. An incomplete plant response to any one of these safety functions could lead to an interruption of adequate natural circulation flow or core cooling.

Initial Trending of Key Parameters

Reactor Power

Immediately following the failure of one or more RCPs, a reactor and turbine trip will be initiated due to a low reactor coolant flow trip at [95%] flow. The reactor trip causes power to decrease.

Pressurizer Pressure and Level

Because of the reactor trip, RCS temperatures will initially decrease. In turn, pressurizer pressure and level will decrease due to the lowering of RCS temperature.

RCS Temperature

The reactor trip will cause a reduction in RCS temperatures, caused by the RCS heat generation reduction to decay heat.

Steam Generator Pressure

Once the turbine control valves go shut following the turbine trip, steam generator pressure increases rapidly.

Steam Generator Level

The Main Feedwater System will ramp down to [5%] flow to prevent overfilling the steam generators. Steam generator level will begin to decrease rapidly because of the closure of the turbine stop valves following the turbine trip.

Event Strategy

Figure 5.2.1 provides a summary of the strategy employed in this guideline. Only the major decision points are indicated. A detailed discussion of the required operator actions and bases is found the following subsections.

Bases Immediate Actions

The following immediate actions are taken to regain plant control in response to a loss of forced reactor coolant flow.

1. The operators first actions following a loss of forced reactor coolant flow will be to follow the standard post-trip actions. The immediate actions for a loss of forced coolant flow will be identical to the reactor trip procedure. After the CEAs are verified inserted, the operator will verify that the turbine stop valves have shut and the generator output breakers have opened.

2. The operator must ensure that secondary water inventory is being maintained by feedwater flow to the steam generators. Proper operation of the Main or Auxiliary Feedwater System will restore steam generator secondary water level. If the Main Feedwater System is operating to restore steam generator level, the operator must verify that the main feedwater flow ramps down to [5%] to prevent an excessive RCS cooldown. If the Auxiliary Feedwater System is operating to restore steam generator level, unequal auxiliary feedwater flow to the steam generators will not lead to unsatisfactory natural circulation as long as all of the decay heat is being removed through the steam generators.

   Natural circulation is assured even if the U-tubes are partially uncovered on the steam generator secondary side. The steam generator heat transfer area is sized for full power operation. Therefore, only a portion of the tubes (approximately 1/3 of the tube height) must remain covered to ensure proper natural circulation flow. This corresponds to approximately 35 - 40% on the wide range steam generator level instrument. The top of the U-tubes is at approximately 24 - 30% indicated level on the narrow range steam generator level instrument. Increasing the steam generator water level above the minimum required level will have a minimal impact on the natural circulation flow rate. However, by increasing the secondary water inventory, the operator provides an extra margin above the limit required to establish and maintain adequate natural circulation flow. The target that an operator should eventually strive to reach is the normal steam generator water level.

3. The operator must also verify that the Turbine Bypass System is controlling steam generator pressure at a no load condition. Proper operation of the Turbine Bypass System will prevent the secondary safety relief valves from lifting. If the condenser vacuum is lost, steam generator pressure can be controlled by manually operating the atmospheric dump valves. Since possible releases to the environment would be steam releases by the steam generator safety valves or the atmospheric dump valves, they are not the preferred methods for the control of steam generator pressure.

Bases Follow-up Actions

The follow-up actions are directed at achieving two objectives:

a) establishing, maintaining and verifying natural circulation conditions in the RCS if all RCPs are lost;
b) if necessary, performing a natural circulation cooldown.

1. All immediate operator actions should be verified. This assures that the critical safety functions that are affected by a loss of RCPs have been attended to.

2. The diagnosis of a Loss of Forced Reactor Coolant Flow should be confirmed. If a misdiagnosis has been made, the proper emergency guideline can then be implemented. If a definitive diagnosis cannot be made, the plant status and trending diagnostic is referenced. This diagnostic is functionally oriented, and critical safety functions are attended to.

3. The operator should maintain at least [20^{o}F + inaccuracies] subcooled margin as a minimum whenever possible within plant and operating restrictions. A [20^{o}F + inaccuracies] subcooling margin minimizes the chances of voiding occurring in the RCS. Although natural circulation flow could continue well into saturated conditions, operation with voids in the RCS is to be avoided since there is no direct method to monitor multiple void locations, sizes or impact on natural circulation flow. The preferred method of primary pressure control is with a bubble in the pressurizer throughout the plant cooldown with no voids in the RCS.

   The inaccuracies to be added to the [20^{o}F] to form the minimum subcooled margin requirement should include the instrumentation inaccuracy and the elevation pressure inaccuracy between the pressurizer and the RCS loops. Instrumentation accuracy will vary dependent upon the containment environmental conditions.

4. The PLCS should be verified to be automatically controlling or restoring pressurizer level. If not, charging and letdown are operated manually to ensure pressurizer level is being maintained. This action verifies that a safety function is being performed; controlling RCS inventory. Pressurizer level should normally be maintained at the normal shutdown reference level throughout the plant cooldown if a cooldown is necessary. The normal shutdown reference level (plant specific) may or may not be the same as the hot zero-power pressurizer reference level.

5. If all RCPs are lost, the operator must contend with a complete loss of forced circulation and must ensure that conditions are established for natural circulation flow. Natural circulation flow should be established within (5 - 15 minutes) after the RCPs were tripped.

   Any plant response as a result of a change during natural circulation will be slow 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 natural circulation flow is established, the RCS indicates the following conditions:

a) Loop ΔT (T_h-T_c) less than normal full power ΔT;
b) Cold leg temperatures constant or decreasing;
c) Hot leg temperatures stable (i.e. not steadily increasing);
d) No abnormal differences between T_h RTDs and core exit thermocouples.

Natural circulation is governed by decay heat, component elevations, primary to secondary heat transfer, loop flow resistance, and voiding. Component elevations on C-E plants are such that satisfactory natural circulation decay heat removal is obtained by density differences between the bottom of the core and the top of the steam generator tube sheet. An additional contribution to natural circulation flow rate is the density difference obtained as the coolant passes through the steam generator U-tubes, but this is not required for satisfactory natural circulation.

After the RCS conditions have stabilized, the operator must investigate the causes of the loss of forced reactor coolant flow. If repair work is required, the RCS may have to be placed in a cold shutdown condition.

6. Adequate forced flow is maintained through the RCS for residual core heat removal if at least one RCP can be restarted. One RCP operating in each loop is the preferred mode of operation. The restarting of the RCPs should be attempted if all of the following criteria are satisfied:

   a) At least one steam generator is removing heat from the RCS, therefore, providing an RCS heat removal function.
   b) Pressurizer level and pressure are responding to the Pressurizer Level and Pressure Control Systems.

c) The RCS is greater than or equal to [$20^{o}F$ + inaccuracies] subcooled. RCS subcooled condition ensures that the RCPs can be operated without damage due to cavitation.

d) All plant specific RCP operating criteria should be satisfied before the RCPs are restarted.

7. The plant must be maintained in a stable condition based on auxiliary systems availability. One concern the operator must have is the remaining supply of feedwater. If the available condensate appears to be marginally adequate, a plant cooldown within Technical Specification Limitations should be commenced immediatley in order to avoid running out of existing condensate before the shutdown cooling system can be placed into operation. Otherwise, a cooldown is not required to be initiated before completion of cold shutdown boration as described in an upcoming step.

8. If required, a natural circulation plant cooldown to SDC initiation conditions should be conducted according to the following actions steps.

9. The plant should be borated to Technical Specification Requirements for reactivity control purposes.

10. Natural circulation flow should be continuously verified to be adequately established. Cold leg temperatures should be verified to be constant or decreasing and hot leg temperatures should be stable and not increasing. Another means available to the operator of verifying adequate natural circulation flow is to verify that no abnormal differences exist between the hot leg RTDs and core exit thermocouples. Cold leg temperatures should also not increase significantly above steam generator saturation temperature. These Symptoms will be the most direct method of indication that natural circulation flow is adequate.

If natural circulation flow has been lost or degraded, efforts should be concentrated towards regaining adequate RCS heat removal, RCS pressure control, RCS inventory control, and reactivity control in both RCS loops. Again, any plant response as a result of a change will be slow (5 - 15 minutes) as compared to the normal forced flow system response time (6 - 12 seconds) since the coolant loop cycle time has significantly increased.

11. During the RCS cooldown, a rapid cooldown rate within Technical Specification Limitations is recommended to enhance the conductive cooling capability of the RV upper head region. A large temperature difference between the RV head and the RCS coolant will provide a large thermal gradient and a greater heat transfer rate.

    Also during the cooldown, pressurizer pressure should be maintained as high as possible within operating restrictions until the time criteria of Action #16 have been satisfied. This cooldown strategy will minimize the possibility of flashing a condensable void in the stagnant RV head dome during a natural circulation plant cooldown. A RV void will not form until the RCS pressure is decreased to below the RV head saturation pressure, regardless of the RCS cooldown rate used. Thus maintaining high pressurizer pressure until time requirements are met, coupled with a large RCS cooldown rate, should ensure that a condensable RV bubble will not be formed during the natural circulation plant cooldown process.

    The RCS cooldown should be commenced by performing steps a) or b), and both c) and d) below:

    a) The RCS is preferentially cooled down by feeding the steam generators with main or auxiliary feedwater and discharging steam using the Turbine Bypass System. This method can only be implemented if the condenser is available.

    b) If the condenser is not available, an RCS cooldown should be commenced using main or auxiliary feedwater and dumping steam using the atmospheric steam dump valves.

c) [The Low Temperature Overpressurization Protection System should be initiated at 275^{0}F.]

d) The available condensate inventory should be monitored and replenished from available sources as necessary to continually provide a source for a secondary heat sink. Example 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 investigated for applicability.

12. The operator should maintain the maximum possible RCS cooldown rate with the Technical Specification Limitations. The Technical Specification operating pressure/temperature curve is based on the cold leg temperature and not on the hot leg temperature.

