CEN - 156

COMBUSTION ENGINEERING EMERGENCY PROCEDURE GUIDELINES DEVELOPMENT

Prepared for the C-E OWNERS GROUP

NUCLEAR POWER SYSTEMS DIVISION
June, 1981

POWER SYSTEMS
COMBUSTION ENGINEERING, INC.

8107020442

LEGAL NOTICE

THIS REPORT WAS PREPARED AS AN ACCOUNT OF WORK SPONSORED BY COMBUSTION ENGINEERING, INC. NEITHER COMBUSTION ENGINEERING NOR ANY PERSON ACTING ON ITS BEHALF:

A. MAKES ANY WARRANTY OR REPRESENTATION, EXPRESS OR IMPLIED INCLUDING THE WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY, WITH RESPECT TO THE ACCURACY, COMPLETENESS, OR USEFULNESS OF THE INFORMATION CONTAINED IN THIS REPORT, OR THAT THE USE OF ANY INFORMATION, APPARATUS, METHOD, OR PROCESS DISCLOSED IN THIS REPORT MAY NOT INFRINGE PRIVATELY OWNED RIGHTS; OR '

B. ASSUMES ANY LIABILITIES WITH RESPECT TO THE USE OF, OR FOR DAMAGES RESULTING FROM THE USE OF, ANY INFORMATION, APPARATUS, METHOD OR PROCESS DISCLOSED IN THIS REPORT.

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 are contained in report CEN-152. Combustion Engineering Emergency Procedure Guidelines. This report describes the development effort that went into the preparation of those guidelines.

TABLE OF CONTENTS

TABLE UF CONTENTS (cont.)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (cont.)

LIST OF REFERENCES

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 of Report

The purpose of this report is to describe the methodology used in preparing the C-E Emergency Procedure Guidelines. This report has been written in response to NUREG-0737, "Guidance for the Evaluation and Development of Procedures for Transients and Accidents", Item I.C.1. Item I.C.1 requires that emergency procedure guidelines be revised to improve the technical content and to expand the scope of multiple failures addressed. Also required is information on the emergency procedure guidelines format and content development. It is this type of information that is contained in this report.

In the early stages of C-E's response to Item I.C.1, several essential characteristics that emergency procedure guidelines must manifest were identified. Most importantly, emergency guidelines must present high quality technical information clearly and concisely if they are to be of use in preparing plant specific operating procedures. Extensive efforts were made to identify the overall requirements of the guidelines, to tailor a product to meet the requirements, and to develop a process for channeling large amounts of information into the guidelines. Judgements were made on the quality of information belonging in the guidelines. The way it is arranged and the manner in which it is most effectively presented are somewhat subjective. This report has been developed to explain the process employed and the information considered in preparing C-E's Emergency Procedure Guidelines.

The process of developing the guidelines can be viewed as several tasks. One task involves the development of improved technical information for inclusion in the guidelines. Realistic plant analyses, combined with existing design and licensing analyses, were employed to upgrade the existing technical content. NSSS vendor-utility workshops were held so that participants could take part in expanding the scope and quality of technical information in the guidelines. The second task involves improving the vehicle that carries the technical information to the operator. This task encompassed understanding the role of the operator, evaluating existing procedures, considering the capability of the physical plant, and obtaining human factors consultation. This information, together with the information available from other industry studies concerning operations and operational guidance (References 1 thru 8), was used to establish ground rules for the development of the emergency procedure guidelines. The final task involves using these ground rules, along with the improved quality and scope of technical information ascertained, to prepare the revised C-E Emergency Procedure Guidelines.

1.2 Report Organization

Included in this report in Section 2.0 is a description of the Item I.C.1 requirements for emergency procedure guidelines.

A summarization of the emergency procedure guideline system is found in Section 3.0. This section includes a general description of how each guideline is intended to function within C-E's guideline system.

In Section 4.0, the information which was used to develop the format and content of the guidelines is presented.

A description of the process of expanding the technical information is presented in Section 5.0.

Section 6.0 provides information relating to the preparation and evaluation of the emergency procedure guideline system. The ground rules for guideline preparation are presented. The purpose of each of the guidelines' sections is detailed. An evaluation of C-E's compliance to NUREG-0737, Item I.C.1 requirements is provided.

The revised emergency procedure guidelines are being provided by a separate report entitled "Combustion Engineering Emergency Procedure Guidelines", CEN-152.

1.3 Relationship to Previous Work

Four significant topical reports provide the basis for the work presented in this report. These include: CEN-114 (Reference 1.13)
CEN-115 (Reference 1.14)
CEN-117 (Reference 1.15)
CEN-128 (Reference 1.2)

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 principle 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 concerning 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 being provided in CEN-152.

SECTION 1 REFERENCES

1.1 NUREG-0737, "Clarification of TMI Action Plant Requirements", November 1980

1.2 CEN-128, "Response of Combustion Engineering Nuclear Steam Supply System to Transients and Accidents", Combustion Engineering, April 1980

1.3 NUREG-0578, "TMI-2 Lessons Learned Task Force Status Report and Short-Term Recommendations", July 1979

1.4 "Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications", Sandia Laboratories, March 1980

1.5 "Human Factors Evaluation of Control Room Design and Operator Performance at Three Mile Island-2", Essex, January 1980

1.6 "Human Factors Review of Nuclear Power Plant Control Room Design", Lockheed, November 1976

1.7 "The Response of the President's Commission on the Accident at Three Mile Island", Kemeny, 1979

1.8 "Three Mile Island, A Report to the Commissioners and to the Public", Rogoven

1.9 W. R. Corcoran, et al, "The Operator's Role and Safety Functions", 1980

1.10 W. R. Corcoran, et al, "The Critical Safety Functions and Plant Operation", October 1980

1.11 U. S. N.R.C., "TMI-2 Lessons Learned Task Force Status Report and Short-Term Recommendations", NUREG-0578, July 1979

1.12 CEN-152, "Combustion Engineering Emergency Procedure Guidelines", 1981

1.13 CEN-114-NP, "Review of Small Break Transients in Combustion Engineering Nuclear Steam Supply Systems", Combustion Engineering, July 1979

1.14 CEN-115-NP, "Response to NRC I&E Bulletin 79-06C, Items 2 and 3, for Combustion Engineering Nuclear Steam Supply Systems", Combustion Engineering, August 1979

1.15 CEN-117, "Inadequate Core Cooling - A Response to NRC I&E Bulletin 79-06C, Item 5 for Combustion Engineering Nuclear Steam Supply Systems", Combustion Engineering, October 1979

2.0 Summary of NUREG-0737 Item I.C.1 Requirements

The objective of an emergency procedure guideline is to make available to the utilities high quality, complete, operational information for incorporation into the utilities' emergency procedure system. Since the format that is used to present this operational information effects the efficiency of information transfer and use, attention is paid to the design of the framework that will relay the operational information.

In Item I.C.1 of NUREG-0737, the NRC requires that multiple failures and operator errors which take the plant beyond its traditional design basis envelope be addressed in the emergency procedure guidelines. Identification of alternate success paths and expanded operational information is required. Furthermore, Item I.C.1 requires a description of the methodology used to develop the emergency procedure guidelines.

A summary of Item I.C.1 requirements for emergency procedure guidelines is presented below:

a) Include the loss of instrumentation and natural phenomena in initiating events;
b) Consider multiple failures (including operator errors), such as:
   - multiple tube ruptures in a single steam generator and a simultaneous tube rupture in more than one steam generator;
   - the failure of main and auxiliary feedwater;
   - the failure of high pressure reactor coolant makeup system;
   - an anticipated transient without SCRAM (ATWS) event following a loss of offsite power, a stuck open relief valve or safety/relief valve, or a loss of main feedwater;
   - operator errors of omission or commission;
c) Address corrective or alternative actions in the event of failures (i.e., alternate success paths);
d) Provide guidance on ICC, including the instrumentation used to detect ICC;
e) Justify the approach used in developing diagnostic guidance;

f) Provide the detailed methodology used to develop the guidelines.

Satisfying the requirements listed above was the major objective of the emergency procedure development effort. These NRC requirements were expanded during the emergency procedure guideline development process. The expanded listing is found in Section 6.0 along with an evaluation of the revised emergency procedures guidelines.

3.0 The Emergency Procedure Guidelines System

The C-E Emergency Procedure Guidelines are a collection of operational information to be used as a basis by the utilities in developing more detailed emergency procedures. Operational information is defined as that information needed by the operator to detect any out of specification plant conditions that would necessitate corrective operator actions to bring the NSSS to a safe shutdown condition. This section provides a summary description of the C-E Emergency Procedure Guideline System. Also provided is a brief overview of guideline development. Detailed discussions on these subjects are presented later in the report.

3.1 Summary Description

The C-E Emergency Procedure Guideline System is summarized in Figure 3.1-1.

Figure 3.1-1
EMERGENCY PROCEDURE GUIDELINE SYSTEM

EVENTED ORIENTED	FUNCTION ORIENTED
EVENT GUIDELINES	**ICC GUIDANCE PACKAGE**
REACTIVITY CONTROL	REACTIVITY CONTROL
REACTOR TRIP	STATUS AND TRENDING DIAGNOSTIC
ATWS	RCS HEAT REMOVAL
RCS HEAT REMOVAL	STATUS AND TRENDING DIAGNOSTIC
LOSS OF FEED	PRESSURE AND INVENTORY CONTROL
LOSS OF FORCED REACTOR COOLANT FLOW	STATUS AND TRENDING DIAGNOSTIC
STEAM LINE BREAK	MATRIX OF ACTIONS AS FOUND IN EPG'S
PRESSURE AND INVENTORY CONTROL	
LOCA	
STEAM GENERATOR TUBE RUPTURE	

EMERGENCY PROCEDURE GUIDELINES SYSTEM SUMMARY DESCRIPTION

Two major components of the C-E Emergency Procedure Guideline System are shown. These components can be viewed as follows:

The event guidelines are on the left. Their function is to efficiently present operational information for those wide range of events that are recognized and comprehended by the operator. These event guidelines contain the corrective responses appropriate for both known events and/or a loss of functions. Furthermore, the grouping of these event guidelines under major function categories is done for ease of access to the corrective responses when an event is unknown.

Shown on the right of Figure 3.1-1 is the ICC Guidance package. This package plays a major role in situations when the operator does not understand the event, and therefore, must implement responses based on a loss of functions.

Summary outlines of the ICC Guidance Package and the Event Guidelines are provided below in Figures 3.1-2 and 3.1-3 respectively.

SUMMARY OUTLINE OF ICC GUIDANCE PACKAGE	
Plant Status and Trending Diagnostic . . .	various normal and accident methods for controlling RCS reactivity, heat removal and inventory and pressure. Parameters that identify the status of each function and a definition of the acceptable performance and trending for each function are provided.
Actions to Promote Adequate Core Cooling . .	a matrix of corrective responses associated with each loss of safety function. Also provided is a key to the location of these responses in the procedure guidelines.

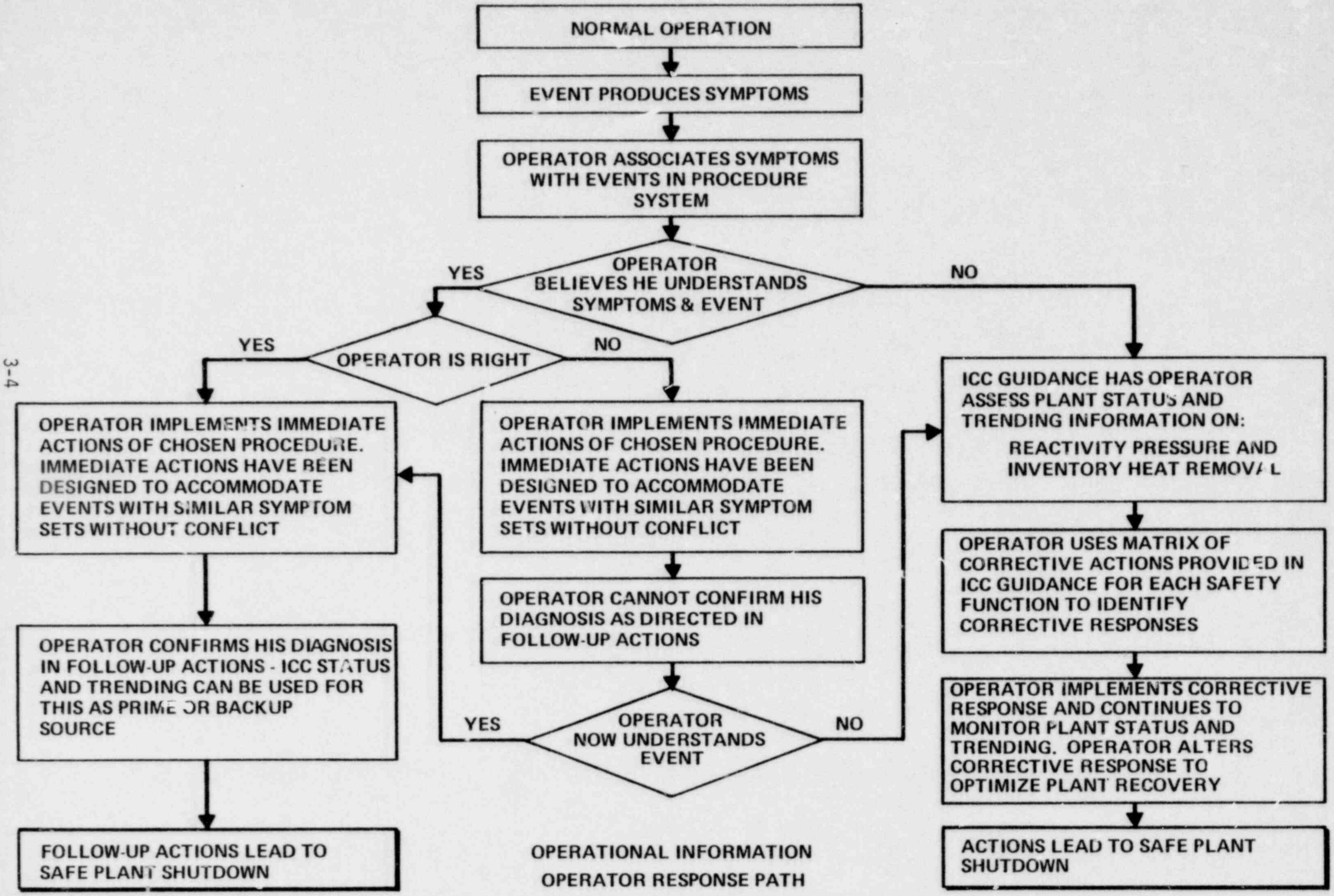
Figure 3.1-2 ICC Guidance Format Summary

SUMMARY OUTLINE OF EVENT GUIDELINES	
Bases	. overview of the event provided in a descriptive format, which gives the reasons for, and the consequences of, those procedural steps which follow.
Symptoms.	. "signposts" that aid an operator in choosing an appropriate course of action.
Immediate Actions . . .	. actions which must be executed in the short-term (i.e., within three minutes) that address the safety functions associated with the symptoms.
Follow-up Actions . . .	. actions necessary to meet the requirements of the safety functions in the long-term; including the requirement to reconfirm the diagnosis of the event.
Precautions	. actions or situations which should be taken, or avoided, during the mitigation of an event in order to ensure that the plant and its systems operate in an acceptable way.

