EGG-EA-6296

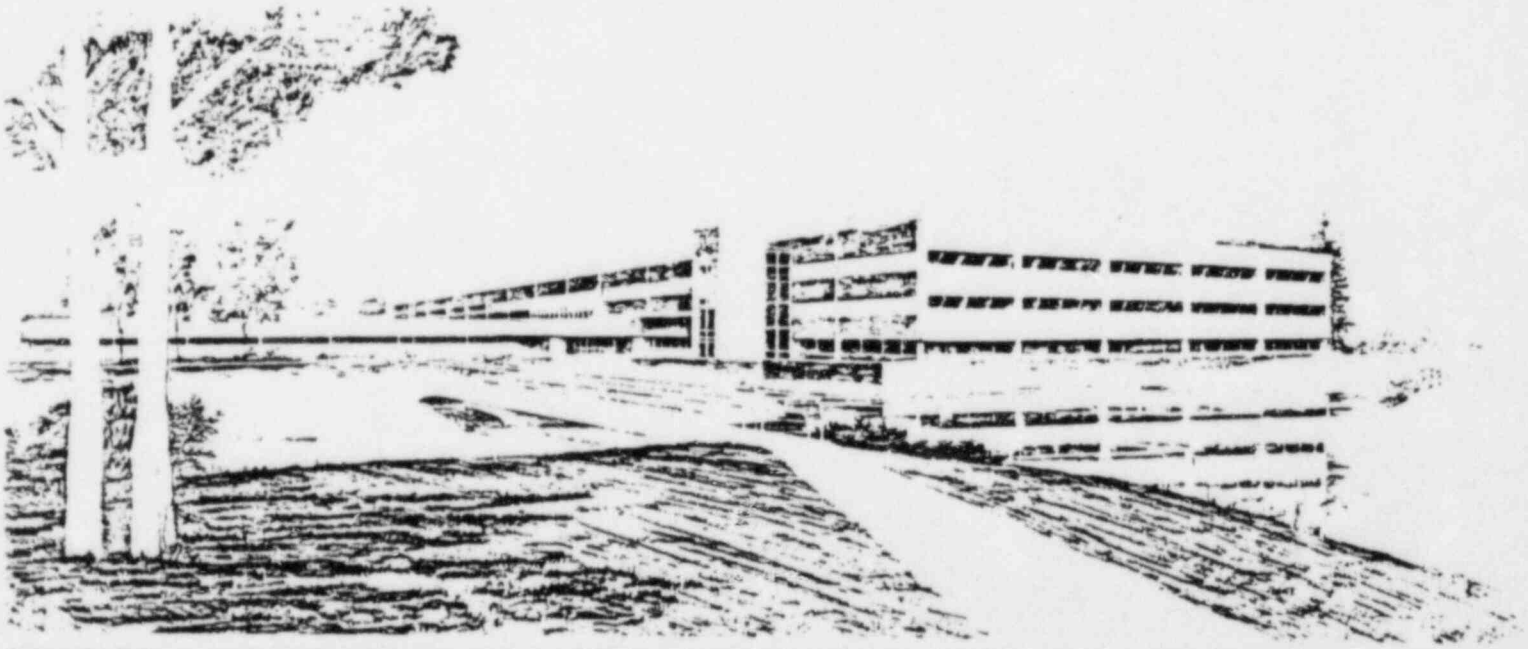
MAY 1983

BROWNS FERRY OTHER TRANSIENTS FAILURE MODES AND EFFECTS ANALYSIS AND REJECTED SYSTEMS JUSTIFICATION REPORT

D. E. Baxter
D. M. Beahm
S. J. Bruske

PRELIMINARY

Idaho National Engineering Laboratory
Operated by the U.S. Department of Energy



This is an informal report intended for use as a preliminary or working document

Prepared for the
U.S. NUCLEAR REGULATORY COMMISSION
Under DOE Contract No. DE-AC07-76ID01570
FIN No. A6477

EG&G Idaho

EGG-EA-6286

BROWN'S FERRY "OTHER TRANSIENTS" FAILURE MODE AND EFFECTS ANALYSIS AND REJECTED SYSTEMS JUSTIFICATION REPORT

D. E. Baxter
D. M. Beahm
S. J. Bruske

Published May 1983

EG&G Idaho, Inc.
Idaho Falls, Idaho 83415

Prepared for the
U.S. Nuclear Regulatory Commission
Under DOE Contract No. DE-AC07-76ID01570
FIN No. A6477

ABSTRACT

Recently concerns dealing with the possibility that certain accidents or transients could be made more severe by control system failures or malfunctions have been raised. These concerns have been documented under Unresolved Safety Issue (USI) A-47, Safety Implications of Control Systems. This EG&G Idaho, Inc., report represents the first phase of a detailed study being performed to evaluate the effects of control system failures on anticipated transients and accidents. This first phase consists of the Failure Mode and Effects Analysis (FMEA) for the Brown's Ferry Other Transients. The FMEA has been performed on all the major control grade systems identified in the Brown's Ferry Final Safety Analysis Report (FSAR). This report also contains the postulated transient scenarios for the systems that have been selected for further in-depth reviews and the justification report for those systems selected as not being capable of creating or contributing to the transient.

SUMMARY

The purpose of this study is to determine which system or systems at commercial Boiling Water Reactor (BWR) units could cause or contribute to any other transients. The other transients of concern are those transients that have been analyzed in the Final Safety Analysis Report (FSAR) with the exception of the overfill and overcooling transients.