13. An event such as a steam generator tube rupture may require that one steam generator be isolated continuously from the RCS, as a heat sink (i.e., all feedwater and steam flow in and out of that steam generator stopped). During normal forced flow conditions in the RCS, when one steam generator must be isolated as a heat sink, sufficient reverse heat transfer occurs to maintain the isolated (bottled up) steam generator at the same relative temperature as the operating RCS loop during a plant cooldown. However, with no RCPs operating, conditions can be generated which will stop natural circulation flow though the isolated steam generator and RCS loop, leaving those components in a hot stagnant condition.

    This condition by itself will not necessarily affect core cooling via natural circulation in the unisolated steam generator and RCS loop. As long as reactivity control, RCS pressure control, RCS inventory control, and RCS heat removal are properly maintained in the operating loop, sufficient natural circulation flow will be maintained through the core and operating loop.

However, a hot isolated steam generator presents a serious problem when trying to depressurize the RCS to initiate shutdown cooling. Depressurization of the RCS below the isolated steam generator's saturation temperature/pressure could then quickly void large portions of the isolated RCS loop which could lead to interruption of the natural circulation cooling established in the operating RCS loop or could cause the isolated steam generator to act like a pressurizer and prevent further depressurization to the shutdown cooling initiation pressure. Thus, an isolated steam generator must be cooled down before shutdown cooling can be aligned.

The preferred method of cooling an isolated steam generator is to start any RCP, if one is available. Forced reactor coolant circulation through an isolated steam generator will provide adequate heat transfer to maintain the isolated steam generator's temperature approximately the same as the operating steam generator's temperature.

Another method, if this is possible, is to drain (not completely dry) and refill the isolated steam generator secondary water volume. Control of the cooldown in the isolated loop should be regulated by the refill rate of the cool feedwater.

14. The subcooled margin [20^{o}F + inaccuracies], should be maintained at all times. However, if the subccoled margin becomes completely degraded and a saturated condition becomes established in the hot legs, natural circulation flow may still be established and maintained. In this event, reestablish subcooled conditions as soon as possible and continue to verify that natural circulation flow is being maintained. If hot and cold leg temperatures indicate that natural circulation flow is lost, alternative emergency methods of core cooling should not be implemented soley because subcooled margin is lost.

15. The pressurizer level should be maintained throughout the cooldown by the following methods:

a) Preferentially, the pressurizer level is maintained by control of charging and letdown.

b) Operation of the HPSI pumps is the next order of priority for maintaining pressurizer level.

If the normal shutdown reference level is not maintained, a pressurizer level [above 10% and below 90%] should be maintained to avoid loosing 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 overheating proctection. A plant cooldown can be initiated without a pressurizer level within the above preferred level indications as long as adequate primary pressure control is being maintained. However, pressurizer level should be brought back to normal as soon as possible.

Once the pressurizer water temperature varies from the normal hot standby temperature, the instrument indication on the normal pressurizer level channel will begin to deviate (i.e. decalibrate) from the true pressurizer level. At this time, the operator should use plant cooldown correction curves to determine the true pressurizer water level. A cold calibrated pressurizer instrument channel is provided. This channel can be used as a quick reference during the plant cooldown. The actual pressurizer water level during pressurizer cooldown will be between the level indicated on the cold calibrated channel (which reads low) and the level indicated on the hot calibrated channel (which reads high).

16. Auxiliary spray is manually operated to depressurize the RCS when the following criteria are satisfied:

a) The RCS has been cooled to SDC initiation temperature [300^{o}F] and either:

b) all RCS hot leg temperatures have been below [300^{o}F] for [7 hours], or

c) [20 hours] has elapsed since the start of the cooldown.

17. If the auxiliary spray system is inoperative, alternative processes must be considered to cool and depressurize the pressurizer. However, if no requirements for an immediate plant cooldown exist (such as limited secondary condensate, Technical Specification requirement, etc.), then hot standby conditions should be maintained while spray flow capability is being restored.

    Methods to cool the pressurizer include the pressurizer drain and fill method, [or operating a PORV]. The pressurizer drain and fill process involves raising the pressurizer water level to the plant specific maximum allowed level by operating all charging pumps and minimizing letdown flow. The pressurizer water level is then lowered to just above the top of the pressurizer heaters by decreasing charging and increasing letdown.

18. The [20^{o}F + inaccuracies] subcooling margin must be maintained throughout the RCS depressurization to prevent void formation in the core.

    The ESFAS signal set point on each safety channel should be bypassed at [1750 psia] to avoid safety systems actuated by the ESFAS, whose operation may not be necessary, from operating at an undesirable time.

    [The safety injection tanks should be isolated, vented, or drained at 250 psig to avoid introducing their nitrogen cover gas into the RCS and increasing the severity of the event.]

19. During a normal plant cooldown with reactor coolant pumps running, a small percentage of the forced flow is circulated in the RV upper head dome region which cools that area during the RCS cooldown. During natural circulation flow conditions in the RCS, the amount of flow through the RV upper head may be virtually negligible. Thus, the RV upper head can become a stagnated region with the only cooling being the heat loss to ambient and the head conducted down through the reactor vessel and internal structures. Even though the RCS can be cooled down to low temperatures by natural circulation flow with a large subcooled margin, the RV head region may remain relatively hot if insufficient time is allowed for ambient heat losses from the RV head areas. Thus, as the RCS is depressurized in preparation for entering shutdown cooling, a steam bubble may form by flashing primary coolant in the RV head dome.

    Pressurizer level change can be used to monitor the growth or collapse of the RV void. Indication of voiding in the upper head may be indicated by the following parameter changes:

    a) letdown flow greater than charging flow, and
    b) pressurizer level increasing significantly greater than expected while operating auxiliary spray, or
    c) pressurizer level decreasing while operating charging pumps.

20. If voiding in the RCS is indicated, letdown is isolated in order to ensure RCS cooling will be maintained. Provided enough condensate is available, the depressurization is stopped and an attempt at eliminating the voiding is commenced.

    The RCS is repressurized, causing the reactor vessel head bubble to collapse. This is followed by a waiting period for further ambient cooling before continuing the RCS depressurization to shutdown cooling entry pressure. If sufficient condensate and/or makeup is not available for the waiting period, plus subsequent cooldown to shutdown cooling entry conditions, conduct the plant cooldown so that entry to shutdown cooling is achieved prior to depleting the condensate inventory.

System pressure should not be allowed to go below the minimum required pressure to maintain RCS loop subcooled margin. A reactor coolant pump should not be started while a condensable void is known to be present in the RV head region. Sudden forced flow of cool reactor coolant into this region may possibly result in a quick collapse of the condensable void with resultant water hammer effects. Avoiding RCP operation with a bubble in the RV head will preclude this concern.

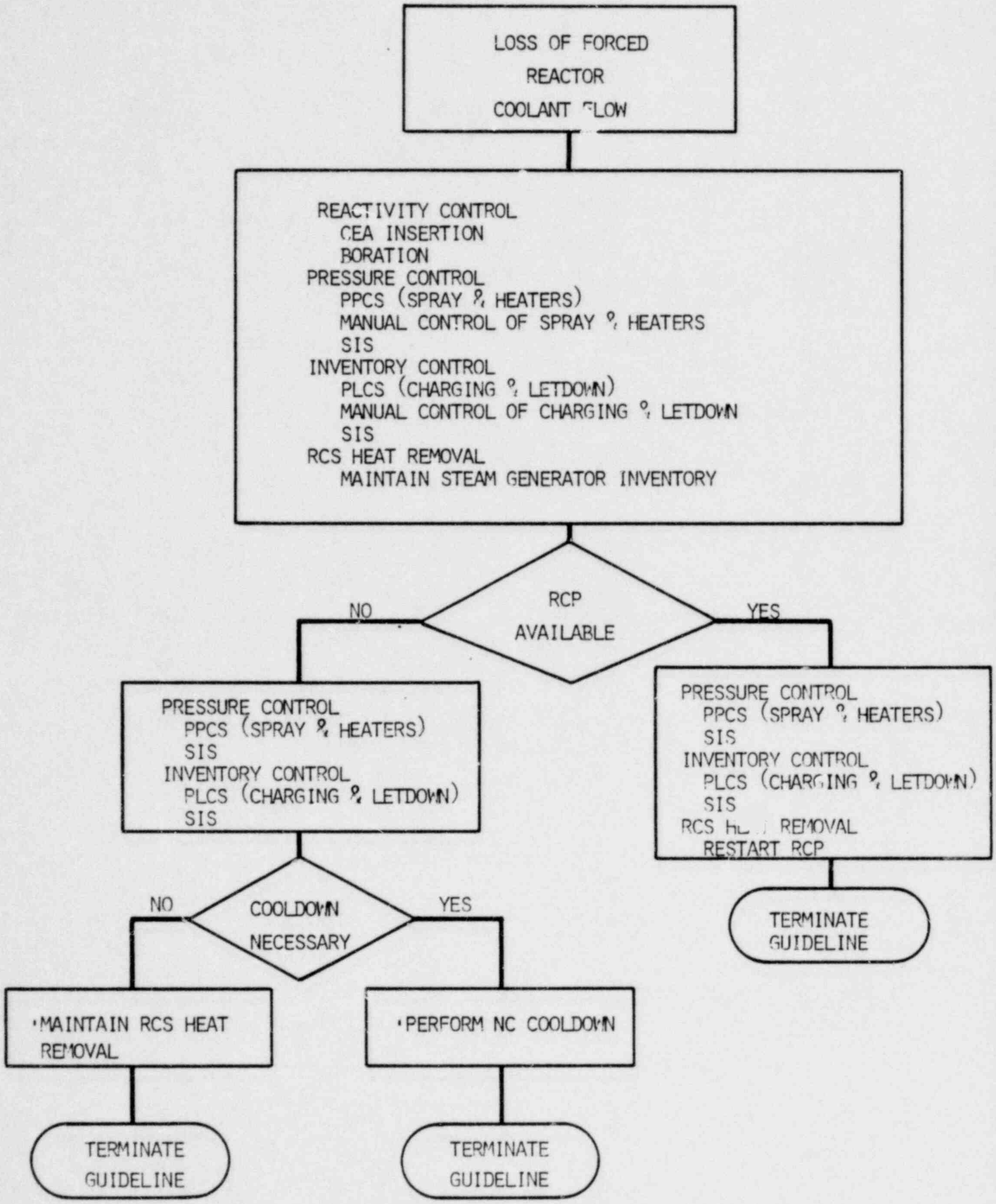
21. Voids which occur in the RCS which cannot be eliminated by the instructions of the previous step may indicate the existence of a void made up of non-condensible gases. [The reactor vessel head vent may be operated as necessary to eliminate these gases.]