Figure 3.1-3 Emergency Procedure Guidelines Format Summary

Shown in Figure 3.1-4 is a flowpath showing the possible operator response using the C-E Emergency Procedure Guideline System.

Figure 3.1-4



OPERATIONAL INFORMATION
OPERATOR RESPONSE PATH

The operator is activated to implement the emergency procedure guideline(s) by symptoms indicated in the control room. The operator has two paths for implementing the operational guidance.

The first path is to match symptom sets seen in the control room with symptom sets provided in the emergency procedure guidelines. If this path is taken, the operator proceeds with implementing actions of the event guideline(s) he is led to. The guidelines have been constructed so that the immediate actions in each guideline address all critical safety functions appropriate to the activating symptom set. In other words, if the operator has misdiagnosed events due to a similarity in symptoms, the immediate actions he takes are not different from those prescribed in the correct procedure. (Followup actions do require that the initial diagnosis be re-confirmed so the appropriate operational guidance can be implemented.)

The second path to implement the emergency procedure guideline(s) is via the functionally oriented status and trending diagnostic found in the ICC Guidance package. This diagnostic is intended to be used as an alternate path for implementation of the guidelines in the event that the plant status is difficult to understand or when the initial diagnostic path has failed to induce the correct plant response.

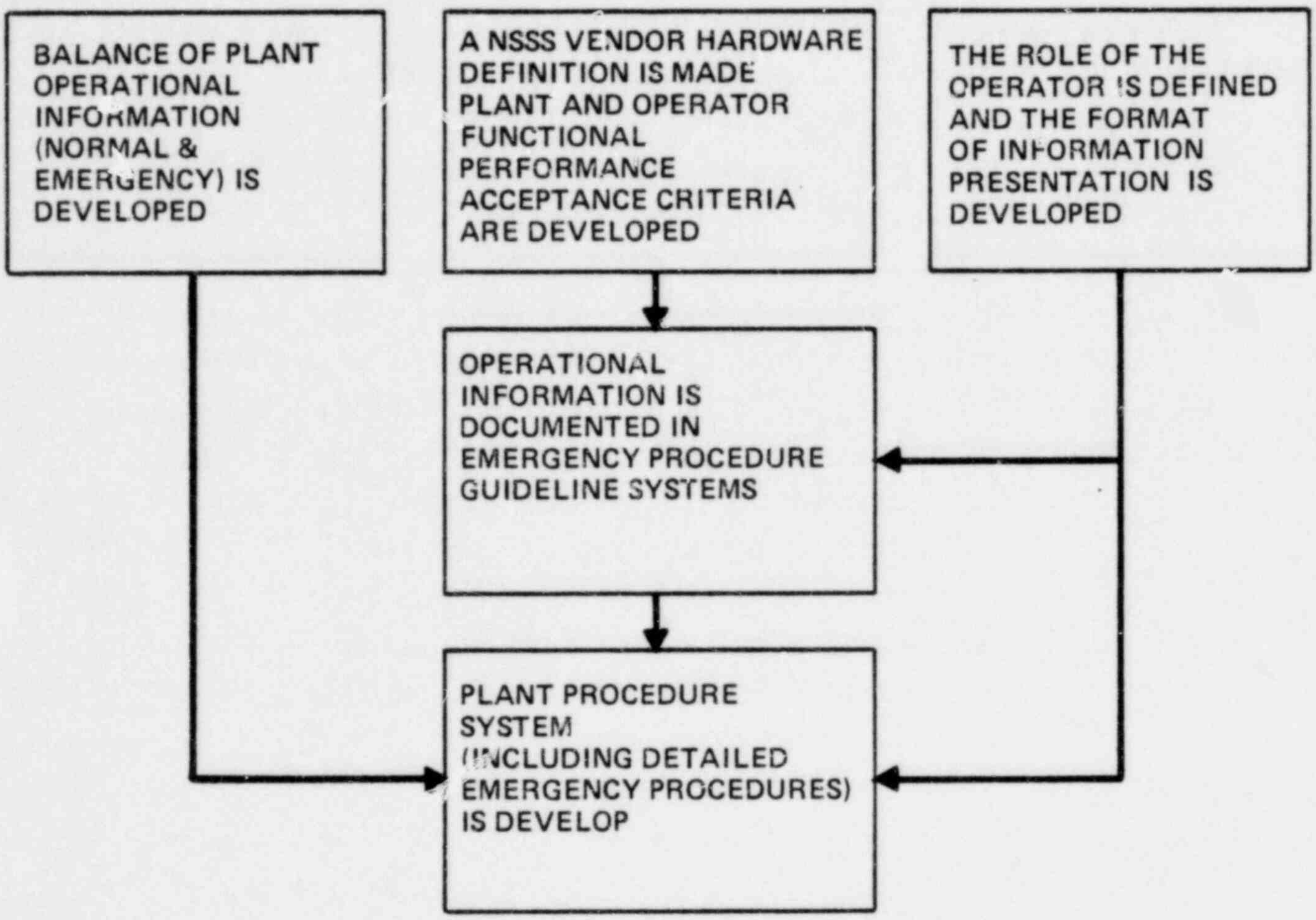
The scope of the emergency procedure guidelines was derived from utility and vendor judgements. A scope which addresses the loss of reactivity, RCS heat removal, and pressure and inventory control is required. Events that are realistic and recognizable are included. Events that result in high threat to the plant or, if left unattended result in high threat, are included. Other factors, such as the rate of the event's progression, the challenge to operator, and the challenge to safety systems are also considered in determining scope.

A factor that influences the choice of event categories is the design of the guideline system. The Reactor Trip Guideline is included, not because a reactor trip is, in itself, an emergency event. It is included because it is associated with and referenced by all the emergency procedure guidelines. Furthermore, it provides the majority of the operational information on reactivity control.

3.2 Simplified Development and Use of Emergency Procedure Guidelines

Figure 3.2-1 below, indicates a simplified flow path for the development and use of the emergency procedure guidelines.

Figure 3.2-1



DEVELOPMENT AND USE OF EMERGENCY PROCEDURE GUIDELINES

Figure 3.2-1 presents two messages. The first is that the emergency procedure guidelines are one of many inputs to the development of the utilities procedures. Secondly, the usage of the emergency procedure guidelines is influenced by both the technical information they contain and the design of the format that delivers it.

4.0 Format and Content Development Information

This section provides a description of the information used to develop the format and content of the guidelines. Section 4.0 contains the following:

- 4.1 A description of a typical plant procedure system is provided in this section.
- 4.2 The results and recommendations of a survey of plant procedures is provided in this section.
- 4.3 Information obtained from operator interviews is provided in this section.
- 4.4 The development of the procedure diagnostic is included in this section.
- 4.5 The manner in which inadequate core cooling is addressed in the C-E Emergency Procedure Guideline System is provided in this section.
- 4.6 A discussion of the Event-Function orientation of the guidelines is provided in this section.

4.1 The Procedure System

Part of the effort to improve the operational information contained in the guidelines includes understanding the procedure system. The improvement of procedure guidelines, which are an input to the utilities' procedure system, requires an understanding of the types of procedures that exist, when they are used, and how they are used. A description of the procedure system follows.

Operational guidance for a nuclear power plant is provided by written procedures; typically grouped as emergency procedures, normal procedures, administrative procedures, etc. Many types of procedures may be utilized simultaneously in the different combinations appropriate for any plant condition. It is important to acknowledge and understand the procedures system in order to produce emergency procedure guidelines that fit into the system.

Within the procedure system there is a hierarchy. Procedures with the broadest plant involvement take priority. Emergency procedures, when implemented, take priority over all others. Figure 4.1-1 illustrates the hierarchy for an example set of procedures. At any one time, several of these procedures could be used. For example, after a reactor trip, the Reactor Trip, Plant Cooldown, Main Turbine Generator, and Tag Out procedures could all be simultaneously involved in plant operations.

Figure 4.1-1

THE PROCEDURE SYSTEM
HIERARCHY OF PROCEDURES

EMERGENCY PROCEDURES	REACTOR TRIP	LOSS OF FEED	LOSS OF COOLANT
ABNORMAL PROCEDURES	PRESSURIZER PRESSURE CONTROL SYSTEM ABNORMALITY	CEA DROP	EXCESS FEEDWATER FLOW
NORMAL PLANT PROCEDURES	SHUTDOWN TO HOT STANDBY	COOLDOWN TO COLD SHUTDOWN	STARTUP TO HOT STANDBY
SYSTEM PROCEDURES	OPERATION OF SHUTDOWN COOLING SYSTEM	OPERATION OF COMPONENT COOLING WATER SYSTEM	
COMPONENT PROCEDURES	MAIN TURBINE GENERATOR	LPSI PUMP	
ADMINISTRATIVE PROCEDURES	TAG OUT	SHIFT RELIEF	LOGS
MAINTENANCE PROCEDURES	CCW PUMP REPAIR	RPS ALIGNMENT	AFW CONTROL VALVE REPAIR

4.2 Survey of Existing Procedures

As part of the guideline development effort, it was considered pertinant to determine the content of existing procedures. Using a systematic approach, a set of emergency procedures was analyzed to determine the extent that safety functions were addressed, the procedural inter-relationships, the format used, and the editorial consistency. A description of the survey and examples of the results are presented below.

Each statement in the immediate and follow-up actions sections was analyzed to determine which safety function had been addressed by the required actions. Each procedure was analyzed to determine whether it included actions for specific safety functions. Table 4.2-1 presents a listing of safety functions identified by the survey. (Note that the categorization of functions is subjective. The functions used in Table 4.2-1 were chosen to facilitate the survey, but other groupings of functions are possible.) Table 4.2-1 also includes an approximate count of the number of times the safety function was addressed in the set of procedures reviewed.

Procedural relationships were examined using a flow chart constructed to illustrate the various paths that could be followed in a procedure. The purpose was to determine if the operator could be directed to another procedure before all the safety functions are verified, or if the procedure contains "loops" where the user is directed from one procedure to another and back again. Figure 4.2-1 is the flow chart for a typical turbine trip procedure.

Format and editorial consistency were also checked. The purpose was to evaluate the conciseness of statements, the potential for confusion, the consistency of language, and the level of detail.

The survey identified areas where procedures are deficient. Some of the major ones are:

1. In several cases, it was discovered that important safety function statements were not included. Figure 4.2-2 depicts one such case.
2. Similar statements are not always presented at a consistent level of detail. This is a potential source of confusion for the operator. Figure 4.2-3 provides an illustration.

3. Some statements are in such detail that they could be a separate procedure. A sample is provided in Figure 4.2-4.
4. The symptoms were not always prioritized. In some cases, improbable symptoms were included.
5. The immediate actions section occasionally contained information that was too long and of a supplementary nature, and should have been included in the follow-up actions section. The operator is required to memorize immediate actions. It is doubtful that this is possible for some of the emergency procedures reviewed.
6. There were excessive branching and cross-referencing of procedures (See Figure 4.2-1). While this may be beneficial in enhancing procedure continuity, it should be minimized in the immediate actions section.

It was concluded that existing procedures can be substantially improved to make them less confusing and more complete. The following conclusions were reached:

1. Retain the basic format of symptoms, immediate actions, follow-up actions, and precautions, and add a bases section to provide supplemental information that should not appear in the operative portions of the procedure. The bases section should provide:
   a) plant conditions for which the procedure is applicable, and the symptoms necessary to allow operator recognition;
   b) a synopsis of the event and the anticipated plant response;
   c) the safety functions associated with the event;
   d) sufficient information for the operator to understand the event and the intent of the actions within the procedure.
2. Provide guidance for each safety function in at least one procedure and reference it in others where appropriate.
3. Present symptoms in an order that reflects their importance to the event.
4. Symptoms should include key parameters, which may be <u>non-changing</u>, to aid in event recognition.
5. Actions should be prioritized.
6. Where practicable, referencing should be used to direct the operator to detailed information in other procedures not explicitly contained in the original procedure. When other procedures are referenced, it should be done to avoid "loops".