A study of the Nuclear Power Experiences and Licensee Event Reports for the years of 1980 to 1982 was performed in an attempt to identify all other transients of concern that have actually occurred. An independent nonmechanistic Failure Mode and Effects Analysis (FMEA) was performed on the major control systems utilized at BWRs to determine which system failures or normal operations could result in any of the other transients.

The results of these reviews have indicated a need to perform in-depth detailed reviews of the major control systems to determine the total extent to which they can cause or contribute to any of the other transients. The postulated basic scenarios of system failure or operation are included in this report to better define why a system has been selected for the in-depth reviews. The in-depth reviews will determine which systems will require modeling and the specific transient scenarios of concern and will be documented in a later report.

FOREWORD

This report is supplied as part of the "Safety Implications of Control System Failures A-47" study being conducted for the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Division of Safety Technology by EG&G Idaho, Inc., NRC Licensing Support Section.

The U.S. Nuclear Regulatory Commission funded the work under the authorization B&R 20-19-50-51-5, FIN No. A6477.

CONTENTS

OTHER TRANSIENTS FAILURE MODES AND EFFECTS ANALYSIS

1. INTRODUCTION

EG&G Idaho, Inc. is technically supporting the Nuclear Regulatory Commission in their efforts to resolve the generic issue on the Safety Implications of Control System Failures A-47. The concern of the A-47 study is to determine if any accidents or transients can be initiated or made more severe than previously analyzed as a result of control system failures or malfunctions. This report addresses the analysis performed to determine if nonmechanistic system failures have the potential to cause or contribute to the severity of any other transients. Other transients encompasses all of the transients analyzed in the Final Safety Analysis Report with the exception of reactor overfill and overcooling transients which have been addressed individually in separate reports. It also includes additional items of concern which include, frequency of transients, actuation of Engineered Safety Features Systems, actuation of Reactor Protection Systems and violations of the Technical Specification safety limits.

By use of a Failure Mode and Effects Analysis (FMEA) and postulated scenarios, the systems are processed and placed in a further review status or rejected from further review. Systems identified as requiring further review will be subjected to a detailed study to determine if any mechanistic failure potential exists to cause the undesired failure. These systems will be evaluated and if necessary will be computer modeled. Transients of significant concern will be analyzed and the results evaluated to provide recommendations for the resolution of Unresolved Safety Issue (USI) A-47, Safety Implications of Control System Failures.

2. METHOD OF ANALYSIS

A Failure Modes and Effects Analysis was performed to determine which systems would require more detailed analysis.

The FMEA is a qualitative analysis which identifies possible nonmechanistic system failure modes and evaluates the effect of the failures on plant performance relating to other transients; the FMEA tables are contained in Appendix B.

3. ASSUMPTIONS

The following assumptions were utilized in this FMEA. A complete listing of the A-47 selection criteria is included as Appendix A.

Any failures which could be postulated to meet the following criteria were recommended for further review.

1. Any control grade system or component failure, either initiating or aggravating, which results in an undesired nuclear system pressure increase beyond the bounds of the present Final Safety Analysis Report (FSAR) analysis results will be recommended for further review.

2. Any control grade system or component failure, either initiating or aggravating, which results in an undesired positive reactivity increase beyond the bounds of the present FSAR analysis results will be recommended for further review.

3. Any control grade system or component failure, either initiating or aggravating, which results in an undesired reactor vessel inventory decrease beyond the bounds of the present FSAR analysis results will be recommended for further review.

4. Any control grade system or component failure, either initiating or aggravating, which results in an undesired reactor core coolant flow decrease beyond the bounds of the present FSAR analysis results will be recommended for further review.

5. Any control grade system or component failure, either initiating or aggravating, which results in an undesired reactor core coolant flow increase beyond the bounds of the present FSAR analysis results will be recommended for further review.

6. Any control grade system or component failures which are projected to cause transients identified as incidents of moderate frequency to occur at a rate significantly more frequent than once per year, or failures which are projected to cause transients identified as infrequent incidents to occur more than once during the lifetime of a plant, or failures which are projected to cause limiting faults will be recommended for further review.

7. Any control grade system or component failures which would adversely affect any assumed or anticipated operator action during the course of a particular transient will be recommended for further review.

8. Any control grade system or component failures which result in manual or automatic actuation of engineered safety features, including the reactor protection system, will be recommended for possible further in-depth review.

9. Any control grade system or component failures which result in exceeding any technical specification safety limit will be recommended for further review.

Operator error was not considered as a failure mode with respect to system operation. However, system failures which could affect correct or timely operator action were identified and recommended for further review.

4. SYSTEM DESCRIPTION

The systems which were evaluated in the FMEA tables were extracted from the systems as identified in the Browns Ferry Final Safety Analysis Report (FSAR). The systems which were evaluated represent the major nonsafety grade systems which are used for reactor plant control. Many systems have several subsystems or support systems associated with them which were not specifically listed in the FMEA. However, failures of these systems were factored into the analysis by considering a support or subsystem failure to result in a nonmechanistic failure of the major system.

5. CONCLUSIONS

Utilizing the nonmechanistic, qualitative FMEA format, 25 of the 56 major control systems indicated a need for further, more detailed review. These systems, with a brief discussion indicating failure mode of concern, plant conditions at which the failures would be most limiting and the postulated effects of the failures are listed in Appendix C.

The remaining systems and the justification for rejection are contained in Appendix D.

APPENDIX A

CRITERIA FOR SELECTING SYSTEMS AND/OR COMPONENTS FOR FURTHER REVIEW

APPENDIX A

CRITERIA FOR SELECTING SYSTEMS AND/OR COMPONENTS FOR FURTHER REVIEW

1. Any control grade system or component failure (initiator) which results in an undesired increase in reactor coolant inventory beyond the bounds of the present FSAR analysis will be recommended for further review. (The Browns Ferry bounding analysis presented in the FSAR for increase in reactor coolant inventory is a feedwater controller failure-maximum demand, 115% feedflow. The addition of feedwater is terminated 5 s after transient initiation by the reactor vessel high water level trip.)