22. The depressurization to SCS entry conditions may be resumed if voiding is eliminated by any of the previous steps.

23. The final step places the Shutdown Cooling System into operation. Entering shutdown cooling need not be a required step in the plant cooldown process. If adequate condensate is available and other operating criteria can be met, continuing to remove decay heat with the steam generators can be an acceptable alternative to using the Shutdown Cooling System for removal of reactor decay heat.

Figure 5.2-1

LOSS OF FORCED REACTOR COOLANT FLOW STRATEGY CHART



LOSS OF FORCED REACTOR COOLANT FLOW GUIDELINE

SYMPTOMS

1. RCP trip alarm.

2. Reactor Trip.

3. Turbine and generator trip alarms.

4. Decreasing steam generator ΔP in the affected RCS loop.

5. RCP trouble alarms.

6. Low RCP motor current.

7. Low RCS flow indication.

8. Initial Trending of Key Parameters

   a) Reactor Power - Decreasing
   b) Pressurizer Pressure - Decreasing
   c) Average RCS Temperature - Decreasing
   d) Pressurizer Level - Decreasing
   e) Steam Generator Pressure - Increasing
   f) Steam Generator Level - Decreasing

IMMEDIATE ACTIONS

1. Verify that the reactor has tripped. If not, manually trip the reactor and carry out the standard post-trip actions.

2. Verify that the Main or Auxiliary Feedwater System is restoring or maintaining steam generator level.

3. Operate the turbine bypass valves to maintain RCS temperature below the set point of the steam generator safety valves. If the bypass valves or the condenser are not available, use the atmospheric dump valves.

FOLLOW-UP ACTIONS

1. Verify all immediate actions have been initiated.

2. Confirm the diagnosis of a Loss of Forced Reactor Coolant Flow event. If a misdiagnosis has been made, implement the proper emergency guideline. If a definitive diagnosis cannot be made, refer to the plant status and trending diagnostic (see Section 6.0).

3. Establish and maintain the hot leg temperature (T_h) at least [20^{o}F + inaccuracies] below saturation temperature corresponding to the RCS pressure (refer to Figure 5.2-2) by doing the following:

   a) Operate pressurizer heaters or auxiliary spray to increase or maintain pressurizer pressure.

   b) Increase the turbine bypass or atmospheric steam dump flow to reduce RCS temperature.

4. Verify that the PLCS is functioning to maintain pressurizer level. If necessary, manually operate charging and letdown to restore and maintain normal pressurizer level.

5. Verify, by the following indications, that natural circulation flow has been established within [5 - 15 minutes] if all RCPs have tripped:

   a) Loop ΔT (T_h-T_c) less than normal full power ΔT.
   b) Cold leg temperatures constant or decreasing.
   c) Hot leg temperatures stable (i.e., not steadily increasing).
   d) No abnormal differences between T_h RTDs and core exit thermocouples.

6. One RCP in each loop may be restarted if the following criteria are satisfied:

   a) At least one steam generator is removing heat from the RCS.
   b) Pressurizer level and pressure are responding normally to the Pressurizer Level and Pressure Control Systems.
   c) The RCS is at least [$20^{o}F$ + inaccuracies] subcooled (refer to Figure 5.2-2).
   d) [Other criteria satisfied per RCP operating instrucitons.]

7. Maintain the plant in a stabilized condition based on auxiliary systems availability (e.g. condensate inventory).

8. If required, conduct a plant cooldown to SDC initiation conditions as addressed in the following sections.

9. Borate the plant in accordance with Technical Specification Limitations.

10. Continuously verify natural circulation flow throughout the cooldown process.

11. Commence an RCS cooldown by performing one of the following (listed in order of preference):

    a) If the condenser and Turbine Bypass System are available, commence the cooldown using the Turbine Bypass System and main or auxiliary feedwater.

b) If the condenser or the Turbine Bypass System are not available, commence the cooldown using the atmospheric dump valves and main or auxiliary feedwater.

c) [Initiate the Low Temperature Overpressurization Protection (LTOP) System at 275^{o}F.]

d) Monitor the available condensate inventory and replenish from alternate sources as required.

12. Establish a maximum cooldown rate in accordance with Technical Specification Limitations.

13. If a steam generator was isolated following a SGTR event, continue the natural circulation cooldown by performing the following activities (listed in order of preference):

    a) If possible, restart one RCP in each loop to establish cooling of the isolated steam generator.

    b) Periodically drain and refill the isolated steam generator with feedwater.

14. During the cooldown, maintain a m' imum of [20^{o}F + inaccuracies] subcooling (refer to Figure 5.2-2) by the following methods (listed in order of preference):

    a) Manual control of pressurizer heaters and auxiliary spray.
    b) Operating charging or HPSI pumps.

15. During the cooldown maintain pressurizer level by the following methods (listed in order of preference):

    a) Control charging and letdown.
    b) Operating HPSI pumps.

16. Depressurize the RCS to SDC initiation pressure by manually operating auxiliary spray if the following criteria are satisfied:

    a) The RCS has been cooled to SDC initiation temperature [300°F], and either:
    b) all RCS hot leg temperatures have been below [300°F] for [7 hours], or,
    c) [20 hours] has elapsed since the start of the cooldown.

17. If the auxiliary spray is not available, perform one or more of the following:

    a) Based on condensate inventory, stay at hot standby conditions until main or auxiliary spray flow can be restored.
    b) Use a pressurizer fill and drain method to depressurize.
    c) [Operate the pressurizer vent.]
    d) [Operate a power operated relief valve (PORV).]

18. During the RCS depressurization, perform the following:

    a) Maintain a [20°F + inaccuracies] subcooled margin (refer to Figure 5.2-2).
    b) [Bypass the ESFAS signal set point on each safety channel at 1750 psia.]
    c) [Isolate, vent, or drain the safety injection tanks (SIT) at 250 psia.]

19. During the RCS depressurization, monitor for void formation. Indications of possibilities of voids are:

    a) A pressurizer level increase significantly greater than expected while operating auxiliary spray.
    b) A pressurizer level decrease while operating charging.
    c) If the PLCS is in automatic, an unanticipated letdown flow greater than charging flow.

20. If voiding of the RCS is indicated, perform the following:

    a) Isolate letdown.
    b) Stop the depressurization.
    c) Stop the RCS cooldown.
    d) Repressurize the RCS to eliminate the void by operating pressurizer heaters or HPSI and charging pumps.

21. [If the void formation is suspected to be non-condensible gases, operate the reactor vessel head vent as necessary to eliminate the gases.]

22. When conditions permit, resume the depressurization to SDC initiation pressure.

23. When the RCS is cooled down to [300°F] and [300 psia] initiate shutdown cooling.

PRECAUTIONS

1. Natural circulation flow cannot be verified until the RCPs have stopped coasting down after being tripped.

2. Verification of plant 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. After a cold shutdown boron concentration is attained in the RCS, makeup water added to the RCS during the cooldown should be at least the same boron concentration as in the RCS to prevent any dilution of RCS boron concentration.

4. 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.

5. Minimize the use 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. Every such cycle must be recorded in accordance with Technical Specification Limitations.

6. If pressurizer spray is not available, boron concentration in the pressurizer may be lower than the RCS loop boron concentration. The RCS boron concentration should be increased to avoid being diluted below minimum requirements by a possible pressurizer outsurge.

7. If the RCS is solid, closely monitor any makeup or draining and any system heatup or cooldown to avoid any unfavorable rapid pressure excursions.

8. [Monitor quench tank parameters since any sustained operation of the PORVs may burst the tank's rupture disc.]