Table 4.2-1

FUNCTION ANALYSIS KEY

Function		No. of Times Addressed
1	Reactivity Control	12
2	Control Secondary Heat Removal	20
3	Equipment Protection	25
4	Emergency Power	12
5	Inventory Control	12
6	Diagnose Event	14
7	Control Primary Heat Removal	10
8	Pressure Control	2
9	Administrative	18
10	Containment Heat Removal	1
11	Containment Integrity	1

Figure 4.2-1

ANALYSIS OF BRANCHING FOR TURBINE TRIP PROCEDURE

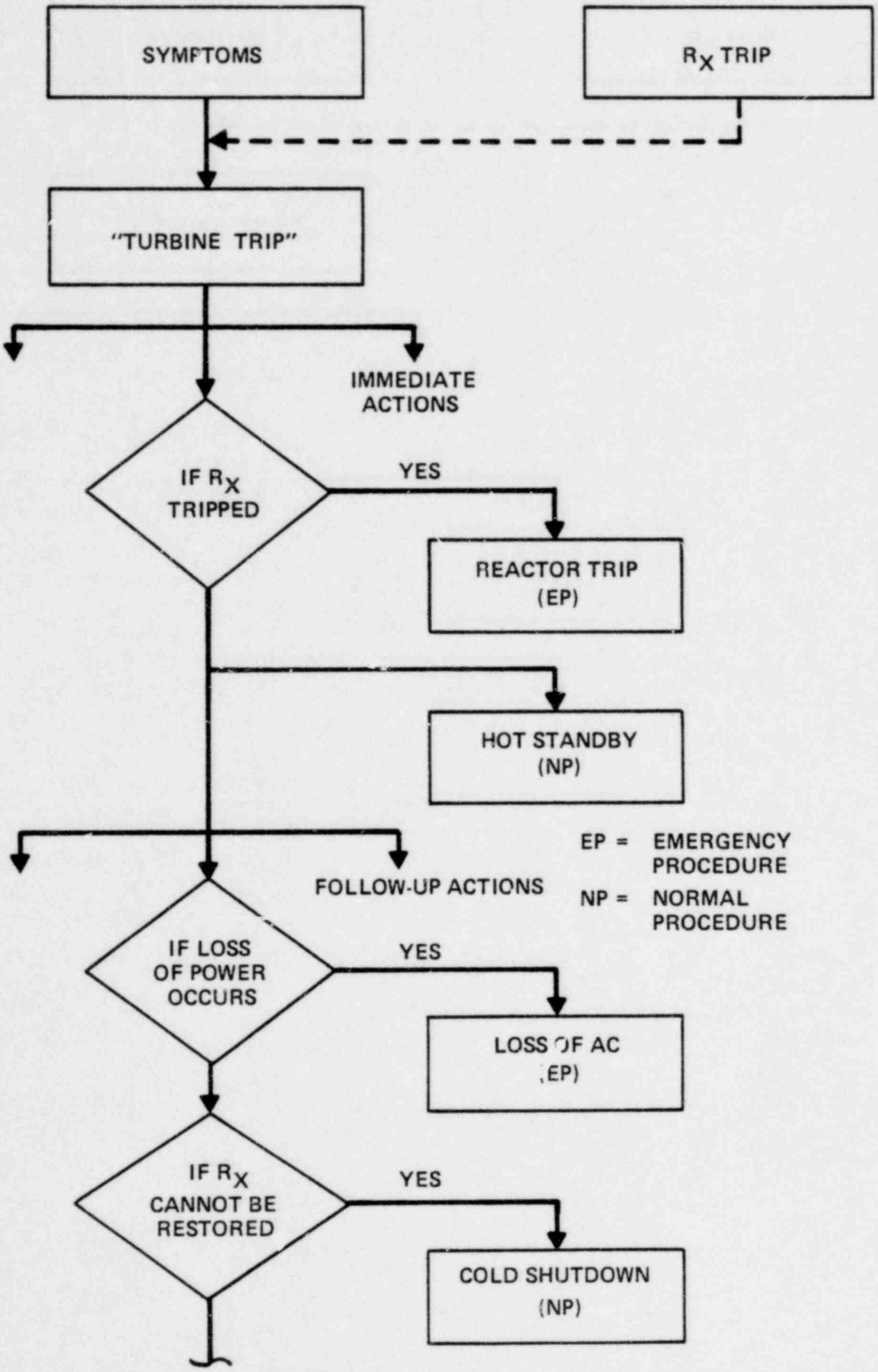


Figure 4.2-2

Example of Lack of Properly Addressing Safety Functions

PRESSURE CONTROL STATEMENTS

REACTOR TRIP	If necessary, use manual control of the pressurizer heaters and/or spray to maintain primary system pressure at 2250 psia
TURBINE TRIP	* NONE
LOSS OF REACTOR COOLANT FLOW	* NONE
LOSS OF COOLANT ACCIDENT	Secure letdown and commence charging at the maximum possible rate.
STEAM LINE RUPTURE	* NONE

* EXAMPLE OF CASE WHERE IMPORTANT FUNCTION STATEMENTS HAVE BEEN OMITTED

Figure 4.2-3
Example of Unnecessary, Redundant Statements

REACTOR TRIP	*2.3 Depress the turbine trip pushbutton at the main control room panel and verify that the turbine has tripped. 2.3.1 Ensure that the following turbine valves are closed: - Main Stop Valves - Control Valves - Intercept Valves - Intermediate Stop Valves - Reheat Steam Source Valves - Reheat Check Valves 2.3.2 Verify that the 230KV generator output breakers have tripped by observing the proper breaker status. 2.4 Verify transfer of the 4.36KV and 6.9KV buses from the unit auxiliary.
TURBINE TRIP	2.2 Depress the turbine trip pushbutton at the main control room panel, verify that the turbine tripped, and ensure that the 4.36KV and 6.9KV buses transferred from the unit auxiliary transformers to the reserve auxiliary transformers by observing the proper breaker. 2.4 Ensure that the following turbine valves are closed: - Main Stop Valves - Control Valves - Intercept Valves - Intermediate Stop Valves - Reheat Steam Source Valves - Reheat Check Valves 2.5 Verify that 230KV generator output breakers have tripped.
LOSS OF REACTOR COOLANT FLOW	NONE
LOSS OF COOLANT	*2.4 Verify turbine tripped and all turbine stop and intercept valves shut. Verify generator output breakers open.
STEAMLINE RUPTURE	2.1 Immediate Automatic Actions 2.1.2 Turbine Trip

* Example of unnecessary, redundant statements. Reference should be made to Turbine Trip Porcedure.

Figure 4.2-4

Example of Excessive Detail Within a Procedure

2.2.1 125 VDC ±05V

2.2.2 Battery current

2.2.3 D-C bus undervoltage alarm-clear

2.3 Investigate why standby diesel generators have not automatically started up and energized the vital 4.16 KV busses, 2A04 and 2A06.

2.4 If standby diesel generators will not start, attempt to restore power to 4.16KV busses 2A04 and 2A06 from a convenient Reserve Auxiliary Transformer.

2.5 If power can be restored to the 4.16KV system via the Reserve Auxiliary Transformers, refer to Degraded power Emergency Guideline, SO-EP-24.

2.6 If electrical power cannot be restored to the RCPs within about 10 minutes, verify core thermal circulation flow. A typical value for T power indication for a trip from 50% would be about 35% in 10 minutes after trip gradually decreasing to about 20% in 130 minutes.

NOTE: T power indication is measuring power to flow ratio.

2.6.1 If T power indication approaches zero, dump steam or put feedwater into generator to re-establish thermal circulation.

2.7 Verify steam dumping when T_{avg} or steam generator pressure exceeds steam dump and bypass setpoints (about 545^{O}F and 1000 psi).

2.7.1 Sound of steam excaping through atmospheric dump valves.

2.7.2 Steam flow indication.

2.7.3 T_{avg} not increasing above setpoint.

2.7.4 Take manual control of atmospheric dump valves if air system is lost.

2.8 Startup steam driven auxiliary feed pump and maintain visible water level. Intermittently, as required, startup system to maintain level between 50 to 75%.

VERIFICATION OF NATURAL CIRCULATION

4.3 Operator Interviews

An understanding of the operator and his attitudes toward emergency procedures is essential to produce effective emergency guidelines. Such information was gathered from human factor studies (References 4.1 and 4.2), from utility/NSSS vendor workshops, and interviews with the operators from operating plants.

Studies of nuclear plant operators' attitudes toward emergency procedures indicate that a majority of the operators are dissatisfied with existing procedures for a number of reasons. The dissatisfaction, in general, is related to the quality of technical information presented, and the basis for it, rather than the format of the procedure that delivers the information.

Operator interviews were conducted to determine the operators' attitudes and opinions in the following areas:

a) Content of procedures (e.g., should a "bases" section be included?)
b) Control Room indication operators monitor most
c) Level of detail in procedures
d) Procedure action and precaution statements
e) Type of procedures (e.g., event vs. function oriented)

When asked their opinion of a "bases" section being incorporated in the porcedures, the operators said that this could be a valuable tool for training. A "bases" section is included in the C-E generic guidelines.

The operators were questioned about the order of appearance of symptoms in procedures. They believe the symptoms should be grouped by the degree of importance, and in each grouping, arranged in the expected order of appearance. The operators were also asked what indications they monitor most frequently during normal operations. They listed the following:

a) Pressurizer level
b) Pressurizer pressure
c) Pressurizer temperature
d) T_{avg}/T_{ref}

e) Reactor power

f) Steam generator level

g) Steam generator pressure

h) Volume control tank level

The following is typical of what the operators indicated they would monitor following a reactor trip:

a) Rod bottom lights on

b) Negative 80 sec. period on power

c) Turbine trip

d) Turbine generator breakers open

e) Emergency diesel starts

f) Offsite power available

Comparisons of the parameters normally monitored vs. those parameters monitored following specific emergency events were used to develop the symptoms sections of each guideline.

The operators indicated that the "immediate actions" section should contain no "caution" statements, and should not have any branches, loops, or explanatory statements. They thought this section should be a checklist; the essence of which can be readily memorized. They did feel that the "follow-up" actions should be more explicit than the immediate actions, and that precautions could appear in "follow-up" action sections. They commented that at times, the "warning" and "precaution" statements are not placed ahead of the applicable step. This could lead to confusion during an emergency condition. Those interviewed want "caution" statements to appear before the applicable "follow-up" action statement, with those "caution" statements containing a brief explanation, if their purpose is not obvious. The generic guideline "action" and "follow-up" action statements reflect the above opinions with the exception that all "caution" statements were placed in a single section.

The operators interviewed believe the procedures should be oriented toward conciseness and ease of use, rather than trying to cover every foreseeable situation. They believe that the "immediate actions" should be kept short and concise. Since studies have indicated that a majority of operators are dissatisfied with the level of detail presented in the emergency procedures, they were questioned on what was adequate. There is a split in opinion among the operators concerning the amount of detail. Many felt that procedures should be kept in general terms to allow the operator some leeway. Others questioned whether enough detail is provided for the operator to correctly analyze the condition of the plant. In both cases, the operators agreed that more information and fewer instructions would be beneficial. The use of the "bases" section and safety functions concept in the guidelines is chosen to facilitate the presentation of more information and fewer instructions.

4.4 Diagnostics

In the operation of nuclear power plants, the process of diagnosing is performed continuously. Diagnosis can be described as a four step process. The operator first perceives a deviation in a plant condition from an acceptable status. Once this has occurred, the new plant status and trend is analyzed to develop and evaluate potential solutions. Next, a course of actions is decided on. Subsequently, actions are performed and the results monitored to confirm that the plant is returning to an acceptable status.

The process can be further illustrated with a simple example. During the course of a plant operating cycle, fuel is continuously being depleted. To counter the resulting decrease in neutron flux, so as to maintain 100% power, the RCS boron concentration must be periodically adjusted. This diluting of the RCS is an action or process that is anticipated by the operating staff. The indications to the control room operator of this occurrence is a slight decrease in reactor power and RCS temperature. Once the operator becomes aware of, or perceives that reactor power is decreasing or has decreased, he analyzes the new status and trend of the plant and develops and evaluates potential solutions. Since a decrease in reactor power may occur for reasons other than fuel depletion, the whole plant status must be evaluated. Once the operator determines that the reason for decrease in reactor power and temperature is due to normal fuel depletion, a course of action is decided. A boron dilution procedure is implemented. The operator takes the required actions and monitors plant conditions (reactor power and RCS temperature) to confirm that the plant is returning to an acceptable status of 100% power.

In practice, diagnosing the plant status is conditional. One situation occurs when the perturbation in plant conditions is known or understood, as in the example presented above. The other is a situation in which the plant conditions are not understood. In an accident situation, the same diagnostic process is employed. However, as noted earlier, because there is a potential that the operator may not understand the plant conditions, therefore, he may not be able to identify the corrective actions necessary to mitigate the consequences of the emergency event. It is this possible situation that has received the greatest emphasis.

The process described above, that includes alerting an operator to take action and determining what action is appropriate, has historically been the least formalized area of the operational information subject. This section describes efforts conducted to further understand and optimize the diagnostic process. Information relating to the diagnostic process was collected from several sources, including simulator experiments, operator interviews, workshops on the subject, and a review of related literature. The following paragraphs describe the efforts related to each source. Conclusions and improvements to the diagnostic process are presented at the end of this section.

In order to gain information on the diagnostic process, experiments were conducted on the C-E full scale plant simulator using licensed operators. Human Factors expertise from Lund Consulting, Inc. contributed to defining objectives and the necessary experiments. Lund was relied on heavily to conduct the experiments and interpret the resulting data. The experiments were designed to collect information relating to the operators' diagnostic process. The results of the experiments provided information on the present process of diagnosing.

An experiment was developed which would ultimately provide insight into the strengths and weaknesses of the present methods used by operators in their control rooms. As an additional source of information, interviews were conducted with plant operations personnel. Sample of the questions asked during these interviews are provided by Table 4.4-1.

TABLE 4.4-1
Sample Operator Interview Questions

Sample Questions Used During Interviews to Determine
How Operators Diagnose Events and Use Procedures

- Did you clearly understand the instructions of the trainer?
- Did you feel that the simulator environment was similar to that in your control room?
- Did the control board at the simulator provide you with similar cues as compared to your control room?
- Are the procedures provided to you here the same as those used at your plant?
- How do you begin to first understand or diagnose what event was happening?
  a) Was it a single cue?
     Or, was it a series or pattern of cues (symptoms)?
- Did you go to the procedure to help you confirm the symptoms you observed?
  a) Was this after or before you performed the immediate actions?
  b) How did you use the symptoms found in the procedure?
     As a checklist (checked each one)?
     To see if one particular symptom was listed?
- Do you use the procedure before or after you diagnose what the event is?
  a) If before, is that because the first steps of the procedure merely help you to bring the plant to a safe condition and the rest of the procedure helps you diagnose the problem?
  b) If after, do you use the procedure to help confirm your diagnosis?

The information gathered during the experiments and interviews provided useful information on the diagnostic process. Firstly, operators build an overall diagnosis by a series of grouped subsets of information. It is not any single indication or symptom observed by an operator which is important, rather, it is the grouping of symptoms, their sequence, and their change in time which is being constantly considered by the operator. This information is compared by the operator to an internal list of possible events, and is used to "add" or "delete" an event from his list of possible diagnoses.

Secondly, a listing of panels, instruments and the sequence in which they are referred to by each operator demonstrated that intra-individual and inter-individual differences in information gathering exists.