2. Any control grade system or component failures (aggravating failures) which are projected to produce less conservative results for reactor coolant inventory increase analysis than those presented in the licensee's Final Safety Analysis Report (FSAR) will be recommended for further review.

3. Any control grade system or component failure (initiator) which results in an undesired reactor vessel water temperature decrease beyond the bounds of the present FSAR analysis will be recommended for further review. (The limiting event for this transient in the Browns Ferry FSAR analysis is the "Loss of Feedwater Heater(s) equivalent to a 100°F decrease in temperature." This represents the maximum temperature decrease obtainable through tripping or bypassing of heaters caused by a single event.)

4. Any control grade system or component failures (aggravating failures) which are projected to produce less conservative reactor vessel water temperature decrease analysis results than those presented in the licensee's Final Safety Analysis Report (FSAR) will be recommended for further review.

5. Any control grade system or component failure (initiator) which results in an undesired nuclear system pressure increase beyond the

bounds of the present Final Safety Analysis Report (FSAR) analysis results will be recommended for further review. (The limiting event for this transient in the Browns Ferry FSAR analysis is the "Loss of Condenser Vacuum." This represents the instantaneous loss of vacuum and closure of the turbine stop valves and bypass valves, therefore, all stored energy must be dissipated through the relief valves.)

6. Any control grade system or component failures (aggravating failures) which are projected to produce less conservative pressure increase analysis results than those presented in the licensee's FSAR will be recommended for further review.

7. Any control grade system or component failure (initiator) which results in an undesired positive reactivity increase beyond the bounds of the present FSAR analysis results will be recommended for further review. (The limiting event for this transient in the Browns Ferry FSAR analysis is a "Continuous Rod Withdrawal During Reactor Startup." This represents the most severe case which is with the reactor just critical at room temperature and a high worth out of sequence rod is continuously withdrawn.)

8. Any control grade system or component failures (aggravating failures) which are projected to produce less conservative positive reactivity increase analysis results than those presented in the licensee's FSAR will be recommended for further review.

9. Any control grade system or component failure (initiator) which results in an undesired reactor vessel inventory decrease beyond the bounds of the present FSAR analysis results will be recommended for further review. (The limiting event for this transient presented in the Browns Ferry FSAR is "Loss of Feedwater Flow from High Power." This represents the maximum rate of inventory decrease due to the high steam flow rate.)

10. Any control grade system or component failures (aggravating failures) which are projected to produce less conservative reactor vessel inventory decrease analysis results than those presented in the licensee's FSAR will be recommended for further review.

11. Any control grade system or component failure (initiator) which results in an undesired reactor core coolant flow decrease beyond the bounds of the present FSAR analysis results will be recommended for further review. (The limiting event for this transient in the Browns Ferry FSAR analysis is a "Recirculation Pump Seizure." This represents the fastest flow decrease possible through any single failure or operator action.)

12. Any control grade system or component failures (aggravating failures) which are projected to produce less conservative core coolant flow decrease analysis results than those presented in the licensee's FSAR will be recommended for further review.

13. Any control grade system or component failure (initiator) which results in an undesired reactor core coolant flow increase beyond the bounds of the present FSAR analysis results will be recommended for further review. (The limiting event for this transient in the Browns Ferry FSAR analysis is "Recirculation Flow Controller Failure--Increasing Flow." This represents the fastest rate at which flow can be increased with the reactor power level at the most optimum level to maximize the severity of the transient.)

14. Any control grade system or component failures (aggravating failures) which are projected to produce less conservative core coolant flow increase analysis results than those presented in the licensee's FSAR will be recommended for further review.

15. Any control grade system or component failures which are projected to cause transients identified as incidents of moderate frequency to occur at a rate significantly more frequent than once per year, or failures which are projected to cause transients identified as

infrequent incidents to occur more than once during the lifetime of a plant, or failures which are projected to cause limiting faults will be recommended for further review.

16. Any control grade system or component failures which would adversely affect any assumed or anticipated operator action during the course of a particular transient will be recommended for further review.

17. Any control grade system or component failures which result in manual or automatic actuation of engineered safety features, including the reactor protection system, will be recommended for possible further in-depth review.

18. Any control grade system or component failures which result in exceeding any technical specification safety limit will be recommended for further review.

APPENDIX B

OTHER TRANSIENTS FAILURE MODE AND EFFECTS ANALYSIS

APPENDIX B. OTHER TRANSIENTS FAILURE MODE AND EFFECTS ANALYSIS

System	System Function	System Failure Mode	Effect of Failure	Applicable A-47 Selection Criteria (App. A)
1. Reactor Recirculation System	Controls flow through the reactor vessel and thereby controls reactor power.	A. High flow rate.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	5, 6, 7, 8, 13, 14, 17
		B. Low flow rate.	B. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	9, 10, 11, 12, 15, 17
2. Nuclear System Pressure Relief System	Provides the required overpressure protection for the nuclear supply system.	A. Inadvertent opening of a relief or safety valve.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	9, 10, 13, 14, 15, 17
		B. Failure to open when required to relieve excess pressure.	B. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations but should not as the system is safety grade and redundant.	None
3. Main Steam Line Isolation Valves	Provides isolation of the reactor vessel from the remainder of the steam system.	A. Inadvertent individual valve closure.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	5, 6, 7, 8, 11, 12, 17
		B. Inadvertent individual valve opening or failure to close upon demand.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
4. Reactor Core Isolation and Standby Cooling Systems	Provides makeup water to the reactor vessel from various sources whenever the vessel is isolated.	A. Failure to provide the required makeup water when necessary.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	9, 10, 15, 17
		B. Inadvertent initiation of makeup water when not necessary.	B. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	5, 6, 7, 8, 17

