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Recovery Actions in PRA for the Risk Methods Integration and Evaluation Program (RMiEP)

Volume 1: Development of the Data-Based Method

Louise M. Weston, Donnie W. Whitehead, Norman L. Graves

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Recovery Actions in PRA for the Risk Methods Integration and Evaluation Program (RMIEP)

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Abstract

In a probabilistic risk assessment (PRA) for a nuclear power plant, the analyst identifies a set of potential core damage events consisting of equipment failures and human errors and their estimated probabilities of occurrence. If operator recovery from an event within some specified time is considered, then the probability of this recovery can be included in the PRA.

This report provides PRA analysts with an improved methodology for including recovery actions in a PRA. A recovery action can be divided into two distinct phases: a Diagnosis Phase (realizing that there is a problem with a critical parameter and deciding upon the correct course of action) and an Action Phase (physically accomplishing the required action). In this methodology, simulator data are used to estimate recovery probabilities for the diagnosis phase. Different time-reliability curves showing the probability of failure of diagnosis as a function of time from the compelling cue for the event are presented. These curves are based on simulator exercises, and the actions are grouped based upon their operational similarities. This is an improvement over existing diagnosis models that rely greatly upon subjective judgment to obtain such estimates. The action phase is modeled using estimates from available sources. The methodology also includes a recommendation on where and when to apply the recovery action in the PRA process.

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LIST OF ABBREVIATIONS AND ACRONYMS

ADS	Automatic Depressurization System
ANOVA	Analysis of Variance
ATWS	Anticipated Transient without Scram
BWR	Boiling Water Reactor
B-man	Roving Plant operator who can be directed by the control room operators to perform specific tasks (e.g., manually open a valve)
CCDF or ccdf	Complementary Cumulative Distribution Function
CNDS	Condensate System
CR	Control Room
CRD	Control Rod Drive System
CSCS	Core Standby Cooling System
CST	Condensate Storage Tank
Cum.	Cumulative
CW	Circulating Water System
DC	Direct Current
DDM	Diagnosis Difficulty Matrix
DG	Diesel Generator
EI	Energy Incorporated
EPGs	Emergency Procedures Guidelines
FW	Feedwater
GARBAGE	GARBAGE systems refer to those systems that are used only as a last resort to prevent core damage. These systems inject "dirty," (non-reactor grade) water into the vessel and are used only if no other means of injecting water into the vessel are available.
HCR	Human Cognitive Reliability
HEP	Human Error Probability
HPCS	High Pressure Core Spray System
HRA	Human Reliability Analysis
HX	Heat Exchanger
IREP	Interim Reliability Evaluation Program
LOCA	Loss of Coolant Accident
LOP	Loss of Offsite Power
LP	Low Pressure
LPCI	Low Pressure Coolant Injection System
L8	Level 8
MAUD	Multi-Attribute Utility Decomposition
MDFWP	Motor Driven Feedwater Pump
MSIV	Main Steam Isolation Valve
NPP	Nuclear Power Plant
NRC	Nuclear Regulatory Commission
NR Level	Narrow Range Level
NR and WR Level	Narrow Range and Wide Range Level
OAET	Operator Action Event Tree
OAT	Operator Action Tree
PCS	Power Conversion System
PDT	Predicted Diagnosis Time
PRA	Probabilistic Risk Assessment
PSF	Performance Shaping Factor

LIST OF ABBREVIATIONS (Continued)

PWR	Pressurized Water Reactor
RBEDT	Reactor Building Equipment Drain Tank
RCIC	Reactor Core Isolation Cooling System
RHR	Residual Heat Removal System
RMIEP	Risk Methods Integration and Evaluation Program
RO	Reactor Operator
RPV	Reactor Pressure Vessel
RV	Reactor Vessel
RX or Rx	Reactor
SAT	Station Auxiliary Transformer
SBGT	Standby Gas Treatment
SBLC	Standby Liquid Control System
SDV	Scram Discharge Volume
SLIM	Success Likelihood Index Methodology
SNL	Sandia National Laboratories
SP	Suppression Pool
SRO	Senior Reactor Operator
SRV	Safety Relief Valve
Sup.	Suppression
SW	Service Water System
TAF	Top of the Active Fuel
TBCCW	Turbine Building Closed Cooling Water System
TDFWP	Turbine Driven Feedwater Pump
TECH. SPECS.	Technical Specifications
TRC	Time Reliability Correlation
VP	Vent and Purge System
X-TIE	Cross-tie

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EXECUTIVE SUMMARY

This document presents a methodology for addressing the contribution of operator recovery actions in a probabilistic risk assessment (PRA). A recovery action, which is defined as an action which must be accomplished by the operators to prevent or mitigate core damage during an accident, is modeled as consisting of two distinct phases: (1) a diagnosis phase (recognizing that a problem exists with one of the critical parameters and deciding what to do about it), and (2) an action phase (physically accomplishing the action(s) decided upon in the diagnosis phase).

A new data-based model for estimating the contribution from the diagnosis phase was developed after (1) examination of existing models indicated a heavy reliance upon judgment data and (2) results from statistical testing of observed operator behavior indicated a lack of correlation to the corresponding judgment data. This new data-based model for the diagnosis phase was developed using information obtained from simulator drills. These simulator drills were based on preliminary results from the LaSalle PRA. These preliminary results were used to define realistic plant-specific accident scenarios which could potentially lead to core damage. The drills were used to obtain time data on the operator team's ability to respond to the accident scenario. These time data, along with the grouping of operator actions based upon the underlying operational similarity of the actions, provides the basis for the model of the diagnosis phase of the recovery action. It was concluded that existing models for the action phase of the recovery action could be used.

The recovery methodology developed in this study can be summarized as follows:

(1) Appropriate recovery actions are identified. This includes both recovery actions which are to be placed directly on the fault trees and recovery actions which result from examination of the information contained in the cut sets.

(2) The recovery actions which are not included in the fault trees are applied to the cut sets.

(3) The recovery actions are modeled as consisting of a diagnosis phase and an action phase.

(4) Estimates of the failure probabilities for each phase are provided using separate models (i.e., the diagnosis phase uses the data-based model developed in this study and the action phase uses existing models).

(5) Estimates for each phase are combined to produce a single nonrecovery probability.

(6) The original cut set failure probability is then multiplied by the nonrecovery probability of the recovery action to give the new cut set failure probability. This new cut set failure probability now reflects the operators' contribution in reducing or mitigating core damage.

This methodology is currently being applied to the LaSalle PRA. This application is discussed in more detail in Volume II.

1.0 INTRODUCTION

The contribution of human errors to the potential risk from hypothesized accidents at nuclear power plants has been a concern since risk was first addressed quantitatively in the Nuclear Regulatory Commission's (NRC's) Reactor Safety Study [1]. Following the Three Mile Island accident, interest in assessing the risks associated with operating nuclear power plants increased. The dominant technique for quantitatively estimating such risk is probabilistic risk assessment (PRA) [2]. In the PRA process, the components of safety systems and their associated estimated failure probabilities are logically combined to provide an estimate of the core damage probability. One such "component" which must be accounted for in a nuclear power plant system is the human interactions with that system.

There are two categories of human actions that are important in a PRA. The first is human actions which occur before the hypothetical accident begins which may affect the ability of a system to respond to the accident. An example is incorrect performance of routine tests on systems. Human actions which occur after the start of an accident comprise the other category [3].

In this work (sponsored by the NRC's Division of Reactor System Safety), a model for the human errors which occur during an accident was developed. These errors include acts of commission (incorrect performance of a task or action) and omission (failure to perform a task or action) [4]. This study deals with both acts of omission and commission, since both affect the probability of recovery; however, random acts of commission that are totally outside of procedures are not included in the recovery methodology. A recovery action is herein defined as an action which must be accomplished by the operators to prevent or mitigate core damage during an accident situation.

A recovery action can be broken into two distinct phases [4,5]. The Diagnosis Phase occurs when the operator team recognizes that some problem exists with one of the critical parameters (i.e., reactor power, containment pressure, reactor vessel level, and reactor pressure) and, from the information available, decides upon a course of action. After a course of action has been decided upon, the Action Phase occurs. In this phase, the operator team must physically accomplish the action(s) decided upon in the Diagnosis Phase.

1.1 Objective

Curves showing the probability of nonrecovery as a function of time (time-reliability curves) are needed to include recovery in PRAs. The PRA analyst begins with a set of events consisting of equipment failures and human errors and their estimated probabilities of occurrence. If recovery from an event, within some specified time, is considered, then the probability of occurrence can be multiplied by the probability of nonrecovery for the event to give an estimate of the probability of a nonrecovered failure.

Existing methods to model the diagnosis phase of a recovery action are heavily based upon expert opinion and have relatively few time-reliability curves to represent the host of recovery actions.

In some approaches, a single time-reliability curve is provided along with guidelines for adjusting the curve for the specific situation. For example, in the Technique for Human Error Rate Prediction (THERP)/Handbook Approach [4], a generic time-reliability curve derived primarily from expert opinion is provided along with rules to adjust the curve for plant-specific performance shaping factors (PSFs). PSFs are factors, such as characteristics of the situation or task, that enhance or degrade human performance. A similar approach, the Operator Action Tree (OAT) model [6], uses a different time-reliability curve derived from expert opinion with provisions for adjusting the curve.

Other approaches have several time-reliability curves. For example, the Time Reliability Correlation (TRC) model [6] uses three time-reliability curves developed largely from expert opinion. The selection of the appropriate curve depends on whether the action of interest is judged to be skill-, rule-, or knowledge-based. Another example is the Human Cognitive Reliability (HCR) model [10] in which three time-reliability curves are used. There is one curve for actions judged to be skill-, rule-, or knowledge-based. These curves can be modified based upon considerations of PSFs. These and other approaches are described in detail in Section 2.1.1.

All of the existing approaches to model the diagnosis phase of recovery actions rely greatly on subjective judgment, since data from actual performance of operators are very sparse. The objective of this work is to reduce the heavy reliance on subjective judgment by providing PRA analysts with an improved method for including recovery actions in a PRA. In this methodology, simulator data are used to estimate recovery for the diagnosis phase, and different diagnosis time-reliability curves are provided based upon the operational similarities of the actions. The action phase is modeled using estimates from available sources. Included in this methodology is a recommendation on where to apply the recovery actions in the PRA.

1.2 Approach to Recovery Methodology Development

This study was conducted in two phases. In Phase 1, a survey was first performed of existing methodologies for including recovery actions and providing estimates of the recovery action failure probabilities. Second, a new approach was developed to model the diagnosis phase of a recovery action. It was decided that existing models could be used for the action phase of a recovery action. The new diagnosis model developed was the Diagnosis Difficulty Matrix (DDM). In the DDM approach, different recovery actions are classified based on judgments of difficulty of recognition (realizing that there is a problem with one of the safety parameters) and evaluation (deciding upon the correct action). Simulator time data for actions having the same recognition and evaluation ratings would be combined to develop diagnosis time-reliability curves. Thus, each cell in the DDM matrix would have a time-reliability curve. This approach was tested using judgment and time data collected during requalification exercises run on the LaSalle simulator located at Commonwealth Edison's Production and Training Center. Results showed the DDM approach to be unsuccessful. Judgments of difficulty performed by instructors and operators were found to be unrelated or only marginally related to the times taken for operating crews to recognize and evaluate the events. In addition, the judgments were found to be inconsistent. This is a significant finding and reflects on all of the approaches that rely primarily on judgment.

Because of the negative results with the DDM approach, another approach was developed and tested in Phase 2. In this phase, diagnosis time data were collected at the LaSalle simulator on accident scenarios which were tentatively identified in the RMIEP study as the dominant accident sequences for the LaSalle boiling water reactor (BWR). The recovery actions were identified and grouped based upon their operational similarities. Once these operational groups were formed, statistical tests were performed on the time data within each of the groups to determine whether the time data could be combined. If the statistical tests supported the operational group, then all data for actions within a group were combined and a function was fitted to the combined empirical data. Ten diagnosis time-reliability curves resulted which provide the PRA analyst with a data-based means of estimating the probability that the operators will fail to correctly diagnose the problem within a specified time.

1.3 Summary of Methodology and Results

From the work done in Phases 1 and 2, two major products result: (1) a complete recovery methodology and (2) a set of data-based curves which are used to provide probability estimates for the diagnosis phase of a recovery action.

The recovery methodology can be summarized as follows:

(1) identification of recovery actions which may be included in the fault trees,

(2) identification of remaining possible recovery actions by examination of the cut sets*

(3) remaining recovery actions are applied directly to the accident sequence cut sets,

(4) recovery actions are modeled as consisting of a diagnosis phase and an action phase,

(5) estimates for the diagnosis failure probabilities, P(ND), are obtained by selecting the appropriate curve from a set of data-based time-reliability curves developed in this study from simulated accidents,

(6) estimates for the action failure probabilities, P(NA), are obtained from NUREG/CR-1278 [4] or equivalent,

(7) estimates from (5) and (6) are combined to produce a single nonrecovery probability, P(NR) for each recovery action,

(8) the original cut set failure probability is then multiplied by the nonrecovery probability of the recovery action to give the new cut set failure probability. For example, if event A in a cut set is recoverable, then:

$$P(\text{cut set})_{\text{original}} = P(\text{event A})*P(\text{event B})$$

$$P(\text{cut set})\text{new} = P(\text{event A})*P(\text{nonrecovery of event A})*P(\text{event B}).$$

The set of curves (Figures B.5.6-1 to B.5.6-10 in Appendix B) used to provide estimates for the diagnosis phase of the recovery action are the results of operational and statistical analyses of operator actions studied during the Phase 2 simulator exercises.

1.4 Conclusion and Recommendations

It was concluded that existing models for the action phase of a recovery action could be used. For the diagnosis phase, a new improved recovery model for estimating diagnosis failure probabilities has been developed. The model is based on actual human actions observed during simulator tests of hypothesized

*A cut set is a minimal combination of equipment failures and operator failures which follow an initiating event and together cause an undesired event.

accident scenarios, and thus is as close to reality as can be obtained in a test. This data-based model is a significant improvement over previous models which have been based only on theoretical human reliability concepts or primarily upon expert opinion. The model developed herein was based on data taken for the LaSalle BWR, but the nature of the recovery actions suggests a much wider applicability. Finally, the model development and data gathering scheme provide useful guidelines for modeling in a wide variety of other applications.

Further research would expand our understanding of diagnosis modeling in several areas. Specific recommendations are to:

(1) determine if different PRA analysts can categorize a set of recovery actions into their appropriate operational groups in a consistent manner,

(2) expand the definitions of the recovery action groups to include other potentially important actions not examined in this study,

(3) collect additional simulator data at the LaSalle simulator for operational groups that had relatively few data points (e.g., Groups 2, 10, and 12),

(4) collect simulator data from other nuclear power plants (i.e., other BWR and pressurized water reactor (PWR) types) and repeat the analyses performed in this study to determine if the groupings of operator actions based upon operational similarities hold for plants other than LaSalle and to see if data-based reliability curves similar to those for LaSalle are found, and

(5) perform an analysis to assess the extent of potential differences between the conditions and the operators' responses in a simulator and during an actual accident, and to perform any necessary and possible calibrations.

1.5 Organization of This Report

The remainder of this report is divided into five sections and two appendices.

- Section 2 describes a survey of other methodologies and presents the recommendations for a new recovery methodology.

- Section 3 describes the data collection program which provided the information necessary to develop the diagnosis model.

- Section 4 describes the complete recovery methodology and provides a sample application.
- Section 5 presents the conclusions of the project and makes recommendations for further improvements in recovery modeling.
- Appendices A and B describe in detail the data collection activities and the subsequent data analyses for Phases 1 and 2, respectively.

2.0 SURVEY OF EXISTING METHODS AND MODEL DEVELOPMENT

In Phase 1 a survey was conducted to evaluate existing methodologies with respect to a list of important criteria. As a result of this survey, a number of areas were identified in which significant improvements in recovery modeling were possible. The new model developed in this work was the result.

2.1 Survey of Other Methods

A survey was undertaken to evaluate existing methodologies for including recovery actions in a PRA as well as to compare models used to estimate the operator team's ability to accomplish the action(s) necessary to mitigate core damage during an accident situation. Important considerations were:

(1) Does the method make recommendations as to how to include recovery in a PRA? In other words, does the method recommend that the recovery actions be included in the cut sets, event tree, or fault tree. The methods were reviewed for such recommendations, since this is an item of interest in developing a complete recovery methodology.

(2) Does it consist of a diagnosis phase and an action phase?

(3) Is the model data-based rather than based on theory or based upon expert opinion?

(4) Does the methodology provide estimates of the likelihood of recovery for the diagnosis and action phases? Are the estimates probabilistic in nature? Are they time dependent? Is there a basis for different response curves for the operating crew depending upon the action necessary to bring the nuclear power plant to a stable condition?

2.1.1 Discussion of Individual Methodologies and Models

In this section the existing methodologies and models reviewed are summarized with respect to their applicability in including recovery actions in the PRA or estimating the likelihood that the operators will fail to accomplish the recovery action.

2.1.1.1 NUREG/CR-1278 Methodology

The methodology for including recovery actions in Chapter 12 of the Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications: Final Report [4] (hereafter called the Handbook) consists of the Initial-screening model and the Nominal model. As the name indicates, the Initial-Screening model is used to perform a preliminary sensitivity analysis of operator team recovery actions. The model accounts for both the diagnosis phase and the action phase of the recovery action. It uses conservative failure probabilities for the operators' failing to diagnose the accident and failing to accomplish the action identified in the diagnosis of the accident. Any operator recovery actions which survive this initial screening are then analyzed using the Nominal model. This model is intended to provide more realistic (best estimate) probabilities for the operators failing to diagnose the accident. The action phase of the surviving recovery actions is estimated using other models in Chapter 20 of the Handbook. These action phase models are both probabilistic and time dependent.

The diagnosis phase of each model is both probabilistic and time dependent in nature. Neither model provides different response curves for different operator actions; however, rules are provided to adjust generic time-reliability curves according to plant-specific PSFs. The response times and the human error probabilities (HEPs) used to produce both models are derived primarily from expert opinion. Such opinions are considered as speculative, as is stated in the Handbook. Guidelines for adjusting the diagnosis HEP are given so that an analyst can modify the HEPs depending upon the event and the operators' familiarity with the event. The Handbook makes no recommendation as to what stage in the PRA the recovery actions should be applied.

2.1.1.2 Operator Action Tree Model

The Operator Action Tree (OAT) model [6] has two basic components: an operator action tree and a time-reliability relationship. The operator action tree is a logic tree which identifies potential failure states that can result from the operators' failing to correctly respond to events during an accident. Three failure states are identified in the operator action tree: (1) observation failures, (2) decision-making failures, and (3) implementation failures. The time-reliability relationship is a single curve based upon expert opinion.

The method is applied in five steps:

(1) Identify functions required to ensure the safety of the plant.

(2) Identify the actions required by the operators to ensure success.

(3) Identify the information displays and timings associated with the operator actions.

(4) Include the errors in the fault or event trees of the PRA.

(5) Estimate the probabilities of the errors.

The OAT model uses a single time-reliability curve which applies only to the diagnosis phase of recovery. The probability of performing the action correctly is assumed to be one (1.0).

2.1.1.3 Time Reliability Correlation Model

The Time Reliability Correlation (TRC) model developed by Wreathall and Fragola [6] is a model which provides estimates for the probability of successful action by the operators. The TRC model does not specifically indicate where the operator actions should be applied in the PRA, but it is intended for use in the OAT methodology.

The TRC technique was developed from an analysis of the times taken to perform various tasks. These data range from response times for single-step learned responses with unambiguous prompts to cognitive data resulting from consensus estimates of clinical judgment. It therefore implicitly includes errors in decision making since the response was defined as "taking a correct action". The data have been tentatively grouped into the categories of skill-, rule-, or knowledge-based behavior. This model again applies just to the diagnosis phase, but utilizes three time-reliability curves to account for all recovery actions. The choice of the appropriate curve depends on whether the recovery action is a skill-, rule-, or knowledge-based action (in the judgment of the analyst).

2.1.1.4 Success Likelihood Index Methodology

In the Success Likelihood Index Methodology--Multi-Attribute Utility Decomposition (SLIM-MAUD) methodology [7,8,9], a computer-based procedure, implemented in the code MAUD, is used to elicit and organize expert opinion within the framework of SLIM. SLIM is based on the assumption that various PSFs (characteristics of the individual, the situation, and the task itself), enhance or degrade the likelihood of successfully accomplishing the task. A logarithmic relationship between expert judgment and success probabilities is assumed to exist. To use the SLIM-MAUD technique, probabilities for two tasks must be known to calibrate the logarithmic relationship.

The SLIM-MAUD methodology is used strictly for providing probability estimates for specific actions and does not make any recommendations as to where these actions should be included in a PRA. The actions for which estimates can be provided include actions for both the diagnosis phase and the action phase.

2.1.1.5 Human Cognitive Reliability Model

The Human Cognitive Reliability (HCR) Model [10] has as its basis three normalized time-reliability curves. The shape of these curves are associated with the different types of human cognitive processes (i.e., skill, rule, or knowledge) associated with the task. The type of cognitive processing in play in any situation can be estimated by an evaluation of conditioning factors. The normalized time is calculated by dividing the actual time required to perform a given task by the median time required to accomplish the task. This process allows the model to produce a situation-specific nonresponse probability versus time curve based on input data which are measurable from either actual or simulated events. Thus the HCR model has three normalized curves which can be used to provide estimates of the operators' probability of non-response. The curve of nonresponse probability versus time can also be modified by use of PSFs (e.g., stress, control room layout, training, etc.). This is accomplished by using the PSFs to modify the median time to perform the task. An important assumption made is that the conditioning factors affecting the cognitive processing are independent of the PSFs that modify the nominal median time.

The HCR model provides estimates for the diagnosis phase of the recovery action. It makes no specific recommendations as to where the recovery action should be included in the PRA. However, recommendations for including the results in fault trees or event trees are provided in [21].

2.1.1.6 Operator Action Event Tree Model

The Operator Action Event Tree (OAET) [11,12] model is a qualitative logical representation which can be used to describe the possible operator actions during an accident at a nuclear power plant. The actions are represented in an event tree format. This format can provide a description of the whole range of operator actions, both successes and failures, in an accident sequence. As such, it is qualitative in nature, and no attempt has been made to provide any probability estimates for the operator actions identified in the OAET.

2.1.1.7 Interim Reliability Evaluation Program (IREP) Procedures Guide

The IREP Procedures Guide [3] contains recommendations for a simplified recovery model. It recommends that recovery actions be included at the cut set level. Recovery actions are separated into two categories: (1) actions which can be accomplished from the control room and (2) actions which must be performed locally. The probability of accomplishing an action is time dependent. Actions which must be accomplished locally require ten minutes longer to accomplish than actions which can be accomplished in the control room. In the IREP Procedures Guide, it is not clear whether the recovery action is composed of a diagnosis phase and an action phase. In any case, the estimates for the recovery action, which are judgment-based, are estimates for the complete recovery action, including diagnosis.

2.1.2 Conclusions

Table 2.1.2-1 summarizes the various model characteristics on the basis of the items of interest identified in section 2.1.

Based on the review, it was seen that several important improvements could be made in the modeling of the diagnosis phase of recovery. First, existing diagnosis phase models and methodologies rely heavily upon expert opinion rather than simulator data from potentially dominant accident scenarios. It was felt that the use of simulator data would provide more accurate estimates of real-world diagnosis failure probabilities than expert judgment. Second, existing models and methodologies produce no more than three response curves (see Table 2.1.2-1). It was felt that the use of simulator data to define a wider variety of time-reliability curves would result in better resolution of different recovery actions and greater ease in application because of more clearly defined actions. Thus, it was decided to develop a new diagnosis phase model and perform an extensive data gathering program on a simulator to ground the model in reality.

2.2 Improved Recovery Methodology

It is recognized that some recovery actions are included in the fault trees. These recovery actions are the high level procedural actions which are prescribed in the Emergency Procedures Guidelines (EPGs) of the plant. There are two basic types of prescribed actions that are considered for inclusion in the fault trees. They are:

(1) Those actions that direct the control room operators to start or to verify the start of automatically actuated systems when the operators reach that check point in the EPGs.

(2) Those actions that direct the control room operators to start manually actuated systems when specified conditions exist.

Given these two types of prescribed actions, the methodology is summarized as follows:

(1) Identify those recovery actions that are to be placed on the fault trees.

Table 2.1.2-1
Comparisons of Models and Methodologies

Model Methodology	Where Recovery Action Included	Provides Estimates of Human Error Probabilities				Different Response Curve for Different Actions	Number of Response Curves
		Diagnosis		Action			
		Probabilistic	Time Dependent	Probabilistic	Time Dependent		
Handbook:							
Initial Screening	NRM	Yes	Yes	Yes	Yes	No	1
Nominal	NRM	Yes	Yes	Yes	Yes	No	1
OAT	(1)	Yes	Yes	No	--	No	1
TRC	NRM	Yes	Yes	No	--	Yes	3
SLIM-MAUD	NRM	Yes	In-directly	Yes	In-directly	No	--
HCR	(2)	Yes	Yes	No	--	Yes	(3)
OAET	ET	No	--	No	--	No	--
IREP	CS	(4)	Yes	(4)	Yes	Yes	2

(1) OAT document [6] suggest ET or FT; however, the Kuosheng PRA [19] uses OAT and applies the recovery actions to the cut sets.
(2) HCR document [10] makes no recommendation; however, the SHARP document [21] does provide recommendations for including the HCR results in ET or FT.
(3) Event specific. Based on the dominant cognitive process associated with the task.
(4) The estimates provided are for the recovery actions as a whole.
NRM - No Recommendation Made
ET - Event Trees
FT - Fault Trees
CS - Cut Sets

(2) The remaining recovery actions are applied directly to the cut sets. This was chosen because each cut set represents one way the accident sequence may occur. The cut set provides a list of the failures which must occur and provides information on the amount of time available to accomplish the recovery action. With this information the analyst can identify actions which the operators can take to prevent or mitigate core damage.

(3) The recovery action is modeled as consisting of a diagnosis phase and an action phase. The diagnosis phase is the phase in which the operators decide what action(s) must be accomplished to prevent or mitigate core damage. In the action phase the operators physically carry out the action(s) decided on in the diagnosis phase.

(4) Estimates of the failure probabilities for each phase are provided using separate models. The HEP estimates for the action phase are based on models from the Handbook [4]. The HEPs are described collectively in Chapter 20 of the Handbook. This provides estimates for operators physically accomplishing the necessary actions (e.g., starting a pump correctly, choosing the correct switch in a set of switches, etc.).

The model for providing probability estimates for the diagnosis phase of the recovery action is derived from the analyses of data gathered during Phase 1 and Phase 2, as described in this report.

(5) Once the recovery actions have been identified, the analyst can use the amount of time available to accomplish the recovery action and the identified action as input to the model for estimating the probability that the operators will fail to accomplish the recovery action. Using the estimated probability, each cut set can be requantified. Since the recovery actions are applied directly to the cut sets, the sequences need be requantified only once.

3.0 DATA COLLECTION AND ANALYSES

The data collection program was conducted in two phases. In Phase 1, data were collected during the requalification exercises conducted on the LaSalle simulator. Phase 2 data were collected during simulated severe accident scenarios which were chosen based on preliminary dominant accident sequence analysis results of the RMIEP PRA of LaSalle. For a detailed discussion of the data collection and analyses for Phases 1 and 2, see Appendices A and B, respectively.

3.1 Phase 1 Data Collection and Analyses

During Phase 1, a quite general model for estimating the diagnosis phase of a recovery action was hypothesized. This model consisted of (1) a Diagnosis Difficulty Matrix (DDM) and (2) a set of Diagnosis Time Curves.

In concept, the DDM was viewed as a means of classifying different recovery actions based on expert opinion as to the relative difficulty of various recovery actions. The DDM would be derived from the results of operator and instructor questionnaires pertaining to judgments of difficulty of recognition (operators realize that a problem exists with one of the safety parameters) and evaluation (operators decide upon a course of action to correct the problem) for various aspects of accident sequences. Using the DDM, the analyst would determine the difficulty of the recovery action in which he is interested. With the level of difficulty determined, the appropriate diagnosis time curve could be chosen. This curve would provide the analyst with the means to estimate the probability that the operators would fail to diagnose the correct recovery action within the allowable time.

3.1.1 Description of Data Collected

Nine simulator scenarios (described in Table 3.1.1-1) were used during Phase 1 data collection. The data obtained during Phase 1 fall into three categories:

(1) Operator experience and training data,

(2) Time-dependent simulator performance data,

(3) Expert opinion on difficulty of recognition and evaluation and other information on drills.

The Operator Biographical Data Form, Figure A.1.1-1 in Appendix A, was used to collect information pertaining to experience and training of individual operators. This information would potentially be used in correlating the expert opinion data collected on the Operator Questionnaires and the simulator performance data collected on the Time Data Sheets

TABLE 3.1.1-1

Description of Simulator Drills Used in Phase 1

Descriptor	Initiating Event	System Status	Malfunction	Operator Action
A1	Load change	Hot full power	Loss of automatic control to the turbine driven feedpump	Balance feedwater flow by taking manual control of the turbine driven feedpump
A2	Surveillance	Hot full power	Standby gas treatment malfunction	Initiate shutdown of the plant based upon a violation of the tech. specs.
A3	Load change	Shutting down	Second turbine driven feedpump control malfunction	Establish flow control with both feedpumps in manual operation
A4	Load following	Feedwater in manual high pressure injection systems available	Loss of feedwater	Establish control of reactor water level
B1	Loss of feedwater control	Full power	Feedwater run up in speed	Establish manual control of the feedwater water to normal flow
B2	Feedwater line rupture	Full power manual control of feedwater	Feedwater line break	Establish control of the water level in the vessel
C1	Loss of electric bus 152	Full power/ motor driven feedpump seizes/RCIC fails after 5 minutes	Three control rods stick out	Operating team decides to take no action since stuck rods pose no threat
D1	HPCS surveillance failure	Full power/ RCIC is unavailable	Tech. Spec. violation when both RCIC & HPCS are unavailable	Initiate a reactor shutdown
D2	Loss of coolant accident	Full power/all high pressure cooling systems unavailable	Loss of level control in the vessel at high pressure	Operators establish a method of low pressure cooling

with such factors as age, experience, education, job classification, etc.

The Time Data Sheets, Figures A.1.1-2 through A.1.1-10 in Appendix A, were used by the instructors to record the times at which the operators recognized that a problem existed and the times when operators performed the necessary actions to bring the plant to a safe condition for each drill.

The Operator Questionnaires (Figures A.1.1-11 through A.1.1-19 and Instructor Questionnaires (Figures A.1.1-20 through A.1.1-28) in Appendix A, were used to provide expert opinions on the level of difficulty of recognition and evaluation for each drill as well as provide additional information on each drill. The purpose of the questionnaires was to provide the information necessary to construct the Diagnosis Difficulty Matrix. A full description of the data gathered is presented in Appendix A.

3.1.2 Description of Analyses

The consistency of the judgment data was examined by calculating the mean and standard deviation of the individual recognition and evaluation ratings for each drill. The judgments were also analyzed through analyses of variance (ANOVAs) to determine the influence of factors such as assignment (operator or instructor), crew, and drill upon the mean recognition and evaluation ratings. To more closely examine the extent of differences among means, Scheffe's multiple comparisons test [13] was run on means for significant factors in the ANOVA.

For the recognition and evaluation time data, an empirical complementary cumulative distribution function (ccdf) of time until recognition and time until evaluation were plotted for each drill. The recognition and evaluation time data were also analyzed through ANOVAs.

Results from the analyses on the judgment data were compared with the results from the analyses on the time data to determine if there were similar patterns of findings for the recognition and evaluation ratings and times. The relationships among the judgment and time data were also examined using Spearman's Rank Correlation Coefficient [14].

3.1.3 Discussion of Results

Results showed that, although there was some limited correspondence between the recognition ratings and the recognition times, the degree of association was weak. The ordering of drill means from most difficult to easiest was sufficiently different for the two sets of data, so that prediction of recognition times from recognition ratings would be highly inaccurate. Results also showed that there was no correspondence between the evaluation ratings and the evaluation times. This negative finding is especially important, since prediction of evaluation time in addition to recognition time is needed to use the DDM approach.

It was also found that the recognition and evaluation ratings were highly inconsistent among the instructors and operators. Individual ratings for the drills often spanned almost the entire range of possible ratings, even though the ratings were performed immediately following each drill simulation. If the ratings are so inconsistent among those with substantial amounts of nuclear power plant operational knowledge and hands-on operational experience, one can expect only less promising results when those without or with less operational experience, such as PRA analysts, are required to make such judgments. This would be especially likely if such judgments were performed without the benefit of a prior drill simulation as may often be the case for PRA analysts.

Thus, the results of the Phase 1 data analyses did not support further development of the DDM approach. The main reasons were the lack of correlation between the judgment and simulator performance data and the inconsistency of the judgment data. Therefore, for Phase 2, a different modeling approach was taken. This new approach categorized the actions into separate groups based upon their operational similarity.

3.2 Phase 2 Data Collection and Analyses

During Phase 2, a new data-based model for analyzing the diagnosis phase of a recovery action was successfully developed. This model consists of (1) a comprehensive set of recovery action groups defined according to the operational similarity of the operator actions within that group, and (2) a complementary cumulative distribution function (ccdf) of diagnosis times for each group.

To use the set of recovery action groups, the analyst selects the group which best describes the most likely recovery action (or actions) for the cut set of interest. While judgment is still required in this methodology, it is a relatively simple type of judgment. Once the analyst has listed the correct actions following an abnormal event, he then only has to select the group of actions that is most similar to the action being analyzed. Once the appropriate recovery action group is identified, the associated ccdf provides the analyst with an estimate of the probability that the operators would fail to diagnose the correct recovery action within the allowable time.

3.2.1 Data Collection Methodology for Phase 2

The data were collected in three steps: (1) development of the simulator drills to test the operators, (2) development of the data collection forms to record the data from the drills, and (3) recording the data for each simulator drill. See Appendix B for a more detailed discussion of the Phase 2 data collection.

Unlike the Phase 1 simulator exercises (which consisted of standard operator requalification drills), the exercises developed for Phase 2 were hypothesized severe accident scenarios identified in preliminary results of the RMIEP PRA. Eight realistic plant-specific accident scenarios (briefly described in Table 3.2.1-1 and described in detail in Tables B.1.1-2 through B.1.1-9 in Appendix B) were developed into simulator drills.

The Operator Biographical Data Form (Figure B.1.2-9 in Appendix B) was used to collect information pertaining to the experience and training of the individual operators. This information would potentially be used to correlate simulator performance data with factors such as age, experience, education, job classification, etc.

Since the Phase 1 data analyses were still in progress when Phase 2 data collection began, expert opinion data on difficulty of recognition and evaluation and other information on the drills were collected in Phase 2. However, in view of the negative findings with respect to expert opinion data in Phase 1, these data were not analyzed in Phase 2.

The primary data in Phase 2 were time-dependent simulator performance data. The Time Data Collection Forms (Figures B.1.2-1 through B.1.2-8 in Appendix B) were used to record the times at which important steps and substeps were taken by the operators in dealing with an accident. Data were collected from twelve different teams of operators. These data were used to develop the model to provide estimates for the diagnosis phase of a recovery action.

3.2.2 Description of Data Analyses

The recovery actions were grouped by systems analysts according to their operational similarity, and statistical tests were conducted to verify the groups.

From the data available for each operator action, a ccdf of observed diagnosis times was plotted (see Figure 3.2.2-1 as an example). This distribution provides the empirical probability of failure to initiate the correct action as a function of time from the cue or compelling signal. The Smirnov test [15] was used to pairwise compare the empirical ccdfs of diagnosis times for different actions within each group to see if the distributions differed significantly.

An analysis of variance (ANOVA) of these data was also performed to see if the mean diagnosis times differed significantly among

Table 3.2.1-1
Brief Description of Phase 2 Accident Scenarios

Descriptor	Accident Description
1A	ATWS - Initiated by MSIV closure, reactor fails to trip, motor driven feedwater pump available.
1B	ATWS - Initiated by MSIV closure, reactor fails to trip, motor driven feedwater pump unavailable.
2	Transient with Narrow Range Level Instrument Malfunction - Initiated by spurious turbine trip, a steam leak into the reactor building causes narrow range level instrumentation to fail high resulting in loss of high pressure injection.
2B	Transient with Narrow Range and Wide Range Level Instrument Malfunctions - Initiated by spurious turbine trip, a steam leak into the reactor building causes narrow range and wide range level instrumentation to fail high resulting in loss of high pressure injection.
3	Station Blackout - Initiated by a loss of offsite power, followed by failure of the diesel generators (DGs), RCIC injection valve fails to open.
4	Delayed Station Blackout - Initiated by a loss of offsite power, followed by failure of two diesel generators, third diesel generator starts and loads. The start and load sequence of third DG causes isolation of RCIC. Third DG fails after approximately twenty minutes.
6	Transient with DC Bus 1A Failure - 125 volt, DC bus 1A shorts to ground and will result in a reactor trip, subsequent failures threaten critical parameters.
8	Feedwater Line Break - A feedwater line breaks in the steam tunnel, results in loss of flow to the reactor pressure vessel from feedwater/condensate. Subsequent failures result in loss of all high pressure systems, low pressure systems are available.

ATWS - Anticipated Transient Without Scram
MSIV - Main Steam Isolation Valve
RCIC - Reactor Core Isolation Cooling System

actions within a group. If the statistical criteria were met (i.e., the data within a group successfully passed both the Smirnov test and the ANOVA), then the data for all actions within a group were combined to develop one empirical ccdf of diagnosis times (see Figure 3.2.2-2 as an example).

The final step was to fit a standard probability distribution to the diagnosis time data. This would improve the accuracy of interpolations and extrapolations, and would permit an evaluation of the uncertainty of estimated failure probabilities at specific times.

Inspection of the empirical ccdfs suggested that a lognormal function would provide a good fit to the data. Two approaches were taken to verify that this was correct. One approach was to inspect normal probability plots of log time versus the cumulative probability of success to see if this relationship was linear. The other approach was to run statistical tests (i.e., either the Kolmogorov D statistic or the Shapiro-Wilk statistic [15,16]) to determine whether the log time data were normally distributed. The best fitting lognormal function was fitted to the combined time data using a statistical program called CENSOR [17].

It should be noted that this is a different use of the lognormal distribution from what has been done in many PRAs. There, the (generally subjective) uncertainty with which some parameter, such as the probability of failure of diagnosis in T minutes, is known has been expressed via a lognormal distribution. Here, the time to correct diagnosis is modeled as a lognormally-distributed random variable. The fitted lognormal curve provides a point estimate of the probability of failure of diagnosis in T minutes, not an assessment of the uncertainty in that estimate. Statistical uncertainty, that is, the uncertainty attributable to the amount of available data going into that estimate, is gauged by statistical confidence limits, which have also been calculated. These limits, at any particular value of T, are not lognormal percentiles.

3.2.3 Discussion of Results

The results of the Phase 2 data analyses showed that the full spectrum of identified recovery actions could be represented by ten recovery action groups. For each group, a single time-reliability curve of lognormal form provides an estimate of the probability of failure to diagnose the appropriate action as a function of time (see Figures B.5.6-1 to B.5.6.-10 in Appendix B and the appropriate tables in Volume 2). The diagnosis failure probability at any given time ($P_{ND}(t)$) is calculated by:

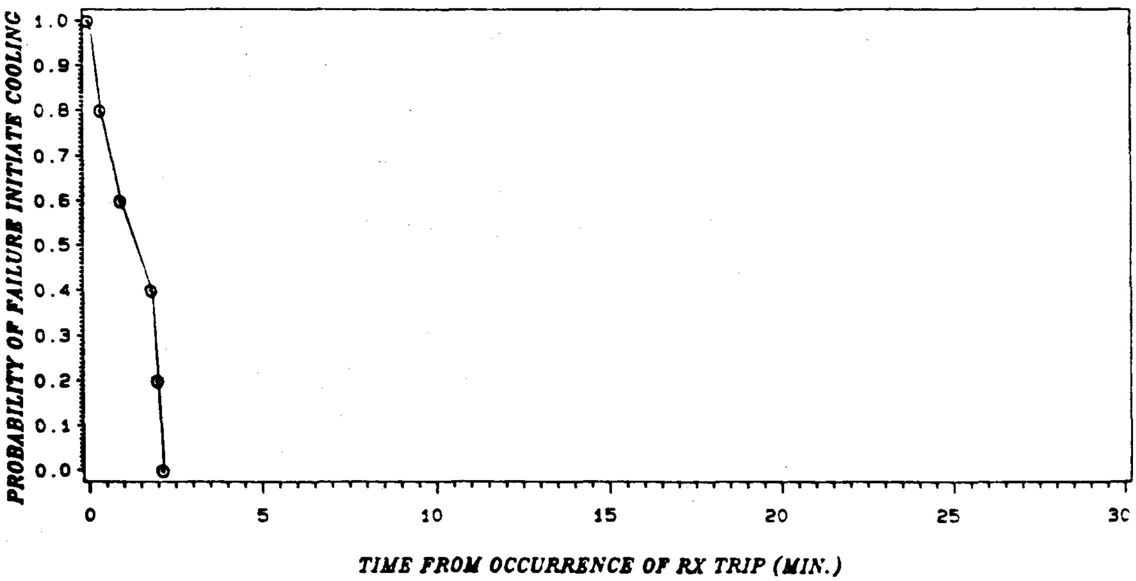
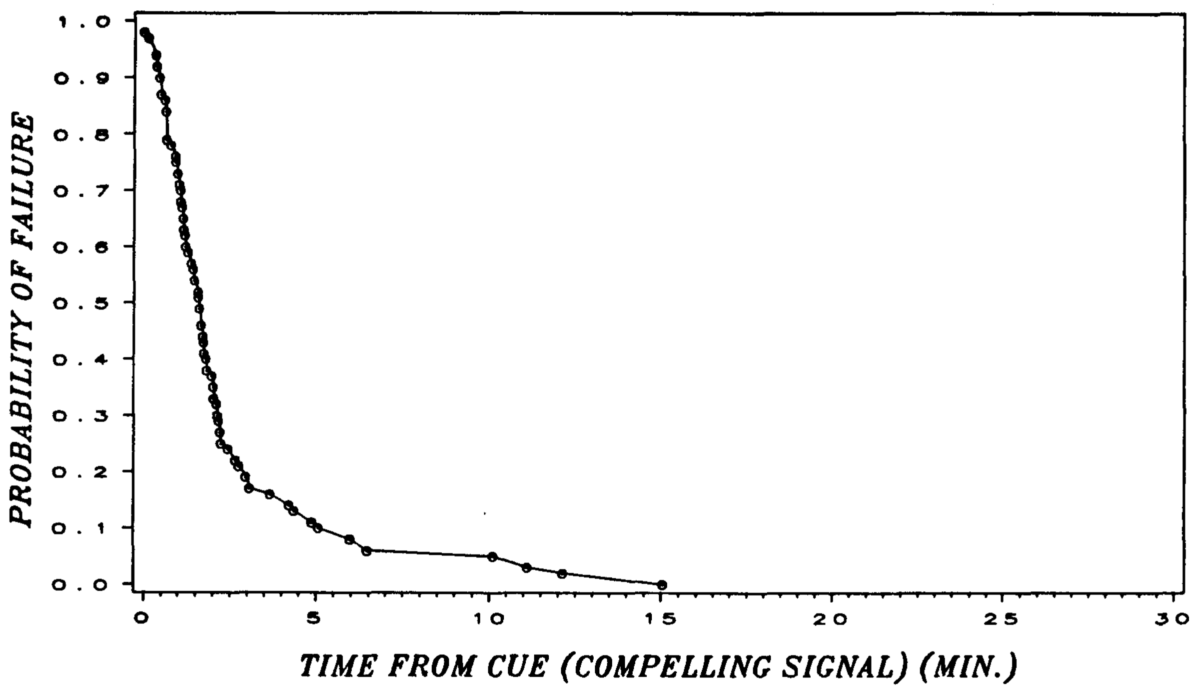


Figure 3.2.2-1. Drill 8, Probability of <u>Failure</u> to Initiate SP Cooling after Occurrence of RX Trip



Sample size = 63.

Group 9 combined with Group 1.

Figure 3.2.2-2. Group 1, Empirical Probability of <u>Failure</u> to Manually Operate a System or Component to Control a Critical Parameter Prior to the Automatic Actuation (if it Has Automatic Actuation) of the System or Component

$P_{ND}(t) = Z(x)$

where t is time,

$Z(x)$ is the value from the Cumulative Standard Normal Distribution at x,

$x = (-\log_{10}(t)+\mu)/\sigma$ and μ and σ are the values of μ and σ obtained from the fitted function.

These diagnosis failure probabilities are combined with human error probabilities for failure to perform the identified action to obtain the overall nonrecovery probability. The ten groups of actions and their associated time-reliability parameter estimates are shown in Table 3.2.3-1. For each group, the table includes estimates of the median diagnosis time (time from the cue or compelling signal to the time when the correct action was started)(minutes), and the mean and standard deviation (of logarithms) of the fitted lognormal function. The last column in the table shows the number of observations (sample size) per group. The recovery actions included in each group are shown in Table 3.2.3-2.

Table 3.2.3-1
Estimated Parameters from Fit of Lognormal Function

Group	Recovery Action Group Description*	Median (mins.)	Mean of Log Time	Standard Deviation of Log Time	Sample Size
1 & 9	Manual operation of system or component to control a critical parameter prior to the automatic actuation (if it has automatic actuation) of the system or component.	1.6	.19	.43	63
2	Use low pressure systems when high pressure systems are unavailable.	8.9	.95	.12	10
3	Manual operation of systems or components which failed to automatically actuate (operate).	2.3	.36	.46	18
4	Restoration of safety-related in-house electrical buses or supply equipment.	1.4	.13	.32	30
5	Restoration of offsite-supplied non-safety-related electrical buses or supply equipment.	11.2	1.05	.44	24
6	Manual backup of an automatic shutdown function.	.1	-0.93	.38	82
8	Manual override of system that automatically functions when automatic operation of the system would challenge a critical parameter.	3.8	.58	.52	24
10	Request use of last line of (GARBAGE)** systems for level control.	1.4	.16	1.01	8
11	Local operation of manually controlled components normally operated from the control room when control-room operation fails.	7.1	.85	.50	15
12	Manual override of a false control signal when no direct indication exists that the control signal is false or erroneous.	10.5	1.02	.23	4

*The items listed in this table refer to the correct diagnosis of the required action.

**GARBAGE systems are those systems which are used only as a last resort to prevent core damage. These systems inject "dirty" (non-reactor grade) water into the vessel and are used only if no other means of injecting water into the vessel are available.

Table 3.2.3-2
Summary of Ten Groups of Crew Recovery Actions*

Group	Description of Recovery Actions	
1 & 9	Manual operation of system or component to control a critical parameter prior to the automatic actuation (if it has automatic actuation) of the system or component.	1. Drill 1 -- Initiate RHR after ATWS 2. Drill 2 & 2B -- Initiate SP cooling after RX Trip. 3. Drill 3 -- Initiate RCIC after station blackout. 4. Drill 4 -- Initiate SP cooling after DG1A loads. 5. Drill 6 -- Close MSIVs after Level 7 alarm. 6. Drill 6 -- Close FW valve 1A after Level 7 alarm. 7. Drill 6 -- Initiate SP cooling after RX trip. 8. Drill 8 -- Initiate SP cooling after RX trip. 9. Drill 1 -- Inject SBLC after SP temperature high-high alarm.
2	Use of low pressure systems when high pressure systems are unavailable.	1. Drill 8 -- Depressurize after RCIC failure. 2. Drill 8 -- Inject LP after RCIC failure.
3	Manual operation of systems or components which failed to automatically actuate (operate).	1. Drill 3 -- Send B-man to open F013 after F013 failure. 2. Drill 4 -- Reset RCIC isolation after DG 1A loads. 3. Drill 8 -- Request RCIC investigation after RCIC failure.
4	Restoration of safety-related in-house electrical buses or supply equipment.	1. Drill 3 -- Request DG 0 repair after station blackout. 2. Drill 3 -- Request DG 1B repair after station blackout. 3. Drill 3 -- Request DG 1A repair after station blackout. 4. Drill 4 -- Request DG 1B repair after SAT failure. 5. Drill 4 -- Recover DG 1A after DG 1A trouble. 6. Drill 6 -- Request DG A investigation after DC A failure.
5	Restoration of off-site-supplied non-safety-related electrical buses or supply equipment.	1. Drill 3 -- Request X-tie after station blackout. 2. Drill 3 -- Request SAT repair after station blackout. 3. Drill 4 -- Request SAT repair after SAT failure. 4. Drill 4 -- Request X-tie after SAT failure. 5. Drill 6 -- Restore Bus 151 locally after RX trip.
6	Manual backup of an automatic shutdown function.	1. All Drills -- Mode switch after RX trip. 2. All Drills -- Manual scram after RX trip.
8	Manual override of a system that automatically function when automatic operation of the system would challenge a critical parameter.	1. Drill 1 -- Jumper VP after drywell isolation. 2. Drill 4 -- Restore VP after drywell isolation. 3. Drill 6 -- Restore VP after DC A failure. 4. Drill 8 -- Restore VP after drywell isolation.
10	Request to use last line of (GARBAGE)** systems for level control.	1. Drill 4 -- Depressurization after station blackout. 2. Drill 4 -- Request diesel fire pump after station blackout.
11	Local operation of manually controlled components normally operated from the control room when control-room operation fails	1. Drill 2 & 2B -- Send B-man to close SDV valves after scram reset attempt. 2. Drill 6 -- Request air restoration after service air pressure low alarm.
12	Manual override of a false control signal when no direct indication exists that the control signal is false or erroneous.	1. Drill 4 -- Request bypass of RCIC isolation after RCIC isolation because of room overheating.

*The items listed in this table refer to the correct diagnosis of the required action.

**GARBAGE systems are those systems which are used only as a last resort to prevent core damage. These systems inject "dirty" (non-reactor grade) water into the vessel and are used only if no other means of injecting water into the vessel are available.

4.0 SUMMARY OF RECOVERY METHODOLOGY AND SAMPLE APPLICATION

4.1 Summary of Recovery Methodology

From the results of Phase 1 and 2, a new recovery methodology was developed. Figure 4.1-1 provides a flow chart for the recovery methodology. The recovery methodology can be summarized as follows:

(1) Appropriate recovery actions are identified. This includes recovery actions which are to be placed directly on the fault trees and recovery actions which result from examination of the information contained in the cut sets.

(2) The recovery actions which are not included in the fault trees are applied to the cut sets (see Section 2.2).

(3) The recovery actions are modeled as consisting of a diagnosis phase and an action phase.

(4) Estimates for the diagnosis phase are obtained by:

(a) Determining how much time the operators have to diagnose the accident. This can be estimated by the following expression:

$$T_D = T_M - T_A$$

where T_M is the maximum time in which both phases of the recovery action must be completed (estimated using thermohydraulic computer codes which provide information on core or containment parameters (i.e., pressure, temperature, water level, etc.)),

T_A is the time required to physically accomplish the action (conservatively estimated as the sum of the maximum time required to reach the area where the action is to be accomplished and the time required to accomplish the action -- these should be based on actual measurements where possible), and

T_D is the time to diagnose the problem and identify an appropriate recovery action.

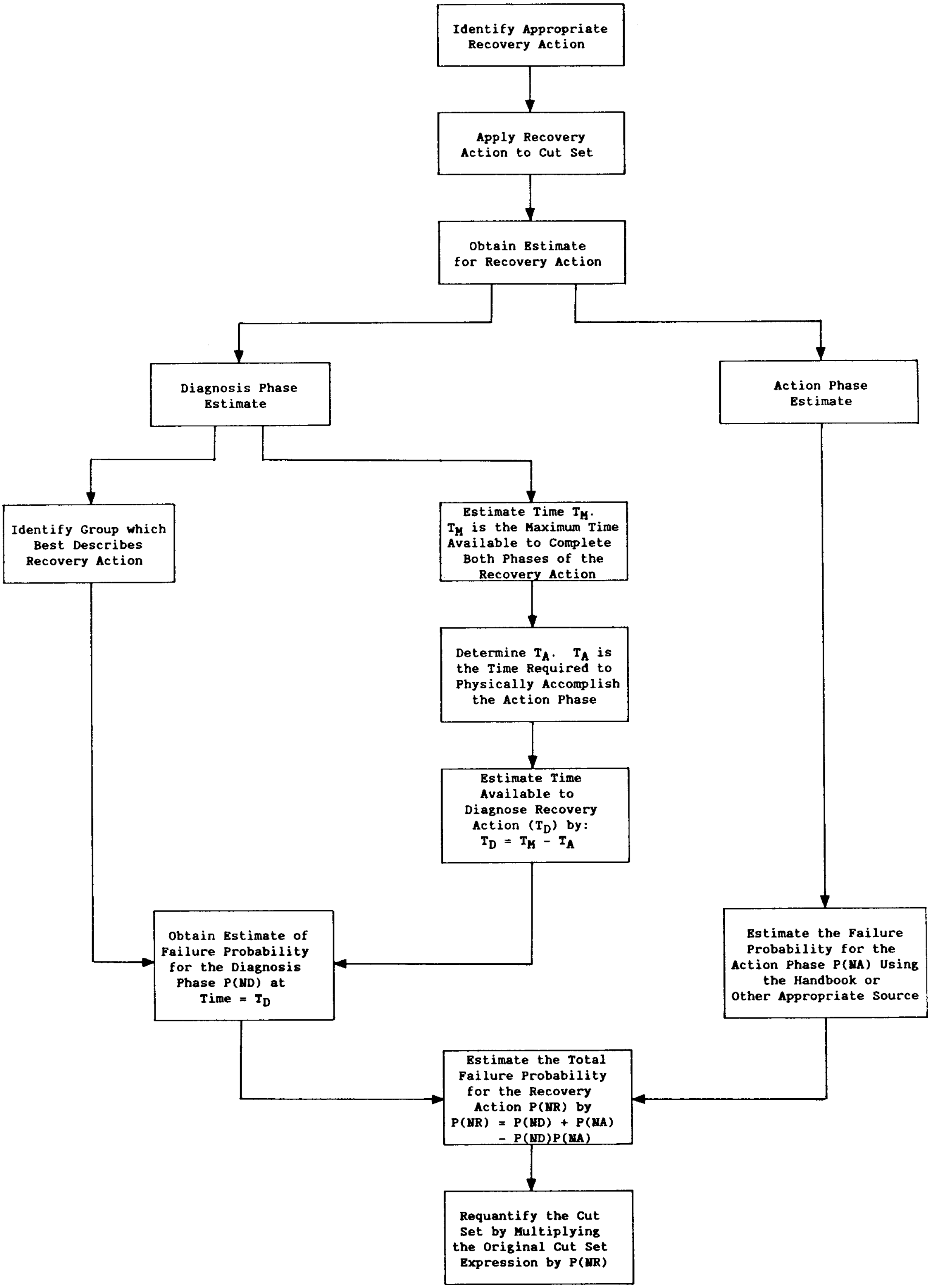


Figure 4.1-1. Recovery Methodology Flow Chart

(b) Selecting the action group from Table 3.2.3-2 which best describes the recovery action. The analyst should examine the actions in each group and choose the group that contains actions that are most similar to the one of interest.

(c) Using the table corresponding to the action group selected in (4b)*, determine the estimated failure probability given the available diagnosis time T_D.

(4) The action phase human error probabilities can be computed from any of a number of different sources, as considerable work has been done in this area. No new models for action probabilities were developed in this project. For application to RMIEP, the models in the Handbook (NUREG/CR-1278) will be used.

(5) Calculate the total failure probability for the recovery action as the probability of either failing to diagnose the appropriate action or failing to perform the recovery action, using the following expression:

$$P(NR) = P(ND) + P(NA) - P(ND)P(NA)$$

where P(NR) is the failure probability for the recovery action,

P(ND) is the failure probability for diagnosing the required action within time T_D,

P(NA) is the failure probability for physically accomplishing the action within time T_A.

This recovery methodology will result in conservative estimates of the total failure probability for a recovery action. This is because the methodology uses two separate time-dependent failure probabilities, the diagnosis failure probability within T_D and the action failure probability within T_A. Thus, for example, a case in which diagnosis occurs at $T_D + 1$ min., say, but action is accomplished in less than $T_A - 1$ min., is not counted as a success when in fact it is since diagnosis and action are accomplished within T_M. Sensitivity of P(NR) to choice of T_A can be examined by the analyst.

*Note: See the appropriate tables in Volume 2.

A more detailed discussion of the recovery methodology including recommendations for application to RMIEP and other PRAs is found in Volume 2 of this report. The tables needed for estimating the diagnosis failure probabilities for recovery actions can also be found in Volume 2.

4.2 Sample Application

To illustrate the application of this recovery methodology, consider the following simplified example consisting of a single accident sequence with one dominant cut set. For the failures which constitute the cut set, it is assumed that the only way the operators can prevent core damage is to manually open a high pressure system valve that failed to automatically open. This recovery action must be accomplished within seventy (70) minutes or core damage will result.

Thus, for the recovery action, $T_M = 70$. From time measurements, it is estimated that a maximum of fifteen (15) minutes is needed for an operator to reach and then to manually open the high pressure system valve, thus $T_A = 15$. Therefore, the time available for diagnosis is,

$$\begin{aligned} T_D &= T_M - T_A \\ &= 70 - 15 \\ &= 55 \text{ minutes} \end{aligned}$$

To estimate P(ND), Table 3.2.3-2 is searched for the action group which best describes the required action. In this case the best description is given by Group 3 (Manual operation of systems or components which failed to automatically actuate). Then using the table associated with this group, Table 4.2-1 (reproduced from Volume 2), and the value for T_D (55 minutes), the estimate for P(ND) is found to be 0.0014.* This estimate is fairly imprecise, as reflected by the lower and upper 95% statistical confidence of .00004 and .047, respectively (see Table 4.2-1). The reason for this imprecision is the fact that the sample size for this group of operations is 18, so estimating the roughly 1-in-a-thousand diagnosis time is a considerable extrapolation.

The Handbook is used to estimate the value for P(NA). Since, in this case, an operator would have directed someone to manually open the valve and is waiting for flow to be established, the estimate for P(NA) is obtained by the following:

Given that the operator has diagnosed the recovery action, the operator calls a B-man to go and manually open the failed high pressure injection valve. The operator will be monitoring a control room indicator (e.g., flow meter) which will provide

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*Note: See Volume 2 of this report for other recommended uses of these data.

Table 4.2-1
Group 3, Parameter Estimates from Fit of Lognormal Function
(N = 18, Mean = .36, Standard Deviation = .46)

Time (min.)*	Standard Deviation of Point	Probability of Failure	Upper 95% Confidence Limit	Lower 95% Confidence Limit
1	.079	.78	.90	.59
2	.094	.55	.72	.37
3	.093	.40	.59	.24
4	.088	.30	.49	.16
5	.081	.23	.43	.11
6	.074	.18	.37	.079
7	.068	.15	.33	.057
8	.062	.12	.30	.043
9	.056	.10	.27	.032
10	.051	.084	.25	.025
11	.046	.071	.23	.019
12	.042	.061	.21	.015
13	.038	.052	.20	.012
14	.035	.045	.19	.0095
15	.032	.039	.18	.0077
16	.029	.034	.17	.0063
17	.027	.030	.16	.0052
18	.025	.027	.15	.0043
19	.023	.024	.14	.0036
20	.021	.021	.14	.0030
21	.019	.019	.13	.0025
22	.018	.017	.12	.0021
23	.017	.015	.12	.0018
24	.015	.014	.11	.0015
25	.014	.013	.11	.0013
26	.013	.011	.11	.0011
27	.012	.010	.10	.00098
28	.012	.0095	.098	.00085
29	.011	.0087	.094	.00074
30	.010	.0080	.011	.00064
31	.010	.0073	.088	.00056
32	.0089	.0067	.085	.00049
33	.0084	.0062	.082	.00043
34	.0079	.0057	.080	.00038
35	.0074	.0053	.077	.00034
36	.0070	.0049	.075	.00030
37	.0066	.0046	.073	.00027

Table 4.2-1 (Continued)

Time (min.)*	Standard Deviation of Point	Probability of Failure	Upper 95% Confidence Limit	Lower 95% Confidence Limit
38	.0062	.0042	.071	.00024
39	.0058	.0039	.069	.00021
40	.0055	.0037	.067	.00019
41	.0052	.0034	.065	.00017
42	.0050	.0032	.063	.00015
30	.0047	.0030	.062	.00014
44	.0044	.0028	.060	.00012
45	.0042	.0026	.059	.00011
46	.0040	.0024	.057	.00010
47	.0038	.0023	.056	.00009
48	.0036	.0022	.055	.00008
49	.0034	.0022	.053	.00007
50	.0033	.0019	.052	.00007
51	.0031	.0018	.051	.00006
52	.0030	.0017	.050	.00006
53	.0028	.0016	.049	.00005
54	.0027	.0015	.048	.00005
55	.0026	.0014	.047	.00004
56	.0025	.0014	.046	.00004
57	.0024	.0013	.045	.00004
58	.0022	.0012	.044	.00003
59	.0022	.0012	.043	.00003
60	.0021	.0011	.042	.00003
61	.0020	.0010	.041	.00003
62	.0019	.00099	.040	.00002

*For times greater than 62 min., use last line of table.

feedback to the operator as to the success of the B-man. It is assumed that fifteen (15) minutes will be available for the B-man to reach the high pressure injection valve and to then physically open the valve.

To estimate the Action Phase of the recovery action (i.e., the probability that the B-man will fail to open the high pressure injection valve), a HRA event tree (Chapter 5 of the Handbook) is constructed. This HRA event tree in conjunction with the HEPs given in Chapter 20 of the Handbook provide a means of estimating the Action Phase of the desired recovery action.

For this sample problem, the HRA event tree is shown in Figure 4.2-1. From the HRA event tree, the probability of failing to accomplish the Action Phase is found by:

$$\begin{aligned} P(NA) &\simeq F_1 + F_2 + F_3 + F_4 \\ &= 0.0 + (.001)(.003) + (.001)(.003) + (.001)(.003) \\ &= 9E-6 \end{aligned}$$

With the values for P(ND)* and P(NA) known, P(NR) can be computed as:

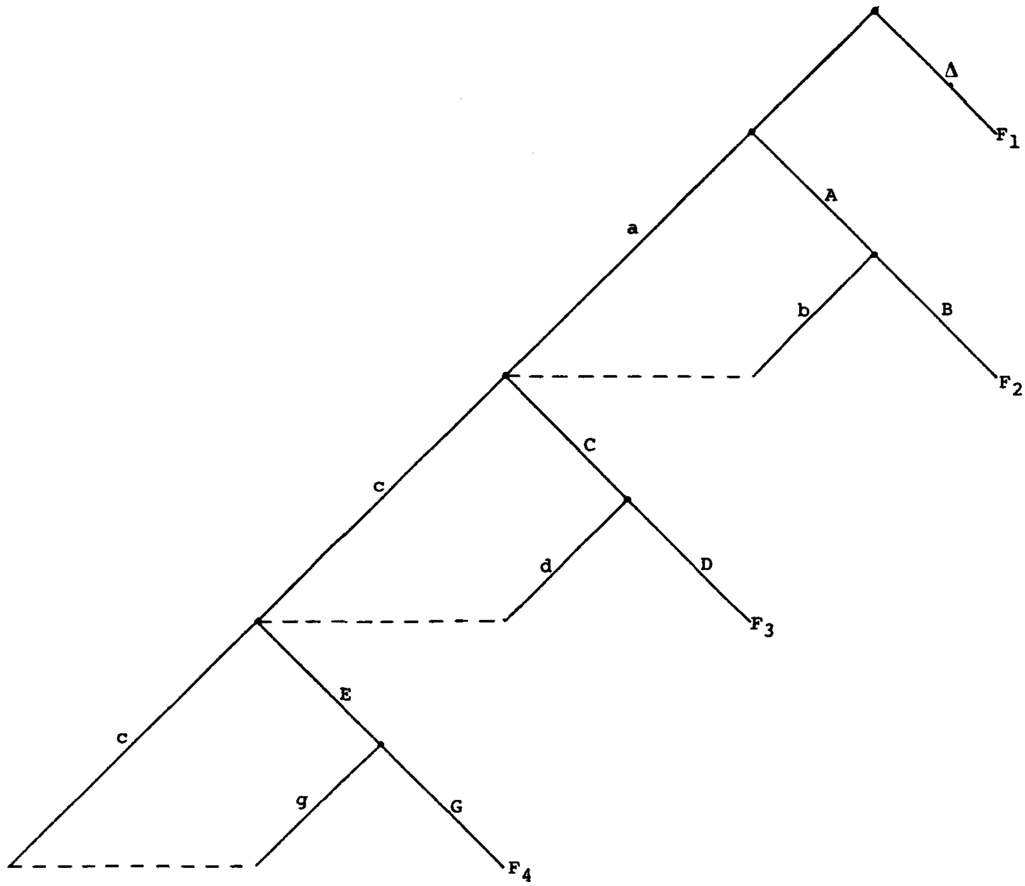
$$\begin{aligned} P(NR) &= P(ND) + P(NA) - P(ND)\ P(NA) \\ &= 1.4E-3 + 9E-6 - (1.4E-3)(9E-6) \\ &= 1.4E-3 \end{aligned}$$

As can be seen, the contribution of the Action Phase of the recovery action is negligible for this case.

The recovery action is then applied to the cut set and the sequence is requantified. For example: original probability of cut set, P(cut set), equals 0.1. With recovery, P(cut set)*P(NR), equals 1.4E-4. This produces a new sequence frequency which accounts for the operator team's probability of failing to successfully respond to the accident situation.

---

*Note: See Volume 2 of this report for other recommendations as to the estimation of the value for P(ND).



EP or HEP	Event	Value for EP or HEP	Source*
Δ	Mechanical or physical failure prohibits operator from getting message to B-man	ε	--
A	Error in message from operator	.001 (EF = 3)	Table 20-8 Item (1a)
B	Operator fails to monitor feedback (recovery action)	.003 (EF = 3)	Page 20-13
C	B-man misunderstands message	.001 (EF = 3)	Table 20-8 Item (1a)
D	Operator fails to monitor feedback (recovery action)	.003 (EF = 3)	Page 20-13
E	B-man selects incorrect valve	.001 (EF = 3)	Table 20-13 Item (5)
G	Operator fails to monitor feedback (recovery action)	.003 (EF = 3)	Page 20-13

*All values are from the Handbook, except the value for Δ. The value for Δ is based on engineering judgment.

Figure 4.2-1. HRA Event Tree for Sample Application

5.0 CONCLUSIONS AND RECOMMENDATIONS

From the results of the data analyses, it has been shown that grouping various recovery actions according to their operational similarities provides an effective means of estimating the operator team's diagnosis failure probability. Coupled with estimates of failure probabilities for the action phase of a recovery action, it is believed that this methodology provides for more realistic (data-based) estimates of the operators' ability to recover in an accident situation than existing methodologies that have relatively few response curves that are theoretically-based or rely upon expert judgment.

Groups that are based upon operational similarities should be relatively easy to use for the PRA analyst, although this has not been tested. One recommendation is to have several PRA analysts categorize a set of actions into the operational groups and determine the accuracy and consistency of their categorizations. It would also be worthwhile to expand the definitions of the groups to include actions not tested in this study. A third recommendation is to collect additional simulator data at the LaSalle simulator for operational groups that had relatively few data points (e.g., Groups 10 and 12).

The plant-specific nature of the diagnosis data should provide for a more accurate representation of the operators' abilities at the LaSalle unit than existing methodologies, especially since many measures were taken to enhance the reliability and realism of the simulations. These measures include testing of the drills on the LaSalle simulator prior to actual data collection, simulation of actions outside the control room with simulated time delays, data collection by multiple observers, and prevention of interruptions by instructors during the simulation runs. There was also evidence of stress responses in the crew members, such as high involvement (running to accomplish actions), impatience (asking whether requested actions had been accomplished yet), perseveration (repeating the same unsuccessful action more than once), and obvious physical fatigue.

The identified recovery action groups are general enough that it is believed that the diagnosis model may be applicable to other types of plants, although this has not been demonstrated. The estimates for the diagnosis phase should therefore be used only after analyses of plant and crew differences. Another important recommendation is that simulator data from other BWRs be collected and analyzed in a manner consistent with the analysis presented here to determine the general applicability of the model. It would also be useful to extend the data collection to cover PWRs.

As a final recommendation, the recovery methodology would be strengthened if data were collected for the action phase of the recovery action. The number of measurements needed could be reduced by first grouping actions based upon similarity of location and type of action. Then, measurements need be taken on only one action per group, since similar responses would be expected for all actions within a group.

Appendix A

Phase 1 Data Collection, Results, and Recommendations

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LIST OF FIGURES

PHASE 1 DATA COLLECTION, RESULTS, AND RECOMMENDATIONS

A survey of existing models of the diagnosis phase of recovery performed as part of Phase 1 (see Section 2) revealed that these models rely heavily upon subjective judgment, since data from actual performance of operators are very sparse. Therefore, as part of Phase 1, a diagnosis model that places less reliance upon subjective judgment was developed and tested. The model uses simulator data as well as judgment data. It consisted of (1) a Diagnosis Difficulty Matrix (DDM), and (2) Diagnosis Time Curves (see Section 2.2 for a more detailed description).

In concept, the DDM would be derived from the results of operator and instructor questionnaires pertaining to judgments of difficulty of recognition (operators realize that a problem exists with one of the safety parameters) and evaluation (operators decide upon a course of action to correct the problem) for various aspects of accident sequences. Using the DDM, the analyst would determine the difficulty of the recovery action he is interested in. With the level of difficulty determined, the appropriate diagnosis time curve (developed from time-dependent simulator performance data) could be chosen. This curve would provide the analyst with the means to estimate the probability that the operators would fail to diagnose the correct recovery action within the allowable time.

The main purpose of the Phase 1 data collection effort was to test the data collection methodology and to identify areas where the collection methodology and diagnosis model could be improved for the Phase 2 effort.

A.1 Description of Operators, Simulator Drills, and Data Collected

The Phase 1 data collection effort took place during the 1985 requalification exercises for Commonwealth Edison's LaSalle nuclear power plant (NPP) operators. During this session, the operators received training in the LaSalle specific-symptom-based procedures for the first time. This training included both classroom instruction and simulator training. The training staff at the simulator provided simulator drills which tested the ability of the operators to use the new symptom-based procedures. The purpose of the drills was to provide training for the operators on the new procedures and, as such, the drills did not lead to a core melt condition. The training nature of the drills and the fact that no modification to the drills was possible limited the amount of useful information the drills could supply. These drills, described in Table A.1-1 were used to test the data collection methodology and to provide information about operator actions where possible.

TABLE A.1-1
Description of Simulator Drills Used in Phase 1

Descriptor	Initiating Event	System Status	Malfunction	Operator Action
A1	Load change	Hot full power	Loss of automatic control to the turbine driven feedpump	Balance feedwater flow by taking manual control of the turbine driven feedpump
A2	Surveillance	Hot full power	Standby gas treatment malfunction	Initiate shutdown of the plant based upon a violation of the tech. specs.
A3	Load change	Shutting down	Second turbine driven feedpump control malfunction	Establish flow control with both feedpumps in manual operation
A4	Load following	Feedwater in manual high pressure injection systems available	Loss of feedwater	Establish control of reactor water level
B1	Loss of feedwater control	Full power	Feedwater run up in speed	Establish manual control of the feedwater water to normal flow
B2	Feedwater line rupture	Full power manual control of feedwater	Feedwater line break	Establish control of the water level in the vessel
C1	Loss of electric bus 152	Full power/ motor driven feedpump seizes/RCIC fails after 5 minutes	Three control rods stick out	Operating team decides to take no action since stuck rods pose no threat
D1	HPCS surveillance failure	Full power/ RCIC is unavailable	Tech. Spec. violation when both RCIC & HPCS are unavailable	Initiate a reactor shutdown
D2	Loss of coolant accident	Full power/all high pressure cooling systems unavailable	Loss of level control in the vessel at high pressure	Operators establish a method of low pressure cooling

RCIC - Reactor Core Isolation Cooling System
HPCS - High Pressure Core Spray System

A.1.1 Description of Data Collected

The data obtained during Phase 1 fall into three categories:

(1) Operator experience and training data (Operator Biographical Data Form)

(2) Time-dependent simulator performance data (Time Data Sheets)

(3) Expert opinion on difficulty of recognition and evaluation and other information on drills (Operator and Instructor Questionnaires)

The Operator Biographical Data Form, Figure A.1.1-1, was used to collect information pertaining to the experience and training of individual operators. The information collected would potentially be used in correlating the results of the Operator Questionnaires and the simulator performance data collected on the Time Data Sheets with such factors as age, experience, education, job classification, etc. Table A.1.1-1 contains the data obtained from the Operator Biographical Data Forms.

The Time Data Sheets, Figures A.1.1-2 through A.1.1-10, were used by the instructors to record the time at which the operators recognized that a problem existed and the times when the operators initiated and completed the necessary actions to bring the plant to a safe condition. Table A.1.1-2 contains the results of the data collected for each drill.