Once the operator has made his diagnosis of the event, he uses an emergency procedure to:

- confirm the diagnosis
- verify that he has completed all immediate actions
- determine subsequent actions

A report on the subject of diagnostics was prepared by Lund Consulting, Inc. (Ref. 4.6)

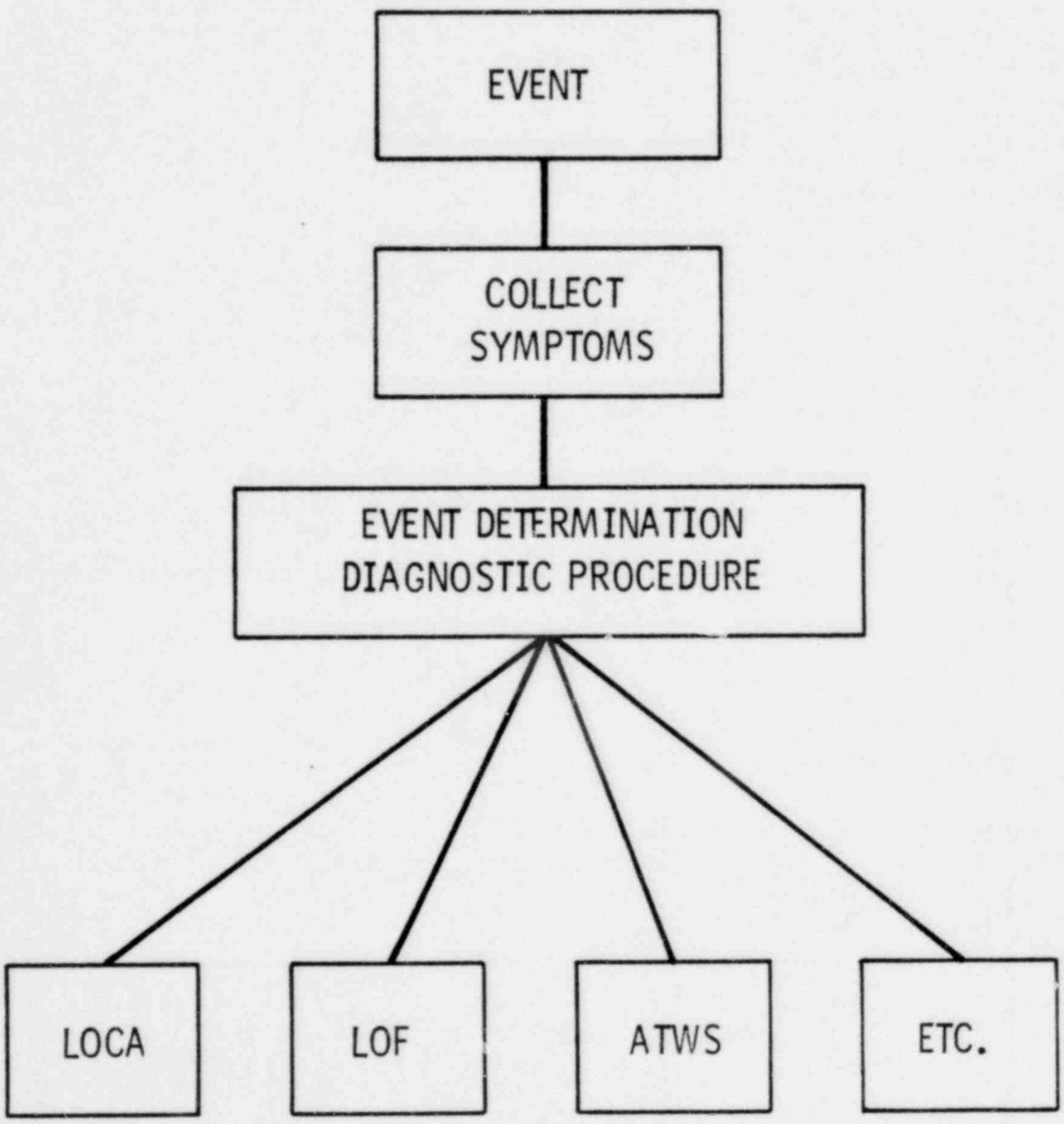
As an additional source of information, a workshop was conducted on the subject of diagnostics. The workshop was held at Combustion Engineering during the month of April, 1981. Operational experts from the utilities and personnel from C-E were in attendance. At the workshop , the simulator experiments and conclusions were reviewed. Results of operator interviews were presented. Operational experiences relating to diagnostics were exchanged.

Several approaches for producing formalized diagnostics were presented.

Figure 4.4-1 illustrates one approach that was evaluated. For this approacn, the diagnostic would determine which event had taken place. This approach, however, was overwhelmingly rejected by the operations personnel.

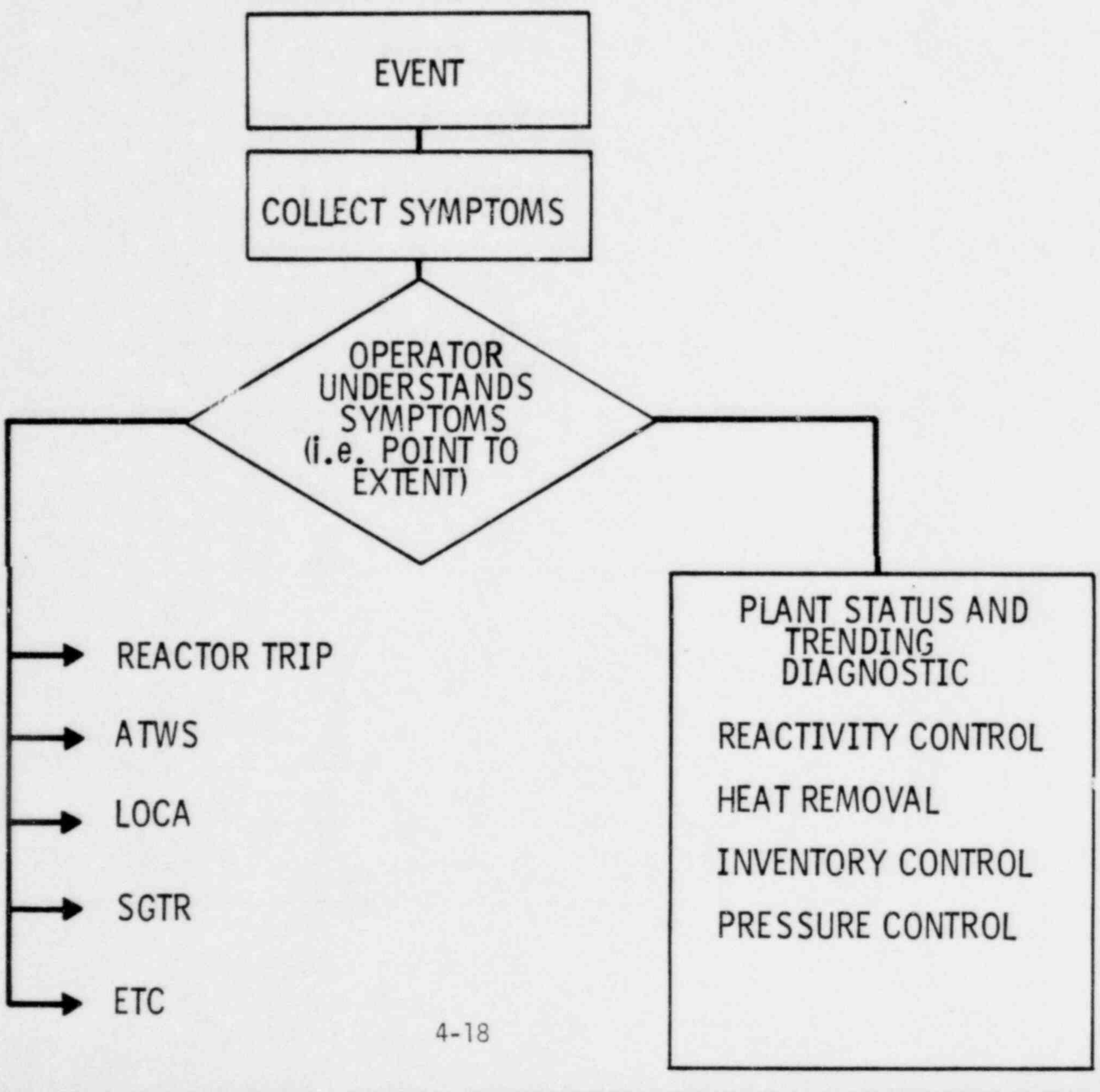
Figure 4.4-1

SAMPLE OF AN EVENT DETERMINATION DIAGNOSTIC FLOWPATH



Another approach that was received favorably was the concept of a plant status and trending diagnostic. A traditional process for event diagnosis is normally used; that is, by matching symptom sets in the control room to symptom sets in the emergency procedure system. However, for the situation where the operator does not understand the symptoms, or if a good fit cannot be found, a functionally oriented plant status and trending diagnostic can be used. The diagnostic and its relation to the procedure system is presented in Figure 4.4-2 below.

Figure 4.4-2
PLANT STATUS AND TRENDING
DIAGNOSTIC FLOWPATH



Another area providing a major contribution to a better understanding of the diagnostic process resulted from a review of subject related literature. References 4.1-4.6 provided additional information on the subject. Major advances have been made in defining the operator's role in the operation of a nuclear power plant and providing information on the concept of safety functions. The concept of safety functions introduces a systematic approach based on a hierarchy of protective actions to mitigate the consequences of an event.

The conclusions below, relating to the diagnostic process, are drawn from the C-E/Lund experiments, related materials, and also from substantial input developed at the C-E/Utility workshops.

Based on the information presented earlier in this section, it can be concluded that a formalized diagnostic can be useful in the safe operation of a nuclear power plant. A diagnostic has been developed which has two general paths. Each path involves defining the status and trending of the plant. The first path can be viewed as a simplified process that is intended to handle the majority of events anticipated. It involves matching those symptom sets seen in the control room to those found in the procedures. If a "good fit" is found, the operator takes actions according to the specific procedure for the event occurring. The diagnostic process continues in a confirmatory role. If a "good fit" is not found, a second path is taken. The second path, normally employed as a backup, or for confirmation, involves defining the plant's status and trending on a functional basis and contrasting this information to benchmarks for acceptable performance. Although the operator does not know what the initial disturbance is, he extracts corrective actions for a loss of functions from the appropriate portion of his procedure system. The C-E Emergency Procedure Guideline System recognizes these alternate diagnostic paths and has included them formally in the system structure.

As a final note, it must be stated that although major advances have been made in understanding the diagnostic process and providing guidance in this area, additional work can be done in this area.

4.5 ICC Guidance

The subject of inadequate core cooling has received much interest since TMI. During the TMI accident, there was a substantial period of time during which the reactor core was inadequately cooled, and the operators failed to take appropriate action to correct the condition. It is generally considered that sufficient instrumentation indications were available to recognize the inadequate core cooling condition, but that the operator training and plant emergency procedures did not prepare the operators to recognize inadequate core cooling and respond properly.

The ICC Guidance package, as found in the guideline system, includes a tutorial on safety functions, a status and trending diagnostic, and table of actions to assure adequate core cooling.

The status and trending diagnostic gives the operator not only the information necessary to identify ICC, but also the trend that the plant is taking in relation to ICC. The status and trending diagnostic gives the information required to identify and deal with ICC. It includes the safety function, the method used in controlling the function, the paramater measured as an indication of the fulfillment of the function, the acceptable value of that parameter needed to fulfill the safety function, the acceptable trend of that parameter, and finally, guidance concerning remedies for ICC. Thus, an operator, by prudent use of the status and trending diagnostic, can methodically question the acceptability of plant parameters with regard to adequate core cooling. An example of the use of this table is provided later in this section.

A table of actions to assure adequate core cooling consists of a checklist of safety functions versus the plant procedures which carry out that function.

It is intended that ICC Guidance material be converted into a utility emergency procedure or instruction that provides an alternate path for diagnosing the plant's status and prompting operator response. As noted in Section 3.1 of this report, the primary diagnostic process is to match symptoms sets seen in the control room to those identified in the emergency procedures. If, for any reason, this is not successfully done, a second process (i.e., the package on ICC Guidance), which draws heavily on the critical function concept, is available. Another role of the ICC Guidance is to confirm the adequacy of the original diagnosis and corrective actions.

Other options for presenting ICC Guidance were considered. One concept resulted in placing the new operator corrective responses, developed since the TMI accident, into one ICC procedure guideline. This was rejected because it was felt that all corrective responses associated with a safety function should be found in the procedure system under the section that addresses that safety function (i.e., the use of PORV's and HPSIP's when faced with total loss of feed should be addressed in the guidance under loss of feed).

The approach to ICC Guidance presented in the C-E Emergency Procedure Guidelines represents a concensus of C-E and utility experts' opinions. The status and trending diagnostic can be used at any time following an accident and is designed to accommodate events including multiple failures. The ICC Guidance also acknowledges the traditional diagnostic process which is a response to symptom sets, while providing an alternate diagnostic process for backup and confirmation.

The ICC Guidance package was developed to aid in the understanding of plant status and trending, independent of detailed knowledge of the event, and also at any time within the event. An example is provided below.

Table 4.5-1 shows an excerpt of the status and trending diagnostic for the section on PCS heat removal using forced circulation and the steam generators (S/G).

Safety Function	RCS Heat Removal
Method for Control	1. Steam Generator Forced Circulation
Parameter	A. RCP Amps B. Steam Generator ΔP C. Steam Generator Level D. RCS ΔT E. RCS T_{avg} F. Incore Thermocouples G. RCS Subcooled
Acceptable Status and Trending	A. >600 Amps and Constant B. >20 PSID and Constant C. >50% in one S/G and Controlled D. <10°F and Constant or Decreasing E. <590°F T_C T_H and Constant or Decreasing F. <620°F and Constant or Decreasing G. >20°F and Constant or Increasing
Implied Condition (if status and trending parameters are out of specification)	A. Gas Voids in RCS B. Loss of RCS Flow C. Insufficient Heat Sink D. Core Heating Up, Low Flow E. RCS Heating Up F. Core Heating Up G. Gas Voids in RCS
Guideline	A. Loss of Flow/NC, LOCA, S/G Tube Rupture B. Loss of Flow/NC, LOCA, S/G Tube Rupture C. Loss of Feed, Loss of Flow/NC, S/G Tube Rupture, Feedline Break D. Loss of Flow/NC, LOCA, S/G Tube Rupture E. Loss of Feed, LOCA, ATWS, Loss of Flow/NC, S/G Tube Rupture F. Loss of Flow/NC, LOCA, ATWS, S/G Tube Rupture G. Loss of Flow/NC, LOCA, S/G Tube Rupture

TABLE 4-3 Excerpt from Status Trending Diagnostic

An operator, wishing to confirm acceptable (and continuing acceptable) RCS heat removal, would first determine the method being used for its control. Forced circulation (i.e., using steam generators) is the supposition. Establishing this, indicators of successful RCS heat removal via forced circulation would be checked. For instance, RCP amperage of greater than 600 amps, and constant, would be verified.

Non-constant RCP amperage implies that the RCP is not pumping subcooled fluid. The next section of Table 4.5-1 is then consulted for direction on the appropriate procedure to be followed for a correction of this condition. Thus, in the example given, the operator would be directed to the Loss of Forced Reactor Coolant Flow, LOCA and SGTR guidelines.

Another example of a use of Table 4.5-1 is the questioning of RCS core differential temperature. Post-reactor trip, this value should never exceed 10^{o}F, and it should be constant or decreasing if continued adequate core cooling is to be assured. If the differential temperature is greater than 10^{o}F, or increasing, the implied condition would be that the core is heating up and/or is experiencing a low flow condition. The operator is then directed to the Loss of Forced Reactor Coolant Flow, LOCA, and SGTR Guidelines for further guidance. Note that, at no time, is the nature of the event, or the time after event initiation required in the use of this diagnostic.