APPENDIX B. (continued)

System	System Function	System Failure Mode	Effect of Failure	Applicable A-47 Selection Criteria (App. A)
5. Residual Heat Removal System	Provides for heat removal from the primary system during normal, shutdown and accident conditions.	A. Failure to supply the required heat removal.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations as the system is safety grade and redundant.	None
		B. Provide excessive heat removal or heat removal when not required.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations as the system is safety grade and redundant.	None
6. Reactor Water Cleanup System	Provides filtration and ion exchange to maintain the reactor water purity. Also serves as a letdown path for excess coolant during reactor startup.	A. Failure to provide water cleanup or letdown flow when required.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
		B. Provide water cleanup or letdown flow when not required.	B. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	9, 10
7. Primary Containment System and Reactor Vessel Isolation Control System	Provides automatic isolation of the primary system and reactor vessel to prevent a release to the environs.	A. Failure to affect isolation when required.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations as the system is safety grade and redundant.	None
		B. Inadvertent isolation when not required.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations as the system is safety grade and redundant.	None

APPENDIX B. (continued)

System	System Function	System Failure Mode	Effect of Failure	Applicable A-47 Selection Criteria (App. A)
8. Secondary Containment System	Provides backup isolation to the primary containment to prevent releases to the environs.	A. Failure to affect isolation when required.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations as the system is safety grade and redundant.	None
		B. Inadvertent isolation when not required.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations as the system is safety grade and redundant.	None
9. Reactor Protection System	Provides protection to the reactor system and fuel from damage due to out of tolerance conditions.	A. Failure to provide the required trips.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations as the system is safety grade and redundant.	None
		B. Inadvertent trips when not required.	B. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations as the system is safety grade and redundant.	None
10. Core Standby Cooling Control and Instrumentation System	Provides protection from excess fuel clad temperatures in the event of a breach in the nuclear process barrier that results in a loss of reactor coolant.	A. Failure to initiate cooling of the core when required.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	15, 17
		B. Failure to terminate cooling of the core when required or inadvertent initiation of cooling systems when not required.	B. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	7, 8, 15, 17

APPENDIX B. (continued)

System	System Function	System Failure Mode	Effect of Failure	Applicable A-47 Selection Criteria (App. A)
11. Neutron Monitoring System	Monitors the neutron flux level of the reactor core over the range of shutdown to full power.	A. Indicate higher than actual level.	A. Failures of this type should not have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations as the system is safety grade and redundant.	None
		B. Indicate lower than actual level.	B. Failures of this type should not have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations as the system is safety grade and redundant.	None
12. Refueling Interlocks System	Restricts the movements of refueling equipment and control rods during refueling to prevent a criticality.	A. Failure to restrict movement when required.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients and undesired situations.	7, 8, 15
		B. Failure to allow movements when required.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
13. Reactor Manual Control and Control Rod Drive Systems	Provides the means to manipulate the control rods for gross reactivity control.	A. Inadvertent rod withdrawal or ejection.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	5, 6, 7, 8, 15, 17
		B. Inadvertent rod drop.	B. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	15, 17
14. Reactor Vessel Instrumentation System	Monitors and transmits information concerning the conditions within and of the reactor vessel.	A. Transmits or indicates higher than actual conditions.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	16
		B. Transmits or indicates lower than actual conditions.	B. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	16

APPENDIX B. (continued)

System	System Function	System Failure Mode	Effect of Failure	Applicable A-47 Selection Criteria (App. A)
15. Feedwater Control System	Provides the necessary signals to maintain the required feed-flow to maintain proper reactor vessel level.	A. High flow rate.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	7, 8, 17
		B. Low flow rate.	B. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	9, 10, 17
16. Pressure Regulator and Turbine Generator Control System	Provides the necessary control to maintain the turbine load and reactor pressure at prescribed levels.	A. Inadvertent opening of turbine governor or bypass valves when not required.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	9, 10, 17
		B. Inadvertent closing of turbine governor or bypass valves when not required.	B. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	5, 6, 7, 8, 17
17. Process Radiation Monitoring System	Monitors various lines for radioactive materials released to the environs in process liquids and gases.	A. Indicates higher than actual levels of radiation.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
		B. Indicates lower than actual levels of radiation.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
18. Area Radiation Monitoring System	Monitors for radiation at various locations within the reactor building, turbine building and radwaste building.	A. Indicates higher than actual levels of radiation.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
		B. Indicates lower than actual levels of radiation.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None

APPENDIX B. (continued)

System	System Function	System Failure Mode	Effect of Failure	Applicable A-47 Selection Criteria (App. A)
19. Site Environmental Radiation Monitoring System	Monitors for natural and other radiation background levels outside the plant.	A. Indicates higher than actual levels of radiation.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
		B. Indicates lower than actual levels of radiation.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
20. Health Physics Lab Radiation Monitoring System	Monitors for abnormal radiation levels within the health physics lab.	A. Indicates higher than actual radiation levels.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
		B. Indicates lower than actual radiation levels.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
21. Process Computer System	Monitors and records process variables and provides certain analytical computations.	A. Provides higher than actual outputs.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	16
		B. Provides lower than actual outputs.	B. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	16
22. Backup Control System	Provides the capability to shut down the reactor and operate emergency systems from outside the control room in the event the control room must be evacuated.	A. Inability to shut down the reactor or start up the emergency systems from remote locations.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
		B. Inadvertent shutdown of the reactor or startup of emergency systems from remote locations.	B. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	5, 6, 7, 8, 15, 17