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

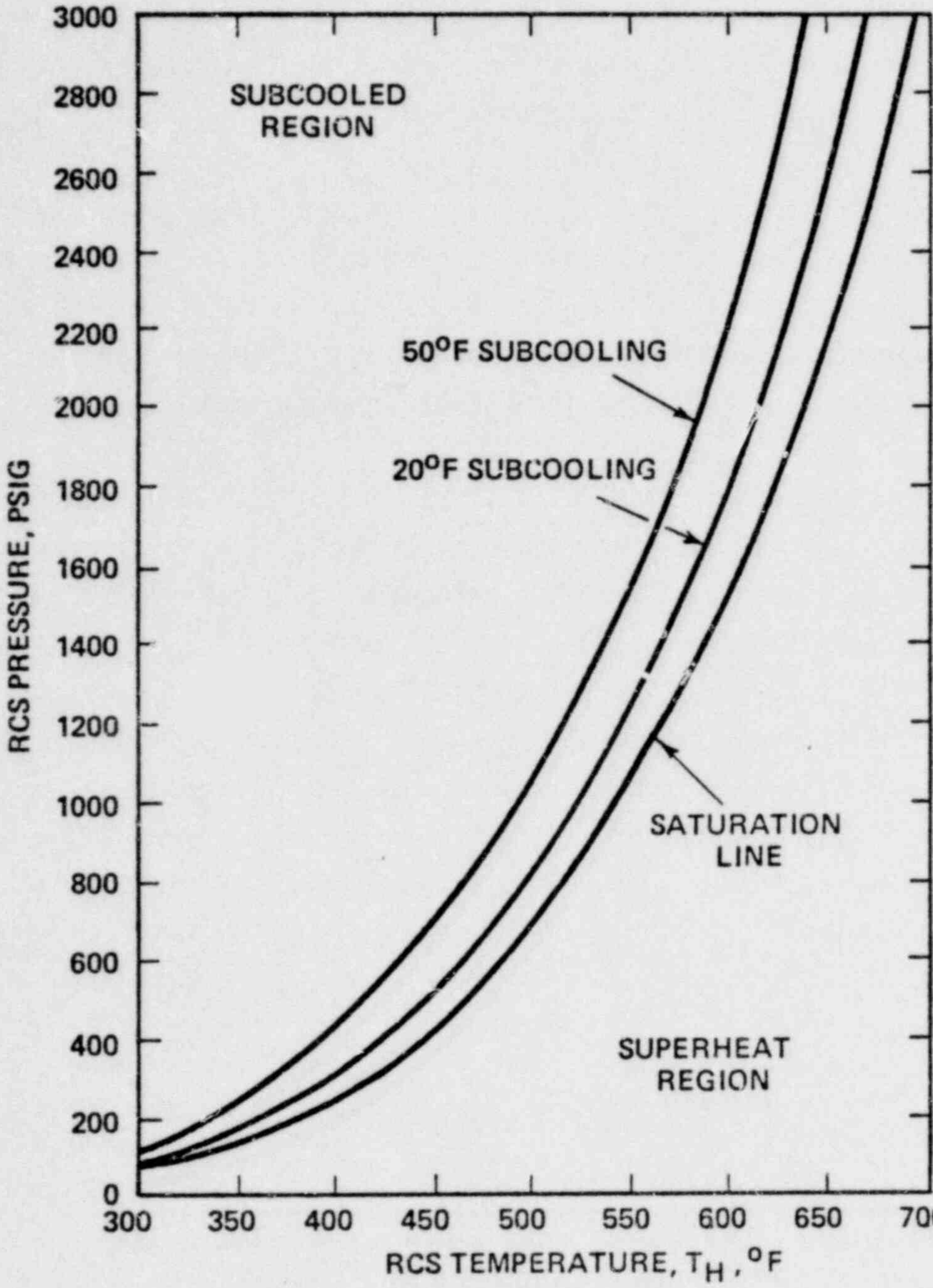
10. If cooling down by natural circulation with an isolated steam generator, an inverted ΔT (i.e. T_c higher than T_h) may be observed in the idle loop. This is due to a small amount of reverse heat transfer in the isolated steam generator and will have no affect on natural circulation flow in the intact steam generator.

11. All available indications should be used to aid in diagnosing the event since the accident may cause irregularities in a particular instrument reading. Critical parameters must be verified when one or more confirmatory indications are available.

12. Evaluate condensate storage inventory. Conduct a plant cooldown and enter shutdown cooling prior to depleting condensate storage inventory. Actions for elimination of voids should only be taken if condensate inventory can sustain the extended cooldown to shutdown cooling entry conditions.

Figure 5.2-2

SATURATION / SUBCOOLING



5.3 STEAM LINE BREAK GUIDELINE

BASES

A steam line break is a break in the steam or feed piping which leads to an unexpected, rapid increase in secondary plant steam flow that 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 or auxiliary 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) (i.e., atmospheric dumps, turbine bypass, etc.).

d) Stuck open steam generator safety valve.

Characterization of an SLB

The following parameters characterize an SLB:

a) Increased steam flow from the steam generators.

b) Decreasing steam generator pressure and water level (initially, there may be level swell).

c) Decreasing primary coolant average temperature causing a decrease in pressurizer pressure and water level.

d) Reactor trip caused by low steam generator water level, low pressurizer pressure, low steam generator pressure, or high containment pressure (if SLB is within containment).

e) SIAS will be generated from low pressurizer pressure or high containment pressure (if SLB is within the containment).

f) A CIAS and CSAS may be generated on high containment pressure (if SLB is within the containment).

g) Possible increase in containment pressure, temperature, radiation humidity or containment sump level.

Safety Functions Affected

A steam line break, depending on location, can directly affect two critical safety functions; RCS inventory control and containment integrity.

A steam line break results in excess steam flow on the secondary side which will cause a reactor trip. If the break is large enough, a turbine trip will occur due to reduced electrical output. This decrease in reactor power (due to turbine and reactor trip), combined with the increase in steam generator heat removal (due to the excess steam flow) reduces RCS temperature. A reduction in RCS temperature causes an inventory loss (shrinkage). This lost inventory will be made up by the Safety Injection System and/or the charging pumps; care should be taken that while the lost inventory is being replaced the RCS pressure does not go solid.

If a break occurs inside containment, the steam flow from the break will result in an increase in containment pressure and temperature. The threat to containment integrity is mitigated by a CIAS when pressure exceeds [5 psig] and a CSAS when pressure exceeds [10 psig].

Initial Trending of Key Parameters

Reactor Power

In response to the increased steam flow, reactor power will initially increase, followed by a reactor trip which may be caused by any one of the following: low pressurizer pressure, low steam generator water level, high containment pressure, or low steam generator pressure.

RCS Temperature

Prior to the reactor trip, RCS temperature will decrease because heat removed by the SLB exceeds heat produced by the core. After the reactor has tripped, heat removal will exceed decay heat, causing further cooling of the RCS.

Pressurizer Pressure and Level

Pressurizer pressure and level will decrease due to the lowering of RCS temperature.

Steam Generator Pressure

Steam generator pressure in the affected steam generator will decrease due to the decrease in resistance caused by the SLB and the decrease in RCS temperature.

Steam Generator Level

Steam generator level will initially increase due to swell and then decrease because the Feedwater Level Control System will be unable to keep up with steam flow.

Event Strategy

Figure 5.[illegible]-1 provides a summary of the strategy employed in this guideline. Only the major decision points are indicated. A detailed discussion of the required operator actions and bases is found in the following sub-sections.

Bases Immediate Actions

The plant responses to a SLB are very rapid, thus precluding immediate operator action at the onset of the transient. Therefore, immediate actions are oriented towards verifying the automatic safety systems are operating properly.

1. Verify the reactor has tripped. If not, a manual trip is initiated. This will verify that the proper shutdown margin is maintained.

2. The initiation of an SIAS must be verified if pressurizer pressure decreases to [1600 psia],[or if containment pressure increases to 5 psig]. If SIAS has not been automatically actuated, it must be initiated manually. This action verifies safety functions are being performed; RCS heat removal and RCS inventory control.

3. If pressurizer pressure decreases to [1300 psia] following an SIAS, all reactor coolant pumps must be stopped.

A system response identified by a depressurization transient to below [1300 psia] following an SIAS (and subsequent operation of the SIS) is characteristic of a LOCA. Continued RCP operation at RCS pressure below [1300 psia] during a LOCA may result in more severe RCS conditions.

It may not be possible to distinguish between events causing a depressurization in the early stages of the transient, specifically during the time period when the immediate actions are taken. The immediate actions required for all events are directed at placing the plant in a safe condition. To avoid the necessity of a confirmation of the initiation event during the time when the immediate actions are taken, anytime pressurizer pressure decreases to [1300 psia] following an SIAS, all RCP operation is terminated.

4. Verify the initiation of an MSIS if steam generator pressure is less than [800 psig]. If not, manually initiate an MSIS. An MSIS will shut the MSIVs, isolating a break downstream of the MSIV automatically. This will also isolate one steam generator from any break associated with the other steam generator and limit the high energy blowdown of the contents of one steam generator.

5. Verify a CIAS if containment pressure increases to [5 psig], [or if pressurizer pressure decreases to 1600 psia]. If not, manually initiate a CIAS. This action minimizes the chances of the containment atmosphere leaking to the environment.

6. If containment pressure increases to [10 psig], verify a CSAS has occurred. If not, manually initiate a CSAS. A CSAS will reduce containment pressure and temperature, thereby minimizing a containment to atmosphere leakage.

Bases Follow-up Actions

The Follow-up Actions are directed toward determining where the SLB is located, isolating the break and bringing the plant back to a stable controlled condition.

1. All immediate actions are verified for their execution to check that all the critical safety functions have been attended to.

2. The diagnosis of a SLB event should be confirmed by referring to Figure 5.3-2. If a misdiagnosis has been made, the proper emergency guideline can then be implemented. If a definitive diagnosis can not be made, the plant status and trending diagnostic is referenced. This diagnostic is functionally oriented, and all critical safety functions are attended to. The proper emergency guideline can then be implemented.

3. Identify the affected steam generator by comparison of steam pressures, cold leg temperature differences and auxiliary feedwater flow (refer to Figure 5.3-2. The steam generator with the break will still be producing steam flow after the MSIVs are shut. This is indicated by a reduced loop T_c, lower steam pressure, and larger auxiliary feed flow than the isolated steam generator.

4. Isolate feedwater to the affected steam generator. This will minimize a further uncontrolled plant cooldown.

5. If both steam generators are found to have breaks, isolate the steam generator with the larger break, if it can be determined, and attempt to maintain an orderly cooldown using one steam generator. This action minimizes the uncontrolled cooldown rate.

6. If unable to determine which steam generator is leaking, isolate both steam generators and determine the affected one. This is the steam generator that will continue to decrease in level. The unaffected steam generator's level will stabilize and its steam pressure will increase. Unisolate and feed the intact steam generator. This will provide RCS heat removal capabilities.

7. Maintain or restore steam generator level in the unaffected steam generator to provide a means for either maintaining core cooling or, if necessary, cooling down the reactor.

8. To ensure a safe shutdown margin, borate the RCS to the cold shutdown boron concentration.

9. If the break has not been isolated a cooldown of the RCS to the shutdown cooling initiation temperature should be controlled by the Turbine Bypass System. If condenser vacuum or the Turbine Bypass System are not available or if the MSIVs have closed, the atmospheric dump valves must be used to effect the RCS cooldown. The maximum cooldown rate should be limited to within Technical Specification Limitations.

10. If the break has been isolated, RCS temperature should be controlled by the Turbine Bypass System. If condensor vacuum is lost or if the MSIVs have closed, the atmospheric dump valves must be used to control RCS temperature. This action will prevent lifting of secondary or primary safety valves.