The Operator Questionnaires (Figures A.1.1-11 through A.1.1-19) and Instructor Questionnaires (Figures A.1.1-20 through A.1.1-28), were used to provide expert opinions on the level of difficulty of recognition and evaluation for each drill and to provide additional information on each drill. The questionnaires were completed after each drill. The purpose of the questionnaires was to provide the information necessary to construct the Diagnosis Difficulty Matrix. The data are found in Tables A.1.1-3 and A.1.1-4 for the Operator and Instructor Questionnaires respectively.

A.2 Study Overview

The recognition and evaluation difficulty ratings and simulator time data were analyzed by methods described in the next section. The purpose of the analyses was to assess the strengths and weaknesses of the proposed DDM approach, an approach where the time data would be categorized by the recognition and evaluation difficulty judgments. The DDM approach was assessed by examining the degree of association between the difficulty rating data and the simulator time data, and the consistency of the rating data.

(Text continued on page A-62)

Operator Number:________

Date:____________________________________

This questionnaire requests information on your training and operational experience. The information you provide will be used as data in a research project conducted by Sandia National Laboratories as part of the Risk Methods Integration and Evaluation Program (RMIEP) in which the LaSalle plant is participating. Statistical summaries of these data will be reported, but no individuals will be identified in any report.

Your replies will be considered completely confidential. In order to maintain anonymity, DO NOT put your name on this form. However, you will note that you have been assigned an "Operator Number" at the top left of this page. Please write down that number for future reference. You will be participating in a simulator exercise and/or in an expert opinion study, and it is necessary that we correlate your simulator performance with the data provided in this form. You will be asked to use this same "Operator Number" in the simulator exercise. In addition, we may need to contact you for any clarification of these data or simulator data. If we do need to contact you, we will post your Operator Number in the plant, and ask you to telephone us at a listed number. In this way, we will not know your name, but will be able to obtain the information which might be required for this study.

1. Sex:________

2. Age:________

3. LaSalle plant experience: Years______ + additional months_____

4. Months of nuclear power plant <u>training</u> (<u>not</u> including Navy):

    a. From utility (classroom & simulator):________

    b. College/technical school:________

5. Years & months in Navy nuclear program: Years______ + additional months________

6. Are you a high school graduate (or have a GED)?________

7. Number of years of college:________

8. College degree(s) and major (in each):____________________________

____

Figure A.1.1-1
Operator Biographical Data Form

9. Years of non-nuclear power plant experience:_______

10. Commercial nuclear power plant experience:

    a. Number of years experience outside of control room:______

    b. Number of years in control room as: AO_____; RO_____; SRO_____

    c. List all NRC licenses earned:____________________________

    d. Date of your highest license for LaSalle plant:__________

11. In your day-to-day work at the plant, are you (check 1):

    a. ______ A trainee

    b. _____ Primarily an operator

    c. _____ Primarily a supervisor

    d. _____ Primarily an engineer

    e. _____ Other (explain):____________________________________

12. Do you usually stand control room watches?_____

13. If you are not primarily an operator, when did you last work in the control room as an RO or SRO (month/year)?_______

Figure A.1.1-1 (Continued)

Table A.1.1-1

```
**************************************************************************
*                        SUMMER DATA                                     *
*              BIOGRAPHICAL DATA ON LA SALLE OPERATORS                   *
*              ****MISSING DATA ON SOME OPERATORS****                    *
**************************************************************************
*      OBS = OBSERVATION NUMBER                                          *
*     OPER = OPERATOR NUMBER                                             *
*   LSNPPE = YRS. LA SALLE NUCLEAR POWER PLANT (NPP) EXPERIENCE          *
*    UNPPT = YRS. UTILITY NPP TRAINING                                   *
*  COLLEGE = YRS. COLLEGE                                                *
*       HS = HIGH SCHOOL GRADUATE (YES, NO)                              *
*   DEGREE = COLLEGE DEGREE (ENGR=ENGINEERING, SCI=SCIENCE)              *
*    NNPPE = YRS. NON-NUCLEAR POWER PLANT EXPERIENCE                     *
* CNPPEOCR = YRS. COMMERCIAL NPP EXPERIENCE OUTSIDE CONTROL ROOM         *
* CNPPEICR = YRS. COMMERCIAL NPP EXPERIENCE INSIDE CONTROL ROOM          *
*  LICENSE = HIGHEST NRC LICENSE (AO, RO, SRO)                           *
*   ASSIGN = DAILY ASSIGNMENT AT PLANT (B=OPERATOR, C=SUPERVISOR,        *
*            D=ENGINEER, E=OTHER)                                        *
*  CRWATCH = USUALLY STAND CONTROL ROOM WATCH (YES, NO)                  *
*   LASTCR = IF NOT OPERATOR, YRS. SINCE LAST IN CONTROL ROOM AS         *
*            RO OR SRO                                                   *
*     CREW = SH = SHIFT, WK = WEEK                                       *
*            1=SH1 WK1, 2=SH2 WK1, 3=SH1 WK2, 4=SH2 WK2,                 *
*            5=SH1 WK3, 6=SH2 WK3, 7=SH1 WK4, 8=SH2 WK4,                 *
*            9=SH1 WK5,10=SH2 WK5,11=SH1 WK6,12=SH2 WK6,                 *
*           13=SH3 WK6,14=SH1 WK7,15=SH2 WK7,16=SH3 WK7,                 *
*           17=SH1 WK8,18=SH1 WK9,19=SH2 WK9.                            *
**************************************************************************

INPUT OBS 1-2 OPER 4-5 SHIFT 7 WEEK 9 SEX $ 11 AGE 13-14 LSNPPE 16-20
  UNPPT 22-26 COLLEGE 28-30 HS $ 32 DEGREE $ 34-38 NNPPE 40-42
  CNPPEOCR 44-48 CNPPEICR 50-54 LICENSE $ 56-58 ASSIGN $ 60
  CRWATCH $ 62 LASTCR 64-68 CREW 70-71;
```

1	3	1	1	M	29	9.50	3.00	2.0	Y	NONE	0.0	5.50	2.50	RO	C	N	1.00	1
2	7	1	1	M	34	9.25	3.00	2.0	Y	OTHER	0.0	0.00	4.00	SRO	C	N	5.50	1
3	1	2	1	M	31	6.50	1.00	0.0	Y	NONE	0.0	5.00	1.50	RO	B	Y	0.00	2
4	4	2	1	M	25	5.50	1.00	2.5	Y		0.0	3.00	0.00	RO	B	N	0.00	2
5	6	2	1	M	33	9.25	2.00	0.0	Y	NONE	0.0	9.00	4.00	SRO	C	N	1.80	2
6	91	1	2	M	35	7.90	5.00	1.0	Y	OTHER	0.0	7.00	0.25	SRO	C	N	0.00	3
7	8	1	2	M	26	6.90	6.90	1.0	Y	OTHER	0.0	5.00	3.00	RO	B	Y	0.00	3
8	9	1	2	M	32	7.33	5.00	0.0	Y	OTHER	4.0	4.00	3.00	RO	B	Y	0.00	3
9	12	1	2	M	29	8.60	1.50	2.0	Y	OTHER	0.0	4.00	4.50	SRO	C	N	1.67	3
10	11	2	2	M	26	5.40	1.00	2.5	Y	OTHER	0.0	5.00	0.00	RO	B	N	0.00	4
11	14	2	2	M	31	9.00	0.00	0.0	Y	OTHER	0.0	0.00	2.00	RO	C	N	2.00	4
12	13	2	2	M	31	8.60	4.00	2.5	Y	OTHER	0.0	4.00	8.00	SRO	C	N	2.40	4
13	10	2	2	M	25	5.10	2.00	2.0	Y	OTHER	0.0	4.67	0.40	RO	B	Y	0.00	4
14	15	1	3	M	36	7.50	5.00	0.0	Y	OTHER	0.0	5.50	2.50	RO	B		0.00	5
15	16	1	3	M	27	7.50	6.00	1.0	Y	OTHER	0.0	3.00	4.00	RO	B	Y	0.00	5
16	19	1	3	M	48	9.80	26.00	0.0	Y	OTHER	2.5	7.50	19.00	SRO	C	Y	0.00	5
17	20	1	3	M	32	9.00	1.25	6.0	Y	ENGR	0.0	8.00	1.00	SRO	C	Y	0.00	5
18	22	2	3	M	33	8.60	1.70	3.0	Y	OTHER	0.0	3.00	5.00	SRO	C	N	6.30	6
19	18	2	3	M	28	8.00	1.25	2.0	Y	OTHER	0.0	3.00	5.50	RO	C	N	0.20	6
20	21	2	3	M	34	9.20	1.67	2.0	Y	OTHER	0.0	11.00	0.00	SRO	C	N	0.00	6
21	17	2	3	M	35	7.00	0.33	1.0	Y	OTHER	0.0	3.00	4.00	RO	B	Y	0.00	6
22	23	1	4	M	29	7.25	2.00	3.0	Y	OTHER	0.0	6.00	1.00	RO	B	Y	0.00	7
23	24	1	4	M	33	8.67	1.90	2.0	Y	OTHER	3.5	8.00	4.00	RO	B	Y	0.00	7
24	27	1	4	M	28	8.50	5.00	1.0	Y	OTHER	0.0	1.90	5.00	RO	E	N	0.25	7
25	28	1	4	M	31	4.40	1.20	4.0	Y	ENGR	3.0	1.00	3.00	SRO	C	Y	0.00	7

Table A.1.1-1 (Continued)

26	25	2	4	M	28	8.00	1.50	2.0	Y	OTHER		4.50	2.50	RO	B	Y		8
27	26	2	4	M	29	5.00	1.67	0.0	Y	OTHER	0.0	3.00	1.00	RO	B	Y		8
28	29	2	4	M	37	8.67	2.00	0.0	Y	OTHER	0.0	5.00	15.00	SRO	C	Y	0.00	8
29	30	2	4	M	38	10.17	1.00	2.0	Y	OTHER	0.0	6.00	4.00	SRO	C	N	0.00	8
30	37	1	5	M	30	9.33	2.00	0.0	Y	OTHER	0.6	3.50	5.00	RO	B	Y	0.00	9
31	43	1	5	M	41	9.50	2.00	4.0	Y	SCI	0.5	12.00	3.00	SRO	C	N	1.90	9
32	40	1	5	M	40	9.50	2.00	4.0	Y	OTHER	0.0	11.00	2.00	SRO	B	Y	0.00	9
33	85	1	5	M	29	8.75	9.00	2.0	Y	OTHER	0.0	1.00	7.00	RO	B	Y	0.00	9
34	38	2	5	M	32	8.20	1.00	0.0	Y	OTHER	0.0	6.00	0.20	RO	B	Y	0.00	10
35	39	2	5	M	39	3.75	1.00	0.0	Y	OTHER	0.0	3.00	0.00	RO	E	N	0.00	10
36	41	2	5	M	28	7.25	1.00	4.0	Y	SCI	0.0	7.00	1.00	SRO	C	N	2.50	10
37	42	2	5	M	36	7.25	1.33	1.0	Y	OTHER	0.0	0.50	4.00	RO	C	N	0.20	10
38	44	1	6	M	35	9.20	0.00	4.0	Y	ENGR	0.5	5.00	2.00	SRO	C	Y	0.00	11
39	47	1	6	M	27	6.83	2.00	2.0	Y	OTHER	0.0	4.00	3.00	RO	B	Y		11
40	89	1	6	M	35	9.50	4.00	1.5	Y	OTHER	0.0	6.00	0.00	SRO	C	N	0.00	11
41	46	1	6	M	29	6.00	1.00	0.0	Y	OTHER	0.0	6.00	0.00	RO	C	N	0.67	11
42	45	2	6	M	39	9.50	2.50	1.5	Y	OTHER	0.0	1.00	6.00	SRO	C	N	2.70	12
43	50	2	6	M	34	8.50	2.50	2.0	Y	OTHER	0.0	8.50	0.00	SRO	C	N	0.00	12
44	49	2	6	M	24	3.90	1.50	0.0	Y	OTHER	0.0	2.00	1.00	AO	E	N	0.00	12
45	87	2	6	M	26	4.00	1.50	2.0	Y	OTHER	0.0	3.50	0.50	RO	B	N	0.00	12
46	51	3	6	M	28	4.00	1.20	0.0	Y	OTHER	0.0	4.00	0.00	SRO	E	N	0.00	13
47	52	3	6	M	33	9.00	1.10	5.0	Y	ENGR	0.0	9.00	0.00	SRO	D	N	0.00	13
48	62	3	6	M	29	8.00	2.00	2.0	Y	OTHER	2.0	2.00	5.00	RO	B	Y	0.80	13
49	63	1	7	M	41	9.20	4.20	6.0	Y	ENGR	0.0	9.00	0.00	SRO	C	N	2.50	14
50	64	1	7	M	34	10.10	1.20	6.0	Y	ENGR	0.0	10.00	0.00	SRO	C	N	0.00	14
51	67	1	7	M	37	8.00	1.20	4.0	Y	ENGR	0.0	6.00	2.00	SRO	C	N	2.10	14
52	0	2	7	M	40	10.00	3.00	4.0	Y	OTHER	0.0	4.00	4.00	SRO	C	N		15
53	59	2	7	M	39	9.70	2.50	4.0	Y	ENGR	0.0	6.00	4.00	SRO	D	N	1.60	15
54	66	2	7	M	39	5.92	1.17	4.0	Y	OTHER	1.0	5.00	0.00	SRO	D	N		15
55	70	2	7	M	39	9.80	3.00	2.0	Y	OTHER	0.0	13.00	0.00	SRO	C	N		15
56	71	2	7	M	40	11.00	1.08	5.0	Y	ENGR	0.0	11.00	0.00	SRO	E	N	1.10	15
57	68	3	7	M	37	5.50	1.33	4.0	Y	OTHER	0.0	5.00	0.50	SRO	E	N	1.00	16
58	69	3	7	M	33	8.92	1.50	3.0	Y	OTHER		7.00	2.00	SRO	E	N	3.67	16
59	73	1	8	M	34	8.00	1.50	0.0	Y	OTHER	0.0	10.00	0.00	SRO	C	N		17
60	75	1	8	M	25	3.75	1.00	3.0	Y	OTHER	0.0	2.50			B	N		17
61	76	1	8	M	25	5.00	1.25	1.0	Y	OTHER		5.00	0.50	RO	B	N		17
62	90	1	8	M	32	6.00	1.40	2.0	Y	OTHER	0.0	6.00	0.00	SRO	C	N		17
63	65	1	9	M	39	9.90	3.00	2.0	Y	OTHER	0.0	12.00	4.00	SRO	C	N		18
64	36	1	9	M	26	6.60	1.33	2.0	Y	OTHER	1.0	4.00	2.50	RO	B	Y		18
65	88	1	9	M	33	1.50	10.00	1.0	Y	OTHER	5.0	4.00	6.00	SRO	C	N		18
66	84	1	9	M	28	6.60	1.33	2.0	Y	OTHER	0.0	3.00	2.00	RO	B	Y		18
67	86	2	9	M	29	4.80	2.00	0.0	Y	OTHER	0.0	4.20	0.50	RO	B	Y		19
68	72	2	9	M	41	9.50	2.20	0.0	Y	OTHER	1.0	14.00	0.00	SRO	C	N	14.00	19
69	58	2	9	M	51	10.25	1.70	1.0	Y	OTHER	0.0	14.00	3.00	SRO	E	N	12.00	19
70	53	2	9	M	37	8.80	1.00	4.0	Y	ENGR	0.5	8.80	0.00	SRO	C	N		19

Instructor:____________________ Date:__________ Shift:__________

1. Time that exercise began: ____________________

Please fill in the times that each of the following events occurred during this exercise associated with the following failure

TDFWP Lockout

	Times
2. TDFWP Lockout initiated:	____________
3. Operating team realized that a malfunction existed in the feedwater system.	____________
4. Operating team identified the malfunction as a lockout of the TDFWP.	____________
5. Operating team took manual control of the TDFWP to restore FW flow to normal (balanced flow).	____________
6. FW flow balanced between both operating TDFWPs.	____________
7. Operators access any procedures.	____________

TDFWP - turbine driven feedwater pump
FW - feedwater

Figure A.1.1-2
Data Sheet
Scenario A1

Instructor:______________________Date:___________Shift:___________

Please fill in the times that each of the following events occurred during this exercise associated with the following failure:

SBGT Malfunction

		Times
1.	SBGT failure occurred.	
2.	Operating team realized that a failure of SBGT had occurred.	
3.	Operating team identified the existence of a tech. spec. violation due to the SBGT failure.	
4.	Operating team determined that a reactor shutdown was required.	
5.	Reactor Shutdown Initiated.	
6.	Operators access any procedures.	

SBGT - standby gas treatment

Figure A.1.1-3
Data Sheet
Scenario A2

Instructor:______________________Date:___________Shift:__________

Please fill in the times that each of the following events occurred during this exercise associated with the following failure:

TDFWP Control Malfunction

	Times
1. TDFWP control failure initiated.	______
2. Operating team realized that a second malfunction occurred in the FW system.	______
3. The operating team identified the malfunction as a failure of the TDFWP control.	______
4. The operating team took manual control of the TDFWP.	______
5. FW flow control established with both TDFWPs in manual.	______
6. Operators access any procedures.	______

TDFWP - turbine driven feedwater pump
FW - feedwater

Figure A.1.1-4
Data Sheet
Scenario A3

Instructor:____________________Date:__________Shift:__________

Please fill in the times that each of the following events occurred during this exercise associated with the following failure:

Loss of Feed

			Times
1.	Loss of feed occurred.		__________
2.	Operating team realized that makeup to the vessel had failed.		__________
3.	Operating team realized that and alternate method of RV level control was necessary.		__________
4.	Level 2 reached.		__________
5.	RCIC Initiated (check one)	Auto ____ Manual ____	__________
6.	HPCS Initiated (check one)	Auto ____ Manual ____	__________
7.	MSIVs Closed (check one)	Auto ____ Manual ____	__________
8.	RV level control established		__________
9.	Plant stabilized		__________
10.	Operators access any procedures.		__________
11.	Exercise ended		__________

RCIC - reactor core isolation cooling system
HPCS - high pressure core spray system
MSIVs - main steam isolation valves
RV - reactor vessel

Figure A.1.1-5
Data Sheet
Scenario A4

Instructor:______________________ Date:___________ Shift:___________

1. Time that exercise began. ______________________

Please fill in the times that each of the following events occurred during this exercise associated with the following failure:

TDFWP Run Up Malfunction

	Times
2. TDFWP run up occurred.	
3. Operating team realized a malfunction existed in the feedwater system.	
4. Operating team identified the malfunction in the feedwater system as a TDFWP run up.	
5. Operating team took manual control of the TDFWP to restore FW flow to normal.	
6. FW flow restored to normal.	
7. Operators access any procedures.	

TDFWP - turbine driven feedwater pump
FW - feedwater

Figure A.1.1-6
Data Sheet
Scenario B1

Instructor:____________________ Date:__________ Shift:__________

Please fill in the times that each of the following events occurred during this exercise associated with the following failure:

FW Line Rupture

			Times
1.	FW line rupture occurred.		______
2.	Operating team realized a malfunction had occurred in the feedwater system.		______
3.	Operating team identified the FW system malfunction as a leak.		______
4.	The operating team initiated a systematic leak location process.		______
5.	The operating team correctly identified the location of the leak.		______
6.	The operating team initiated power reduction (Rx shutdown).		______
7.	The operating team realized the necessity for establishing an alternate method of RV level control.		______
8.	Reactor scram occurred (check one)	Auto ____ Manual ____	______
9.	RCIC Initiated (check one)	Auto ____ Manual ____	______
10.	HPCS Initiated (check one)	Auto ____ Manual ____	______
11.	RV level control established.		______
12.	Plant stabilized.		______
13.	Drill terminated.		______

Figure A.1.1-7
Data Sheet
Scenario B2

14. Operators access any procedures. ____________________

FW - feedwater
Rx - reactor
RV - reactor vessel

Figure A.1.1-7 (Continued)

Instructor:______________________ Date:___________ Shift:__________

Please fill in the times that each of the following events occurred during this exercise associated with the following failure:

Loss of Bus 152/Failure of Some Rods to Insert

	Times
1. Time that exercise began	________
2. Bus 152 failed.	________
3. Operating team noted all rods were not fully inserted.	________
4. SBLC Injected (NA if not accomplished).	________
5. Operating team determined the stuck rods did not pose a threat to plant safety.	________
6. Drill terminated.	________
7. Operators access any procedures.	________

SBLC - standby liquid control system

Figure A.1.1-8
Data Sheet
Scenario C1

Instructor:____________________Date:__________Shift:__________

Please fill in the times that each of the following events occurred during this exercise associated with the following failure:

HPCS Fail Surveillance Test

		Times
1.	Time that exercise began	______
2.	HPCS test initiated.	______
3.	HPCS failure initiated.	______
4.	Operators realize that a HPCS malfunction exists.	______
5.	Operators determine that a tech. spec. violation exists.	______
6.	Reactor shutdown initiated.	______
7.	Operators access any procedures.	______

HPCS - high pressure core spray system

Figure A.1.1-9
Data Sheet
Scenario D1

Instructor:______________________Date:___________Shift:___________

1. Time that exercise ______________________

Please fill in the times that each of the following events occurred during this exercise associated with the following failure:

LOCA/High Pressure Core Cooling Failure Malfunction

	Times
2. Bus 152 failed.	______________________
3. LOCA initiated.	______________________
4. Operating team realized that all methods of high pressure core cooling were lost.	______________________
5. ADS initiated (check one) Auto ______ Manual ______	______________________
6. Operating team determined that low pressure systems should be used and were available to maintain RV level.	______________________
7. Drill terminated.	______________________
8. Operators access any procedures.	______________________

LOCA - loss of coolant accident
ADS - automatic depressurization system
RV - reactor vessel

Figure A.1.1-10
Data Sheet
Scenario D2

Table A.1.1-2
Time Data for Phase 1 Drills

```
******************************************************************************************
*                                     ALL SUMMER DATA                                     *
*                                  EDITED SIMULATOR DATA                                  *
* CORRECTED DATA: 1. DIAGNOSIS CHANGED TO Y OR N                                          *
*                 2. MEDIANS FOR SUCCESSFUL TRIALS ON RECOGNITION AND EVALUATION TIMES PUT IN *
*                    FOR SUCCESSFUL TRIAL RECOGNITION AND EVALUATION TIMES THAT WERE      *
*                    QUESTIONNABLE OR HAD MISSING DATA                                    *
*                 3. PROJECTED TIMES PUT IN FOR RECOGNITION AND EVALUATION TIMES WHERE TRIAL *
*                    WAS FAILURE - USE (3) ONLY FOR ANOVA                                 *
******************************************************************************************
* CREW = 1=SH1 WK1, 2=SH2 WK1, 3=SH1 WK2 4=SH2 WK2, 5=SH1 WK3, 6=SH2 WK3, 7=SH1 WK4, 8=SH2 WK4, *
*        9=SH1 WK5, 10=SH2 WK5, 11=SH1 WK6, 12=SH2 WK6, 13=SH3 WK6, 14=SH1 WK7, 15=SH2 WK7, *
*        16=SH3 WK7, 17=SH1 WK8 18=SH1 WK9 19=SH2 WK9                                     *
******************************************************************************************
*              INSTRUCT = INSTRUCTOR                                                      *
*               TIMEREC = TIME UNTIL RECOGNITION                                          *
*              TIMEEVAL = TIME UNTIL EVALUATION                                           *
*               TIMECOR = TIME RECOVERY ACTIONS WERE COMPLETED                            *
*              TIMEPROC = TIME PROCEDURES WERE ACCESSED                                   *
*                  DIAG = SUCCESSFUL DIAGNOSIS OR NOT                                     *
******************************************************************************************
*                       8888 = REQUIRED ACTION NOT COMPLETED                              *
******************************************************************************************
```

INPUT OBS 1-3 CREW 5-6 SCENARIO $ 8-9 SHIFT 11 WEEK 13 INSTRUCT $ 15-21 TIMEREC 23-29
TIMEEVAL 31-37 TIMECOR 39-45 TIMEPROC 47-53 DIAG $ 55 COMMENTS $ 58-97;

1	1	A1	1	1	COX	1.00	1.00	1.00	2.00	Y	TDFWP FLOW DID NOT NEED TO BE BALANCED
2	1	A2	1	1	COX	1.00	1.00	2.00	3.00	Y	
3	1	A3	1	1	COX	2.00	2.00	2.00	2.00	Y	ALREADY HAD MANUAL CONTROL OF "A"
4	1	B1	1	1	COX	1.00	1.00	3.00		Y	
5	1	B2	1	1	COX	4.00	10.25	16.00		Y	TIMEEVAL BLANK ASS. 1 MIN BEFORE TIMECOR
6	1	C1	1	1	COX	5.00	5.00	5.00	5.00	Y	
7	1	D1	1	1	COX	5.00	6.00	9.00	10.00	Y	
8	1	D2	1	1	COX	1.00	15.00	30.00	3.00	Y	
9	2	A1	2	1	BELL	1.00	1.00	1.00	8888.00	Y	
10	2	A2	2	1	BELL	1.00	5.00	6.00	3.00	Y	
11	2	A3	2	1	BELL	1.00	3.00	5.00	8888.00	Y	
12	2	A4	2	1	BELL	1.00	1.00	2.00		Y	
13	2	B1	2	1	BELL	1.00	1.00	1.00	8888.00	Y	
14	2	C1	2	1	BELL	3.00	4.00	4.00	2.00	Y	
15	2	D1	2	1	BELL	6.00	7.00	8.00	7.00	Y	
16	2	D2	2	1	BELL	5.00	10.00	20.00	2.00	Y	ADS INITIATED: MANUAL
17	3	A1	1	2	COX	2.00	2.00	3.00		Y	
18	3	A2	1	2	COX	0.50	1.00	2.00	1.00	Y	
19	3	A3	1	2	COX	1.00	2.00	3.00		Y	
20	3	A4	1	2	COX	1.00	1.00	4.00	6.00	Y	
21	3	B1	1	2	COX	1.00	1.00	1.00	8888.00	Y	THEY RESET LOCKOUT RIGHT AWAY
22	3	B2	1	2	COX	7.00	10.25	35.00	20.00	Y	TIMEEVAL ASS. 1 MIN BEFORE TIMECOR
23	3	D1	1	2	COX	1.00	2.00	2.00		Y	
24	3	D2	1	2	COX	1.00	17.00	31.00	2.00	Y	DRILL STOPPED FOR 10 MIN BEFORE TIMECOR
25	4	A1	2	2	WEIDNER	6.75	8.50	16.50	8888.00	Y	
26	4	A2	2	2	WEIDNER	0.50	1.00	1.00	1.00	Y	
27	4	B1	2	2	WEIDNER	0.50	1.50	2.50	8888.00	Y	
28	4	B2	2	2	WEIDNER	6.00	38.00	51.00		N	FREEZE FOR 12 MIN TIMEEVAL ASS'ED
29	4	C1	2	2	WEIDNER	55.00	55.00	8888.00	8888.00	N	NEVER NOTED ALL RODS NOT IN
30	5	A1	1	3	WEIDNER	0.50	1.25	12.25	17.25	Y	
31	5	A2	1	3	WEIDNER	0.25	14.75	15.75	1.50	Y	
32	5	A3	1	3	WEIDNER	1.25	1.50	5.40	8888.00	Y	
33	5	B2	1	3	WEIDNER	9.00	11.00	14.00	18.00	Y	
34	5	C1	1	3	WEIDNER	18.40	20.00	20.00	5.00	Y	
35	5	D1	1	3	WEIDNER	4.00	8.20	8.30	4.00	Y	
36	6	A1	2	3	BELL	1.00	2.00	3.00	8888.00	Y	
37	6	A2	2	3	BELL	1.00	1.00	1.00	1.00	Y	
38	6	A3	2	3	BELL	1.00	2.00	2.00		Y	
39	6	A4	2	3	BELL	1.00	1.00	5.00	2.00	Y	
40	6	B1	2	3	BELL	1.00	1.00	1.00		Y	
41	6	B2	2	3	BELL	1.00	7.00	16.00	2.00	Y	

Table A.1.1-2 (Continued)
Time Data for Phase 1 Drills

42	6	C1	2	3	BELL	3.00	3.00	3.00	3.00	Y	
43	6	D1	2	3	BELL	4.00	4.00	7.00	4.00	Y	
44	6	D2	2	3	BELL	1.00	40.00	42.00	2.00	Y	ADS INITIATED: MANUAL
45	7	A1	1	4	COX	1.00	1.00	1.00	8888.00	Y	TOOK TDFWP OFF, POWER LOW, 1 P HANDLE IT
46	7	A2	1	4	COX	1.00	1.16	2.00		Y	
47	7	A3	1	4	COX	9.00	9.00	8888.00	8888.00	N	LOFW OCCURED BEFORE THEY NOTICED PROB.
48	7	A4	1	4	COX	1.00	1.16	3.16	8888.00	Y	
49	7	B1	1	4	COX	1.00	1.00	1.60	8888.00	Y	
50	7	B2	1	4	COX	3.67	10.25	14.90	15.00	Y	TEMEEVAL IS SMALLER THAN TIMECOR?
51	7	C1	1	4	COX	10.50	10.50	10.50	5.50	Y	
52	7	D1	1	4	COX	1.00	4.50	5.50	8888.00	Y	
53	8	A1	2	4	RUSSELL	1.00	1.00		8888.00	Y	TIME BLANK FOR TIMECOR
54	8	A2	2	4	RUSSELL	1.00	99.00	99.00		Y	IS THIS A SUCCESS?
55	8	B1	2	4	RUSSELL	0.96	1.05			Y	NO TIMES GIVEN
56	8	B2	2	4	RUSSELL	5.17	10.25			Y	NO TIMES GIVEN
57	8	C1	2	4	RUSSELL	3.70	6.05		8888.00	Y	NO TIMES GIVEN
58	8	D2	2	4	RUSSELL	1.25	12.50			Y	NO TIMES GIVEN
59	9	A1	1	5	SCHAVEY	1.00	1.00	2.20	1.00	Y	
60	9	A2	1	5	SCHAVEY	1.00	3.00	11.00	1.00	Y	
61	9	B1	1	5	SCHAVEY	1.00	3.20	5.70	3.70	Y	
62	9	B2	1	5	SCHAVEY	4.00	14.30	23.00	8888.00	Y	
63	9	C1	1	5	SCHAVEY	3.00	8.00	8.00	8888.00	Y	
64	9	D1	1	5	SCHAVEY	4.00	4.25		1.00	Y	BLANKS FOR TIMEEVAL AND TIMECOR
65	10	A1	2	5	WEIDNER	1.00	1.00		1.00	Y	BLANK FOR TIMECOR
66	10	A3	2	5	WEIDNER	1.00	1.50	2.90	4.00	Y	
67	10	A4	2	5	WEIDNER	1.00	1.00	6.40	11.00	Y	
68	10	B1	2	5	WEIDNER	1.00	1.00	5.00	1.00	Y	
69	10	B2	2	5	WEIDNER	4.80	9.50	12.50		Y	
70	11	A1	1	6	RUSSELL	1.00	1.00	3.00	1.00	Y	
71	11	A2	1	6	RUSSELL	1.00	1.00	1.00	1.00	Y	
72	11	A3	1	6	RUSSELL	3.00	3.00	3.00	10.00	Y	
73	11	B1	1	6	DEDIN	1.00	1.00	1.00	2.00	Y	
74	11	B2	1	6	DEDIN	6.00	10.25			Y	TIMEEVAL AND TIMECOR BLANK
75	11	C1	1	6	ROSS	4.40	7.10	7.10	6.30	Y	
76	11	D2	1	6	ROSS	1.00	12.50		5.80	Y	TIMEEVAL AND TIMECOR BLANK
77	12	A1	2	6	ROSS	1.00	1.00	1.00	1.30	Y	
78	12	A2	2	6	ROSS	1.00	3.00	8.20	7.20	Y	
79	12	A3	2	6	ROSS	1.00	1.00	1.20	5.00	Y	
80	12	C1	2	6	COX	15.00	15.00	15.00	3.00	Y	SIMULATOR OFF 3 MIN, OD7 DID NOT WORK
81	12	D1	2	6	COX	2.00	5.00	5.75		Y	
82	13	A1	3	6	BELL	1.00	1.00	4.00	5.00	Y	
83	13	A2	3	6	BELL	1.00	5.00	10.00	2.00	Y	
84	13	A3	3	6	BELL	1.00	1.00	3.00	8888.00	Y	
85	13	A4	3	6	BELL	1.00	2.00	5.00	8.00	Y	
86	13	B1	3	6	BELL	1.00	2.00	10.00	2.00	Y	
87	13	B2	3	6	BELL	7.00	17.00	27.00	8888.00	Y	
88	13	C1	3	6	BELL	2.00	2.00	2.00	2.00	Y	
89	13	D1	3	6	BELL	2.00	2.00	4.00	3.00	Y	
90	13	D2	3	6	BELL	1.00	28.00	30.00	1.00	Y	
91	14	A1	1	7	SCHAVEY	2.00	3.00	7.00	13.00	Y	
92	14	A2	1	7	SCHAVEY	1.00	4.00	16.00	8888.00	Y	
93	14	C1	1	7	SCHAVEY	3.70	6.05		1.00	Y	NO TIMES GIVEN FOR RECG, EVAL, COR
94	14	D1	1	7	SCHAVEY	8.00	12.00	17.00	12.00	Y	
95	14	D2	1	7	SCHAVEY	2.00	10.00		4.00	Y	NO TIME GIVEN FOR COR.
96	15	A1	2	7	BELL	4.00	4.00	9.00		Y	NO TIME GIVEN FORM PROCEDURES
97	15	A2	2	7	BELL	1.00	1.00	7.00	5.00	Y	
98	15	A3	2	7	BELL	1.00	1.00	5.00	10.00	Y	
99	15	A4	2	7	BELL	1.00	1.00	12.00	7.00	Y	
100	15	B1	2	7	BELL	1.00	1.00	10.00	5.00	Y	
101	15	B2	2	7	BELL	5.00	10.25	13.00	9.00	Y	ASSUMED TIMEEVAL 1 MIN < TIME COR
102	15	C1	2	7	BELL	30.00	30.00	30.00	5.00	Y	
103	15	D1	2	7	BELL	2.00	2.00	3.00	2.00	Y	
104	15	D2	2	7	BELL	1.00	2.00	8888.00	1.00	Y	NO TIME GIVEN FOR TIMECOR
105	16	A1	3	7	RUSSELL	1.00	1.00	3.00	1.00	Y	
106	16	A2	3	7	RUSSELL	1.00	6.00	8.00	1.00	Y	
107	16	A3	3	7	RUSSELL	2.00	2.00			Y	TIMECOR NOT GIVEN OR NOT DONE
108	16	B1	3	7	RUSSELL	1.00	1.00	2.00		Y	PROCEDURES ACCESSED BUT NO TIME GIVEN
109	16	B2	3	7	RUSSELL	12.00	45.00			N	NO TIMES GIVEN

Table A.1.1-2 (Continued)
Time Data for Phase 1 Drills

110	16	D1	3	7	RUSSELL	2.00	3.00	4.00		Y	NO TIME GIVEN FOR PROCEDURES
111	16	D2	3	7	RUSSELL	3.00	3.00			Y	NO TIMES GIVEN FOR COR & PROC
112	17	A1	1	8	COX	0.10	0.28	1.28		Y	
113	17	A2	1	8	COX	0.02	3.00	3.27		Y	
114	17	A3	1	8	COX	0.75	1.00	3.00		Y	
115	17	A4	1	8	COX	0.08	0.25	4.00		Y	
116	17	B1	1	8	COX	0.42	0.42	4.00		Y	TIMECOR IS ASSUMED
117	17	C1	1	8	COX	1.75	1.75	1.75		Y	SIMULATOR STOPPED AFTER TIMECOR
118	17	D1	1	8	COX	0.50	2.50	3.50		Y	
119	18	A2	1	9	BELL	1.00	1.00	3.00	1.00	Y	
120	18	A3	1	9	BELL	2.00	3.00	5.00		Y	
121	18	A4	1	9	BELL	1.00	1.00	8.00	5.00	Y	
122	18	B1	1	9	BELL	1.00	1.00	2.00		Y	
123	18	B2	1	9	BELL	5.00	6.00	17.00	8.00	Y	
124	19	A1	2	9	WEIDNER	0.23	0.65	1.90	9.90	Y	
125	19	A4	2	9	WEIDNER	0.63	0.82	2.58	4.00	Y	
126	19	C1	2	9	WEIDNER	2.57	4.00	4.00		Y	

Operator Number:________________Date:__________Shift:_________

Please give <u>your</u> impressions of the following aspects associated with the failure listed below that occurred during this exercise.

TDFWP Lockout

1. How difficult do you feel it was for you to:

   a. Recognize that the FW system was not operating normally (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

   b. Decide that manual control of the TDFWP was required (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

2. Please indicate with check marks in the following tables how useful each type of control room indication was in:

	a. Realizing the FW was not operating normally			b. Helping you determine that manual control of the TDFWP was required		
	Very Useful	Useful	Not Useful	Very Useful	Useful	Not Useful
a) Annunciator						
b) Panel Indicators						
c) Component Status Lights						
d) Switch Positions						
e) CRT Display						
f) Other						

(Describe)____

____

TDFWP - turbine driven feedwater pump
FW - feedwater

Figure A.1.1-11
Operator Questionnaire
Scenario A1

3. Are you routinely trained to recognize and respond to this type of failure?

Yes______ No______ If yes, how often?____________________

____

4. Do you feel this failure would be more difficult to recognize and respond to in the plant?

(a) Yes______ (b) No______

(c) Why?____

5. Please identify and explain occurrences (if any) that made it difficult for you to correctly respond to this failure.

____

____

____

Figure A.1.1-11 (Continued)

Operator Number:______________Date:____________Shift:___________

Please give your impressions of the following aspects associated with the failure listed below that occurred during this exercise.

SBGT Malfunction

1. How difficult do you feel it was for you to:

   a. Recognize that a SBGT failure had occurred (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

   b. Decide that a tech. spec. violation had occurred and that reactor shutdown was required (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

2. Please indicate with check marks in the following tables how useful each type of control room indication was in:

	a. Realizing that a SBGT system failure had occurred			b. Helping you determine a tech. spec. violation had occurred		
	Very Useful	Useful	Not Useful	Very Useful	Useful	Not Useful
a) Annunciator						
b) Panel Indicators						
c) Component Status Lights						
d) Switch Positions						
e) CRT Display						
f) Other						

(Describe)____

____

SBGT - standby gas treatment

Figure A.1.1-12
Operator Questionnaire
Scenario A2

3. Are you routinely trained to recognize and respond to this type of failure?

Yes_____ No_____ If yes, how often?_________________

____

4. Do you feel this failure would be more difficult to recognize and respond to in the plant?

(a) Yes_____ (b) No_____

(c) Why?____

5. Please identify and explain occurrences (if any) that made it difficult for you to correctly respond to this failure.

____

____

____

Figure A.1.1-12 (Continued)

Operator Number:______________Date:____________Shift:___________

Please give <u>your</u> impressions of the following aspects associated with the failure listed below that occurred during this exercise.

TDFWP Control Malfunction

1. How difficult do you feel it was for you to:

a. Recognize that a second FW system malfunction had occurred (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

b. Decide that you should take manual control of the TDFWP and balance flow (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

2. Please indicate with check marks in the following tables how useful each type of control room indication was in:

	a. Realizing a second FW system malfunction had occurred			b. Helping you determine to take manual control of TDFWP and balance flow		
	Very Useful	Useful	Not Useful	Very Useful	Useful	Not Useful
a) Annunciator						
b) Panel Indicators						
c) Component Status Lights						
d) Switch Positions						
e) CRT Display						
f) Other						

(Describe)____

TDFWP - turbine driven feedwater pump
FW - feedwater

Figure A.1.1-13. Operator Questionnaire Scenario A3

3. Are you routinely trained to recognize and respond to this type of failure?

Yes_____ No_____ If yes, how often?_________________

____

4. Do you feel this failure would be more difficult to recognize and respond to in the plant?

(a) Yes_____ (b) No_____

(c) Why?____

5. Please identify and explain occurrences (if any) that made it difficult for you to correctly respond to this failure.

____

____

____

Figure A.1.1-13 (Continued)

Operator Number:______________Date:____________Shift:___________

Please give your impressions of the following aspects associated with the failure listed below that occurred during this exercise.

Loss of Feed Malfunction

1. How difficult do you feel it was for you to:

   a. Recognize that normal level control (vessel makeup) had failed (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

   b. Decide that RCIC/HPCS should be used to maintain reactor vessel level (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

2. Please indicate with check marks in the following tables how useful each type of control room indication was in:

	a. Realizing that makeup to the vessel had failed			b. Helping you determine that HPCS/RCIC should be used to maintain vessel level control		
	Very Useful	Useful	Not Useful	Very Useful	Useful	Not Useful
a) Annunciator						
b) Panel Indicators						
c) Component Status Lights						
d) Switch Positions						
e) CRT Display						
f) Other						

(Describe)____

RCIC - reactor core isolation cooling system
HPCS - high pressure core spray system

Figure A.1.1-14. Operator Questionnaire Scenario A4

3. Are you routinely trained to recognize and respond to this type of failure?

Yes_____ No_____ If yes, how often?________________________

____

4. Do you feel this failure would be more difficult to recognize and respond to in the plant?

(a) Yes_____ (b) No_____

(c) Why?____

5. Please identify and explain occurrences (if any) that made it difficult for you to correctly respond to this failure.

____

____

____

Figure A.1.1-14 (Continued)

Operator Number:_______________Date:____________Shift:____________

Please give your impressions of the following aspects associated with the failure listed below that occurred during this exercise.

TDFWP Run Up Malfunction

1. How difficult do you feel it was for you to:

a. Recognize that the FW system had experienced a malfunction (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

b. Decide to take manual control of the TDFWP and balance flow (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

2. Please indicate with check marks in the following tables how useful each type of control room indication was in:

	a. Realizing the FW system had experienced a malfunction			b. Helping you determine you should take manual control of the TDFWP and balance flow		
	Very Useful	Useful	Not Useful	Very Useful	Useful	Not Useful
a) Annunciator						
b) Panel Indicators						
c) Component Status Lights						
d) Switch Positions						
e) CRT Display						
f) Other						

(Describe)____

____

TDFWP - turbine driven feedwater pump
FW - feedwater

Figure A.1.1-15
Operator Questionnaire
Scenario B1

3. Are you routinely trained to recognize and respond to this type of failure?

Yes_____ No_____ If yes, how often?________________

____

4. Do you feel this failure would be more difficult to recognize and respond to in the plant?

(a) Yes_____ (b) No_____

(c) Why?____

5. Please identify and explain occurrences (if any) that made it difficult for you to correctly respond to this failure.

____

____

____

Figure A.1.1-15 (Continued)

Operator Number:____________Date:__________Shift:__________

Please give your impressions of the following aspects associated with the failure listed below that occurred during this exercise.

FW Line Rupture Malfunction

1. How difficult do you feel it was for you to:

a. Recognize that a second malfunction had occurred in the FW system (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

b. Identify the malfunction as a leak (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

c. Determine the leak location (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

d. Determine that HPCS/RCIC should be used to control RV level (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

FW - feedwater
HPCS - high pressure core spray system
RCIC - reactor core isolation cooling system
RV - reactor vessel

Figure A.1.1-16
Operator Questionnaire
Scenario B2

2. Please indicate with check marks the usefulness of the control room indications for accomplishing items a through d above:

	a.			b.			c.			d.		
	Very Use-ful	Use-ful	Not Use-ful	Very Use-ful	Use-ful	Not Use-ful	Very Use-ful	Use-ful	Not Use-ful	Very Use-ful	Use-ful	Not Use-ful
a) Annunciators												
b) Panel Indications												
c) Component Status Lights												
d) Switch Positions												
e) CRT Display												
f) Other												

(Describe)____

____

3. Are you routinely trained to recognize and respond to this type of failure?

Yes_____ No_____ If yes, how often?_________________

____

4. Do you feel this failure would be more difficult to recognize and respond to in the plant?

(a) Yes_____ (b) No_____

(c) Why?______________________________________

5. Please identify and explain occurrences (if any) that made it difficult for you to correctly respond to this failure.

____

____

____

Figure A.1.1-16 (Continued)

Name:______________________________Date:______________Shift:____________

Please give your impressions of the following aspects associated with the failures listed below that occurred during this exercise.

Loss of Bus 152/Failure of Some Rods to Insert

1. How difficult do you feel it was for you to:

   a. Realize that all rods were not fully inserted (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

   b. Decide that the stuck rods did not pose a threat to plant safety and that ATWS procedures should not be implemented (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

2. Please indicate with check marks in the following tables your feeling of how useful each of the following types of control room indications was in:

	a. Realizing the rods were stuck			b. Helping you determine that this was not an ATWS situation		
	Very Useful	Useful	Not Useful	Very Useful	Useful	Not Useful
a) Annunciator						
b) Panel Indicators						
c) Component Status Lights						
d) Switch Positions						
e) CRT Display						
f) Other						

(Describe)____

____

ATWS - anticipated transient without scram

Figure A.1.1-17
Operator Questionnaire
Scenario C1

3. Are you routinely trained to recognize and respond to this type of failure?

Yes______ No______ If yes, how often?__________________

____

4. Do you feel this failure would be more difficult to recognize and respond to in the plant?

(a) Yes______ (b) No______

(c) Why?____

5. Please identify and explain occurrences (if any) that made it difficult for you to correctly respond to this failure.

____

____

____

Figure A.1.1-17 (Continued)

Operator Number:______________Date:____________Shift:___________

Please give your impressions of the following aspects associated with the failure listed below that occurred during this exercise.

HPCS Fails Surveillance Test

1. How difficult do you feel it was for you to:

   a. Recognize that HPCS failed the surveillance test (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

   b. Correlate this failure to the tech. specs. and decide a reactor shutdown was required (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

2. Please indicate with check marks in the following tables how useful each type of control room indication was in:

	a. Realizing that HPCS failed the surveillance test			b. Helping you determine that plant shutdown was required		
	Very Useful	Useful	Not Useful	Very Useful	Useful	Not Useful
a) Annunciators						
b) Panel Indications						
c) Component Status Lights						
d) Switch Positions						
e) CRT Display						
f) Other						

(Describe)____

____

HPCS - high pressure core spray

Figure A.1.1-18
Operator Questionnaire
Scenario D1

3. Are you routinely trained to recognize and respond to this type of failure?

Yes______ No______ If yes, how often?____________________

____

4. Do you feel this failure would be more difficult to recognize and respond to in the plant?

(a) Yes______ (b) No______

(c) Why?____

5. Please identify and explain occurrences (if any) that made it difficult for you to correctly respond to this failure.

____

____

____

Figure A.1.1-18 (Continued)

Operator Number:______________Date:____________Shift:__________

Please give your impressions of the following aspects associated with the failure listed below that occurred during this exercise.

LOCA/Failure of High Pressure Core Cooling Malfunction

1. How difficult do you feel it was for you to:

   a. Recognize that all high pressure core cooling systems had failed (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

   b. Decide that low pressure systems should be used and were available to cool the core (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

2. Please indicate with checks marks in the following tables how useful each type of control room indication was in:

	a. Realizing that vessel inventory makeup via high pressure systems was lost			b. Helping you determine that low pressure systems should be used and were available to cool the core		
	Very Useful	Useful	Not Useful	Very Useful	Useful	Not Useful
a) Annunciators						
b) Panel Indications						
c) Component Status Lights						
d) Switch Positions						
e) CRT Display						
f) Other						

(Describe)____

LOCA - loss of coolant accident

Figure A.1.1-19
Operator Questionnaire
Scenario D2

3. Are you routinely trained to recognize and respond to this type of failure?

Yes______ No______ If yes, how often?__________________

____

4. Do you feel this failure would be more difficult to recognize and respond to in the plant?

(a) Yes______ (b) No______

(c) Why?____

5. Please identify and explain occurrences (if any) that made it difficult for you to correctly respond to this failure.

____

____

____

Figure A.1.1-19 (Continued)

Name:______________________Date:__________Shift:__________

Please provide your evaluation of the following failure associated with this exercise. This may be completed following the exercise.

TDFWP Lockout Malfunction

1. How difficult do you feel it should have been for the operating team to:

   a. Realize that the FW system was not operating normally (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

   b. Decide that they should take manual control of the TDFWP and balance flow (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

2. Please indicate with check marks in the following tables your feeling of how useful each of the following types of control room indications was to the operating team in:

	a. Realizing the FW system was not operating normally			b. Helping them determine that they should take control of the TDFWP and balance flow		
	Very Useful	Useful	Not Useful	Very Useful	Useful	Not Useful
a) Annunciators						
b) Panel Indications						
c) Component Status Lights						
d) Switch Positions						
e) CRT Display						
f) Other						

(Describe)____

____

TDFWP - turbine driven feedwater pump
FW - feedwater

Figure A.1.1-20. Instructor Questionnaire: Scenario A1

3. Please indicate which of the following statements related to the SBGT failures is true (check one or more).

   a.______ No procedures exist for responding to this failure.
   b.______ Procedures exist, but were not used.
   c.______ Procedures exist and were used.
   d.______ The operating team attempted to use procedures that were not applicable to this failure.

4. Is the typical control room operator routinely trained to recognize and respond to this type of failure?

   Yes______ No______ If yes, how often?____________________

   ____

5. Would this failure be more difficult to recognize and respond to in the plant?

   (a) Yes______ (b) No______

   (c) Why?____

6. Please identify and explain occurrences (if any) that distracted the operating team while responding to this failure (e.g., irrelevant alarms, poor communications, etc.).

   ____

   ____

   ____

   ____

7. Please identify and explain inappropriate actions (if any) that the operating team took while responding to this failure.

   ____

   ____

   ____

   ____

   ____

SBGT - standby gas treatment

Figure A.1.1-20 (Continued)

Name:____________________________Date:_____________Shift:____________

Please provide <u>your</u> evaluation of the following failure associated with this exercise. This may be completed following the exercise.

SBGT Malfunction

1. How difficult do <u>you</u> feel it <u>should</u> have been for the operating team to:

   a. Realize that SBGT was failed (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

   b. Correlated this failure to the tech. specs. and decide a reactor shutdown was required (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

2. Please indicate with check marks in the following tables <u>your</u> feeling of how useful each of the following types of control room indications was to the operating team in:

	a. Realizing the SBGT system had failed			b. Helping them determine that a a tech. spec. violation had occurred		
	Very Useful	Useful	Not Useful	Very Useful	Useful	Not Useful
a) Annunciators						
b) Panel Indications						
c) Component Status Lights						
d) Switch Positions						
e) CRT Display						
f) Other						

(Describe)____

SBGT - standby gas treatment

Figure A.1.1-21
Instructor Questionnaire
Scenario A2

3. Please indicate which of the following statements related to the SBGT failures is true (check one or more).

a.______ No procedures exist for responding to this failure.
b.______ Procedures exist, but were not used.
c.______ Procedures exist and were used.
d.______ The operating team attempted to use procedures that were not applicable to this failure.

4. Is the typical control room operator routinely trained to recognize and respond to this type of failure?

Yes______ No______ If yes, how often?__________________

____

5. Would this failure be more difficult to recognize and respond to in the plant?

(a) Yes______ (b) No______

(c) Why?____

6. Please identify and explain occurrences (if any) that distracted the operating team while responding to this failure (e.g., irrelevant alarms, poor communications, etc.).

____

____

____

____

7. Please identify and explain inappropriate actions (if any) that the operating team took while responding to this failure.

____

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Figure A.1.1-21 (Continued)

Name:_________________________Date:____________Shift:____________

Please provide <u>your</u> evaluation of the following failure associated with this exercise. This may be completed following the exercise.

TDFWP Control Malfunction

1. How difficult do <u>you</u> feel it <u>should</u> have been for the operating team to:

   a. Realize that a second FW system failure had occurred (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

   b. Decide that they should take manual control of the TDFWP and balance flow (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

2. Please indicate with check marks in the following tables <u>your</u> feeling of how useful each of the following types of control room indications was to the operating team in:

	a. Realizing a Second FW system failure had occurred			b. Helping them determine that they should take manual control of the TDFWP and balance flow		
	Very Useful	Useful	Not Useful	Very Useful	Useful	Not Useful
a) Annunciators						
b) Panel Indications						
c) Component Status Lights						
d) Switch Positions						
e) CRT Display						
f) Other						

(Describe)____

TDFWP - turbine driven feedwater pump
FW - feedwater

Figure A.1.1-22. Instructor Questionnaire: Scenario A3

3. Please indicate which of the following statements related to the TDFWP control failure is true (check one or more).

a.______ No procedures exist for responding to this failure.
b.______ Procedures exist, but were not used.
c.______ Procedures exist and were used.
d.______ The operating team attempted to use procedures that were not applicable to this failure.

4. Is the typical control room operator routinely trained to recognize and respond to this type of failure?

Yes______ No______ If yes, how often?__________________

____

5. Would this failure be more difficult to recognize and respond to in the plant?

(a) Yes______ (b) No______

(c) Why?____

6. Please identify and explain occurrences (if any) that distracted the operating team while responding to this failure (e.g., irrelevant alarms, poor communications, etc.).

____

____

____

____

7. Please identify and explain inappropriate actions (if any) that the operating team took while responding to this failure.

____

____

____

____

____

TDFWP - turbine driven feedwater pump

Figure A.1.1-22 (Continued)

Name:________________________Date:___________Shift:___________

Please provide <u>your</u> evaluation of the following failure associated with this exercise. This may be completed following the exercise.

Loss of Feed Malfunction

1. How difficult do <u>you</u> feel it <u>should</u> have been for the operating team to:

   a. Realize that normal level control (vessel makeup) had failed (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

   b. Decide that RCIC/HPCS should be used to maintain RV (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

2. Please indicate with check marks in the following tables <u>your</u> feeling of how useful each of the following types of control room indications was to the operating team in:

	a. Realizing that makeup to the vessel had failed			b. Helping them determine that HPCS/RCIC should be used to maintain RV level		
	Very Useful	Useful	Not Useful	Very Useful	Useful	Not Useful
a) Annunciators						
b) Panel Indications						
c) Component Status Lights						
d) Switch Positions						
e) CRT Display						
f) Other						

(Describe)____

RCIC - reactor core isolation cooling system
HPCS - high pressure core spray system
RV - reactor vessel

Figure A.1.1-23. Instructor Questionnaire: Scenario A4

3. Please indicate which of the following statements related to the Loss of feed is true (check one or more).

a.______ No procedures exist for responding to this failure.
b.______ Procedures exist, but were not used.
c.______ Procedures exist and were used.
d.______ The operating team attempted to use procedures that were not applicable to this failure.

4. Is the typical control room operator routinely trained to recognize and respond to this type of failure?

Yes______ No______ If yes, how often?__________________

____

5. Would this failure be more difficult to recognize and respond to in the plant?

(a) Yes______ (b) No______

(c) Why?____

6. Please identify and explain occurrences (if any) that distracted the operating team while responding to this failure (e.g., irrelevant alarms, poor communications, etc.).

____

____

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____

7. Please identify and explain inappropriate actions (if any) that the operating team took while responding to this failure.

____

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____

Figure A.1.1-23 (Continued)

Name:__________________________Date:____________Shift:___________

Please provide your evaluation of the following failure associated with this exercise. This may be completed following the exercise.

TDFWP Run Up Malfunction

1. How difficult do you feel it should have been for the operating team to:

   a. Realize that the FW system had experienced a malfunction (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

   b. Decide that they should take manual control of the TDFWP and balance flow (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

2. Please indicate with check marks in the following tables your feeling of how useful each of the following types of control room indications was to the operating team in:

	a. Realizing the FW system had experienced a malfunction			b. Helping them determine that they should take manual control of the TDFWP and balance flow		
	Very Useful	Useful	Not Useful	Very Useful	Useful	Not Useful
a) Annunciators						
b) Panel Indications						
c) Component Status Lights						
d) Switch Positions						
e) CRT Display						
f) Other						

(Describe)____

TDFWP - turbine driven feedwater pump
FW - feedwater

Figure A.1.1-24. Instructor Questionnaire: Scenario B1

3. Please indicate which of the following statements related to the TDFWP run up failure is true (check one or more).

a.______ No procedures exist for responding to this failure.
b.______ Procedures exist, but were not used.
c.______ Procedures exist and were used.
d.______ The operating team attempted to use procedures that were not applicable to this failure.

4. If the typical control room operator routinely trained to recognize and respond to this type of failure?

Yes______ No______ If yes, how often?__________________

____

5. Would this failure be more difficult to recognize and respond to in the plant?

(a) Yes______ (b) No______

(c) Why?____

6. Please identify and explain occurrences (if any) that distracted the operating team while responding to this failure (e.g., irrelevant alarms, poor communications, etc.).

____

____

____

____

7. Please identify and explain inappropriate actions (if any) that the operating team took while responding to this failure.

____

____

____

____

____

TDFWP - turbine driven feedwater pump

Figure A.1.1-24 (Continued)

Name:_________________________Date:___________Shift:___________

Please provide your evaluation of the following failure associated with this exercise. This may be completed following the exercise.

FW Line Rupture

1. How difficult do you feel it should have been for the operating team to:

   a. Realize that a second malfunction had occurred in the feedwater system (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

   b. Identify the malfunction as a leak (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

   c. Determine the leak location (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

   d. Determine that HPCS/RCIC should be used to control RV level (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

FW - feedwater
HPCS - high pressure core spray system
RCIC - reactor core isolation cooling system
RV - reactor vessel

Figure A.1.1-25
Instructor Questionnaire
Scenario B2

2. Please indicate with check marks the usefulness of the control room indications for accomplishing items a through d above.

	a.			b.			c.			d.		
	Very Use-ful	Use-ful	Not Use-ful	Very Use-ful	Use-ful	Not Use-ful	Very Use-ful	Use-ful	Not Use-ful	Very Use-ful	Use-ful	Not Use-ful
a) Annunciators												
b) Panel Indications												
c) Component Status Lights												
d) Switch Positions												
e) CRT Display												
f) Other												

(Describe)____

____

3. Please indicate which of the following statements related to the feedwater line rupture is true (check one or more).

a._____ No procedures exist for responding to this failure.
b._____ Procedures exist, but were not used.
c._____ Procedures exist and were used.
d._____ The operating team attempted to use procedures that were not applicable to this failure.

4. Is the typical control room operator routinely trained to recognize and respond to this type of failure?
Yes_____ No_____ If yes, how often?______________________

____

5. Would this failure be more difficult to recognize and respond to in the plant?
(a) Yes_____ (b) No_____
(c) Why?____

6. Please identify and explain occurrences (if any) that distracted the operating team while responding to this failure (e.g., irrelevant alarms, poor communications, etc.).

____
____
____

7. Please identify and explain inappropriate actions (if any) that the operating team took while responding to this failure.

____
____
____

Figure A.1.1-25 (Continued)

Name:____________________________Date:______________Shift:______________

Please provide <u>your</u> evaluation of the following failure associated with this exercise. This may be completed following the exercise.

Loss of Bus 152/Failure of Some Rods to Insert

1. How difficult do <u>you</u> feel it <u>should</u> have been for the operating team to:

   a. Realize that HPCS failed the surveillance test (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

   b. Decide that the stuck rods did not pose a threat to plant safety and that ATWS procedures should not be implemented (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

2. Please indicate with check marks in the following tables <u>your</u> feeling of how useful each of the following types of control room indications was to the operating team in:

	a. Realizing the rods were stuck			b. Helping them determine that this was not an ATWS situation		
	Very Useful	Useful	Not Useful	Very Useful	Useful	Not Useful
a) Annunciator						
b) Panel Indicators						
c) Component Status Lights						
d) Switch Positions						
e) CRT Display						
f) Other						

(Describe)____

____

HPCS - high pressure core spray system
ATWS - anticipated transient without scram

Figure A.1.1-26. Instructor Questionnaire: Scenario C1

3. Please indicate which of the following statements related to the stuck rods is true (check one or more).

   a.______ No procedures exist for responding to this failure.
   b.______ Procedures exist, but were not used.
   c.______ Procedures exist and were used.
   d.______ The operating team attempted to use procedures that were not applicable to this failure.

4. Is the typical control room operator routinely trained to recognize and respond to this type of failure?

   Yes______ No______ If yes, how often?__________________

   ____

5. Would this failure be more difficult to recognize and respond to in the plant?

   (a) Yes______ (b) No______

   (c) Why?____

6. Please identify and explain occurrences (if any) that distracted the operating team while responding to this failure (e.g., irrelevant alarms, poor communications, etc.).

   ____

   ____

   ____

   ____

7. Please identify and explain inappropriate actions (if any) that the operating team took while responding to this failure.

   ____

   ____

   ____

   ____

   ____

   ____

Figure A.1.1-26 (Continued)

Name:____________________Date:__________Shift:__________

Please provide your evaluation of the following failure associated with this exercise. This may be completed following the exercise.

HPCS Fails Surveillance Test

1. How difficult do you feel it should have been for the operating team to:

   a. Realize that HPCS failed the surveillance test (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

   b. Correlated this failure to the tech. specs. and decide a reactor shutdown was required (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

2. Please indicate with check marks in the following tables your feeling of how useful each of the following types of control room indications was to the operating team in:

	a. Realizing HPCS failed the surveillance test			b. Helping them determine that a tech. spec. violation had occurred		
	Very Useful	Useful	Not Useful	Very Useful	Useful	Not Useful
a) Annunciator						
b) Panel Indicators						
c) Component Status Lights						
d) Switch Positions						
e) CRT Display						
f) Other						

(Describe)____________________________________

HPCS - high pressure core spray

Figure A.1.1-27. Instructor Questionnaire: Scenario D1

3. Please indicate which of the following statements related to this failure is true (check one or more).

a.______ No procedures exist for responding to this failure.
b.______ Procedures exist, but were not used.
c.______ Procedures exist and were used.
d.______ The operating team attempted to use procedures that were not applicable to this failure.

4. Is the typical control room operator routinely trained to recognize and respond to this type of failure?

Yes______ No______ If yes, how often?____________________

____

5. Would this failure be more difficult to recognize and respond to in the plant?

(a) Yes______ (b) No______

(c) Why?____

6. Please identify and explain occurrences (if any) that distracted the operating team while responding to this failure (e.g., irrelevant alarms, poor communications, etc.).

____

____

____

____

7. Please identify and explain inappropriate actions (if any) that the operating team took while responding to this failure.

____

____

____

____

____

____

____

Figure A.1.1-27 (Continued)

Name:______________________________Date:_____________Shift:____________

Please provide your evaluation of the following failure associated with this exercise. This may be completed following the exercise.

LOCA/High Pressure Core Cooling Failure

1. How difficult do you feel it should have been for the operating team to:

   a. Realize that vessel inventory makeup via high pressure systems was lost (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

   b. Decide that low pressure systems should be used and were available to cool the core (check one).

Much Easier Than Average	Easier Than Average	Average	More Difficult Than Average	Much More Difficult Than Average

2. Please indicate with check marks in the following tables your feeling of how useful each of the following types of control room indications was to the operating team in:

	a. Realizing that vessel inventory makeup via high pressure systems was lost			b. Helping them determine that low pressure systems should be used and were available to cool the core		
	Very Useful	Useful	Not Useful	Very Useful	Useful	Not Useful
a) Annunciator						
b) Panel Indicators						
c) Component Status Lights						
d) Switch Positions						
e) CRT Display						
f) Other						

(Describe)____

____

LOCA - loss of coolant accident

Figure A.1.1-28. Instructor Questionnaire: Scenario D2

3. Please indicate which of the following statements related to the LOCA/failure of high pressure injection is true (check one or more).

   a._____ No procedures exist for responding to this failure.
   b._____ Procedures exist, but were not used.
   c._____ Procedures exist and were used.
   d._____ The operating team attempted to use procedures that were not applicable to this failure.

4. Is the typical control room operator routinely trained to recognize and respond to this type of failure?

   Yes_____ No_____ If yes, how often?________________

   ____

5. Would this failure be more difficult to recognize and respond to in the plant?

   (a) Yes_____ (b) No_____

   (c) Why?____

6. Please identify and explain occurrences (if any) that distracted the operating team while responding to this failure (e.g., irrelevant alarms, poor communications, etc.).

   ____

   ____

   ____

   ____

7. Please identify and explain inappropriate actions (if any) that the operating team took while responding to this failure.

   ____

   ____

   ____

   ____

   ____

   ____

LOCA - loss of coolant accident

Figure A.1.1-28 (Continued)

Table A.1.1-3
Data from Operator Questionnaires

SUMMER DATA

OPERATOR QUESTIONNAIRE RESPONSES

CREW = 1=SH1 WK1, 2= SH2 WK1, 3=SH1 WK2, 4= SH2 WK2, 5=SH1 WK3, 6=SH2 WK3, 7=SH1 WK4,
8=SH2 WK4, 9=SH1 WK5, 10=SH2 WK5, 11=SH1 WK6, 12=SH2 WK6, 13=SH3 WK6,
14=SH1 WK7, 15=SH2 WK7, 16=SH3 WK7,
17=SH1 WK8, 18=SH1 WK9, 19=SH2 2K9.