APPENDIX B. (continued)

System	System Function	System Failure Mode	Effect of Failure	Applicable A-47 Selection Criteria (App. A)
23. Diesel Generator Systems	Provides the necessary services to ensure the diesel generators are capable of coming on line and supplying electrical power.	A. Failures that prevent the diesels from starting.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations as the system is safety grade and redundant.	None
		B. Failures that cause inadvertent startup of the diesels.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations as the system is safety grade and redundant.	None
24. Normal Auxiliary Power System Note: Failures are evaluated within individual systems.	Provides the power sources for the unit auxiliaries through various transformers.	A. Failure to provide the required power to the unit auxiliaries.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	None
25. Standby AC Power Supply System Note: Failures are evaluated within individual systems.	Provides an emergency supply of electrical power to emergency and safety equipment.	A. Failure to provide the required power to the designated equipment.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
26. 250 V DC Power Supply System Note: Failures are evaluated within individual systems.	Provides the power source for the engineered safety features of one unit and the safe shutdown loads of the other two units.	A. Failure to provide the required power to the designated equipment.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
27. 120 V AC Power Supply System Note: Failures are evaluated within individual systems.	Provides power to equipment through, (a) 120 V instrument and control power, (b) plant preferred and nonpreferred 120 V system and (c) unit preferred 120 V system.	A. Failure to provide the required power to the designated equipment.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
28. Auxiliary DC Power Supply System	Provides 48 V power to the plant communications and annunciator systems during all modes of operation.	A. Failure to provide the required power to the designated equipment.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	16

APPENDIX B. (continued)

System	System Function	System Failure Mode	Effect of Failure	Applicable A-47 Selection Criteria (App. A)
29. Liquid Radwaste System	Provides for the collection and storage of the liquid radwaste generated at the unit.	A. Failure to provide the required collection disposal storage of liquid radwaste.	A. Failure of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
30. Solid Radwaste System	Provides for the collection, storage and disposal of the solid radwaste generated at the unit.	A. Failure to provide the required collection, storage or disposal of solid radwaste.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
31. Gaseous Radwaste System	Provides for the collection, storage and disposal of the gaseous radwaste generated at the unit.	A. Failure to provide the required collection, storage or disposal of the gaseous radwaste generated at the unit.	A. Failure of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
32. New Fuel Storage System	Provides for the dry storage of new fuel until ready for loading.	A. Failure to store the fuel safely and effectively.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
33. Spent Fuel Storage System	Provides for the storage of spent fuel until ready for shipment.	A. Failure to store the spent fuel safely and effectively.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
34. Fuel Pool Cooling and Cleanup System	Provides for water cleanup and cooling of the spent fuel pool.	A. Failure to maintain water temperature or purity requirements.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
35. Reactor Building Closed Cooling Water System	Provides cooling water to designated auxiliary plant equipment during both normal and emergency conditions.	A. Loss of cooling water to designated equipment.	A. Failures of this type should not have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations as the system is safety grade and redundant.	None
		B. Excessive cooling water to designated equipment.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations as the system is safety grade and redundant.	None

APPENDIX B. (continued)

System	System Function	System Failure Mode	Effect of Failure	Applicable A-47 Selection Criteria (App. A)
36. Raw Cooling Water System	Provides cooling water to the RBCCW system and the turbine associated equipment.	A. Loss of cooling water flows.	A. Failures of this type have the potential to meet one or more of the selection criteria established for other transients or undesired situations.	9, 10
		B. Excessive cooling water flows.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
37. Raw Service Water System	Provides cooling water to miscellaneous plant equipment and yard watering supply.	A. Loss of cooling water flows.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
		B. Excessive cooling water flows.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
38. RHR Service Water System	Provides cooling water to the RHR system and the emergency equipment cooling water system.	A. Loss of cooling water flows.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations as the system is safety grade and redundant.	None
		B. Excessive cooling water flows.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations as the system is safety grade and redundant.	None

APPENDIX B. (continued)

System	System Function	System Failure Mode	Effect of Failure	Applicable A-47 Selection Criteria (App. A)
39. Emergency Equipment Cooling Water System	Provides cooling water flows to essential equipment during accident situations.	A. Loss of cooling water flows.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations as the system is safety grade and redundant.	None
		B. Excessive cooling flows.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations as the system is safety grade and redundant.	None
40. Fire Protection System	Provides the plant with the required fire protection and fire combatants.	A. Failure to provide the necessary fire protection.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
		B. Inadvertent actuation.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
41. Heating, Ventilation and Air Conditioning Systems	Provides the plant with the necessary heating, ventilating and air conditioning.	A. Failure to provide sufficient H&V or air conditioning.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
		B. Providing excessive H&V or air conditioning.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
42. Demineralized Water System	Provides the necessary demineralized water for plant makeup and other uses.	A. Failure to provide the necessary quantities of demineralized water.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
		B. Failures resulting in an excessive amount of demineralized water being supplied.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None

APPENDIX B. (continued)