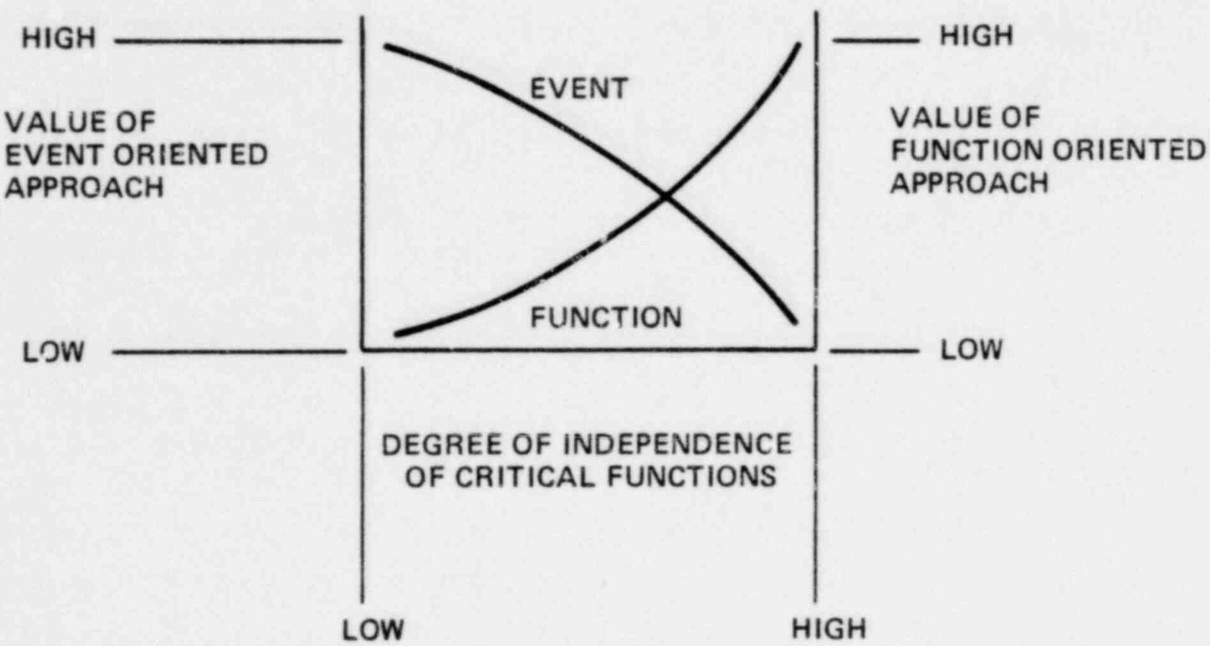
4.6 Event-Function Oriented Guidelines

This section contrasts "event oriented emergency guidelines" to "function oriented emergency guidelines". The value of each approach, relative to the complexity of the machine being operated, is discussed. Use of the event-function theme in the emergency procedure guidelines is also explained.

As noted in Section 2.0, operational guidance is valued by the quality of technical information contained and the design of the vehicle that presents the information. The technical information is derived from engineering documentation which is classically event oriented. In order to extrapolate this event oriented information to cover a broader range of similar events, the procedure writer views the event in terms of a control of functions. Regardless of the number of functions to be controlled, if all functions are independent of one another (i.e., the actions taken to control one function do not have an adverse impact on controlling another function), then a totally function oriented approach to operational information is needed. If the functions do not meet the above definition of independence (i.e., actions taken to control one function can affect the control of another) then a more event oriented approach to operational guidance is indicated. Figure 4.5-1 below presents this theme graphically.

Figure 4.5-1

EVENT vs FUNCTION ORIENTATION VALUE



The safety functions for a PWR are considered to have a low degree of independence from one another (although the interdependence of safety functions can be operationally beneficial). Addressed in another section of this report are studies of critical functions and the systematic process used to determine the degree of independence of these functions.

The goal of the guideline system designer is to provide operational information with maximum effectiveness. Due to the complex relationships between the major critical functions for the PWR, the emergency procedure guidelines were structured to accommodate both event and function oriented operational information. The guideline system is divided into three major function oriented divisions: reactivity control, pressure and inventory control, and heat removal. Within these functional divisions, a minimum number of event oriented emergency procedure guidelines which accommodate the interdependant critical functions are provided.

All the guidelines contain operational information on all critical functions as appropriate. In addition, the alternate diagnostic approach provided within the system is heavily functionally oriented. Details on this are provided later in the report.

SECTION 4.0 REFERENCES

4.1 "The Operators Role and Safety Functions", WRC et al

4.2 "The Critical Safety Functions and Plant Operation", WRC et al, October 1980

4.3 EPRI NP-309, "Human Factors Review of NPP Control Room Design", Lockheed, November 1976

4.4 NUREG/CR-1270, "Human Factors Evaluation of Control Room Design and Operator Performance at TMI-2", January 1980

4.5 NUREG/CR-1278, "Handbook of uman Reliability Analysis with Emphasis on Nuclear Power Plant Applications", Sandia Laboratories, March 1980

4.6 Lund Report, "Review of Effectiveness of Emergency Procedures for Operator Use", February 1981

5.0 Technical Content Development

5.1 Existing Information Base

In April of 1980, C-E provided CEN-128, which included upgraded interim emergency procedure guidelines. These interim guidelines were derived from an information base that is available from the design, construction, licensing and operation of the plant. For the April 1980 submittal, extensive best estimate analysis was done to supplement the existing information base for operational guidance.

Shown below, in Figure 5.1-1, is the general process of developing the emergency procedure guidelines and a summary of the information base that is employed in the process. The process is shown in the boxes and the information base is shown beneath the boxes.

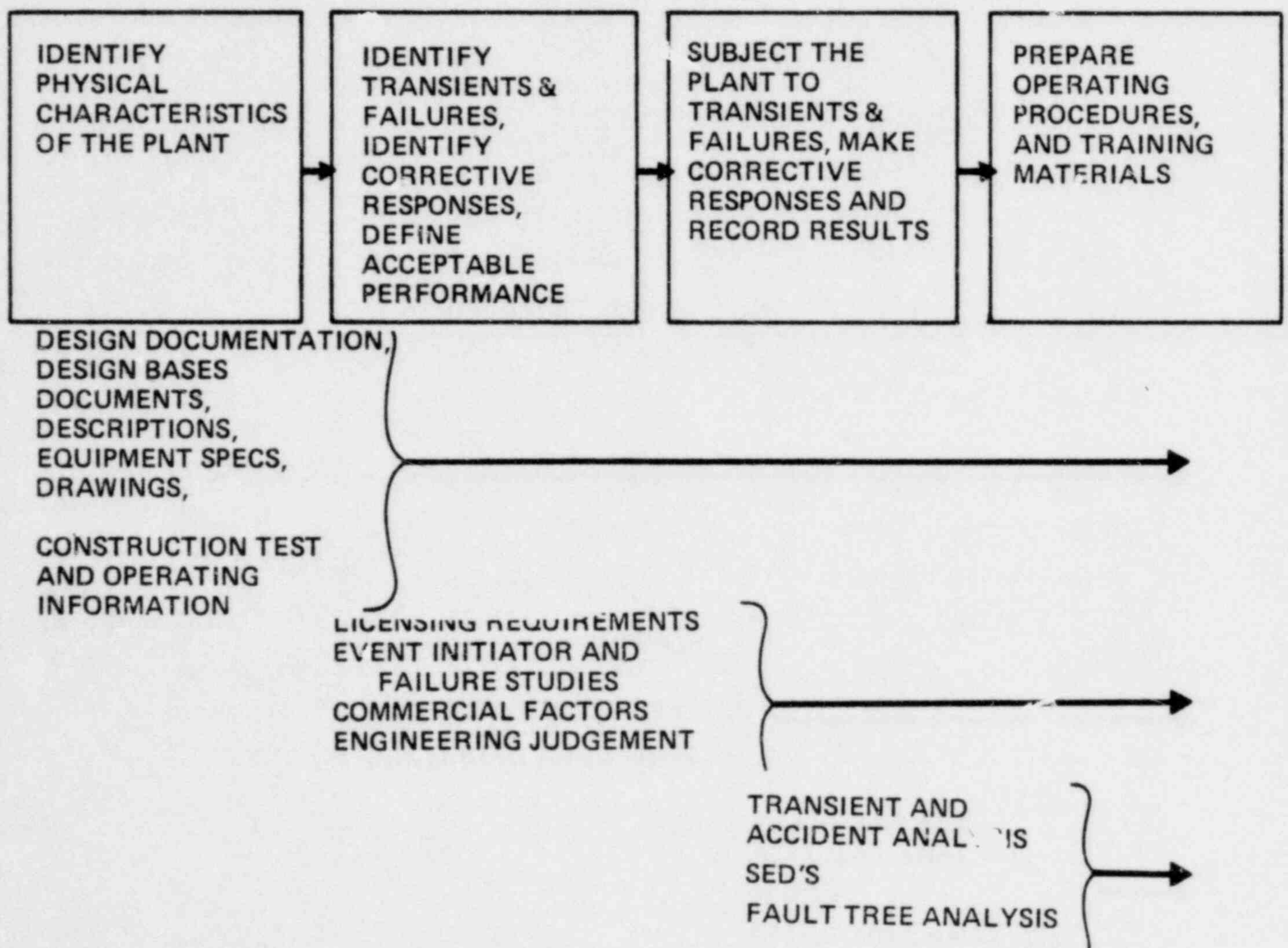


Figure 5.1-1

EPG DEVELOPMENT PROCESS AND INFORMATION BASE

Operating procedures for any component, system or plant can be developed by conducting a four step process. The initial step is to define the component, system or plant, and what it is supposed to do. The second step is to define acceptable performance, define the possible transients and failures, and identify the necessary corrective responses. The third step consists of subjecting the plant to transients and failures along with the corrective responses, while recording the results and contrasting them to acceptance criteria. This third step can be done empirically or analytically. The final step is to prepare operating procedure procedures from the informational base developed in steps 1 through 3.

In NUREG-0737, Item I.C.1, the NRC requested that emergency procedure guidelines that address multiple failures beyond those considered in CEN-128 be developed. The NRC also requested information on the development process. The following section discusses efforts conducted to develop this improved quality and scope of technical information requested by the NRC.

5.2 Emergency Procedure Guideline Workshops

The purpose of the EPG workshops was to expand the operational information for events which are outside the plants design bases. The workshops also provided input into the development of the emergency procedure guideline system. This section addresses the development of the improvements to the technical information found in the CEN-152 emergency procedure guidelines.

The workshop process was based on the operational information development process, which is shown in Figure 5.1-1. Consequently, the guidelines have been expanded to include alternative operator responses, the potential impact of multiple failures potentially leading to inadequate core cooling, and any resultant influence on the cooldown process. These workshops also identified the information which will be included in the preparation of training material related to the improved guidelines.

The C-E/utility workshops were held for a three day period in each of the first four months of 1981. Experts from C-E and each utility owning a C-E NSSS participated in the workshops. This included personnel from the design, analytical, procedure development, and operational areas. From the design area, C-E provided personnel experienced in the design, procurement, installation, and initial operation of each NSSS sold by C-E. Their experience included knowledge of emergency safeguards and auxiliary components and systems. Their expertise included:

1. An equipment-level understanding of component and systems' functional capabilities and their relationships to connected systems;
2. An understanding of component and systems' design bases;
3. Information from feedback of field operations from all operating C-E plants;
4. Related operating experiences.

From the analytical area, personnel from C-E provided background transient and accident information for incorporation in the guidelines. This information included:

1. Evaluation and simulation results of probable event scenarios (greater than 10^{-6}/yr), including multiple equipment or operator errors;
2. Related sequence of events diagrams (SEDs) showing the step by step success paths for automatic and operator initiated equipment operation required to accomplish each safety functions, as well as any alternative path available, and;
3. Related lists of the minimum required responses of various mitigating systems, the expected ranges and trending of parameter variations, and the expected response to control room instrumentation throughout the event.

From the procedure development area, C-E provided the basis for the format and content of the improved emergency procedure guidelines. This information included:

1. A justification of the overall format and detailed format (order of presentation, use of charts, etc.) of the guidelines;
2. An evaluation of the level of detail and volume of information presented to the operators;
3. An evaluation of the relationship of the emergency procedure guidelines to existing guidelines, standards, etc., and;
4. Direct input based on their experience in generating guidelines and interacting with operators.

From the operations area, the utilities with C-E NSSS provided an operators' point-of-view. Their input included:

1. A critique of the event scenarios considered by or included in the development of each emergency procedure guideline;
2. An identification and/or verification of expected equipment, instrument, or operator responses identified in the guidelines;
3. An evaluation of the anticipated operator reaction to the guidelines and provision of their feedback for further improvement, and
4. An evaluation of the generic applicability of the guidelines and related training material.

A set of "What If" questions was developed and distributed for each guideline prior to discussion of the guidelines in the workshops. The questions dealt with both the technical content and the format of the respective guideline. The technically oriented "What If" questions stimulated discussion on the adequacy of the guidelines in the area of multiple failures. Figure 5.2-1 provides a representative list of these questions for each guideline. The results of discussions on the format and content "What If" questions are presented in Section 4.0.

A typical workshop meeting would begin with an overview of the three day agenda. The attendance included both C-E and the utility personnel and totaled approximately twenty-five people. Because of the number of questions involved, the workshop was divided into three groups. The "What If" questions would be equally divided among the groups. Each group would address the assigned questions and would also critique one of the major areas of the guidelines (i.e., Symptoms, Immediate Actions, Follow-up Actions, and Precautions). These critiques provided discussions on the consistency of information among the different sections of the guidelines, along with a check on consistency among the various guidelines. After completing the questions, the three groups would meet as a whole and present the resolutions for their respective questions. If the full group was not satisfied with an individual group's response, further discussion would be generated and the question resolved.

Figure 5.2-1
Sample List of "What If" Questions

Reactor Trip

- What if the pressurizer sprays and auxiliary sprays are not operable?
- What if the safety injection tanks cannot be depressurized during cooldown?

Loss of Feedwater

- What if there is a loss of main and auxiliary feedwater, the PORVs open and one does not reclose (consider block valve is also failed open)?
- Should guidance be provided for use of the condensate pumps if the main feedwater pumps are failed and auxiliary feedwater is not available?

Steam Generator Tube Rupture

- Should operator be instructed to maintain minimum subcooled margin since a high subcooled margin will cause high RCS pressure and a high leak rate?
- What if affected SG cannot be isolated (i.e., MSIV will not close)? Should a contingency action be provided to guideline in the event of this failure?

LOCA

- What if a small LOCA has occurred and an SIAS is generated but the high pressure safety injection pumps do not start?
- What if a small steam line break inside containment has occurred but the operator is convinced that it is a small LOCA?

Steam Line Break

- What if the steam bypass control valve(s) fail to close and MSIS is actuated and one MSIV fails to close (on normal turbine trip)?
- What if Steam Line Break occurs upstream of MSIV and have failure of ADV(s) in other steam generator (fail high or low)?