11. The PLCS is verified to be automatically controlling or restoring pressurizer level. If not, charging and letdown are operated manually to ensure pressurizer level is being maintained. This action verifies that a safety function is being performed; controlling RCS inventory.

12. The PPCS is verified to be automatically controlling or restoring RCS pressure. If not, pressurizer heaters and spray are operated manually to control pressurizer pressure. This action verifies that a safety function is being performed; controlling RCS pressure.

13. Operation of the reactor coolant pumps should be attempted to ensure continued forced circulation of coolant through the core and to provide the capability for the normal mode of pressurizer spray. However, only one reactor coolant pump in each loop needs to be operated in an effort to minimize heat input to the RCS.

The possibility of RCP operation is determined if all of the following criteria are satisfied:

a) A steam generator is removing heat from the RCS and thus providing a primary heat removal function.

b) Pressurizer level and pressure are responding normally to the Pressurizer Level and Pressure Control Systems. This assures that primary inventory is being controlled.

c) The RCS is greater than or equal to [20°F + inaccuracies] subcooled. An RCS subcooled condition ensures that the RCPs can be operated without damage due to cavitation.

d) [All plant specific RCP operating criteria should be satisfied before the RCPs are restarted.]

14. Upon termination of all RCP operations, natural circulation must be established in the RCS. This condition can be verified by referring to the Loss of Forced Reactor Coolant Flow Guideline and following its instruction concurrently with this guideline.

15. If an SIAS has been initiated and the SIS is operating, it must continue to operate until SIS termination criteria is met. This criteria is:

a) RCS hot and cold leg temperatures are at least [20°F + inaccuracies] below saturation temperature for pressurizer pressure (refer to Figure 5.3-3. Establishing [20°F + inaccuracies] of subcooling prevents void formation in the core when SIS flow is terminated, and provides sufficient margin for reestablishing flow should the [20°F + inaccuracies] of subcooling deteriorate when flow is secured. [For plants with high head HPSI pumps, this margin is attainable prior to the opening of the PORV's, enabling the operator to prevent an unnecessary loss of primary coolant.]

b) Pressurizer level is in the normal operating band and is responding normally to the Pressurizer Level and Pressure Control Systems. A pressurizer level in the normal operating band and responding normally ensures that RCS inventory control has been reestablished.

c) At least one steam generator has an indicated level and is removing heat from the RCS. A steam generator having an indicated level and removing heat from the RCS ensures that primary to secondary heat removal is being maintained.

16. If [20°F + inaccuracies] of subcooling can not be maintained after the SIS has been stopped, SIS operation must be reinitiated to ensure core heat removal and minimize the chance of voiding occurring in the RCS

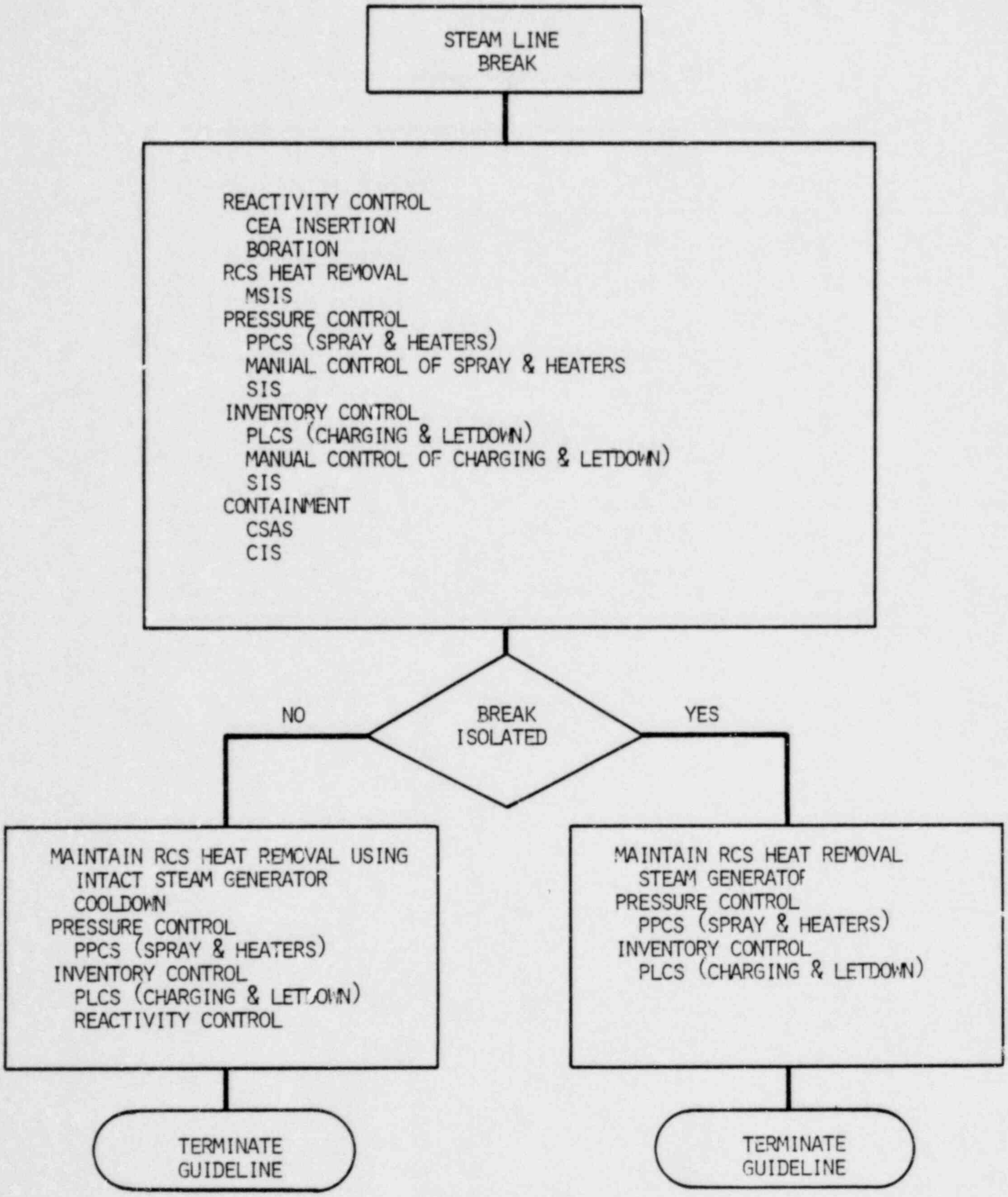
17. If containment pressure is [8 psig] and is stable or decreasing, containment spray can be secured and realigned for automatic operation. This action minimizes the adverse effects of containment spray.

18. Maintain the plant in a stabilized condition based on auxiliary systems availability (e.g., condensate inventory). If required, conduct a plant cooldown to SCS initiation conditions to repair the SLB.

19. When RCS temperature is cooled to [300°F] and the RCS is depressurized to [300 psig], initiate shutdown cooling, to cooldown and repair the break.

FIGURE 5.3-1

STEAM LINE BREAK STRATEGY CHART



STEAM LINE BREAK GUIDELINES

SYMPTOMS

1. Possible increase in containment pressure and sump level.

2. Loud noise indicative of a high energy line break.

3. Reactor trip alarm.

4. Increased steam generator steam flow with decreased electrical output.

5. Main Steam Isolation Signal (MSIS) actuation.

6. Containment Isolation Actuation Signal (CIAS) (rupture inside containment). Possible Containment Spray Actuation Signal (CSAS).

7. SIAS generated.

8. Increase in feedwater flow until MFIVs are closed on a MSIS.

9. No high radiation in containment - indicative of a rupture outside containment or differentiates between an MSLB in containment and a LOCA.

10. Initial Trending of Key Parameters:

    a) Reactor power - increasing (only before the trip).
    b) Pressurizer pressure - decreasing.
    c) Pressurizer level - decreasing.
    d) RCS temperature - decreasing.
    e) Steam generator pressure - decreasing.
    f) Steam generator level - increasing then decreasing.

IMMEDIATE ACTIONS

1. Verify the reactor has tripped. If not, manually trip the reactor and carry out standard post trip actions.

2. If pressurizer pressure decreases to [1600 psia], [or containment pressure increases to 5 psig], verify that an SIAS has been initiated. If not, manually initiate an SIAS.

3. If pressurizer pressure decreases to [1300 psia] following an SIAS, stop all reactor coolant pumps.

4. If steam generator pressure is less than [800 psig], verify that an MSIS has been initiated. If not, manually initiate and verify closure of the MSIVs.

5. If containment pressure increases to [5 psig], [or if pressurizer pressure decreases to 1600 psia], verify that a CIAS has been initiated. If not, manually initiate a CIAS.

6. If containment pressure is greater than [10 psig], verify that a CSAS has been initiated. If not, manually initiate a CSAS.

FOLLOW-UP ACTIONS

1. Verify that all immediate actions have been initiated.

2. Confirm the diagnosis of a SLB event by referencing Figure 5.3-2. If a misdiagnosis has been made, implement the proper emergency guideline. If a definitive diagnosis cannot be made, refer to the plant status and trending diagnostic.

3. Identify the affected steam generator by comparison of steam pressures, cold leg temperature differences and auxiliary feedwater flow (refer to Figure 5.3-2. The unit with the lower or decreasing steam pressure and cold leg temperature subsequent to an MSIS is the one with the break path.

4. Isolate the affected steam generator by performing the following actions:

   a) Isolate feedwater to the affected steam generator.

   b) [If additional actions are required to isolate the affected steam generator, insert that information here.]

5. If both steam generators are found to have breaks, isolate the steam generator with the larger break if it can be determined, and attempt to maintain an orderly cooldown using one steam generator.

6. If unable to determine which steam generator is affected, isolate both steam generators and determine the affected one, then unisolate and feed the unaffected steam generator for an RCS cooldown.