Q NUMBERS REFER TO QUESTIONS ON OPERATOR QUESTIONNAIRE

INPUT OBS 1-3 CREW 6-7 OPER 9-10 S $ 12-13 SHIFT 15 WEEK 17 Q1A $ 19-21 Q1B $ 23-25
Q2AA $ 29-30 Q2AB $ 33-34 Q2AC $ 37-38 Q2AD $ 41-42 Q2AE $ 45-46 Q2AF $ 49-50
Q2BA $ 53-54 Q2BB $ 57-58 Q2BC $ 61-62 Q2BD $ 65-66 Q2BE $ 69-70 Q2BF $ 73-74
Q3A $ 77-78 Q3B 83-85 Q4A $ 88 Q4B $ 90 Q5 $ 92-95;

1	1	3	A1	1	1	A	A	NU	VU	VU	VU	NU		NU	VU	VU	VU	NU		Y	1	N	Y	NONE
2	1	7	A2	1	1	E	A	VU	VU	VU	NU	NU		U	U	VU	U	U		Y	1	N	Y	NONE
3	1	3	A3	1	1	MD	E	NU	U	VU	U	NU		NU	U	VU	U	NU		N	0	N	Y	NONE
4	1	3	B1	1	1	A	A	NU	VU	VU	VU	NU		NU	VU	VU	U	NU		Y	1	N	Y	NONE
5	1	7	B2	1	1	A	A	U	U	U	U	U								Y	1	N		
6	1	7	D1	1	1	E	E	U	VU	U	U	NU		NU	U	U	NU	NU		Y	1	N	Y	NONE
7	1	3	D2	1	1	A	A	NU	VU	U	U	NU		NU	VU	U	U	NU		Y	1	N	Y	NONE
8	2	1	A1	2	1	A	A	U	U	U	U	U								N	0	Y	Y	
9	2	6	A2	2	1	E	A	U	U	U	NU	NU		U	U	U	U	U		Y	1	N	Y	NONE
10	2	1	A3	2	1	A	A	U	U	U	U	U								N	0	Y	Y	
11	2	6	A4	2	1	A	E	U	U	U	U	NU		U	U	U	U	NU		Y	365	Y	Y	
12	2	1	B1	2	1	A	A	U	U	U	U	U								N	0	Y	Y	
13	2	1	C1	2	1	A	A	NU	U	U	U	U		NU	VU	U	U	U		N	0	Y	Y	Y
14	2	4	D1	2	1	ME	E	NU	VU	NU	NU	NU		NU	NU	NU	NU	NU		Y	1	N	Y	NONE
15	2	4	D2	2	1	E	E	U	U	U	U	NU		U	U	U	U	NU		Y	1	N		NONE
16	3	8	A1	1	2	E	E	VU	VU	U	NU	NU		VU	VU	VU	VU	NU		Y	1	N		NONE
17	3	9	A2	1	2	E	E	VU	VU	NU	NU	NU	Y	NU	U	U	U	U	Y	Y	1	N	Y	NONE
18	3	8	A3	1	2	E	E	U	VU	NU	NU	NU	Y	U	VU	VU	VU	NU		Y	1	N		NONE
19	3	9	A4	1	2	A	E	VU	U	U	U	U	Y	U	VU	U	U	NU	Y	Y	1	N	Y	NONE
20	3	8	B1	1	2	E	E	VU	VU	NU	NU	U		U	VU	VU	U	U		Y	1	N		
21	3	9	B2	1	2	A	E	U	U	NU	NU	NU								Y	1	N		
22	3	8	D1	1	2	E	A	NU	VU	NU	NU	NU		NU	NU	NU	NU	NU	Y	Y	365	N		NONE
23	3	9	D2	1	2	ME	ME	VU	VU	U	U	NU		U	U	U	U	NU		Y	1	N		
24	4	10	A1	2	2	MD	ME	NU	VU	U	NU	NU		U	VU	U	U	NU		Y	1	Y	Y	Y
25	4	14	A1	2	2	MD	A	NU	VU	VU	VU	NU		NU	VU	VU	VU	NU		Y	1	N	Y	Y
26	4	13	A2	2	2	E	E	U	VU	VU	U	NU		NU	VU	VU	U	NU		Y	12	N	Y	
27	4	11	A2	2	2	ME	MMD	VU	VU	VU	NU	NU		NU	NU	NU	NU	NU		Y	1	N	Y	NONE
28	4	13	B1	2	2	E	MD	NU	U		NU	NU		U	U	NU	U	U		Y	1	N	Y	
29	4	10	B1	2	2	E	MD	VU	VU	U	NU	NU		U	VU	NU	NU	NU		Y	1	N	Y	
30	4	11	B2	2	2	A	E	U	NU	NU	NU	NU		NU	NU	NU	NU	NU		Y	1	N	Y	NONE
31	4	14	B2	2	2	A	E	U	U	U	U	NU		NU	NU	NU	NU	NU		Y	1	N		
32	4	10	C1	2	2	MD	E	NU	U	NU	NU	NU		NU	NU	NU	NU	NU		Y	1	N	Y	
33	4	13	C1	2	2	A	A	NU	U	U	NU	NU		NU	U	U	NU	NU		Y	1	N	Y	Y
34	5	15	A1	1	3	E		U	VU	NU	NU	NU		NU	VU	U	NU	NU		Y	1	N	Y	Y
35	5	19	A1	1	3	A	A	VU	VU	U	U	VU		VU	VU	U	U	VU		Y	1	N	Y	Y
36	5	16	A2	1	3	A	A	VU	VU	VU	NU	NU		VU	NU	NU	NU	NU		N	0	N	Y	Y
37	5	20	A2	1	3	ME	MD	VU	U	VU	NU	NU	Y	NU	NU	NU	NU	NU	Y	Y	2	N		
38	5	15	A3	1	3	MD	A	NU	VU	VU	U	NU		NU	VU	U	U	NU		Y	1	N		Y
39	5	20	B2	1	3	MD	E	U	U	NU	NU	NU		NU	U	NU	NU	NU		Y	1	N		
40	5	16	B2	1	3	MD	E	U	VU	NU	NU	NU		U	VU	NU	NU	NU		Y	1	N	Y	
41	5	16	C1	1	3	A	E	NU	VU	VU	NU	NU		NU	U	NU	NU	NU		Y	1			Y
42	5	20	C1	1	3	MD	A	NU	NU	U	NU	NU		U	VU	NU	NU	NU		Y	2	N		
43	5	16	D1	1	3																			
44	6	17	A1	2	3	E	ME	VU	VU	VU	VU	NU								Y	1	N		
45	6	17	A2	2	3	E	A	U	U	U	U	NU								Y	1	N		
46	6	18	A3	2	3	ME	ME		VU	VU				NU			NU	NU		Y		N		
47	6	18	A4	2	3	ME	ME	U	VU	VU	NU	NU		U	VU	U	NU	NU		Y		N		
48	6	18	B1	2	3	ME	ME	U	VU	VU	NU	NU								Y	2	N		
49	6	18	B2	2	3	MD	E	VU	U	NU	U	NU								Y	1	N	Y	
50	6	21	C1	2	3	MD	MD	NU	VU	U				U	U	U				Y	2	N	Y	Y
51	6	21	D1	2	3	A	A	NU	VU	NU	NU	NU		U	NU	NU	NU	NU		Y	1	N		
52	6	21	D2	2	3	A	A	NU	VU	NU	NU	NU	Y	U	VU	U	U	U		Y	1	N		
53	7	27	A1	1	4	ME	A	NU	VU		VU	NU		NU	NU	NU	NU	NU	Y	Y	1	Y	Y	NONE
54	7	28	A2	1	4	ME	ME	VU	VU	VU	VU							U		Y	1	N		NONE
55	7		A3	1	4																			
56	7	23	A4	1	4	E	E	NU	VU	VU	NU	NU		U	VU	VU	NU	NU		N	0	Y	Y	
57	7	24	B1	1	4	A	A	VU	VU	VU	NU	NU		U	VU	VU	NU	NU		Y	365	N	Y	NONE
58	7	27	B2	1	4	A	A	U	U	U	U									Y	1	N	Y	Y
59	7	23	C1	1	4	ME	A	U	U	U							NU	NU		Y		Y	Y	
60	7	24	D1	1	4	A	A	NU	U	NU	NU	NU	Y	NU	NU	NU	NU	NU	Y	Y	1	N		NONE
61	8	26	A1	2	4	A	MD	U	NU	VU	VU	NU	Y	NU	NU	NU	NU	NU	Y	Y	1	N	Y	Y
62	8	29	A1	2	4	A	A	U		U	U				U		U			Y	1	N		
63	8	30	A2	2	4	A	A	VU	U	VU	U	NU		U	U	NU	NU	NU		Y		N	Y	Y
64	8	25	A2	2	4	ME	ME	VU	VU	VU	VU	NU	Y							Y		N		NONE
65	8	25	A3	2	4	A	E	U	VU	VU	VU	NU								Y		N		
66	8	29	A3	2	4	A	E	VU	VU	NU	NU	NU								Y	1	N	Y	
67	8	30	B1	2	4	A	A	U	U	NU	NU	VU		U	VU	U	NU	VU		Y	1	N	Y	Y
68	8	26	B1	2	4	A	A	U	U	U	U				U	U	U			Y	1	N		
69	8	29	B2	2	4	A	A	U	U	NU	NU	NU		NU	U	NU	NU	NU		Y	1	N	Y	
70	8	25	B2	2	4	A	A	NU	U	NU	U	NU								Y		Y	Y	
71	8	26	C1	2	4	A	A		U						U					Y	1	N		
72	8	29	C1	2	4	MD	E	U	VU	VU	U	NU		U	U	NU	U	NU		Y	1	N		
73	8	30	C1	2	4	MD	A	NU	VU	VU	NU	NU		NU	VU	VU	NU	NU		Y	1	N	Y	NONE
74	8	25	C1	2	4	A	E	U	U	U	U		Y							Y		N		
75	8	25	D2	2	4	A	A	U	U	U	U	U	Y							Y		N		
76	8	30	D2	2	4	A	A	NU	U	NU	NU	NU		NU	U	U	U	NU			1	N	Y	Y
77	8	26	D2	2	4	A	A		U	U				U	U					Y		N		
78	8	29	D2	2	4	E	E	U	U	U	U	U		VU	VU	VU	U	U		Y	1	N		
79	9	37	A1	1	5	E	A	VU	U	U	U	NU		U	VU	NU	NU	NU		Y	1	N	Y	NONE
80	9	43	A1	1	5	ME	A	VU	U	U	U	NU		U	U	U	U	U		N	0	N		NONE
81	9	85	A2	1	5	ME	E	VU	VU	VU	VU	NU								Y	9	N	Y	NONE
82	9	40	A2	1	5	ME	ME	VU	VU	VU	NU	NU		U	VU	U		NU		Y	1	N		NONE
83	9	85	B1	1	5	E	E	VU	VU	VU	VU	NU								Y		N		NONE
84	9	43	B1	1	5	ME	ME	U	U	U	U	U		U	U	U	U	U		N	0	N		NONE
85	9	37	B2	1	5	MD	E	NU	VU	NU	NU	NU		U	VU	NU	NU			Y	1	N		

Table A.1.1-3 (Continued)
Data from Operator Questionnaires

86	9	40	B2	1	5	A	A	U	VU	NU	NU	NU		U	VU	NU	NU	NU		Y	1	Y		
87	9	43	C1	1	5	E	E	U	VU	VU	U	U		U	VU	VU	U	U		N	0	N		NONE
88	9	85	C1	1	5	E	E	VU	VU	VU	VU	NU								Y	9	N	Y	
89	9	85	D1	1	5	A	E	VU	VU	VU	VU	NU								Y	9	N	Y	
90	9	43	D1	1	5	ME	ME	NU	VU	U	U	NU		U	VU	VU	U	U		N	0	N	Y	
91	10	42	A1	2	5	E	E	VU	U	U	NU	NU	Y	VU	U	U	NU	NU	Y	Y	1	N		
92	10	41	A1	2	5	ME	E	VU	U	U	NU	NU		U	VU	U		NU		Y	1	Y	Y	
93	10	38	A3	2	5	E	E	U	U	U	U	NU	Y	NU	VU	NU				Y	1	Y	Y	
94	10	39	A3	2	5	E	A	U	VU	NU	NU	NU		U	VU	U	U	NU		Y	1	N		
95	10	42	A4	2	5	E	E	U	U	U	NU	NU		U	U	U	NU	NU		Y	1	N		
96	10	41	A4	2	5	E	E	VU	VU	U	NU	NU		U	U	U	U	NU		Y	2	N		
97	10	39	A4	2	5	A	A	VU	VU	U	U	U		VU	VU	U	NU	NU						
98	10	38	A4	2	5	E	E	U	VU	VU	U	NU		U	U	U	U	NU	Y	Y	1	N	Y	Y
99	10	42	B1	2	5	E	E	U	VU	U	NU	NU		U	VU	U	NU	NU		Y	1	N		
100	10	39	B1	2	5	E	E	VU	U	NU	NU	NU		VU	U	U	NU	NU		Y	1	N		
101	10	41	B2	2	5	ME	ME	NU	VU	NU	NU	NU		NU		NU	NU	NU		Y		N	Y	
102	10	38	B2	2	5	E	E	U	U	U	NU	NU	Y	NU	U	NU	U	NU	Y	Y	1	Y	Y	
103	11	44	A1	1	6	A	A	VU	VU	U	NU	NU		U	U	U	NU	NU		Y	1	Y	Y	
104	11	46	A1	1	6	E	A	VU	U	U		NU		NU	VU	U		NU		Y	1	Y	Y	
105	11	47	A1	1	6	A	A	VU	VU	U	NU	NU	Y	U	U	VU	VU	NU	Y	Y	1	N	Y	NONE
106	11	89	A1	1	6	A	MD	VU	U	U	NU	U	Y	VU	NU	NU	NU	NU		Y	1	Y	Y	Y
107	11	44	A2	1	6	A	A	NU	VU	VU	NU	NU		NU	VU	VU	NU	NU		Y	1	N	Y	
108	11	46	A2	1	6	ME	E	VU	U	U	NU	NU		NU	NU	NU	NU	NU		Y	1	N		
109	11	47	A2	1	6	A	A	VU	VU	VU	NU	NU	Y	NU	NU	NU	NU	NU	Y	Y	1	N		NONE
110	11	89	A2	1	6	ME	ME	VU	VU	VU	VU			U	U	U	U	U	Y	Y		N	Y	Y
111	11	44	A3	1	6	A	A	NU	VU	VU	VU	NU		NU	VU	VU	VU	NU		Y	1	Y	Y	
112	11	46	A3	1	6	A	A	NU	VU	VU		NU		NU	VU	NU	VU	NU		Y	1	Y	Y	
113	11	47	A3	1	6	A	A	VU	VU	U	VU	VU	Y	U	U	VU	VU	U	Y	Y	1	N	Y	NONE
114	11	89	A3	1	6	A	A	NU	U	NU	NU	NU	Y	NU	VU	NU	NU	NU	Y	Y	1	Y	Y	Y
115	11	44	B1	1	6	A	A	U	U	NU	U	NU		U	U	NU	U	NU		Y	1	N	Y	
116	11	46	B1	1	6	ME	ME	NU	VU	U	NU	NU		NU	VU	NU	U	NU		Y	1	Y	Y	
117	11	47	B1	1	6	A	A	U	U	U	U	NU	Y	NU	VU	VU	NU	NU	Y	Y	1	N		
118	11	89	B1	1	6	A	A	VU	VU	U	NU	NU	Y	U	U	U	NU	NU	Y	Y	1	Y	Y	Y
119	11	44	B2	1	6	MD	A	U	U	NU	NU	NU	.	U	U	NU	NU	NU		Y	1	N	Y	
120	11	46	B2	1	6	A	A	NU	U	NU	NU	NU		NU	U	NU	NU	NU		Y	1	Y	Y	
121	11	47	B2	1	6	MD	E	U	U	U	NU	NU	Y							Y	1	N	Y	Y
122	11	89	B2	1	6	MD	A	NU	NU	NU	NU	NU	Y	VU	VU	U	NU	NU	Y	Y	1	N	Y	Y
123	11	44	C1	1	6	A	A	NU	U	U	NU	NU	Y	NU	VU	NU	NU	NU		Y	1	N	Y	
124	11	46	C1	1	6	A	A	NU	U	VU	NU	NU		NU	U	U	NU	NU		Y	1	Y	Y	
125	11	47	C1	1	6	A	A	NU	U	U	NU	NU	Y	NU	U	U	NU	NU	Y	Y	1	N	Y	NONE
126	11	89	C1	1	6	A	E	NU	NU	NU	NU	NU	Y	NU	U	U	NU	NU	Y	Y	1	N	Y	NONE
127	11	44	D2	1	6	ME	A	NU	U	U	NU	NU		NU	U	NU	NU	NU		Y	1	N	Y	
128	11	46	D2	1	6	ME	A	U	U	U	U	NU		NU	U	U	U	NU		Y	1			
129	11	47	D2	1	6	A	A	NU	U	NU	NU	NU	Y	NU	VU	NU	NU	NU	Y	Y	1	N	Y	
130	11	89	D2	1	6	A	A	U	U	U	U	U	Y	VU	VU	U	U	U		Y	1	N	Y	
131	12	49	A1	2	6	ME	ME	NU	VU	VU	VU	NU	Y	NU	NU	NU	NU	NU		Y	1	Y	Y	
132	12	50	A1	2	6	ME	ME	U	U	U	NU	NU		NU	U	U	NU	NU		Y	1	N	Y	NONE
133	12	87	A1	2	6	ME	ME	NU	VU	VU	VU	NU		NU	U	U	U	NU		Y	1	N		
134	12	45	A2	2	6	A	A	U	U	U	U	U		U	U	U	U	U		Y	1	N		NONE
135	12	49	A2	2	6	ME	ME	VU	VU	VU	NU	NU		U	U	U	U	U	Y	Y	1	N	Y	
136	12	50	A2	2	6	E	E	U	U	U	NU	NU	Y	NU	NU	NU	NU	NU		Y	1	Y	Y	Y
137	12	45	A3	2	6	A	A	U	U	U	U	U		U	U	U	U	U		Y	1	N		NONE
138	12	49	A3	2	6	ME	ME	NU	VU	VU	NU	NU		U	U	U	U	U	Y	N	0	N		
139	12	50	A3	2	6	A	A	NU	U	U	NU	NU		NU	U	U	NU	NU		Y	1	N		NONE
140	12	87	A3	2	6	A	A	NU	NU	U	NU	NU	Y	NU	NU	NU	NU	NU						
141	12	49	C1	2	6	MD	ME	NU	NU	VU	NU	NU		NU	VU	NU	NU	NU		Y	1	N	Y	
142	13	51	A1	3	6	A	A	VU	U	NU				U	U		U			Y		N		Y
143	13	52	A2	3	6	E	E	VU	U	U	NU	NU		VU	U	U	NU	NU		Y	1	N		
144	13	62	A3	3	6	A	A	VU	VU	VU	U	U		VU	VU	VU	VU	U		Y	1	N	Y	NONE
145	13	51	A4	3	6	MD	E	VU	U	U	U			U	VU	U	U			Y		N		
146	13	51	B1	3	6	MMD	MMD	U	U	U	U	U	Y	U	U	U	U	U	Y	Y	1	N		Y
147	13	52	B2	3	6	MD	A	NU	U	NU	NU	NU		U	VU	NU	NU	NU		Y	1	N	Y	Y
148	13	62	C1	3	6	MD	E	NU	NU	VU	NU	NU		NU	NU	VU	NU	NU		Y	1	N	Y	Y
149	13	52	D1	3	6	ME	ME	U	VU	NU	NU	NU		U	VU	NU	NU	NU		Y	1	N	Y	Y
150	13	51	D2	3	6	E	E	U	VU	VU				VU	VU	U				Y	1	N		
151	14	64	A1	1	7	ME	A	VU	VU	VU	VU			VU	VU	VU	VU			Y	1	N		NONE
152	14	67	A1	1	7	E	A	U	U	U	U	NU		NU	VU	NU	U	NU		Y	1	N		
153	14	63	A2	1	7	ME	ME	U	U	U	U	NU		VU	VU			NU		Y	1	N	Y	NONE
154	14	63	C1	1	7	E	ME	NU	U	U	NU	NU		NU	VU	VU	NU	NU		Y	1	N	Y	Y
155	14	67	C1	1	7	E	E	NU	VU	VU	NU	NU	Y	NU	VU	VU	NU	NU	Y	Y	1	N		
156	14	67	D1	1	7	E	E	NU	VU	NU	NU	U		NU	VU	NU	NU	U		Y	1	N		
157	14	64	D1	1	7	ME	A	NU	VU	U	U	U		NU	U	NU	NU	NU		Y	1	N	Y	NONE
158	14	67	D2	1	7	E	E	NU	VU	NU	U	U		NU	VU	NU	U	U		Y	1	N		
159	14	63	D2	1	7	ME	ME	VU	VU	VU	VU	NU	Y	VU	VU	VU	VU	U	Y	Y	1	Y	Y	Y
160	15	59	A1	2	7	A	E	VU	VU	U	NU	NU		U	VU	NU	NU	NU		Y	1	N	Y	
161	15	66	A2	2	7	ME	ME	U	U	U	U			U	U	U	U			Y	1	N	Y	
162	15	59	A3	2	7	A	MD	U	VU	NU	NU	NU		U	VU	U	NU	NU		Y	1	N	Y	
163	15	0	A4	2	7	A	A	NU	U	U	NU	NU		NU	U	NU	NU	NU		Y	1	N		Y
164	15	66	B1	2	7	A	A	NU	VU	VU	U	NU		NU	VU	VU	U	NU		Y	1	N		
165	15	59	B2	2	7	A	MD	NU	VU	NU	U	NU		U	VU	U	U	NU		Y	1	N		
166	15	0	C1	2	7	MD	A	NU	VU	U	NU	NU		NU	VU	U	U	NU		Y	1	N		Y
167	15	59	D1	2	7	ME	ME	NU	VU	U	U	NU		NU	NU	NU	NU	NU		Y	1	N		
168	15	66	D2	2	7	E	E	U	VU	VU	NU	NU		U	VU	VU	U	NU		Y	1	N		
169	16	71	A1	3	7	ME	E	VU		VU	NU	NU			VU		NU	NU		Y	1	N	Y	NONE
170	16	69	A1	3	7	A	A	VU	VU	U	VU	NU	Y	VU	VU	U	VU	NU		Y	1	Y	Y	
171	16	68	A2	3	7	ME	ME		U	U	NU	NU		U	U	U	NU	NU		Y		N		
172	16	70	A2	3	7	ME	E	U	U	NU	NU	NU		VU	VU	NU	NU	NU		Y	1	N		
173	16	68	A3	3	7	MD		U	VU	VU	NU	NU								Y	1	N		
174	16	70	A4	3	7	ME	ME	VU	VU	VU	U	NU		U	U	U	U	NU		Y	1	N		
175	16	68	A4	3	7	E	ME	VU	VU	VU	NU	NU		U	VU	U	U	NU		Y		N		
176	16	70	B1	3	7	ME	ME	U	VU	U	NU	NU		U	U	U	NU	NU		Y	1	N	Y	
177	16	71	B1	3	7	A	A	VU	VU	VU	NU	NU		VU	VU	VU	NU	NU		Y	1	N	Y	NONE
178	16	69	B2	3	7	MD	A	VU	VU	U	U	NU		NU	NU	NU	NU	NU		Y	1	N		
179	16	68	B2	3	7	MD	E	VU	VU	NU	NU	NU		U	U	U	NU	NU		Y		N		
180	16	71	C1	3	7	A	A	NU	U	U	NU	NU		NU	U	U	NU	NU		Y		Y	Y	
181	16	69	C1	3	7	A	E	NU	U	U	U	NU		NU	U	VU	NU			Y	1	N		
182	16	69	D1	3	7	E	MD	NU	VU	NU	U	NU		NU	U	NU	U	NU		Y	1	N		
183	16	70	D1	3	7	ME	E	U	VU	U	NU	NU								N	0	N		NONE
184	16	69	D2	3	7	E	E	VU	VU	VU	NU	NU		VU	VU	VU	VU	NU		Y		N		
185	16	71	D2	3	7	ME	ME	NU	VU	VU	VU			NU	VU	VU	VU			Y	1	N		NONE
186	17	76	A1	1	8	E	E	VU	U	VU	VU	NU		.U	U	VU	VU	NU		Y		N	Y	Y

Table A.1.1-3 (Continued)
Data from Operator Questionnaires

187	17	90	A2	1	8	ME	MD	VU	U	VU	U	NU		NU	NU	NU	NU	NU		Y	1	N		NONE
188	17	73	A3	1	8	E	E	VU	VU	U	NU	NU		VU	U	NU	U	NU		Y	1	N	Y	NONE
189	17	76	A4	1	8	E	E	VU	U	NU	NU	U	Y	VU	VU	NU	NU	U	Y	Y	1	N		
190	17	76	B1	1	8	E	E	U	VU	VU	U	U		U	VU	VU	U	U		Y		Y	Y	Y
191	17	73	C1	1	8	A	A	NU	VU	VU	NU	NU	Y	U	VU	VU	NU	NU		Y	2	N	Y	Y
192	18	65	A1	1	9	A	A	VU	U	NU	U	NU		VU	U	NU	U	NU		N				
193	18	65	A2	1	9	ME	ME	VU	VU	VU	NU	NU		VU	VU	VU	NU	NU		Y	8	N	Y	
194	18	88	A3	1	9	A	A	NU	VU	VU	U	NU	Y	NU	VU	NU	U	NU	Y	N		N		
195	18	36	A4	1	9	A	A	U	VU	VU	VU	NU		NU	U	U	U	NU		Y		Y	Y	
196	18	65	B1	1	9	A	MD	U	U	NU	NU	NU	Y	U	U	U	NU	NU	Y	N		Y	Y	
197	18	36	B2	1	9	MD	A	NU	U	U	U	NU		NU	U	U	U	NU		Y		Y	Y	
198	19	72	A1	2	9	A	A	U	VU	VU	U	NU								Y	1	Y	Y	NONE
199	19	58	A1	2	9	A	A	NU	VU	NU	NU	NU		U	VU	NU	NU	NU		Y	1	N	Y	Y
200	19	53	A4	2	9	A	E	VU	VU	VU	*NU	NU		VU	VU	VU	NU	NU		Y	1	N		
201	19	86	A4	2	9	E	ME	U	VU	U	NU	NU		VU	VU	U	NU	NU		Y	8	Y	Y	
202	19	58	C1	2	9	A	A	NU	VU	U	NU	NU	Y	NU	VU	NU	NU	NU	Y	Y	1	N	Y	NONE
203	19	53	C1	2	9	A	A	VU	VU	U	NU	NU		NU	VU	VU	NU	NU		Y	1	N		NONE
204	19	86	C1	2	9	E	E	NU	NU	U	NU		Y	NU	U	NU	NU			Y		Y	Y	

Table A.1.1-4
Data from Instructor Questionnaires

```
**********************************************************************************
*                                  SUMMER DATA                                   *
*                        INSTRUCTOR QUESTIONNAIRE RESPONSES                      *
**********************************************************************************
*          CREW = 1=SH1 WK1, 2=SH2 WK1, 3=SH1 WK2, 4=SH2 WK2, 5=SH1 WK3, 6=SH2 WK3,  *
*                 7=SH1 WK4, 8=SH2 WK4, 9=SH1 WK5, 10=SH2 WK5, 11=SH1 WK6, 12=SH2 WK6, *
*                 13=SH3 WK6, 14=SH1 WK7, 15=WH2 WK7, 16=SH3 WK7,                *
*                 17=SH1 WK8, 18=SH1 WK9, 19=SH2 WK9.                            *
**********************************************************************************
*            Q NUMBERS REFER TO QUESTIONS ON INSTRUCTOR QUESTIONNAIRE            *
**********************************************************************************
```

INPUT OBS 1-3 CREW 5-6 SHIFT 8 WEEK 10 INSTRUC $ 12-18 S $ 20-21 Q1A $ 24-26 Q1B $ 29-31
Q2AA $ 35-36 Q2AB $ 39-40 Q2AC $ 43-44 Q2AD $ 47-48 Q2AE $ 51-52 Q2AF $ 55-56
Q2BA $ 59-60 Q2BB $ 63-64 Q2BC $ 67-68 Q2BD $ 71-72 Q2BE $ 75-76 Q2BF $ 79-80
Q3 $ 84 Q4A $ 88 Q4B 91-93 Q5A $ 95 Q5B $ 98 Q6 $ 100-103 Q7 $ 105-108;

1	1	1	1	COX	A1	A	A	U	U	U	U	NU		U	U	U	U	U		C	Y	1	N		NONE	Y
2	1	1	1	COX	A2	ME	E	VU		VU	NU	NU		VU	U	VU	NU	NU		C	Y	1	N	Y	NONE	NONE
3	1	1	1	COX	A3	MD	A	NU	VU	U	NU	NU		NU	VU	U	NU	NU		C	Y	1	N		NONE	NONE
4	1	1	1	COX	B1	A	A	NU	U	U	NU	NU		NU	U	U	NU	NU		C	Y	1	N		NONE	NONE
5	1	1	1	COX	B2	MD	A	NU	VU	NU	NU	NU		U	U	NU	NU	U		C	Y	1	N		NONE	NONE
6	1	1	1	COX	D1	E	E	NU	VU	U	NU	NU		NU	VU	U	NU	NU		A	Y	1	N		NONE	NONE
7	1	1	1	COX	D2	MD	MD	U	U	NU	NU	NU		NU	U	NU	NU	NU			Y	1	N		NONE	NONE
8	2	2	1	BELL	A1	E	E	U	VU	U	U	NU		NU	VU	U	NU	NU		B	Y	1	N	Y		
9	2	2	1	BELL	A2	A	E	U	U	U	NU	NU		NU	VU	NU	NU	NU		B	Y	1	N	Y		
10	2	2	1	BELL	A3	A	E	VU	U	U	NU	NU		NU	U	U	NU	NU	Y	B	Y	1	N	Y		
11	2	2	1	BELL	A4	ME	E	VU	VU	U	NU	NU		U	VU	U	NU	NU			Y	1	N	Y		
12	2	2	1	BELL	B1	A	E	U	VU	NU	NU	NU			VU	U	U	NU		B	Y	1	N	Y		
13	2	2	1	BELL	C1	E	E	NU	NU	U	NU	NU	Y	NU	VU	U	NU	U			Y		N	Y	Y	
14	2	2	1	BELL	D1	E	E	NU	VU	NU	U	NU		NU	U	NU	NU	NU								
15	2	2	1	BELL	D2	A	A	U	U	U	NU	NU		U	U	U	NU	NU		C	Y	1	N	Y		
16	3	1	2	COX	A1	A	A	NU	U	VU	VU	NU		NU	U	VU	VU	NU		C	Y	1	N		NONE	NONE
17	3	1	2	COX	A2	ME	ME	VU	VU	VU	NU	NU		VU	VU	VU	NU	NU		C	Y	1	N		NONE	NONE
18	3	1	2	COX	A3	A	A	NU	VU	U	NU	NU		NU	VU	U	NU	NU		C	Y	1	N		NONE	NONE
19	3	1	2	COX	A4	E	A	VU	U	U	U	NU		VU	U	U	U	NU		B	Y	1	N		NONE	NONE
20	3	1	2	COX	B1	E	A	NU	U	U	VU	NU		NU	U	U	VU	NU		B	Y	1	N		NONE	NONE
21	3	1	2	COX	B2	MD	A		VU	NU	NU	NU		NU	NU	NU	NU	NU		B	Y	1	N		NONE	NONE
22	3	1	2	COX	D1	E	E	U	VU	NU	NU	NU		U	VU	NU	NU	NU		C	Y	1	N		NONE	NONE
23	3	1	2	COX	D2	A	A	NU	U	U	NU	NU		NU	U	U	NU	NU		C	Y	1	N		NONE	NONE
24	4	2	2	WEIDNER	A1	E	A	NU	VU	VU	VU	NU		NU	VU	VU	VU	NU		B	Y		Y	Y	NONE	Y
25	4	2	2	WEIDNER	A2	ME	E	VU	U	VU	U	NU								C	Y		N		NONE	NONE
26	4	2	2	WEIDNER	B1	A	E	VU	VU	U	U	NU		NU	U	NU	NU	NU		B	Y		Y	Y		
27	4	2	2	WEIDNER	B2	MMD	MD	NU	U	U	U	NU		NU	U	NU	NU	NU		A	Y	1	N	Y		
28	4	2	2	WEIDNER	C1	A	MD	NU	U	U	NU	NU	Y	NU	NU	NU	NU	NU		B	Y	365	Y	Y	Y	Y
29	5	1	3	WEIDNER	A2	ME	A	VU	U	U	NU	NU		NU	NU	NU	NU			B	Y	1	N			
30	5	1	3	WEIDNER	C1																					
31	5	1	3	WEIDNER	D1	A	MD	NU	U	NU	NU	NU		NU	VU	NU	NU	NU		C	Y	1	N			
32	6	2	3	BELL	A1	E	E	NU	U	VU	U	NU		NU	U	U	U	NU		B	Y	1	N	Y		
33	6	2	3	BELL	A2	A	E	VU	U	U	NU	NU		U	VU	U	NU	NU		C	Y	1	N	Y		
34	6	2	3	BELL	A3	E	E	NU	U	VU	NU	NU		NU	U	VU	NU	NU								
35	6	2	3	BELL	A4	E	E	U	U	U	NU	NU		U	VU	U	NU	NU		C	Y	1	N	Y		
36	6	2	3	BELL	B1	ME	E	U	VU	VU	U	NU		NU	VU	U	U	NU		C	Y	1	N	Y		
37	6	2	3	BELL	B2	A	A	U	U	NU	NU	NU		NU	VU	NU	NU	NU		C	Y	1	N	Y		
38	6	2	3	BELL	C1	A	A	NU	NU	VU	NU	NU		NU	VU	U	NU	NU		C	Y	1	N	Y		
39	6	2	3	BELL	D1	E	E	NU	VU	NU	NU	NU		NU	VU	NU	NU	NU		C	Y	1	N	Y		
40	6	2	3	BELL	D2	A	E	U	U	U	NU	NU		NU	NU	U	NU	NU		C	Y	1	N	Y		
41	7	1	4	COX	A1	A	E	NU	VU	NU	VU	NU		NU	VU	NU	VU	NU		B	Y	1	N		NONE	NONE
42	7	1	4	COX	A2	E	E	VU	U	U	U	NU		VU	U	U	U	NU		A	Y	1	N		NONE	NONE
43	7	1	4	COX	A3																					
44	7	1	4	COX	A4	A	A	VU	VU	NU	NU	NU		VU	VU	NU	NU	NU		B	Y	1	N		NONE	NONE
45	7	1	4	COX	B1	E	E	U	U	U	U			U	U	U	U	U		B	Y	1	N		NONE	NONE
46	7	1	4	COX	B2	A	A	NU	VU	NU	NU	NU		NU	NU	NU	NU	NU			Y	1	N		NONE	NONE
47	7	1	4	COX	C1	A	A	NU	VU	VU	NU	NU	Y	NU	VU	NU	NU	NU		B	Y	1	N		NONE	Y
48	7	1	4	COX	D1	ME	ME	U	VU	U	NU	NU		U	VU	U	NU	NU		B	Y	1	N		NONE	NONE
49	8	2	4	RUSSELL	A1	A	A	U	NU	U	U	NU			NU	U	U	NU		B	Y	2	N		Y	Y
50	8	2	4	RUSSELL	A2	A	A	U	U	U	U	NU		U	NU	NU	NU	NU		C	Y	2	N		NONE	NONE
51	8	2	4	RUSSELL	A3																					

Table A.1.1-4 (Continued)
Data from Instructor Questionnaires

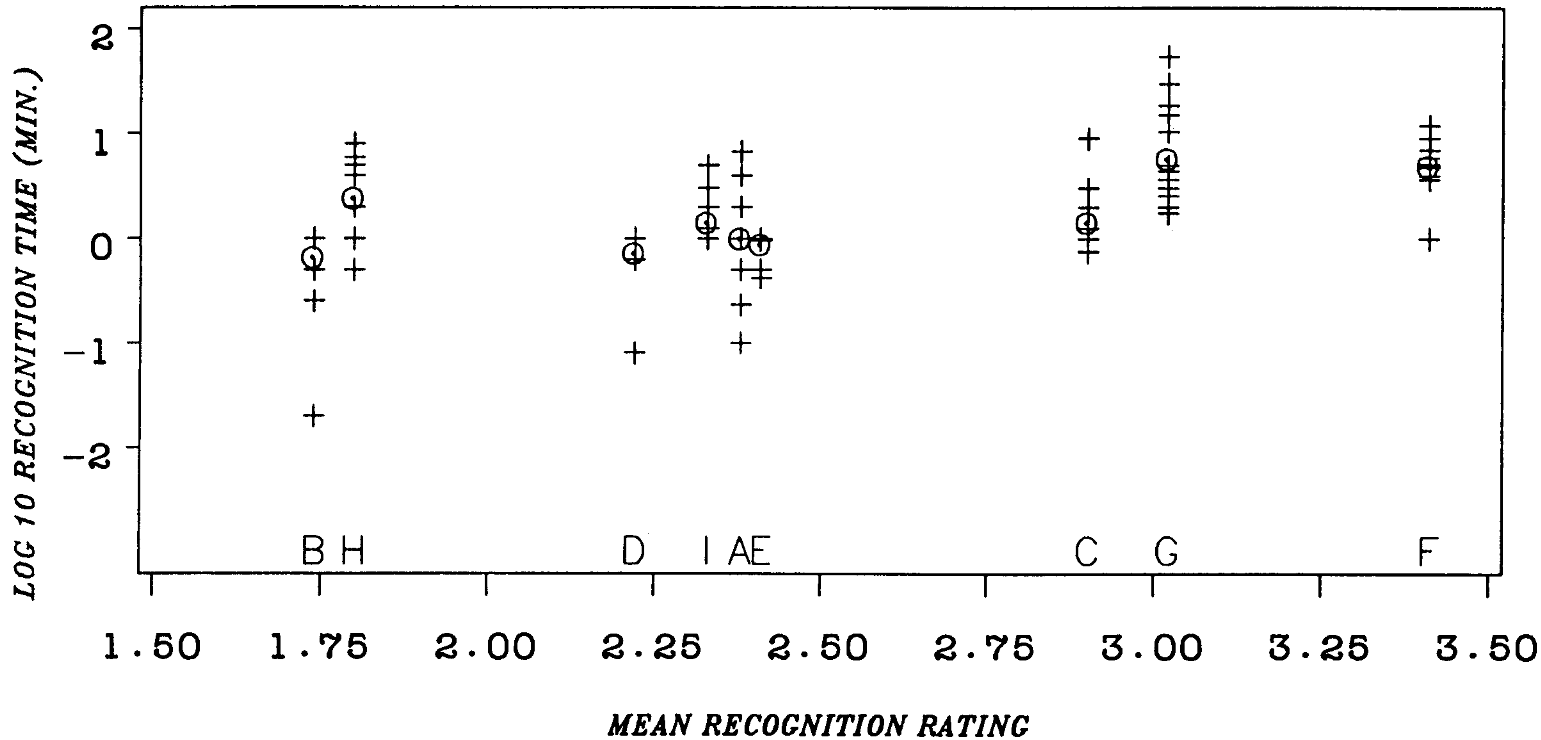
52	8	2	4	RUSSELL	C1	A	A	NU	U	U	NU	NU		NU						B	Y		N			
53	8	2	4	RUSSELL	D2	A	A	U	U	U	U	NU		U	U	U	U	NU		C			N			
54	9	1	5	SCHAVEY	A1	E	E	U	U	U	U	U								C	Y	1	N			
55	9	1	5	SCHAVEY	A2	E	E	VU	VU	VU	NU	NU	Y							B	Y	1	N		NONE	NONE
56	9	1	5	SCHAVEY	B1	E	E	U	U	U							U	U	Y	C	Y	1	N			
57	9	1	5	SCHAVEY	B2	A	E	U	NU	U										B	Y	1	N		NONE	NONE
58	9	1	5	SCHAVEY	C1	A	E	NU	NU	U	NU		Y	NU	NU	NU	NU	NU		B	Y	1	N		NONE	NONE
59	9	1	5	SCHAVEY	D1	E	E	NU			NU	U		NU	NU	NU	NU	NU	Y	A	Y	1	N		NONE	NONE
60	11	1	6	DEDIN	A1	A	A	VU	VU	VU	VU	NU		NU	VU	NU	NU	NU	Y	C	Y	1	N	Y	NONE	Y
61	11	1	6	DEDIN	A2	A	A	VU	VU	VU	NU	NU		VU	VU	VU	NU	NU		C	Y	1	N	Y	NONE	NONE
62	11	1	6	DEDIN	A3	MMD	A	NU	VU	VU	NU	NU		NU	VU	VU	NU	NU		C	Y	1	N	Y	NONE	NONE
63	11	1	6	DEDIN	B1	A	A	VU	VU	VU	VU	NU		VU	VU	VU	VU	NU		C	Y	1	N	Y	NONE	NONE
64	11	1	6	DEDIN	B2	A	A	NU	U	NU	NU	NU		U	U	NU	NU	NU		A	Y	1	N	Y	NONE	NONE
65	11	1	6	ROSS	C1	A	A	NU	U	VU	NU	NU		NU	U	U	NU	NU		C	Y	1	N	Y	NONE	NONE
66	11	1	6	ROSS	D2	E	A	U	VU	VU	VU	NU		U	VU	VU	VU	NU		C	Y	1	N	Y	NONE	NONE
67	12	2	6	ROSS	A2	E	A	VU	U	U	VU	NU		VU	U	U	U	NU		C	Y	1	N	Y	NONE	NONE
68	12	2	6	ROSS	A3	A	A	NU	VU	VU	NU	NU		NU	VU	VU	NU	NU		C	Y	1	N	Y	NONE	NONE
69	12	2	6	COX	C1	MD	A	NU	VU	U	NU	NU		NU	VU	U	NU	NU		B	Y	1	N		NONE	NONE
70	12	2	6	COX	D1	ME	ME	NU	VU	NU	NU	NU		NU	VU	NU	NU	NU			Y	1	N		NONE	NONE
71	13	3	6	BELL	A1	E	E	U	VU	VU	U	NU		NU	U	NU	NU	NU		C	Y	1	N	Y		
72	13	3	6	BELL	A2	ME	E	VU	VU	VU	NU	NU		U	U	U	NU	NU		C	Y	1	N	Y		
73	13	3	6	BELL	A3	A	E	NU	U	U	NU	NU		U	U	U	NU	NU		B	Y	1	N	Y		
74	13	3	6	BELL	A4	E	A	VU	U	U	NU	NU		U	U	NU	NU	NU		C	Y	1	N	Y		
75	13	3	6	BELL	B1	E	E	U	NU	U	NU	NU		U	U	U	U	NU		C	Y	1	N	Y		
76	13	3	6	BELL	B2	A	A	NU	VU	NU	NU	NU		NU	U	NU	NU	NU		B	Y	1	N	Y		
77	13	3	6	BELL	C1	A	E	NU	NU	VU	NU	NU		NU	VU	VU	NU	NU		C	Y	1	N	Y		
78	13	3	6	BELL	D1	E	E	NU	VU	NU	NU	NU		NU	VU	NU	NU	NU		C	Y	1	N	Y		
79	13	3	6	BELL	D2	E	E	U	VU	U	NU	NU		NU	U	U	NU	NU		C	Y	1	N	Y		
80	14	1	7	SCHAVEY	A1	A	A	U	U	U	NU	NU		U	U	U	NU	NU		C	Y	1	N			
81	14	1	7	SCHAVEY	A2	ME	E	VU	VU	VU	NU	NU		NU	NU	NU	NU	NU	Y	B	Y	1	N		NONE	NONE
82	14	1	7	SCHAVEY	C1	A	E	NU	U	VU	NU	NU		NU	NU	NU	NU	NU	Y	C	Y	1	N			
83	14	1	7	SCHAVEY	D1	ME	E	NU	U	NU	NU	NU		NU	U	NU	NU	NU	Y	A	Y	1	N			
84	14	1	7	SCHAVEY	D2	A	A	NU	U	U	U	NU		U	U	U	NU			C	Y	1	N			
85	15	2	7	BELL	A1																				Y	
86	15	2	7	BELL	A2																					
87	15	2	7	BELL	A3																					
88	15	2	7	BELL	A4																					
89	15	2	7	BELL	B1																					
90	15	2	7	BELL	B2																					
91	15	2	7	BELL	C1	A	E	NU	NU	VU	NU	NU	Y	NU	U	U	NU	NU		C	Y	1	N	Y	Y	Y
92	15	2	7	BELL	D1	E	E	NU	VU	NU	NU	NU		NU	VU	NU	NU	NU		C	Y		N	Y		
93	15	2	7	BELL	D2	E	E	NU	U	U	NU	NU		NU	U	U	NU	NU								
94	17	1	8	COX	A1	E	E	NU	VU	VU	VU	NU	Y	NU	VU	VU	VU	NU	Y	B	Y	1	N		NONE	NONE
95	17	1	8	COX	A2	A	E	VU	VU	U	NU	NU	Y	VU	VU	U	U	U	Y	B	Y	1	N		NONE	NONE
96	17	1	8	COX	A3	A	A	VU	U	NU	NU	NU	Y	VU	U	NU	NU	NU	Y	B	Y	1	N		NONE	NONE
97	17	1	8	COX	A4	E	E	VU	U	NU	NU	U	Y	VU	VU	NU	NU	U	Y	B	Y	1	N		NONE	NONE
98	17	1	8	COX	B1	A	A	U	U	U	U	NU		U	U	U	U	NU		B	Y	1	N		NONE	NONE
99	17	1	8	COX	C1	A	E	NU	VU	NU	NU	NU	Y	NU	VU	NU	NU	NU	Y	B	Y	1	N		NONE	NONE
100	17	1	8	COX	D1	E	E	NU	VU	U	NU	NU		NU	VU	U	NU	NU		C	Y	1	N		NONE	NONE
101	18	1	9	BELL	A1	A	E	VU	NU	VU	NU	NU		NU	U	VU	NU	NU		C	Y	1	N	Y		
102	18	1	9	BELL	A2	E	E	VU	VU	U	NU	NU		U	U	U	NU	NU		C	Y	1	N	Y		
103	18	1	9	BELL	A3	A	E	NU	U	U	NU	NU		NU	U	U	NU	NU		B	Y	1	N	Y		
104	18	1	9	BELL	A4	ME	A	VU	U	VU	NU	NU		NU	U	NU	NU	NU		C	Y	1	N	Y		
105	18	1	9	BELL	B1	E	A	U	U	U	NU	NU		U	U	U	NU	NU		B	Y	1	N	Y		
106	18	1	9	BELL	B2	MD	E	U	U	NU	NU	NU		NU	U	NU	NU	NU		C	Y	1	N	Y		

Results showed that there was little association between the rating and time data. Statistically significant differences were found among the mean recognition ratings and mean log 10 recognition times for the drills, but the degree of association was weak (see Figure A.2-1). For the evaluation data, there were no significant differences among the mean evaluation ratings, indicating that the instructors and operators considered the drills to be similar in difficulty level. However, there were significant differences among the mean log 10 evaluation times. Therefore, there was no relationship between the evaluation ratings and the time data.

It was also found that the recognition and evaluation ratings were highly variable among the instructors and operators (see Figures A.2-2 and A.2-3). Individual ratings for the drills often spanned almost the entire range of possible ratings, even though the ratings were performed immediately following each drill simulation. If the ratings are so inconsistent among those with substantial amounts of NPP operational knowledge and hands-on operational experience, one can expect only less promising results when those without or with less operational experience, such as probabilistic risk assessment (PRA) analysts, are required to make such judgments. This would be especially likely if such judgments were performed without the benefit of a prior drill simulation as may often be the case for PRA analysts.

If the DDM approach were pursued, it would be necessary to provide strict guidelines on how PRA analysts would arrive at valid judgments of recognition and evaluation difficulty. For example, one approach might be to have many PRA analysts provide such ratings after prior drill simulations and use mean ratings to enter the DDM matrix. Alternatively, one could have many instructors and operators perform such ratings after the drill simulations and use their mean ratings. However, because of the observed weak association between the mean ratings and simulator times and the expense and time this type of approach would entail, the effort appears to be without merit.

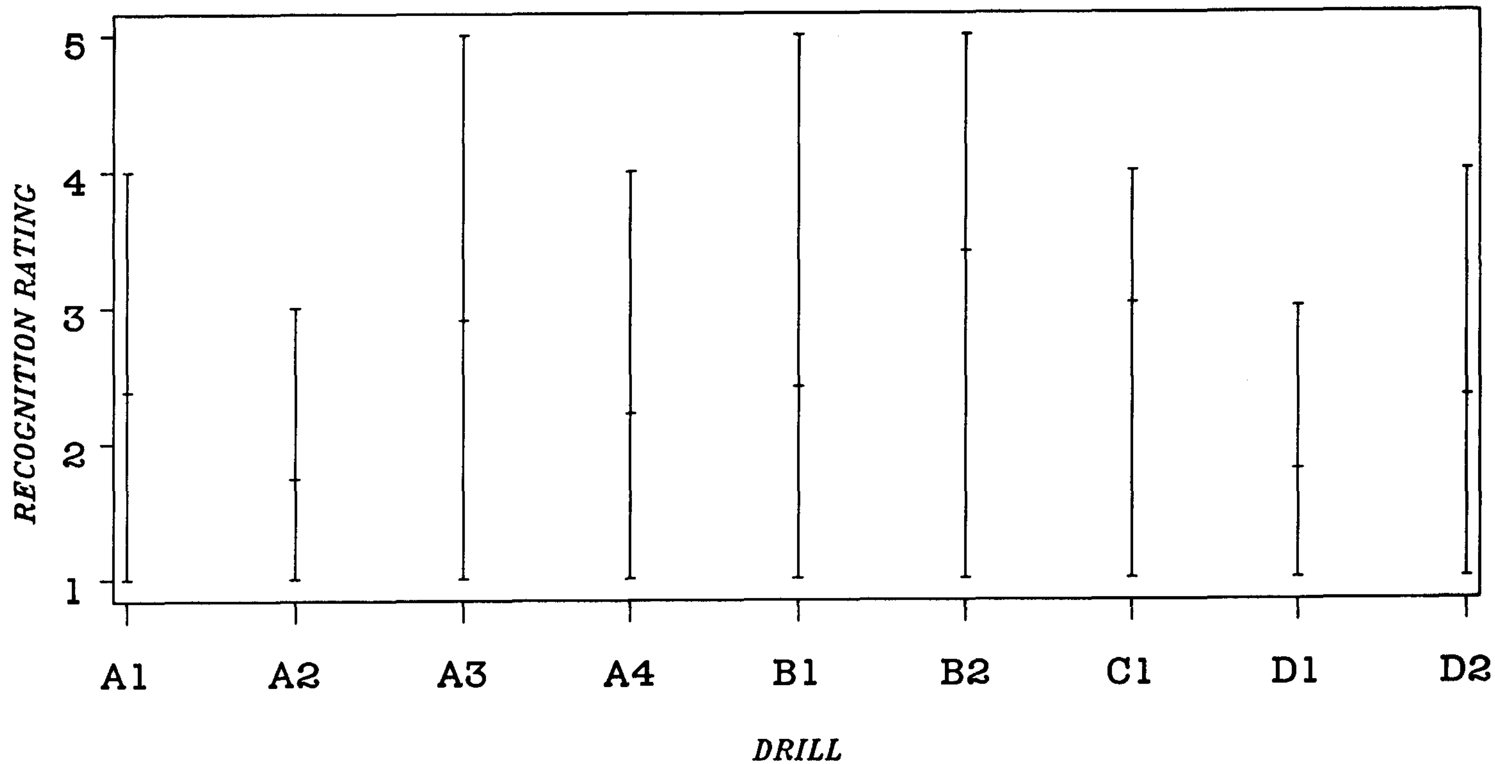
In conclusion, results of the Phase 1 data analyses did not show much promise for the DDM approach. The degree of association between the rating and time data was insufficient, and the ratings of recognition and evaluation difficulty from those with substantial amounts of NPP operational expertise were highly inconsistent, even when the ratings were performed immediately following each drill simulation. Therefore, a new approach was needed and developed for the Phase 2 data analyses.



DATA						
	A	Drill A1	B	Drill A2	C	Drill A3
	D	Drill A4	E	Drill B1	F	Drill B2
	G	Drill C1	H	Drill D1	I	Drill D2
	+	Data point	⊙	Mean		

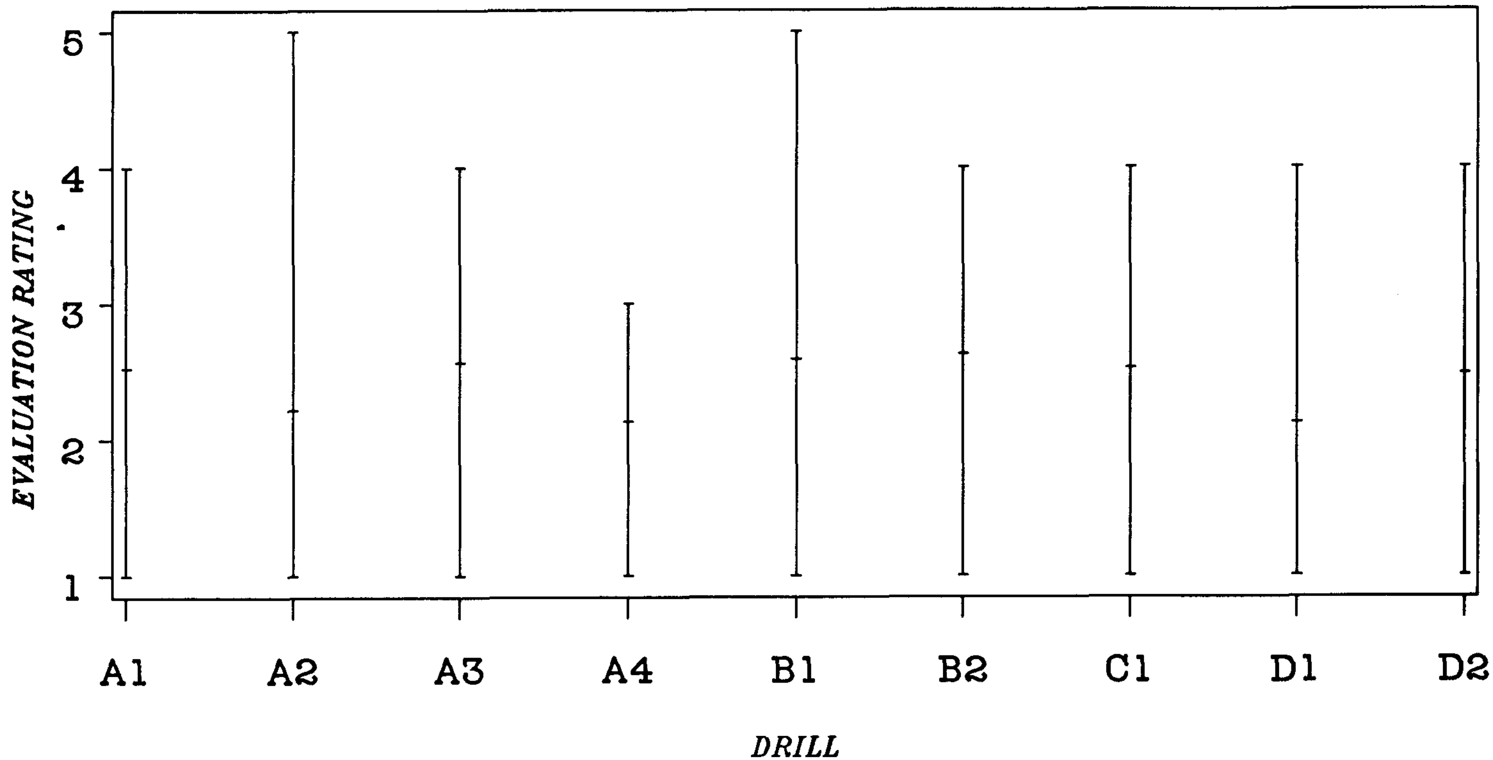
RATING 1 = Much Easier than Average, 2 = Easier than Average, 3 = Average, 4 = More Difficult than Average, 5 = Much More Difficult than Average

Figure A.2-1. **Individual and Mean Recognition Times as a Function of Mean Recognition Rating for Each Drill**



Rating 1=Much Easier than average, 2=Easier than average, 3=Average, 4=More difficult than average, 5=Much more difficult than average.

Figure A.2-2. Range of Recognition Ratings and Mean Rating as a Function of Drill



Rating 1=Much Easier than average, 2=Easier than average, 3=Average, 4=More difficult than average, 5=Much more difficult than average.

Figure A.2-3. Range of Evaluation Ratings and Mean Rating as a Function of Drill

In Phase 2, actions were first categorized into separate groups based upon their operational similarity. The actions within groups were then statistically compared to determine whether the operational groups could be statistically supported. This type of approach was adopted, since it requires little judgment on the part of the PRA analyst, and does not require hands-on operational experience or drill simulations. Only knowledge of the correct actions following an abnormal event, knowledge that a PRA analyst would have, is needed.

A.3 Methods of Data Analysis

As described in the introduction to Section A.1 and summarized in Table A.1-1, data were available for nine simulator drills. This section provides a description of the data analysis methods that were used to analyze the recognition and evaluation judgments and the times taken until correct recognition and evaluation.

The purpose of the analyses was to determine the strengths and weaknesses of the proposed DDM approach by examining the consistency of the judgment data and the relationship between the judgment data and the simulator time data.

A.3.1 Description of Data Analyzed

Each of the operators in 19 crews and the instructors for the particular crews and drills were instructed to rate the difficulty of recognition and evaluation at the completion of each drill. Ratings were performed on a five-point scale ranging from much easier than average (rating of 1) to much more difficult than average (rating of 5). The number of observations for each drill in Table A.1-1 varied from 23 to 45 (average of 33) for recognition and from 25 to 44 (average of 33) for evaluation ratings.

Simulator time data consisted of the cumulative time until a correct recognition and the cumulative time until a correct evaluation. There were a few missing times. In those cases, the data for the drill, including judgments of difficulty of recognition and evaluation, were reviewed to determine whether the crew was successful (correct recognition or evaluation was reached) or not. If it was determined that the crew was successful, the median time computed from the available data for the drill was used as the time.

There were four cases where the crew did not reach a correct recognition and/or evaluation. In some of those cases, the time when the drill was terminated was known. In other cases, it was known that the appropriate recognition and/or evaluation had not been reached as of a particular time. Such times are referred to as censoring times, and such observations are referred to as censored observations. Conventional methods for comparing groups of data cannot be used with censored observations. Therefore, censoring times were replaced with predicted success times prior to data analyses. A predicted success time was determined by graphically fitting a curve to a plot of data showing the cumulative probability of successful recognition or evaluation as a function of time from the start of the drill. By extrapolating the curve and considering the censoring time, a predicted success time was found.

The number of observations for each drill in Table A.1-1 varied from 10 to 18 (average of 14) for recognition and evaluation time measures.

A.3.2 Description of Analyses

The consistency of the judgment data was examined by calculating the mean and standard deviation of the individual recognition and evaluation ratings for each drill. The mean recognition and evaluation ratings plus and minus two standard deviations for each drill were then plotted. This type of plot shows the range within which approximately 95% of the ratings were.

The judgment data were also analyzed through analyses of variance (ANOVAs) to determine the influence of factors such as assignment (operator or instructor), crew, and drill upon the mean recognition and evaluation ratings. The level of significance used was .05 (The level of significance or p value is the probability that an observed difference that is not real is wrongly considered real). Two ANOVA models were run on each type of rating. One was a three-factor ANOVA with the factors being Assignment, Crew, and Drill. The model was a mixed model with Crew being a random variable and Assignment and Drill being fixed variables [13]. Because the effect of Assignment was found to be highly insignificant in the analyses of the recognition and evaluation ratings, this factor was dropped from the model, and a two-factor model with the factors being Crew and Drill was then run on each type of rating. If there is a significant effect in an ANOVA for a factor such as drill, this means that two or more drill means differ significantly. To more closely examine the extent of differences among means, Scheffe's multiple comparisons test was run on means for significant factors in the ANOVA [13]. The level of significance used was .05. It should be noted that Scheffe's test is a conservative test of pairwise differences among means. Therefore, it is possible to obtain no significant differences among means with the Scheffe test, even though a significant factor effect is found with the ANOVA.

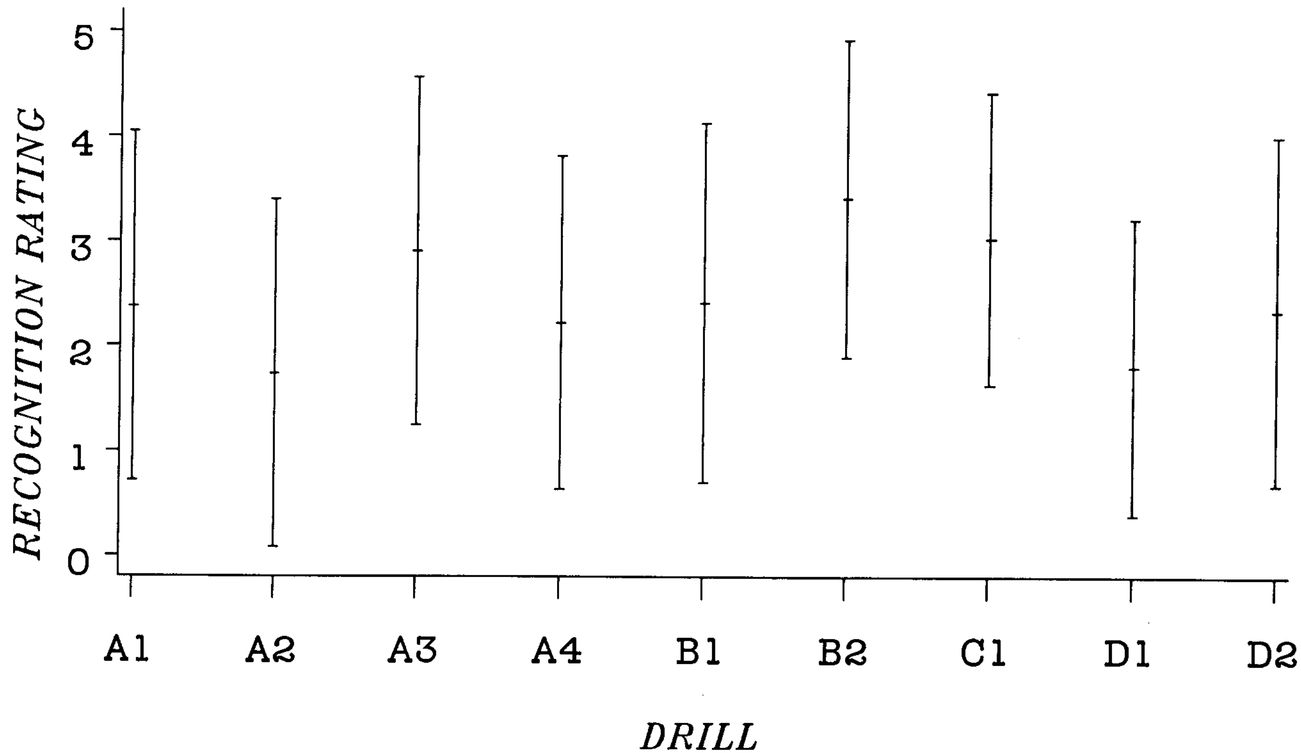
For the recognition and evaluation time data, an empirical complementary cumulative distribution function (ccdf) of time until recognition and time until evaluation was plotted for each drill. This type of distribution provides the empirical probability of failure of correct recognition or evaluation as a function of time from the start of the drill. Each plotted point is equal to (1-cumulative probability of success). For example, if 2 of 10 crews failed to recognize the problem in a drill by one minute after the start of the drill, then the empirical probability of failure at that time would be .8. A new data point was plotted whenever there was a new success time. The recognition and evaluation time data were also analyzed through ANOVAs. For these analyses, the predicted success times were substituted for the censoring times. The model was a two-factor ANOVA with the factors being Crew and Drill. The level of significance was .05. In addition to an ANOVA on recognition time and cumulative time until evaluation, an ANOVA was also performed on evaluation time (cumulative time until evaluation minus recognition time). One of the assumptions of the ANOVA is that the variances for the different crews and drills are equal. In many cases, this assumption was not met. To more nearly satisfy the assumption of equal variances, the data were transformed using the log 10 transformation prior to data analysis. Multiple comparisons were performed on the log 10 data using Scheffe's test and the .05 level of significance.

Results from the analyses on the judgment data were compared with results from the analyses on the time data to determine if there were similar patterns of findings for the recognition and evaluation ratings and times. The relationships among the judgment and time data were also examined using Spearman's Rank Correlation Coefficient (rho) [14]. This statistic is a measure of the degree of association between two sets of ranked data. The mean ratings and times for each drill were converted to ranks, and the rating ranks were correlated with the time ranks. The correlation coefficient can vary from -1 to +1 with 0 indicating no association and -1 and +1 indicating perfect negative and positive associations between the two sets of ranked data.

A.4 Results of Analyses

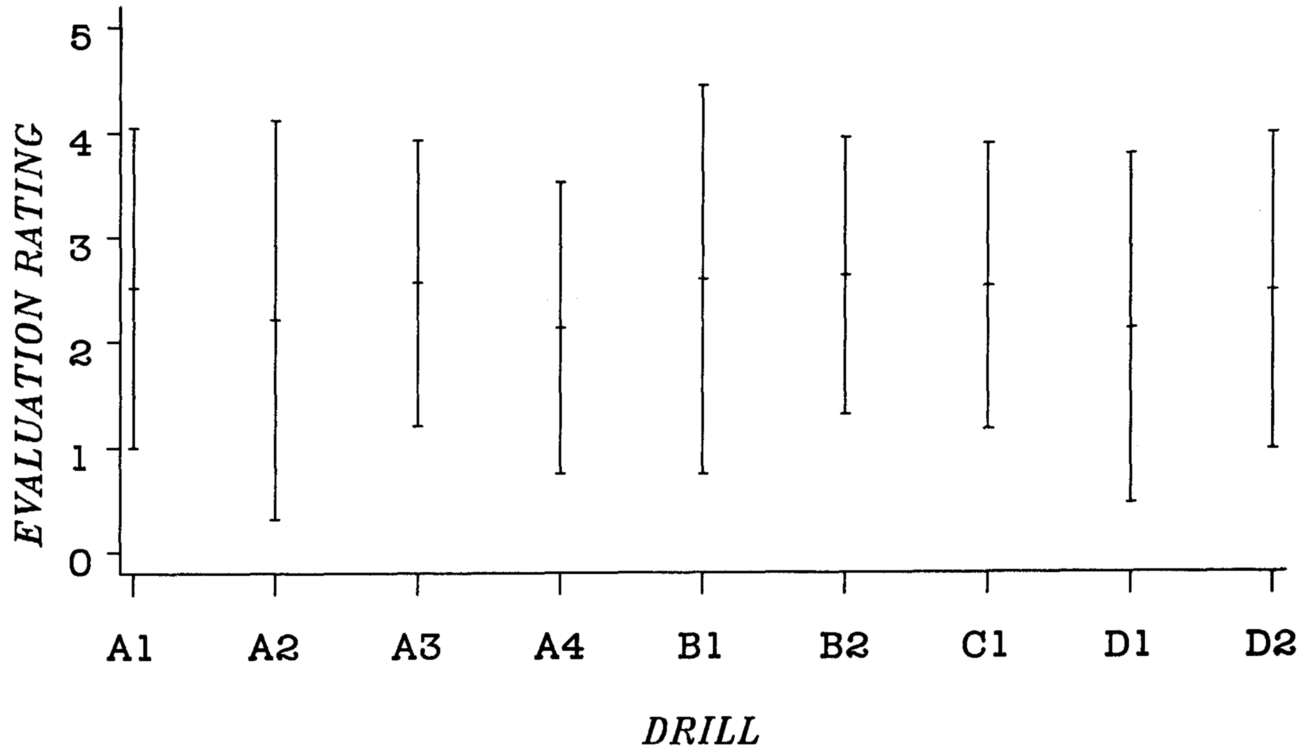
Figures A.4-1 and A.4-2 show the means plus and minus two standard deviations for the individual recognition and evaluation ratings for each drill. As shown, both recognition and evaluation ratings were highly variable (A portion of this variability may be due to differences among crews. The effect for Crew is adjusted for in the ANOVA to compare Drills).

Results of the ANOVAs on the recognition ratings are shown in Table A.4-1. Results of the three-factor model showed that the effect of Assignment (operator or instructor) was highly insignificant ($p = .6$), indicating that the ratings were similar for operators and instructors. Therefore, Assignment was dropped from the model, and a two-factor ANOVA was run. Results of the two-factor model showed statistically significant



Rating 1=Much Easier than average, 2=Easier than average, 3=Average, 4=More difficult than average, 5=Much more difficult than average.

Figure A.4-1. Phase 1 Data, Mean Recognition Rating as a Function of Drill, Showing Plus & Minus Two Standard Deviations



Rating 1=Much Easier than average, 2=Easier than average, 3=Average, 4=More difficult than average, 5=Much more difficult than average.

Figure A.4-2. **Phase 1 Data, Mean Evaluation Rating as a Function of Drill, Showing Plus & Minus Two Standard Deviations**

Table A.4-1
Results of ANOVAs on Recognition Ratings

(a) Three-factor Model

Source	DF	SS	F	Prob > F
Assignment (A)	1	0.2	0.3	.6
Crew (C)	18	24.0	2.7	.002
Drill (D)	8	64.8	13.2	.0001
A X C	15	10.3	1.4	.2
A X D	8	6.8	1.6	.1
C X D	101	62.0	1.2	.2
A X C X D	70	37.7	1.1	.4
Error	77	38.7		

(b) Two-factor Model

Source	DF	SS	F	Prob > F
Crew (C)	18	29.0	2.9	.0002
Drill (D)	8	71.2	14.5	.0001
C X D	101	62.1	1.1	.3
Error	171	94.2		

effects for the factors of Crew and Drill ($p = .0002$ and .0001, respectively). However, none of the crew differences were large enough to be significant with Scheffe's test (all p values > .05). The effect for Drill is shown in Figure A.4-3. Scheffe's test showed the following:

1. Drill A3 was rated as more difficult on recognition than Drills A2 and D1.

2. Drill B2 was rated as more difficult on recognition than Drills A1, A2, A4, B1, D1, and D2.

3. Drill C1 was rated as more difficult on recognition than Drills A2, A4, and D1.

Results of the ANOVAs on the evaluation ratings are shown in Table A.4-2. As found with the analysis on the recognition ratings, the three-factor model showed that the effect of Assignment was insignificant ($p = .3$). Therefore, this factor was dropped from the model and a two-factor ANOVA was run. Results of the two-factor model showed a statistically significant effect for Crew ($p = .0003$). However, none of the crew differences were large enough to be significant with Scheffe's test (all p values > .05). The effect for Drill was not significant ($p = .1$), indicating that the drills were judged to be similar in evaluation difficulty.

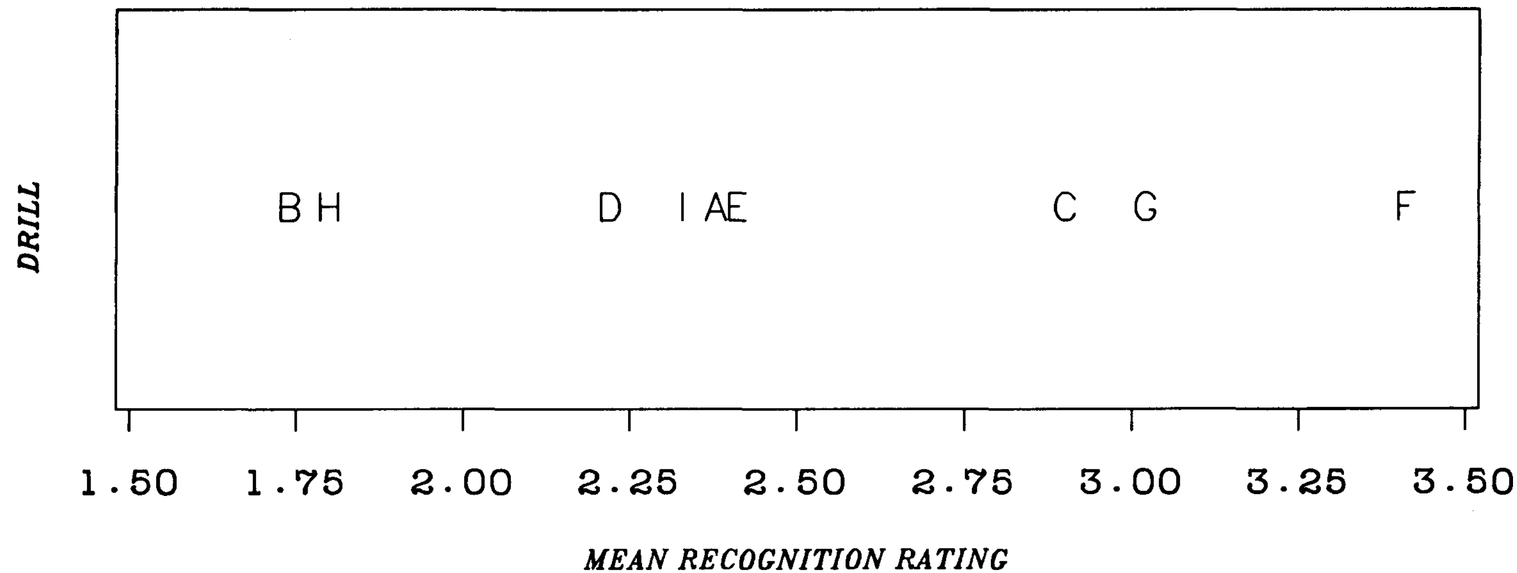
The empirical ccdfs of time until recognition and cumulative time until evaluation for each drill are shown in Figures A.4-4 through A.4-13. These distributions show the empirical probability of failure of correct recognition and evaluation as a function of time from the start of the drill.

Results of the ANOVAs on the recognition and evaluation time data are shown in Table A.4-3. The ANOVA on the log 10 recognition times showed statistically significant effects for both Crew and Drill ($p = .0001$ for both factors). The effect for Crew is presented in Figure A.4-14. Scheffe's test showed that the average recognition time for one crew (Crew 17) was significantly shorter than the average time for many other crews (Crews 1, 4, 5, 7, 9, 12, 14, 15, and 16). The effect for Drill is presented in Figure A.4-15. Scheffe's test showed the following:

1. Average recognition time was significantly longer for Drill B2 than for Drills A1, A2, A3, A4, B1, and D2.

2. Average recognition time was significantly longer for Drill C1 than for Drills A1, A2, A3, A4, B1, and D2.

(Text continued on page A-83)



DRILL	A	Drill A1	B	Drill A2	C	Drill A3
	D	Drill A4	E	Drill B1	F	Drill B2
	G	Drill C1	H	Drill D1	I	Drill D2

Figure A.4-3. Mean Recognition Rating for each Drill

Table A.4-2
Results of ANOVAs on Evaluation Ratings

(a) Three-factor Model

Source	DF	SS	F	Prob > F
Assignment (A)	1	0.7	1.2	.3
Crew (C)	18	22.7	2.5	.003
Drill (D)	8	8.4	1.9	.07
A X C	15	8.8	1.2	.3
A X D	8	4.9	1.2	.3
C X D	100	56.2	1.1	.3
A X C X D	70	36.8	1.1	.4
Error	76	38.2		

(b) Two-factor Model

Source	DF	SS	F	Prob > F
Crew (C)	18	25.9	2.8	.0003
Drill (D)	8	8.3	1.6	.1
C X D	100	65.7	1.3	.08
Error	170	87.8		

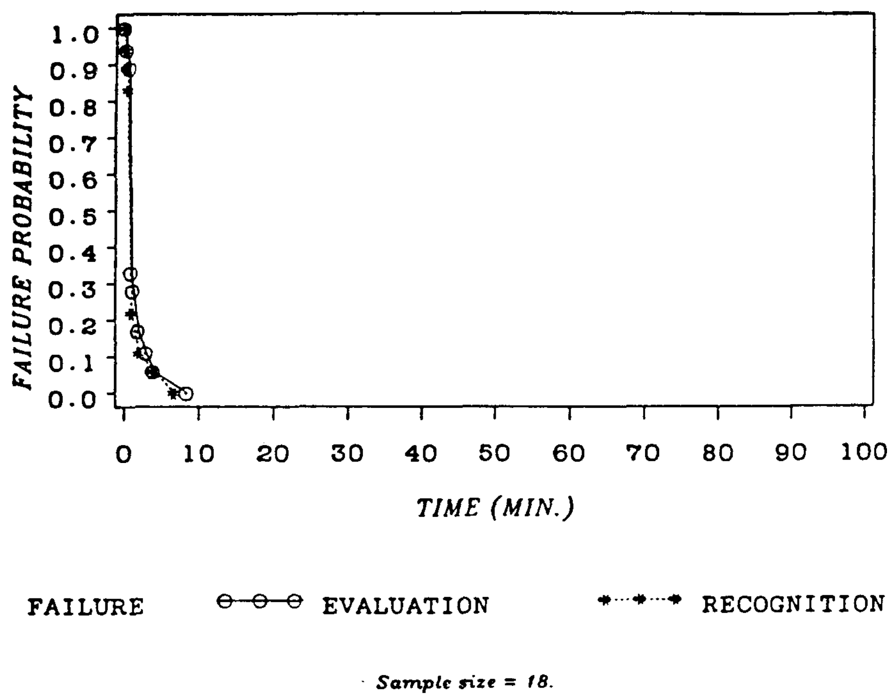


Figure A.4-4. Drill A1, Probability of Failure of Correct Recognition and Evaluation

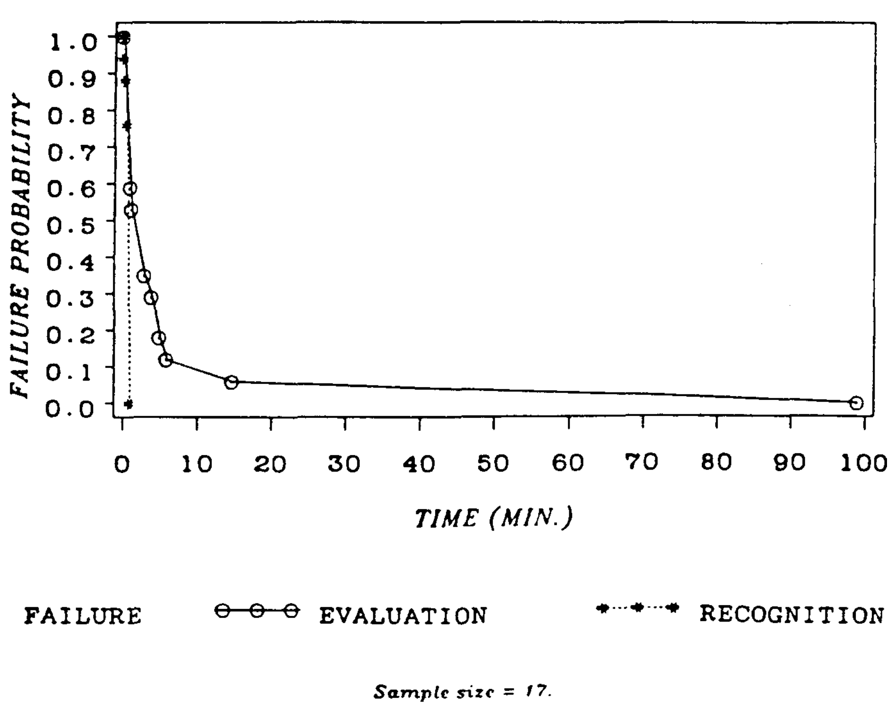
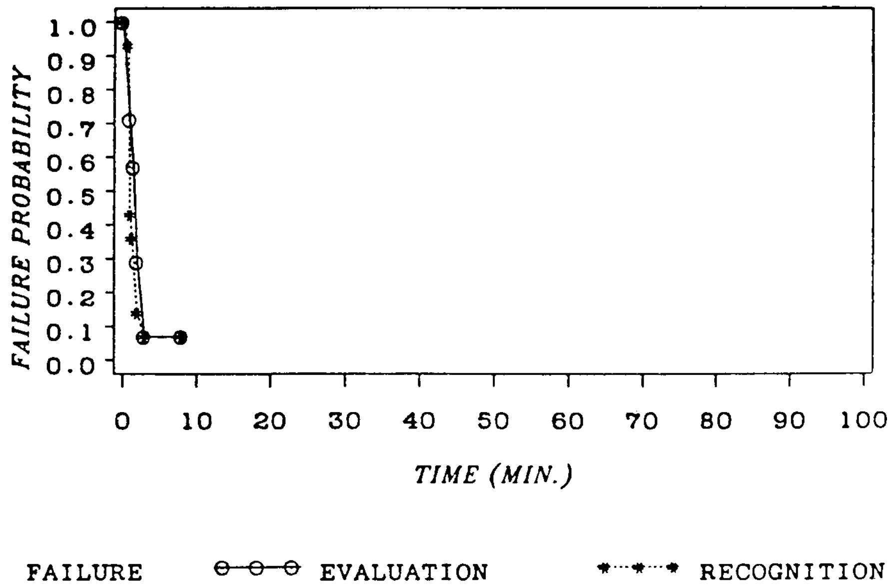
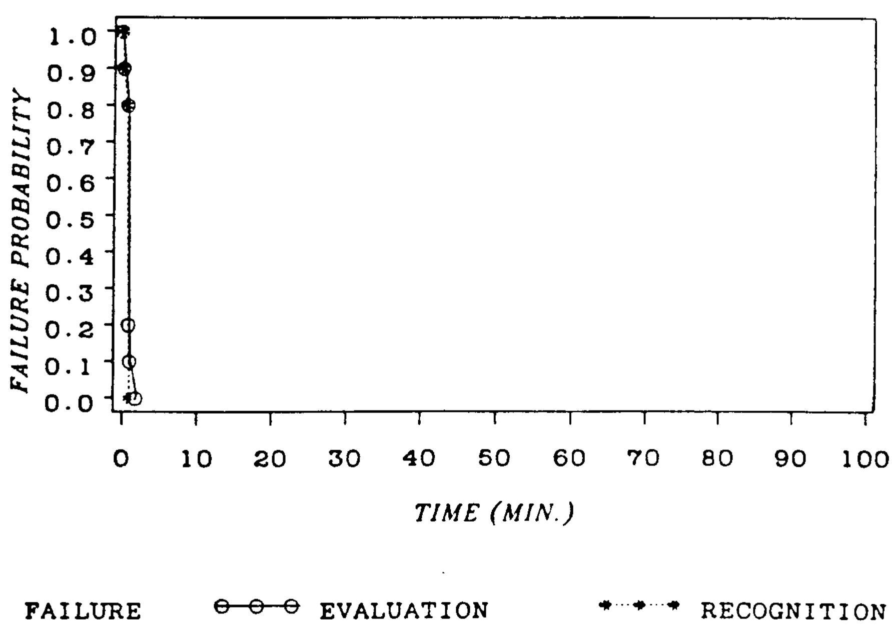


Figure A.4-5. Drill A2, Probability of Failure of Correct Recognition and Evaluation



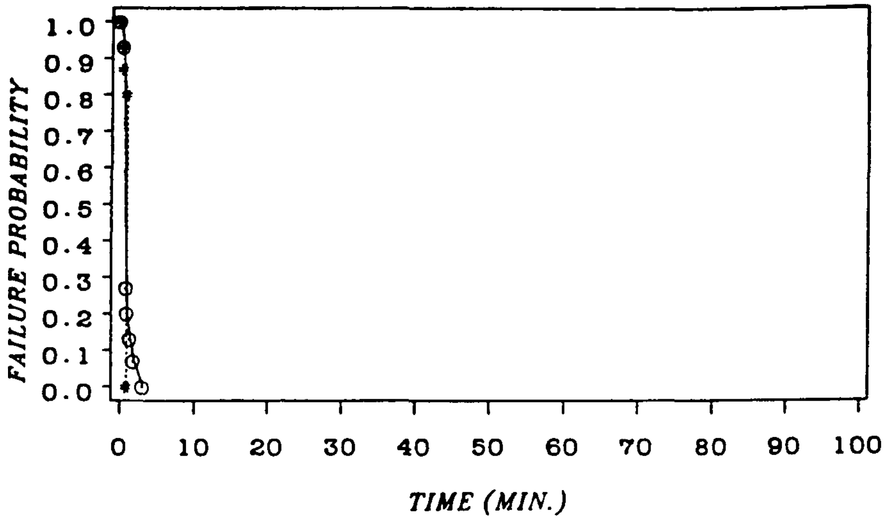
Sample size = 14. One crew did not reach a correct recognition or evaluation as of 8 min. after the start of the drill.