System	System Function	System Failure Mode	Effect of Failure	Applicable A-47 Selection Criteria (App. A)
#3. Control and Service Air Systems (NOTE: Air pressure failures are evaluated within individual systems in depth studies.)	Supplies air to all pneumatically operated instruments, controls, and control valves.	A. Control air pressure fails low.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations but are analyzed within the individual systems.	None
		B. Control air pressure fails high.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
#4. Potable Water and Sanitary System	Supplies drinking water and water to bathrooms.	A. Loss of flow.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
		B. High flow.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
#5. Equipment and Floor Drainage System	Collect and remove all noncontaminated liquid wastes from the plant.	A. Failure to provide the required collection, and removal of liquid wastes from the plant.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
#6. Process Sampling System	Sample process liquids and gases to determine plant performance.	A. Sample system valve(s) fail open.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
		B. Sample system valve(s) fail closed.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
#7. Plant Communications System	Provide interplant and intraplant communications.	A. System failure.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None

APPENDIX B. (continued)

System	System Function	System Failure Mode	Effect of Failure	Applicable A-47 Selection Criteria (App. A)
48. Lighting Systems	Provide lighting for plant operation.	A. System failure.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
49. Auxiliary boiler System	Supplies building heat and steam for systems testing prior to or during startup.	A. Low steam pressure.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations. (System used only during low temperature or low power operations to supply air ejectors and seal steam.)	None
		B. High steam pressure.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations. (System used only during low temperature or low power operations to supply air ejectors and seal steam.)	None
50. Turbine Generator System (See System 16 for Turbine Generator Control System)	Utilizes steam produced in the reactor to produce electric power.	A. Transient power increase.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	9, 10, 17
		B. Transient power decrease.	B. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	5, 6, 7, 8, 17

APPENDIX B. (continued)

System	System Function	System Failure Mode	Effect of Failure	Applicable A-47 Selection Criteria (App. A)
51. Main Steam System	Deliver steam from the Reactor System to the Main, RFP, HPCI, and RCIC turbines as well as auxiliary steam loads.	A. Steam flow fails high.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations but are caused by some other component connected to the main steam system and are evaluated within those systems.	None
		B. Steam flow fails low.	B. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations but are caused by some other component connected to the main steam system and are evaluated within those systems.	None
52. Main Condenser System	Provides a heat sink for the steam leaving the turbine generator during power operations.	A. Loss of condenser vacuum.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	5, 6, 7, 8, 17
		B. Increased condenser vacuum.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None
53. Turbine Bypass System	Provides a bypass around the turbine directly to the condenser for steam flow.	A. Bypass valve(s) fail open.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	9, 10, 17
		B. Bypass valve(s) fail closed.	B. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	7, 8, 17
54. Condenser Circulating Water System	Provides a heat sink for condensing unused steam from power generation.	A. Circulating water flow fails low.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	5, 6, 7, 8, 17
		B. Circulating water flow fails high.	B. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations.	None

APPENDIX B. (continued)

System	System Function	System Failure Mode	Effect of Failure	Applicable A-47 Selection Criteria (App. A)
55. Condensate and Reactor Feedwater System (See System 15 for Feedwater Control System)	Provides feedwater to the reactor; condensate storage and transfer.	A. Feedwater/condensate flow fails high.	A. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	7, 8, 17
		B. Feedwater/condensate flow fails low.	B. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations.	9, 10, 17
56. Standby Liquid Control System	Provides a backup method to make the reactor subcritical.	A. Fails to actuate when required.	A. Failures of this type should not have the potential to meet or exceed any of the selection criteria established for other transients or undesired situations as the system is safety grade and redundant.	None
		B. Inadvertent actuation.	B. Failures of this type have the potential to meet or exceed one or more of the selection criteria established for other transients or undesired situations but the contribution would be insignificant.	None

APPENDIX C

OTHER TRANSIENT SCENARIOS

APPENDIX C

OTHER TRANSIENT SCENARIOS

SECTION A--INCREASE PRESSURE TRANSIENTS

1. Reactor Recirculation System

   Failure Mode: High flow rate

   Plant Condition: Any power level

   Discussion: The increased flow rate will cause reactor power to increase, thus causing heat input to exceed heat removal and pressure will increase.

2. Main Steam Line Isolation Valves

   Failure Mode: Inadvertent individual valve closure

   Plant Condition: High power level

   Discussion: The inadvertent closure of a main steam isolation valve will cause pressure to increase due to reduced heat removal with the same or higher power level.

3. Reactor Core Isolation and Standby Cooling Systems

   Failure Mode: Inadvertent initiation of makeup system

   Plant Condition: Any power level

Discussion: Inadvertent startup of HPCI or RCIC would cause a power increase due to cool water injection with a resultant pressure increase which could exceed a pressure limit.

4. Reactor Manual Control and Control Rod Drive System

Failure Mode: Inadvertent rod withdrawal or ejection

Plant Condition: Any power level

Discussion: Inadvertent rod withdrawal or ejection could cause a power increase and resultant pressure increase transient due to increased heat input.

5. Pressure Regulator and Turbine Generator Control System

Failure Mode: Inadvertent closing of turbine governor or bypass valve

Plant Condition: High power level

Discussion: Inadvertent closure of a turbine governor or bypass valve could cause a pressure increase due to the reduced steam flow from the reactor and the void depression may cause a power increase which could also increase pressure.

6. Backup Control System

Failure Mode: Inadvertent startup of an emergency system

Plant Condition: High power level

Discussion: Inadvertent startup of HPIC or RCIC from a remote location could cause a power increase with a resultant pressure increase.

7. Turbine Generator System

Failure Mode: Transient power decrease

Plant Condition: High power level

Discussion: Failures of systems or components which can result in a trip of the turbine generator (i.e.) closure of the turbine control valve, could cause a rapid increase in reactor pressure because of the decrease in steam flow from the reactor.

8. Main Condenser System

Failure Mode: Loss of condenser vacuum

Plant Condition: High power level

Discussion: The loss of main condenser vacuum may result in an overpressure transient since the loss of vacuum causes a trip of the turbine generator system by closing the turbine and bypass system valves which reduces the steam flow from the reactor.