7. Verify that the steam generator level on the unaffected steam generator is being restored or maintained.

8. Initiate boration of the plant. Continue the boration process until the RCS cold shutdown boron concentration has been attained, per Technical Specification Requirements.

9. If the break has not been isolated, operate atmospheric steam dump valves or turbine bypass valves if the condenser is available to cool down the RCS, within Technical Specification limitations, to the shutdown cooling initiation temperature, [300°F].

10. If the break has been isolated, operate atmospheric steam dump valves or turbine bypass valves if the condenser is available in an effort to stabilize RCS temperature.

11. Verify that the PLCS is automatically restoring pressurizer level. If not, manually operate charging and letdown to restore and maintain pressurizer level.

12. Verify that the PPCS is automatically restoring RCS pressure. If not, manually control heaters or spray to restore pressurizer pressure.

13. If the RCPs were stopped, one RCP in each loop may be restarted if the following criteria are satisfied:

    a) The steam generators are removing heat from the RCS.

    b) Pressurizer level and pressure are responding normally to the Pressurizer Level and Pressure Control Systems.

    c) The RCS is at least [20°F + inaccuracies] subcooled. Refer to Figure 5.3-3.

    d) [Other criteria satisfied per RCP operating instruction].

14. If all RCPs are stopped, verify that natural circulation is accomplished per the Loss of Forced Reactor Coolant Flow Guideline concurrently with this guideline.

15. If the SIS is operating, it may be stopped if the following conditions are satisfied:

a) RCS hot and cold leg temperatures are at least [20°F + inaccuracies] below saturation temperature for pressurizer pressure (refer to Figure 5.3-3), and

b) pressurizer level is in the normal operating band and is responding normally to the Pressurizer Level and Pressure Control System,and

c) at least one steam generator has an indicated level and is removing heat from the RCS.

16. If [20°F + inaccuracies] subcooling (refer to Figure 5.3-3 cannot be maintained after the SIS has been stopped, the SIS must be restarted.

17. If containment pressure falls below [8 psig], containment spray may be terminated. Upon termination, it must be realigned for automatic operation.

18. Maintain the plant in a stabilized condition based on auxiliary systems availability (e.g. condensate inventory). If required, conduct a plant cooldown to SCS initiation conditions.

19. When RCS temperature is cooled to [300°F] and the RCS is depressurized to [300 psig], initiate shutdown cooling.

PRECAUTIONS

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.

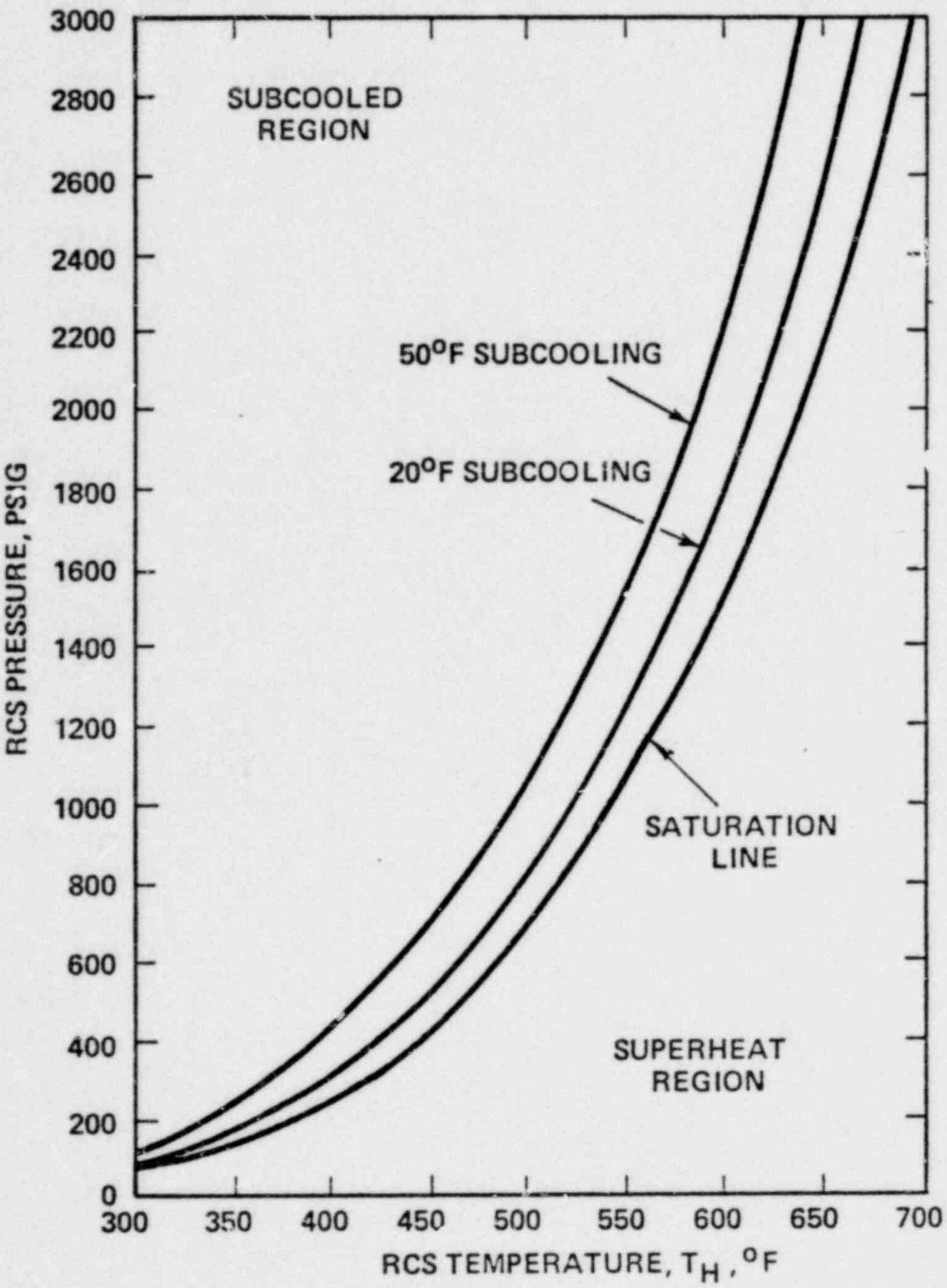
2. During all phases of the cooldown, monitor RCS temperature and pressure to avoid exceeding a maximum cooldown rate greater than Technical Specifications.

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. Critical parameters must be verified when one or more confirmatory indications are available.

FIGURE 5.3-3

SATURATION / SUBCOOLING



6.0 Inadequate Core Cooling

6.1 Introduction

Inadequate core cooling (ICC) is a term that defines a reactor core condition that is degraded beyond that anticipated during normal plant operation. The ICC condition can result from operator error or from equipment failures. However, to induce ICC, operating procedures have to be improperly implemented or equipment failures beyond that considered credible in design must occur.

ICC Guidance has been factored into the existing system of emergency procedure guidelines. For example, the use of PORVs and the HSPI System is addressed in the Loss of Feedwater Guideline, as opposed to being found in a separate package. The ICC Guidance found in this section provides a functional approach to plant status and trending, as explained below.

6.2 Plant Status and Trending

While implementing a particular emergency procedure guideline or group of emergency procedure guidelines within the guideline system, the operator is required to monitor for adequate core cooling and appropriate reactor core conditions associated with the particular mode of plant operation.

In addition to the manner in which adequate core cooling monitoring is effected in the individual emergency procedure guidelines, a supplemental methodology for determining the adequacy of the existing mode of core cooling is found in Table 6.2-1, entitled "Plant Status and Trending".

The plant status and trending table features an independent means to assess reactor cooling. The utilization of the table does not require any concurrent knowledge of the plant emergency event.

6.3 Features of the Plant Status and Trending Table

The critical plant safety functions which must be attended to during any emergency event (following a reactor trip) are listed. Specific parameters are normally monitored which demonstrate if the safety function is being completed adequately. Associated with these parameters are anticipated post-trip trendings and limitations within which their status is regarded as acceptable.

Utilization of this table, by comparing the listed parameter status and trending for a safety function against those noted in the control room, will identify if adequate cooling is established in the core.

6.4 Summary of Actions to Mitigate ICC

As stated previously, the existing emergency procedure guidelines prescribe actions consistant with preventing or mitigating ICC. These actions assure the completion of the critical safety functions found on Table 6.2-1.

On Table 6.4-1, all the actions which assure adequate core cooling have been summarized. Alternative actions are also listed. If an action is found in one or more of the emergency procedure guidelines, this is indicated by a star. This table demonstrates the adequacy of the actions found in the procedure guidelines in preventing or mitigating ICC.