Figure A.4-6. Drill A3, Probability of Failure of Correct Recognition and Evaluation



Sample size = 10.

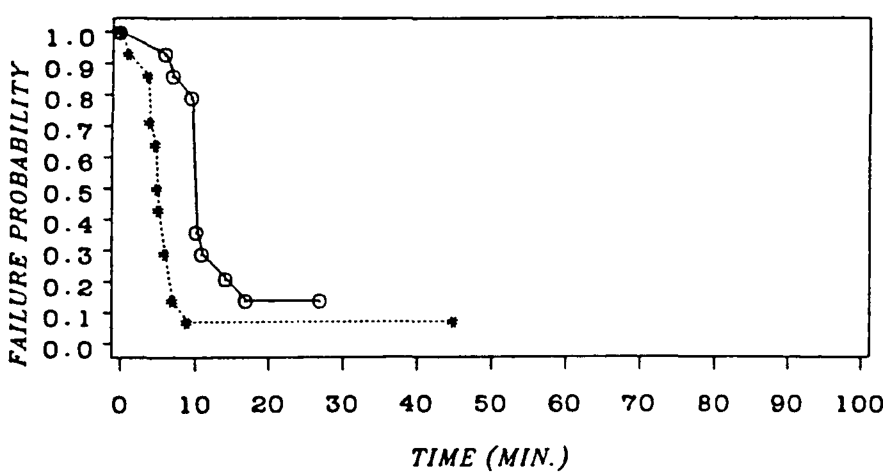
Figure A.4-7. Drill A4, Probability of Failure of Correct Recognition and Evaluation



FAILURE ⊖—⊖—⊖ EVALUATION *···*···* RECOGNITION

Sample size = 15.

Figure A.4-8. Drill B1, Probability of <u>Failure</u> of Correct Recognition and Evaluation

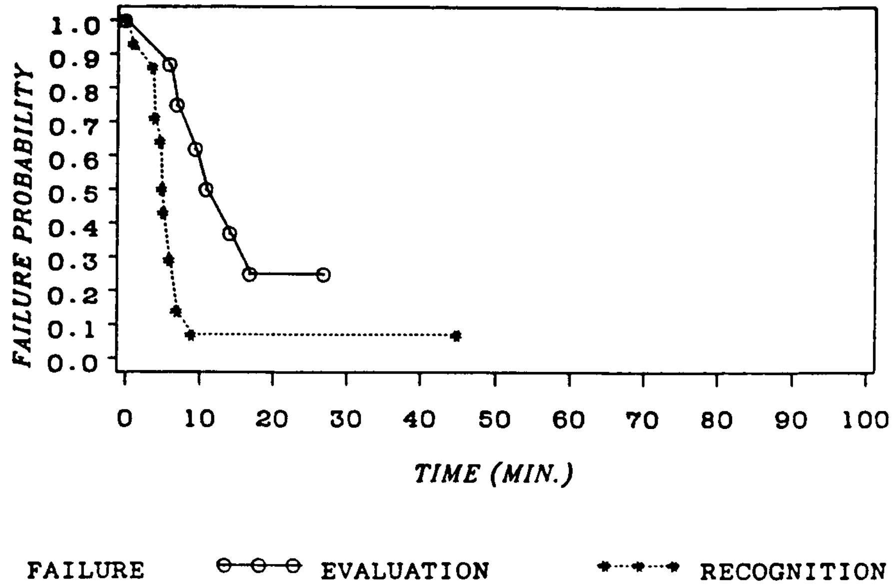


FAILURE ⊖—⊖—⊖ EVALUATION *···*···* RECOGNITION

Sample size = 14. One crew did not reach a correct evaluation as of 27 min. after the start of the drill.
A second crew did not reach a correct recognition or evaluation as of 45 min. after the start of the drill.

Figure A.4-9. Drill B2, Probability of <u>Failure</u> of Correct Recognition and Evaluation

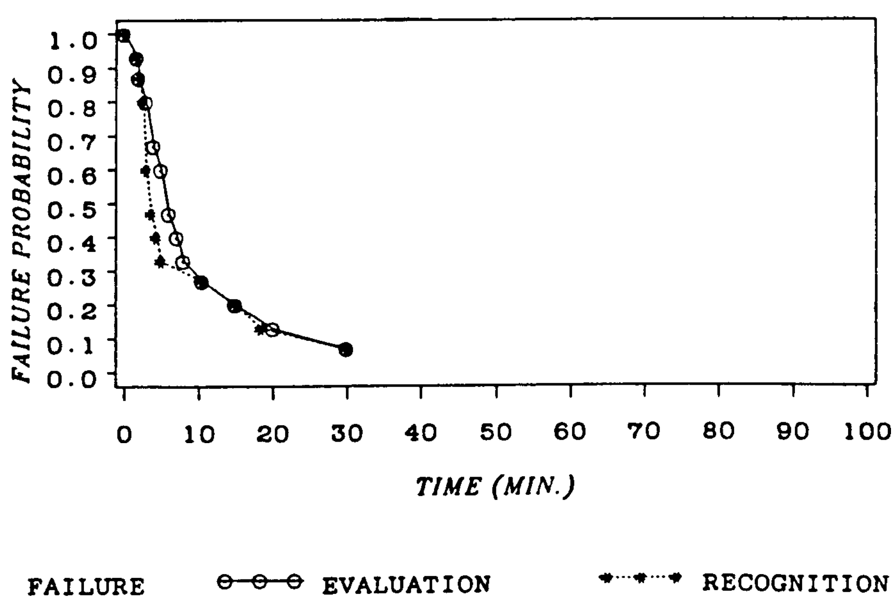
(Medians inserted for 6 successful evaluations with missing times)



Sample size = 14 for recognition & 8 for evaluation. One crew did not reach a correct evaluation as of 27 min. after the start of the drill. A second crew did not reach a correct recognition or evaluation as of 45 min. after the start of the drill.

Figure A.4-10. Drill B2, Probability of Failure of Correct Recognition and Evaluation

(Six successful evaluations with missing times excluded)



Sample size = 15. One crew did not reach a correct recognition or evaluation as of 30 min. after the start of the drill.

Figure A.4-11. **Drill C1, Probability of Failure of Correct Recognition and Evaluation**

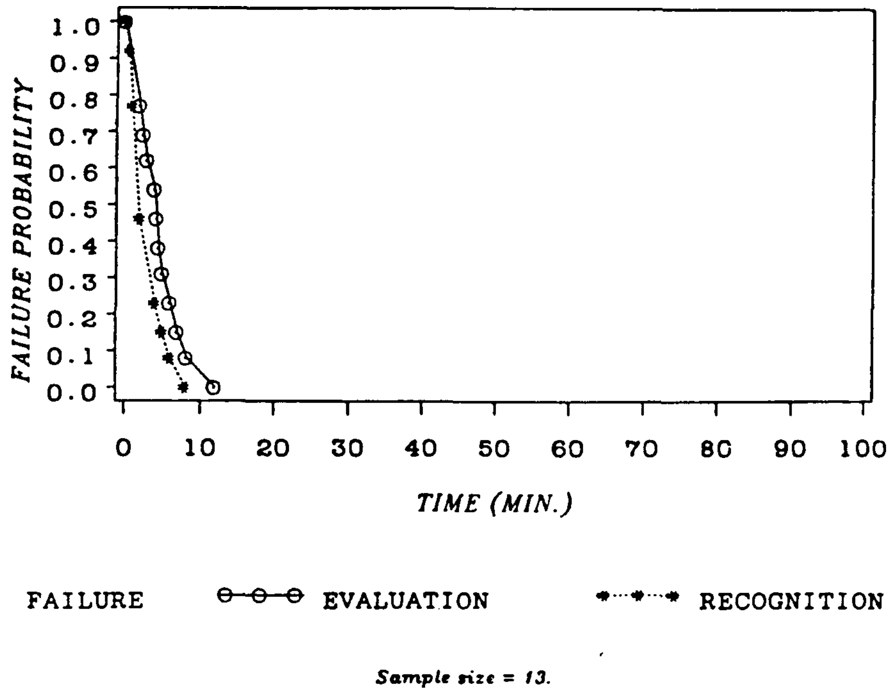


Figure A.4-12. Drill D1, Probability of Failure of Correct Recognition and Evaluation

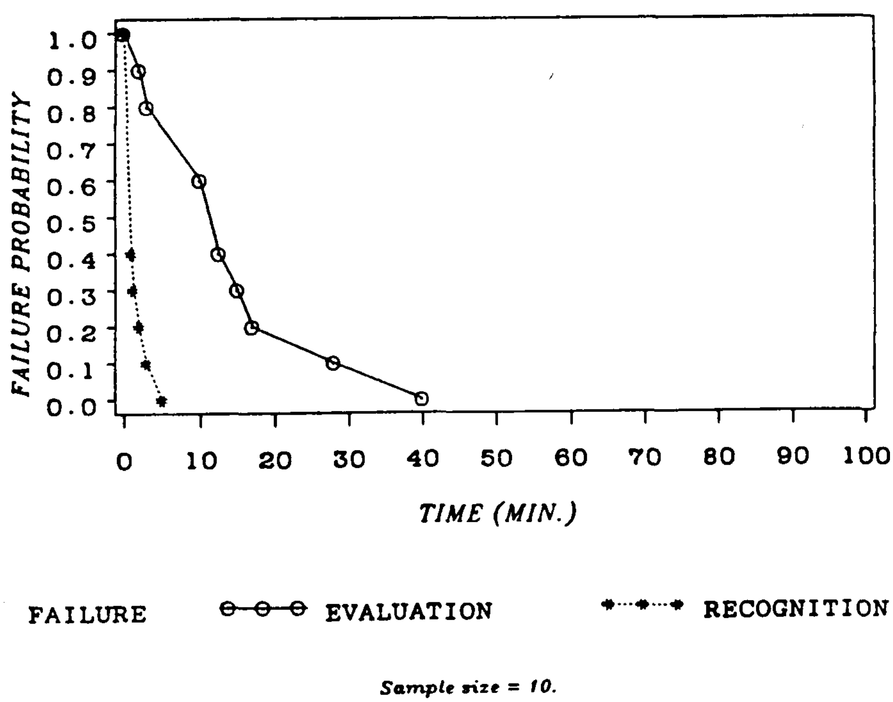


Figure A.4-13. Drill D2, Probability of Failure of Correct Recognition and Evaluation

Table A.4-3
Results of ANOVAs on Log 10 Recognition and Evaluation Ratings

(a) Recognition Time

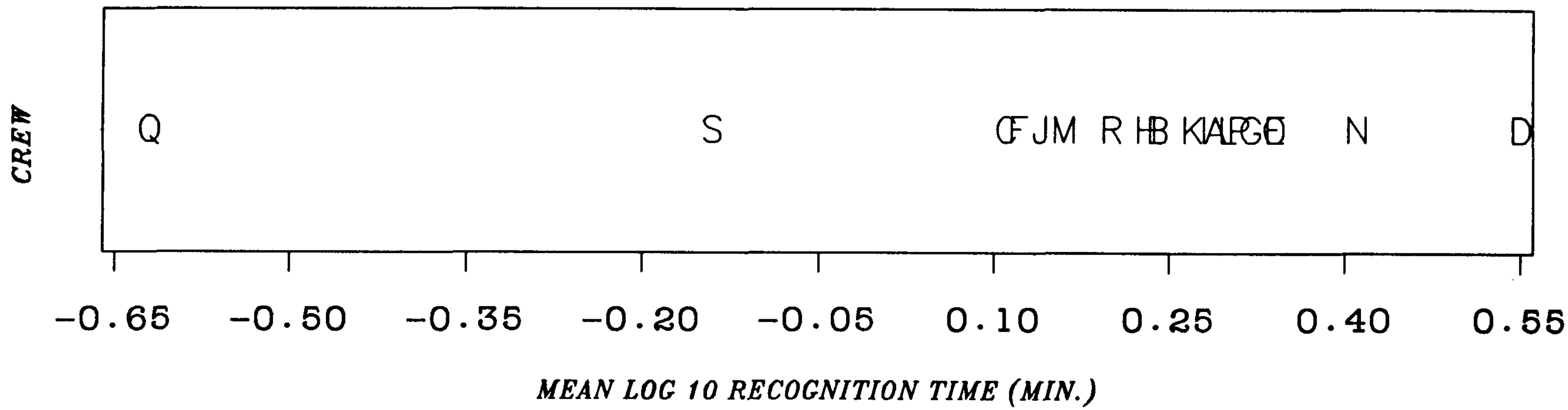
Source	DF	SS	F	Prob > F
Crew (C)	18	5.9	4.1	.0001
Drill (D)	8	13.1	20.6	.0001
Error	99	7.8		

(b) Cumulative Evaluation Time

Source	DF	SS	F	Prob > F
Crew (C)	18	3.1	1.6	.08
Drill (D)	8	16.7	19.4	.0001
Error	99	10.7		

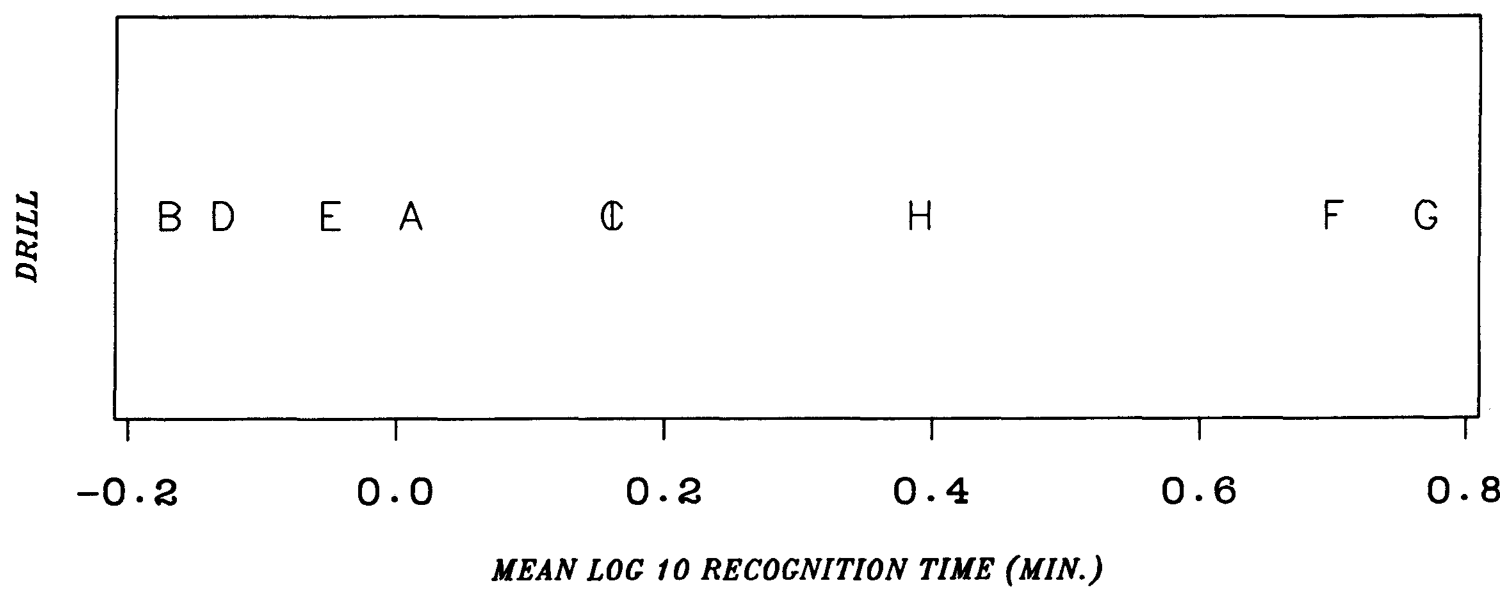
(c) Evaluation Time

Source	DF	SS	F	Prob > F
Crew	18	2.1	1.3	.2
Drill	8	11.1	15.1	.0001
Error	99	9.1		



CREW						
	A	Crew 1	B	Crew 2	C	Crew 3
	D	Crew 4	E	Crew 5	F	Crew 6
	G	Crew 7	H	Crew 8	I	Crew 9
	J	Crew 10	K	Crew 11	L	Crew 12
	M	Crew 13	N	Crew 14	O	Crew 15
	P	Crew 16	Q	Crew 17	R	Crew 18
	S	Crew 19				

Figure A.4-14. **Mean Log 10 Recognition Time for Each Crew**



DRILL						
	A	Drill A1	B	Drill A2	C	Drill A3
	D	Drill A4	E	Drill B1	F	Drill B2
	G	Drill C1	H	Drill D1	I	Drill D2

Figure A.4-15. Mean Log 10 Recognition Time for Each Drill

3. Average recognition time was significantly longer for Drill D1 than for Drills A2, A4, and B1.

Results of the ANOVA on log 10 cumulative evaluation times showed a statistically significant effect for Drill ($p = .0001$). This effect is presented in Figure A.4-16. Scheffe's test showed the following:

1. Average cumulative evaluation time was significantly longer for Drill B2 than for Drills A1, A2, A3, A4, and B1.

2. Average cumulative evaluation time was significantly longer for Drill C1 than for Drills A1, A3, A4, and B1.

3. Average cumulative evaluation time was significantly longer for Drill D2 than for Drills A1, A2, A3, A4, and B1.

Results of the ANOVA on log 10 evaluation times (cumulative evaluation time minus recognition time) showed a statistically significant effect for Drill ($p = .0001$). This effect is shown in Figure A.3-17. Scheffe's test showed the following:

1. Average evaluation time was longer for Drill B2 than for Drills A1, A3, A4, B1, C1, and D1.

2. Average evaluation time was longer for Drill D2 than for Drills A1, A2, A3, A4, B1, C1, and D1.

Table A.4-4 shows the data used to compute the Spearman Rank Correlation Coefficients between the rating and time data. The resulting rho values are shown in Table A.4-5. The only statistically significant correlation was the one between the recognition rating and recognition time data. However, this correlation was significant at only the .05 level of significance, and, as shown in Figure A.4-18, the relationship between the rating and time data was weak. The cumulative evaluation time data and evaluation time data were not significantly associated with the evaluation rating data (both p values > .05); This was expected, since there were no significant differences among the evaluation ratings for the drills. Since the evaluation difficulty ratings for the drills did not differ, it was thought that perhaps the recognition ratings would be related to the evaluation time data; However, the cumulative evaluation time data and evaluation time data were not significantly associated with the recognition ratings either (both p values > .05).

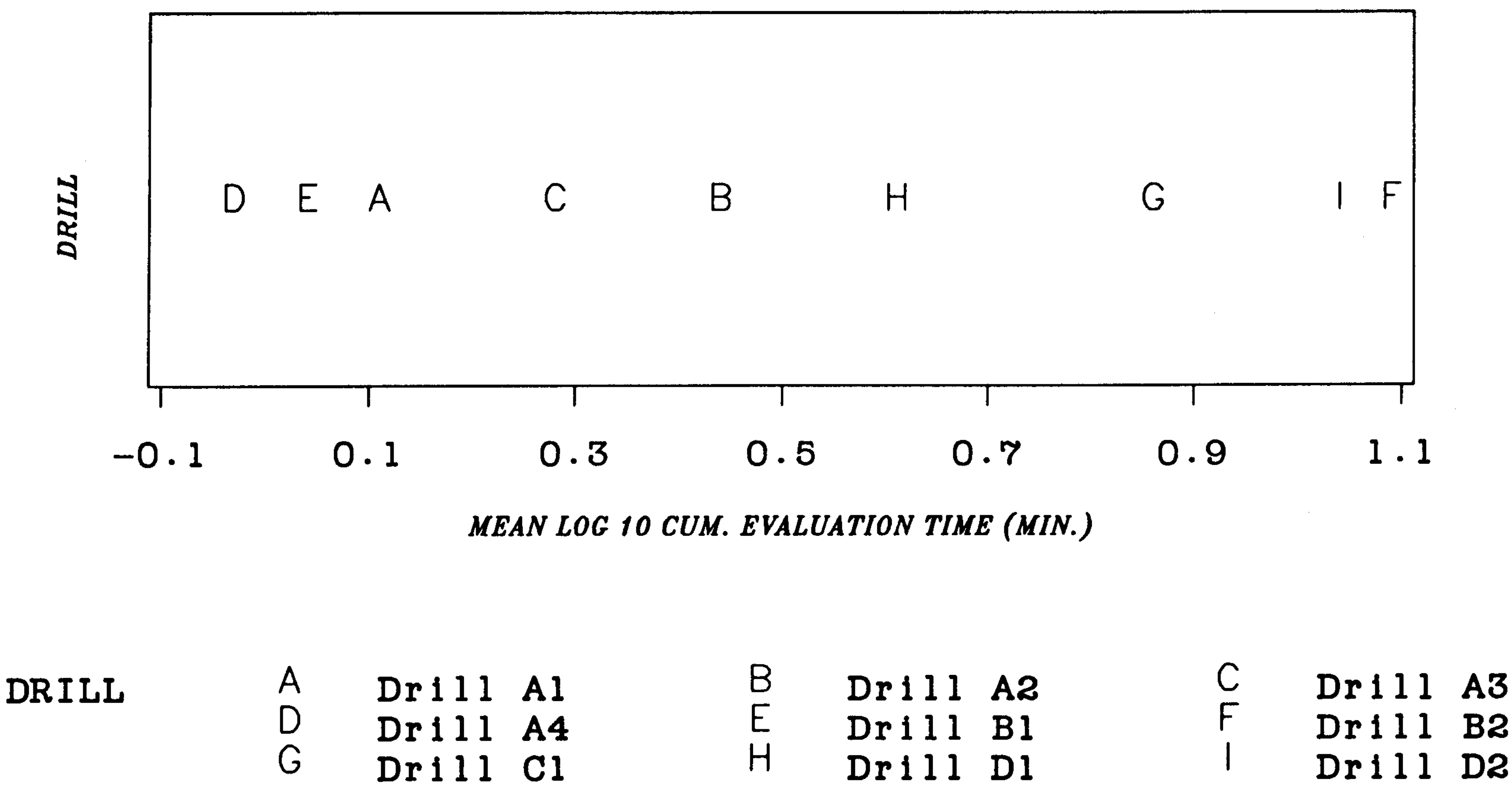
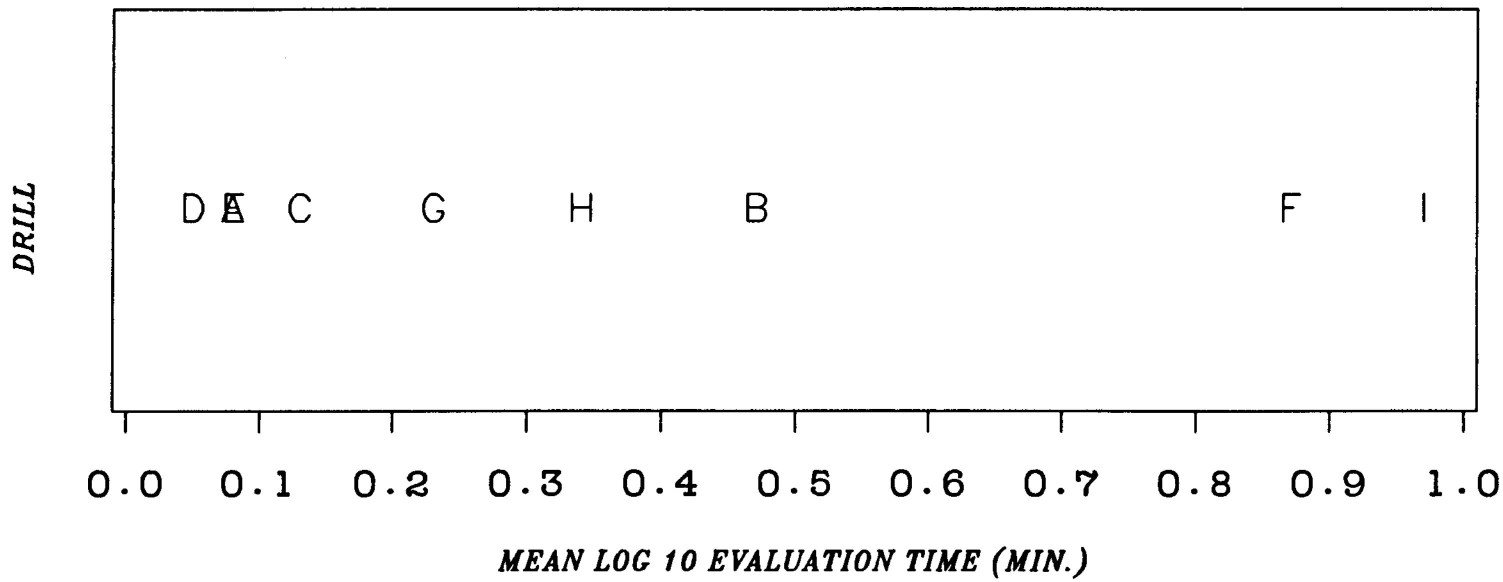


Figure A.4-16. **Mean Log 10 Cumulative (Cum.) Evaluation Time for Each Drill**



DRILL						
	A	Drill A1	B	Drill A2	C	Drill A3
	D	Drill A4	E	Drill B1	F	Drill B2
	G	Drill C1	H	Drill D1	I	Drill D2

Figure A.4-17. **Mean Log 10 Evaluation Time for Each Drill**

Table A.4-4
Mean Recognition and Evaluation Ratings
and Times and Ranks

(a) Means

	Ratings		Times (min.)		
Drill	Recognition	Evaluation	Recognition	Evaluation	Cumulative Evaluation
A1	2.4	2.5	1.5	1.8	.3
A2	1.7	2.2	.8	8.9	8.0
A3	2.9	2.6	1.9	2.4	.4
A4	2.2	2.1	.9	1.0	.2
B1	2.4	2.6	.9	1.2	.3
B2	3.4	2.6	5.7	15.0	9.3
C1	3.0	2.5	0.7	11.8	1.1
D1	1.8	2.1	3.2	4.8	1.6
D2	2.3	2.5	1.7	15.0	13.3

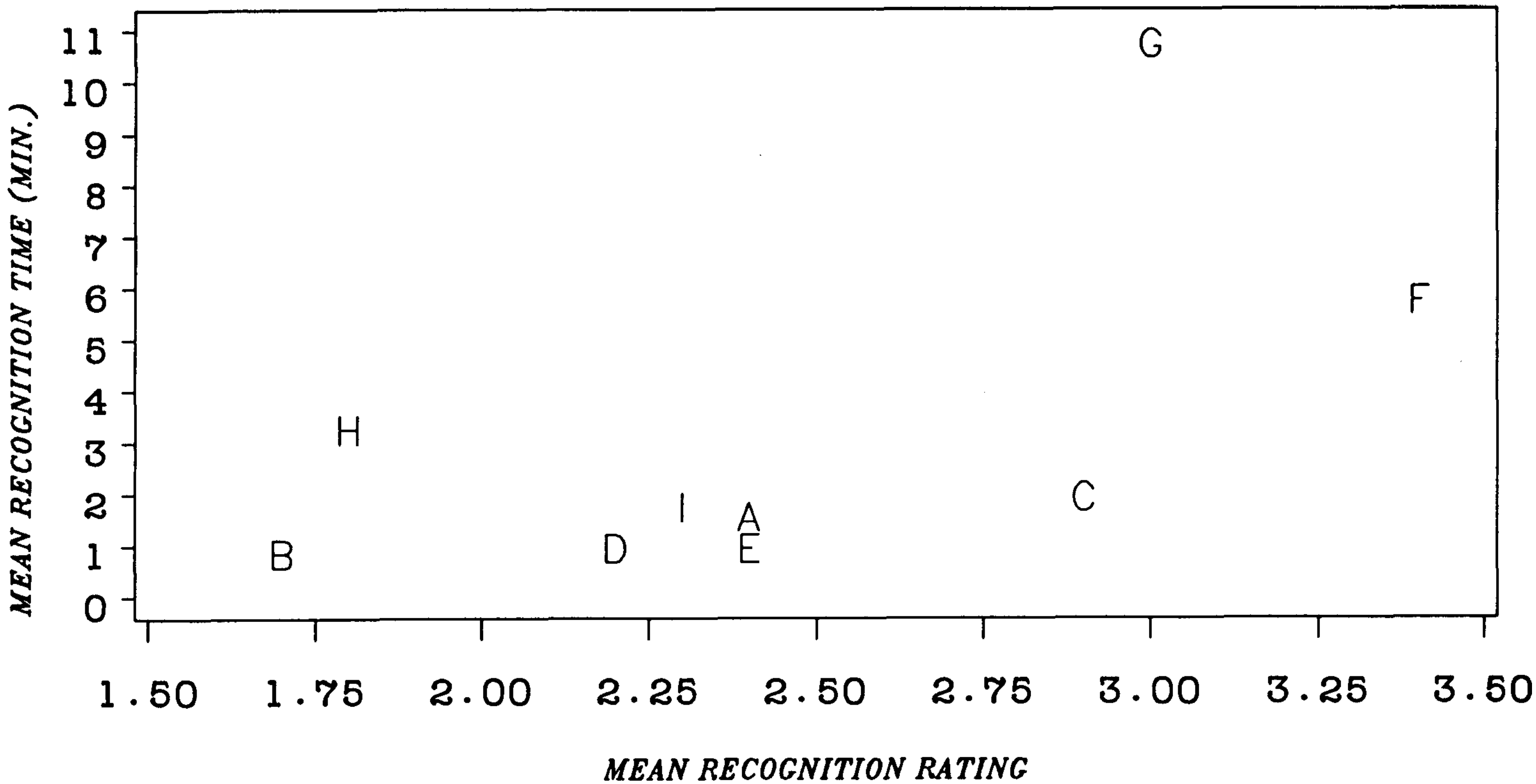
(b) Ranks

	Ratings		Times (min.)		
Drill	Recognition	Evaluation	Recognition	Evaluation	Cumulative Evaluation
A1	5.5	5	4	3	2.5
A2	1	3	1	6	7
A3	7	8	6	4	4
A4	3	1.5	2.5	1	1
B1	5.5	8	2.5	2	2.5
B2	9	8	8	8.5	8
C1	8	5	9	7	5
D1	2	1.5	7	5	6
D2	4	5	5	8.5	9

Table A.4-5
Spearman Rank Correlation Coefficients Between
Recognition and Evaluation Rating and Time Data

Comparison	rho
Recognition rating vs. recognition time	.66*
Evaluation rating vs. cumulative evaluation time	.22
Evaluation Rating vs. evaluation time	.13
Recognition rating vs. cumulative evaluation time	.28
Recognition rating vs evaluation time	.02

*p < .05.



DRILL	A	Drill A1	B	Drill A2	C	Drill A3
	D	Drill A4	E	Drill B1	F	Drill B2
	G	Drill C1	H	Drill D1	I	Drill D2

Figure A.4-18. Mean Recognition Time as a Function of Mean Recognition Rating for Each Drill

A.5 Discussion and Recommendations

Results showed that although there was some correspondence between the recognition ratings and recognition times, the degree of correspondence was weak. ANOVAs on both the rating and time data revealed significant differences among the drills. However, the ordering of drill means (from most difficult to easiest) was quite different for the two sets of data. Although the Spearman Rank Correlation Coefficient computed between the ranks of the mean recognition ratings and ranks of the mean recognition times for the drills was statistically significant (rho = .66), it was significant at only the .05 level and a plot of the relationship showed that the degree of relationship was inadequate for use. In summary, the patterning of findings for the recognition rating and time data was sufficiently different so that prediction of recognition times from recognition ratings would be highly inaccurate and cannot be recommended.

Results also showed that there was no correspondence between the evaluation rating and time data. ANOVAs on the evaluation data showed that all drills were considered to be similar in evaluation difficulty, yet, statistically significant differences were found in cumulative time until evaluation and in evaluation time. As expected, the Spearman Rank Correlation Coefficients computed among the ranks of the mean evaluation ratings and ranks of the cumulative evaluation and evaluation times were negligible (rho = .22 and .13, respectively). There were also negligible associations among the recognition ratings and cumulative evaluation and evaluation times (rho = .28 and .02, respectively). These negative findings are especially important, since estimated cumulative evaluation time is what is needed to perform PRAs.

It was also found that the recognition and evaluation ratings were highly inconsistent among the instructors and operators. Individual ratings for the drills often spanned almost the entire range of possible ratings, even though the ratings were performed immediately after each drill simulation. If the ratings are so inconsistent among those with substantial amounts of NPP operational knowledge and hands-on operational experience, one can expect only less promising results when those without or with less operational expertise, such as PRA analysts, are required to make such judgments, especially if the judgments are performed without benefit of a prior drill simulation. The consistency results suggest that it would be dangerous to have one or a small number of PRA analysts make judgments on recognition and evaluation difficulty. If the DDM approach were pursued, it would be necessary to have a large number of experts make such judgments, preferably after prior drill simulations, and use the mean difficulty judgments to enter the DDM matrix. However, in view of the observed weak relationship between the rating and judgment data and the cost and expense such an approach would entail, this type of effort appears to be without merit.

In conclusion, results of the Phase 1 data analyses did not show much promise for the DDM approach. The degree of association between the rating and time data was insufficient, and the ratings of recognition and evaluation difficulty from those with substantial amounts of NPP operational expertise were highly inconsistent, even when such ratings were performed immediately following each drill simulation. Therefore, it was recommended that a new approach be developed for the Phase 2 data analyses.

In Phase 2, actions were first categorized into separate groups based upon their operational similarity. The actions within groups were then statistically compared to determine whether the operational groups could be statistically supported. This type of approach was adopted, since it requires little judgment on the part of the PRA analyst, and does not require hands-on operational experience or drill simulations. Only knowledge of the correct actions following an abnormal event, knowledge that a PRA analyst would have, is needed.

Appendix B

Phase 2 Data Collection, Results, and Recommendations

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B.1 Data Collection Methodology for Phase 2

Because the DDM approach developed in Phase 1 was found to be unsuccessful (see Section 3.1 and Appendix A), another approach based upon operational groupings of recovery actions and simulator data was developed and tested in Phase 2.

There were three steps in the data collection effort for Phase 2. They were: (1) development of simulator drills to test the operators, (2) development of data collection forms to record the data from the drills, and (3) recording of the data for each simulator drill.

B.1.1 Development of Simulator Drills

Unlike the Phase 1 simulator drills, the simulator drills developed for Phase 2 were based on preliminary results from the LaSalle PRA being conducted by Sandia National Laboratories (SNL) as part of the Risk Methods Integration and Evaluation Program (RMIEP). These preliminary results were used to define realistic plant-specific accident scenarios which would challenge some or all of the four critical parameters (i.e., reactor power containment pressure, reactor vessel level, and reactor pressure) and which could lead to core damage.

From these preliminary results eight accident scenarios (briefly described in Table B.1.1-1 and described in detail in Tables B.1.1-2 through B.1.1-9) were chosen for development into drills. These drills were then used on the LaSalle simulator to obtain time data on the operator team's ability to respond to the accident scenarios. They were also used to obtain operator and instructor opinions about the accidents.

The development of the simulator drills included:

(1) Review of the scenarios by SNL, Energy Incorporated (EI), NUS Corporation (NUS), and the training staff at the simulator for suitability as drills.

(2) Trial runs for each scenario to identify any simulation difficulties.

(3) Discussions with the training staff to review what the procedures suggested should be done and to identify any deviations that the crews might take during a drill.

(4) Modifications to the scenarios to reflect any limitations identified in (2) and (3).

B.1.2 Development of the Data Collection Forms

The primary data collection forms used were the Time Data Collection Forms (see Figures B.1.2-1 through B.1.2-8). These

(Text continues on page B-41)

Table B.1.1-1
Brief Description of Phase 2 Accident Scenarios

Descriptor	Accident Description
1A	ATWS - Initiated by MSIV closure, reactor fails to trip, motor driven feedwater pump available.
1B	ATWS - Initiated by MSIV closure, reactor fails to trip, motor driven feedwater pump unavailable.
2	Transient with Narrow Range Level Instrument Malfunction - Initiated by spurious turbine trip, a steam leak into the reactor building causes narrow range level instrumentation to fail high resulting in loss of high pressure injection.
2B	Transient with Narrow Range and Wide Range Level Instrument Malfunctions - Initiated by spurious turbine trip, a steam leak into the reactor building causes narrow range and wide range level instrumentation to fail high resulting in loss of high pressure injection.
3	Station Blackout - Initiated by a loss of offsite power, followed by failure of the diesel generators (DGs), RCIC injection valve fails to open.
4	Delayed Station Blackout - Initiated by a loss of offsite power, followed by failure of two diesel generators, third diesel generator starts and loads. The start and load sequence of third DG causes isolation of RCIC. Third DG fails after approximately twenty minutes.
6	Transient with DC Bus 1A Failure - 125 volt, DC bus 1A shorts to ground and will result in a reactor trip, subsequent failures threaten critical parameters.
8	Feedwater Line Break - A feedwater line breaks in the steam tunnel, results in loss of flow to the reactor pressure vessel from feedwater/condensate. Subsequent failures result in loss of all high pressure systems, low pressure systems are available.

ATWS - Anticipated Transient Without Scram
MSIV - Main Steam Isolation Valve
RCIC - Reactor Core Isolation Cooling System

Table B.1.1-2
Drill 1A
(Scenario; ATWS)

INITIAL PLANT CONDITIONS

Power:	100%
Elect:	Normal operational lineup
PCS:	Normal operational lineup
CW:	Normal lineup - A, B, C pumps operating
CNDS:	Condensate/Condensate Booster Pumps A, B, D operating, C in standby
FW:	Both TDFWPs operating, MDFWP in standby
SW:	Normal lineup - A pump operating
TBCCW:	Normal lineup - A pump operating
CSCS:	Normal standby lineup
HPCS:	Normal standby lineup
RCIC:	Out of commission due to maintenance
ADS:	Normal standby lineup
LPCS:	Normal standby lineup
LPCI A:	Normal standby lineup
B:	Normal standby lineup
C:	Normal standby lineup
SBLC:	Normal standby lineup
CRD:	A pump operating

INITIATOR, FAILURES, TRANSIENT

1. All MSIVs close due to a miscalibration of the steam tunnel high temperature instruments to old limit.

2. Reactor receives half scram channel B, fails to trip and all methods of manual scram fail.

3. Recirculation pump trip occurs as designed.

4. HPCS actuates upon level 2 as designed. RCIC does not start since it is out for maintenance.

5. HPCS switches over to suppression pool (SP) on high SP level as designed.

6. HPCS is assumed to fail within one minute after SP temperature reaches 190°F if suction not switched back to CST.

Table B.1.1-2 (Continued)
Drill 1A)
(Scenario: ATWS)

SYSTEM STATES FOLLOWING INITIATOR

SYSTEM	AVAILABLE	FAILED	
		RECOVERABLE	NOT RECOVERABLE
FW	X		
SBLC	X		
RCIC			X
HPCS	X*		
ADS	X		
LPCS	X		
LPCI A	X		
B	X		
C	X		
CNDS	X		

* - HPCS is initially available. It will fail if SP temperature exceeds 190°F.

OPERATOR ACTION(S) REQUIRED TO RECOVER

1. Follow ATWS procedure (i.e., inject boron, lower vessel level to TAF, initiate and maintain suppression pool cooling, raise level after boron injection) and bring the plant to a safe shutdown condition. To successfully establish a safe shutdown condition, we conservatively assume that all of the following must occur:

   a) After occurrence of the initial power spike, subsequent power spikes must be avoided.

   b) An automatic ADS must be prevented.

   c) The level must not drop below -200 inches for greater than X minutes.

   d) The SP temperature must not exceed 190°F while HPCS is aligned to the SP.

   e) A stable shutdown condition must be established (i.e., level above TAF, Rx power <1%, SP temperature trending downward).

Table B.1.1-3
Drill 1B
(Scenario: ATWS)

INITIAL PLANT CONDITIONS

Power:	100%
Elect:	Normal operational lineup
PCS:	Normal operational lineup
CW:	Normal lineup - A, B, C pumps operating
CNDS:	Condensate/Condensate Booster Pumps A, B, D operating, C in standby
FW:	Both TDFWPs operating, MDFWP out of commission due to maintenance
SW:	Normal lineup - A pump operating
TBCCW:	Normal lineup - A pump operating
CSCS:	Normal standby lineup
HPCS:	Normal standby lineup
RCIC:	Out of commission due to maintenance
ADS:	Normal standby lineup
LPCS:	Normal standby lineup
LPCI A:	Normal standby lineup
B:	Normal standby lineup
C:	Normal standby lineup
SBLC:	Normal standby lineup
CRD:	A pump operating

INITIATOR, FAILURES, TRANSIENT

1. All MSIVs close due to a miscalibration of the steam tunnel high temperature instruments to old limit.

2. Reactor receives half scram channel B, fails to trip and all methods of manual scram fail.

3. Recirculation pump trip occurs as designed.

4. HPCS actuates upon level 2 as designed. RCIC does not start since it is out for maintenance.

5. HPCS switches over to suppression pool (SP) on high SP level as designed.

6. HPCS is assumed to fail within one minute after SP temperature reaches 190°F if suction not switched back to CST.

Table B.1.1-3 (Continued)
Drill 1B
(Scenario: ATWS)

SYSTEM STATES FOLLOWING INITIATOR

SYSTEM	AVAILABLE	FAILED	
		RECOVERABLE	NOT RECOVERABLE
FW			X
SBLC	X		
RCIC			X
HPCS	X*		
ADS	X		
LPCS	X		
LPCI A	X		
B	X		
C	X		
CNDS	X		

* - HPCS is initially available. It will fail if SP temperature exceeds 190°F.

OPERATOR ACTION(S) REQUIRED TO RECOVER

1. Follow ATWS procedure (i.e., inject boron, lower vessel level to TAF, initiate and maintain suppression pool cooling, raise level after boron injection) and bring the plant to a safe shutdown condition. To successfully establish a safe shutdown condition, we conservatively assume that all of the following must occur:

   a) After occurrence of the initial power spike, subsequent power spikes must be avoided.

   b) An automatic ADS must be prevented.

   c) The level must not drop below -200 inches for greater than X minutes.

   d) The SP temperature must not exceed 190°F while HPCS is aligned to the SP.

   e) A stable shutdown condition must be established (i.e., level above TAF, Rx power <1%, SP temperature trending downward).

Table B.1.1-4
Drill 2
(Scenario: NR Level Instrument Malfunction)

INITIAL PLANT CONDITIONS

Power:	100%
Elect:	Normal operational lineup
PCS:	Normal operational lineup
CW:	Normal lineup - A, B, C pumps operating
CNDS:	Condensate/Condensate Booster Pumps A, B, D operating, C in standby
FW:	Both TDFWPs operating, MDFWP in standby
SW:	Normal lineup - A pump operating
TBCCW:	Normal lineup - A pump operating
CSCS:	Normal standby lineup
HPCS:	Normal standby lineup
RCIC:	Normal standby lineup
ADS:	Normal standby lineup
LPCS:	Normal standby lineup
LPCI A:	Normal standby lineup
B:	Normal standby lineup
C:	Normal standby lineup
SBLC:	Normal standby lineup
CRD:	A pump operating

INITIATOR, FAILURES, TRANSIENT

1. A reactor trip occurs due to spurious turbine trip.

2. Following trip, first stage pressure scram bypass fails preventing scram reset. This causes the SDV and RBEDT to overflow into the reactor building. This steam leak can only be isolated if the operators diagnose the scram reset failure or interrupt the air supply of the SDV drain valves.

3. The MDFWP, HPCS, and RCIC are available for core cooling.

4. Humidity causes narrow range level instruments to malfunction upscale causing TDFWP runback to maintain level in green band. Wide range instruments will begin to show level decrease. When TDFWPs reach minimum flow, CRD injection will cause narrow range level to slowly increase to Level 8.

   (NOTE: SRV lifts controlling pressure may cause a temperature swell to the Level 8 trip point.)

   When Level 8 is actuated, it will malfunction and cannot be reset.

5. All high pressure core cooling is lost at this point.

Table B.1.1-4 (Continued)
Drill 2
(Scenario: NR Level Instrument Malfunction)

SYSTEM STATES FOLLOWING INITIATOR

SYSTEM	AVAILABLE	FAILED RECOVERABLE	FAILED NOT RECOVERABLE
FW		X*	
SBLC	X		
RCIC		X*	
HPCS		X*	
ADS		X*	
LPCS	X		
LPCI A	X		
B	X		
C	X		
CNDS	X		

*These systems are initially available, but trip after the erroneous L8 signal is generated. They may be recovered by "jumpering" L8 signals.

OPERATOR ACTION(S) REQUIRED TO RECOVER

1. Operators realize level malfunction early in transient and take manual control of FW and control level in normal range using wide range indication.

or

2. Recognize that the level instruments are not a reliable measure of adequate core cooling

and

3. Implement the core flooding procedure, i.e., open the SRVs and allow LPCS, LPCI or the condensate pumps to flood the vessel.

Table B.1.1-5
Drill 2B
(Scenario: NR and WR Level Instrument Malfunctions)

INITIAL PLANT CONDITIONS

Power:	100%
Elect:	Normal operational lineup
PCS:	Normal operational lineup
CW:	Normal lineup - A, B, C pumps operating
CNDS:	Condensate/Condensate Booster Pumps A, B, D operating, C in standby
FW:	Both TDFWPs operating, MDFWP in standby
SW:	Normal lineup - A pump operating
TBCCW:	Normal lineup - A pump operating
CSCS:	Normal standby lineup
HPCS:	Normal standby lineup
RCIC:	Normal standby lineup
ADS:	Normal standby lineup
LPCS:	Normal standby lineup
LPCI A:	Normal standby lineup
B:	Normal standby lineup
C:	Normal standby lineup
SBLC:	Normal standby lineup
CRD:	A pump operating

INITIATOR, FAILURES, TRANSIENT

1. A reactor trip occurs due to spurious turbine trip.

2. Following trip, first stage pressure scram bypass fails preventing scram reset. This causes the SDV and RBEDT to overflow into the reactor building. This steam leak can only be isolated if the operators diagnose the scram reset failure or interrupt the air supply of the SDV drain valves.

3. The MDFWP, HPCS, and RCIC are available for core cooling.

4. Humidity causes narrow range and wide range level instruments to malfunction upscale causing TDFWP runback to maintain level in green band. When TDFWPs reach minimum flow, CRD injection will cause narrow range level to slowly increase to Level 8.

   (NOTE: SRV lifts controlling pressure may cause a temperature swell to the Level 8 trip point.)

   When Level 8 is actuated, it will malfunction and cannot be reset.

5. All high pressure core cooling is lost at this point.

Table B.1.1-5
Drill 2B
(Scenario: NR and WR Level Instrument Malfunctions)

SYSTEM STATES FOLLOWING INITIATOR

SYSTEM	AVAILABLE	FAILED	
		RECOVERABLE	NOT RECOVERABLE
FW		X*	
SBLC	X		
RCIC		X*	
HPCS		X*	
ADS		X*	
LPCS	X		
LPCI A	X		
B	X		
C	X		
CNDS	X		

*These systems are initially available, but trip after the erroneous L8 signal is generated. They may be recovered by "jumpering" L8 signals.

OPERATOR ACTION(S) REQUIRED TO RECOVER

1. Recognize that the level instruments are not a reliable measure of adequate core cooling

and

2. Implement the core flooding procedure, i.e., open the SRVs and allow LPCS, LPCI or the condensate pumps to flood the vessel.

Table B.1.1-6
Drill 3
(Scenario: Station Blackout)

INITIAL PLANT CONDITIONS

Power:	100%
Elect:	Normal operational lineup
PCS:	Normal operational lineup
CW:	Normal lineup - A, B, C pumps operating
CNDS:	Condensate/Condensate Booster Pumps A, B, D operating, C in standby
FW:	Both TDFWPs operating, MDFWP in standby
SW:	Normal lineup - A pump operating
TBCCW:	Normal lineup - A pump operating
CSCS:	Normal standby lineup
HPCS:	Normal standby lineup
RCIC:	Normal standby lineup
ADS:	Normal standby lineup
LPCS:	Normal standby lineup
LPCI A:	Normal standby lineup
B:	Normal standby lineup
C:	Normal standby lineup
SBLC:	Normal standby lineup
CRD:	A pump operating

INITIATOR, FAILURES, TRANSIENT

1. A loss of offsite power occurs and is not recoverable for one hour.

2. Diesels A and O fail to start. Diesel 1B starts, then trips immediately after picking up the bus.

3. The RCIC injection value (FO13) begins to open but breaker trips as soon as the closed indication goes out preventing manual opening from the control room.

4. All major safety systems are unavailable at this point and all level indications are also lost.

Table B.1.1-6
Drill 3
(Scenario: Station Blackout)

SYSTEM STATES FOLLOWING INITIATOR

SYSTEM	AVAILABLE	FAILED RECOVERABLE	FAILED NOT RECOVERABLE
FW			X
SBLC			X
RCIC		X	
HPCS			X
ADS		X	
LPCS			X
LPCI A			X
B			X
C			X
CNDS			X

OPERATOR ACTION(S) REQUIRED TO RECOVER

1. Instruct a B man to locally open valve F013

or

2. Establish core cooling via diesel driven fire pump ("garbage systems") within one hour.

Table B.1.1-7
DRILL 4
(Scenario: Delayed Station Blackout)

INITIAL PLANT CONDITIONS

Power:	100%
Elect:	Normal operational lineup
PCS:	Normal operational lineup
CW:	Normal lineup - A, B, C pumps operating
CNDS:	Condensate/Condensate Booster Pumps A, B, D operating, C in standby
FW:	Both TDFWPs operating, MDFWP in standby
SW:	Normal lineup - A pump operating
TBCCW:	Normal lineup - A pump operating
CSCS:	Normal standby lineup
HPCS:	Normal standby lineup
RCIC:	Normal standby lineup
ADS:	Normal standby lineup
LPCS:	Normal standby lineup
LPCI A:	Normal standby lineup
B:	Normal standby lineup
C:	Normal standby lineup
SBLC:	Normal standby lineup
CRD:	B pump operating

Additional Information

Diesel Generator O is out for maintenance.

Table B.1.1-7 (Continued)
Drill 4
(Scenario: Delayed Station Blackout)

INITIATOR, FAILURES, TRANSIENT

1. A loss of offsite power occurs which cannot be restored for two hours.

2. Diesel generator 1B starts but trips when loaded.

3. Safety systems unavailable at this point are HPCS (due to failure of DG1B), LPCS, LPCIA (due to maintenance outage of DGO), FW and CBP (due to LOP).

4. Diesel generator 1A successfully starts and loads.

5. The steam supply to RCIC is isolated due to a "sneak circuit" that occurs during power restoration to the buses powered by DG1A. (Read Attachment A for a detailed description of the sneak circuit.)

6. If RCIC is restarted by the operator following the isolation, the system will again be isolated when the RCIC room temperature reaches 200°F. We conservatively assume that 200°F will be reached approximately 17 minutes after the RCIC restart. (Failure of DGO causes failure of the RCIC room cooling system.) [During the simulation, assume the "LPCS/RCIC Pump Cubicle Temp High" annunciator (P601) occurs 2 minutes after the first RCIC restart (annunciates at 108°F) followed by the 200°F RCIC isolation signal at 17 minutes following first RCIC restart.]

7. Diesel generator 1A fails 23 minutes following first RCIC restart.

Table B.1.1-7 (Continued)
Drill 4
(Scenario: Delayed Station Blackout)

SYSTEM STATES FOLLOWING INITIATOR

SYSTEM		AVAILABLE	FAILED	
			RECOVERABLE	NOT RECOVERABLE
FW				X
SBLC		X		
RCIC			X	
HPCS				X
ADS		X		
LPCS				X
LPCI	A			X
	B	X*		
	C	X*		
CNDS				X

* - These systems are only initially available. They will fail when DG1A fails late in the scenario.

OPERATOR ACTION(S) REQUIRED TO RECOVER

1. Restart RCIC after the first isolation

and

Bypass a second RCIC isolation by placing the RCIC steam isolation switches (SW, S1A, S1B) in the test position prior to failure of DG1A

or

2. Establish core cooling via "garbage systems" within one hour.

Table B.1.1-8
DRILL 6
(Scenario: Failure of DC Bus 1A)

INITIAL PLANT CONDITIONS

Power:	100%
Elect:	Normal operational lineup
PCS:	Normal operational lineup
CW:	Normal lineup - A, B, C pumps operating
CNDS:	Condensate/Condensate Booster Pumps A, B, D operating, C in standby
FW:	Both TDFWPs operating, MDFWP in standby
SW:	Normal lineup - A pump operating
TBCCW:	Normal lineup - A pump operating
CSCS:	Normal standby lineup
HPCS:	Normal standby lineup
RCIC:	Normal standby lineup
ADS:	Normal standby lineup
LPCS:	Normal standby lineup
LPCI A:	Normal standby lineup
B:	Normal standby lineup
C:	Normal standby lineup
SBLC:	Normal standby lineup
CRD:	A pump operating

Table B.1.1-8 (Continued)
Drill 6
(Scenario: Failure of DC Bus 1A)

INITIATOR, FAILURES, TRANSIENT

1. 125V DC bus 1A shorts to ground due to unknown causes and cannot be restored for the duration of the transient.

2. TDFWP 1A locks up, TDFWP 1B may be manually tripped. ADSA, RCIC, LPCS, LPCIA, and CRD 1A are disabled. Drywell pneumatic and drywell chillers isolate. Instrument Air is degraded by the loss of DC 1A (lose 2 of 3 compressors on Rx trip because of fast transfer). To speed up the scenario, a "leak" has been built into the IA system. When the air pressure reaches approximately 35 lbs.: (1) Hotwell makeup from CST is isolated, (2) Hotwell emergency overfill valve opens diverting water to CST, (3) recirc. valves fail open, (4) MSIV begins to drift closed (15-30 min.), (5) MDFWP discharge valve is not controllable, and (6) TDFWP steam control valves fail closed.

3. Failure of this bus also fails the auto backwash mechanism 1DG01F which prevents plugging of the strainer in the CSCS line that cools LPCI pump room coolers 1B and 1C.

4. The reactor will trip in a few minutes due to Hi drywell pressure.

5. HPCS starts then immediately fails when demanded.

6. RPV level increases following Rx trip.

7. The CSCS strainer plugs five minutes after LPCI start.

8. LPCIB and LPCIC are conservatively assumed to fail 15 minutes after the strainers plug due to loss of room cooling.

9. Since makeup to the hotwell is lost, the CNDS pumps will eventually deplete it.

Table B.1.1-8 (Continued)
Drill 6
(Scenario: Failure of DC Bus 1A)

SYSTEM STATES FOLLOWING INITIATOR

SYSTEM	AVAILABLE	FAILED RECOVERABLE	FAILED NOT RECOVERABLE
FW			X
SBLC			
RCIC			X
HPCS			X
ADS		X	
LPCS			X
LPCI A			X
B			X*
C			X*
CNDS	X		
MDFWP			

* - These systems are initially available.

OPERATOR ACTION(S) REQUIRED TO RECOVER

1. Prevent RPV level from reaching steam lines by tripping TDFP 1B and manually shutting TDFWP 1A discharge valve

AND

2. Realizing that makeup to hotwell must be restored by opening valve CD023

   a. locally

   OR

   b. by restoring IA/SA compressors

OR

3. Depressurize and use LPCI B and C to control level AND restore room cooling to LPCI B and C when it fails

OR

4. Establish core cooling via garbage systems.

Table B.1.1-9
DRILL 8
(Scenario: Feedwater Line Break)

INITIAL PLANT CONDITIONS

Power:	100%
Elect:	Normal operational lineup
PCS:	Normal operational lineup
CW:	Normal lineup - A, B, C pumps operating
CNDS:	Condensate/Condensate Booster Pumps A, B, D operating, C in standby
FW:	Both TDFWPs operating, MDFWP in standby
SW:	Normal lineup - A pump operating
TBCCW:	Normal lineup - A pump operating
CSCS:	Normal standby lineup
HPCS:	OOC for maintenance
RCIC:	Normal standby lineup
ADS:	Normal standby lineup
LPCS:	Normal standby lineup
LPCI A:	Normal standby lineup
B:	Normal standby lineup
C:	Normal standby lineup
SBLC:	Normal standby lineup
CRD:	A pump operating

INITIATOR, FAILURES, TRANSIENT

1. Feedwater line breaks in steam tunnel. Leak must be isolated preventing all flow to RPV with feedwater condensate.

2. RCIC is either:

   a) manually initiated by operators.
   b) automatically initiates level 2 depending upon speed of operator's response.

4. Two minutes after RCIC initiation, it fails due to a loss of lube oil.

5. High decay heat load causes 2 SRVs to open.

6. Level begins to decrease pressure holds above 1000 pounds.

7. Level continues to decrease to fuel zone. Clad temperatures begin to increase.

Table B.1.1-9 (Continued)
Drill 8
(Scenario: Feedwater Line Break)

SYSTEM STATES FOLLOWING INITIATOR

SYSTEM	AVAILABLE	FAILED RECOVERABLE	FAILED NOT RECOVERABLE
FW			X
SBLC	X		
RCIC			X
HPCS			X
ADS	X		
LPCS	X		
LPCI A	X		
B	X		
C	X		
CNDS			X
MDFWP	X		

OPERATOR ACTION(S) REQUIRED TO RECOVER

1. Manually open SRVs to allow depressurization and injection with LPCI and LPCS.

Cue	Event Description	Time
	1. Exercise began	______
601 E-407, F-401 and F-404	2. High temperature alarm occurs	______
Cued by Knowledge of Temperature Trip Setpoints	3. Operators check back panel steam tunnel temperature indications. Yes______ No______ ND______	______
Cued by Knowledge of Temperature Trip Setpoints	4. Operators realize temperature trips are occurring at the wrong setpoint. Yes______ No______ ND______	______
Cued by #2 and 603 Recirc. Flux Control	5. Operators reduce power (run back Recirc pumps)	______
Cued by #2	6. Operators notify load dispatcher	
Cued by #2	7. Operator calls for instrument tech to defeat steam tunnel temperature setpoints	______
Cued by #2	8. Operator decides to manually scram before scram occurs	______
603, B-105 and B-109 or MSIV valve closed lights on 601 Below E	9. MSIV closure	______
Red Lights on Core Display, One Row of Scram Channel Indicators Dark or on 603 B Only One Side has Lights	10. Half scram occurs	______

Figure B.1.2-1. Drill 1A Time Data Sheet Scenario: ATWS

Cue	Event Description	Time
Cued by #10	11. Operators push scram buttons	
Cued by #10	12. Operators place mode switch in shutdown	
Cued by #s 10, 11, and 12	13. Operators recognize ATWS	
Cued by #13 and Procedures	14. Operators attempt alternate rod insertions	
	a) Operators decide to pull fuses	
	b) Operators attempt to trip back panel breakers	
	c) Operators attempt manual rod insertions	
	d) Dispatch operators to scram outside control room	
Cued by #13 and Procedures	15. Operators access ATWS procedures	
Cued by #13 and Procedures, Recirc Flux Controller or Flow Control M/A Station	16. Operators verify recirc. pump trip	
601, A-208, A-308 Amber Lights on 601 A	17. a) Level 2 reached	
	b) HPCS starts	
	18. HPCS placed in: a) Manual override	
	b) Pull to lock	

Figure B.1.2-1 (Continued)

Cue	Event Description	Time
13J A-102, B-102, A-202, B-202	19. Both suppression pool high temperature alarms annunciate	______
Cued by #19	20. Operators recognize suppression pool high temperature alarms exist	______
Cued by #20 and Procedures 603 in Corner Turns Two Keys	21. Operators initiate SBLC	______
Cued by #20 and Procedures Bottom Row at 601 B and C	22. Operators initiate suppression pool cooling	______
Operator at 603 Needs to Talk to Someone at 601	23. Operators commence to purposely lower level to TAF	______
SBLC Tank Indicator Reads 4000 Gal.	24. Boron hot shutdown weight reached	______
	25. Operators realize boron hot shutdown weight reached	______
	26. Operators commence manual depressurization	______
603 FW S/U Controller	27. Vessel reflood initiated	______
601 HX Shell Bypass Valve Try Until Red Light Stays On	28. Operators establish RHR HX in suppression pool cooling mode	______
	29. Stable conditions reached (Rx power 1%, level above TAF, suppression pool temperature trending downward	______
	30. Drill terminated	______

Figure B.1.2-1 (Continued)

The following data should be collected from the simulator after completion of the exercise while in freeze mode.

31. What was the final state of the RHR pumps at the completion of this exercise (check one)?

LPCI mode ________
Sup pool cooling mode ________

32. Did the operators maintain suppression pool cooling throughout this exercise? (Note: Level 1 may realign SP cooling mode to LPCI mode)

Yes________ No________

33. Did the operators realign HPCS from the suppression pool back to the CST during this exercise?

Yes________ No________

34. Did an automatic ADS occur during this exercise?

Yes________ No________

35. What was the maximum suppression pool temperature during this exercise? ________

36. Approximately what time did this occur? ________

37. Approximately how long was the core level below -200 inches during this exercise? ________

38. Max Clad Temperature ________

39. After occurrence of the initial power spike, did subsequent power spikes occur?

Yes________ No________

If yes, how many? ________

Note: #37 and #38 must be obtained from the instructor.
#37 must be given in feet.

Figure B.1.2-1 (Concluded)

Cue	Event Description	Time
	1. Exercise began	______
601 E-407, F-401 and F-404	2. High temperature alarm occurs	______
Cued by Knowledge of Temperature Setpoints	3. Operators check back panel steam tunnel temperature indications. Yes______ No______ ND______	______
Cued by Knowledge of Temperature Trip Setpoints	4. Operators realize temperature trips are occurring at the wrong setpoint. Yes______ No______ ND______	______
Cued by #2 and 603 Recirc. Flux Control	5. Operators reduce power (run back Recirc pumps)	______
Cued by #2	6. Operators notify load dispatcher	
Cued by #2	7. Operator calls for instrument tech to defeat steam tunnel temperature setpoints	______
Cued by #2	8. Operator decides to manually scram before scram occurs	______
603, B-105 and B-109 or MSIV valve closed lights on 601 Below E	9. MSIV closure	______
Red Lights on Core Display, One Row of Scram Channel Indicators Dark or on 603 B Only One Side has Lights	10. Half scram occurs	______

Figure B.1.2-2. Drill 1B Time Data Sheet Scenario: ATWS

Cue	Event Description	Time
Cued by #10	11. Operators push scram buttons	
Cued by #10	12. Operators place mode switch in shutdown	
Cued by #s 10, 11, and 12	13. Operators recognize ATWS	
Cued by #13 and Procedures	14. Operators attempt alternate rod insertions	
	a) Operators decide to pull fuses	
	b) Operators attempt to trip back panel breakers	
	c) Operators attempt manual rod insertions	
	d) Dispatch operators to scram outside control room	
Cued by #13 and Procedures	15. Operators access ATWS procedures	
Cued by #13 and Procedures, Recirc Flux Controller or Flow Control M/A Station	16. Operators verify recirc. pump trip	
601, A-208, A-308 Amber Lights on 601 A	17. a) Level 2 reached	
	b) HPCS starts	
	18. HPCS placed in: a) Manual override	
	b) Pull to lock	

Figure B.1.2-2 (Continued)

Cue	Event Description	Time
13J A-102, B-102, A-202, B-202	19. Both suppression pool high temperature alarms annunciate	______
Cued by #19	20. Operators recognize suppression pool high temperature alarms exist	______
Cued by #20 and Procedures 603 in Corner Turns Two Keys	21. Operators initiate SBLC	______
Cued by #20 and Procedures Bottom Row at 601 B and C	22. Operators initiate suppression pool cooling	______
Operator at 603 Needs to Talk to Someone at 601	23. Operators commence to purposely lower level to TAF	______
SBLC Tank Indicator Reads 4000 Gal.	24. Boron hot shutdown weight reached	______
	25. Operators realize boron hot shutdown weight reached	______
	26. Operators commence manual depressurization	______
603 FW S/U Controller	27. Vessel reflood initiated	______
601 HX Shell Bypass Valve Try Until Red Light Stays On	28. Operators establish RHR HX in suppression pool cooling mode	______
	29. Stable conditions reached (Rx power 1%, level above TAF, suppression pool temperature trending downward)	______
	30. Drill terminated	______

Figure B.1.2-2 (Continued)

The following data should be collected from the simulator after completion of the exercise while in freeze mode.

31. What was the final state of the RHR pumps at the completion of this exercise (check one)?

LPCI mode ________
Sup pool cooling mode ________

32. Did the operators maintain suppression pool cooling throughout this exercise? (Note: Level 1 may realign SP cooling mode to LPCI mode)

Yes________ No________

33. Did the operators realign HPCS from the suppression pool back to the CST during this exercise?

Yes________ No________

34. Did an automatic ADS occur during this exercise?

Yes________ No________

35. What was the maximum suppression pool temperature during this exercise? ________

36. Approximately what time did this occur? ________

37. Approximately how long was the core level below -200 inches during this exercise? ________

38. Max Clad Temperature ________

39. After occurrence of the initial power spike, did subsequent power spikes occur?

Yes________ No________

If yes, how many? ________

Note: #37 and #38 must be obtained from the instructor. #37 must be given in feet.