Natural Circulation

- What if the CVCS system fails to maintain pressurizer level and/or pressure?
- What if SDC system is not available and the LTOP protection is part of that system?

Anticipated Transient Without SCRAM

- Does the Bases section adequately describe what is expected to occur during an ATWS transient?
- Are adequate indications of insufficient RCS heat removal addressed?

A system for documenting information generated by the workshops was established. Each "What If" question, along with any other questions raised by the group, was documented. The method for gathering information is best described by Figure 5.2-2.

Figure 5.2-2 Workshop Information Generation

Information Items	Example
1. What has happened?	A small LOCA has occurred and an SIAS is generated but the high pressure safety injection pumps do not start.
Define initial conditions:	Reactor at power RCS at normal T_h and T_c Loss of HPSI due to either a signal failure or a loss of power
2. Assessment of likelihood of condition:	2.6×10^{-6} for LOCA with no HPSI pump. 1×10^{-4} for LOCA and one HPSI pump (this information is useful to determine how much attention this item gets in the guideline response as well as where it belongs)
Has it or anything like it happened before?	No
3. On a plant specific bases, are there any plant features that would:	
a) render this concern a non-problem?	None
b) make the problem worse?	None
4. Event result from no operator action:	Core damage
5. Corrective responses:	
Establish order of preference.	Attempt to start/restart HPSI pumps manually Cooldown via SGs as fast as possible. Ensure charging pumps are started. Open PORV (this is plant specific)
6. What is the appropriate plant design information? manual initiation/control local control remote control redundant/diverse separation quality of power supply seismic code class (safety grade) shielding capacity access	SIS is a safety grade system
7. Disposition of data	Include in training Include in guideline Refer to another guideline Discard

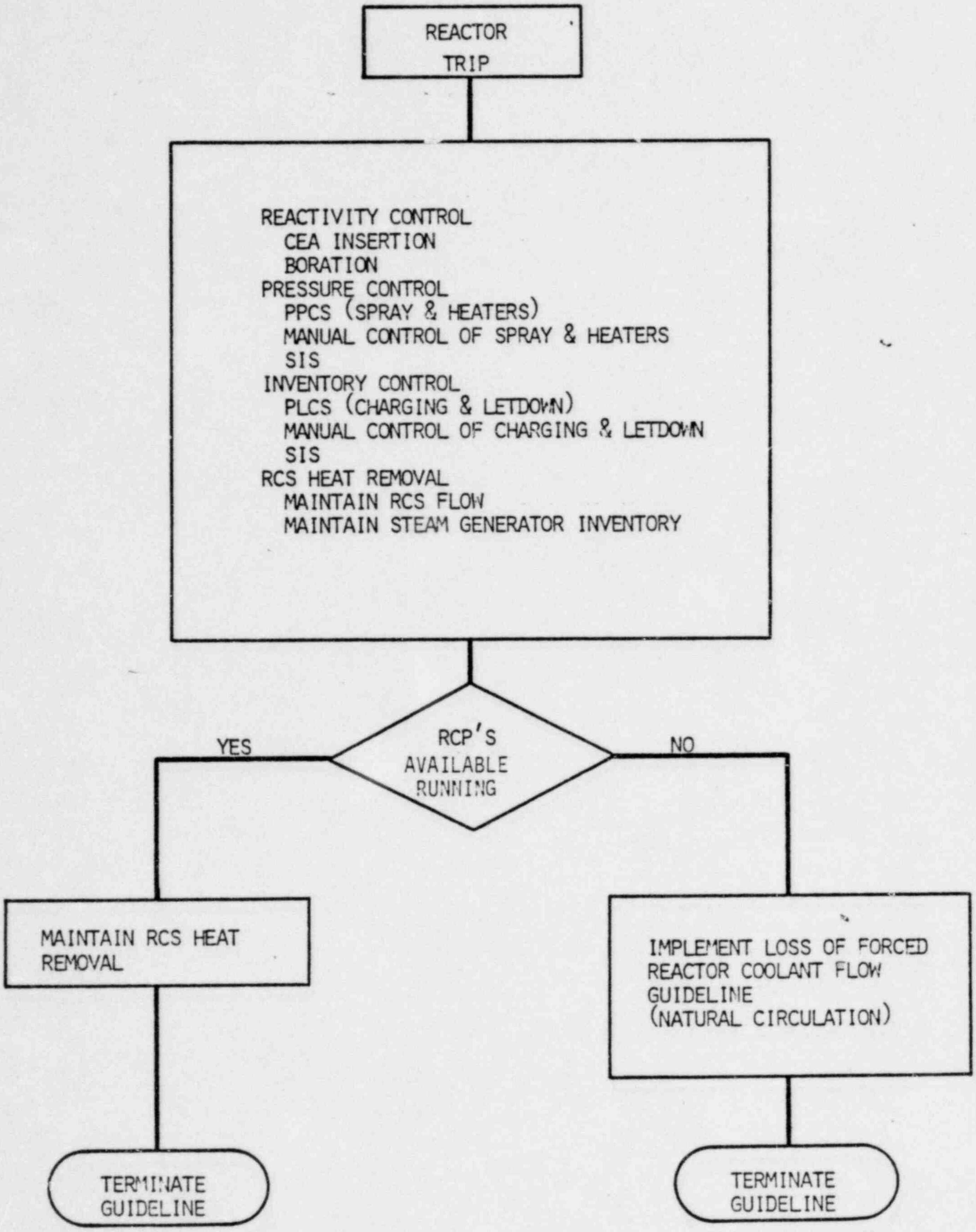
Another very important improvement that resulted from the workshops was strategy charts for each of the emergency procedure guidelines. These charts provide a valuable tool for verifying that the intent of the guideline has been satisfactorily addressed. A sample strategy chart for the Reactor Trip Guideline is provided by Figure 5.2-3.

The first statements encountered when moving down the chart are the critical safety functions required to be satisfied in the immediate actions section. For the Reactor Trip Guideline Strategy Chart in Figure 5.2-3, this involves verifying reactivity control, inventory and pressure control, and RCS heat removal safety functions. The flow path also indicates the safety functions to be satisfied by the follow-up actions. These statements often consider equipment failures and therefore, alternate success paths. In the Reactor Trip Guideline Strategy Chart, alternate paths are provided dependent on RCP availability. If the RCPs are not available, the Loss of Reactor Coolant Flow Guideline is implemented. For either path, at the appropriate plant condition, the guideline is terminated.

The strategy charts also provide an excellent overview of the guideline which could be a significant aid in the training process.

FIGURE 5.2-3

REACTOR TRIP STRATEGY CHART



6.0 Guideline System Preparation and Evaluation

This section provides information relating to the preparation and evaluation of the emergency procedure guideline system. Section 6.1 provides the ground rules, Section 6.2 describes the preparation effort and sources of information, and Section 6.3 provides an evaluation to show that the Item I.C.1 requirements of NUREG-0737 are satisfied.

6.1 Format and Content Groundrules

The format and content of the guidelines are based on ground ules developed using the results of work described in the previous sections. The ground rules providing specific guidance on guideline system preparation are presented below.

6.1.1 Bases

The bases section provides technical information that increases the operator's ability to identify the event, understand the plant response to an event, and understand the corrective actions he is expected to take. The following points are addressed in the bases section:

1. The bases section should include a brief overview of the event.
2. The general characteristics and possible causes of the event should be discussed.
3. The potential effect of the event on the reactor, plant equipment, and the environment should be noted.
4. The bases section should include a detailed discussion of the range of plant and operator responses to an event or class of events. The following list contains examples of the significant plant parameters that were considered:

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

5. Key parameters (e.g., RCS temperature) and trending that can be used to classify the event and determine its severity should be explained.
6. The bases section should describe the objective of the actions (automatic and manual) taken in response to the event, and why these actions are taken (which safety function is being dealt with).
7. The immediate and long range goals of the actions (i.e., strategy) of each guideline should be explained.
8. Preferred and alternate success paths to accomplish essential functions should be included.

6.1.2 Symptoms

The symptoms section consists of a list of parameters and indications which an operator is expected to utilize in identifying and confirming the event. The lists of symptoms were written with the following points in mind:

1. Symptoms should be prioritized, with priority given to the first and most important indication(s).
2. Symptoms should be readily available to the operator as indications. For example, use pressurizer level instead of RCS inventory.
3. If several indications are available for the same symptom, the best indication was selected and used in the symptoms list. For example, RCS temperature could be T_{hot}, T_{avg}, or T_{cold}.
4. The bases section should discuss those symptoms included in the guideline section.
5. The symptoms should be stated in the present tense as though the event occurs as the operator reads.
6. There should be a list of key parameters (e.g., pressurizer pressure) following the symptoms. State whether each parameter is expected to be increasing, decreasing, or remaining constant.

6.1.3 Immediate Actions

The immediate actions section consists of those actions which are required to place the plant in a safe condition. The action statements were written with the following points in mind:

1. The statements must be clear and concise to facilitate memorization by the operator.
2. The statements must be prioritized.
3. Multiple action statements are avoided.
4. Conditional action statements are identified by an "If" statement.
5. If more than one acceptable action sequence exists, the simpler one is preferred.
6. If necessary, successive actions and concurrent actions are identified for clarity.
7. The referencing of a standard operating procedure, which is to be performed in conjunction with the immediate actions, is permissible. However, care should be taken to avoid referenicng which results in a loop back to the original procedure.
8. Immediate actions should be written so that precautions are not required.
9. The completion of the immediate actions should result in a safe, stable condition. Their completion should minimize the impact of the event and permit the beginning of the follow-up actions.

6.1.4 Follow-up Actions

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

1. Points 1 through 7 in Section 6.1.3 apply to the following actions.
2. Accident magnitude determinations should be made in this section.
3. The completion of follow-up action must result in a plant condition which allows recovery operations to commence (return to operation or repair, clean-up, etc.).

6.1.5 Precautions

The precaution section consists of supplementary information which the operator should consider. The precautions are intended to be included in appropriate locations in the procedure that is written from the guideline. The precautions were written with the following points in mind:

1. Precautions are written to provide supplementary information that applies to the guideline.
2. Precautions should not present or imply operator actions that are not presented in the immediate or follow-up actions sections.

6.1.6 ICC Guidance

The ICC guidance consists of a plant status and trending diagnostic which provides an alternate path for implementing corrective action. The plant status and trending diagnostic is normally employed as a backup diagnostic tool, and also provides confirmation of corrective actions. Although the manner in which this diagnostic is implemented in the plant's procedure system need not be rigid, it should be implemented with the following points in mind:

1. The diagnostic should be functionally oriented. This allows corrective actions to be made without explicit knowledge of the event.
2. Information relating to the method used to satisfy safety functions should be provided (i.e. for RCS heat removal, is circulation being maintained by RCPs, natural circulation, etc.).
3. A listing of the parameters that should be monitored to identify the status of a safety function should be included.
4. For each parameter listed, an acceptable plant specific status and trend should be provided.
5. For each parameter, an implied condition that does not satisfy status and trending criteria should be listed.
6. For each parameter or group of parameters that do not satisfy status and trending criteria, the related guideline or corrective actions should be designated.

6.2 Guideline System Preparation

This section provides descriptions and examples of the preparation of the emergency procedure guidelines and the plant status and trending diagnostic. The examples reflect consideration of the concepts, information collection, and preparation process development presented in earlier sections. Section 6.2.1 provides a description of the bases preparation. Section 6.2.2 provides a description of the preparation of the symptoms section. Sections 6.2.3, 6.2.4, and 6.2.5 provide descriptions of the preparation of the immediate actions, follow-up actions and precautions, respectively. Section 6.2.6 provides a description of the preparation of the plant status and trending diagnostic.

6.2.1 Bases

The bases section is a dialogue between the guideline preparer and the procedure writer/operator. The guideline preparer has available a large amount of information on the event, including plant hardware data, licensing analysis, realistic transient analysis, incident reports, sequence of events diagrams, and operating experience. Following the format and content ground rules presented in Section 6.1.1 for preparation of the bases, the preparer presents the information for the operator in a condensed form. Care has been taken to include sufficient detail in the explanations without burdening the operator with specific analytical data. The plant responses are basically a verbal interpretation of the realistic analysis data. The diagnostic methods and corrective actions are a product of the extensive efforts as described in Sections 3.0 and 4.0. The development of a bases section is accomplished in parallel with the symptoms and corrective action sections to assure uniform treatment and internal consistency.

6.2.2 Symptoms

The generalized procedure for the preparation of a symptoms section of the guidelines is shown in Figure 6.2.2-1. The initial step was a survey of C-E operating plants' emergency procedures, which provided a listing of all symptoms currently in use for a given event. Next, the symptoms for the subject event identified in the realistic analyses were added to the list. The combined list was then analyzed to determine a best judgment set of symptoms. They were prioritized, and made reasonably compatible with all operating plant procedures. An example of the list and the results of the analysis are found in Figure 6.2.2-2. Upon completion of the process, for each event, a comparison of the event specific symptom sets was made to ensure that each set was unique to a specific event. If similar symptoms sets were found, the associated events were evaluated and combined where appropriate. Where symptom sets were found to be similar for diverse events (Loss of Coolant Accident and Steam Line Break), care was taken to emphasize the specific symptoms that would help the operator distinguish between the events. An example of the symptom set comparison is found in Figure 6.2.2-3. Key parameters were added to the symptoms section to provide trends to aid the operator in diagnosing the event. The key parameters, which are essential to the diagnostic process, were derived from operator interviews and may include paramaters which do not change. An illustration of the trending of key parameters for various events is given in Figure 6.2.2-4.

6.2.3 Immediate Actions

The immediate actions section of the guidelines consists of those actions required to place the reactor in a safe condition. The preparation of the immediate actions section of the guidelines followed a process similar to that used in the preparation of the symptoms section. It consisted of an immediate actions survey for each event, the preparation of a best judgment immediate actions listing for each event, an analysis and adjustment of the assembled "best judgment" listings, and finally the preparation of the guideline immediate actions. See Figure 6.2.3-1 flow diagram of this process.

As mentioned in the previous section, it was found that certain events are difficult to differentiate from each other in the short-term. Examples of this are "an open atmospheric dump valve" and "a steam line break". Examination of the immediate actions for such events reveals that a set of immediate actions applicable to both events can readily be produced. It was decided, therefore, to combine events which affect the plant in the same way and for which a common set of immediate actions were applicable. The advantages to combining events are:

a) The number of events is reduced, which reduces the number of guidelines, and the amount of memorization required of the operator. This should make the guidelines easier to use.
b) Some of the burden on the operator for diagnosing potentially unclear situations is removed.
c) The emphasis in preparing the guidelines is shifted away from a fixed set of events towards a practical treatment of events having similar symptoms and immediate actions.