TABLE 6.7-1 - PLANT STATUS AND TRENDING

SAFETY FUNCTION	METHOD FOR CONTROL	PARAMETER	ACCEPTABLE STATUS AND TREND (1)	IF UNACCEPTABLE, IMPLIED CONDITION	GUIDELINE
REACTIVITY CONTROL	1. CEA'S	A. REACTOR POWER	A. DECREASING	A. REACTOR NOT SHUTDOWN	A. REACTOR TRIP, ATWS
		B. CEA POSITION	B. BOTTOM < 10 STUCK OUT AND INTO CORE	B. CEA'S NOT INSERTED	B. REACTOR TRIP, ATWS
		C. SUR	C. 1/3 Dpm AND DECREASING	C. RETURN TO POWER OR CRITICALITY	C. REACTOR TRIP, ATWS
	2. BORON CONCENTRATION	A. SHUTDOWN MARGIN	A. > 5.0% ΔK/K > 210°F AND CONSTANT OR INCREASING	A. REACTOR NOT SUBCRITICAL FOR COOL CONDITIONS	A. REACTOR TRIP, ATWS
		B. REACTOR POWER	B. DECREASING	B. CEA'S NOT INSERTED	B. REACTOR TRIP, ATWS
		C. SUR	C. < 0 AND CONSTANT OR DECREASING	C. RETURN TO POWER OR CRITICALITY	C. REACTOR TRIP, ATWS
RCS HEAT REMOVAL	1. STEAM GENERATOR FORCED CIRCULATION	A. RCS AMPS	A. > [600] AMPS AND CONSTANT	A. VOIDS IN RCS	A. LOSS OF FLOW/NC
		B. STEAM GENERATOR ΔP	B. > 20 PSID AND CONSTANT	B. LOSS OF RCS FLOW	B. LOSS OF FLOW/NC
		C. STEAM GENERATOR LEVEL	C. > 60% IN ONE S/G AND CONTROLLED	C. INSUFFICIENT HEAT SINK	C. LOSS OF FEED
		D. RCS ΔT	D. < 10°F AND CONSTANT OR DECREASING	D. CORE HEATING UP, LOW FLOW	D. LOSS OF FLOW/NC
		E. RCS T_{AVG}	E. < 590°F $T_C \approx T_H$ AND CONSTANT OR DECREASING	E. RCS HEATING UP	E. LOSS OF FEED, LOCA
		F. CORE EXIT THERMOCOUPLES	F. < 620°F AND CONSTANT OR DECREASING	F. CORE HEATING UP	F. LOCA S/G TUBE RUPTURE
		G. RCS SUBCOOLED	G. > 20°F AND CONSTANT OR INCREASING	G. VOIDS IN RCS	G. LOCA
	2. STEAM GENERATOR NATURAL CIRCULATION	A. STEAM GENERATOR LEVEL	A. > 50°F IN ONE S/G AND CONSTANT OR INCREASING	A. INSUFFICIENT HEAT SINK	A. LOSS OF FEED
		B. RCS T_{AVG}	B. < 590°F AND CONSTANT OR DECREASING	B. RCS HEATING UP	B. LOSS OF FLOW/NC
		C. CORE EXIT THERMOCOUPLES	C. < 620°F AND CONSTANT OR DECREASING	C. CORE HEATING UP	C. LOSS OF FLOW/NC, LOCA
		D. RCS SUBCOOLED	D. > 20°F AND CONSTANT OR INCREASING	D. VOIDS IN RCS	D. LOSS OF FLOW/NC, LOCA
		E. T_C	E. $T_C \approx T_{STEAM\ GENERATOR}$	E. REDUCED HEAT TRANSFER TO S/G, LOSS OF RCS FLOW	E. LOSS OF FLOW/NC,
	3. COOLANT FLOW FROM RCS (LARGE BREAK)	A. T_H	A. < 620°F AND CONSTANT OR DECREASING	A. LOSS OF LIQUID PHASE COOLANT	A. LOCA, LOSS OF FLOW/NC
		B. CORE EXIT THERMOCOUPLES	B. < 620°F AND CONSTANT OR DECREASING	B. CORE HEATING UP	B. LOSS OF FLOW/NC, LOCA
		C. T_C	C. < 560°F AND CONSTANT OR DECREASING	C. LOSS OF HEAT TRANSFER TO S/G	C. LOSS OF FEED, LOCA
		D. RCS SUBCOOLED	D. > 20°F AND CONSTANT OR INCREASING	D. VOIDS IN RCS	D. LOSS OF FLOW/NC, LOCA
		E. SIS HPSI FLOW LPSI FLOW CSP FLOW SIT LEVEL	E. > 600 GPM AND CONSTANT > 4000 GPM PRE RAS AND CONSTANT > 1000 GPM IF CONTAINMENT PRESSURE > 10 PSIG AND CONSTANT	E. LOSS OF COOLANT REPLACEMENT	E. LOCA, S/G TUBE RUPTURE

(1) TYPICAL POST TRIP VALUES

TABLE 6.2-1- PLANT STATUS AND TRENDING

SAFETY FUNCTION	METHOD FOR CONTROL	PARAMETER	ACCEPTABLE STATUS AND TREND ①	IF UNACCEPTABLE, IMPLIED CONDITION	GUIDELINE
RCS HEAT REMOVAL (CONTINUED)	4. SMALL BREAK LOCA COMBINATION OF STEAM GENERATOR AND SMALL BREAK COOLANT FLOW	A. STEAM GENERATOR LEVEL	A. > 50% IN ONE S/G AND CONSTANT OR INCREASING	A. INSUFFICIENT HEAT SINK	A. LOSS OF FEED
		B. RCS T_{AVG}	B. < 590°F T_C > T_H AND CONSTANT OR DECREASING	B. RCS HEATING UP	B. LOSS OF FLOW/NC, LOCA
		C. CORE EXIT THERMOCOUPLES	C. < 620°F AND CONSTANT OR DECREASING	C. CORE HEATING UP	C. LOSS OF FLOW/NC, LOCA
		D. RCS SUBCOOLED	D. > 20°F AND CONSTANT OR INCREASING	D. VOIDS IN RCS	D. LOSS OF FLOW/NC, LOCA
		E. T_C	E. T_C > $T_{STEAM\ GENERATOR}$	E. REDUCED HEAT TRANSFER TO S/G, LOSS OF RCS FLOW	E. LOSS OF FLOW/NC, LOCA
		F. HPSI PUMP FLOW	F. > 30 GPM < 400 GPM AND CONSTANT	F. LOSS OF COOLANT REPLACEMENT	F. LOCA
RCS INVENTORY AND PRESSURE CONTROL	1. AUTOMATIC OR MANUAL CONTROL OF CVCS	A. CHARGING PUMP FLOW	A. MAINT. PRESS. LEVEL BETWEEN 42% AND 56% AND CONSTANT	A. LOSS OF RCS COOLANT REPLACEMENT LOSS OF CHEM/REACTIVITY CONTROL	A. REACTOR TRIP
		B. LETDOWN FLOW	B. MAINT. PRESS. LEVEL BETWEEN 42% AND 56% AND CONSTANT	B. LOSS OF CHEM/REACTIVITY CONTROL	B. REACTOR TRIP
		C. PRESSURIZER LEVEL	C. MAINT. PRESS. LEVEL BETWEEN 42% AND 56% AND CONSTANT	C. LOSS OF RCS COOLANT REPLACEMENT LOSS OF CHEM/REACTIVITY CONTROL	C. REACTOR TRIP
		D. RCS SUBCOOLED	D. > 20°F SUBCOOLED AND CONSTANT OR INCREASING	D. VOIDS IN RCS	D. LOCA, LOSS OF FLOW/NC
		E. T_H	E. < 620°F AND CONSTANT OR DECREASING	E. LOSS OF LIQUID PHASE COOLANT REDUCES EFFECTIVENESS OF PRESSURIZER	E. LOCA, LOSS OF FLOW/NC
		F. CORE EXIT THERMOCOUPLES	F. < 620°F AND CONSTANT OR DECREASING	F. CORE HEATING UP	F. LOCA, LOSS OF FLOW/NC
	2. SIS OPERATING	A. HPSI FLOW	A. > 600 GPM AND CONSTANT OR DECREASING	A. LOSS OF COOLANT REPLACEMENT	A. LOCA, S/G TUBE RUPTURE
		B. LPSI FLOW	B. < 4000 GPM PER RAS AND CONSTANT OR DECREASING	B. LOSS OF COOLANT REPLACEMENT	B. LOCA
		C. RCS SUBCOOLED	C. > 20°F SUBCOOLED AND CONSTANT OR INCREASING	C. VOIDS IN RCS	C. LOCA, S/G TUBE RUPTURE, LOSS OF FLOW/NC
		D. T_H	D. < 620°F AND CONSTANT OR DECREASING	D. LOSS OF LIQUID PHASE COOLANT	D. LOCA, LOSS OF FLOW/NC
		E. CORE EXIT THERMOCOUPLES	E. < 620°F AND CONSTANT OR DECREASING	E. CORE HEATING UP	E. LOCA, LOSS OF FLOW/NC
	3. AUTOMATIC OR MANUAL CONTROL OF PRESSURIZER HEATER OR SPRAY VALVE	A. HEATERS	A. MAINT. PZR. PRESS. BETWEEN 2010 PSIA AND 1975 PSIA	A. PRESSURE DECREASING	A. REACTOR TRIP
		B. SPRAY FLOW	B. MAINT. PZR. PRESS. BETWEEN 2010 PSIA AND 1975 PSIA	B. PRESSURE INCREASING	B. REACTOR TRIP
		C. AUXILIARY SPRAY	C. MAINT. PZR. PRESS. WHEN SPRAY FLOW IS NOT AVAILABLE	C. PRESSURE INCREASING	C. LOSS OF FLOW/NC
		D. RCS SUBCOOLED	D. > 20°F AND CONSTANT OR INCREASING	D. VOIDS IN RCS	D. LOCA, LOSS OF FLOW/NC,
CONTAINMENT INTEGRITY	CONTAINMENT ISOLATION AND PRESSURE CONTROL	A. CSP FLOW	A. > 2500 GPM IF CONTAINMENT PRESSURE > 10 PSIG AND CONSTANT OR DECREASING	A. STEAM BUILDUP IN CONTAINMENT LONG TERM HEAT REMOVAL REDUCED	A. LOCA, STEAM LINE BREAK
		B. CONTAINMENT ISOLATION VALVES	B. SHUT IF CONTAINMENT PRESSURE > 19 PSIG	B. POTENTIAL RELEASE OF ACTIVITY SYSTEM MISALIGNMENT	B. LOCA, STEAM LINE BREAK
		C. CONTAINMENT PRESSURE	C. < 60 PSIG AND CONSTANT OR DECREASING	C. HEAT GENERATION BEYOND THE PLANT BASIS. POTENTIAL RELEASE OF ACTIVITY	C. LOCA, STEAM LINE BREAK
		D. AREA RADIATION MONITORS	D. NOT ALARMING AND CONSTANT OR DECREASING	D. SYSTEM MISALIGNMENT. RELEASE OF ACTIVITY	D. LOCA, STEAM LINE BREAK