Figure B.1.2-2 (Concluded)

Cue	Event Description	Time
	1. Exercise began	_____
	2. Reactor trip	_____
Cued by #2 and Procedures	3. Operators place mode switch in shutdown	_____
Cued by #2 and Procedures	4. Operators push scram buttons	_____
	5. a) Level 2 reached	_____
	b) HPCS starts	_____
	c) RCIC starts	_____
	6. Level above 12.5 inches	_____
Cued by #2	7. Operator attempts to reset scram	_____
Cued by #2	8. Operator realizes scram did not reset	_____
Cued by #2	9. Operators decide to block scram relays	_____
601 B and D Leak Detection Alarms or Scram Isol. Vent Valve Should be Closed (red) 603 Near FW/SW Controller	10. Operators realize there is a leak outside the drywell	
	11. Narrow range level instruments begin to malfunction	_____
	12. Operating team realizes that level instruments are malfunctioning	_____
603 Right Corner	13. Operator takes manual control of feedwater and controls on wide range instruments	_____

Figure B.1.2-3. Drill 2 Time Data Sheet Scenario: NR Level Instrument Malfunction

Cue	Event Description	Time
O3J High Level Trips (Note: L8 Occurs After MSIV Closure)	14. Level 8 trip of MDFWP, HPCS, RCIC occurs	______
	15. Operators block level 8 trips	______
	16. Operating team realizes that all high pressure core injection is lost	______
	17. High pressure system restored by overriding trips by procedures	______
Ops Open Valves Alphabetically	18. Depressurization initiated to allow low pressure core cooling to occur	______
Ops Could Begin @700# With Condensate Pumps or at 440 With LP Pumps	19. Core flooding procedure initiated	______
	20. Level restored	______
	21. Drill terminated	

Figure B.1.2-3 (Continued)

Cue	Event Description	Time
	1. Exercise began	______
	2. Reactor trip	______
Cued by #2 and Procedures	3. Operators place mode switch in shutdown	______
Cued by #2 and Procedures	4. Operators push scram buttons	______
	5. a) Level 2 reached	______
	b) HPCS starts	______
	c) RCIC starts	______
	6. Level above 12.5 inches	______
Cued by #2	7. Operator attempts to reset scram	______
Cued by #2	8. Operator realizes scram did not reset	______
Cued by #2	9. Operators decide to block scram relays	______
601 B and D Leak Detection Alarms or Controller: Scram Isol. Vent Valve Should be Closed (red) 603 Near FW S/W or 13J 203 and 303 up, but Should Clear	10. Operators realize there is a leak outside the drywell	______
	11. NR and WR level instruments begin to malfunction	______
	12. Operating team realizes that level instruments are malfunctioning	______

Figure B.1.2-4. Drill 2B Time Data Sheet Scenario: NR and WR Level Instrument Malfunction

Cue	Event Description	Time
603 Right Corner		______
O3J High Level Trips (Note: L8 Occurs After MSIV Closure)	13. Level 8 trip of MDFWP, HPCS, RCIC occurs	______
	14. Operators block level 8 trips	______
	15. Operating team realizes that all high pressure core injection is lost	______
	16. High pressure system restored by overriding trips by procedures	______
Ops Open Valves Alphabetically	17. Depressurization initiated to allow low pressure core cooling to occur	______
Ops Could Begin @700# With Condensate Pumps or at 440 With LP Pumps	18. Core flooding procedure initiated	______
	19. Level restored	______
	20. Drill terminated	______

Figure B.1.2-4 (Continued)

Cue	Event Description	Time
	1. Exercise began	______
Lights Go Off	2. Loss of offsite power occurs	______
Lights Back On	3. 1B diesel (HPCS) starts	______
Lights Off	4. 1B diesel fails	______
	5. a) Level 2 reached	______
	b) RCIC starts	______
F013 Light is Out	6. Operating team realizes that all core cooling systems are unavailable (realize F013 not open)	______
	7a. Operators attempt to restore DGs from control room	______
	7b. Operators attempt to restore DGs locally	______
	8. Operators attempt to recover offsite power (call load dispatcher)	______
601 Under D	9. Operators attempt to manually open F013 from CR	______
	10. Operators call for B-man to open F013 locally	______
	11. Operators access procedures	______
	12. Operators call B-man to establish core cooling via diesel-driven Garbage Systems	______
	13. Operators perform manual depressurization	______
	14. Operators restore level	______

Figure B.1.2-5. Drill 3 Time Data Sheet Scenario: Station Blackout

Cue	Event Description	Time
	1. Exercise began	
Lights Go Off	2. Loss of offsite power occurs	
Lights Back On	3. Operators successfully start RCIC manually (first time)	
	4. Level 2 reached	
	5. Operators access procedures	
	6a. Operators attempt to start DG1B from CR	
	6b. Operators attempt to start DG1B locally	
	7. Operators attempt to recover offsite power (Call Load dispatch)	
	8. Operators manually depressurize to allow LPC1B/LPCIC to inject	
Room Temperature Indications	9. Operators notice that the RCIC room is over-heating by RCIC	
	10. Operators realize that RCIC will isolate when 200°F is reached	
	11. RCIC isolates	
	12. Operating team realizes that all high pressure core cooling is unavailable	

Figure B.1.2-6. Drill 4 Time Data Sheet Scenario: Delayed Station Blackout

	13. Operators bypass 2nd RCIC isolation via placement of SW 51A and 51B in test position	____
Lights Go Out	14. DG1A failure occurs	____
	15. Operators attempt to recover DG1A in CR	____
	16. Operators attempt to recover DG1A locally	____
	17. Operators call B-man to establish core cooling via diesel driven Garbage System	____

Figure B.1.2-6 (Continued)

Cue	Event Description	Time
	1. TDFWP1A locks up	_____
	2. Operators attempt to restore TDFWP1A	_____
	3. DC bus 1A fails	_____
	4. Drywell isolates	
	5. Operators realize containment pressure increasing	_____
	6. Operators decide to manually scram	_____
	7. Operators attempt to run back power	_____
	8. Operators manually shut TDFWP1A discharge valve	_____
	9. Operators close FCV on recirc. pumps	_____
	10. Operators trip recirc. pumps	_____
	11. Operators attempt to restore DC Bus 1A	_____
	12. Operators attempt to control drywell pressure	_____
	13. Rx trips	_____
	14. RPV increases	_____
	15. Operators attempt to trip TDFWP 1A	_____
	15. Operators attempt to trip TDFWP 1B	_____

Figure B.1.2-7. Drill 6 Time Data Sheet Scenario: Failure of DC BUS 1A

Cue	Event Description	Time
	17. Operators realize TDFWP1A will not trip	______
	18. Operators manually shut TDFWP1A discharge valve	______
	19. Operators control level	______
	a) Using 1B TDFWP reg. valve	______
	b) Using bypass valves	______
	20. Level 8 reached	______
	21. RPV water level reaches steam lines	______
	22. Operators establish condensate flow to RPV	______
	23. Operators initiate low pressure systems	______
	24. Station air pressure decrease to 35 lbs.	______
	25. Recirc valves go full power	______
	26. Hotwell makeup isolates	______
	27. Operators run FW reactor level control back to zero	______
	28. Operators locally reestablish hotwell makeup.	______
	29. Operators attempt to restart HPCS in the control room	______

Figure B.1.2-7 (Continued)

Cue	Event Description	Time
	30. Operators realize LPCI B & C rooms are overheating	______
	31. Operators attempt to restore room cooling to LPCI B & C	______
	32. Operators cycle LPCI pumps to maintain room temperature	______
	33. Operators go to Garbage Systems	______

Figure B.1.2-7 (Concluded)

Cue	Event Description	Time
	1. Exercise Began	______
	2. FW Break Occurs	______
FW flow pegs high		______
FW pumps go to runout		______
Level begins to decrease		______
	3. Rx Trips	______
Core display		
Alarms		
	4. RCIC Initiated:	
	a. Manually	______
	b. Automatically (Level 2)	______
Operator starts RCIC		______
Level 2 annunciated		______
RPV level indicates 50"		

Figure B.1.2.8. Drill 8 Time Data Sheet Scenario: Feedwater Line Break

Cue	Event Description	Time
	5. RCIC Fails	______
RCIC low lube oil pressure alarm		______
RCIC turbine trips		______
RCIC F013 closes		______
RCIC flow decreases to zero		______
	6. ADS Manually Inhibited to Prevent Blowdown Before Required	______
Operator action		______
	7. Level Reaches TAF	______
WR level indication off scale low		______
Fuel zone level indication comes on scales and decreases to TAF mark (yellow zone)		______
	8. ADS Manually Initiated	______
RPV level -161 inches		______
Operator action		______

Figure B.1.2-8 (Concluded)

forms were used to record the times at which the important steps and substeps were taken by the operators in dealing with the accident.

The Operator Biographical Data Form (Figure B.1.2-9) was used to collect information pertaining to the experience and training of the individual operators. This information would potentially be used to correlate simulator performance data with factors such as age, experience, education, job classification, etc.

Two other types of data collection forms were developed and used in Phase 2, but the data from them were not analyzed. Since the Phase 1 data analyses were still in progress when Phase 2 data collection began, expert opinion data on difficulty of recognition and evaluation and other information were collected using Operator and Instructor Questionnaires (see Figures B.1.2-10 and B.1.2-11 for examples). Because of the negative findings with respect to expert opinion data in Phase 1, these data were not analyzed in Phase 2.

In addition, Instructor Evaluation Forms were used to obtain instructor ratings of the operating crews' responses to the accident scenarios (see Figure B.1.2-12). These ratings were seen as backup measures to the objective simulation performance measures recorded on the Time Data Collection Forms. Since the objective measures were of good quality, it was not necessary to use the instructor ratings.

B.1.3 Data Collection Procedure

The data were collected in the following manner:

(1) The instructors were asked to complete their questionnaires prior to the drill so that observations of a specific crew would not influence their generalized responses.

(2) The time data forms were used by three observers during the course of the drill to record when various operator actions occurred. Tape recorders were also used to note times when actions occurred and to provide a means of making notes on what the operators were doing or saying during the accident. The printout from the sequence event timer located in the simulated control room was collected as another source of timing information for the accident scenario.

(3) After the drill was completed, the operators were asked to fill out their questionnaires, expressing their individual opinions on the accident they had just witnessed.

(Text continues on page B-58)

Operator Number:_______

Date:________________________________

This questionnaire requests information on your training and operational experience. The information you provide will be used as data in a research project conducted by Sandia National Laboratories as part of the Risk Methods Integration and Evaluation Program (RMIEP) in which the LaSalle plant is participating. Statistical summaries of these data will be reported, but no individuals will be identified in any report.

Your replies will be considered completely confidential. In order to maintain anonymity, DO NOT put your name on this form. However, you will note that you have been assigned an "Operator Number" at the top left of this page. Please write down that number for future reference. You will be participating in a simulator exercise and/or in an expert opinion study, and it is necessary that we correlate your simulator performance with the data provided in this form. You will be asked to use this same "Operator Number" in the simulator exercise. In addition, we may need to contact you for any clarification of these data or simulator data. If we do need to contact you, we will post your Operator Number in the plant, and ask you to telephone us at a listed number. In this way, we will not know your name, but will be able to obtain the information which might be required for this study.

1. Sex:_______

2. Age:_______

3. LaSalle plant experience: Years_____ + additional months____

4. Months of nuclear power plant <u>training</u> (<u>not</u> including Navy):

    a. From utility (classroom & simulator):_______

    b. College/technical school:_______

5. Years & months in Navy nuclear program: Years_____ + additional months_______

6. Are you a high school graduate (or have a GED)?_______

7. Number of years of college:_______

8. College degree(s) and major (in each):______________________

Figure B.1.2-9
Operator Biographical Data Form

9. Years of non-nuclear power plant experience:_______

10. Commercial nuclear power plant experience:

    a. Number of years experience outside of control room:______

    b. Number of years in control room as: AO_____; RO_____; SRO_____

    c. List all NRC licenses earned:____________________________

    d. Date of your highest license for LaSalle plant:__________

11. In your day-to-day work at the plant, are you (check 1):

    a. ______ A trainee

    b. _____ Primarily an operator

    c. _____ Primarily a supervisor

    d. _____ Primarily an engineer

    e. _____ Other (explain):____________________________________

12. Do you usually stand control room watches?_____

13. If you are not primarily an operator, when did you last work in the control room as an RO or SRO (month/year)?_______

Figure B.1.2-9 (Continued)

Operator Number______________________Date__________Shift__________

Please indicate which position you were assigned in the control room during this drill.

RO_____________CD/AUX OP_____________SRO/SCREE_____________

1. Did the steam tunnel high temperature alarms lead you to initially believe that:

   a) a steam leak existed in the steam tunnel _____

   b) a feed leak existed in the steam tunnel _____

   c) a steam leak outside of tunnel being drawn into tunnel by ventilation system _____

   d) instruments were miscalibrated _____

   e) power level was higher than indicated _____

   f) ventilation fans had failed _____

2. Did you initially realize that the leak detection instrument trips were set lower than normal?

   Yes_____ No_____

3. Did you anticipate an MSIV closure?

   Never_________________________
   After the 1st alarm___________
   After the 2nd alarm___________

4. Did you expect HPCS to fail if the suction were left lined up to the suppression pool after the pool temperature started increasing?

   Yes_____ No_____

Please explain your answer._____________________________________

____

____

Figure B.1.2-10
Operator Questionnaire
ATWS: Drill 1A

5. Please rank the difficulty of this scenario both in recognizing that control of the following parameters could become a problem and evaluating which actions to take by <u>checking the appropriate boxes</u>.

		1	2	3	4	5
		Much easier than average	Easier than average	Average	More difficult than average	Much more difficult than average
A. RPV Level	Recognize					
	Evaluate					
B. RPV Pressure	Recognize					
	Evaluate					
C. RX Power	Recognize					
	Evaluate					
D. SP Temp.	Recognize					
	Evaluate					

6a. Do you feel this failure would be more difficult to recognize and respond to in the plant?

Yes_____ No_____

6b. Why?____

7. Please identify and explain occurrences (if any) that made it difficult for you to correctly respond to this failure.

____

Figure B.1.2-10 (Continued)

8. Please answer each of the following questions by checking the appropriate boxes. In choosing your answer, please answer as if each event was an isolated exercise and not in the context of the scenario you were just exposed to.

		(1)Spurious MSIV Closure	(2)ATWS	(3)Alternate Rod Insertion	(4)Suppression Pool Cooling	(5)Boron Injection	(6)ATWS Level Control	(7)ATWS Pressure Control
Indicate which of these you have been involved in or trained in before.								
A. Was this involvement in the plant or at the simulator (check both) boxes if applicable)	Plant							
	Simulator							
B. Please indicate the number of times at each place	Plant							
	Simulator							
C. Do you consider this amount of exposure as	Less than average							
	Average							
	More than average							
D. Do you feel that more training would improve your ability to correctly respond to each of these	Yes							
	No							
E. Do you feel that referencing the procedures is helpful to properly control these	Yes							
	No							

Figure B.1.2-10 (Continued)

9. Please answer the following questions by checking the appropriate boxes. Please answer these questions in the context of the overall drill. In answering these questions, please use the following scale.

	1	2	3	4	5		
	Much easier than average	Easier than average	Average	More difficult than average	Much more difficult than average	Procedures Required	
XXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXX	XXXXXXXX	XXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXX	Yes	No
A. Recognize ATWS had occurred							
Determine that: XXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXX	XXXXXXXX	XXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXX	XXXXXX	XXXXXXX
B. HPCS had initiated							
C. RCIC was unavailable for level control							
D. HPCS would fail if left lined up to the suppression pool							
Decide to: XXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXX	XXXXXXXX	XXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXX	XXXXXX	XXXXXXX
E. Manually scram							
F. Shift mode switch to shutdown							
G. Attempt alternate rod insertion							
H. Secure HPCS							
I. Inhibit the automatic ADS							
J. Lower level to TAF							
K. Initiate suppression pool cooling							
L. Initiate SBLC							
M. Use MDFWP to control level							
N. Restart HPCS to control level							

Figure B.1.2-10 (Continued)

	1 Much easier than average	2 Easier than average	3 Average	4 More difficult than average	5 Much more difficult than average	Procedures Required	
XXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXX	XXXXXXXXX	XXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXX	Yes	No
O Shift HPCS suction to CST							
P. Manually Depressurize							
Q. Restore RPV level with low pressure systems							
R. Establish RHR HX in SP cooling mode							

10. Please use the following scale to indicate the usefulness of each type of control room indication in recognizing or evaluating each of the actions listed below.

1 = very useful   2 = useful   3 = not useful

	Annunciator	Panel Indicators	Component Status lights	Switch Positions	CRT Display	Other
A. Recognizing an ATWS had occurred						
Determining That: XX	XXXXXXXXXXXXXXX	XXXXXXXXXXXXXXX	XXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXX
B. HPCS had Initiated						
C. RCIC was unavailable for level control						
D. HPCS would fail if left lined up to suppression pool						

Figure B.1.2-10 (Continued)

1 = very useful   2 = useful   3 = not useful

	Annunciator	Panel Indicators	Component Status lights	Switch Positions	CRT Display	Other
Decide to:	XXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXXX	XXXXXXXXXXX	XXXXXXXX
E. Manually scram						
F. Shift mode switch to shutdown						
G. Attempt alternate rod insertion						
H. Secure HPCS						
I. Inhibit the automatic ADS						
J. Lower level to TAF						
K. Initiate suppression pool cooling						
L. Initiate SBLC						
M. Use MDFWP to control level						
N. Restart HPCS to control level						
O. Shift HPCS suction to CST						
P. Manually depressurize						
Q. Restore RPV level with low pressure systems						
R. Establish RHR HX in SP cooling mode						

Figure B.1.2-10 (Concluded)

Instructor______________________________

Please evaluate this scenario according to your impressions after studying the attached scenario outline.

1. Do you feel that the procedures will be helpful to the crew or tend to confuse them in overall control of this scenario?

Helpful _____ Confuse _____

2a. Do you feel this failure would be more difficult to recognize and respond to in the plant?

Yes _____ No _____

2b. Why? ____

____

____

____

3. Please rank the difficulty of this scenario both in recognizing that control of the following parameters could become a problem and evaluating which actions to take by checking the appropriate boxes.

		1 Much easier than average	2 Easier than average	3 Average	4 More difficult than average	5 Much more difficult than average
A. RPV Level	Recognize					
	Evaluate					
B. RPV Pressure	Recognize					
	Evaluate					
C. RX Power	Recognize					
	Evaluate					
D. SP Temp.	Recognize					
	Evaluate					

Figure B.1.2-11
Instructor Questionnaire
ATWS: Drill 1A

4. Please indicate in the following table by checking the appropriate boxes, your evaluation of the difficulty of each of the aspects of this scenario listed below.

	1 Much easier than average	2 Easier than average	3 Average	4 More difficult than average	5 Much more difficult than average	Procedures Required	
XXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXX	XXXXXXXXX	XXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXX	Yes	No
A. Recognize ATWS had occurred							
Determine that: XXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXX	XXXXXXXXX	XXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXX	XXXXXX	XXXXXXX
B. HPCS had initiated							
C. RCIC was unavailable for level control							
D. HPCS would fail if left lined up to the suppression pool							
Decide to: XXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXX	XXXXXXXXX	XXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXX	XXXXXX	XXXXXXX
E. Manually scram							
F. Shift mode switch to shutdown							
G. Attempt alternate rod insertion							
H. Secure HPCS							
I. Inhibit the automatic ADS							
J. Lower level to TAF							
K. Initiate suppression pool cooling							

Figure B.1.2-11 (Continued)

	1 Much easier than average	2 Easier than average	3 Average	4 More difficult than average	5 Much more difficult than average	Procedures Required	
XXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXX	XXXXXXXXX	XXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXX	Yes	No
L. Initiate SBLC							
M. Use MDFWP to control level							
N. Restart HPCS to control level							
O. Shift HPCS suction to CST							
P. Manually Depressurize							
Q. Restore RPV level with low pressure systems							
R. Establish RHR HX in SP cooling mode							

5. Please use the following scale to indicate how useful you feel each of the following types of control room indications should be to the crew in recognizing or evaluating each of the actions or realizations listed below.

1 = very useful 2 = useful 3 = not useful

	Annunciator	Panel Indicators	Component Status lights	Switch Positions	CRT Display	Other
A. Recognizing an ATWS had occurred						
Determining That: XX	XXXXXXXXXXXXXX	XXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXX	XXXXXXXXXXX	XXXXXXXX
B. HPCS had Initiated						

Figure B.1.2-11 (Continued)

1 = very useful   2 = useful   3 = not useful

	Annunciator	Panel Indicators	Component Status lights	Switch Positions	CRT Display	Other
C. RCIC was unavailable						
D. HPCS would fail if left lined up to suppression pool						
Decide to: XXXXXXX	XXXXXXXXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXXXXXX	XXXXXXXXXXXXX	XXXXXXXXXXX	XXXXXXXX
E. Manually scram						
F. Shift mode switch to shutdown						
G. Attempt alternate rod insertion						
H. Secure HPCS						
I. Inhibit the automatic ADS						
J. Lower level to TAF						
K. Initiate suppression pool cooling						
L. Initiate SBLC						
M. Use MDFWP to control level						

Figure B.1.2-11 (Continued)

1 = very useful 2 = useful 3 = not useful

	Annunciator	Panel Indicators	Component Status lights	Switch Positions	CRT Display	Other
N. Restart HPCS to control level						
O. Shift HPCS suction to CST						
P. Manually depressurize						
Q. Restore RPV level with low pressure systems						
R. Establish RHR HX in SP cooling mode						

Figure B.1.2-11 (Concluded)

Instructor________________________________

Date _____ Shift _____

Please evaluate the following aspects of the crew's overall performance during this scenario.

I. COMMUNICATIONS

A. Please check the appropriate description of the crew's communications

1_____ Communications were clearly conveyed and contributed to clear understanding.

2_____ Communications were not always conveyed initially requiring minor repetitions to insure understanding.

3_____ Communications were not always clearly conveyed and were sometimes incomplete or insufficient often requiring several repetitions for understanding.

4_____ Communications were inadequate, critical information was often not conveyed and frequently misunderstood.

B. Did the description identified above: (Check One)

1_____ Contribute to the crew responding successfully to the scenario.

2_____ Delay but not materially affect the crew's response.

3_____ Materially degrade the crew's response but overall did not prevent a successful response.

4_____ Degraded the crew's response to such an extent that it was a major contributor to the crew failing to successfully respond to the scenario as described in this scenario outline.

II. CREW STRUCTURE

A. Please check the appropriate description listed below to identify the organization or structure of the overall crew in responding to this scenario.

Figure B.1.2-12
Instructor Evaluation

1______ The SRO exhibited strong authority, by directing all activities and seldom, if ever, requested opinions from the other members of the crew.

2______ The SRO maintained decision-making authority; however, he allowed crew members to offer opinions and allowed them to take appropriate independent actions during the scenario.

3______ The SRO generally sought a consensus of opinion from the crew before deciding upon a course of action for the crew to follow.

4______ The SRO usually allowed the crew consensus to dictate the course of action the crew would follow.

5______ The SRO seemed to allow independent, uncoordinated actions by all members of the crew.

B. Do you feel that the description of the crew organization described above: (Check One)

1______ Contributed to the crew responding successfully to the scenario.

2______ Delayed but did not materially affect the crew's response.

3______ Materially degraded the crew's response but overall did not prevent a successful response.

4______ Degraded the crew's response to such an extent that it was a major contributor to the crew failing to successfully respond to the scenario as described in the scenario outline.

III. PROCEDURES

A. Please select one of the following descriptions to describe your evaluation of the operators' use of the procedures.

1______ The operators depended heavily upon procedures to guide their response to this scenario.

2______ The operators referred to the procedures to ensure all required actions had been or were being accomplished during this scenario.

Figure B.1.2-12 (Continued)

3_____ The operators' referred to procedures only when they were unsure of the proper response to a situation that occurred during the scenario.

4_____ The operators rarely, if ever, referred to the procedures.

B. Do you feel that the operators use of the procedures: (Check One)

1_____ Contributed to the crew responding successfully to the scenario.

2_____ Delayed but not materially affect the crew's response.

3_____ Materially degraded the crew's response but overall did not prevent a successful response.

4_____ Degraded the crew's response to such an extent that it was a major contributor to the crew failing to successfully respond to the scenario as described in the scenario outline.

C. Do you feel the procedures, as they currently exist, adequately cover the situation and should be helpful to the operators?

Yes _____ No _____

D. If no, select one of the below

1_____ Adequately cover the individual malfunctions and failures but are difficult to utilize in this type of situation.

2_____ Cover most of the individual malfunctions and failures but are very difficult to utilize in this type of situation.

3_____ Are only marginally helpful in this type of situation.

Figure B.1.2-12 (Concluded)

(4) The instructors rated each operating crew by completing the instructor evaluation form after the operators had completed the drill.

B.1.4 Results of Data Collection

Table B.1.4-1 contains the data obtained from the Operator Biographical Data Form. The diagnosis time data collected for each drill can be found in Tables B.1.4-2 through B.1.4-9. The data presented in these tables represent the best estimates for the identified operator actions and are given as clock time from the start of the scenario (cumulative times). These estimates were produced by examination of the Time Data Collection Forms, the sequence event timer output for each drill, and the tape recordings made for the drill. The generally close agreement [20] among the observers made it easy to provide best estimates for the identified actions. This information was used to isolate the operator recovery actions and to determine if other actions taken by the operators affected these recovery actions. These time data were used in the analyses described in section B.4.

The data obtained using the Operator and Instructor Questionnaires are available in a computerized data base.

B.2 Grouping of Operator Actions

It was decided to attempt to group the actions according to their operational similarity. Once the operational groupings were made, statistical tests were conducted to determine if the actions could be grouped statistically.

The operator actions were grouped in the following manner. First, each drill was studied to identify those actions which could significantly affect the outcome of the drill. These actions are presented in Table B.2-1. Next, the actions were studied to determine if any operational similarities existed among them (e.g. operation of a system or component manually because it may or may not operate automatically, manual operation of a system or component because it failed to automatically operate, etc.). Finally, after examination, the actions listed in Table B.2-1 were grouped into eleven (11) preliminary groups as summarized in Table B.2-2.

B.3 Study Overview

The diagnosis time data were analyzed by methods described in the next section. One purpose of the analyses was to determine if statistical tests on the data supported the operational groupings of actions. Such tests were performed on data for the actions within each of the groups listed in Table B.2-2.

(Text continues on page B-71)

Table B.1.4-1

```
***************************************************************************
*                            FALL DATA                                    *
*                BIOGRAPHICAL DATA ON LA SALLE OPERATORS                  *
*                ****MISSING DATA ON SOME OPERATORS****                   *
***************************************************************************
*       OBS = OBSERVATION NUMBER                                          *
*      OPER = OPERATOR NUMBER                                             *
*    LSNPPE = YRS. LA SALLE NUCLEAR POWER PLANT (NPP) EXPERIENCE          *
*.    UNPPT = YRS. UTILITY NPP TRAINING                                   *
*   COLLEGE = YRS. COLLEGE                                                *
*        HS = HIGH SCHOOL GRADUATE (YES, NO)                              *
*    DEGREE = COLLEGE DEGREE (ENGR=ENGINEERING, SCI=SCIENCE)              *
*     NNPPE = YRS. NON-NUCLEAR POWER PLANT EXPERIENCE                     *
*  CNPPEOCR = YRS. COMMERCIAL NPP EXPERIENCE OUTSIDE CONTROL ROOM         *
*  CNPPEICR = YRS. COMMERCIAL NPP EXPERIENCE INSIDE CONTROL ROOM          *
*   LICENSE = HIGHEST NRC LICENSE (AO, RO, SRO)                           *
*    ASSIGN = DAILY ASSIGNMENT AT PLANT (B=OPERATOR, C=SUPERVISOR,        *
*             D=ENGINEER, E=OTHER)                                        *
*   CRWATCH = USUALLY STAND CONTROL ROOM WATCH (YES, NO)                  *
*    LASTCR = IF NOT OPERATOR, YRS. SINCE LAST IN CONTROL ROOM AS         *
*             RO OR SRO                                                   *
*      CREW = SH = SHIFT, WK = WEEK                                       *
*             1=SH1,WK10 2=SH1,WK10 3=SH1,WK11 4=SH2,WK11 5=SH1,WK12      *
*             6=SH1,WK13 7=SH2,WK13 8=SH1,WK14 9=SH2,WK14                 *
*             10=SH1,WK15 11=SH2,WK15 12=SH3,WK14                         *
***************************************************************************

INPUT OBS 1-2 OPER 4-5 SHIFT 7 WEEK 9-10 SEX $ 12 AGE 14-15 LSNPPE 17-21
  UNPPT 23-27 COLLEGE 29-31 HS $ 33 DEGREE $ 35-39 NNPPE 41-43
  CNPPEOCR 45-49 CNPPEICR 51-55 LICENSE $ 57-60 ASSIGN $ 62
  CRWATCH $ 64 LASTCR 66-70 CREW 72-73;

 1 66 1 10 M 39  5.92  1.17 4.0 Y OTHER 1.0  5.00  0.0   SRO D N         1
 2 69 1 10 M 33  8.92  1.50 3.0 Y OTHER      7.00  2.0   SRO E N  3.67   1
 3 81 1 10                                                               1
 4 B1 2 10 M 34  6.33  2.50 2.0 Y OTHER 0.0  6.33  0.0  NONE E N         2
 5 B2 2 10 M 33  3.17  2.00 4.0 Y   SCI 0.0  3.00  0.0  NONE E N         2
 6 B3 2 10 M 24  3.33  1.50 4.0 Y  ENGR 0.0  3.50  3.5  NONE E N         2
 7 25 1 11 M 28  8.00  1.50 2.0 Y OTHER      4.50  2.5    RO B Y         3
 8 43 1 11 M 41  9.50  2.00 4.0 Y   SCI 0.5 12.00  3.00  SRO C N  1.90   3
 9 87 1 11 M 26  4.00  1.50 2.0 Y OTHER 0.0  3.50  0.50   RO B N  0.00   3
10 88 1 11 M 33  1.50 10.00 1.0 Y OTHER 5.0  4.00  6.00  SRO C N         3
11  9 2 11 M 32  7.33  5.00 0.0 Y OTHER 4.0  4.00  3.00   RO B Y  0.00   4
12 45 2 11 M 39  9.50  2.50 1.5 Y OTHER 0.0  1.00  6.00  SRO C N  2.70   4
13 85 2 11 M 29  8.75  9.00 2.0 Y OTHER 0.0  1.00  7.00   RO B Y  0.00   4
14 24 1 12 M 33  8.67  1.90 2.0 Y OTHER 3.5  8.00  4.00   RO B Y  0.00   5
15 49 1 12 M 24  3.90  1.50 0.0 Y OTHER 0.0  2.00  1.00   AO E N  0.00   5
16 56 1 12                                                               5
17 60 1 12                                                               5
18  7 1 13 M 34  9.25  3.00 2.0 Y OTHER 0.0  0.00  4.00  SRO C N  5.50   6
19 15 1 13 M 36  7.50  5.00 0.0 Y OTHER 0.0  5.50  2.50   RO B    0.00   6
20 41 1 13 M 28  7.25  1.00 4.0 Y   SCI 0.0  7.00  1.00  SRO C N  2.50   6
21 75 1 13 M 25  3.75  1.00 3.0 Y OTHER 0.0  2.50           B N         6
22 23 2 13 M 29  7.25  2.00 3.0 Y OTHER 0.0  6.00  1.00   RO B Y  0.00   7
23 55 2 13                                                               7
24 65 2 13 M 39  9.90  3.00 2.0 Y OTHER 0.0 12.00  4.00  SRO C N         7
25 16 1 14 M 27  7.50  6.00 1.0 Y OTHER 0.0  3.00  4.00   RO B Y  0.00   8
26 17 1 14 M 35  7.00  0.33 1.0 Y OTHER 0.0  3.00  4.00   RO B Y  0.00   8
27 28 1 14 M 31  4.40  1.20 4.0 Y  ENGR 3.0  1.00  3.00  SRO C Y  0.00   8
28 30 1 14 M 38 10.17  1.00 2.0 Y OTHER 0.0  6.00  4.00  SRO C N  0.00   8
29 47 2 14 M 27  6.83  2.00 2.0 Y OTHER 0.0  4.00  3.00   RO B Y         9
30 50 2 14 M 34  8.50  2.50 2.0 Y OTHER 0.0  8.50  0.00  SRO C N  0.00   9
31 78 2 14 M 29  4.08  4.08 3.5 Y OTHER 0.0  4.00  0.00   RO B N         9
32  8 1 15 M 26  6.90  6.90 1.0 Y OTHER 0.0  5.00  3.00   RO B Y  0.00  10
33 36 1 15 M 26  6.60  1.33 2.0 Y OTHER 1.0  4.00  2.50   RO B Y        10
34 72 1 15 M 41  9.50  2.20 0.0 Y OTHER 1.0 14.00  0.00  SRO C N 14.00  10
35 84 1 15 M 28  6.60  1.33 2.0 Y OTHER 0.0  3.00  2.00   RO B Y        10
36 26 2 15 M 29  5.00  1.67 0.0 Y OTHER 0.0  3.00  1.00   RO B Y        11
37 76 2 15 M 25  5.00  1.25 1.0 Y OTHER      5.00  0.50   RO B N        11
38 38 3 15 M 32  8.20  1.00 0.0 Y OTHER 0.0  6.00  0.20   RO B Y  0.00  12
39 39 3 15 M 39  3.75  1.00 0.0 Y OTHER 0.0  3.00  0.00   RO E N  0.00  12
40 46 3 15 M 29  6.00  1.00 0.0 Y OTHER 0.0  6.00  0.00   RO C N  0.67  12
41 73 3 15 M 34  8.00  1.50 0.0 Y OTHER 0.0 10.00  0.00  SRO C N        12
```

Table B.1.4-2
Drill 1A Cumulative Times (min.:sec.)

	CREW 10/2	CREW 11/1	CREW 12/1	CREW 14/2	CREW 15/1	CREW 15/2	CREW 15/3
ATWS Occurs	1:48	2:05	1:58	1:50	1:55	1:55	1:49
RHR Initiated	3:23	3:56	MD	2:29	3:22	2:54	3:52
SP Temp. Hi Alarm	2:33	2:25*	MD	2:24	2:30	2:20	2:17
SBLC Injected	3:21	6:48	MD	4:09	3:10	7:25	8:16
Drywell Isolates	3:22	MD(1)	MD	3:20	7:24	MD(1)	6:32
VP Jumpers	MD	12:34	MD	3:26	4:43	5:18	14:40
Mode Switch	1:54	2:06	2:05	2:03	2:04	2:01	1:59
Manual Scram	1:53	2:10	2:03	2:04	2:05	2:00	1:58
Drill Terminated	(2)	23:23	3:58	27:58	31:44	24:14	33:59

*Calculated average
MD = Missing data. (For Crew 12/1: Instructor error during simulation.)
F = Failure. Required action not initiated.
(1) Replaced with median time for drywell isolation calculated from available data for Drills 1A and 1B (Median = 4:13).
(2) Drill successfully terminated. Drill termination time unimportant.

Table B.1.4-3
Drill 1B Cumulative Times (min.:sec.)

	CREW 10/1	CREW 11/2	CREW 13/1	CREW 13/2	CREW 14/1
ATWS Occurs	2:11	1:58	1:50	1:48	1:49
RHR Initiated	2:48	3:44	3:27	3:28	MD
SP Temp. Hi Alarm	2:40	2:29	2:21	3:57	2:15
SBLC Injected	3:58	4:42	6:35	8:51	4:26
Drywell Isolates	4:24	3:47	4:02	4:01	6:21
VP Jumpers	19:15	6:42	6:30	20:15	MD
Mode Switch	2:20	2:37	1:53	1:50	1:54
Manual Scram	2:21	2:39	2:00	1:57	1:55
Drill Terminated	(1)	28:06	25:01	(1)	(1)

MD = Missing data.
(1) Drill successfully terminated. Drill termination time unimportant.

Table B.1.4-4
Drill 2 Cumulative Times (min.:sec.)

	CREW 10/1	CREW 10/2	CREW 11/1	CREW 11/2	CREW 15/2	CREW 12/1
RX Trip	2:05	0:00	0:00	0:00	0:00	0:00
Scram Reset Attempted	8:45	4:20	1:16	MD(1)	3:20	1:14
B man sent to Close SDVs	37:41	13:56	11:20	F	5:04	7:41
Bypass of 30% Relay Requested	NR	NR	16:05	F	NR	10:08
Level Inst. Malfunction	3:00	3:00	3:00	3:00	3:00	3:00
Level 8 Trip	4:44	5:48	4:29	2:24	17:00	1:44
HPCS Restored	16:53	28:29	NR	10:58	NR	10:08
MDFWP Restored	NR	30:08	NR	10:58	NR	10:08
RCIC Trip Bypassed	NR	25:42	NR	NR	NR	10:08
Depressurize	19:20	NR	4:48	NR	23:12	NR
LPCS, Condensate or LPCI	20:30	NR	19:32	NR	23:19	NR
RCIC Isolates	7:32	6:14	3:58	5:18*	10:25	9:09
Isolation Bypassed	NR	14:02	NR	NR	NR	NR
SP Cooling Initiated	14:13	10:07	0:30	0:00	1:44	15:04
Mode Switch	2:20	0:02	0:06	0:08	0:06	0:01
Manual Scram	2:21	0:03	0:07	0:15	0:07	0:07
Drill Terminated	(2)	(2)	(2)	17:13	(2)	(2)

*Calculated average.
F = Failure. Required action was not initiated.
NR = Action was not required.
(1) Replaced with median time for scram reset attempt calculated from available data for drill (Median = 3:20).
(2) Drill successfully terminated. Drill termination time unimportant.

Table B.1.4-5
Drill 2B Cumulative Times (min.:sec.)

	CREW 13/1	CREW 13/2	CREW 14/1	CREW 14/2	CREW 15/1
RX Trip	0:00	0:00	0:00	0:00	0:00
Scram Reset Attempted	3:48	3:50	3:05	4:28	1:20
B man sent to Close SDVs	10:41	7:45	4:16	F	2:31
Bypass of 30% Relay Requested	NR	NR	NR	F	12:30
Level Inst. Malfunction	3:00	3:00	3:00	3:00	3:00
Level 8 Trip	9:11	1:57	11:49	2:40	MD
HPCS Restored	NR	NR	NR	NR	MD
MDFWP Restored	NR	NR	NR	NR	MD
RCIC Trip Bypassed	NR	NR	NR	NR	MD
Depressurize	17:37	16:09	11:30	11:42	MD
LPCS, Condensate or LPCI	19:10	17:02	13:14	15:43	MD
RCIC Isolates	9:07	MD	10:24	5:54	MD
Isolation Bypassed	NR	NR	NR	NR	MD
SP Cooling Initiated	1:12	1:09	2:15	2:27	0:40
Mode Switch	0:11	0:06	0:06	0:40	0:06
Manual Scram	0:12	0:07	0:06	0:40	0:06
Drill Terminated	(1)	(1)	(1)	30:22	(1)

F = Failure. Required action was not initiated.
MD = Missing data. (For crew 15/1: Simulation problems. No information available.)
NR = Action was not required.
(1) Drill successfully terminated. Drill termination time unimportant.

Table B.1.4-6
Drill 3 Cumulative Times (min.:sec.)

	CREW 10/1	CREW 11/1	CREW 13/1	CREW 13/2	CREW 15/1
SAT Fails, Reactor Trip	0:21	0:00	0:00	0:00	0:00
Manual Scram	MD	MD	0:27	MD	0:38
Mode Switch to Shutdown	MD	MD	0:26	MD	0:37
RCIC Initiated	1:47	1:53	0:43	1:34	0:53
F013 Fails	3:00	2:27	1:13*	1:58	1:17*
F013 Recognized	14:40(2)	3:16	1:24	3:03	1:27
B Man Sent to Open F013	17:05(3)	3:28	1:27	6:02	1:35
Depressurize	21:26(4)	8:24	NR	NR	NR
Diesel Fire Pump Requested	6:20	NR	13:00	NR	NR
DG1A Repair Requested	2:34	1:00	1:09	4:24	2:30
DG1B Repair Requested	2:34	4:18	1:09	4:24	2:30
DGO Repair Requested	2:34	1:00	1:09	4:24	2:30
SAT Repair Requested	11:02	6:58	8:47	F	0:34
UAT Feed Requested	NR	NR	NR	NR	NR
X-tie Requested	4:44	4:42	F	10:30	6:20
Power Restored	21:41	10:05	19:25	21:44	12:00
RCIC Isolation Reset	MD	13:57	MD	27:50	20:14
VP Restored	MD	14:20	MD	MD	13:57
SP Cooling Established	22:48	11:18	MD	22:06	12:30
Depressurize	already started	already started	MD	35:23*	NR
LPCS, Condensate, or LPCI	22:23	NR	MD	NR(1)	NR
Station Blackout	0:43	0:29	0:23	0:24	0:25

*Best estimate.
F = Failure. Required action was not initiated.
MD = Missing data.
NR = Not required.
(1) Used motor driven FW pump.
(2) Incorrect indication caused delay in recognizing. Replaced with 3:30. This is equal to 3:00 plus 0:30, the latter being the median difference between F013 failure and F013 recognition calculated from available data for the drill.
(3) Replaced with 5:55. This is equal to 3:30, the estimated time for F013 recognition for Crew 10/1, plus 2:25, the difference between F013 recognition (14:40) and sending a B-man to open F013 (17:03) for Crew 10/1.
(4) Replaced with 10:16. This is equal to 5:50, the estimated time for sending a B-man to open F013 for Crew 10/1, plus 4:21, the difference between sending a B-man to open F013 (17:05) and depressurizing (21:26) for Crew 10/1.

Table B.1.4-7
Drill 4 Cumulative Times (min.:sec.)

	CREW 10/2	CREW 11/2	CREW 12/1	CREW 14/1	CREW 15/3
SAT Fails, Reactor Trip	0:00	0:00	0:09	0:00	0:00
Manual Scram	0:03*	0:11*	0:11	0:15	0:22*
Mode Switch to Shutdown	0:02*	0:10*	0:10	0:14	0:21
SP Cooling Initiated	2:49	1:13	6:38	2:55	NR
VP Restored	7:40	24:03	11:20	14:04	6:40
DG1B Repair Requested	4:47	14:11	3:03	2:24	15:51
DGO Repair Requested	(4)	(4)	(4)	(4)	25:00
SAT Repair Requested	16:32	22:15	F	7:08	19:28
UAT Feed Requested	NR	NR	NR	8:06	NR
X-tie Requested	16:15	4:10	12:24	F	19:09
DG 1A Loads	0:09	0:09	0:09	0:09	0:09
RCIC Isolation Reset	0:52	5:30	3:45	0:47	2:59
RCIC Room Overheating	13:04	MD	Never(2) Started	4:22	12:14
RCIC Isolation	16:09	19:18	NA	22:39	18:36
RCIC Isolation Bypass Requested	28:32	23:37	NA	27:11	F
DG1A Trouble	19:41	24:19	21:50	20:00	15:38
DG1A Recovery	(1)NR	24:39	22:40	24:35	17:28
Station Blackout	20:19	27:26	27:12	33:42	27:39
Depressurize	NR	2:00	54:09	45:00(5)	26:20
Diesel Fire Pump Requested	NR	21:30	43:33	40:14	28:18(3)
Dry Well Isolates	5:00*	5:00*	5:00*	5:15*	5:00*
Drill Terminated	(6)	(6)	71:10	59:32	28:18

*Best estimate.
F = Failure. Required action was not performed.
MD = Missing data.
NA = Not available.
NR = Not required.
(1) Knew what happened (was happening) to DG
(2) Inexperienced personnel on boards
(3) Problem with simulator. Asked operators what their next step would have been.
(4) Knew DGO out for maintenance.
(5) Operators knew that they would depressurize at this point.
(6) Drill successfully terminated. Drill termination time unimportant.

Table B.1.4-8
Drill 6 Cumulative Times (min.:sec.)

	CREW 13/1	CREW 13/2	CREW 14/1	CREW 14/2	CREW 15/2	CREW 15/3
DCA Fails, Drywell Isolates	0:00	0:00	0:00	0:00	0:00	0:00
DCA Investigation Requested	2:14	2:14	0:54	1:53	0:40	1:37
VP Restoration Attempted	29:18	10:15	3:40	3:21	2:40	14:47
Reactor Trip, Fast Transfer	4:43	4:45	4:48	3:03 (2)	4:41	3:54
Manual Scram	4:48	4:48	4:57	3:04 (2)	4:51	4:04
Mode Switch to Shutdown	4:47	4:47	4:56	3:03 (2)	4:50	4:00
SP Cooling Initiated	7:48	5:47	MD	14:10	7:39	4:34
Bus 151 Restored	1:08	MD(1)	12:10	7:45	15:20	NR
RV Level Inc. Level 7 Alarm	5:02	5:05	4:54	3:59	5:00*	4:24
MSIVs Closed	6:37	6:45	6:23	6:01	5:56	6:32
FW Valve 1A Closed	8:43	MD(1)	NR	4:06	NR	NR
Service Air Pressure Low Alarm	6:23	5:10	5:20	3:55*	MD	5:21
Air Restoration Requested	32:55	MD(1)	9:20	16:19	NR(3)	8:35

*Best estimate.
MD = Missing data.
NR = Not required.
(1) Tape malfunction. No data.
(2) Operator manually scrams Rx before auto scram.
(3) Only two people in CR, they did not request air restoration. Not needed.

Table B.1.4-9
Drill 8 Cumulative Times (min.:sec.)

	CREW 10/1	CREW 11/1	CREW 12/1	CREW 14/2	CREW 15/1
RX Trip	0:05	0:20	0:08	0:06	0:05
Manual Scram	0:10	0:31	0:13	0:13	0:12
Mode Switch to Shutdown	0:11	0:30	0:10	0:12	0:11
SP Cooling Initiated	2:13	1:15	0:28	1:55	2:05
VP Restored	MD	2:27	5:20	2:40	18:23
RCIC Fails	2:10*	2:10*	2:10*	2:10*	2:10*
RCIC Investigation Requested	6:08	8:38	6:30	6:19	4:30
Depressurize	8:31	13:08	8:52	9:19	13:00
LP Injection	14:31	11:13	8:55	10:16	16:24
Drywell Isolates	MD	(1)	3:50	(1)	12:08

*Best estimate (see note on telecom dated 3/7/86 with Randy Weidner).
MD = Missing data.
(1) Never isolates.

Table B.2-1
Actions Affecting Outcome of a Drill*

Drill	Actions
1A & 1B	1. Initiate RHR after ATWS
	2. Mode switch after Rx trip
	3. Manual Scram after Rx trip
	4. Jumper VP after drywell isolation
	5. Inject SBLC after SP temperature hi-hi alarm
2 & 2B	1. Initiate SP cooling after Rx trip
	2. Mode switch after Rx trip
	3. Manual scram after Rx trip
	4. Send B-man to close SDV valves after scram reset attempt
3	1. Initiate RCIC after station blackout
	2. Send B-man to open F013 after F013 failure
	3. Request DG 0 repair after station blackout
	4. Request DG 1B repair after station blackout
	5. Request DG 1A repair after station blackout
	6. Request crosstie to unit 2 after station blackout
	7. Request SAT repair after station blackout
	8. Mode switch after Rx trip
	9. Manual scram after Rx trip
4	1. Initiate SP cooling after DG 1A loads
	2. Reset RCIC isolation after DG 1A loads
	3. Request DG 1B repair after SAT failure
	4. Recover DG 1A after DG 1A trouble
	5. Request SAT repair after SAT failure
	6. Request crosstie to unit 2 after SAT failure
	7. Mode switch after Rx trip
	8. Manual scram after Rx trip
	9. Restore VP after drywell isolation
	10. Depressurize after station blackout
	11. Request diesel Fire water pump after station blackout
	12. Request bypass of RCIC isolation after RCIC isolation because of room overheating
6	1. Close MSIVs after Level 7 alarm
	2. Close FW valve 1A after Level 7 alarm
	3. Initiate SP cooling after Rx trip

*The items listed in this table refer to the correct diagnosis of the required action.

Table B.2-1 (Continued)
Actions Affecting Outcome of a Drill*

Drill	Actions
	4. Request DC A investigation after DC A failure
	5. Restore Bus 151 locally after Rx trip
	6. Mode switch after Rx trip
	7. Manual scram after Rx trip
6	8. Restore VP after DC A failure
	9. Request air restoration after service air in terms of diagnosis pressure low alarm
8	1. Initiate SP cooling after Rx trip
	2. Depressurize after RCIC failure
	3. Inject LP after RCIC failure
	4. Request RCIC investigation after RCIC failure
	5. Mode switch after Rx trip
	6. Manual scram after Rx trip
	7. Restore VP after drywell isolation

*The items listed in this table refer to the correct diagnosis of the required action.

Table B.2-2
Summary of Eleven Groups of Crew Recovery Actions*

Group	Description of Recovery Actions	
1	Manual operation of system or component to control a critical parameter prior to the automatic actuation (if it has automatic actuation) of the system or component.	1. Drill 1 -- Initiate RHR after ATWS 2. Drill 2 & 2B -- Initiate SP cooling after RX Trip. 3. Drill 3 -- Initiate RCIC after station blackout. 4. Drill 4 -- Initiate SP cooling after DG1A loads. 5. Drill 6 -- Close MSIVs after Level 7 alarm. 6. Drill 6 -- Close FW valve 1A after Level 7 alarm. 7. Drill 6 -- Initiate SP cooling after RX trip. 8. Drill 8 -- Initiate SP cooling after RX trip.
2	Use of low pressure systems when high pressure systems are unavailable.	1. Drill 8 -- Depressurize after RCIC failure. 2. Drill 8 -- Inject LP after RCIC failure.
3	Manual operation of systems or components which failed to automatically actuate (operate).	1. Drill 3 -- Send B-man to open F013 after F013 failure. 2. Drill 4 -- Reset RCIC isolation after DG 1A loads. 3. Drill 8 -- Request RCIC investigation after RCIC failure.
4	Restoration of safety-related in-house electrical buses or supply equipment.	1. Drill 3 -- Request DG 0 repair after station blackout. 2. Drill 3 -- Request DG 1B repair after station blackout. 3. Drill 3 -- Request DG 1A repair after station blackout. 4. Drill 4 -- Request DG 1B repair after SAT failure. 5. Drill 4 -- Recover DG 1A after DG 1A trouble. 6. Drill 6 -- Request DC A investigation after DC A failure.
5	Restoration of off-site-supplied non-safety-related electrical buses or supply equipment.	1. Drill 3 -- Request X-tie after station blackout. 2. Drill 3 -- Request SAT repair after station blackout. 3. Drill 4 -- Request SAT repair after SAT failure. 4. Drill 4 -- Request X-tie after SAT failure. 5. Drill 6 -- Restore Bus 151 locally after RX trip.
6	Manual backup of an automatic shutdown function.	1. All Drills -- Mode switch after RX trip. 2. All Drills -- Manual scram after RX trip.
8	Manual override of a system that automatically function when automatic operation of the system would challenge a critical parameter.	1. Drill 1 -- Jumper VP after drywell isolation. 2. Drill 4 -- Restore VP after drywell isolation. 3. Drill 6 -- Restore VP after DC A failure. 4. Drill 8 -- Restore VP after drywell isolation.
9	Injection of SBLC.	1. Drill 1 -- Inject SBLC after SP temperature high-high alarm.
10	Request to use last line of (GARBAGE)** systems for level control.	1. Drill 4 -- Depressurization after station blackout. 2. Drill 4 -- Request diesel fire pump after station blackout.
11	Local operation of manually controlled components normally operated from the control room when control-room operation fails	1. Drill 2 & 2B -- Send B-man to close SDV valves after scram reset attempt. 2. Drill 6 -- Request air restoration after service air pressure low alarm.
12	Manual override of a false control signal when no direct indication exists that the control signal is false or erroneous.	1. Drill 4 -- Request bypass of RCIC isolation after RCIC isolation because of room overheating.

*The items listed in this table refer to the correct diagnosis of the required action.
**GARBAGE systems are those systems which are used only as a last resort to prevent core damage. These systems inject "dirty" (non-reactor grade) water into the vessel and are used only if no other means of injecting water into the vessel are available.

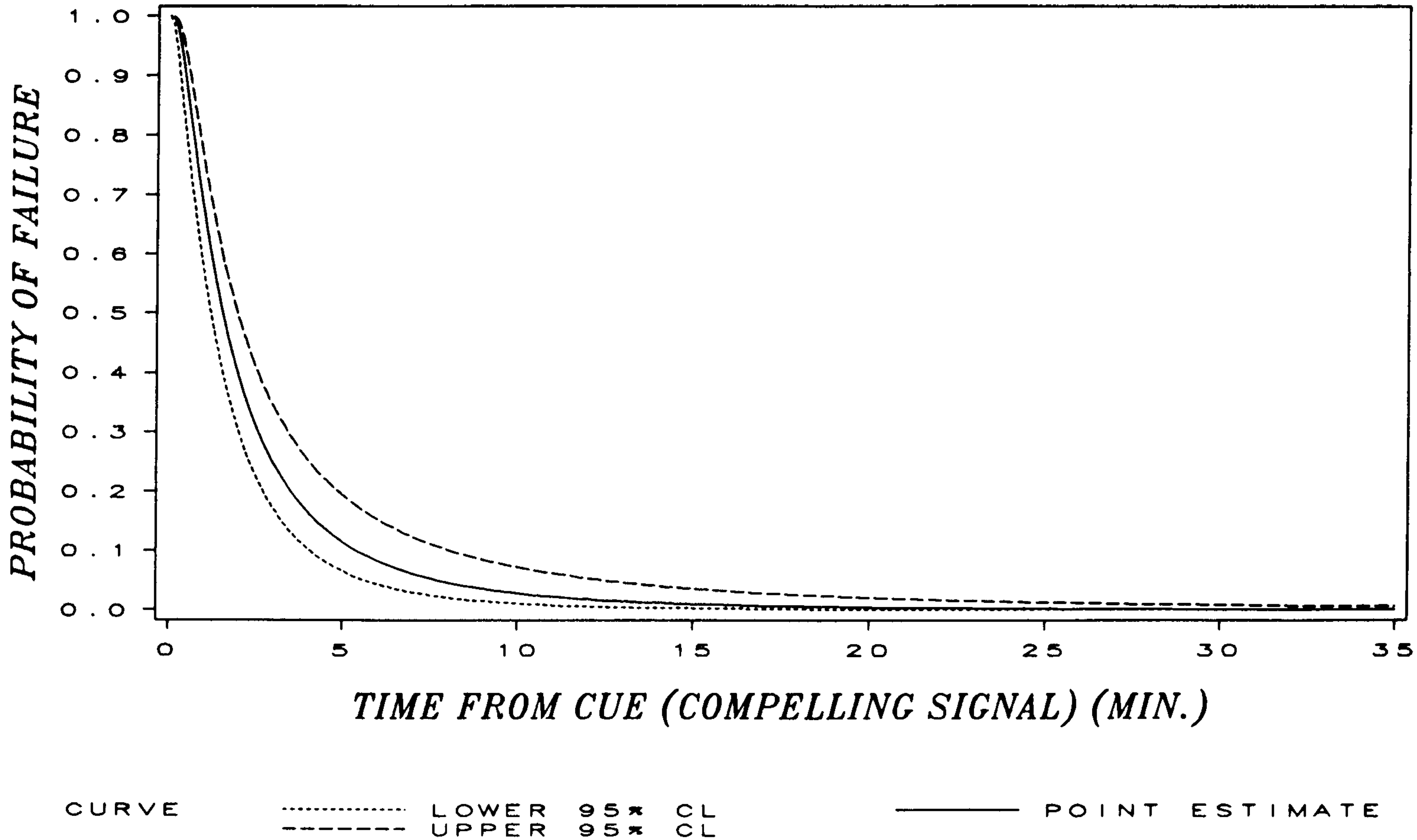
In addition, since actions within Groups 1 and 9 and within Groups 2 and 10 were judged to be somewhat similar, statistical comparisons among the data for the actions within each of these two sets of groups were also performed.

For those groupings of actions that could be statistically supported, a second purpose of the analyses was to determine a suitable function for the combined diagnosis time data. Finally, that function was fit to each group of data to develop an estimated complementary cumulative distribution function (ccdf) of diagnosis times. Such a function gives the estimated probability of failure of diagnosis as a function of time from the compelling signal.

With only one exception, the analysis showed that the actions could be grouped according to their operational similarities. The exception was that Group 2 actions could not be combined with Group 10 actions (see Table B.2-2). One potential explanation of this is that there may be some hesitancy on the part of the operators to perform Group 10 actions because such actions could potentially be costly to the facility. The overall conclusion is that the grouping of actions by their operational similarities appears to be a useful approach to obtain estimates of diagnosis failure probabilities for PRA applications.

Lognormal distributions are frequently used for various phenomena in risk assessments. In support of this usage, the analysis showed that the lognormal function provided a reasonably good fit to the empirical data. Fitting of the lognormal function was a means to improve the accuracy of interpolations and extrapolations and permitted an assessment of the uncertainty of estimated failure probabilities at specific times, all of which are important for PRA analyses. An example of a fitted ccdf from this study is shown in Figure B.3-1.

Further research would be of benefit in several areas. First, it would be valuable to determine whether different PRA analysts can categorize a set of actions into their appropriate groups in a consistent manner. Although there is little judgment involved in this categorization and major problems are not expected, the usability of the approach has not been tested. In addition, it would be useful to expand the definitions of the groups to include actions which, although they were not examined in this study, would fit into certain groups from an operations standpoint. Relatively little effort and expense would be required to accomplish these important objectives.



CL = Confidence Limit.

Group 9 combined with Group 1.

Lognormal function fitted to data (N=63, μ = .19, σ = .43).

Figure B.3-1. Group 1, Probability of <u>Failure</u> to Manually Operate a System or Component to Control a Critical Parameter Prior to the Automatic Actuation (If it has Automatic Actuation) of the System or Component

Second, the estimates in this report are specific to the LaSalle plant and should provide realistic information for the LaSalle PRA. However, it would be important to know the extent to which these estimates are valid for PRAs on other BWR plants and on PWR plants. Differences in factors such as plant configuration and procedures and crew composition and training could affect crew performance. The extent to which the estimates in this report can be applied to PRAs at other nuclear power plants (NPPs) could be determined by collecting simulator data at other types of plants and repeating the analyses that were performed in this study. It is not recommended that the estimates in this report be used to perform PRAs on other plants without, at least, prior analyses of plant and crew differences.

Finally, in this study, no attempt was made to calibrate the simulator data to take into consideration any differences that may exist between simulator and "real world" conditions. Measures were taken in this study to enhance the reliability and realism of the simulations. These measures included testing of the drills on the LaSalle simulator prior to actual data collection, simulation of actions outside the control room that were requested by crews (e.g., checking valves) with simulated time delays, data collection by multiple observers, and prevention of interruptions by instructors during the simulation runs. There was also evidence of stress responses in the crew members. This included high involvement (e.g., running to accomplish actions), impatience (e.g., asking whether requested actions had been accomplished yet), subtle appeals for help from the instructors, perseveration (repeating the same unsuccessful action more than once), and obvious fatigue. It is not known whether the stress levels present here are as high as what one would expect when confronted with a real-world abnormal event, but one can conclude that the crew members were stressed to a significant degree.

Nevertheless, a formal analysis of potential differences between the simulator and real-world conditions was not undertaken. Therefore one additional avenue of research would be to assess the extent of such differences and to perform any necessary and possible calibrations.

B.4 Methods of Data Analysis

This section describes the data analysis approach that was used to compare distributions of times to initiate actions (diagnosis times) and to compare mean diagnosis times. Comparisons among the actions contained in each group were performed to determine if the operational groupings of actions could be statistically justified. In addition, the actions in Groups 1 and 9 and in Groups 2 and 10 were judged to be somewhat similar. Therefore, comparisons among the actions in each of these two sets of groups were also performed.

This section also provides a description of the approaches taken to determine a function for the diagnosis time data after combination and the procedure used to fit that function to the data are described.

B.4.1 Description of Data

For each action in Table B.2-2, data were available for the time (minutes) taken for a crew to initiate the action after the cue or compelling signal (diagnosis time). There were three cases where the time at which a crew initiated an action was obtained, but the time of the preceding cue was missing (see Tables B.1.4-2 and B.1.4-4). In those cases, the missing cue time was replaced with the median cue time calculated from available times for other crews tested on the drill.

In one case, a crew recognized a failure, but the time of recognition was inaccurate due to a simulation problem (see Table B.1.4-6). In that case, the median time from the failure to recognition of the failure calculated from available data for other crews tested on the drill was used to arrive at a replacement recognition time.

For cases where the crew did not initiate the appropriate action, the time from the cue to when the drill was terminated was known. The time from the cue to the drill termination time is referred to as the censoring time, and this type of observation is referred to as a right-censored observation.

When an observation is right-censored, all that is known is that the action would have been initiated at some time greater than the censoring time. Conventional methods for comparing groups of data cannot be used with censored data, so, for such cases, the censoring times were replaced with predicted diagnosis times using a method described in Section B.4.8. These replacements were performed prior to comparisons of the data.

There were also cases where a crew may not have initiated the specific actions under consideration because the operators had performed an alternative action which succeeded in handling the problem. All actions were reviewed for such occurrences. If it was determined that a previous action had been taken that successfully mitigated the problem addressed in the drill, then failures to take additional actions that pertained to the same problem were not counted as failures, but as missing observations.

The number of observations for each action in Table B.2-2 varied from 2 to 12 (average of 6).

B.4.2 Development of Individual Empirical Complementary Cumulative Distribution Functions (CCDFS) of Diagnosis Times

From the data discussed in Section B.4.1, a ccdf of diagnosis time was plotted for each action in Table B.2-2. This distribution provides the empirical probability of failure to initiate the correct action as a function of time from the cue or compelling signal. Figure B.4.2-1 shows the distribution of diagnosis times for the first action in Group 1. The ordinate of each plotted point is equal to (1 - cumulative probability of success). For example, since 3 of 10 crews had initiated RHR by 1 minute after occurrence of ATWS in Drill 1, the empirical probability of failure at that time is .7 (see Figure B.4.2-1). A new data point was plotted whenever there was a new success time.

B.4.3 Comparisons of Individual Empirical CCDFS of Diagnosis Times

The Smirnov test [15] was used to pairwise compare empirical ccdfs of diagnosis times for actions within each of the eleven groups listed in Table B.2-2, for actions within groups 1 and 9 combined, and for actions within groups 2 and 10 combined.

The Smirnov test is a test of differences between two empirical distribution functions. The measure of disparity between two empirical distributions is the maximum vertical difference between them. The maximum vertical distance is compared with tabled critical values to ascertain the level of significance. (The level of significance or p value is the probability that an observed difference that is not real is wrongly considered real.) The tabled critical values are dependent upon the sample sizes of the two distributions and the level of significance chosen. The level of significance used in this study was .01. The difference was considered to be statistically significant if it exceeded the tabled value at the .01 level of significance.

As an example, Figure B.4.3-1 shows the ccdfs of diagnosis times for the first two actions in Group 1 listed in Table B.2-2. The empirical distribution functions are step functions. The maximum vertical distance between the two distributions is .45 which occurs at approximately two minutes. The critical value with sample sizes of 10 and 11 is approximately .6 at the .01 level of significance. Since the maximum vertical distance is less than the critical value, it can be concluded that the empirical distributions are not significantly different from each other at the .01 level of significance. Another example is shown in Figure B.4.3-2.

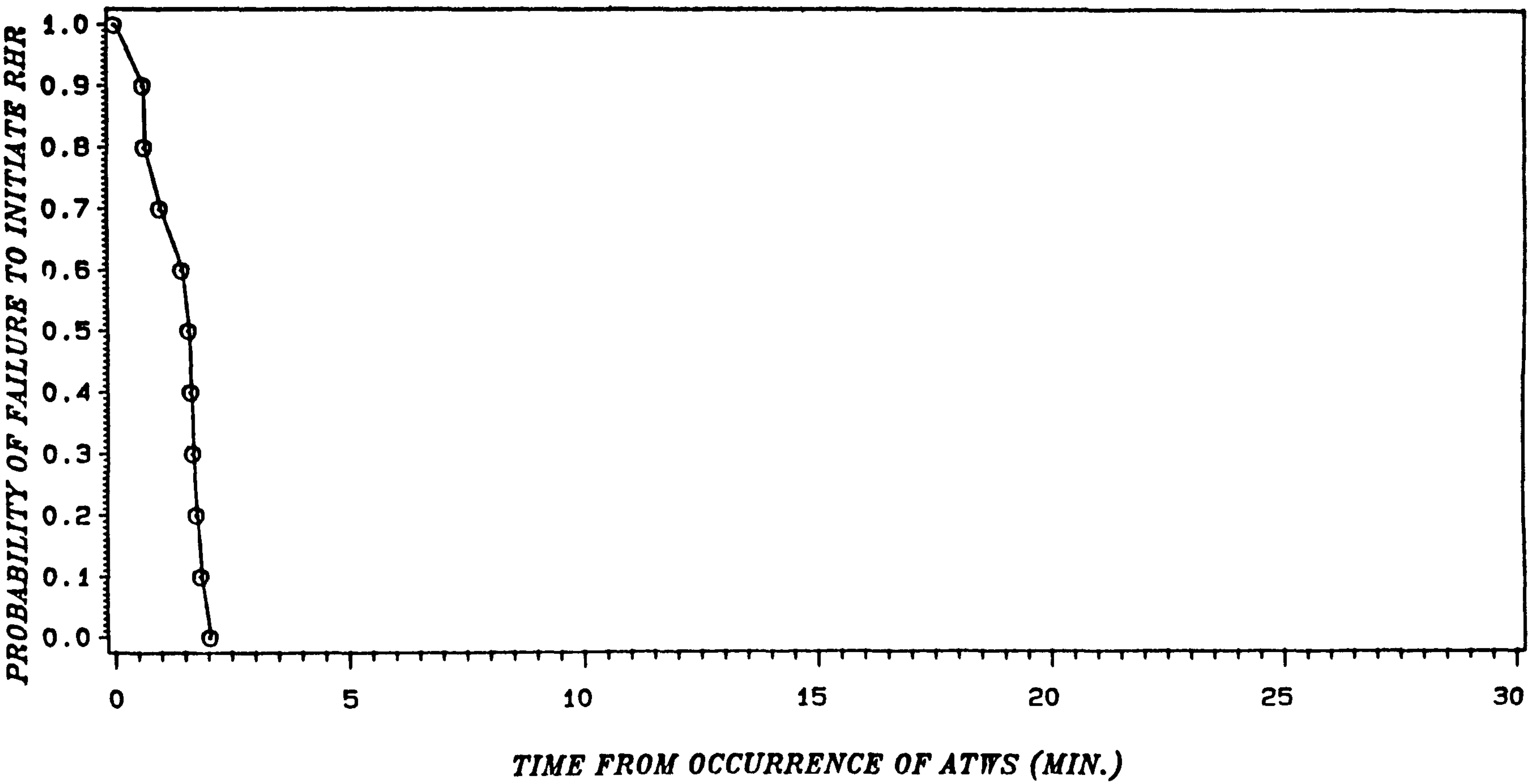


Figure B.4.2-1. Drill 1--Probability of Failure to Initiate RHR After Occurrence of ATWS

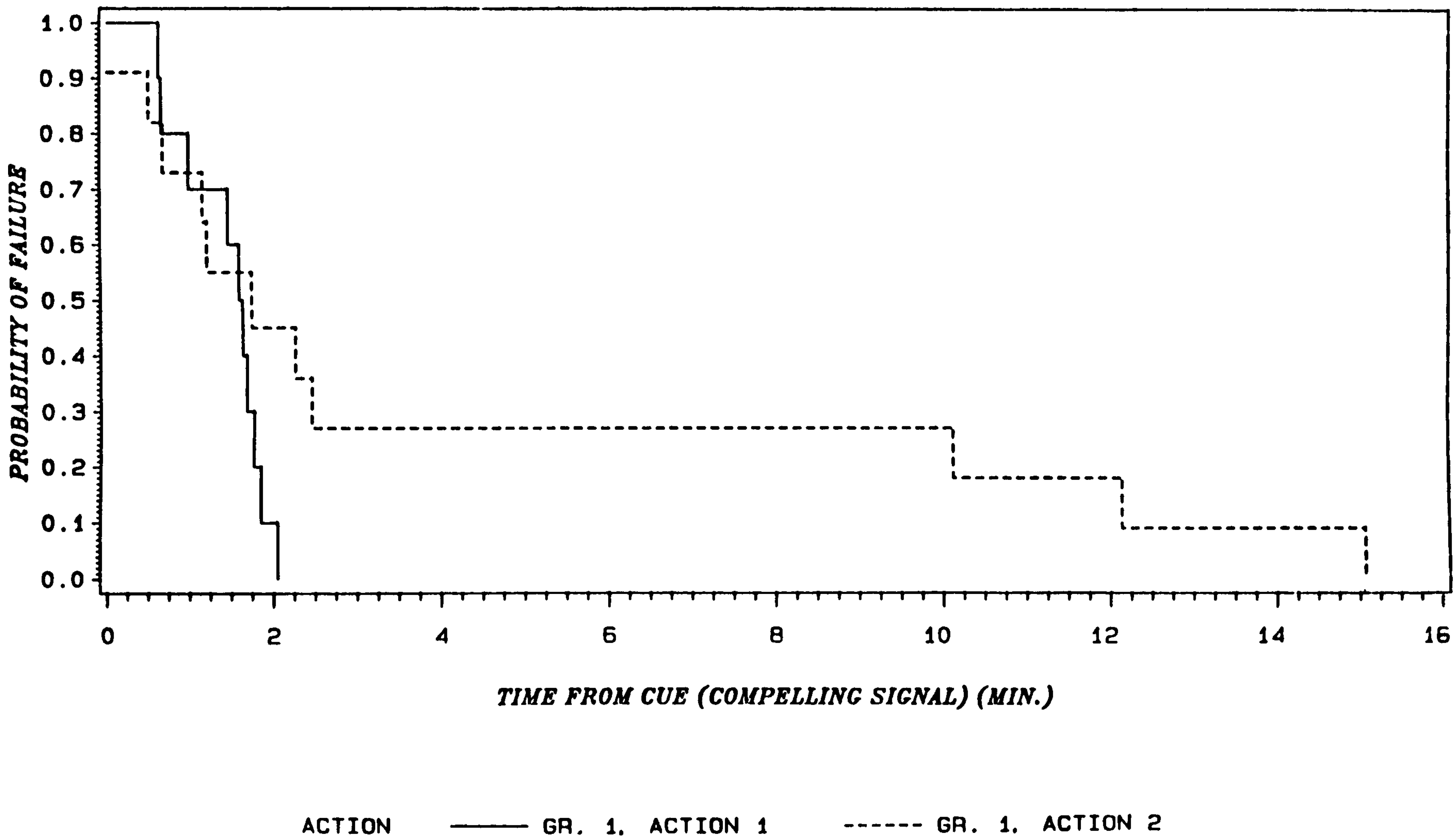


Figure B.4.3-1. Probability of Failure to Initiate Action After Cue for First Two Actions in Group 1

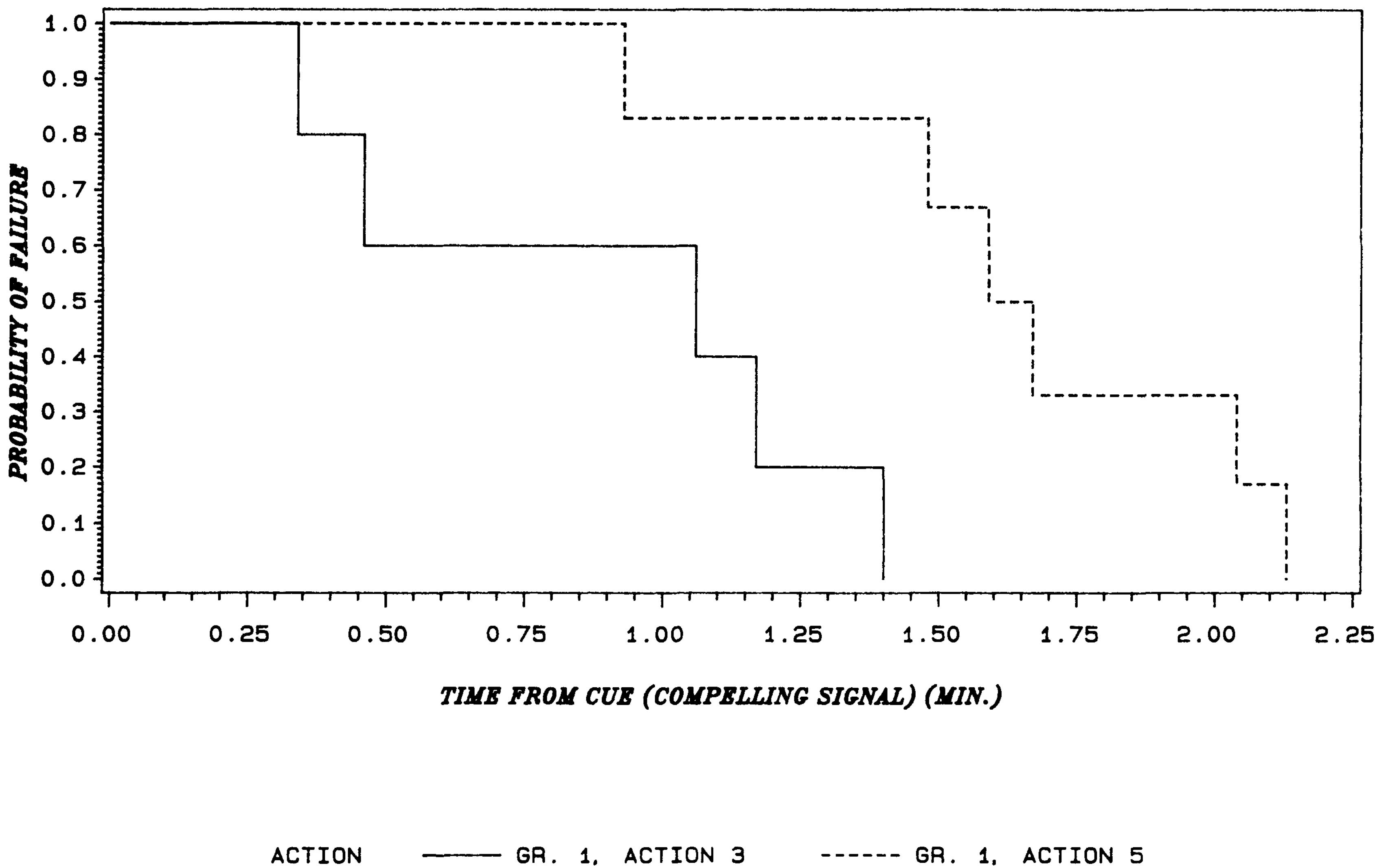


Figure B.4.3-2. Probability of Failure to Initiate Action After Cue for Third and Fifth Actions in Group 1

B.4.4 Comparisons of Mean Diagnosis Times

One of the assumptions of the Smirnov test is that the samples for the different actions within a group are independent. This assumption was not fully met, since some crews were tested on more than one of the actions within a group. This is one reason why an additional type of analysis, an analysis of variance (ANOVA), was used to compare diagnosis times. Additionally the ANOVA permitted an examination of the effect of crew as well as action upon diagnosis time.

Comparisons were performed on the mean diagnosis times. A separate ANOVA was performed on each of the eleven groups of actions listed in Table B.2-2, for the actions in groups 1 and 9 combined, and for the actions in groups 2 and 10 combined. The model was a two-factor ANOVA, with the factors being Action and Crew. This type of analysis was done to determine whether there were significant differences among the different actions and crews in mean diagnosis time. The level of significance used was .01.

One of the assumptions of the ANOVA is that the variances for the different actions and crews are equal. In many cases, this assumption was not met. To more nearly satisfy the assumption of equal variances, the data were transformed using the log 10 transformation prior to data analysis.

B.4.5 Development of Empirical CCDFS of Diagnosis Times for Combined Actions

There were several statistical criteria that had to be satisfied before data for the actions within a group were combined:

(1) The pairwise comparisons of the individual empirical ccdfs of diagnosis times using the Smirnov tests showed that the ccdfs did not differ significantly.

(2) The ANOVA showed that the mean diagnosis times did not differ significantly among actions.

The presence of a significant effect for Crew, indicating that the crews differed in their diagnosis times across actions, did not mean that the data could not be combined. In most cases, there were insufficient data to consider developing subgroups of distributions of diagnosis times, such as one distribution for crews with relatively short times and another distribution for crews with relatively long times. In the absence of an accompanying significant effect for Action, one can consider crew effects to be variability in performance that would normally exist among control room crews at the LaSalle plant.

However, a significant Crew effect was cause for further examination of the data. Data for each action were reviewed to make certain that the data were reduced correctly, and that there were no circumstances that would invalidate the data. Possible causes for concern would be differences among the crews in how the drills were simulated and differences in crew composition. For example, one of the crews contained only two members rather than the typical 3 or 4 members. If the performance of the two-member crew was found to be discrepant from other crews, the data for this crew would be deleted for reason of being nonrepresentative of actual control room crews.

If the statistical criteria were met, supporting the operational grouping of actions, then the data for all actions within a group were combined to develop one empirical ccdf of diagnosis times.