Next, the emergency procedure guidelines were reviewed to assure that guidance for the control of all critical safety functions, appropriate for the event, were addressed. A summary of the actions required for reactivity control, inventory and pressure control, heat removal and containment integrity is provided by Figure 6.2.3-2. Included are the primary and alternate means of accomplishing the safety functions.

6.2.4 Follow-up Actions

The follow-up actions provide the operator with additional guidance starting at the point at which the immediate actions stop. In general, follow-up actions also tend to contain more explanation, and cover a greater range of possible failures and alternative actions. Thus, follow-up actions for a particular event diverge from those for other events. For these reasons, preparation of the follow-up actions is not amenable to the type of analysis conducted on the symptoms and immediate actions. Instead, the goal of the guideline writer was to develop the follow-up actions which would place the plant in a stable condition, permit problems to be corrected, and allow recovery operations to commence. Depending on the event, this could be hot standby, hot shutdown, or cold shutdown.

In the preparation of both immediate actions and follow-up actions, care was taken to lead the operator along a progressive path, and to avoid "loops" within a guideline, or among different guidelines. If a particular failure, taken in conjunction with an initiating event, places the plant in a position from which recovery is possible by following the actions of another guideline, the immediate or follow-up action refers the operator to that guideline. The operator is not referred back to the initiating guideline. An example of this is a reactor/turbine trip followed by a loss of feedwater. The operator is referred to the Loss of Feedwater Guideline, which encompasses both events.

6.2.5 Precautions

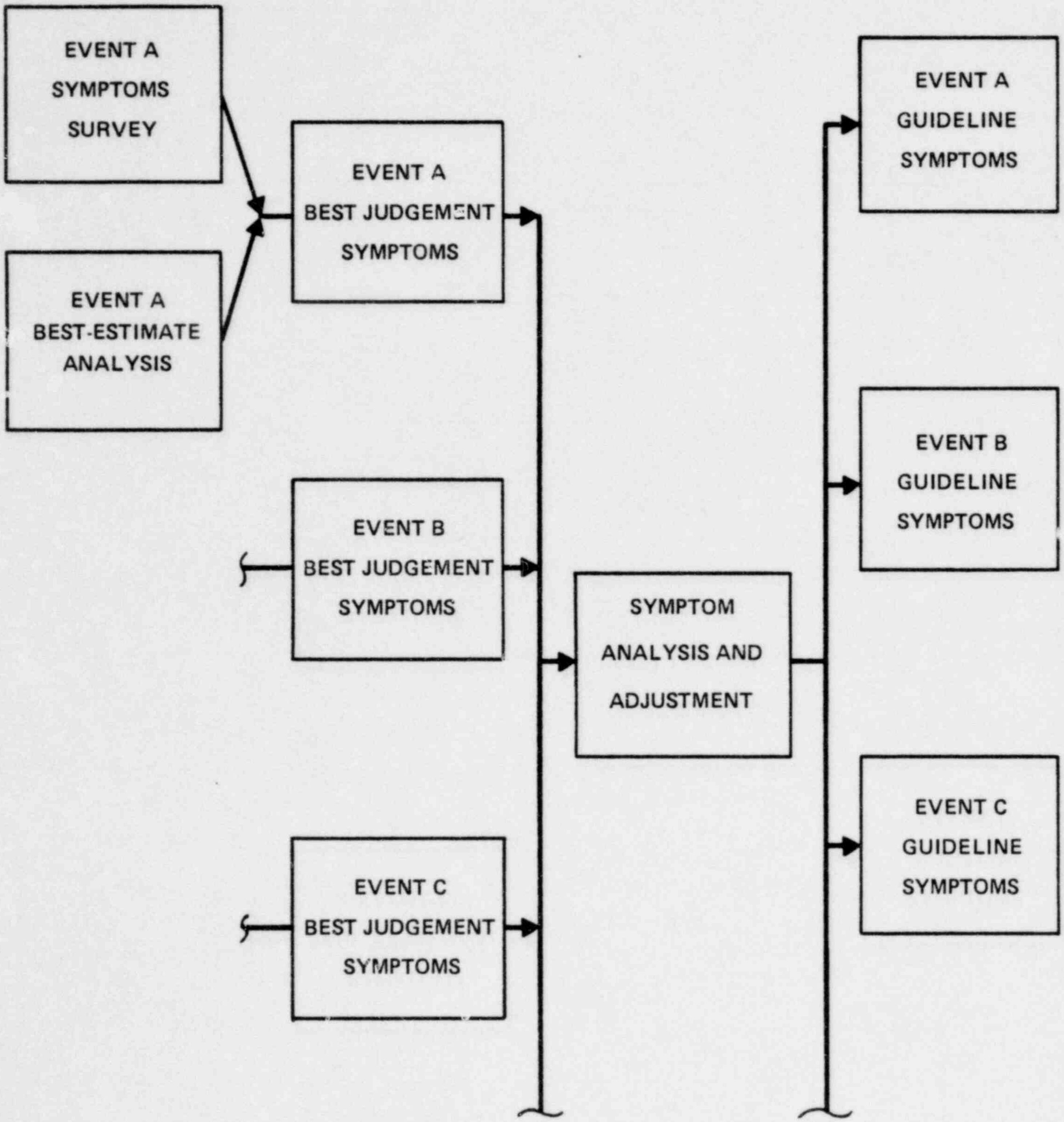
The type of information presented in the precautions section is oriented towards alerting the operator to conditions in which certain actions or inaction, on his part, could lead to the defeat of essential safety functions. It does not include the precautions typically found in equipment technical manuals. The immediate actions and follow-up actions were examined for each event, and any changes deemed necessary to ensure the proper implementation of the essential safety functions were identified and listed in the precautions.

6.2.6 ICC Guidance

As a backup method to assure adequate core cooling, a plant status and trending diagnostic was prepared. A description of the diagnostic and its use is presented in Section 4.5. This section provides a description of the effort made in producing the diagnostic.

Earlier efforts in producing a plant status and trending diagnostic were aimed at defining the role of diagnostics in the safe operation of the plant, and the type of information that should be included. A generic diagnostic is provided in CEN-152, Section 6.0. Information for the diagnostic was gathered through the workshop process, interviews, and results of transient analyses.

Figure 6.2.2-1



SCHEMATIC REPRESENTATION OF PRODUCTION OF EMERGENCY GUIDELINE SYMPTOMS

FIGURE 6.2.2-2

LOSS OF FORCED REACTOR COOLANT FLOW SYMPTOMS SURVEY

Symptoms	Plant A	Plant B	Plant C	Plant D	Plant E	Transient Analysis	Best Judgment
RCP trip alarms		X	X		X		X
Low RCS flow indication	X					X	X
Low RCS flow reactor trip	X	X	X	X			X
Turbine Trip							X
Low voltage on one or both 6.9 kv busses			X	X	X		
Low DNBR reactor trip					X		
Low voltage on 4.16 kv bus	X						
Decreasing Tavg on affected loop	X					X	X
RCP trouble alarms						X	X
Reactor trip alarm	X						X
Generator trip	X	X					X
RCP overload alarm trip	X			X			
RCP reverse rotation alarm				X			
RCP differential lockout alarm	X						
RCP ΔP Indicator reading zero					X		
COLSS DNBR limited					X		
Low RCP motor current					X		X
Decreasing SG ΔP							X
Key Parameters							
Decreasing reactor power						X	X
Decreasing pressurizer pressure						X	X
Decreasing RCS temperature						X	X
Decreasing pressurizer level						X	X
Increasing steam generator pressure						X	X
Decreasing steam generator level						X	X

FIGURE 6.2.2-3 - COMPARISON OF SYMPTOMS FOR EMERGENCY PROCEDURE GUIDELINES

	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
INCREASE IN STEAM GENERATOR STEAM FLOW						X	
POSSIBLE HIGH RADIATION IN CONTAINMENT				X			
MSIS						X	
CIAS			X	X		X	
STEAM GENERATOR BLOWDOWN HIGH ACTIVITY ALARM					X		
AIR EJECTOR HIGH ACTIVITY ALARM					X		
DECREASE IN VOLUME CONTROL TANK LEVEL					X		
HIGH ACTIVITY AND CONDUCTIVITY IN STEAM GENERATOR LIQUID SAMPLE					X		
INCREASE IN STEAM GENERATOR LEVEL					X		
DECREASE IN STEAM GENERATOR WATER LEVEL/ALARM			X				
MAIN FEEDWATER PUMP TRIP ALARM			X				
LOW MAIN FEEDWATER PUMP FLOW			X				
LOW MAIN FEEDWATER PUMP SUCTION PRESSURE			X				
POSSIBLE LOSS OF FEEDWATER FLOW CONTROL INDICATION			X				
POSSIBLE FAILURE OF FEEDWATER FLOW CONTROL VALVES			X				

FIGURE 6.2.2-3 - COMPARISON OF SYMPTOMS FOR EMERGENCY PROCEDURE GUIDELINES (cont.)

	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
POSSIBLE CLOSURE OF A MAIN FEEDWATER SYSTEM ISOLATION VALVE			X				
RCP TRIP ALARM							X
DECREASE IN STEAM GENERATOR ΔP IN THE AFFECTED RCS LOOP							X
RCP TROUBLE ALARM							X
LOW RCP MOTOR CURRENT							X
REACTOR TRIP ALARM	X		X	X	X	X	X
CONTROL ROD POSITIONS INDICATE ZERO	X						
DECREASE IN START-UP RATE	X						
CEA TRIP CIRCUIT BREAKER ALARMS	X						
ANY REACTOR PROTECTION SYSTEM TRIP ALARMS	X						
TURBINE BYPASS ATMOSPHERIC DUMP VALVES OPEN	X						
TURBINE-GENERATOR TRIP AND TROUBLE ALARMS	X		X				X
>10 CEAs DO NOT INDICATE INSERTED		X					
>CEA ROD BOTTOM LIGHTS ARE NOT LIT		X					
CEA TRIP BREAKERS ARE NOT OPEN		X					

FIGURE 6.2.2-3 - COMPARISON OF SYMPTOMS FOR EMERGENCY PROCEDURE GUIDELINES (cont.)

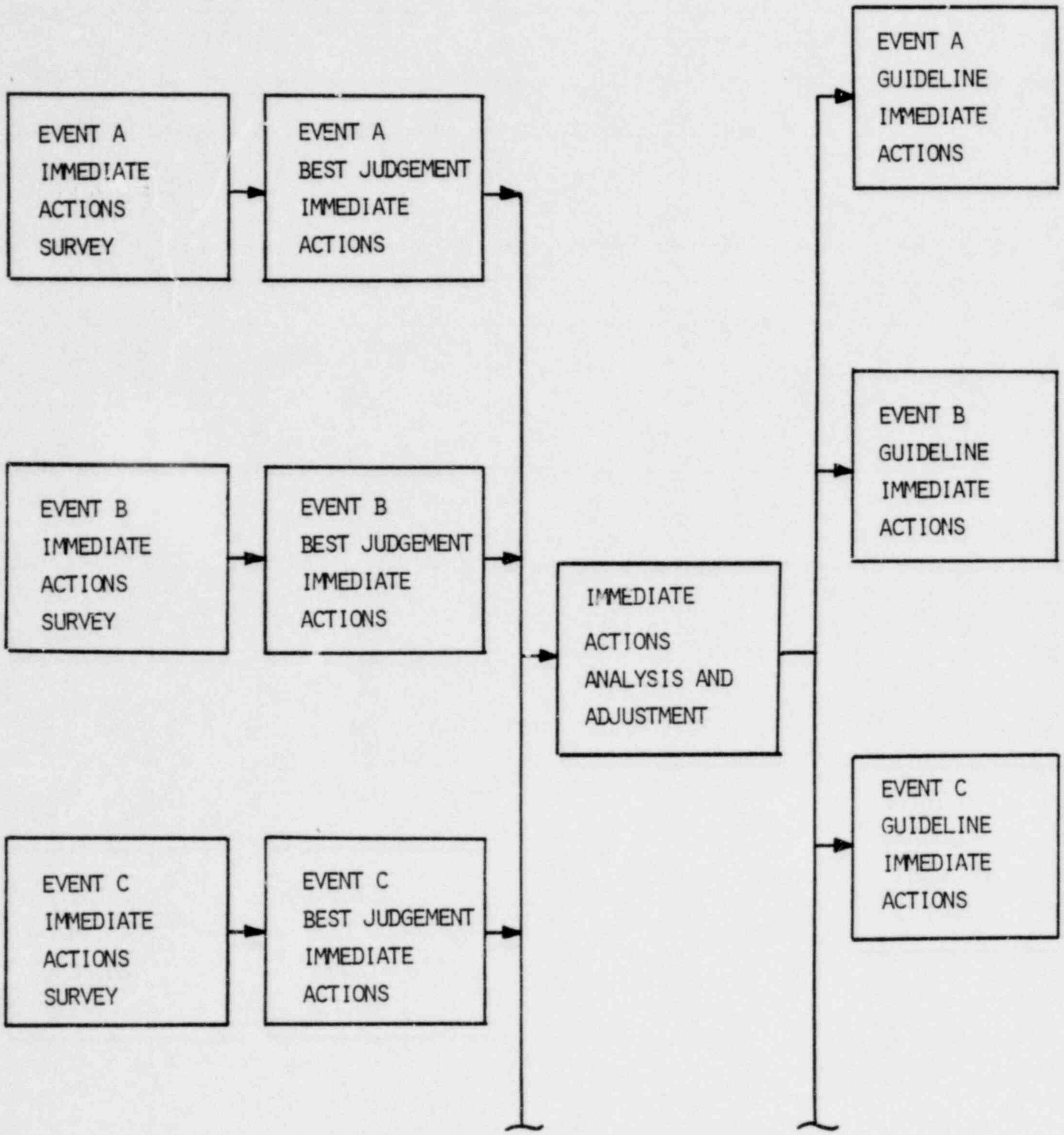
	REACTOR TRIP	ANTICIPATED TRANSIENT WITHOUT SCRAM	LOSS OF FEED WATER	LOSS OF COOLANT ACCIDENT	STEAM GENERATOR TUBE RUPTURE	STEAM LINE BREAK	LOSS OF FORCED REACTOR COOLANT FLOW
CEDM POWER UNDER VOLTAGE LIGHTS ARE NOT OPEN		X					
POSSIBLE INCREASE IN CONTAINMENT PRESSURE			X	X		X	
POSSIBLE INCREASE IN CONTAINMENT TEMPERATURE			X	X		X	
POSSIBLE INCREASE IN CONTAINMENT HUMIDITY			X	X		X	
POSSIBLE INCREASE IN CONTAINMENT SUMP LEVEL			X	X		X	
POSSIBLE CSAS			X	X		X	
POSSIBLE SIAS				X		X	
POSSIBLE NOISE INDICATIVE OF A HIGH ENERGY LINE BREAK			X	X		X	
RCS LEAKAGE EXCEEDS THAT OF AVAILABLE CPs				X	X		
POSSIBLE HIGH QUENCH TANK LEVEL				X			