9. Condenser Circulating Water System

Failure Mode: Circulating water flow fails low

Plant Condition: High power level

Discussion: Failure of the condenser circulating water flow may cause or contribute to an overpressure transient as this failure would cause a loss of condenser vacuum which in turn causes a trip of the turbine generator system as described above under Main Condenser System.

SECTION B--INCREASE REACTIVITY TRANSIENTS

1. Reactor Recirculation System

   Failure Mode: High flow rate

   Plant Condition: Any power level

   Discussion: The increased flow rate could cause a positive reactivity insertion with a subsequent power increase. The reactivity insertion could exceed the present FSAR analysis.

2. Main Steam Line Isolation Valves

   Failure Mode: Inadvertent individual valve closure

   Plant Condition: Any power level

   Discussion: Closure of an individual valve may cause a pressure increase, voids to collapse and positive reactivity could increase thereby causing power to increase.

3. Reactor Core Isolation and Standby Cooling Systems

   Failure Mode: Inadvertent initiation of makeup when not required

   Plant Condition: Any power level

   Discussion: Initiation of one or more makeup systems may cause the core water temperature to be reduced which could cause voids to collapse and positive reactivity to increase thereby causing power to increase.

4. Core Standby Cooling Control and Instrumentation System

Failure Mode: Inadvertent initiation when not required

Plant Condition: Any power level

Discussion: Initiation of one or more makeup systems when not required could cause a collapsing of voids and a positive reactivity increase. This in turn could cause a power increase.

5. Refueling Interlocks System

Failure Mode: Failure to restrict movements when required

Plant Condition: Shutdown--Refueling

Discussion: Failure of the system to restrict fuel movements could cause the positive reactivity addition to exceed allowable limits.

6. Reactor Manual Control and Control Rod Drive System

Failure Mode: Inadvertent rod withdrawal or ejection

Plant Condition. Any power level

Discussion: Inadvertent withdrawal and rod ejections could add positive reactivity to the reactor and may exceed the allowable insertion rate limits.

7. Reactor Vessel Instrumentation System

Failure Mode: Transmits or indicates lower than actual level

Plant Condition: Any power level

Discussion: If the instrumentation system were indicating lower than actual level the feed system would attempt to bring level to normal. The increase feed flow would collapse voids causing a positive reactivity insertion and a power increase.

8. Feedwater Control System

Failure Mode: High flow rate

Plant Condition: Any power level

Discussion: Higher than required feed flow could cause a cooling of the reactor vessel water, collapsing of voids and a positive reactivity insertion. This could exceed reactivity insertion rate limits.

9. Pressure Regulator and Turbine Generator Control System

Failure Mode: Inadvertent closing of turbine governor or bypass valve

Plant Condition: Any power level

Discussion: The inadvertent closing of a turbine governor valve could cause the pressure to increase, the voids to collapse and power to increase due to the positive reactivity increase. This could exceed a reactivity insertion rate limit.

10. Backup Control System

Failure Mode: Inadvertent startup of emergency systems

Plant Condition: Any power level

Discussion: The inadvertent startup of an emergency makeup system could cause void collapse and positive reactivity insertion due to the introduction of cooler water. Power would increase and the reactivity insertion rate limit could be exceeded.

11. Turbine Generator System

Failure Mode: Transient power decrease

Plant Condition: Any power level

Discussion: A transient power decrease has the potential to cause a reactivity increase by decreasing the flow of steam from the reactor which causes coolant voids to decrease and this causes a reactivity increase.

12. Main Condenser System

Failure Mode: Loss of condenser vacuum

Plant Condition: High power level

Discussion: A loss of condenser vacuum would cause steam flow from the reactor to decrease. This will cause voids to collapse and positive reactivity to increase. The reactivity insertion rate could exceed allowable limits.

13. Turbine Bypass System

Failure Mode: Bypass valve(s) fail closed

Plant Condition: Any power level

Discussion: While discharging steam to the main condenser through the bypass valve(s), if the valve(s) fail closed, this causes steam flow to decrease, and steam pressure to increase which causes voids to collapse in the reactor and a positive reactivity increase which could exceed allowable limits.

14. Condenser Circulating Water System

Failure Mode: Circulating water flow fails low

Plant Condition: High power level

Discussion: A failure of the circulating water system flow while at high power could result in a positive reactivity increase since the loss of flow would cause a loss of condenser vacuum, steam flow would decrease, pressure would increase and voids would collapse and power would increase.

15. Condensate and Reactor Feedwater System

Failure Mode: Feedwater flow fails high

Plant Condition: Any power level

Discussion: A failure in the feedwater system that causes an inadvertent increase of feedwater flow has the potential to cause an overcool transient which could cause a positive reactivity increase.

SECTION C--DECREASE IN REACTOR VESSEL INVENTORY

1. Reactor Recirculation System

Failure Mode: Recirculation Pump Seal Failure

Plant Conditions: Any power level

Discussion: The failure of the recirculation pump seals will cause a loss of vessel inventory and if the failure occurs in conjunction with another failure could result in a transient that exceeds the loss of coolant accident analysis.

2. Nuclear System Pressure Relief System

Failure Mode: Inadvertent opening of a safety or relief valve

Plant Condition: Any power level

Discussion: The inadvertent opening of a safety or relief valve will cause reactor vessel inventory to be exhausted to the torus or containment and the vessel inventory could deplete beyond allowable low level limits.