B.4.6 Approaches to Determine a Function for Combined Diagnosis Time Data

The final step for the combined data is to attempt to fit a function to the diagnosis time data. This would improve the accuracy of interpolations and extrapolations, and would permit an evaluation of the uncertainty of estimated failure probabilities at specific times.

Before the final step can be taken, an appropriate function must be found. Lognormal distributions are frequently used for various phenomena in risk assessments. Inspection of the empirical ccdfs of diagnosis times for the grouped actions tended to support the appropriateness of the lognormal function for these diagnosis time data.

Two approaches were taken to determine whether a lognormal function could be reasonably fitted to the diagnosis time data. One approach was to inspect plots of log time versus the cumulative probability of success. If the data are lognormally distributed, then this relationship should be linear.

The second approach was to run statistical tests to determine whether the log time data were normally distributed. When the sample size was greater than 50, the Kolmogorov D statistic was computed [15]. This statistic is similar to the Smirnov test discussed in Section B.4.3, except that instead of comparing two empirical distribution functions, an empirical distribution function is compared to the normal distribution function. When the sample size was less than or equal to 50, the Shapiro-Wilk statistic was computed. Computational procedures for the latter are too lengthy to present here. A discussion of this statistic may be found in [15] and in [16].

B.4.7 Approach to Fit Lognormal Function to Diagnosis Time Data

If it was found that the data for actions within a group could be combined and that the data reasonably followed a lognormal distribution, then the lognormal function was fitted to the combined time data using a statistical program called CENSOR [17]. CENSOR is designed to perform analyses on data sets with censored observations.

The maximum likelihood approach was used. In this approach, the likelihood of obtaining each observation (diagnosis time or time greater or less than censored time) is calculated assuming different values for estimates of the population mean and standard deviation. The program iterates until estimates of the population mean and standard deviation are found that maximize the product of the likelihoods. Formulas for obtaining likelihoods may be found in [17].

For each group, the plot of log time versus the cumulative probability of success was inspected to determine whether the fit could be improved. Occasionally it was found that the fit could be improved by making a small number of observations with very short diagnosis times left-censored. When an observation is left-censored, all that is known is that the action would have been initiated at some time prior to the censoring time. These very short diagnosis times were caused by some crews anticipating the occurrence of the cue and, therefore, responding immediately after the cue or before it. Cases of left-censoring were few. Left-censoring was done in 2 of 24 observations in Group 5 and in 4 of 24 observations in Group 8 (see Table B.2-2). After left-censoring, the lognormal function was then refitted to the data, and new maximum-likelihood parameter estimates were obtained. The general effect of the left-censoring was to make the fitted curve more conservative (higher failure probabilities) at the beginning, where most of the empirical data were. It also tended to reduce the estimate of the population standard deviation, shorten the tail of the distribution, and to provide a better fit to the longer diagnosis times.

B.4.8 Replacement of Right-Censored Observations with Predicted Diagnosis Times

In Section B.4.1, it was noted that right-censored observations were replaced with predicted diagnosis times prior to performing comparisons on the individual distributions of diagnosis times and comparisons of mean diagnosis times. This subsection provides a description of the method used to compute the predicted diagnosis times.

If a crew failed to perform a particular action within a group, the following formula was used to compute the predicted diagnosis time (PDT):

PDT = Antilog [mean + (normal deviate) (standard deviation)]

where:

mean = estimated population mean from fit of lognormal function to data

normal deviate = tabled expected value of kth largest normal deviate for particular sample size (see [18])

standard deviation = estimated population standard deviation from fit of lognormal function to data.

Estimates of the population mean and standard deviation were usually obtained by fitting the lognormal function to the combined data for the relevant group. This was necessary because often there were insufficient data to fit the lognormal function to only the data for the particular action. Before the combined data were used, the individual empirical ccdfs of diagnosis times were examined to make certain that there weren't any large discrepancies among them.

B.5 Results of Analysis

Following is a summary of the results of the data analyses. Subsections here correspond to those in Section B.4.

B.5.1 Individual Empirical CCDFS of Diagnosis Times

The empirical ccdfs of diagnosis times are shown in Figures B.5.1-1 through B.5.1-46). Those distributions show the empirical probability of failure to initiate the correct action as a function of time from the cue or compelling signal. The figures are ordered to correspond to the ordering in Table B.2-2.

B.5.2 Results of Comparisons of Individual Empirical CCDFS of Diagnosis Times

Smirnov tests to compare individual empirical ccdfs of diagnosis times were not performed for the following groups:

1. Group 6, since the empirical ccdfs were nearly identical visually (see Table B.2-2 and Figures B.5.1-25 through B.5.1-36 in Section B.5.1).

2. Group 12, since there was only one action in this group.

For each of the remaining groups listed in Table B.2-2, the Smirnov tests showed that the ccdfs were not significantly different (p values > .01). It was also found that the ccdfs for Group 1 could be combined with the one for Group 9, and the

(Text continues on page B-107)

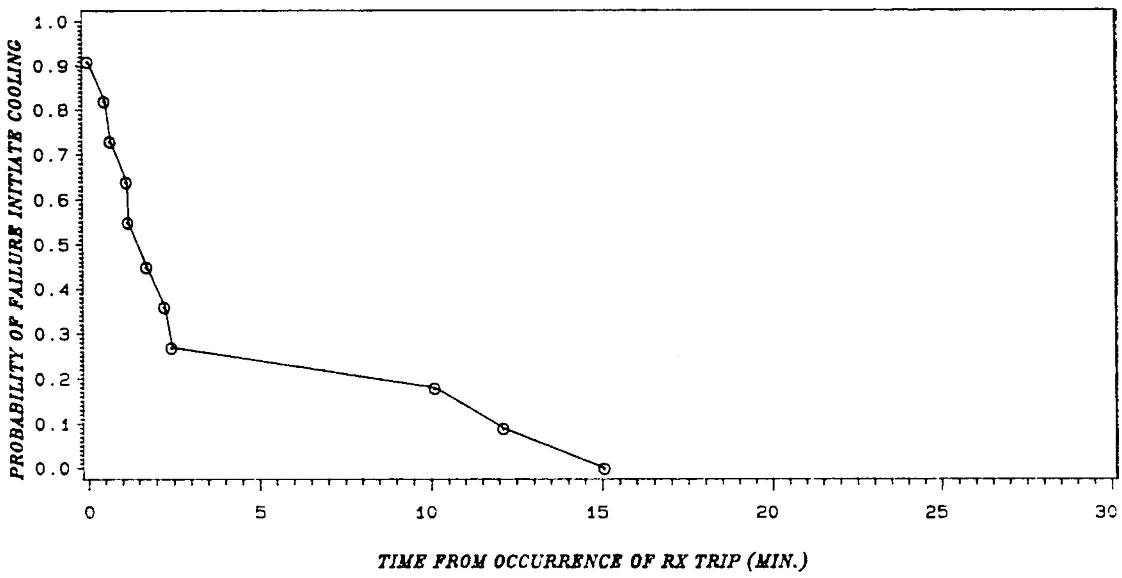


Figure B.5.1-1. Drills 2 & 2B, Probability of Failure to Initiate SP Cooling after Occurrence of RX Trip

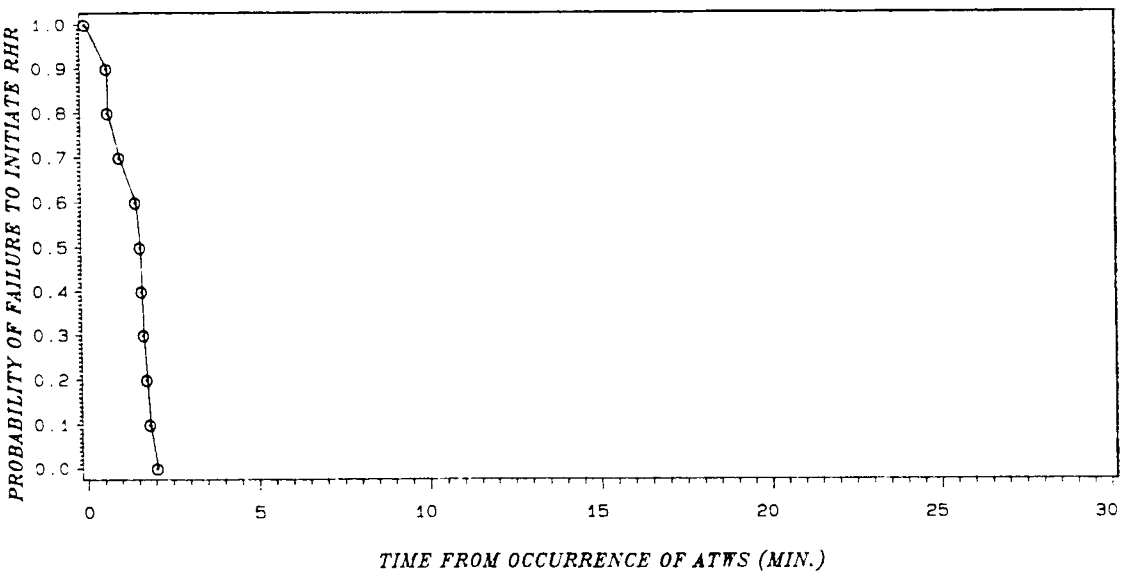


Figure B.5.1-2. Drill 1, Probability of Failure to Initiate RHR after Occurrence of ATWS

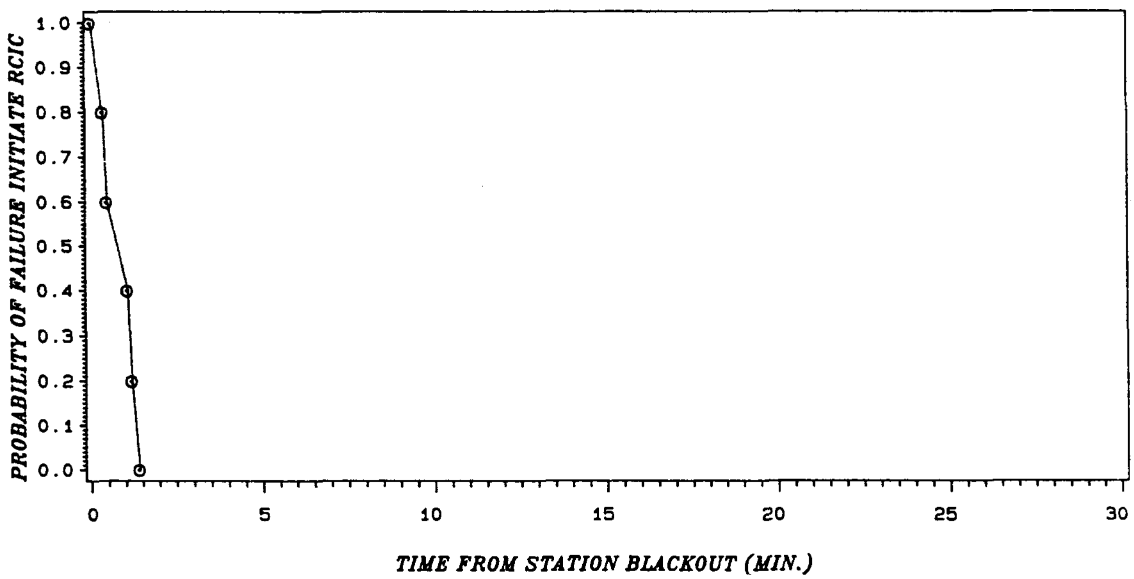


Figure B.5.1-3. Drill 3, Probability of Failure to Initiate RCIC after Occurrence of Station Blackout

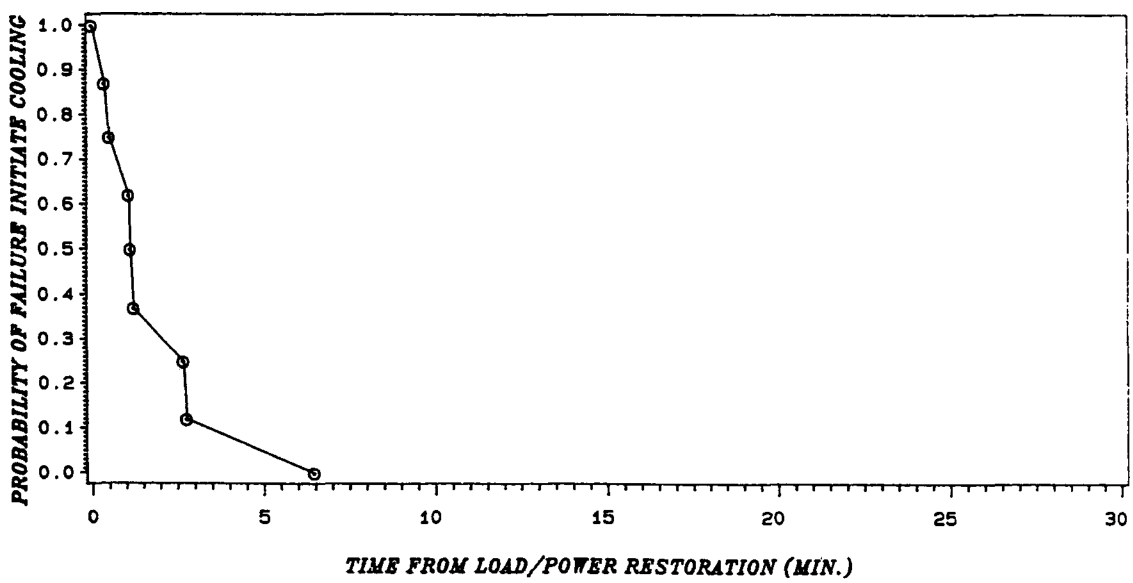


Figure B.5.1-4. Drill 4, Probability of Failure to Initiate SP Cooling after DG1A Load (or Power Restoration)

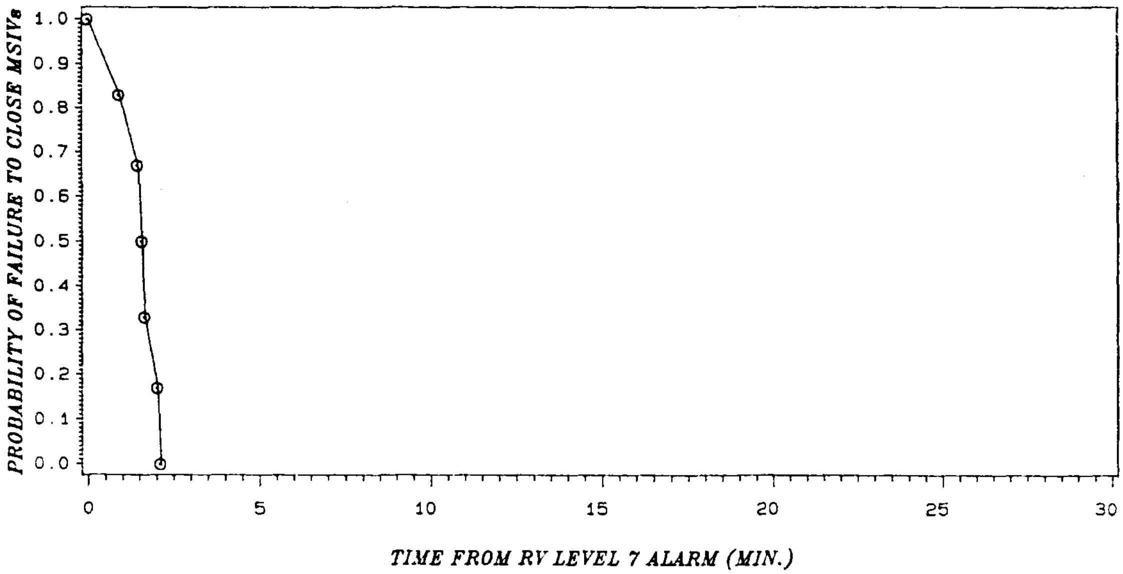
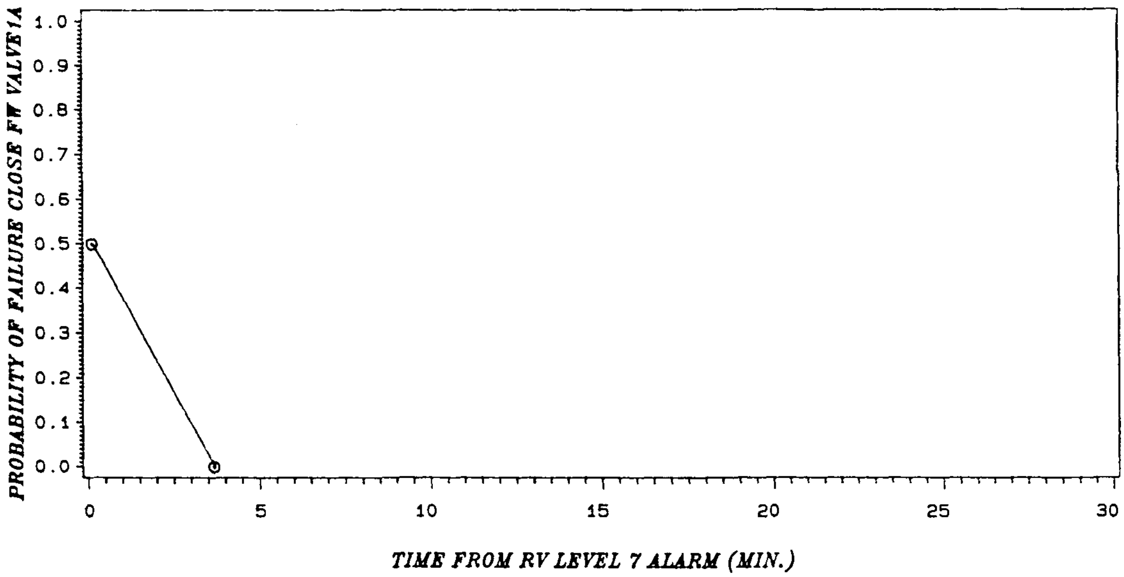


Figure B.5.1-5. Drill 6, Probability of Failure to Close MSIVs after Occurrence of RV Level 7 Alarm



Only 2 data points available.

Figure B.5.1-6. Drill 6, Probability of Failure to Close FW Valve 1A after Occurrence of RV Level 7 Alarm

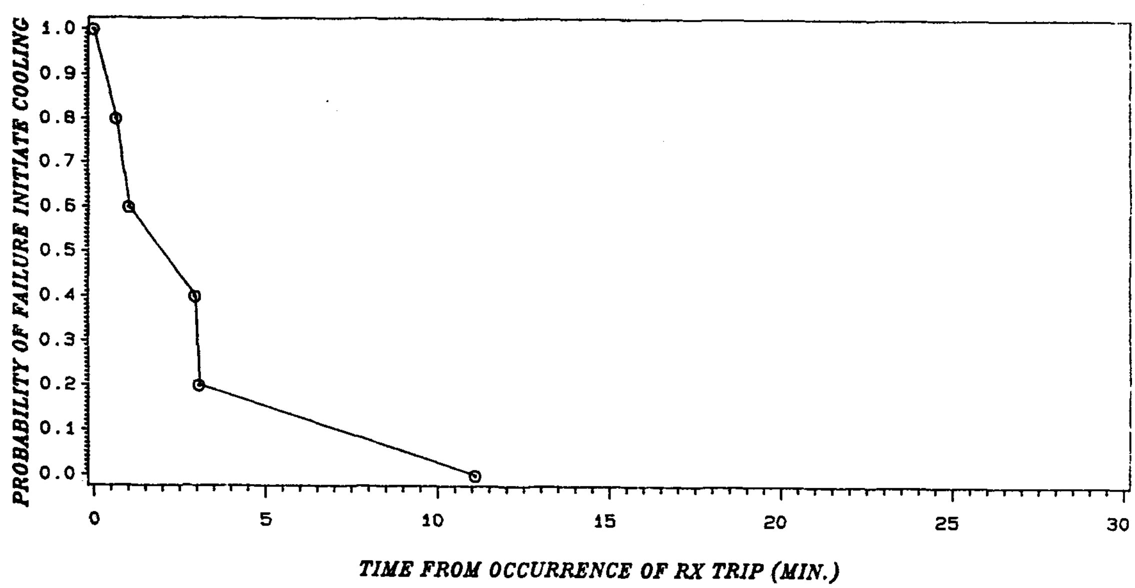


Figure B.5.1-7. Drill 6, Probability of Failure to Initiate SP Cooling after Occurrence of RX Trip

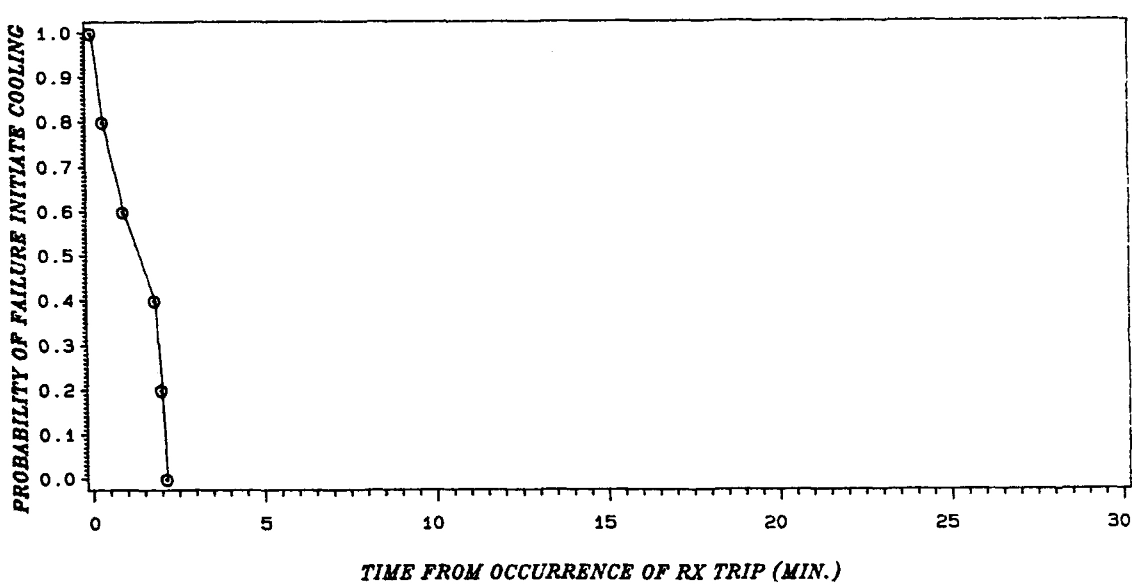


Figure B.5.1-8. Drill 8, Probability of Failure to Initiate SP Cooling after Occurrence of RX Trip

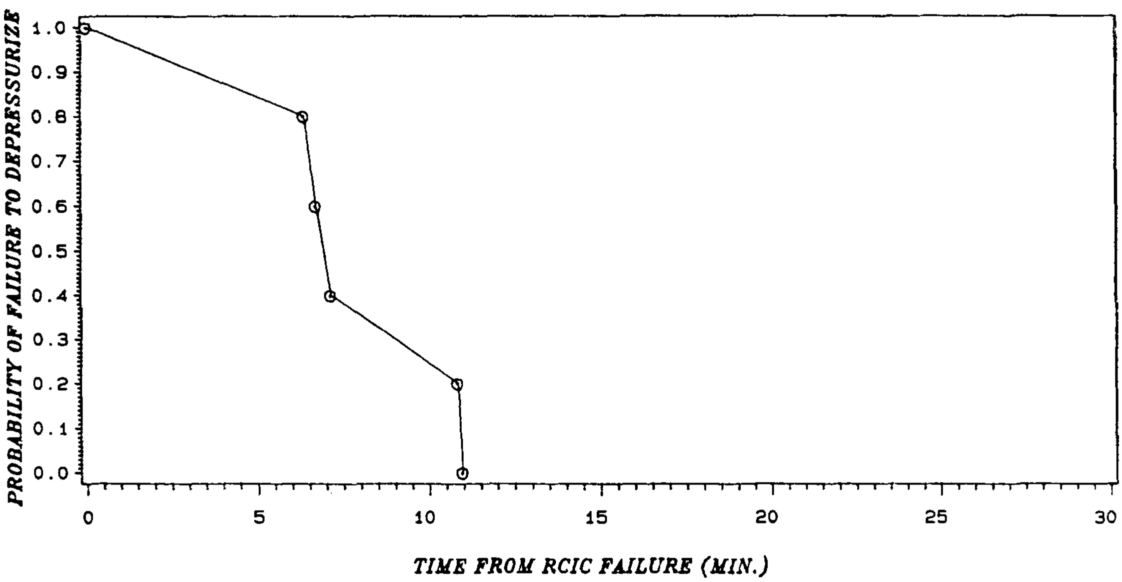


Figure B.5.1-9. Drill 8, Probability of Failure to Depressurize after Occurrence of RCIC Failure

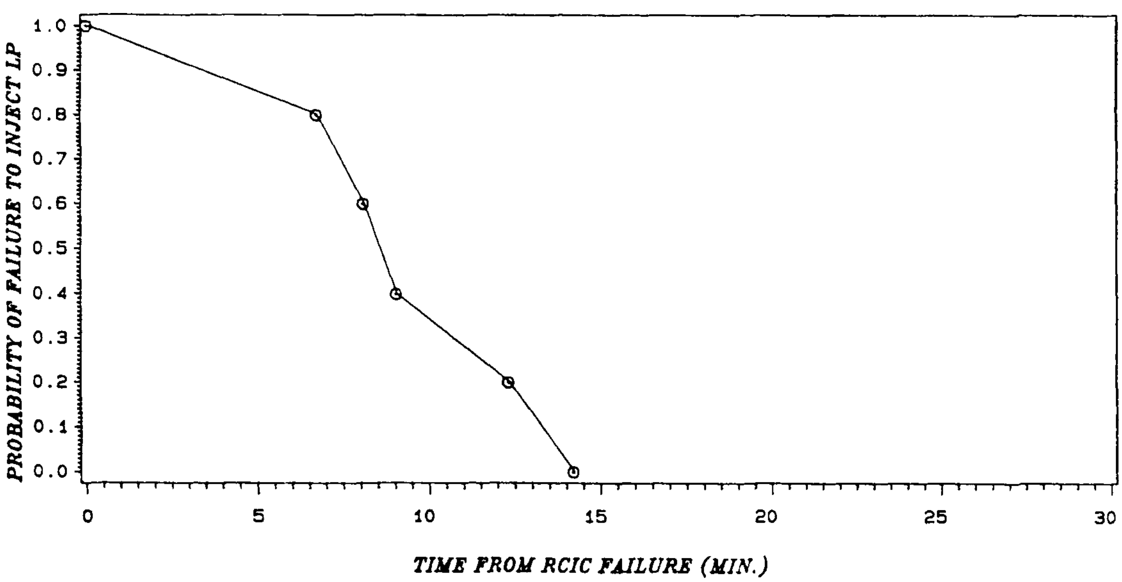


Figure B.5.1-10. Drill 8, Probability of Failure to Inject LP After Occurrence of RCIC Failure

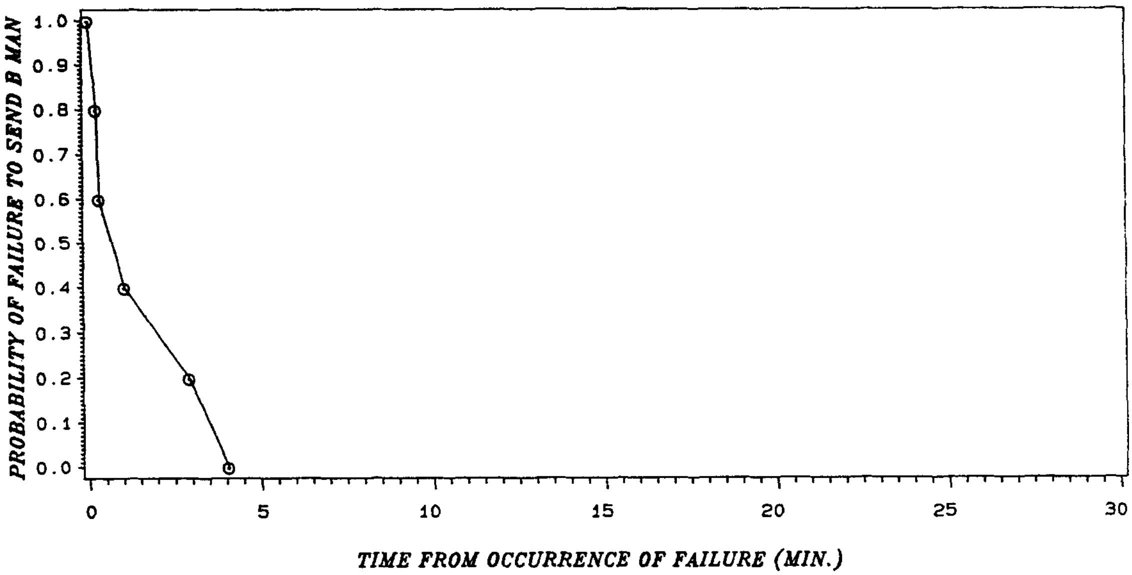


Figure B.5.1-11. Drill 3, Probability of Failure to Send B Man to Open F013 after Occurrence of F013 Failure

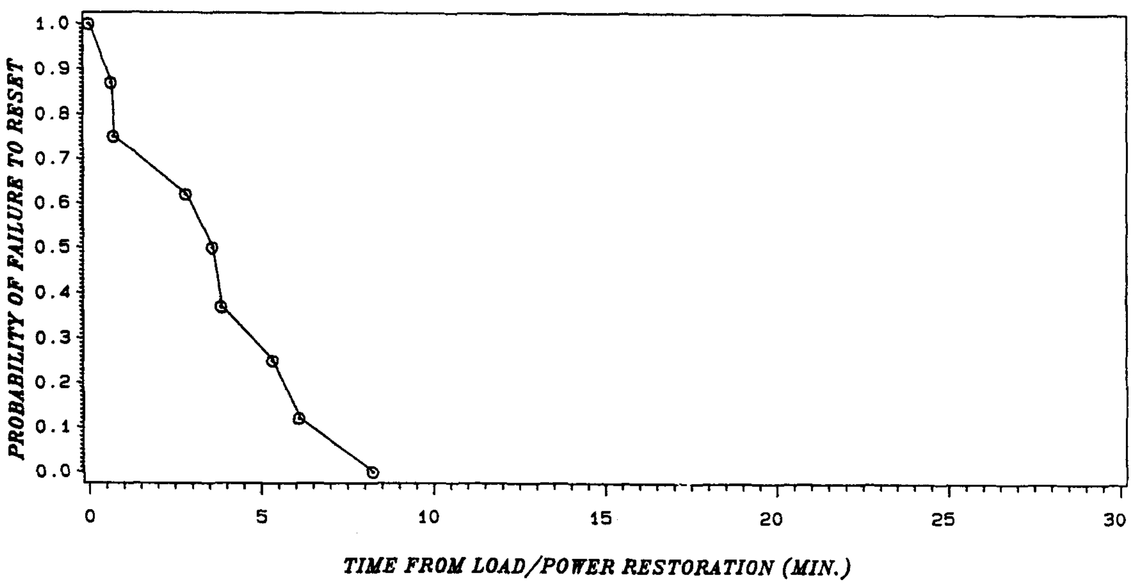


Figure B.5.1-12. Drill 4, Probability of Failure to Reset RCIC Isolation after Occurrence of DG1A Load (or Power Restoration)

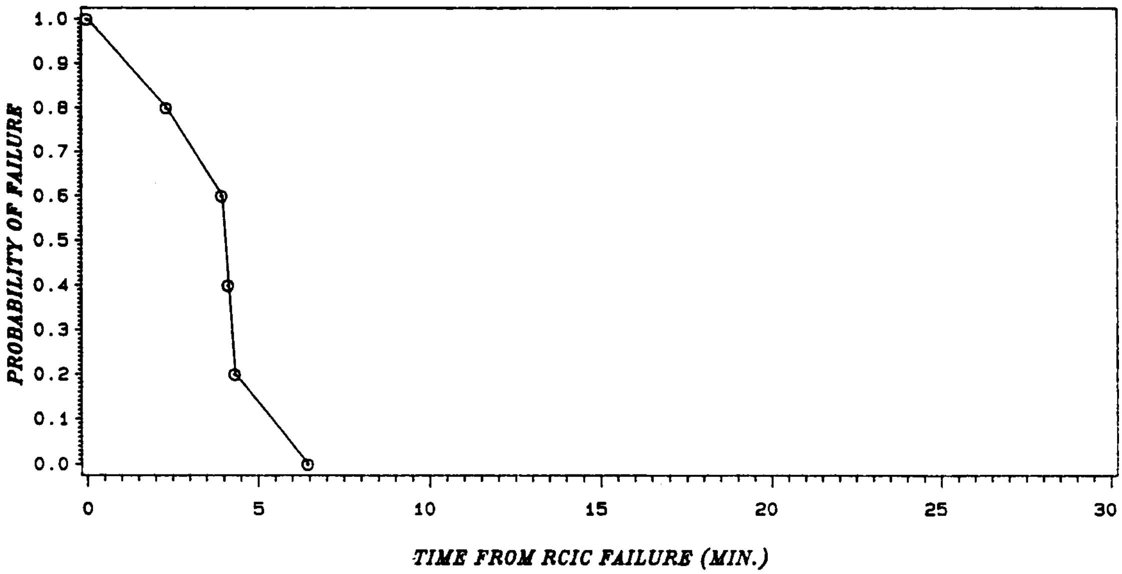


Figure B.5.1-13. Drill 8, Probability of Failure to Request RCIC Investigation after Occurrence of RCIC Failure

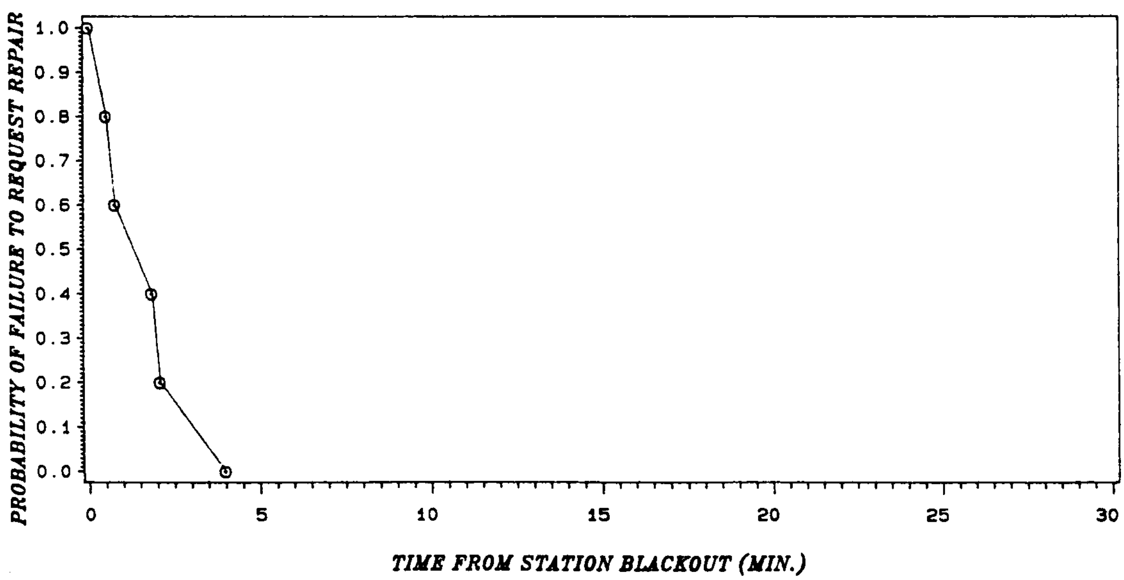


Figure B.5.1-14. Drill 3, Probability of Failure to Request DGO Repair after Occurrence of Station Blackout

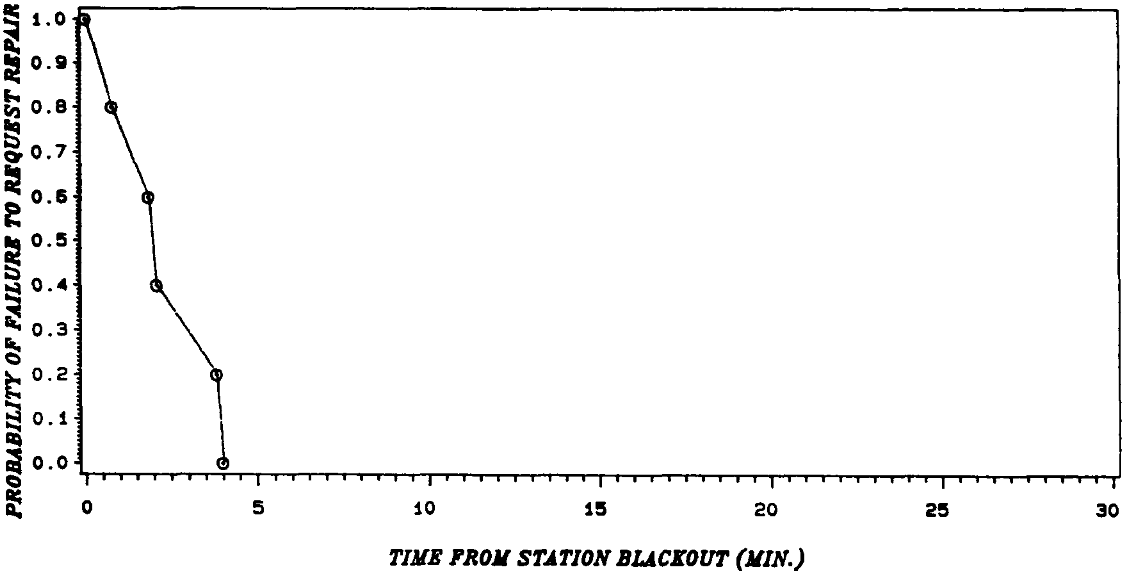


Figure B.5.1-15. Drill 3, Probability of Failure to Request DG1B Repair after Occurrence of Station Blackout

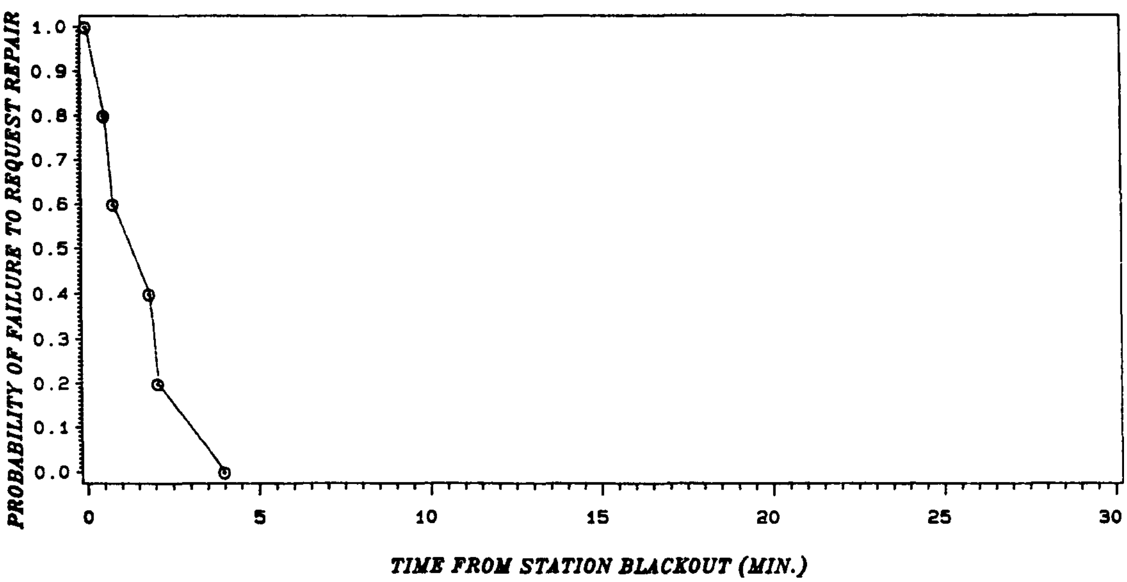


Figure B.5.1-16. Drill 3, Probability of Failure to Request DG1A Repair after Occurrence of Station Blackout

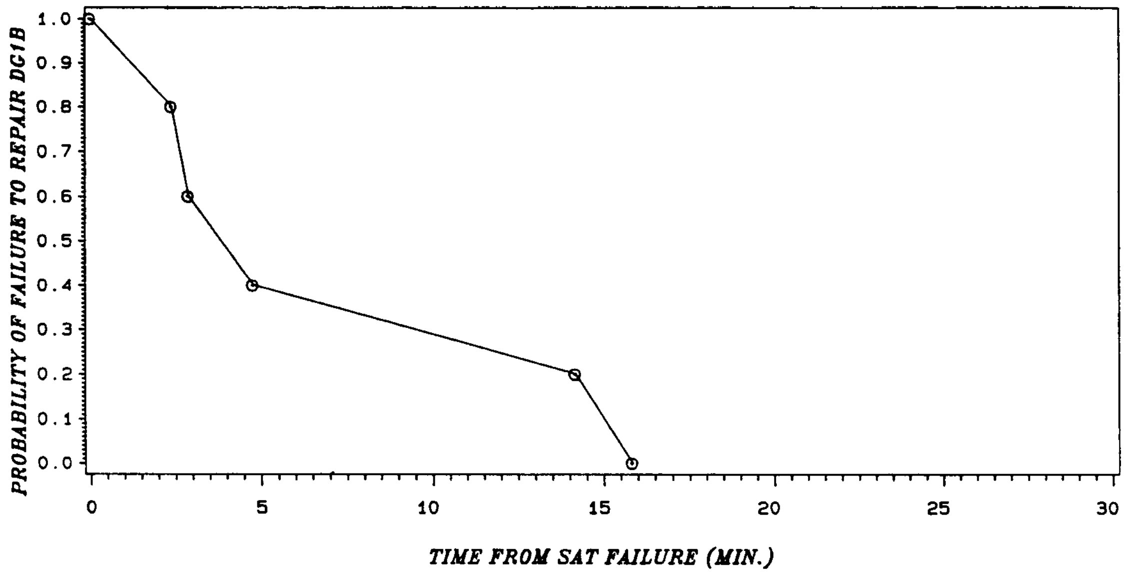


Figure B.5.1-17. Drill 4, Probability of Failure to Request DG1B Repair after Failure of SAT (Reactor Trip)

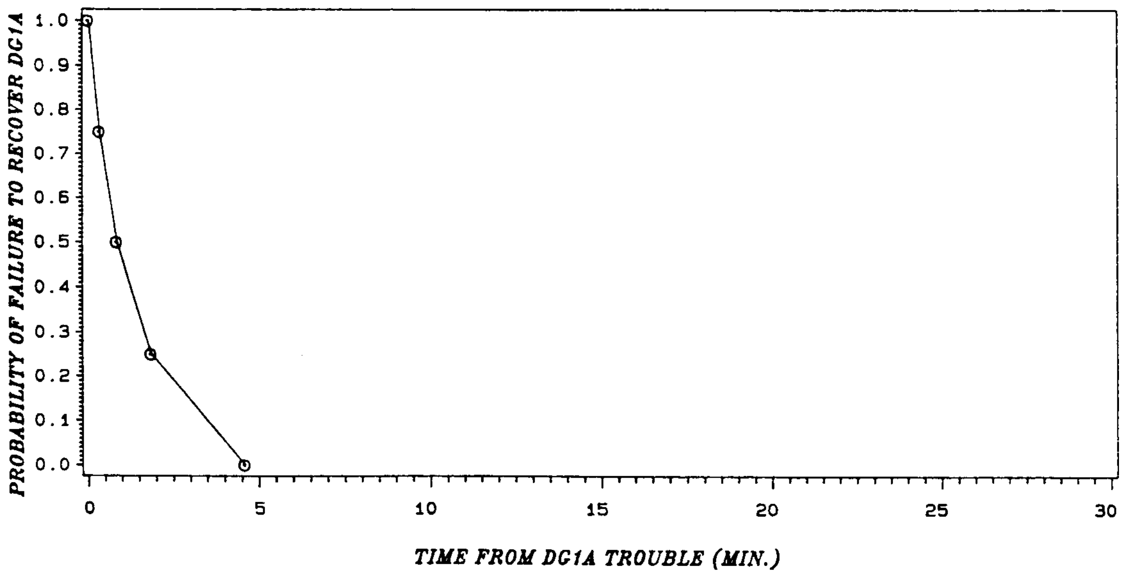


Figure B.5.1-18. Drill 4, Probability of Failure to Recover DG1A after Occurrence of DG1A Trouble

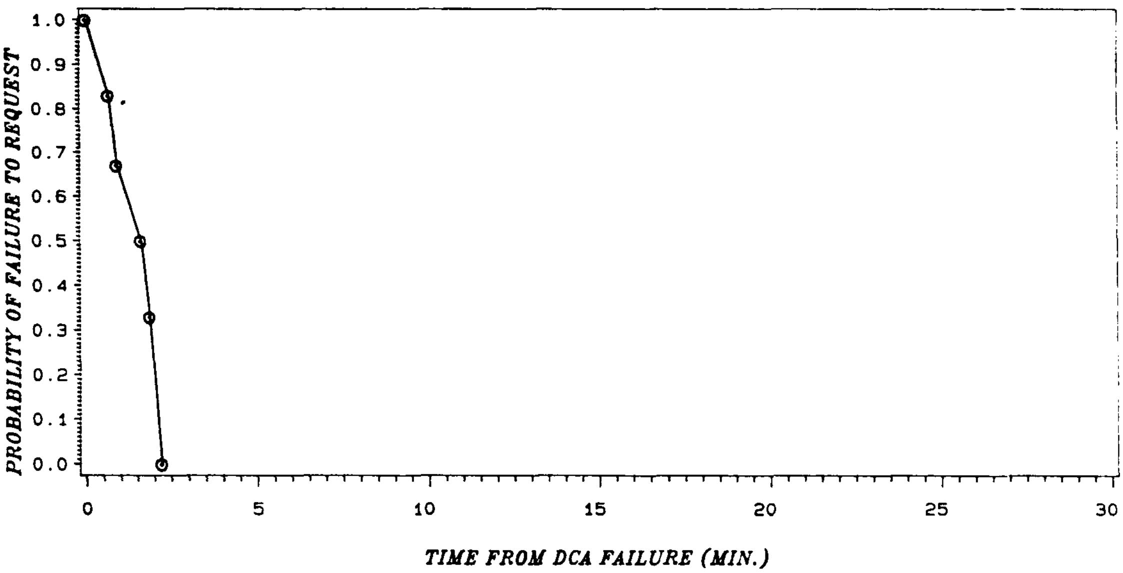
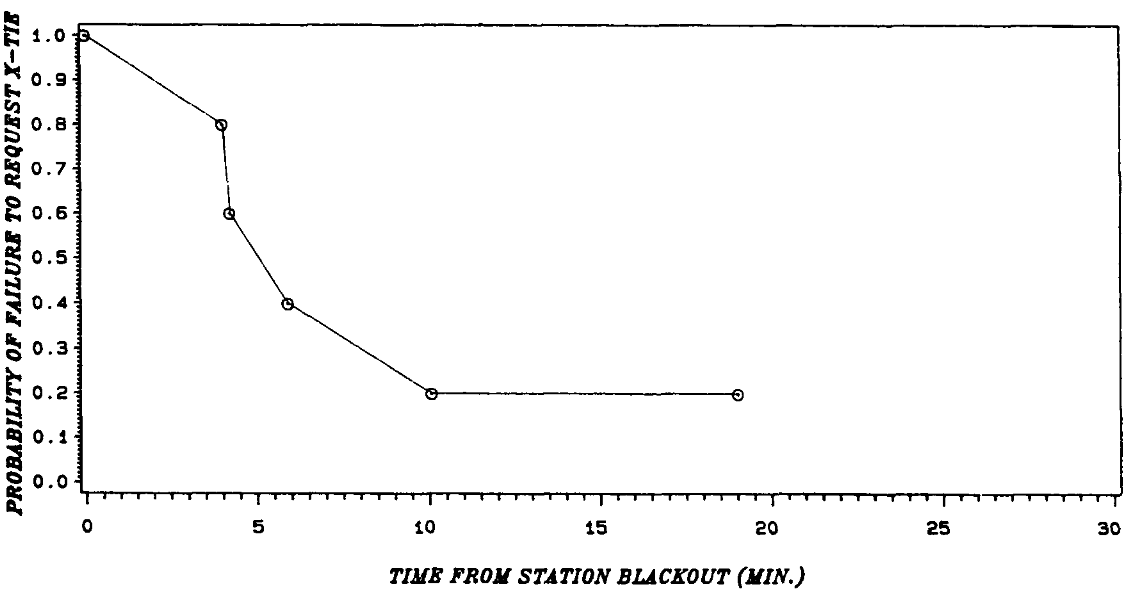


Figure B.5.1-19. Drill 6, Probability of <u>Failure</u> to Request DCA Investigation After Occurrence of DCA Failure (Drywell Isolation)



One of 5 crews did not request SAT repair as of 19.04 min. after station blackout, at which time power was restored.

Figure B.5.1-20. Drill 3, Probability of <u>Failure</u> to Request X-Tie after Occurrence of Station Blackout

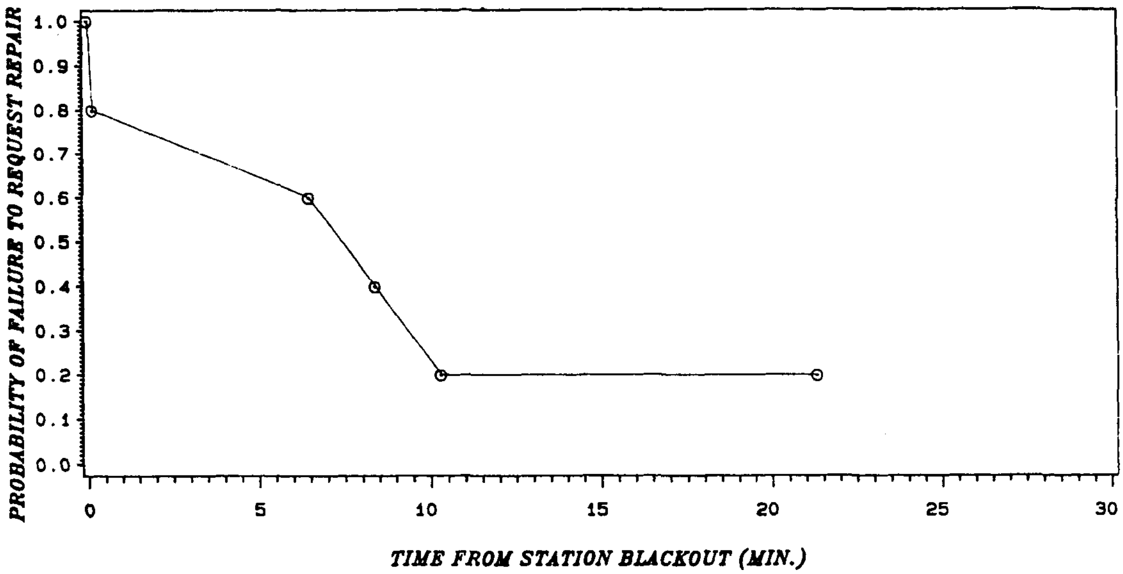
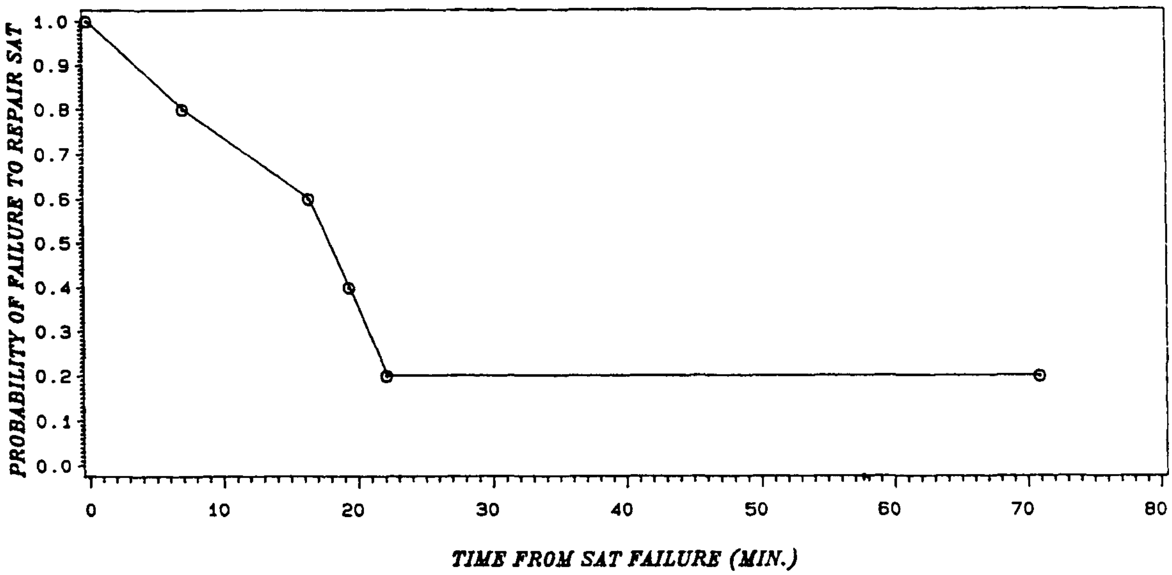
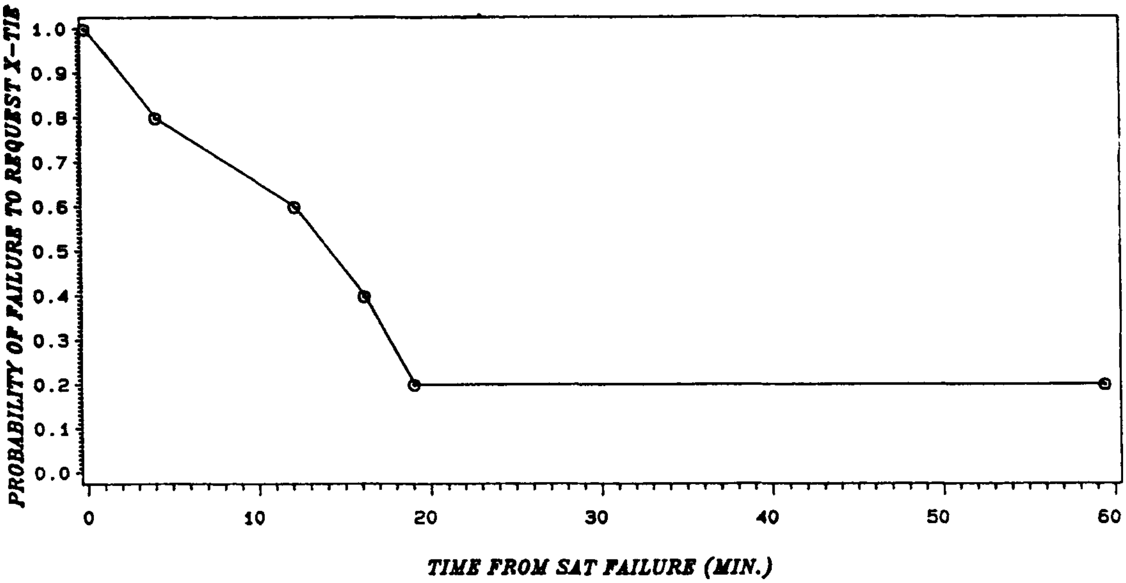


Figure B.5.1-21. Drill 3, Probability of Failure to Request SAT Repair after Occurrence of Station Blackout



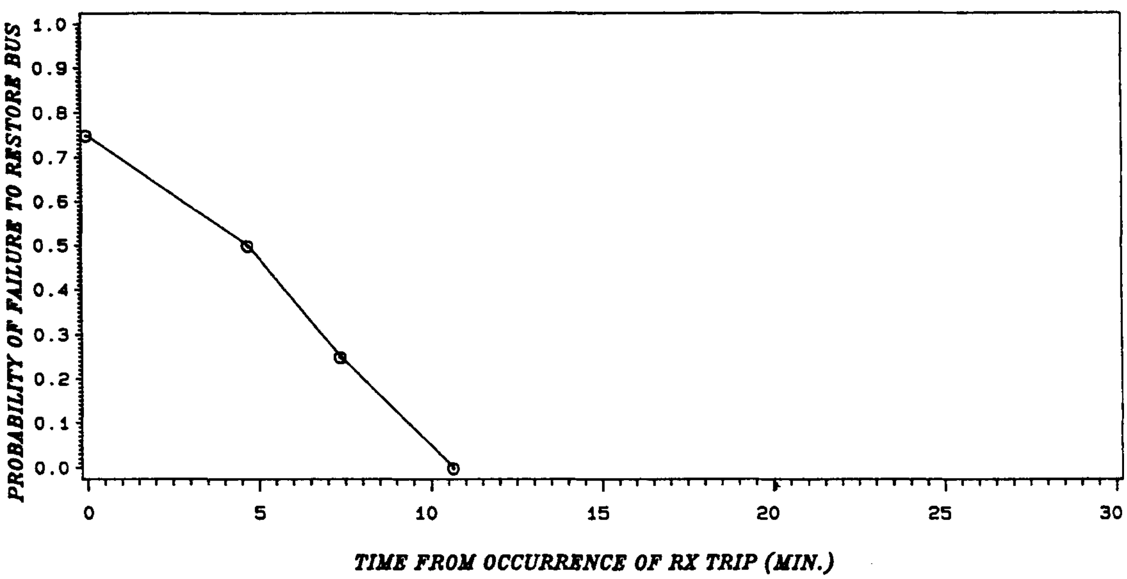
One of 5 crews did not request SAT repair as of 71.02 min. after SAT failure, at which time the drill was terminated.

Figure B.5.1-22. Drill 4, Probability of Failure to Request SAT Repair after Failure of SAT (Reactor Trip)



One of 5 crews did not request X-tie as of 69.63 min. after SAT failure, at which time the drill was terminated.

Figure B.5.1-23. Drill 4, Probability of <u>Failure</u> to Request X-Tie after Failure of SAT (Reactor Trip)



One two-man crew included.

Figure B.5.1-24. Drill 6, Probability of <u>Failure</u> to Restore Bus 151 Locally after Occurrence of RX Trip

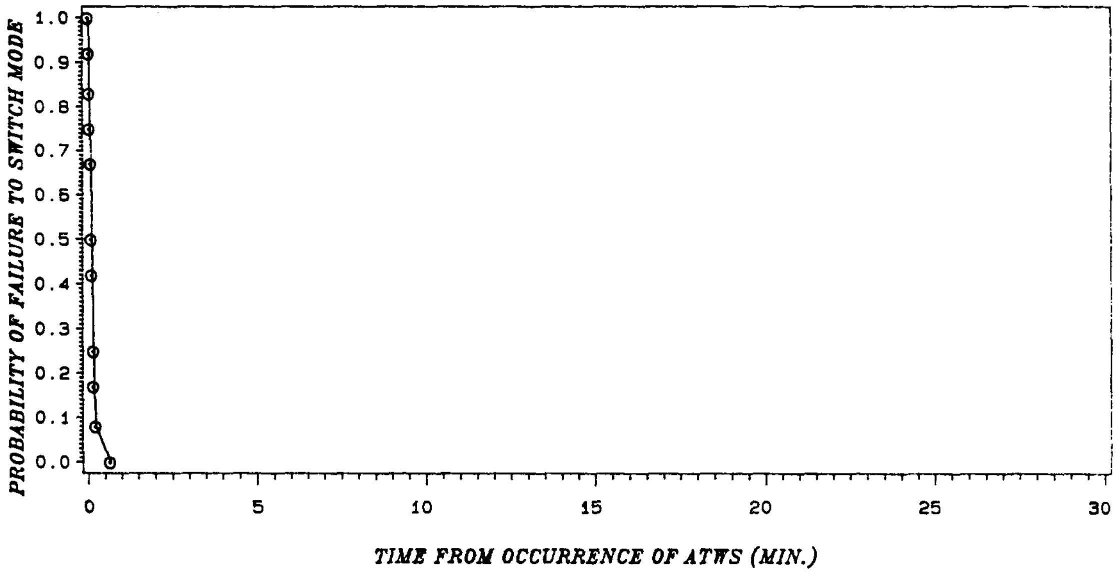


Figure B.5.1-25. Drill 1, Probability of Failure to Switch Mode Occurrence of ATWS

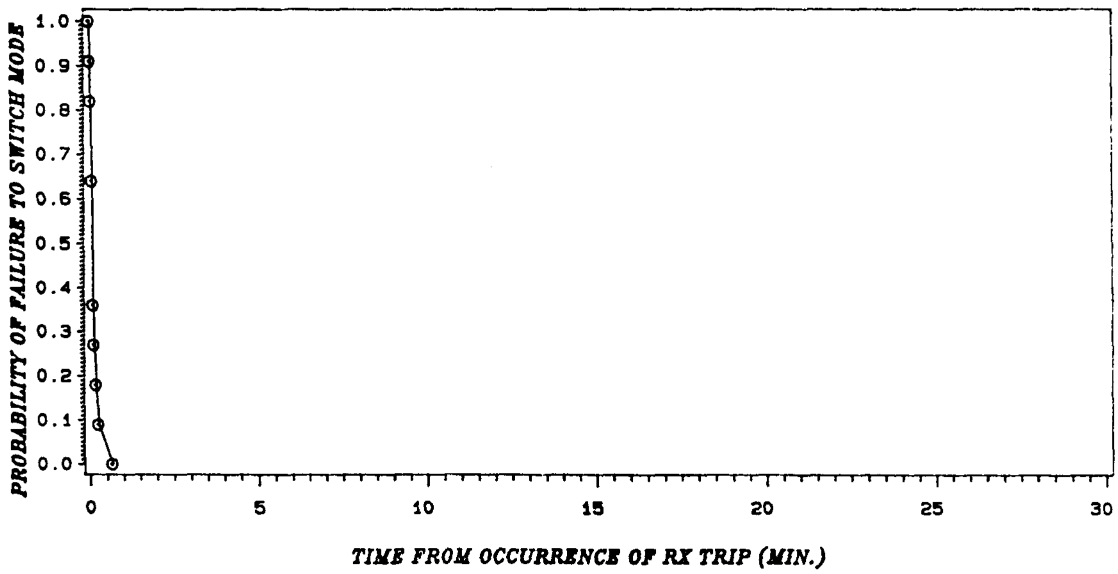


Figure B.5.1-26. Drills 2 & 2B, Probability of Failure to Switch Mode after Occurrence of RX Trip

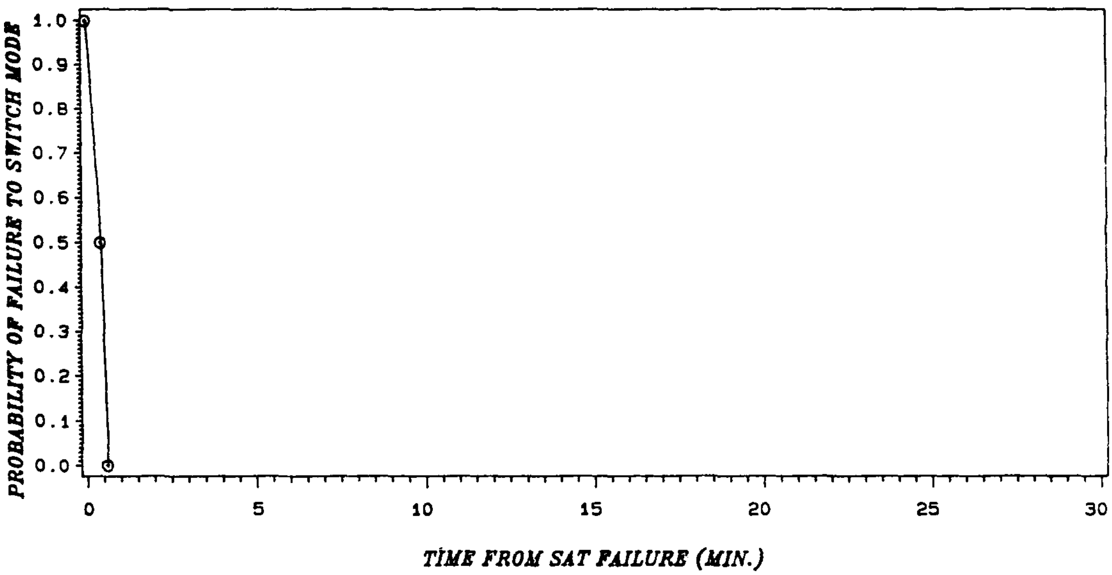


Figure B.5.1-27. Drill 3, Probability of Failure to Switch Mode after Failure of SAT (Reactor Trip)

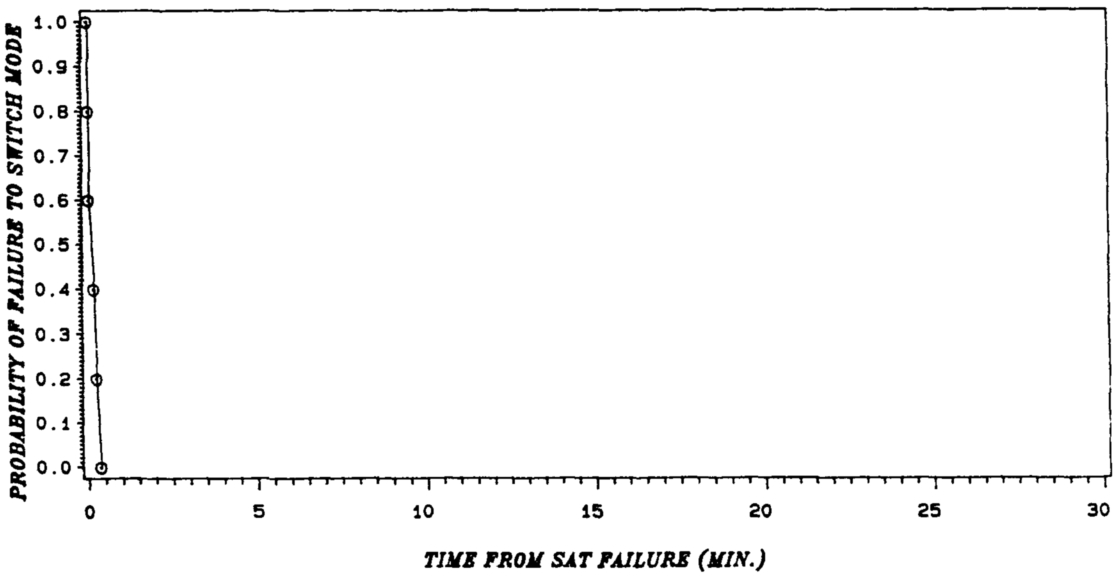


Figure B.5.1-28. Drill 4, Probability of Failure to Switch Mode after Failure of SAT (Reactor Trip)

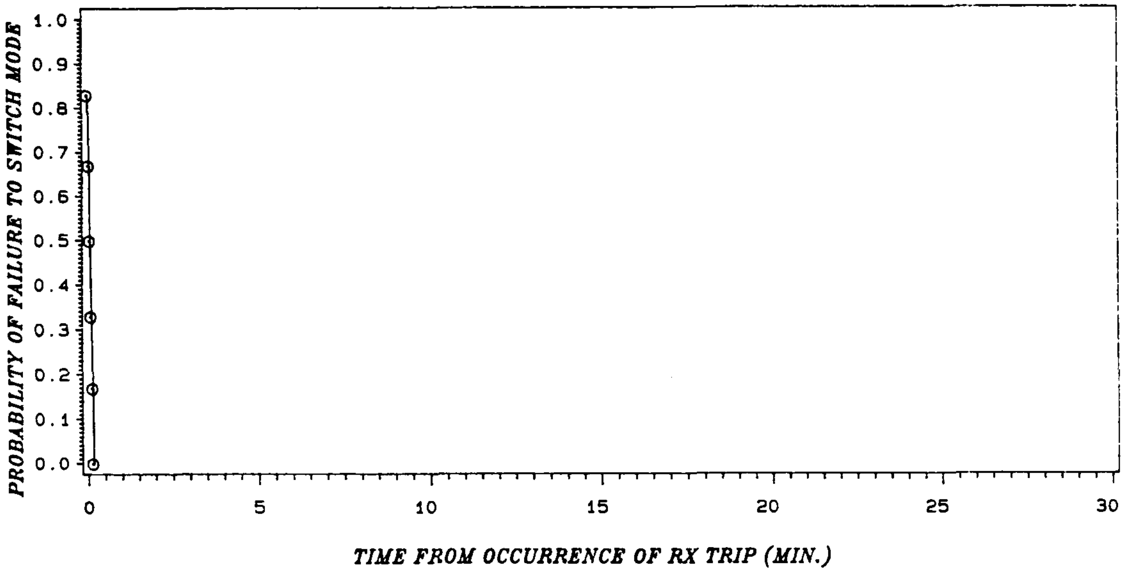


Figure B.5.1-29. Drill 6, Probability of Failure to Switch Mode after Occurrence of RX Trip

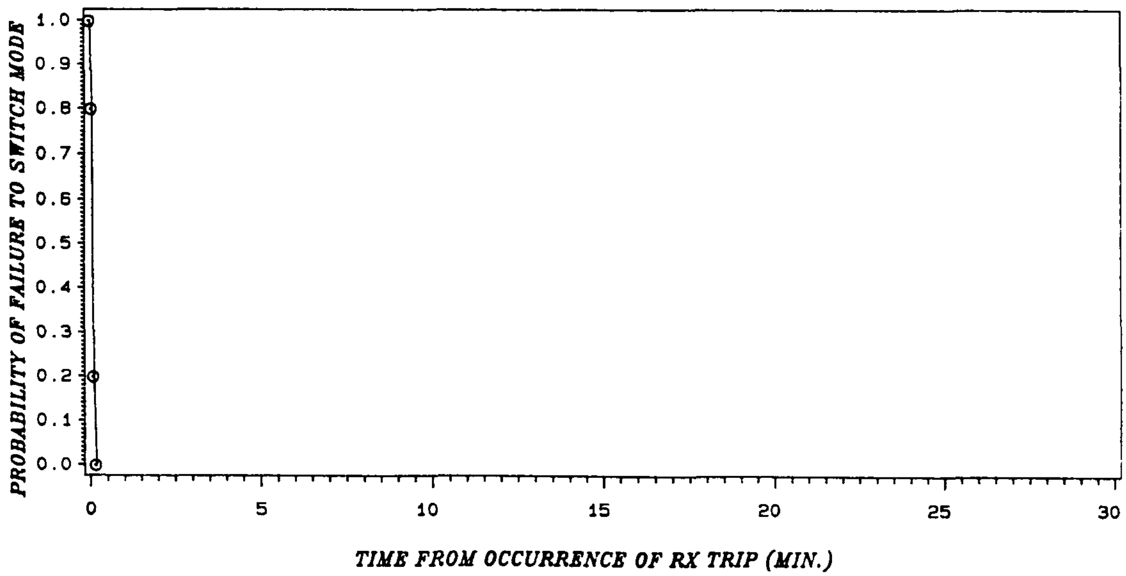


Figure B.5.1-30. Drill 8, Probability of Failure to Switch Mode after Occurrence of RX Trip

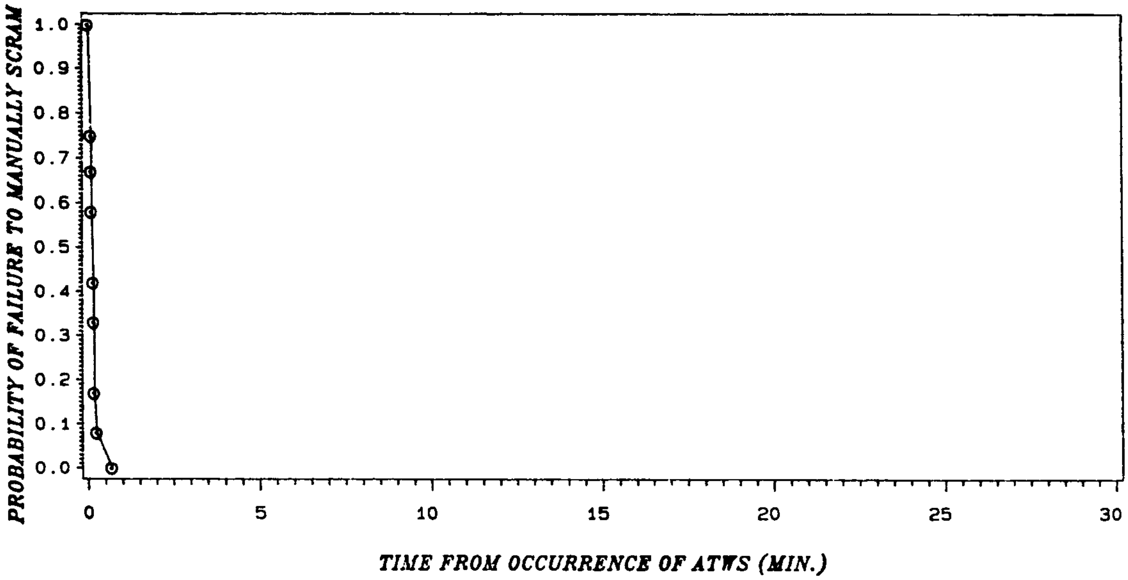


Figure B.5.1-31. Drill 1, Probability of Failure to Manually Scram after Occurrence of ATWS