FIGURE 6.2.2-4 - COMPARISON OF INITIAL TRENDING OF KEY PARAMETERS FOR EMERGENCY PROCEDURE GUIDELINES

	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
REACTOR POWER	D	I/D	C	C or D	C	I	D
PRESSURIZER PRESSURE	D	I	IorD	D	C or D	D	D
RCS TEMPERATURE	D	I	I/D	C or D	C	D	D
PRESSURIZER LEVEL	D	I	I/D	C or D or I	C or D	D	D
STEAM GENERATOR PRESSURE	I	I	I/D	C or D	C	D	D
STEAM GENERATOR LEVEL	D	D	D	C or D	C or I	I/D	D

C CONSTANT
D DECREASING
I INCREASING
I/D INCREASING THEN DECREASING

Figure 6.2.3-1



SCHEMATIC REPRESENTATION OF PRODUCTION OF EMERGENCY GUIDELINES IMMEDIATE ACTIONS

FIGURE 6.2.3-2 - SUMMARY OF ACTIONS TO SATISFY SAFETY FUNCTIONS

REACTIVITY:	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
VERIFY REACTOR TRIP	X	X	X	X	X	X	X
IF NECESSARY, TRIP THE REACTOR	X	X	X	X	X	X	X
INVENTORY AND PRESSURE:							
ISOLATE THE BREAK				X			
VERIFY PLCS IS RESTORING RCS LEVEL	X	X	X	X	X	X	X
IF NECESSARY, MANUALLY OPERATE CHARGING & LETDOWN TO RESTORE LEVEL	X	X	X	X	X	X	X
VERIFY PPCS IS RESTORING RCS PRESSURE	X	X	X	X	X	X	X
IF NECESSARY, MANUALLY CONTROL HEATERS OR SPRAY TO RESTORE PRESSURE	X	X	X	X	X	X	X
IF PRESSURIZER PRESSURE <[1600 PSIA], VERIFY SIAS	X	X	X	X	X	X	X
IF NECESSARY, INITIATE SIAS	X	X	X	X	X	X	X
IF PRESSURIZER PRESSURE <[1300 PSIA], STOP RCPs	X	X	X	X	X	X	X
HEAT REMOVAL:							
VERIFY TURBINE TRIP	X		X	X	X	X	X
IF NECESSARY, TRIP TURBINE	X	X	X	X	X	X	X
VERIFY ACTUATION OF THE AUXILIARY FEEDWATER SYSTEM	X	X	X	X	X	X	X

FIGURE 6.2.3 2 - SUMMARY OF ACTIONS TO SATISFY SAFETY FUNCTIONS (cont.)

	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
IF NECESSARY, INITIATE AUXILIARY FEEDWATER SYSTEM	X	X	X	X	X	X	X
IF PRESSURIZER PRESSURE <[1600 PSIA], VERIFY SIAS	X	X	X	X	X	X	X
IF NECESSARY, INITIATE SIAS	X	X	X	X	X	X	X
CONTAINMENT:							
IF CONTAINMENT PRESSURE >[5 PSIG], VERIFY CIAS		X		X		X	
IF NECESSARY, INITIATE CIAS		X		X		X	
IF CONTAINMENT PRESSURE >[10 PSIG], VERIFY CSAS		X		X		X	
IF NECESSARY, INITIATE CSAS		X		X		X	

6.3 Evaluation

Provided by this section are the results of an evaluation performed on the emergency procedure guideline system. NUREG-0737, Item I.C.1 "Guidance for the Evaluation and Development of Procedures for Transients and Accidents", requires that the emergency procedure guidelines be revised to improve the technical content and to expand the scope of multiple failures addressed. This section provides confirmation that those requirements are satisfied. Additional requirements were established by C-E. A summary of the NUREG-0737, Item I.C.1 requirements and the C-E requirements is provided in Table 6.3-1. This list of C-E requirements is not exhaustive. A summary of the manner in which each of the requirements is addressed as well as specific examples from the guidelines is provided hereafter.

Summary of NUREG-0737 Item I.C.1
and C-E Requirements

TABLE 6.3-1

Per the requirements of NUREG-0737, Item I.C.1, procedure development should consider the occurances of multiple and consequential failures. These could include:

a) The loss of instrumentation and natural phenomena in initiating events;
b) The consideration of multiple failures, (including operator errors) such as:
   - multiple tube ruptures in a single steam generator and ruptures in more than one generator;
   - the failure of main and auxiliary feedwater; the failure of high pressure reactor coolant makeup system;
   - an anticipated transient without SCRAM (ATWS) event following a loss of offsite power, stuck open relief valve or safety relief valve, or loss of main feedwater;
   - operator errors of omission or commission;
c) ... addressing of corrective or alternative actions in the event of failures (i.e., identify alternate success paths);
d) Providing guidance on ICC, including instrumentation use to detect ICC;
e) Justifying the approach used in developing diagnostic guidance;
f) Providing the detailed methodology used to develop the guidelines.

Furthermore, C-E has identified items which were considered during the development of the emergency procedure guidelines. These items include:

1. Does the system-plant inter-relationship exist and operate as implied by the procedure?
2. Are the symptoms presented in an order that reflects their importance?
3. Do the symptoms include key non-changing parameters to aid in event recognition?

4. Do the procedures tell what to do if the system does not respond as expected?
5. Does the procedure warn of actions or conditions to be avoided?
6. Is the guidance that is provided for each safety function appropriate to the event and to similar events?
7. Does the procedure reference other procedures or other material adequately?
8. Are steps included to bring plant conditions back to normal or achieve long-term stability?

6.3.1 Compliance to NUREG-0737, Item I.C.1 Requirements:

a) Include the loss of instrumentation and natural phenomena in initiating events.

The emergency procedure guidelines adequately address the potential impact of loss of instrumentation and natural phenomena. This conclusion was determined as a result of the workshop process. Also, in addition to the plant emergency procedures (developed from the emergency procedure guidelines), other plant procedures provide additional guidance on the loss of instrumentation and natural phenomena events. It is intended that those procedures be used concurrently with the emergency procedures if the event occurs at the same time as an emergency event.

b) Consider multiple failures, (including operator errors), such as:

- multiple tube ruptures in a single steam generator and ruptures in more than one generator;
- the failure of main and auxiliary feedwater;
- the failure of high pressure reactor coolant makeup system;
- an anticipated transient without SCRAM (ATWS) event following a loss of offsite power, stuck open relief valve or safety relief valve, or loss of main feedwater;
- operator errors of omission or commission.

- multiple tube reptures in a single steam generator and ruptures in more than one generator;

Guidance on multiple tube ruptures in a single steam generator and ruptures in more than one generator have been included. See below.

Excerpt from the SGTR Guideline:

✓ For the double ended rupture of one steam generator tube, without 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.

If both generators are affected, the steam generator with the highest radiation indications should be isolated.

· failure of main and auxiliary feedwater;

Guidance on the actions required following the failure of both main and auxiliary feedwater is provided in the Loss of Feedwater Guideline. An action statement from this guideline is found below.

Excerpt from the Loss of Feedwater Guideline:

✓ 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 non-vital secondary discharge must be secured. Until feedwater is re-established, 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 cannot 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.

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 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.]

- failure of high pressure reactor coolant makeup system;

Guidance on the actions required following a failure of the high pressure reactor coolant makeup system is found in the emergency procedure guidelines where the SIS may be operated following the initiation of the event. The following example is found in the LOCA Guideline.

Excerpt from the LOCA Guideline:

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

- an anticipated transient with SCRAM (ATWS) event following a loss of offsite power, stuck open relief valve or safety relief valve, of loss of main feedwater;

Guidance on an ATWS event following the above-mentioned scerarios is included in the guideline system as exhibited below.

Excerpts from ATWS Guideline:

✓ A scenario for the ATWS event involves a mismatch of feedwater flow to steam generation. This is a maximum if a total loss of feedwater initiated the ATWS. This could occur due to a loss of offsite power. 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 causes 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 lift the reactor vessel head and thereby, allow fluid leakage and reduction in pressure through the reactor vessel flange "O" ring seal. Pressure will begin to decrease as reactor power is reduced by the large negative moderator reactivity feedback caused by the high RCS temperature. This negative reactivity addition, due to increased RCS temperature, is what limits the consequences of an 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.

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

✓ Attempt to manually insert the CEAs into the core. Perform one of the following actions:

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

Excerpts from all Guidelines:

√ Verify that the Main or Auxiliary Feedwater System is restoring or maintaining steam generator level. Feedwater flow to the steam generators provides a means for maintaining RCS heat removal.

√ If pressurizer pressure decreases to [1600 psia], [or if containment pressure increases to 5 psig], verify initiation on SIAS. If necessary, manually initiate safety injection.

•operator error of omission or commission.

Consideration has been given in each guideline to operator errors of omission or commission. Each guideline contains the statements found below (made applicable to the guidelines they are found in). The intent of these statements is to recheck previous operator actions in an effort to eliminate operator errors.

Excerpts from the LOCA Guideline:

√ The diagnosis of a loss of coolant accident should be confirmed by referring to Figure 1. If a misdiagnosis has been made, the proper emergency guideline can then be implemented. If a definative 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.

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

c) Address corrective or alternative actions in the event of failures (i.e., identify alternate success paths);

The guidelines provide the operator with alternate actions for the mitigation of the event. A direct result of the workshops was considering failures for safety and non-safety systems, and providing the operator with alternate paths to follow. An example of the use of alternate actions for accomplishing a safety function is provided below from the Follow-up Actions of the Loss of Feedwater Guideline.

Excerpt from Loss of Feedwater Guideline:

√ 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 non-vital steam discharge.
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.]

d) Provide guidance on ICC, including the instrumentation use to detect ICC;

ICC guidance, which is an integral part of the emergency procedure guideline system, is discussed in Section 4.5 of this report. A plant status and trending diagnostic (refer to CEN-152) provides the operator with a means of comparing plant parameters to verify that adequate core cooling is being maintained.

e) Justify the approach used in developing diagnostic guidance.

Section 4.4 of this report provides the discussion for development of the diagnostic guidance.

f) Provide a detailed ethodology used to develop guidelines.

This topical report, CEN-156, provides the guideline development process.

6.3.2 Compliance to C-E Requirements

a) Does the system-plant interrelationship exist and operate as implied by the procedure?

One of the purposes of the EPG workshops between C-E and the utilities was to gain input from the plants to ensure the generic guidelines are applicable to all C-E plants. Following the workshop input process, the guidelines were sent out to the utilities for further review to ensure that the guidelines satisfied any plant specific items.

Also, very early in the emergency procedure guideline work, site visits were made to a number of the C-E operating plants by the guideline preparers. Layouts of the control room along with photos were gathered for input into the guidelines work.

An example of the manner in which system-plant interrelationships exist in the C-E guidelines is by distinguising plant specific information by using brackets. Provided below is an example from the SGTR Guideline of the use of brackets. The statement in the guideline provides the operator with a means of draining the affected steam generator to a plant specific system.

Excerpt from the SGTR Guideline:

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

b) Are the symptoms presented in an order that reflects their importance to the event?

The symptoms section consists of a list of parameters and indications that have been prioritized according to the importance of each of the parameters when diagnosing the event. A schematic representation of the production of emergency procedure guidelines symptoms sets for each event is shown in Figure 6.2.2-1

c) Do the symptoms include key non-changing parameters to aid in event recognition?

Key parameters are included in the /mptoms section of the guidelines to provide trends to aid the operator in diagnosing the event. An example of event specific key parameters is found in Figure 6.2.2-4. The parameters chosen include the information obtained from operator interviews. They are essential to the diagnostic process and may include parameters that do not change.

d) Do the procedures tell what to do if the system does not respond as expected?

For certain situations when it is considered critical to address the plant response to specific actions taken, it is provided. This is illustrated by examples from the EPGs.

Excerpts from the LOCA Guideline:

✓ 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 2).
b) Pressurizer level is in the normal operating band and is responding normally to the Pressurizer Level and Pressure Control Systems.
c) At least one steam generator has an indicated level and is removing heat from the RCS.

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

Excerpts from the Loss of Forced Reactor Coolant Flow Guideline:

✓ During the RCS depressurization, monitor for voiding. 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.

✓ If voiding in 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.

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

Furthermore, the guideline system has included a status and trending diagnostic, (refer to CEN-152). Utilization of this diagnostic by comparing the listed parameter status and trending for a safety function against those noted in the control room will identify if all systems are responding as expected in maintaining adequate cooling of the reactor core. If they are not, appropriate corrective actions are identified.

e) Does the procedure warn of actions or conditions to be avoided?

A precaution section is included in the EPGs which provide warning, where necessary, to protect either equipment or personnel. Statements are also provided to the operator to ensure proper and optimum performance of the systems. Examples from the Steam Line Break Guidelines are provided:

Excerpt from the Steam Line Break Guideline:

✓ Lengthy operation of the Containment Spray System may jeopardize the operation of equipment which would be desirable to mitigate the consequences of the event. Early consideration should be given to termination of spray operation.

✓ 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.

f) Is the guidance that is provided for each safety function appropriate to the event and to similar events?

The safety function concept is the major underlying theme of the guideline system. Each of the emergency procedure guidelines are structured so that all appropriate safety functions are addressed. Figure 6-7 provides a comparison of the actions performed for each safety function to assure adequate core cooling.

g) Does the procedure reference other procedures or other material adequately?

A concious effort has been made to minimize the amount of cross referencing in the C-E Emergency Procedure Guideline System. However, if one EPG requires that the actions of another EPG be implemented, this cross reference is made in a manner as shown below.

Excerpt from the SGTR Guideline:

✓ 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.

Excerpt from the Loss of Feedwater Guideline:

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

If an emergency procedure guideline requires that an action be taken that invokes the usage of plant operating procedures other than emergency event procedures, this type of reference is shown below.

Excerpt from the LOCA Guideline:

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

Excerpt from the Reactor Trip Guidelines:

✓ 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 1).
d) [Other criteria satisfied per RCP operating instructions.]

h) Are steps included to bring plant conditions back to normal or achieve long-term stability?

Each guideline terminates with statements which provide the operator with the expected final plant conditions. An example of a termination statement is included from the Loss of Forced Reactor Coolant Flow Guideline. The operator is provided with a choice of either maintaining the plant in a stabilized condition or is instructed to conduct a plant cooldown. The statements read as follows:

Excerpts from the Loss of Forced Reactor Coolant Flow Guideline:

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

✓ If required, conduct a plant cooldown to SDC initiation conditions.