① TYPICAL POST TRIP VALUES

TABLE 6.4-1- SUMMARY OF ACTIONS TO ASSURE ADEQUATE CORE COOLING

	REACTOR TRIP	ANTICIPATED TRANSIENT WITHOUT SCRAM	LOSS OF FEED WATER	LOSS OF COOLANT ACCIDENT	STEAM GENERATOR TUBE RUPTURE	STEAM LINE BREAK	LOSS OF FORCED REACTOR COOLANT FLOW
REACTIVITY CONTROL 1. VERIFY THAT THE REACTOR HAS TRIPPED	X	X	X	X	X	X	X
2. IF NOT, MANUALLY TRIP THE REACTOR	X	X	X	X	X	X	X
3. IF MORE THAN ONE CEA HAS NOT INSERTED FULLY, BORATE THE PLANT IN ACCORDANCE WITH TECHNICAL SPECIFICATIONS	X						
4. ATTEMPT TO MANUALLY INSERT THE CEA'S INTO THE CORE. PERFORM ONE OF THE FOLLOWING ACTIONS A. PUSH MANUAL TRIP BUTTONS AT MAIN CONTROL BOARD		X					
B. OPEN CEA TRIP BREAKERS		X					
C. DEENERGIZE CONTROL ROD DRIVE MOTOR GENERATORS		X					
D. [IF OTHER METHODS ARE AVAILABLE TO INSERT CEA'S, INSERT THAT INFORMATION HERE]		X					
RCS INVENTROY CONTROL 1. ISOLATE THE BREAK IF POSSIBLE			X	X	X	X	
2. VERIFY THAT THE PLCS IS AUTOMATICALLY RESTORING PRESSURIZER LEVEL	X	X	X	X	X	X	X
3. IF NECESSARY, MANUALLY OPERATE CHARGING AND LETDOWN TO RESTORE AND MAINTAIN NORMAL PRESSURIZER LEVEL	X	X	X	X	X	X	X
4. MAINTAIN RCS INVENTORY USING THE SIS A. IF PRESSURIZER PRESSURE FALLS BELOW [1600 PSIA], VERIFY INITIATION OF SAFETY INJECTION. IF NECESSARY, MANUALLY INITIATE SAFETY INJECTION	X	X	X	X	X	X	
B. IF THE SIS IS OPERATING, IT MAY BE STOPPED IF THE FOLLOWING CONDITIONS ARE SATISFIED:	X	X	X	X	X	X	
1. RCS HOT AND COLD LEG TEMPERATURES ARE AT LEAST 20°F + [INACCURACIES] BELOW SATURATION TEMPERATURES FOR PRESSURIZER PRESSURE	X	X	X	X	X	X	

TABLE 6.4-1 - SUMMARY OF ACTIONS TO ASSURE ADEQUATE CORE COOLING

	REACTOR TRIP	ANTICIPATED TRANSIENT WITHOUT SCRAM	LOSS OF FEED WATER	LOSS OF COOLANT ACCIDENT	STEAM GENERATOR TUBE RUPTURE	STEAM LINE BREAK	LOSS OF FORCED REACTOR COOLANT FLOW
RCS INVENTORY CONTROL (Cont'd)							
2. A PRESSURIZER LEVEL IS INDICATED	X	X	X	X	X	X	X
3. ONE STEAM GENERATOR HAS AN INDICATED LEVEL AND IS REMOVING HEAT FROM THE RCS	X	X	X	X	X	X	X
C. IF 20°F + [INACCURACIES] OF SUBCOOLING (REFER TO FIGURE 2) CANNOT BE MAINTAINED AFTER THE SIS HAS BEEN STOPPED, THE HPSI SYSTEM MUST BE RESTARTED	X	X	X	X	X	X	X
RCS PRESSURE CONTROL							
1. VERIFY THAT THE PPCS IS AUTOMATICALLY RESTORING RCS PRESSURE	X	X	X	X	X	X	X
2. IF NECESSARY, MANUALLY CONTROL HEATERS OR SPRAY TO RESTORE PRESSURIZER PRESSURE	X	X	X	X	X	X	X
3. MAINTAIN RCS PRESSURE CONTROL USING THE SIS A. IF PRESSURIZER PRESSURE FALLS BELOW [1600 PSIA], VERIFY INITIATION OF SAFETY INJECTION. IF NECESSARY, MANUALLY INITIATE SAFETY INJECTION	X	X	X	X	X	X	
B. IF THE SIS IS OPERATING, IT MAY BE STOPPED IF THE FOLLOWING CONDITIONS ARE SATISFIED: 1. RCS HOT AND COLD LEG TEMPERATURES ARE AT LEAST 20°F + [INACCURACIES] BELOW SATURATION TEMPERATURE FOR PRESSURIZER PRESSURE (REFER TO FIGURE 1)	X	X	X	X	X	X	
2. A PRESSURIZER LEVEL IS INDICATED	X	X	X	X	X	X	
3. ONE STEAM GENERATOR HAS AN INDICATED LEVEL AND IS REMOVING HEAT FROM THE RCS	X	X	X	X	X	X	
C. IF 20°F + [INACCURACIES] OF SUBCOOLING (REFER TO FIGURE 1) CANNOT BE MAINTAINED AFTER THE SIS HAS BEEN STOPPED, THE HPSI SYSTEM MUST BE RESTARTED	X	X	X	X	X	X	
4. [IF RCS PRESSURE IS BELOW 2400 PSIA, VERIFY THAT THE PROVS HAVE RESTARTED. IF NECESSARY, ISOLATE THE PROVS OR SHUT THE PROV BLOCK VALVES]	X	X	X	X			

TABLE 6.4-1- SUMMARY OF ACTIONS TO ASSURE ADEQUATE CORE COOLING

	REACTOR TRIP	ANTICIPATED TRANSIENT WITHOUT SCRAM	LOSS OF FEED WATER	LOSS OF COOLANT ACCIDENT	STEAM GENERATOR TUBE RUPTURE	STEAM LINE BREAK	LOSS OF FORCED REACTOR COOLANT FLOW
RCS HEAT REMOVAL MAINTAIN STEAM GENERATOR INVENTORY 1. VERIFY THAT THE MAIN OR AUXILIARY FEEDWATER SYSTEM IS RESTORING OR MAINTAINING STEAM GENERATOR LEVEL	x	x	x	x	x	x	x
2. IF ALL FEEDWATER (MAIN AND AUXILIARY) IS LOST, CONDUCT THE FOLLOWING ACTIVITIES:			x				
A. REDUCE THE NUMBER OF OPERATING RCP'S TO ONE PER LOOP TO MINIMIZE HEAT INPUT INTO THE RCS			x				
B. SECURE STEAM GENERATOR BLOWDOWN, SECONDARY SAMPLING AND ANY NON-VITAL STEAM DISCHARGE			x				
C. TAKE ACTIONS TO REGAIN MAIN OR AUXILIARY FEEDWATER SYSTEM OPERATION			x				
D. [IF OTHER SOURCES OF WATER ARE AVAILABLE FOR STEAM GENERATOR HEAT REMOVAL, INSERT THAT INFORMATION HERE]			x				
MAINTAIN RCS FLOW 1. MAINTAIN FORCES CIRCULATION IF POSSIBLE	x	x	x	x	x	x	
A. IF PRESSURIZER PRESSURE DECREASED TO [1300 PSIA] FOLLOWING AN SIAS, STOP ALL REACTOR COOLANT PUMPS	x	x	x	x	x	x	
B. IF THE RCPS WERE STOPPED, ONE RCP IN EACH LOOP MAY BE RESTARTED IF THE FOLLOWING CRITERIA ARE SATISFIED:	x	x	x	x	x	x	x
1. AT LEAST ONE STEAM GENERATOR IS REMOVING HEAT FROM THE RCS	x	x	x	x	x	x	x
2. PRESSURIZER LEVEL AND PRESSURE ARE RESPONDING NORMALLY TO THE PRESSURIZER LEVEL AND PRESSURE CONTROL SYSTEMS	x	x	x	x	x	x	x
3. THE RCS IS AT LEAST 20°F + [INACCURACIES] SUBCOOLED (REFER TO FIGURE 2)	x	x	x	x	x	x	x
4. [OTHER CRITERIA SATISFIED PER RCP OPERATING INSTRUCTIONS]	x	x	x	x	x	x	x
2. IF ALL RCP'S ARE STOPPED, VERIFY THAT NATURAL CIRCULATION IS ACCOMPLISHED PER THE LOSS OF FORCED REACTOR COOLANT FLOW GUIDELINES CONCURRENTLY WITH THIS GUIDELINE	x	x	x	x	x	x	x

TABLE 6.4-1- SUMMARY OF ACTIONS TO ASSURE ADEQUATE CORE COOLING

RCS HEAT REMOVAL (Cont'd)	REACTOR TRIP	ANTICIPATED TRANSIENT WITHOUT SCRAM	LOSS OF FEED WATER	LOSS OF COOLANT ACCIDENT	STEAM GENERATOR TUBE RUPTURE	STEAM LINE BREAK	LOSS OF FORCED REACTOR COOLANT FLOW
OTHER HEAT REMOVAL ACTIONS							
1. COMMENCE A RAPID CONTROLLED PLANT COOLDOWN AS SOON AS POSSIBLE VIA THE STEAM GENERATORS. CONTINUE FEEDING THE STEAM GENERATORS WITH MAIN OR AUXILIARY FEEDWATER AND DISCHARGE STEAM TO THE CONDENSER OR ATMOSPHERE TO REDUCE RCS PRESSURE TO INCREASE SIS FLOW				X			
2. MAINTAIN SIS FLOW TO MAINTAIN RCS HOT AND COLD LEG TEMPERATURE AT LEAST 20°F + [INACCURACIES] BELOW SATURATION TEMPERATURE	X	X	X	X	X	X	X
3. [OPEN THE PORVS AND ACTUATE THE HPSI PUMPS ALIGNED TO COLD LEGS]			X				
4. [IF OTHER METHODS ARE AVAILABLE FOR HEAT REMOVAL FROM THE RCS, INSERT THAT INFORMATION HERE]			X				