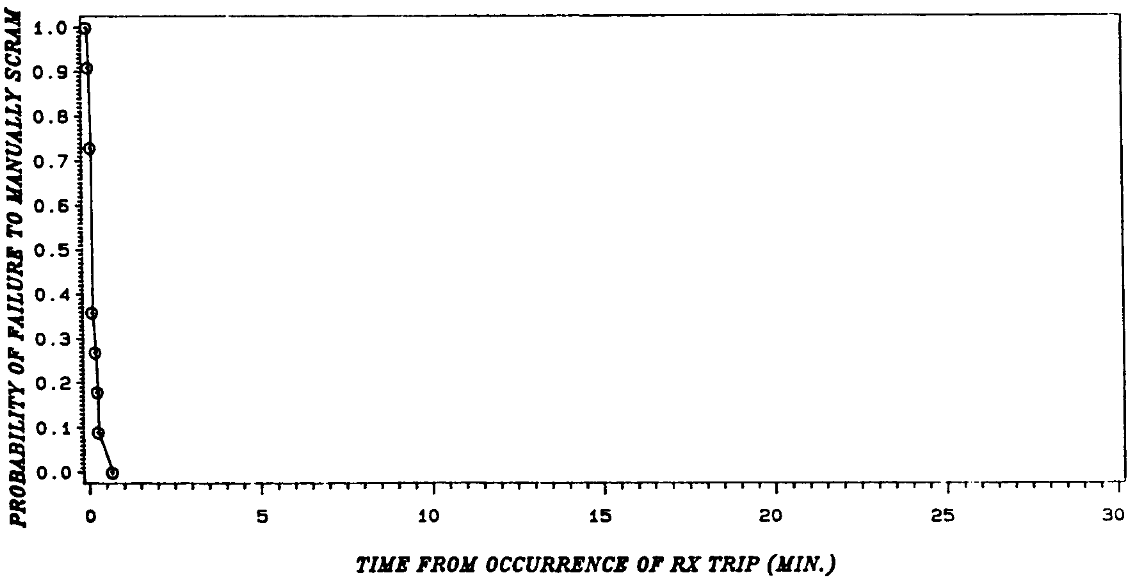


Figure B.5.1-32. Drills 2 & 2B, Probability of Failure to Manually Scram after Occurrence of RX Trip

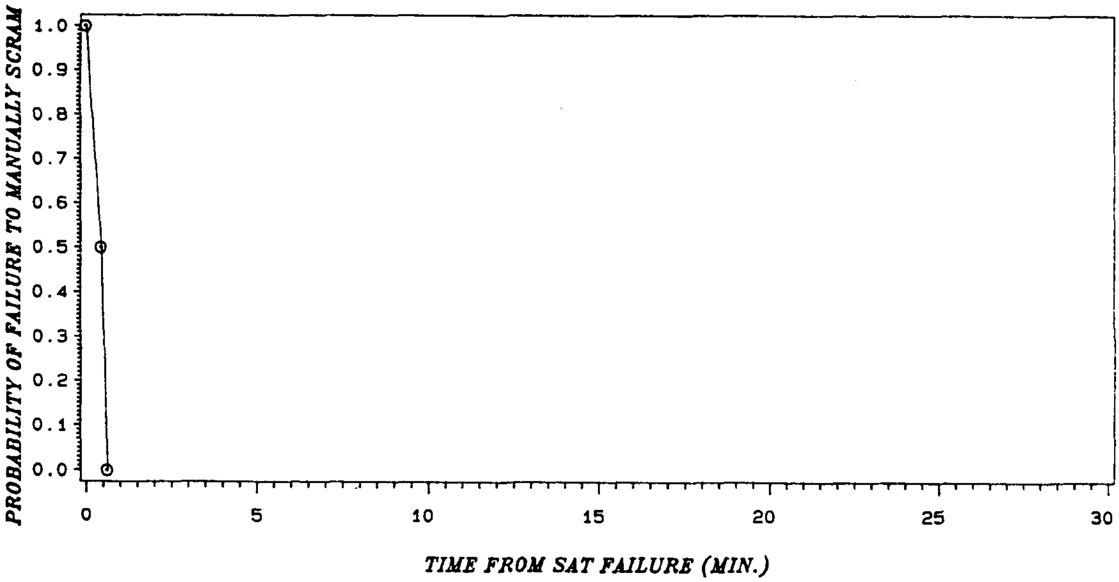


Figure B.5.1-33. Drill 3, Probability of Failure to Manually Scram after Failure of SAT (Reactor Trip)

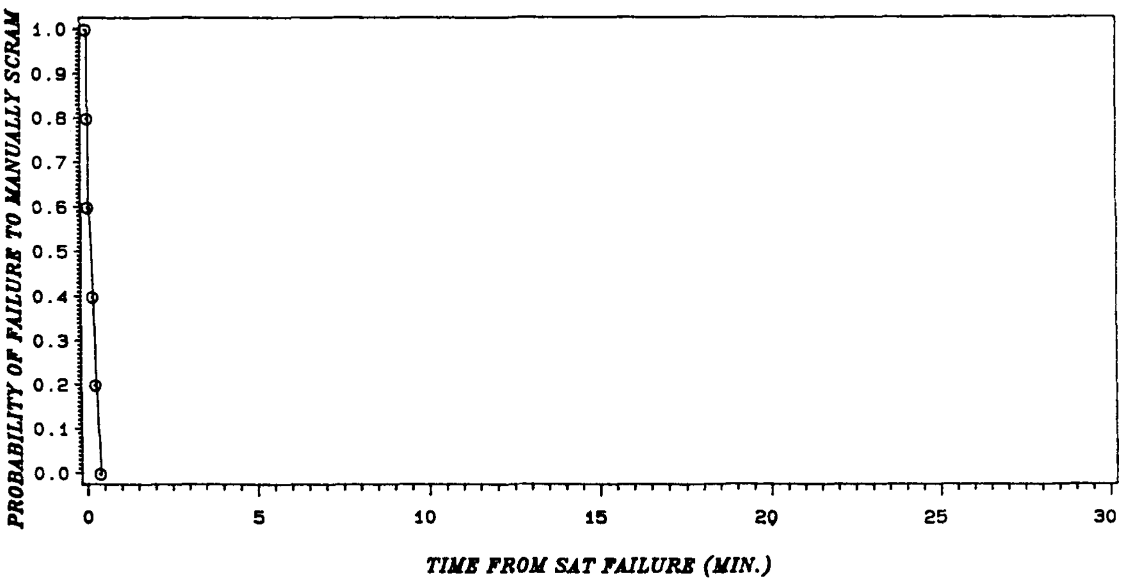


Figure B.5.1-34. Drill 4, Probability of Failure to Manually Scram after Failure of SAT (Reactor Trip)

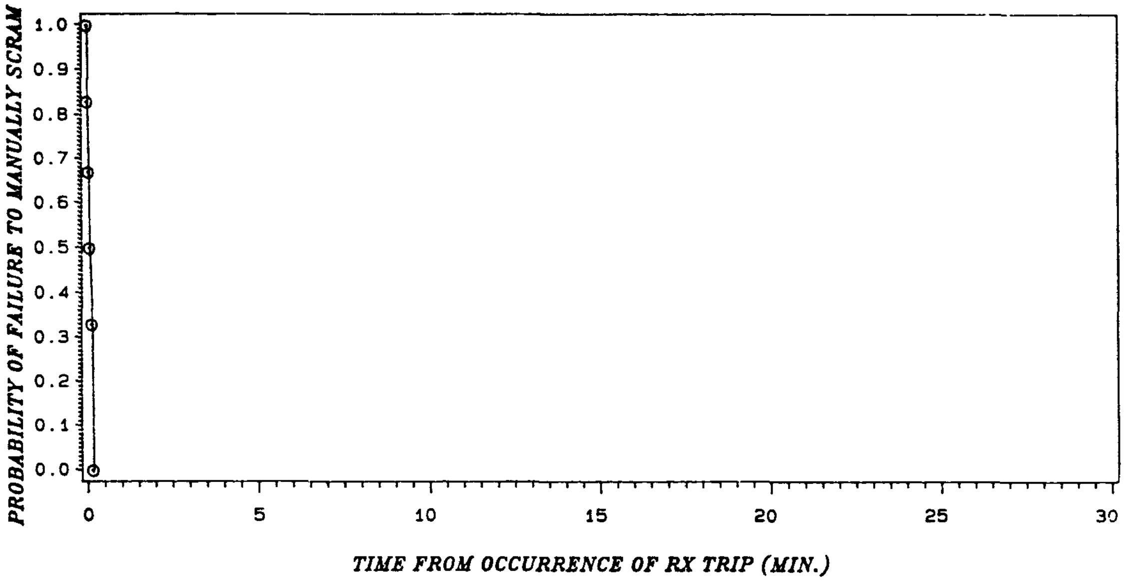


Figure B.5.1-35. Drill 6, Probability of Failure to Manually Scram after Occurrence of RX Trip

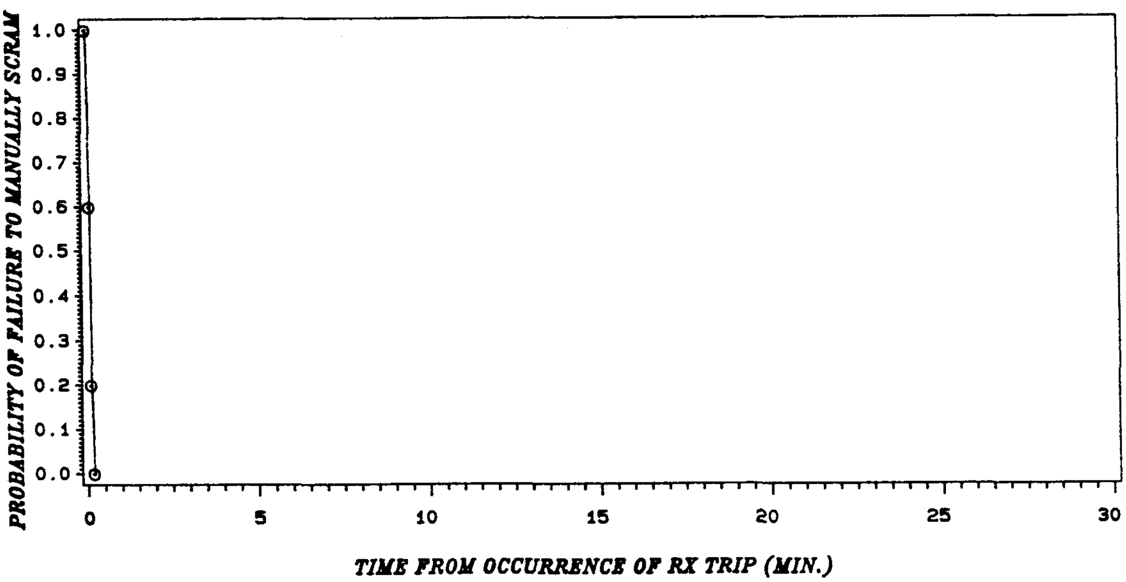
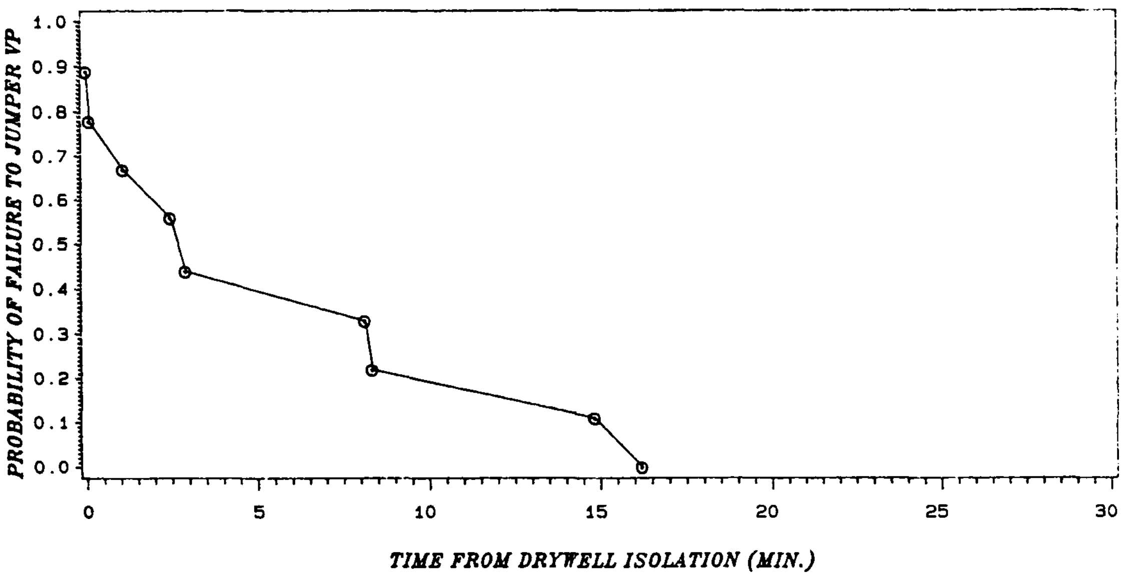


Figure B.5.1-36. Drill 8, Probability of Failure to Manually Scram after Occurrence of RX Trip



Action occurring prior to drywell isolation assigned time of zero

Figure B.5.1-37. **Drill 1, Probability of Failure to Jumper VP After Drywell Isolation**

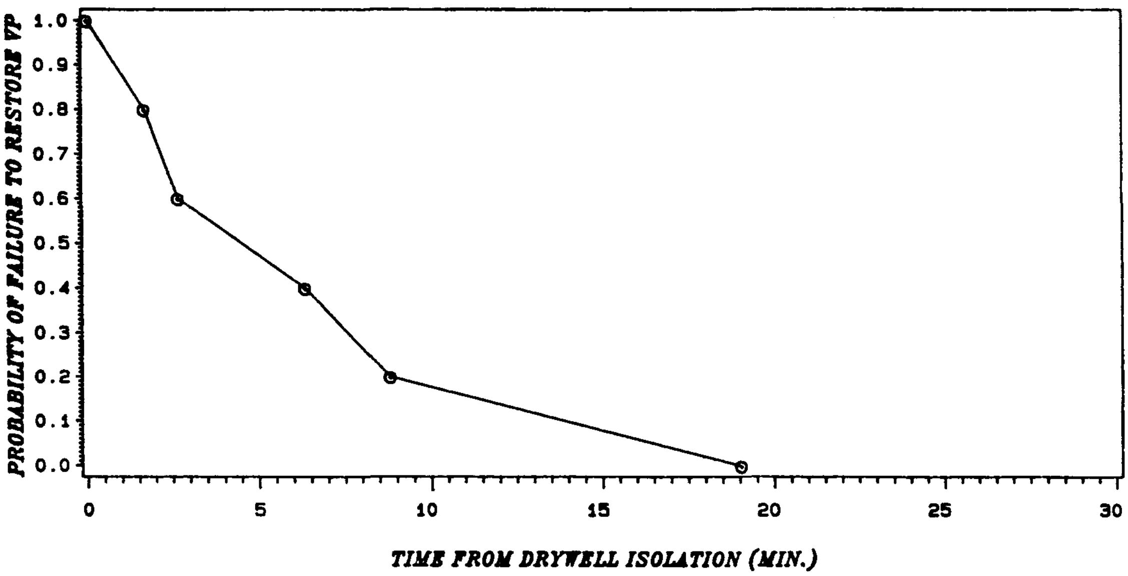


Figure B.5.1-38. Drill 4, Probability of <u>Failure</u> to Restore VP after Drywell Isolation

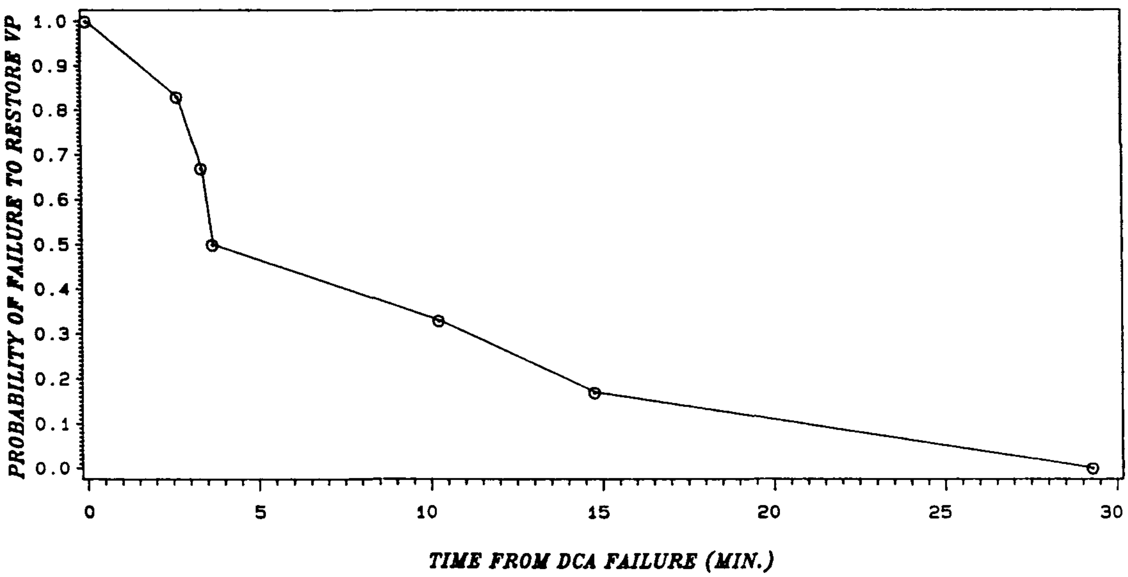


Figure B.5.1-39. Drill 6, Probability of <u>Failure</u> to Restore VP after Occurrence of DCA Failure (Drywell Isolation)

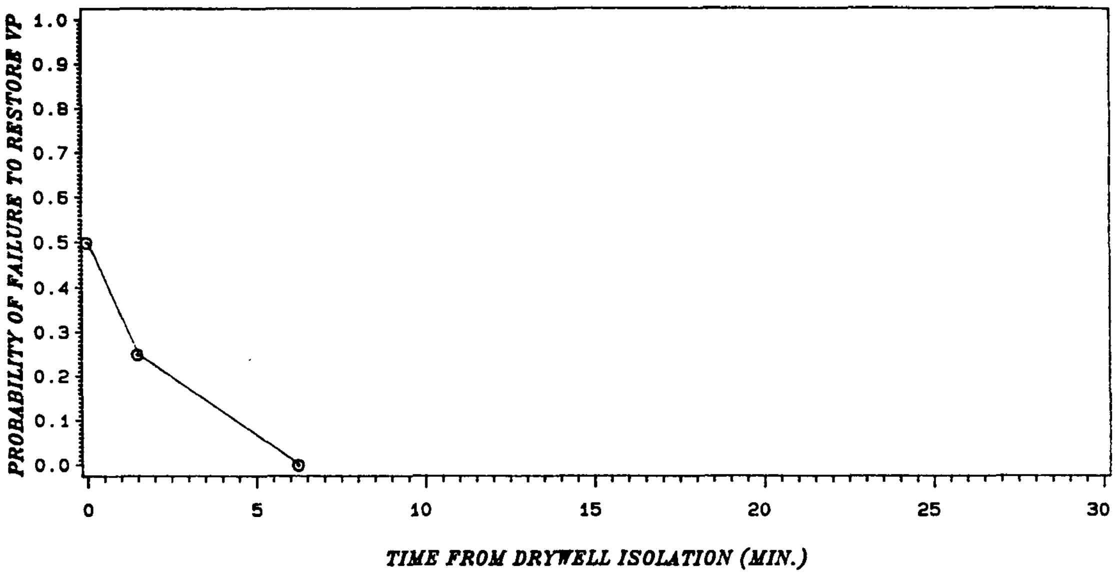


Figure B.5.1-40. Drill 8, Probability of Failure to Restore VP after Occurrence of Drywell Isolation

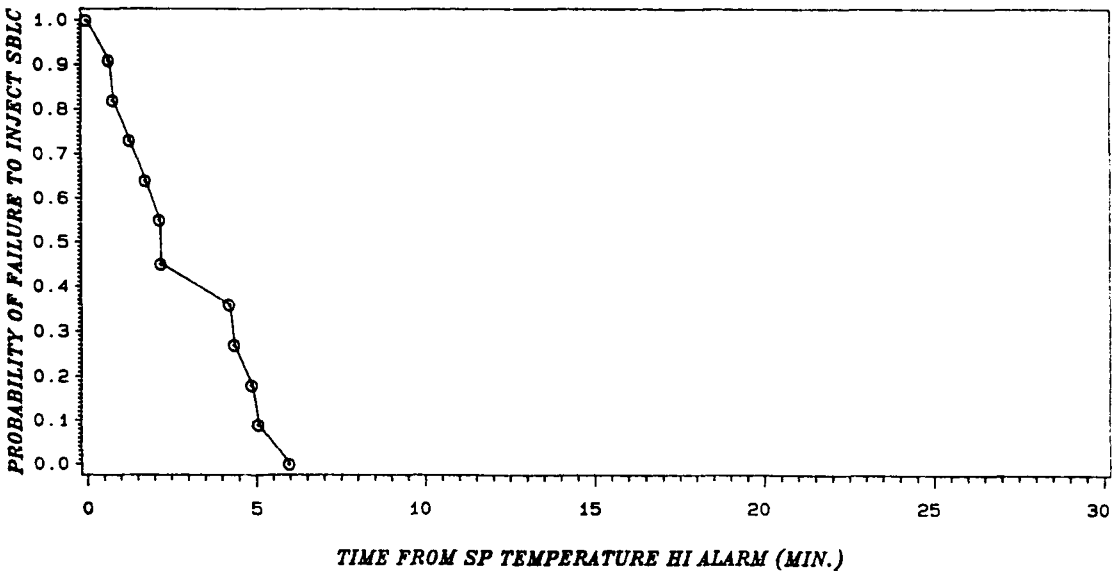
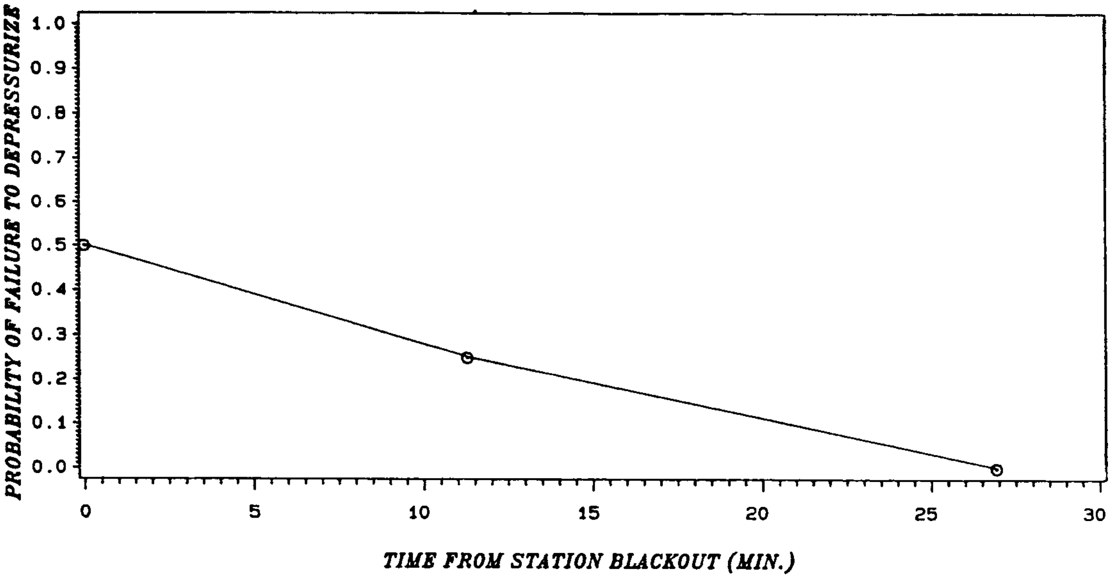
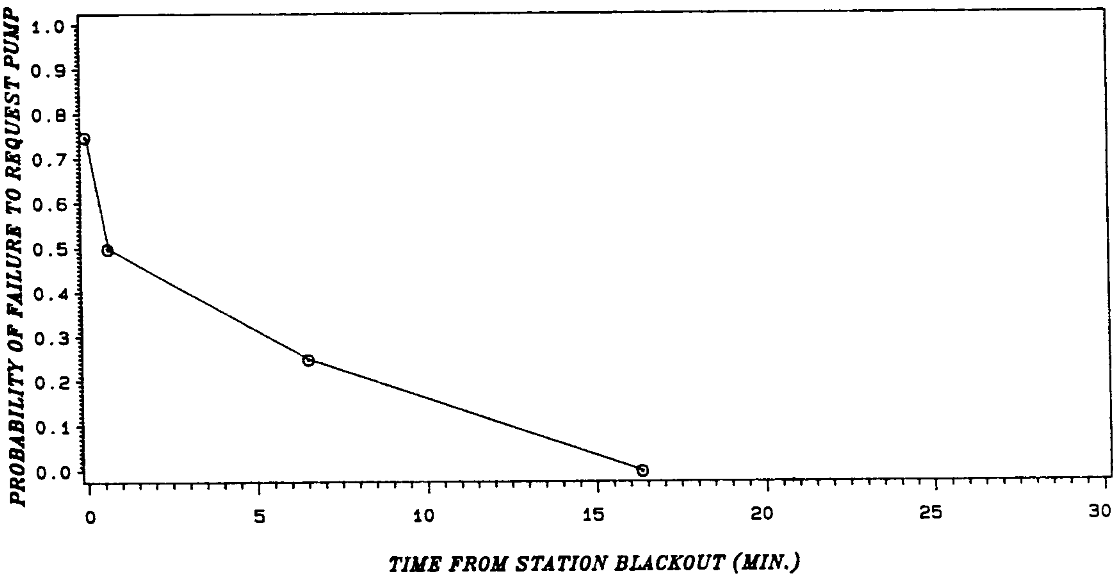


Figure B.5.1-41. Drill 1, Probability of Failure to Inject SBLC after Occurrence of SP Temperature Hi Alarm



Actions occurring prior to occurrence of station blackout assigned time of 0

Figure B.5.1-42. Drill 4, Probability of <u>Failure</u> to Depressurize After Occurrence of Station Blackout



Action occurring prior to occurrence of station blackout assigned time of 0

Figure B.5.1-43. Drill 4, Probability of <u>Failure</u> to Request Diesel Fire Pump after Occurrence of Station Blackout

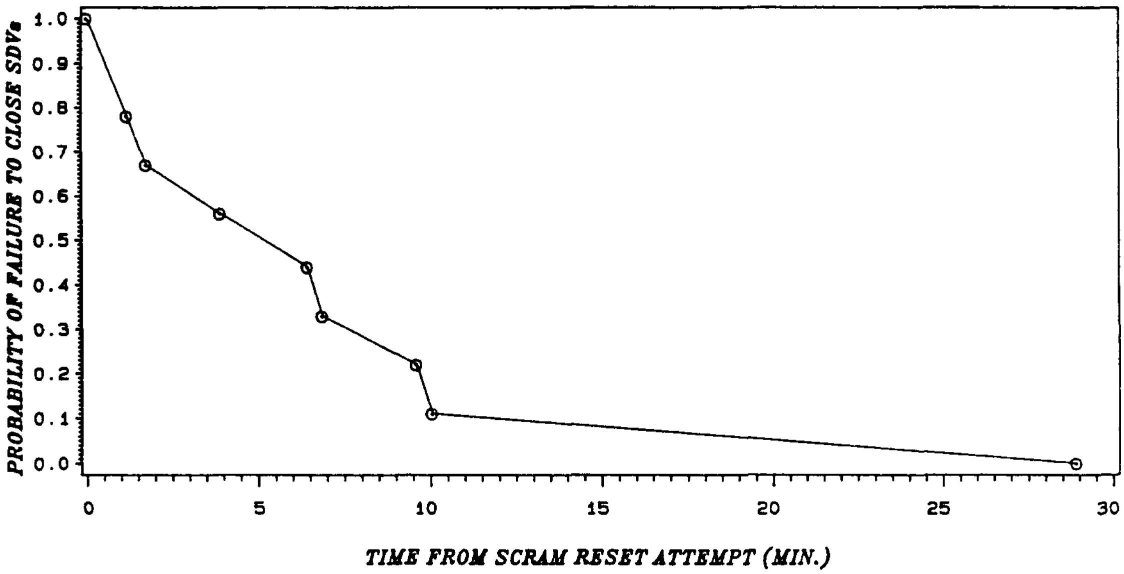


Figure B.5.1-44. Drills 2 & 2B, Probability of <u>Failure</u> to Send B Man to Close SDVs after Scram Reset Attempt

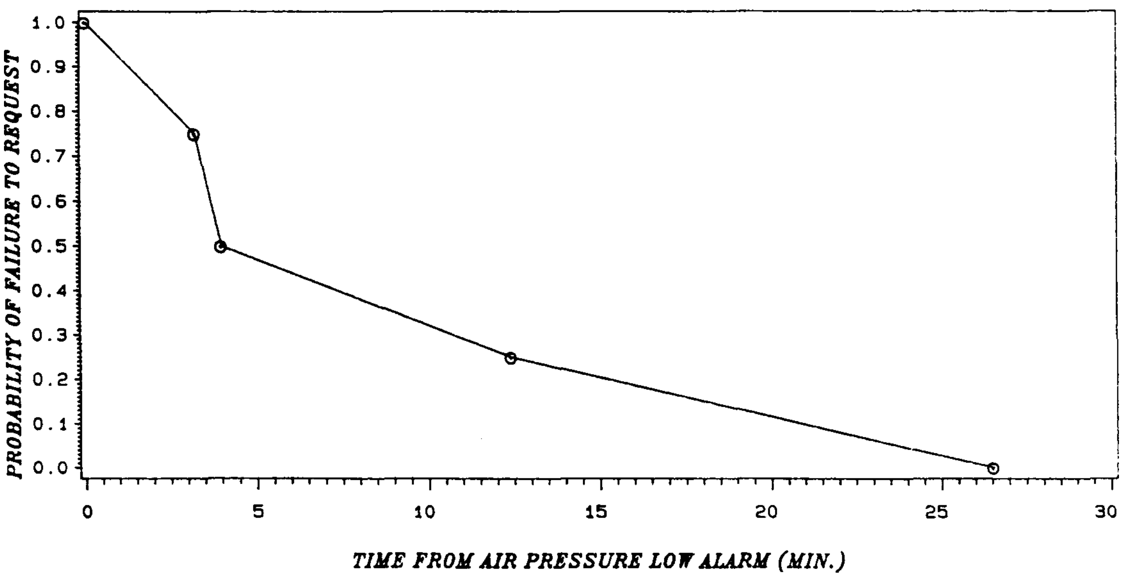


Figure B.5.1-45. Drill 6, Probability of <u>Failure</u> to Request Air Restoration after Occurrence of Service Air Pressure Low Alarm

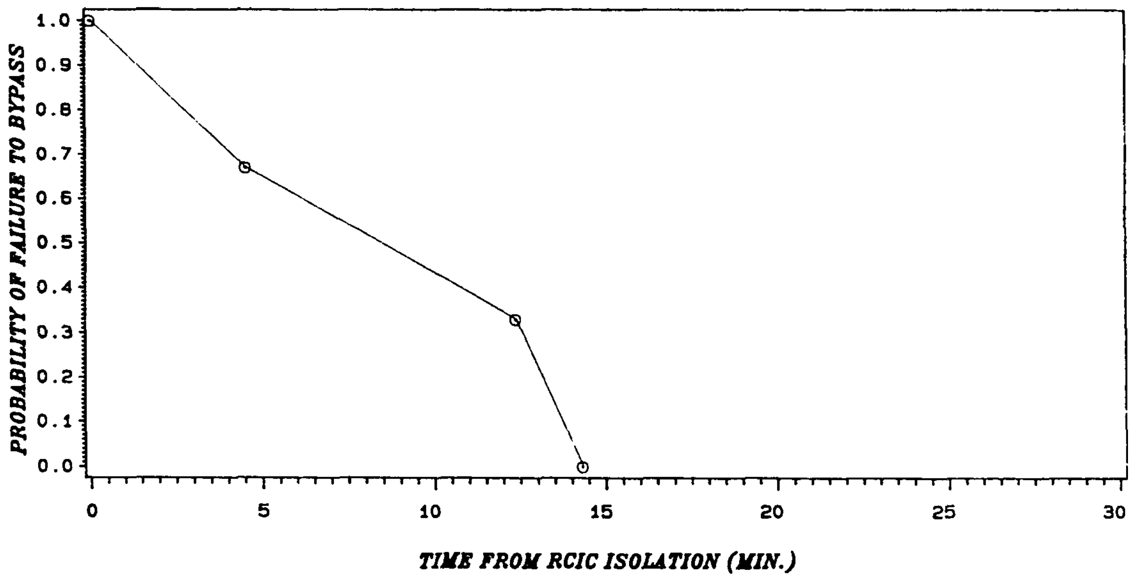


Figure B.5.1-46. **Drill 4, Probability of Failure to Request Bypass of RCIC Isolation After Occurrence of RCIC Isolation (Because of RCIC Room Overheating)** ccdfs for Group 2 could be combined with those for Group 10 (p values > .01).

B.5.3 Results of Comparisons of Mean Diagnosis Times

ANOVAs to compare mean diagnosis times were not performed for Groups 6 or 12 for reasons stated in Section B.5.2. Results of the ANOVAs on the remaining groups are shown in Table B.5.3-1. In agreement with the Smirnov tests, it was found that the diagnosis times were not significantly different for the groups and that the data for Group 1 could be combined with the data for Group 9 (p values for Drill effect > .05).

The ANOVA on Group 2 and 10 data left doubt that the data for these two groups should be combined (see Table B.5.3-1 (i)); the p value for the Drill effect was .03. In addition, in Group 10 there was large variability in diagnosis times, with some crews performing the actions at very short times and others performing the actions at relatively long times. This type of distribution might be expected when there is hesitancy about performing an action. Given the above considerations and the fact that Group 10 involves actions which could potentially result in considerable cost to the facility, while Group 2 involves actions that pose no cost to the facility, it was decided to keep these groups separate.

A statistically significant Crew effect was found in only two of the ten ANOVAs (see Table B.5.3-1 (h) and (i)).

B.5.4 Empirical CCDFS of Diagnosis Times for Combined Actions

The empirical ccdfs for the actions that were combined are shown in Figures B.5.4-1 through B.5.4-10). These include ccdfs for diagnosis times for Groups 1 and 9 combined, and Groups 2, 3, 4, 5, 6, 8, 10, 11, and 12.

B.5.5 Results of Tests to Determine Fit of Lognormal Function to Diagnose Time Data

Figures B.5.5-1 through B.5.5-10 show plots of log time versus the cumulative probability of success for each of the resulting groups. Overall, the plots show that the lognormal function could be reasonably fitted to the empirical data. This finding is further supported by statistical goodness-of-fit tests that were performed.

Table B.5.5-1 shows the results of tests to determine whether the log time data for each group were normally distributed. In these analyses, right and left censored observations were deleted from the data sets. Of the ten tests run, two were statistically significant (p > .01). These were the tests for Groups 3 and 6. For Group 3, the statistic was barely significant at the .01 level of significance. For Group 6, the

(Text continues on page B-126)

Table B.5.3-1
Results of ANOVAs on Log 10 Diagnosis Times

(a) Group 1 ANOVA

Source	DF	SS	F	Prob > F
Crew	11	0.94	1.37	.2
Drill	7	0.42	0.96	.5
Error	33	2.05		

(b) Group 1 and 9

Source	DF	SS	F	Prob > F
Crew	11	0.64	0.88	.6
Drill	8	0.54	1.02	.4
Error	43	2.84		

(c) Group 2

Source	DF	SS	F	Prob > F
Crew	4	0.09	2.18	.2
Drill	1	0.01	1.49	.3
Error	4	0.04		

(d) Group 3

Source	DF	SS	F	Prob > F
Crew	10	1.99	1.71	.3
Drill	2	0.84	3.60	.1
Error	5	0.58		

(e) Group 4

Source	DF	SS	F	Prob > F
Crew	11	1.33	1.02	.5
Drill	5	1.51	2.53	.08
Error	13	1.55		

Table B.5.3-1 (Continued)
Results of ANOVAs on Log 10 Diagnosis Times

(f) Group 5

Source	DF	SS	F	Prob > F
Crew	11	1.48	0.72	.7
Drill	4	.88	1.18	.4
Error	8	1.50		

(g) Group 8

Source	DF	SS	F	Prob > F
Crew	11	1.67	0.78	.7
Drill	3	.56	0.95	.5
Error	9	1.75		

(h) Group 10

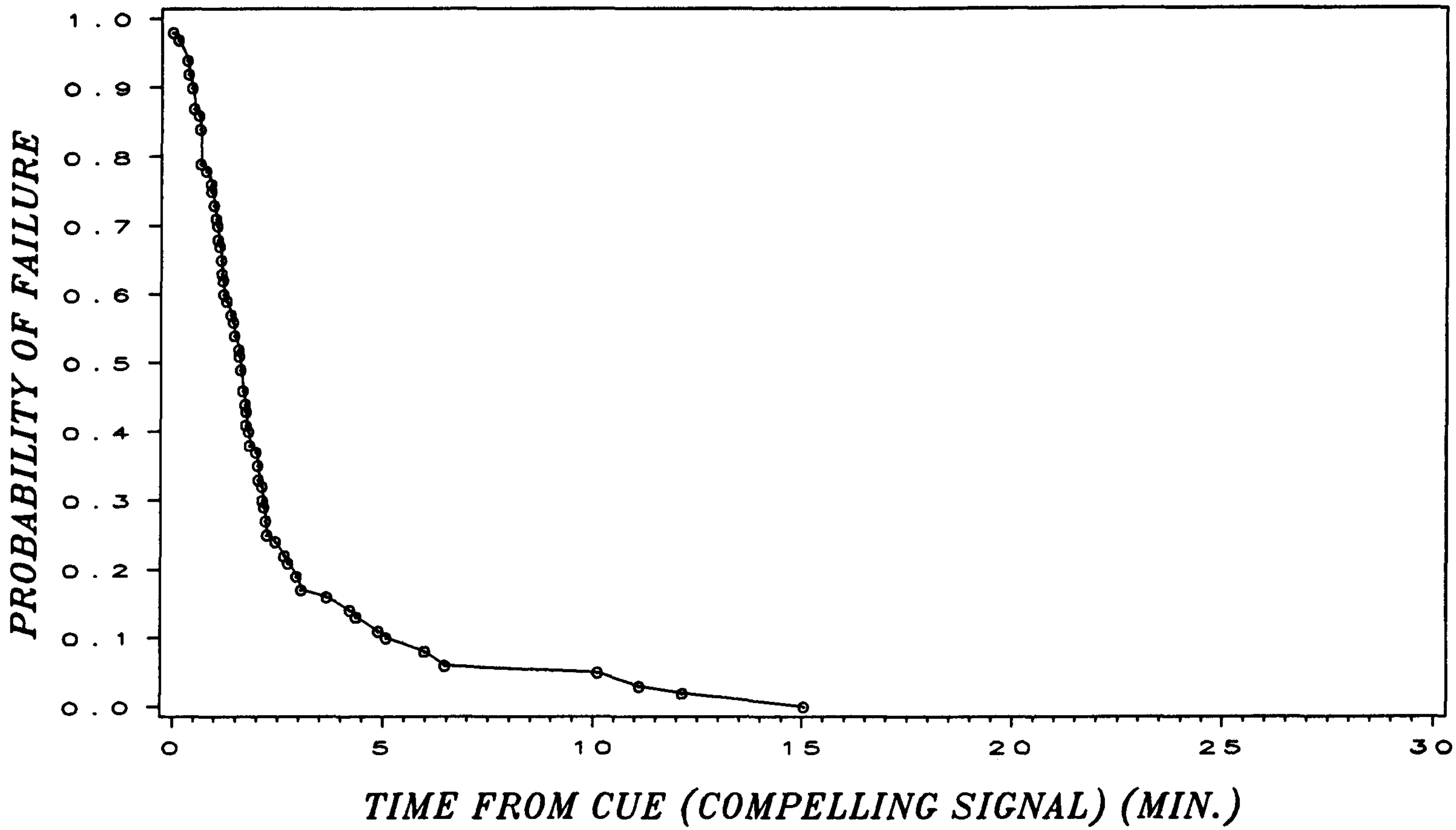
Source	DF	SS	F	Prob > F
Crew	3	2.60	41.49	.006
Drill	1	0.005	0.25	.7
Error	3	0.06		

(i) Group 2 and 10

Source	DF	SS	F	Prob > F
Crew	7	2.67	28.26	.0001
Drill	3	0.22	5.53	.03
Error	7	0.09		

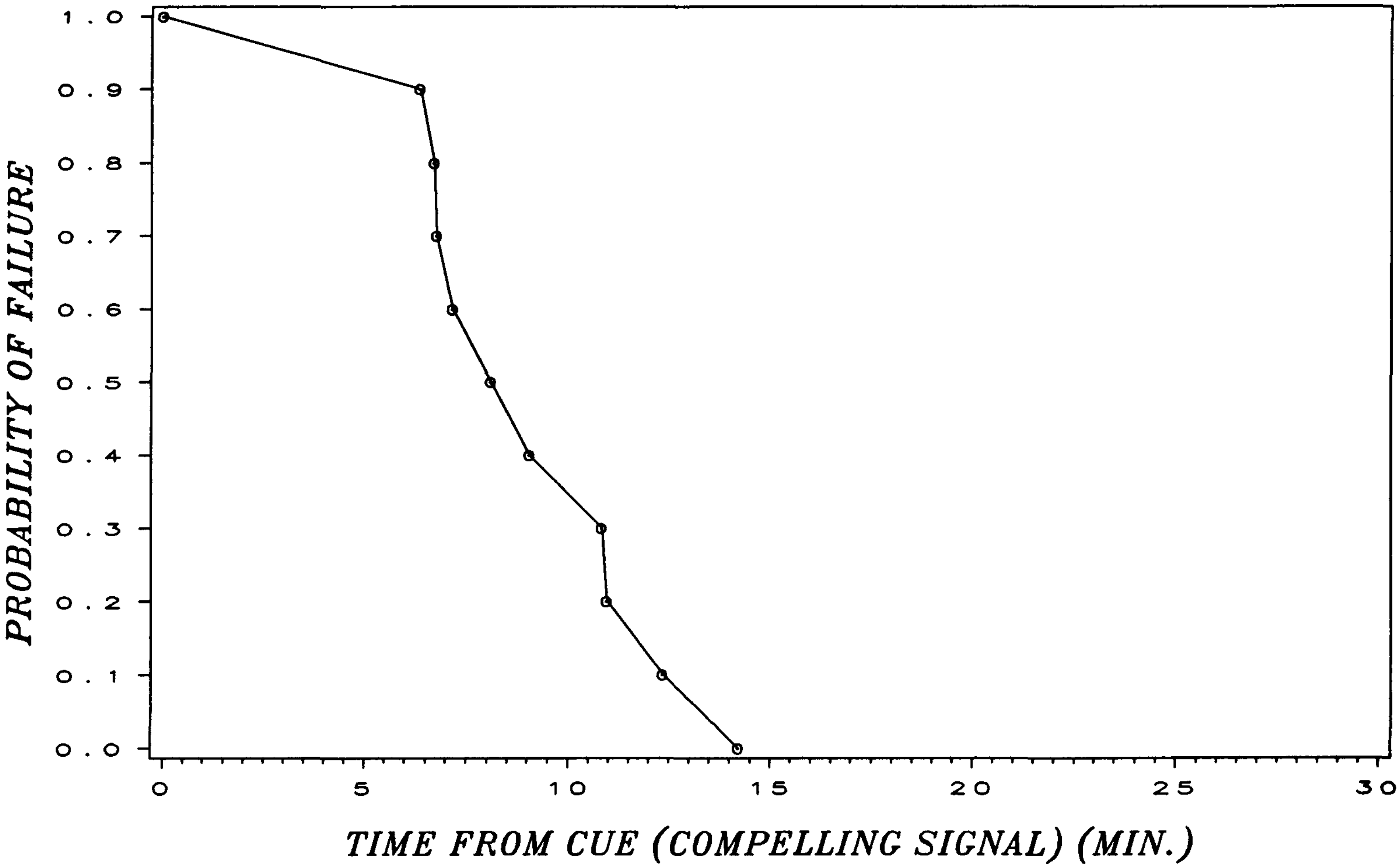
(j) Group 11

Source	DF	SS	F	Prob > F
Crew	10	3.29	2.08	.3
Drill	1	0.07	0.45	.6
Error	3	0.48		



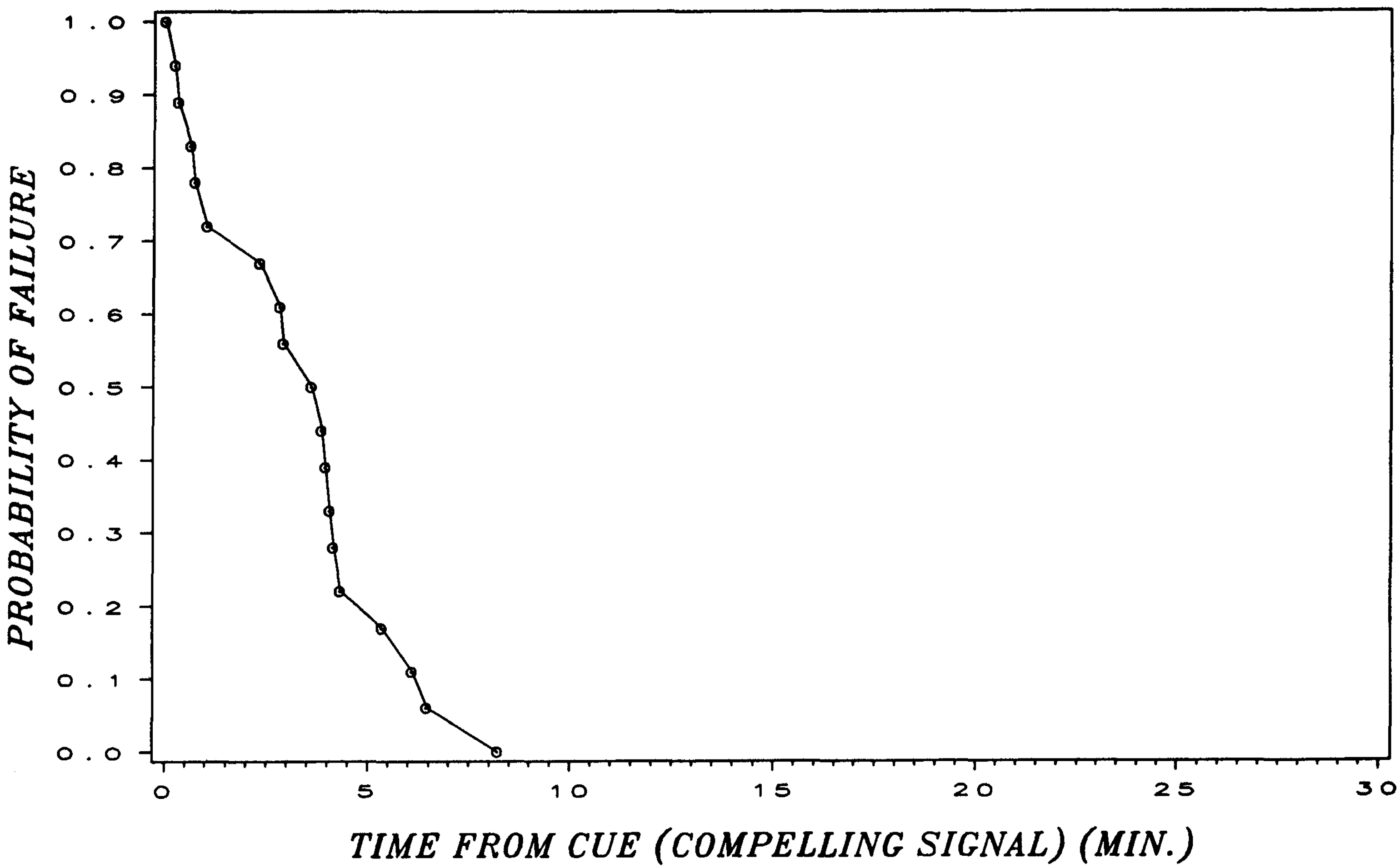
Sample size = 63.
Group 9 combined with Group 1.

Figure B.5.4-1. Group 1, Empirical Probability of Failure to Manually Operate a System or Component to Control a Critical Parameter Prior to the Automatic Actuation (if it Has Automatic Actuation) of the System or Component



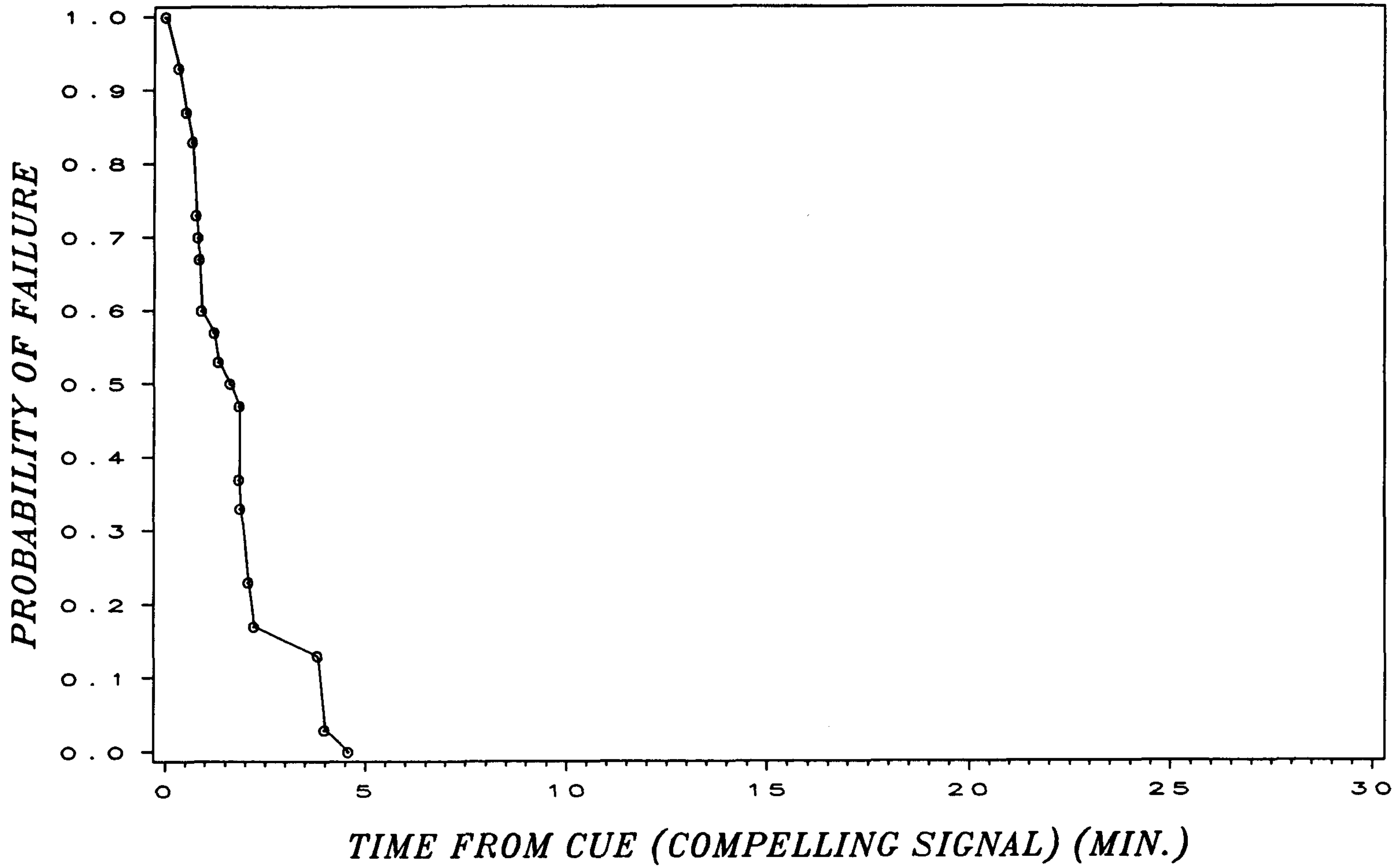
Sample size = 10.

Figure B.5.4-2. Group 2, Empirical Probability of Failure to Use Low Pressure Systems when High Pressure Systems are Unavailable



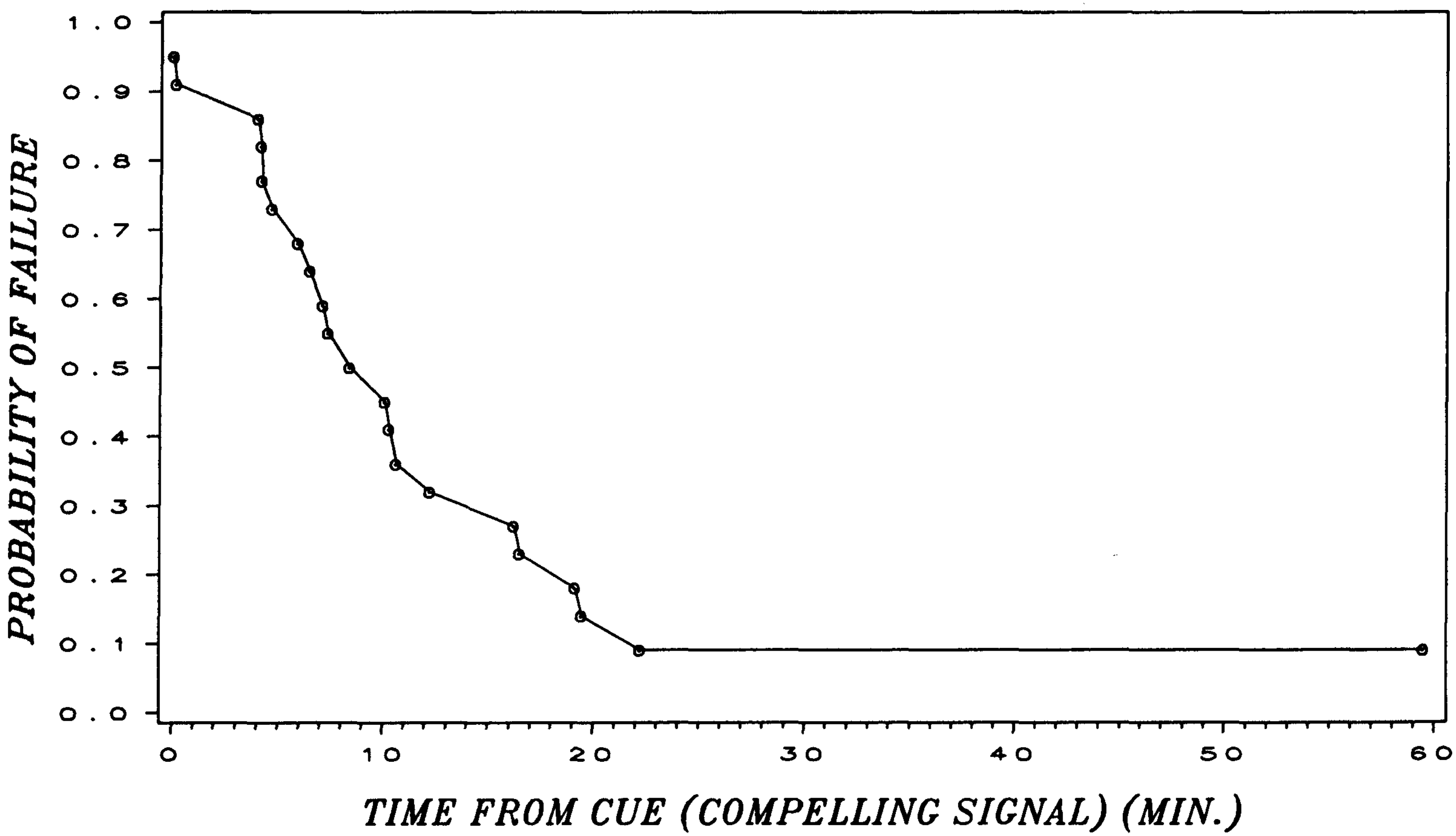
Sample size = 18.

Figure B.5.4-3. Group 3, Empirical Probability of <u>Failure</u> to Manually Operate Systems or Components which Failed to Automatically Actuate (Operate)



Sample size = 30.

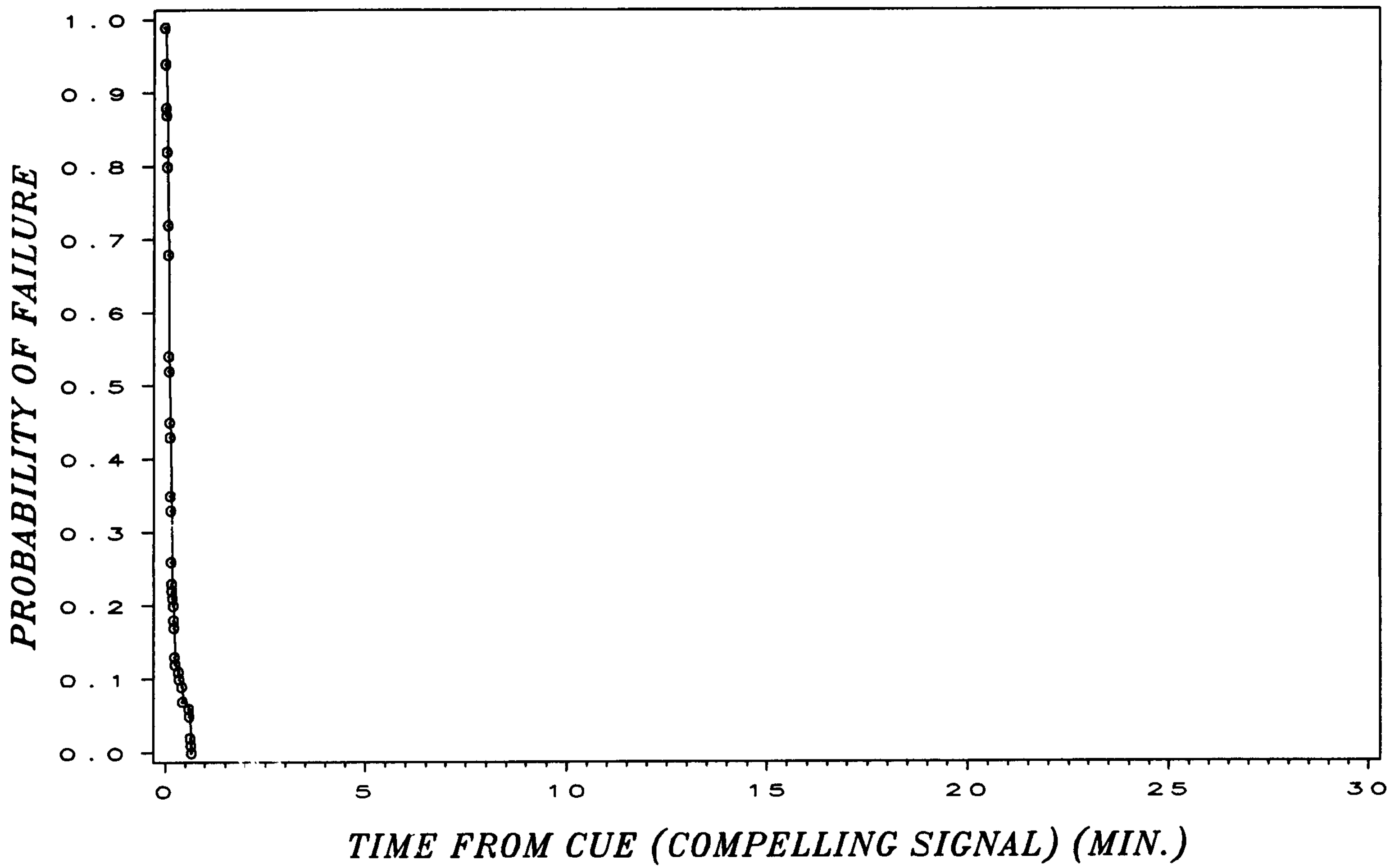
Figure B.5.4-4. **Group 4, Empirical Probability of <u>Failure</u> to Restore Safety-Related In-House Electrical Buses or Supply Equipment**



Sample size = 22. Two of 22 crews did not restore electrical buses or supply equipment as of 59.53 and 71.02 min. after the cue, the drill termination times.

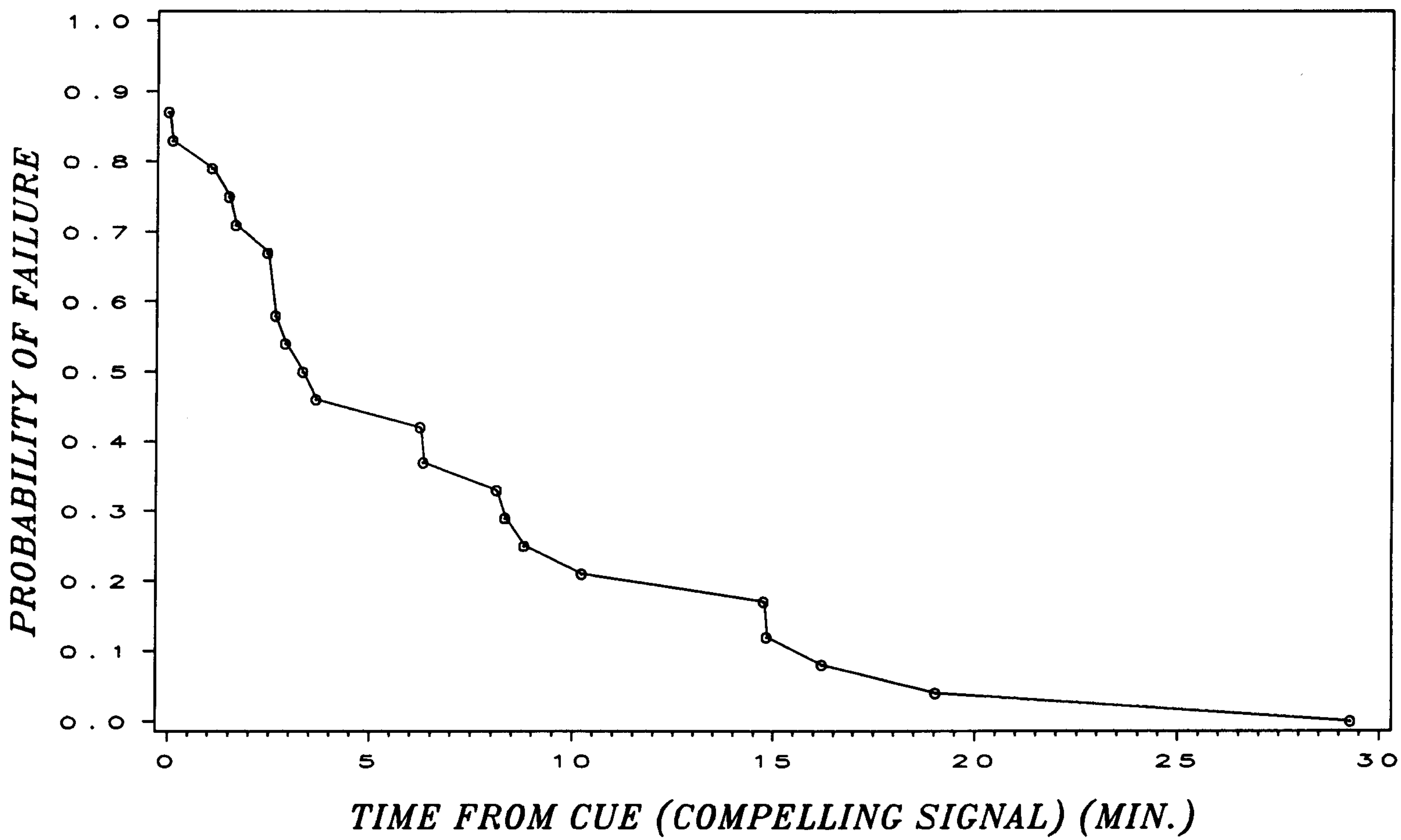
Two crews are not counted in the curve since they failed to take appropriate actions as of 19.04 and 21.33 min. after the cue, the drill termination times. Those times were shorter than the last success time.

Figure B.5.4-5. Group 5, Empirical Probability of Failure to Restore Off-Site-Supplied Non-Safety-Related Electrical Buses or Supply Equipment



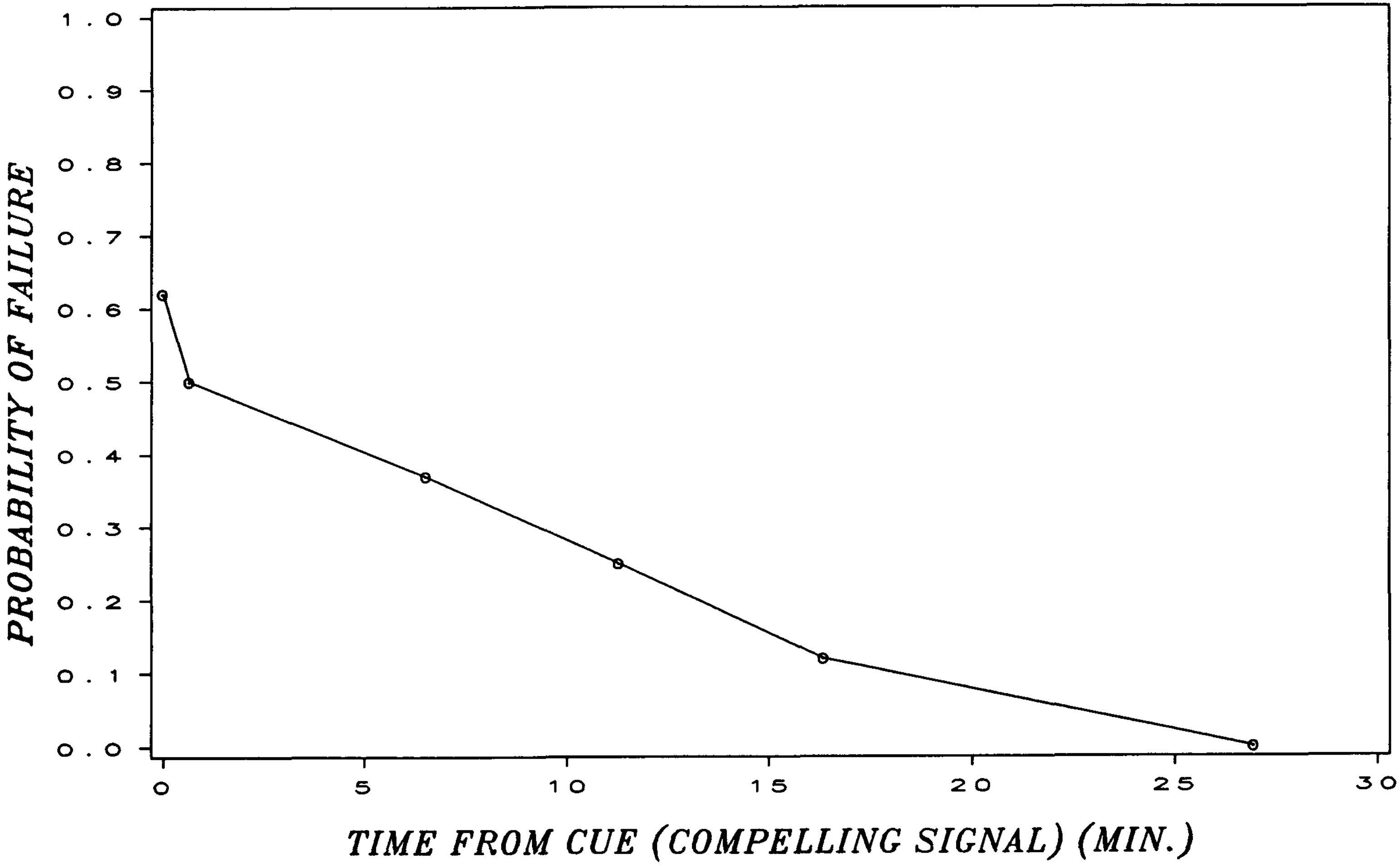
Sample size = 82.

Figure B.5.4-6. Group 6, Empirical Probability of Failure to Perform Manual Backup of an Automatic ShutDown Function



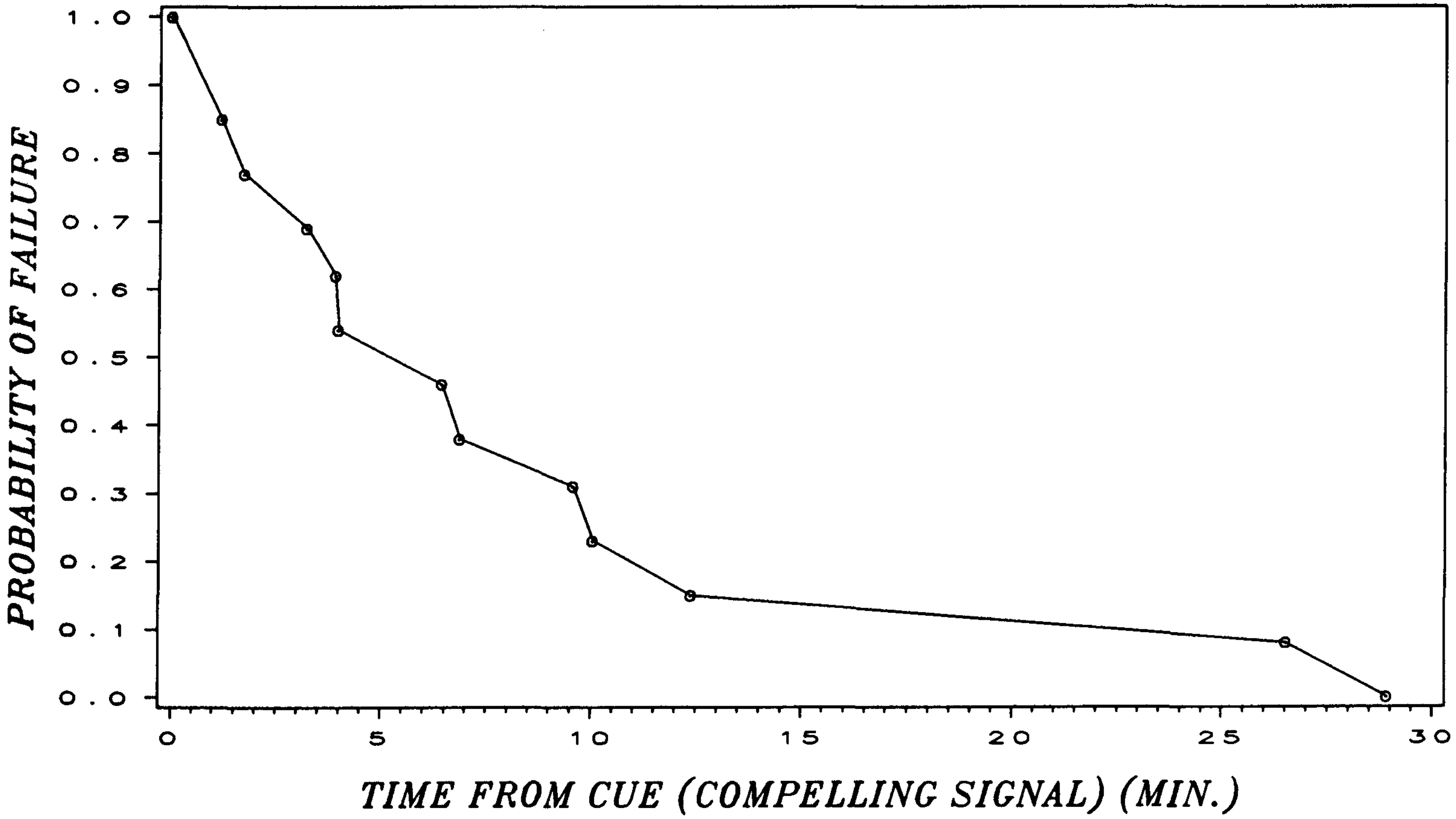
Sample size = 24.

Figure B.5.4-7. Group 8, Empirical Probability of Failure to Manually Override a System that Automatically Functions when Automatic Operation of the System Would Challenge a Critical Parameter



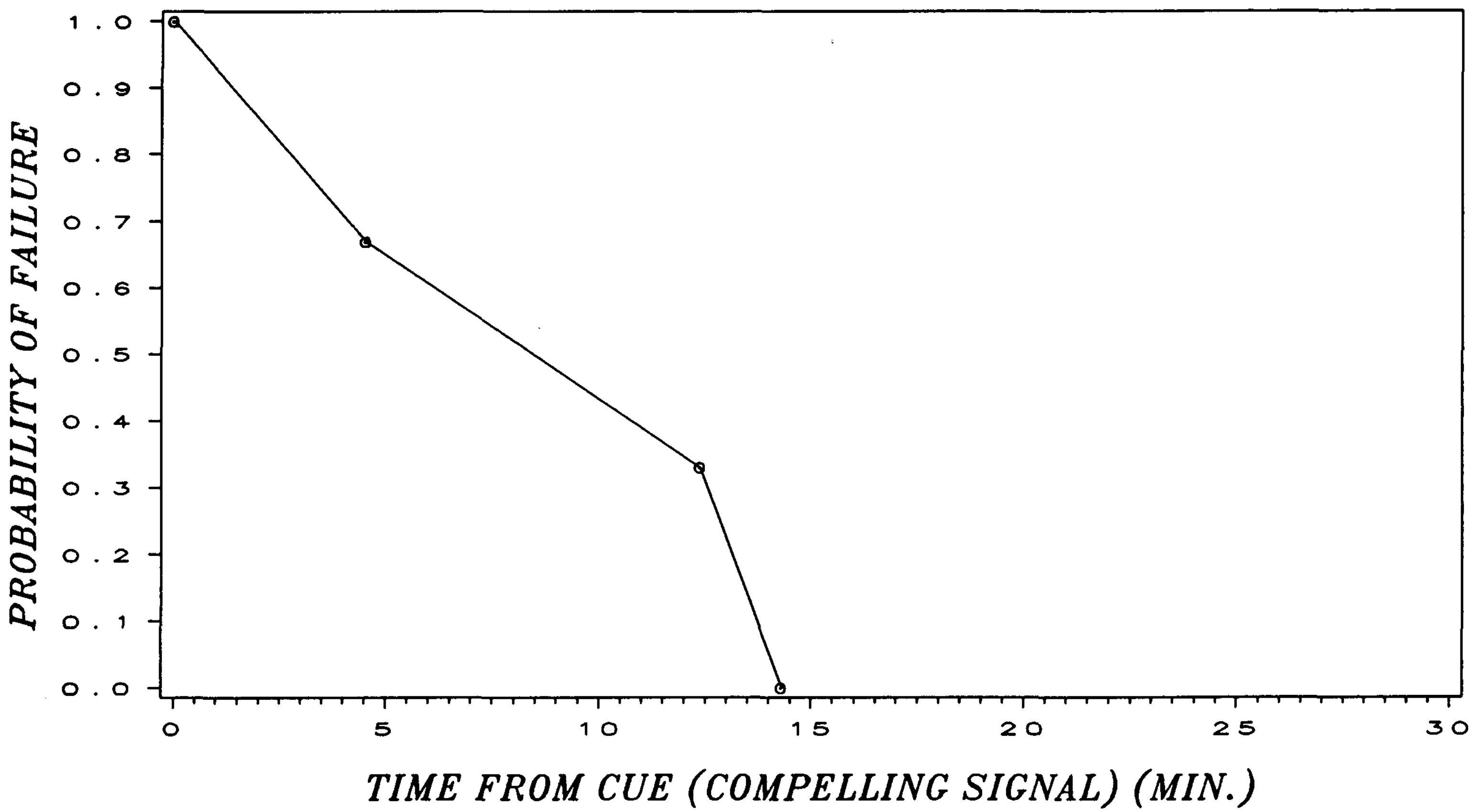
Sample size = 8.

Figure B.5.4-8. **Group 10, Empirical Probability of Failure to Request Use of Last Line of (GARBAGE) Systems for Level Control**



Sample size = 13.
Two crews are not counted in the curve since they failed to take appropriate actions as of 13.89 and 25.90 min. after the cue, the drill termination times. Those times were shorter than the last success time.

Figure B.5.4-9. Group 11, Empirical Probability of Failure to Locally Operate Manually Controlled Components Normally Operated from Control Room When Control-Room Operations Fail



Sample size = 3.

One crew was not counted in the curve since the crew failed to take appropriate action as of 9.7 min. after the cue, the drill termination time. This time was shorter than the last success time.

Figure B.5.4-10. Group 12, Empirical Probability of <u>Failure</u> to Manually Override a False Control Signal when no Direct Indication Exists that the Control Signal is False or Erroneous

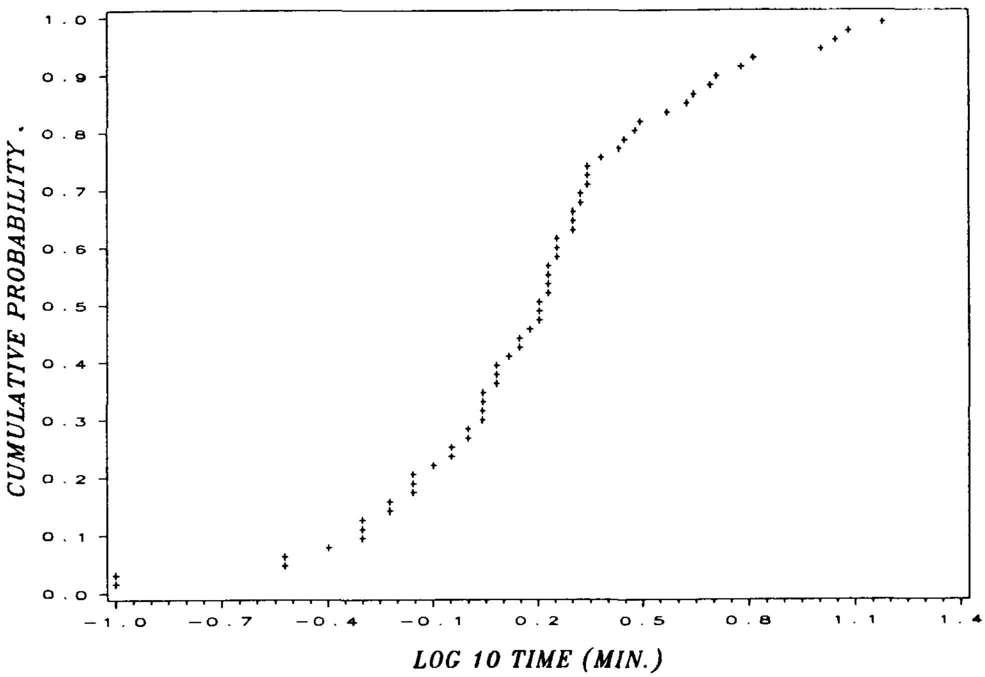


Figure B.5.5-1. Groups 1 and 9, Cumulative Probability of Success vs. Log 10 Time

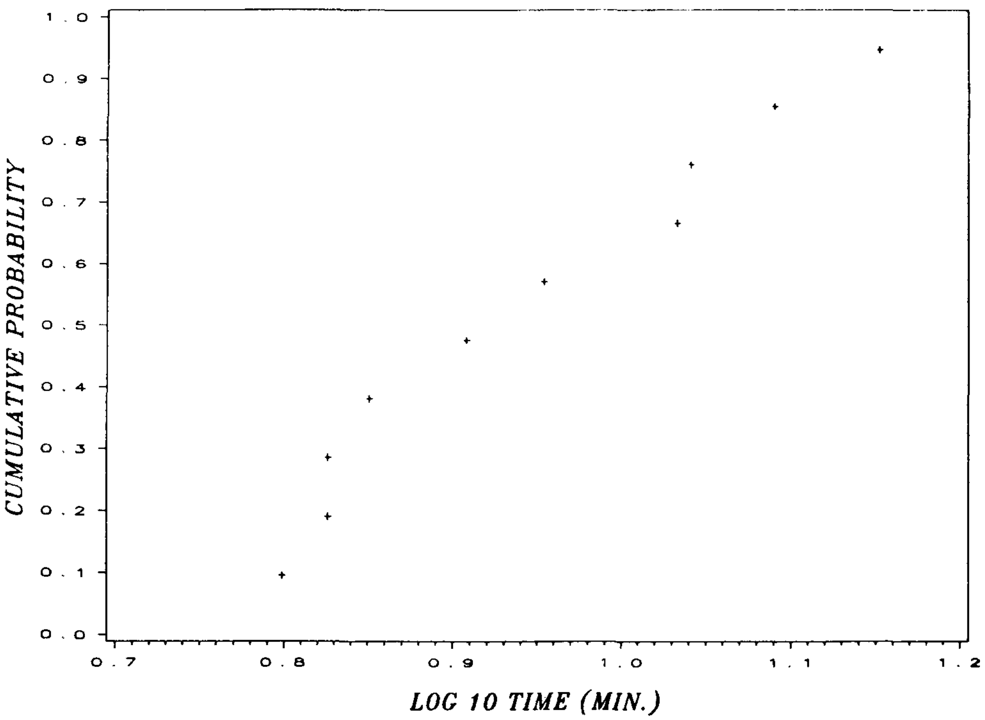


Figure B.5.5-2. Group 2, Cumulative Probability of Success vs. Log 10 Time

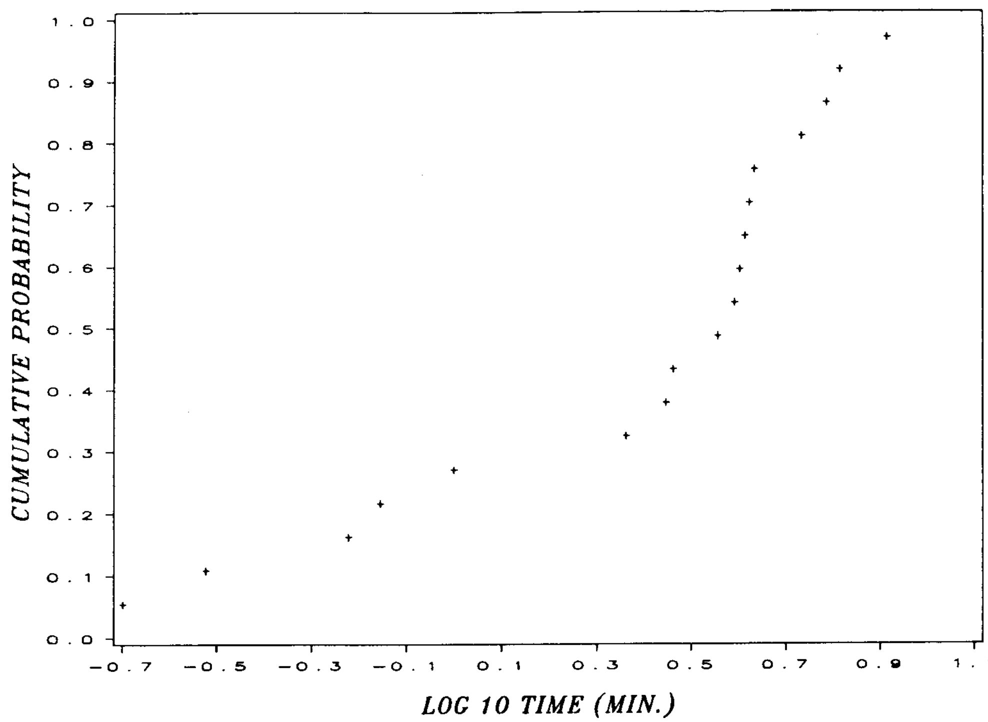


Figure B.5.5-3. **Group 3, Cumulative Probability of Success vs. Log 10 Time**

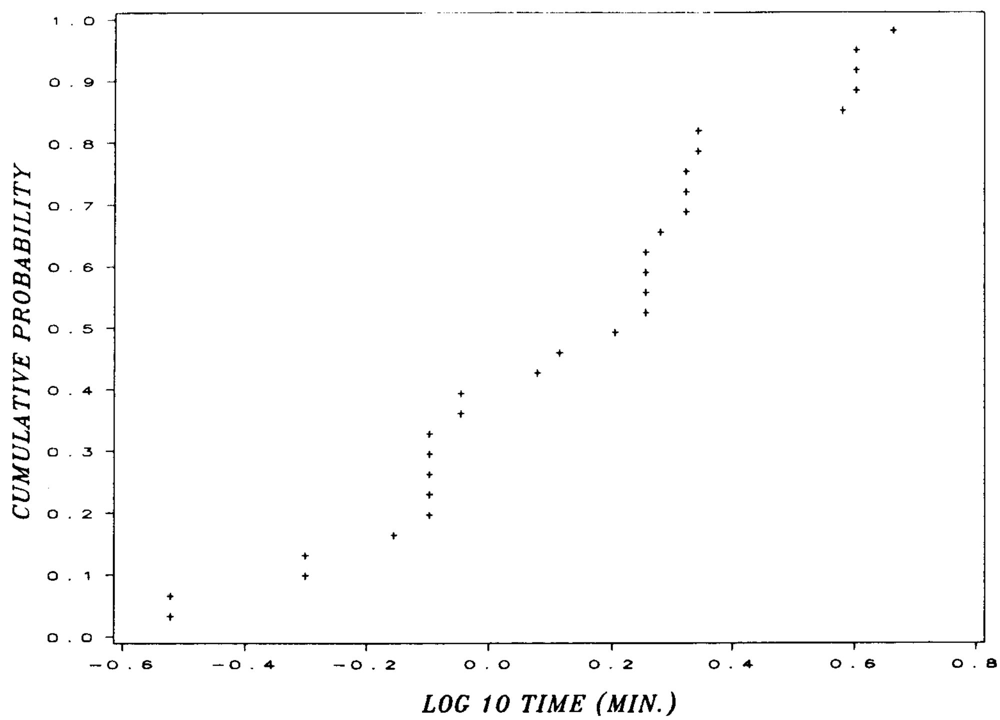
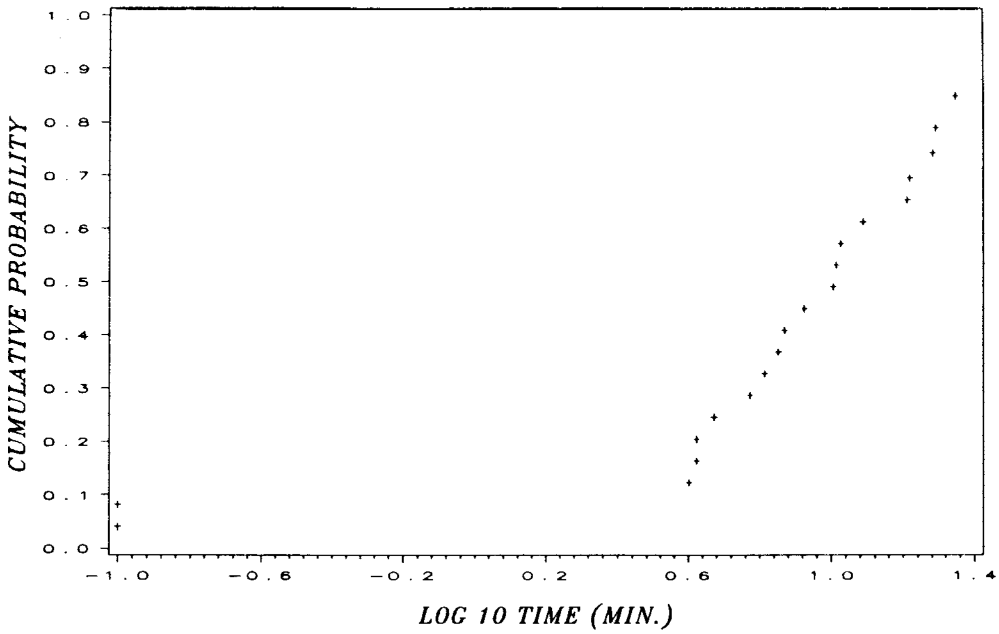


Figure B.5.5-4. **Group 4, Cumulative Probability of Success vs. Log 10 Time**



Two observations with shortest times were left censored to improve fit.
There were 4 right censored observations.

Figure B.5.5-5. **Group 5, Cumulative Probability of Success vs. Log 10 Time**

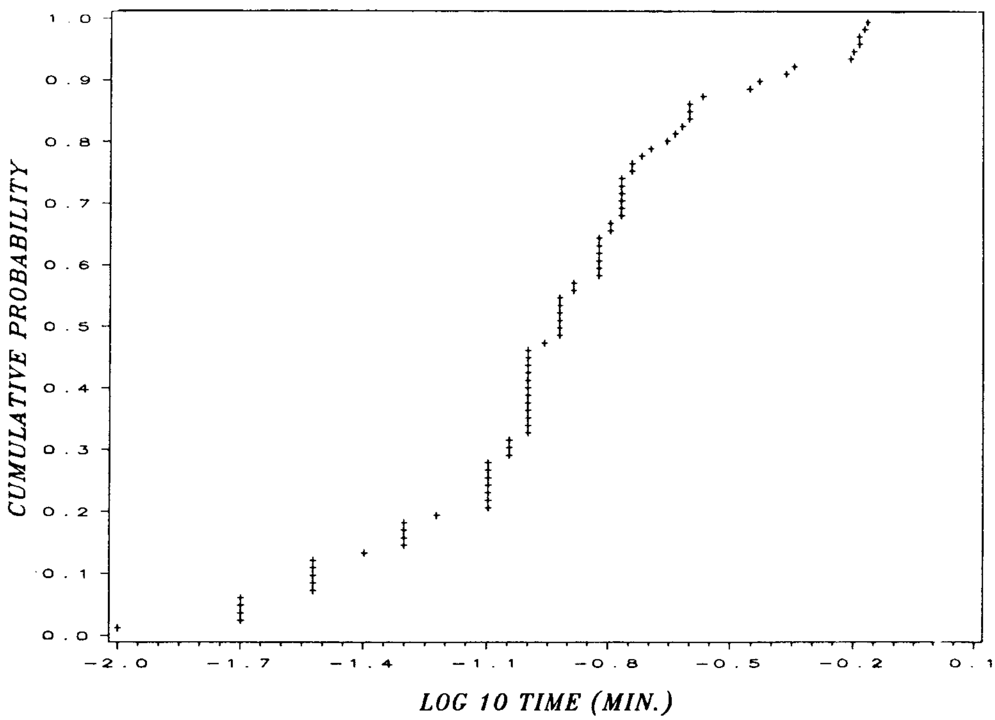
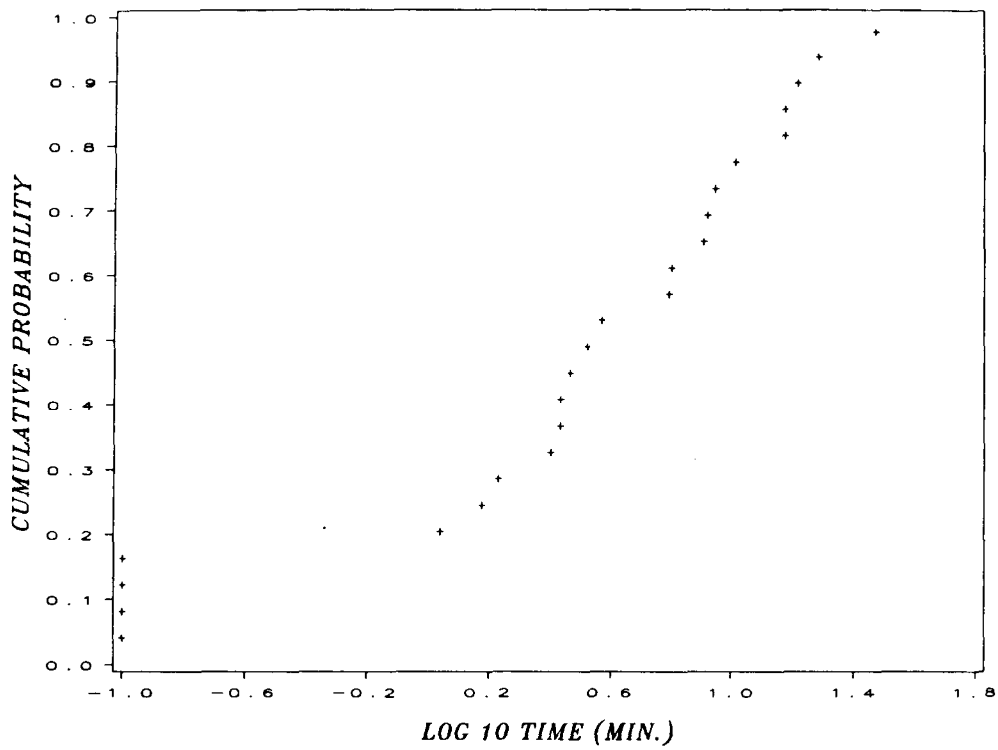


Figure B.5.5-6. **Group 6, Cumulative Probability of Success vs. Log 10 Time**



Four observations with the shortest times were left censored to improve the fit.

Figure B.5.5-7. Group 8, Cumulative Probability of Success vs. Log 10 Time

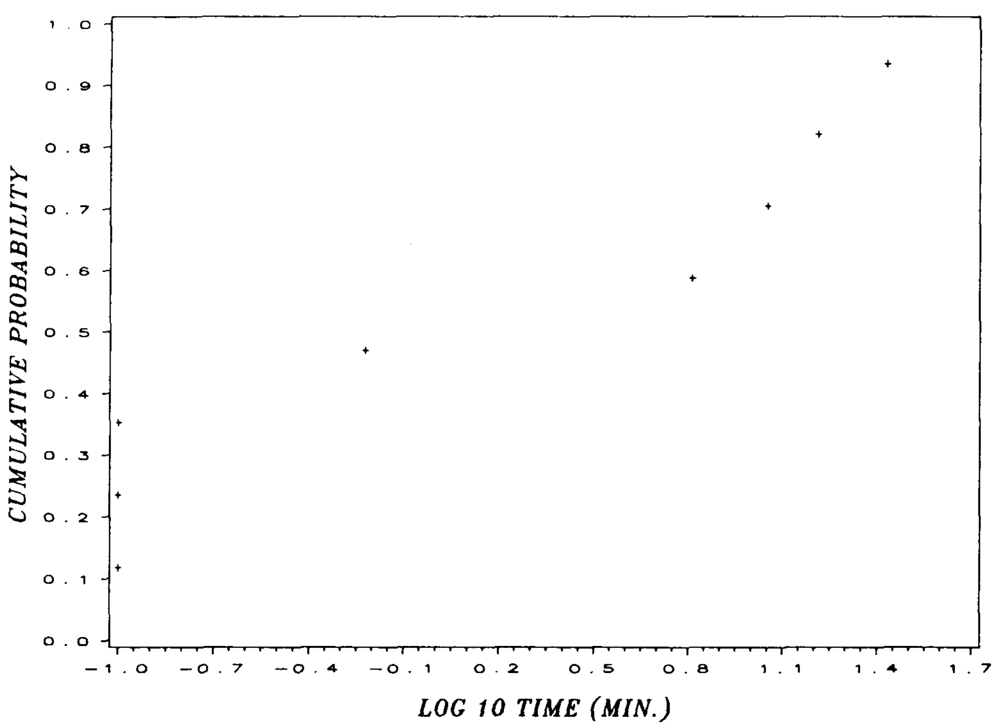
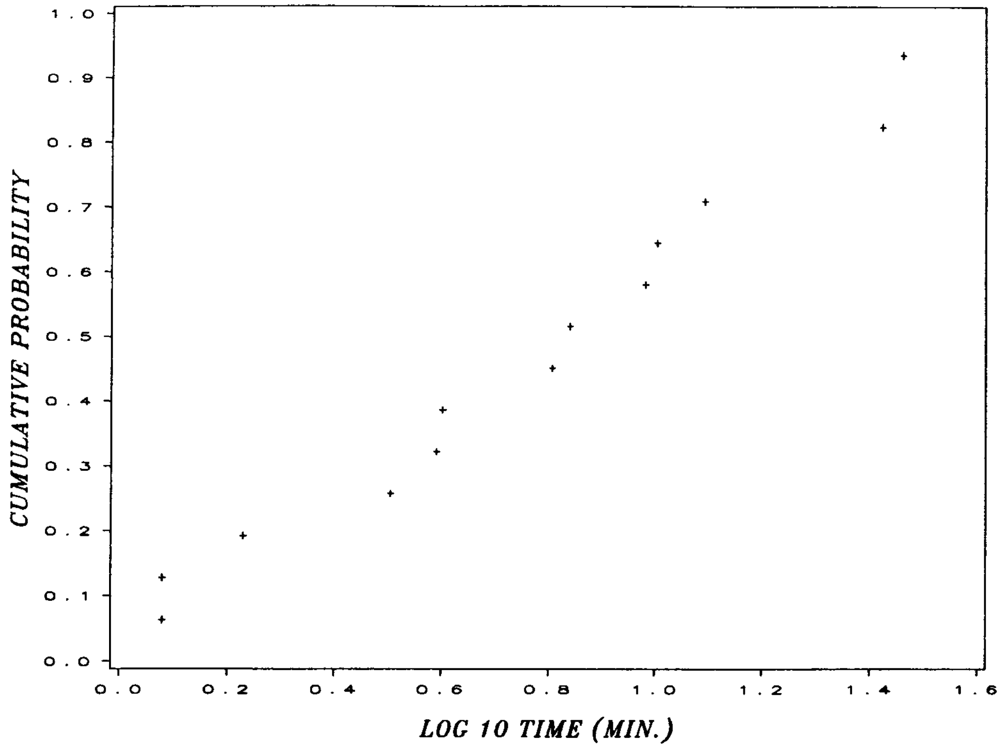
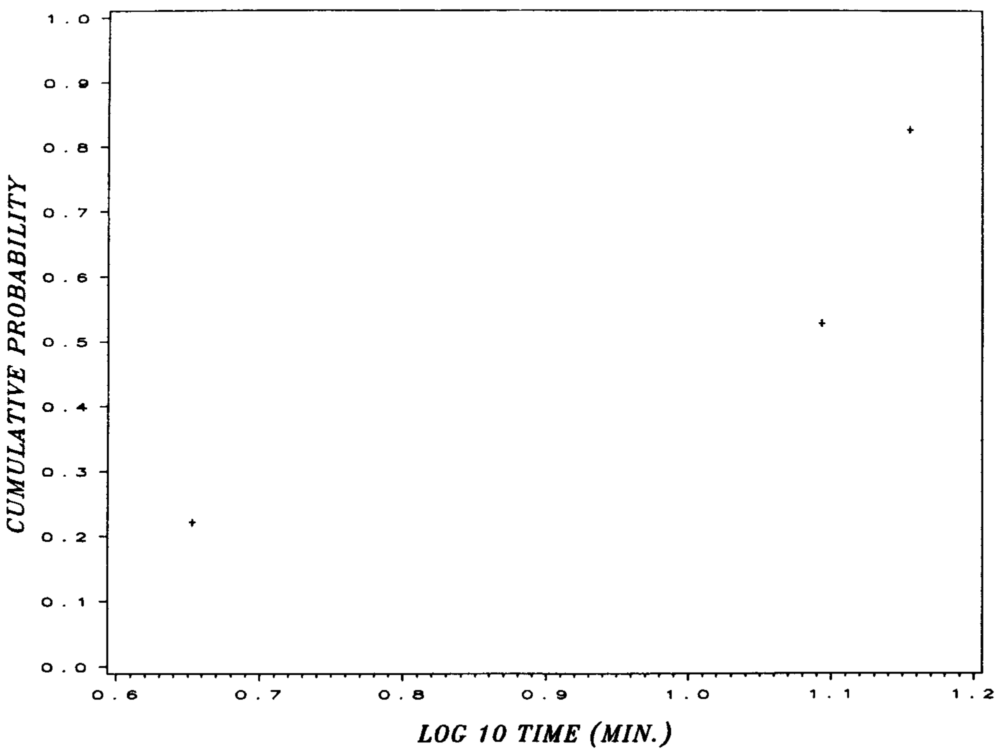


Figure B.5.5-8. Group 10, Cumulative Probability of Success vs. Log 10 Time



There were 2 right censored observations

Figure B.5.5-9. Group 11. Cumulative Probability of Success vs. Log 10 Time



There was one right censored observation.

Figure B.5.5-10. Group 12. Cumulative Probability of Success vs. Log 10 Time

Table B.5.5-1
Results of Tests to Determine Whether
Log Time Data Were Normally Distributed

Group	Statistic	Sample Size	Obtained Value	Prob.
1 and 9	Kolmogorov D	63	.10	.8
2	Shapiro-Wilk	10	.92	.4
3	Shapiro-Wilk	18	.86	<.01
4	Shapiro-Wilk	30	.95	.2
5	Shapiro-Wilk	18	.94	.3
6	Kolmogorov D	82	.14	<.01
8	Shapiro-Wilk	20	.96	.6
10	Shapiro-Wilk	8	.82	.06
11	Shapiro-Wilk	13	.95	.6
12	Shapiro-Wilk	3	.84	.2

sample size was very large (82), resulting in an extremely sensitive test such that even a small difference would produce a statistically significant result. Thus, these findings also show that the lognormal function provided a reasonably good fit to the data.

B.5.6 Fit of Lognormal Function to Diagnosis Time Data

Table B.5.6-1 summarizes estimated parameters from the fit of the lognormal function to the diagnosis time data. Figures B.5.6-1 through B.5.6-10 show plots of the fitted ccdfs. Each figure shows the point estimates and lower and upper 95% confidence limits. These confidence limits are calculated as part of the CENSOR program [17] and are therefore not discussed in detail in this volume. See Volume 2 for more discussion on confidence limits. The figures were terminated when the failure probability reached approximately 1.0E-3. Tables in Volume 2 show the same information as do the figures, but they provide more detail than the figures and are more suitable for PRA analyses.

B.6 Discussion and Recommendations

With only one exception, the analyses showed that the actions could be grouped according to their operational similarities. Thus, the operational grouping of actions appears to be a useful method to obtain estimates of diagnosis failure probabilities for PRA applications. However, it is recognized that, if more data are collected, the groupings could require refinements.

The analyses also showed that the lognormal function provided a reasonably good fit to the empirical data. Fitting of the lognormal function was a means to improve the accuracy of interpolations and extrapolations. It also allowed an evaluation of the uncertainty of estimated failure probabilities at specific times, information that is important for PRA analyses.

Further research would be of benefit in several areas. First, it would be valuable to determine whether different PRA analysts can categorize a set of actions into their appropriate groups in a consistent manner. Although there is little judgment involved in this categorization and major problems are not expected, the usability of the approach has not been tested. In addition, it would be useful to expand the definitions of the groups to include actions which, although they were not examined in this study, would fit into certain groups from an operation's standpoint. Relatively little effort and expense would be required to accomplish these important objectives.

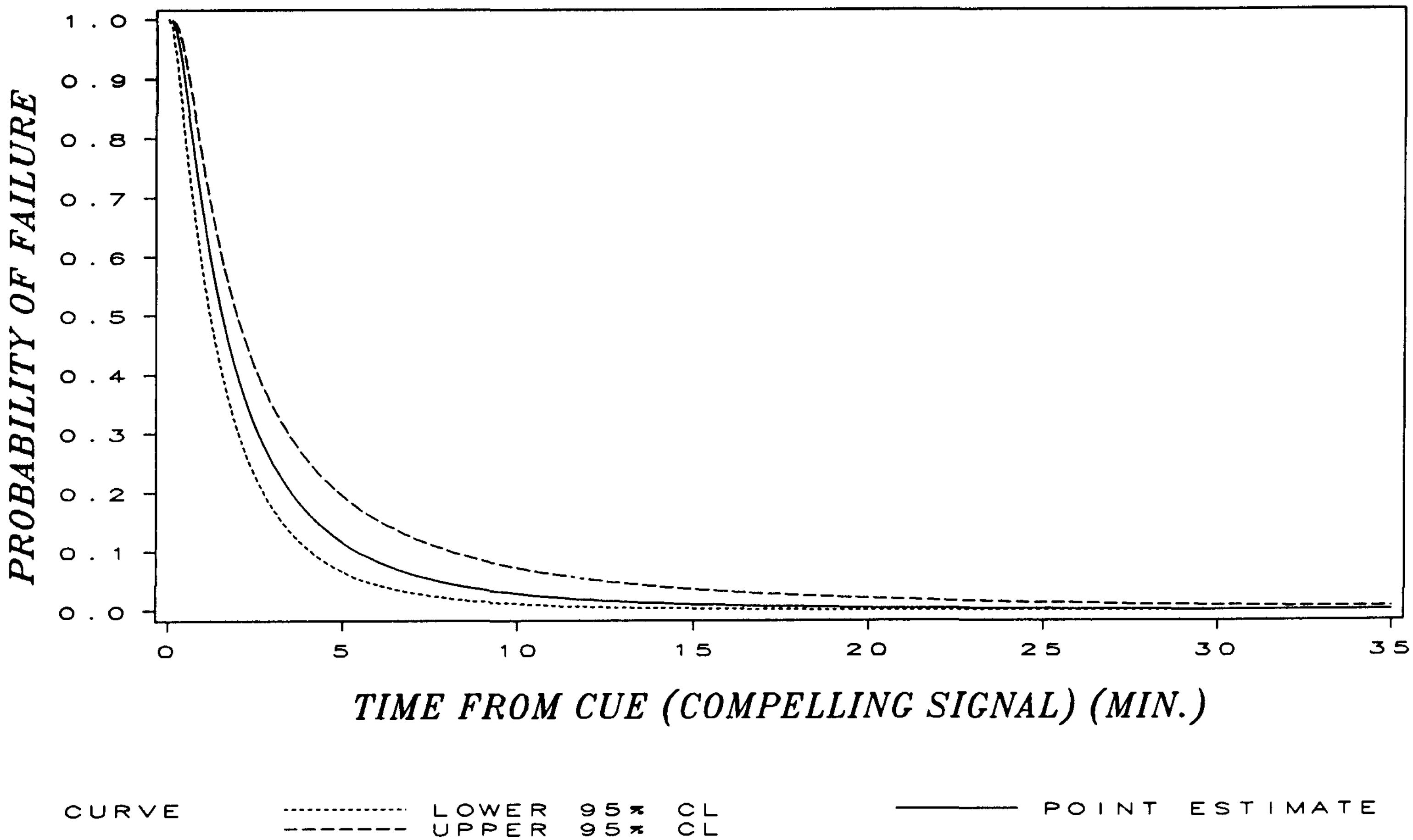
Second, the estimates in this report are specific to the LaSalle plant and should provide realistic information for the LaSalle PRA. However, it would be important to know the extent to which these estimates are valid for PRAs on other BWR plants

(Text continues on page B-138)

Table B.5.6-1
Estimated Parameters from Fit of Lognormal Function*

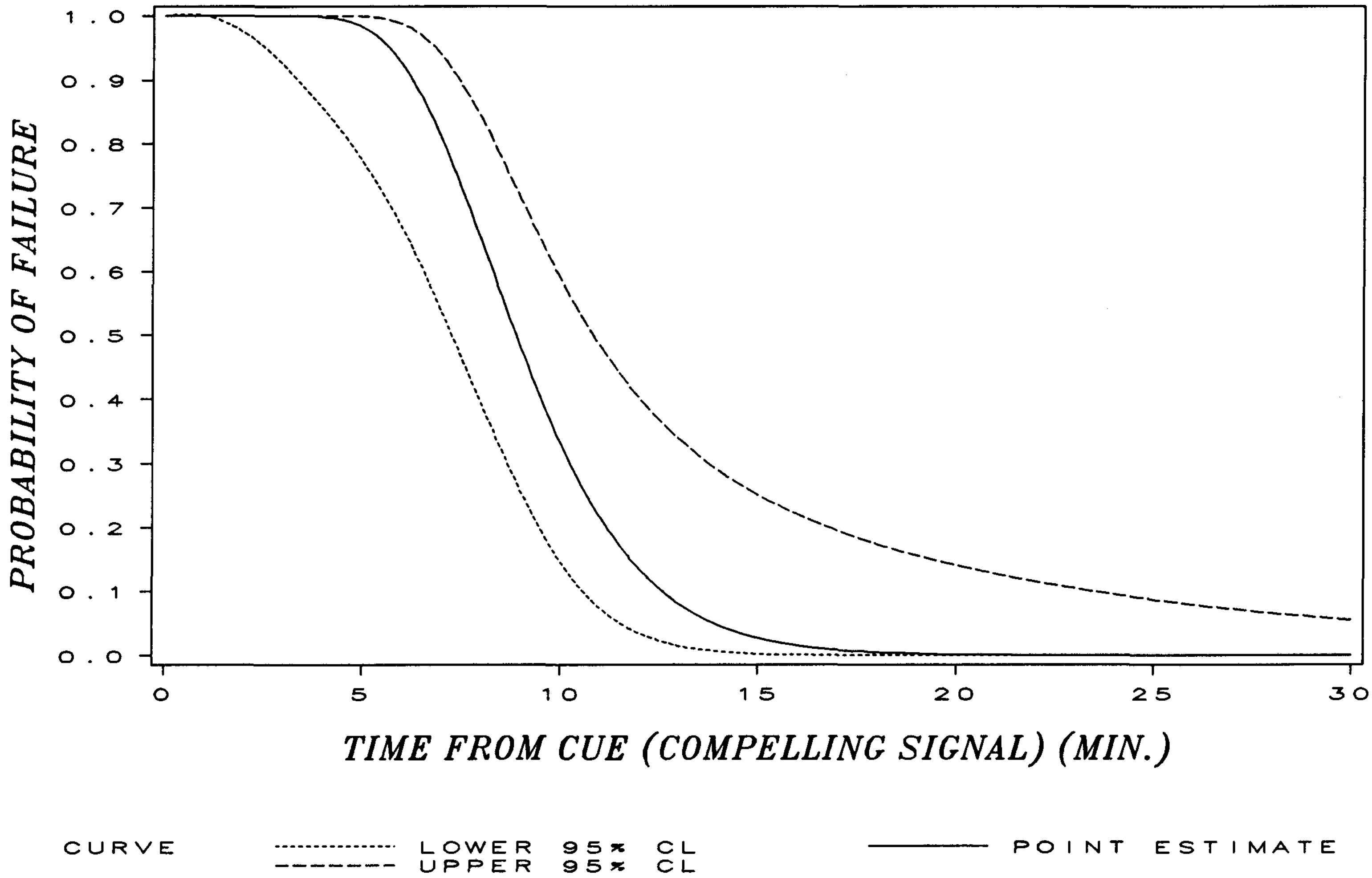
Group	Recovery Action Group Description	Median (mins.)	Mean of Log Time	Standard Deviation of Log Time	Sample Size
1 & 9	Manual operation of system or component to control a critical parameter prior to the automatic actuation (if it has automatic actuation) of the system or component.	1.6	.19	.43	63
2	Use low pressure systems when high pressure systems are unavailable.	8.9	.95	.12	10
3	Manual operation of systems or components which failed to automatically actuate (operate).	2.3	.36	.46	18
4	Restoration of safety-related in-house electrical buses or supply equipment.	1.4	.13	.32	30
5	Restoration of off-site-supplied non-safety-related electrical buses or supply equipment	11.2	1.05	.44	24
6	Manual backup of an automatic shutdown function.	.1	-0.93	.38	82
8	Manual override of system that automatically functions when automatic operation of the system would challenge a critical parameter.	3.8	.58	.52	24
10	Request use of last line of (GARBAGE)** systems for level control.	1.4	.16	1.01	8
11	Local operation of manually controlled components normally operated from the control room when control-room operation fails.	7.1	.85	.50	15
12	Manual override of a false control signal when no direct indication exists that the control signal is false or erroneous.	10.5	1.02	.23	4

*The items listed in this table refer to the correct diagnosis of the required action.
**GARBAGE systems are those systems which are used only as a last resort to prevent core damage. These systems inject "dirty" (non-reactor grade) water into the vessel and are used only if no other means of injecting water into the vessel are available.



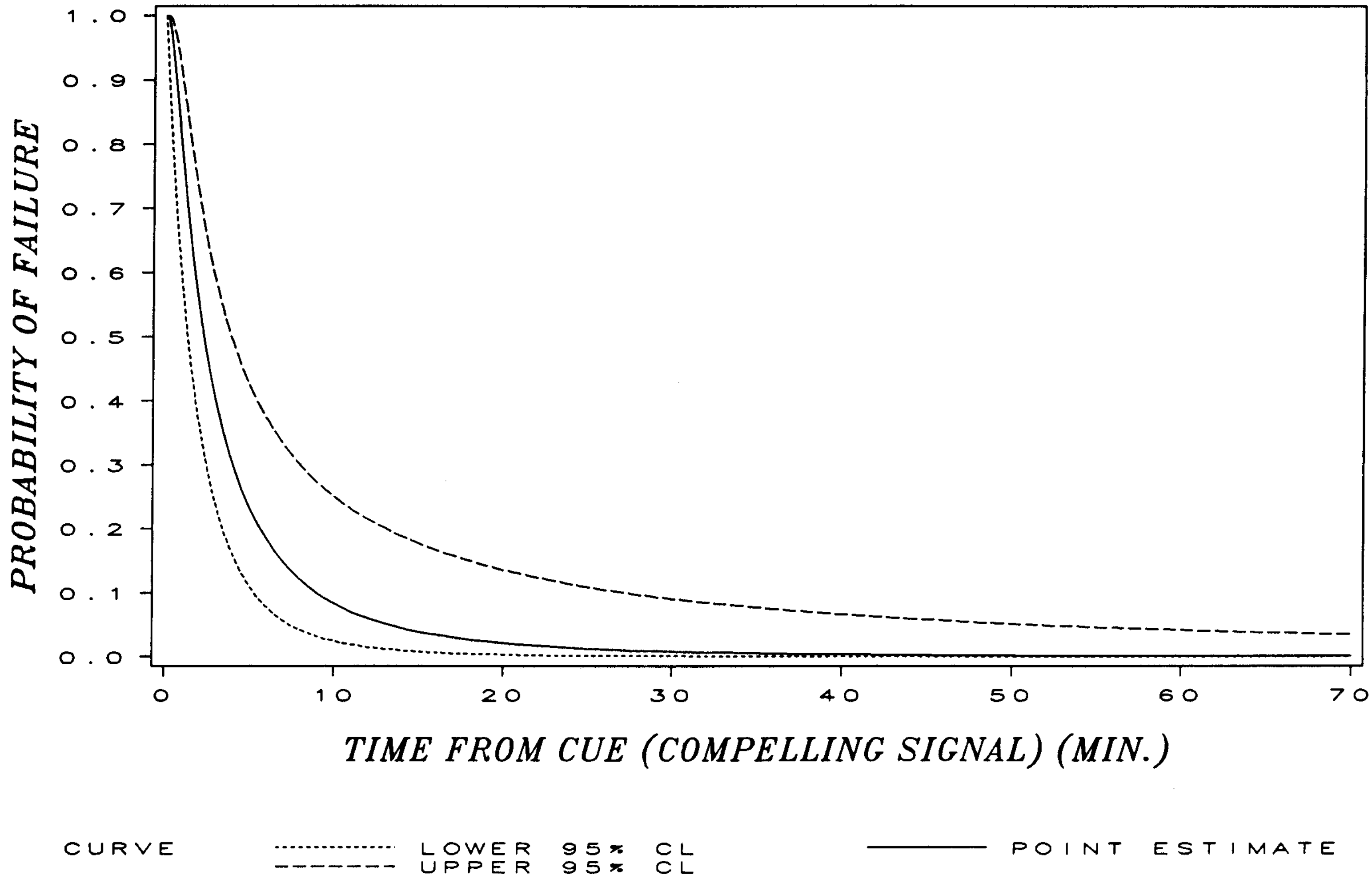
CL = Confidence Limit.
Group 9 combined with Group 1.
Lognormal function fitted to data (N=63, μ = .19, σ = .43).

Figure B.5.6-1. Group 1, Probability of Failure to Manually Operate a System or Component to Control a Critical Parameter Prior to the Automatic Actuation (if it Has Automatic Actuation) of the System or Component



CL = Confidence Limit.
Lognormal function fitted to data (N=10, μ = .95, σ = .12).

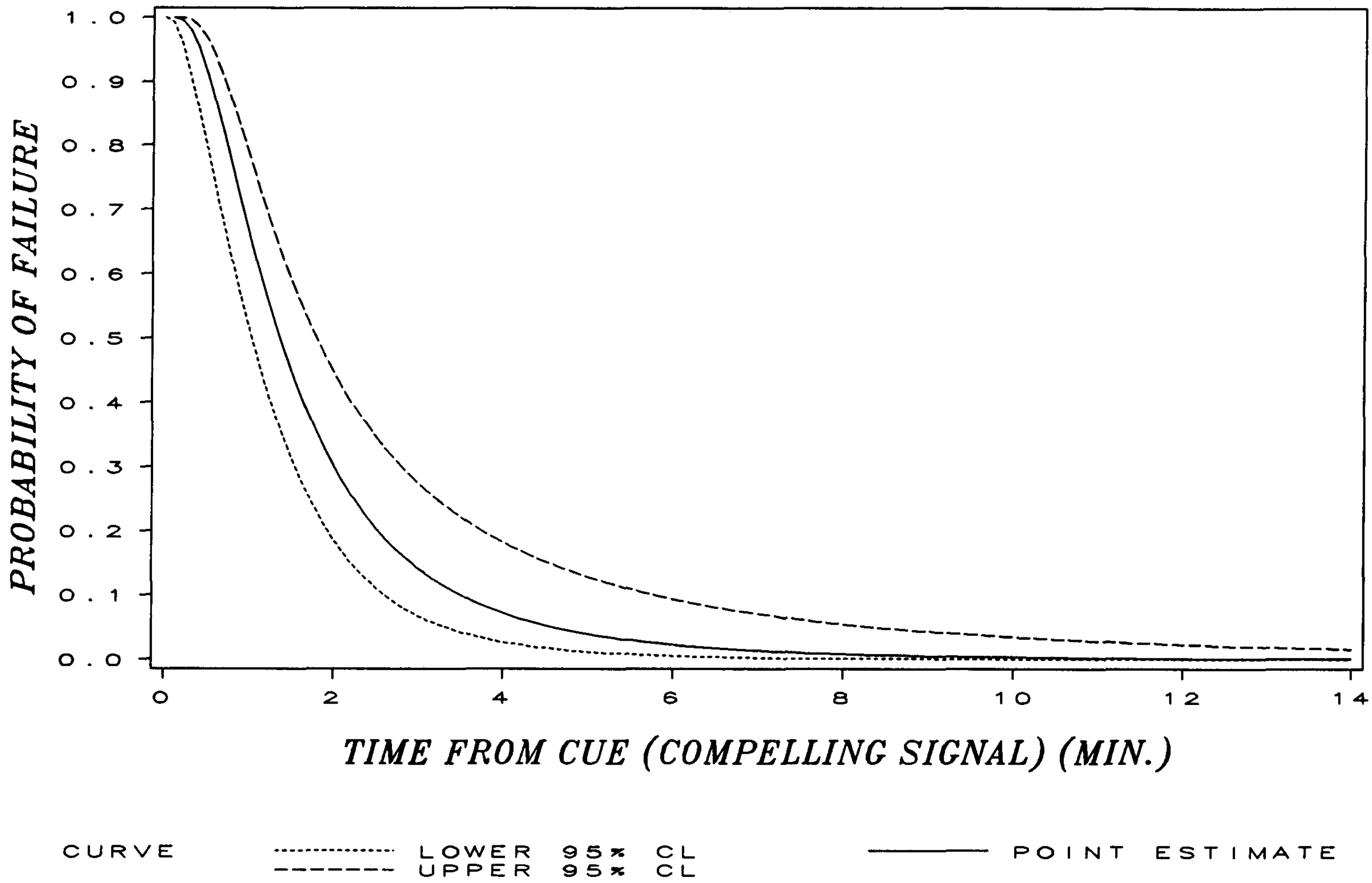
Figure B.5.6-2. **Group 2, Probability of Failure to Use Low Pressure Systems when High Pressure Systems Are Unavailable**



CL = Confidence Limit.

Lognormal function fitted to data (N=18, μ = .36, σ = .46).

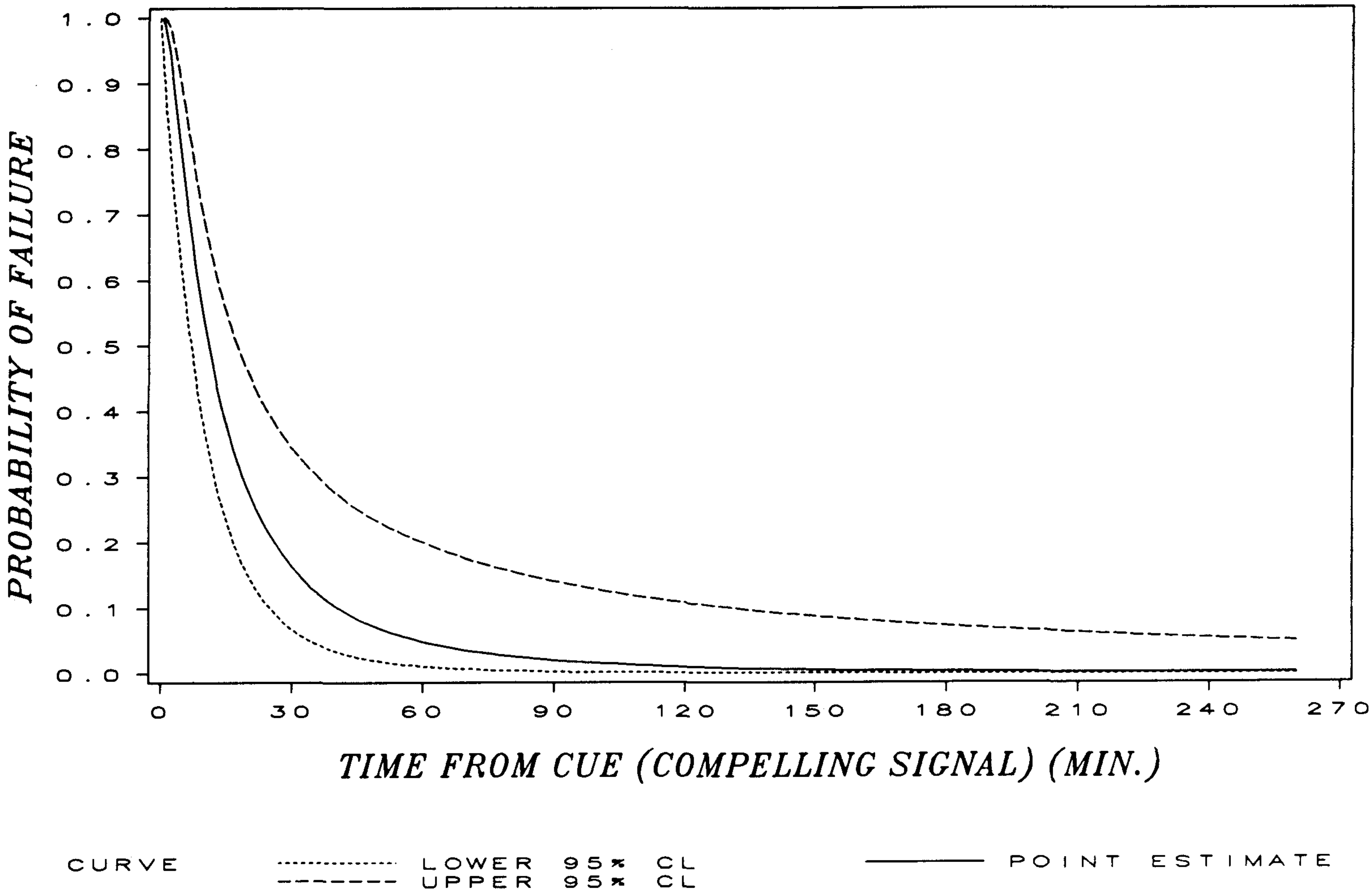
Figure B.5.6-3. Group 3, Probability of <u>Failure</u> to Manually Operate Systems or Components which Failed to Automatically Actuate (Operate)



CL = Confidence Limit.

Lognormal function fitted to data (N=30, μ = .13, σ = .32).

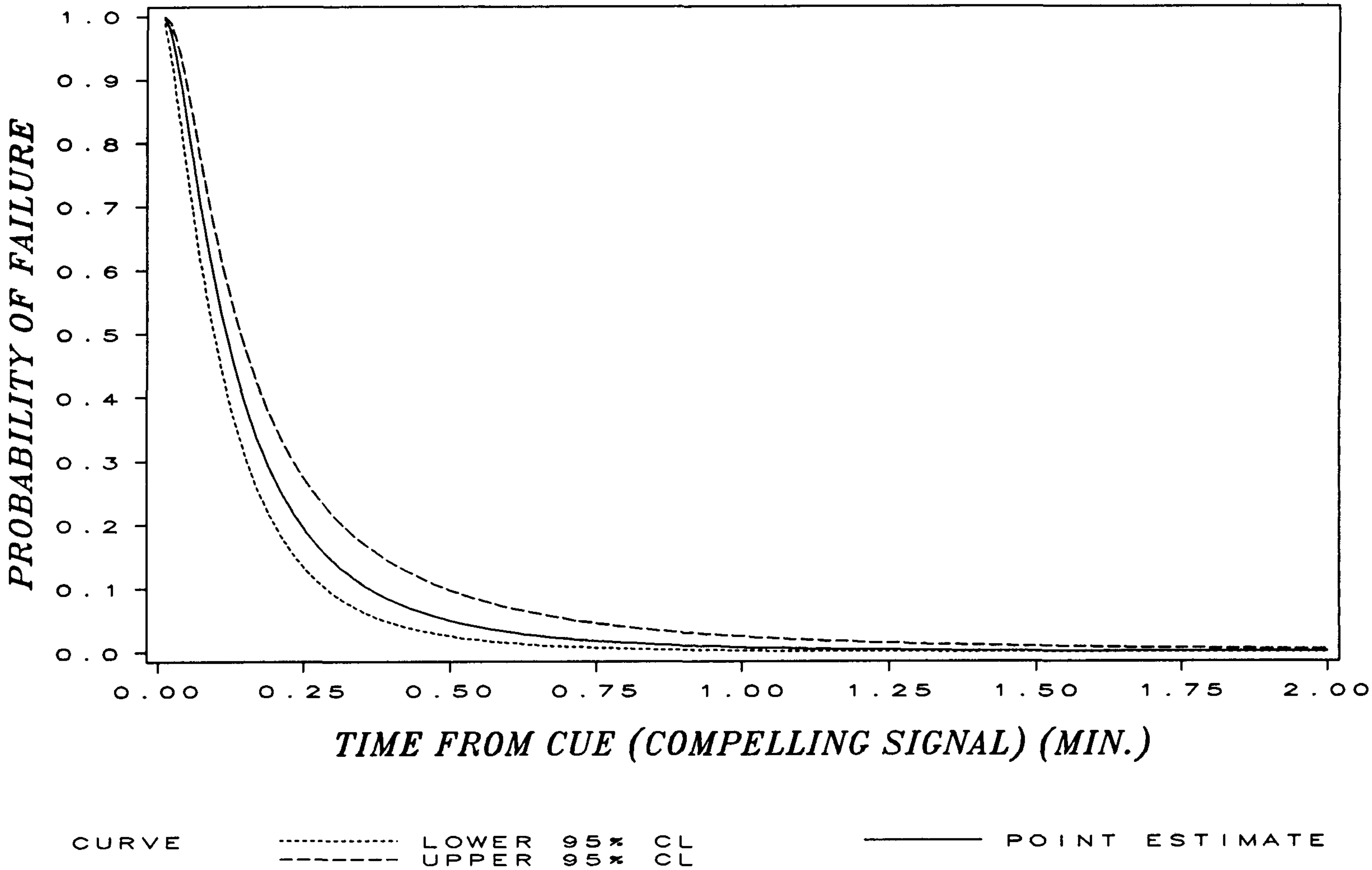
Figure B.5.6-4. Group 4, Probability of <u>Failure</u> to Restore Safety-Related In-House Electrical Buses or Supply Equipment



CL = Confidence Limit.

Lognormal function fitted to data (N=24, μ = 1.05, σ = .44).

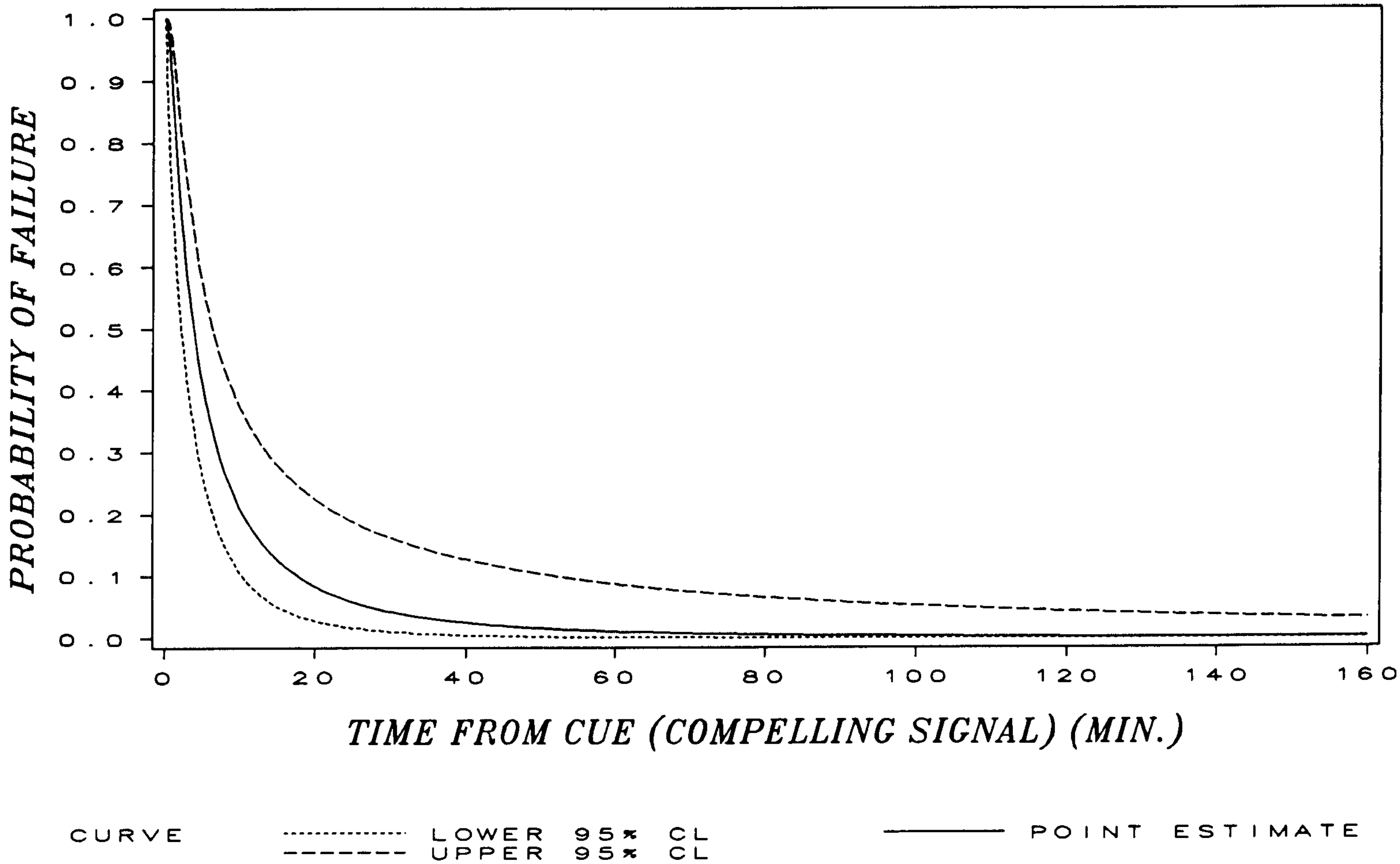
Figure B.5.6-5. Group 5, Probability of Failure to Restore Off-Site-Supplied Non-Safety-Related Electrical Buses or Supply Equipment



CL = Confidence Limit.

Lognormal function fitted to data (N=82, $\mu = -.93$, $\sigma = .38$).

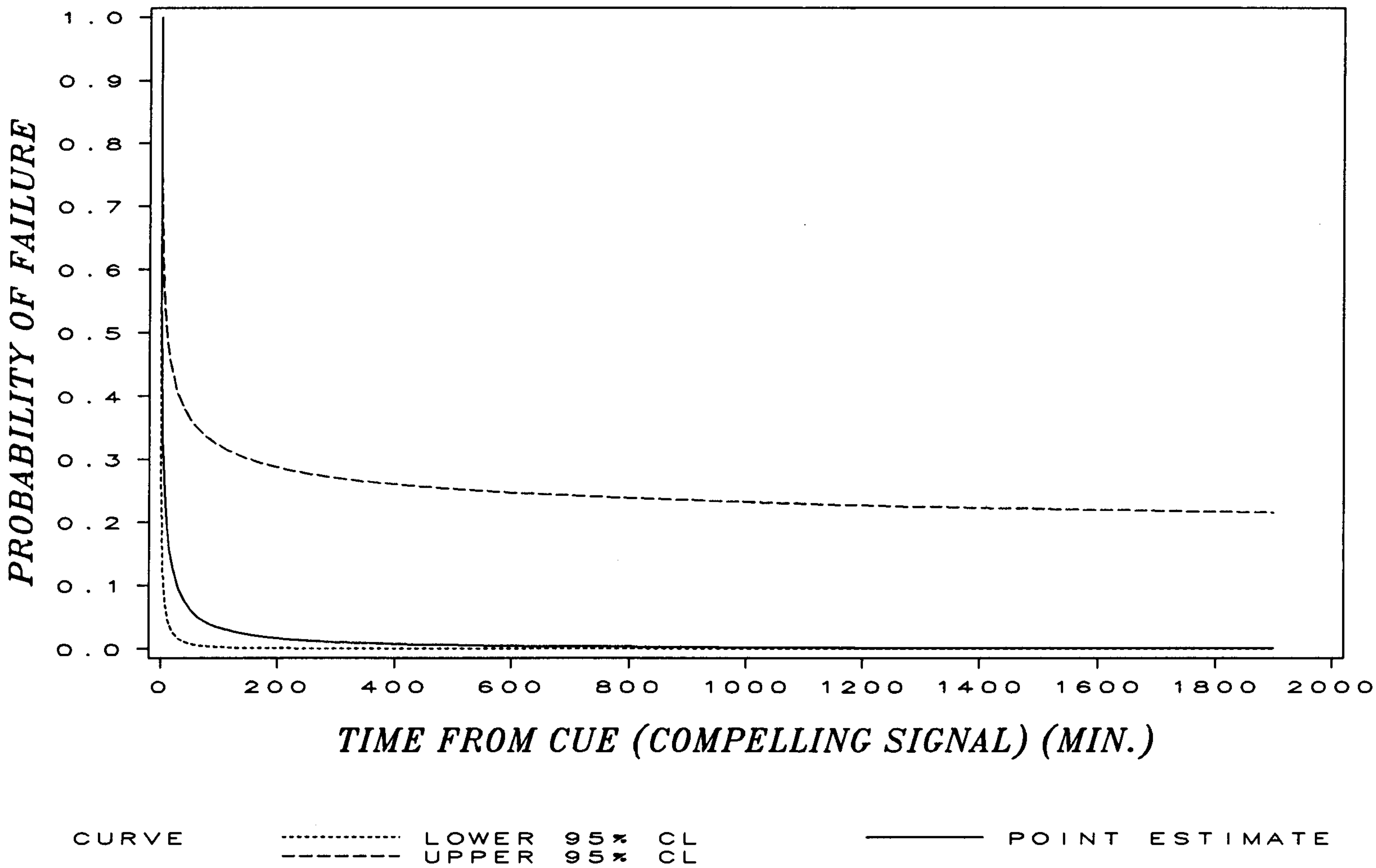
Figure B.5.6-6. **Group 6, Probability of <u>Failure</u> to Perform Manual Backup of an Automatic Shutdown Function**



CL = Confidence Limit.

Lognormal function fitted to data (N=24, μ = .58, σ = .52).

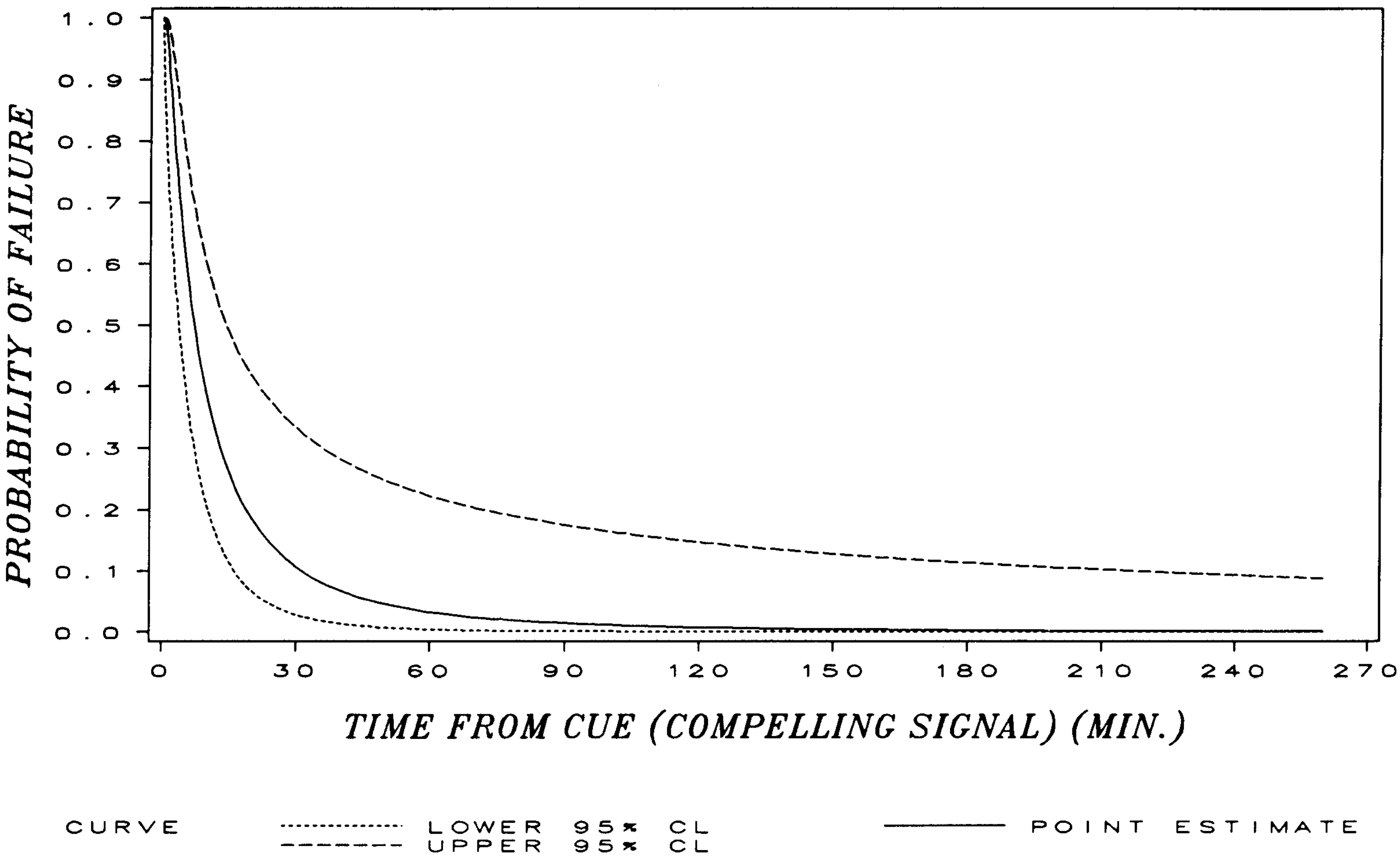
Figure B.5.6-7. Group 8, Probability of Failure to Manually Override a System that Automatically Functions when Automatic Operation of the System Would Challenge a Critical Parameter



CL = Confidence Limit.

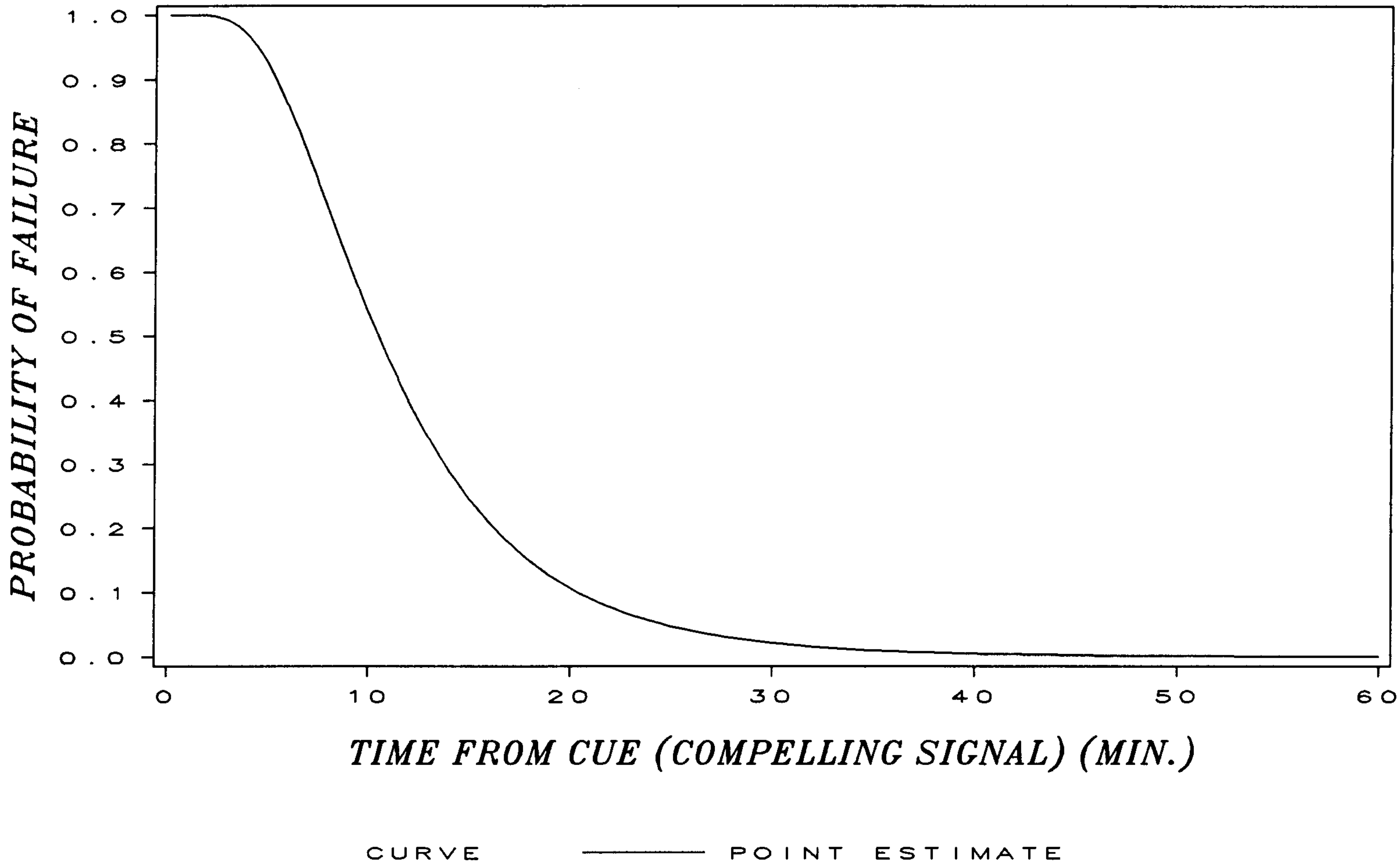
Lognormal function fitted to data (N=8, μ = .16, σ = 1.01).

Figure B.5.6-8. Group 10, Probability of Failure to Request Use of Last Line of (GARBAGE) Systems for Level Control



CL = Confidence Limit.
Lognormal function fitted to data (N=15, μ = .85, σ = .50).

Figure B.5.6-9. Group 11, Probability of <u>Failure</u> to Locally Operate Manually Controlled Components Normally Operated from Control Room when Control-Room Operation Fails



There were insufficient data to generate meaningful confidence limits.
Lognormal function fitted to data (N=4, μ = 1.02, σ = .23).

Figure B.5.6-10. Group 12, Probability of Failure to Manually Override a False Control Signal when no Direct Indication Exists that the Control Signal is False or Erroneous and on PWR plants. Differences in factors such as plant configuration and procedures and crew composition and training could affect crew performance. The extent to which the estimates in this report can be applied to PRAs at other NPPs could be determined by collecting simulator data at other types of plants and repeating the analyses that were performed in this study. It is not recommended that the estimates in this report be used to perform PRAs on other plants without, at least, prior analyses of plant and crew differences.

Finally, in this study, no attempt was made to calibrate the simulator data to take into consideration any differences that may exist between simulator and "real world" conditions. Measures were taken in this study to enhance the reliability and realism of the simulations. These measures included testing of the drills on the LaSalle simulator prior to actual data collection, simulation of actions outside the control room that were requested by crews (e.g., checking valves) with simulated time delays, data collection by multiple observers, and prevention of interruptions by instructors during the simulation runs. There was also evidence of stress responses in the crew members. This included high involvement (e.g., running to accomplish actions), impatience (e.g., asking whether requested actions had been accomplished yet), subtle appeals for help from the instructors, perseveration (repeating the same unsuccessful action more than once), and obvious fatigue. It is not known whether the stress levels present here are as high as what one would expect when confronted with a real-world abnormal event, but one can conclude that the crew members were stressed to a significant degree.

Nevertheless, a formal analysis of potential differences between the simulator and real-world conditions was not undertaken. Therefore, one additional avenue of research would be to assess the extent of such differences and to perform any necessary and possible calibrations.

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