3. Reactor Core Isolation and Standby Cooling Systems

Failure Mode: Failure to provide makeup when required

Plant Condition: Any power level

Discussion: Failure of the system to provide the required makeup water could allow the inventory to decrease below the allowable limits with possible subsequent core damage.

4. Reactor Vessel Instrumentation System

Failure Mode: Transmits or indicates higher than actual level

Plant Condition: Any power level

Discussion: Transmittal or indication of higher than actual level conditions could cause the feed system to decrease flow and inventory to deplete to less than allowable inventory limits.

5. Feedwater Control System

Failure Mode: Loss of or low feedwater flow rate

Plant Condition: Any power level

Discussion: Loss of feedwater flow at high power level could cause a rapid loss of vessel inventory. If the vessel level is low at the onset of the transient allowable level limits could be exceeded.

6. Pressure Regulator and Turbine Generator Control System

Failure Mode: Inadvertent opening of a turbine governor or bypass valve

Plant Condition: Any power level

Discussion: Inadvertent opening of a turbine governor or bypass valve could cause reactor vessel invertory to deplete at a rate faster than the feed system is replenishing it while in MANUAL and the allowable inventory low limit could be exceeded.

7. Reactor Water Cleanup System (RWCS)

Failure Mode: Inadvertent letdown when not required

Plant Condition: Any power level

Discussion: Inadvertent initiation of letdown flow through the 4 in. RWCS letdown line could result in an inventory decrease beyond allowable low level limits.

8. Raw Cooling Water System (RCWS)

Failure Mode: Loss of cooling water flow

Plant Condition: Any power level

Discussion: A loss of raw cooling water flow may cause or contribute to an inventory decrease since the RCWS supplies cooling water to the reactor feedpump turbine oil coolers. A loss of cooling water would necessitate the shutdown of the feedwater pumps.

9. Turbine Generator System

Failure Mode: Transient power increase

Plant Condition: Any power level

Discussion: An increased power transient may cause or contribute to an inventory decrease as the increase in the rate of steam flow leaving the reactor vessel may exceed the flow of water entering the vessel if the feedwater system is in MANUAL.

10. Turbine Bypass System

Failure Mode: Bypass valve(s) fail open

Plant Condition: Any power level

Discussion: The increased steam flow that would result from the bypass valve(s) failing open could cause an inventory decrease since the steam flow from the reactor may exceed the flow of feedwater to the reactor vessel if in MANUAL control.

11. Condensate and Reactor Feedwater System

Failure Mode: Feedwater flow fails low

Plant Condition: Any power level

Discussion: Feedwater flow failing low may cause or contribute to a decrease in coolant inventory since the steam flow from the reactor vessel may exceed the flow of feedwater entering the vessel.

SECTION D--DECREASE IN VESSEL FLOW RATE

1. Reactor Recirculation System

Failure Mode: Low flow or loss of flow

Plant Condition: Any power level

Discussion: Loss of both recirculation pumps by seizure will cause a total loss of flow and the bounding analysis only covers seizure of one. It appears as though loss of both could be more severe.

2. Reactor Building Closed Cooling Water System (RBCCWS)

Failure Mode: Loss of cooling water to designated equipment

Plant Condition: Any power level

Discussion: A loss of cooling water to equipment supplied by the RBCCWS may cause or contribute to a reactor coolant flow decrease as the RBCCWS supplies cooling water to the recirculation pump and motor coolers. A loss of the cooling water would necessitate a shutdown or runback of the recirculation pumps which results in a flow decrease through the reactor vessel.

3. Raw Cooling Water System (RCWS)

Failure Mode: Loss of cooling water flows

Plant Condition: Any power level

Discussion: A loss of cooling water flow from the RCWS may cause or contribute to a reactor coolant flow decrease as the RCWS supplies coolant water to the recirculation pump M-G set coolers and the reactor building closed cooling water heat exchangers. A loss of the cooling water would necessitate a shutdown or runback of the recirculation pumps.

SECTION E--INCREASE IN VESSEL FLOW RATE

1. Reactor Recirculation System

Failure Mode: High flow rate

Plant Condition: Optimum power level to maximize the consequences

Discussion: Failure of the M-G scoop tube drive circuit may cause the speed of the recirculation pumps to be increased at a rate in excess of allowable limits.

SECTION F--FREQUENCY, OPERATOR ACTION AND ENGINEERED SAFETY FEATURES TRANSIENTS

1. Reactor Recirculation System

   Failure Mode: High or low flow

   Plant Condition: Any power level

   Discussion: Excessive flow changes in either the high or low direction have the potential to cause Engineered Safety Features actuations and/or Reactor Protection System trips.

2. Nuclear System Pressure Relief System

   Failure Mode: Inadvertent opening

   Plant Condition: Any power level

   Discussion: Inadvertent opening of a safety or relief valve may cause a pressure drop and could result in an ESF actuation. The number of inadvertent openings in a defined time period could be significantly greater than allowed.

3. Main Steam Line Isolation Valves

   Failure Mode: Inadvertent closure

   Plant Condition: Any power level

   Discussion: Inadvertent closure of an individual isolation valve could cause an ESF actuation.

4. Reactor Core Isolation and Standby Cooling System

Failure Mode: Inadvertent initiation of cooling

Plant Condition: Any power level

Discussion: Inadvertent initiation of emergency cooling systems could create an additional Engineered Safety Features actuation and a violation of a Technical Specification safety limit.

5. Reactor Protection System

Failure Mode: Inadvertent trips

Plant Condition: Any power level

Discussion: Inadvertent trips of the RPS and ESF systems produce challenges that could exceed the design limits for frequency of protective system actuations and therefore compromise the ability of the system to function when actually required.

6. Core Standby Cooling Control and Instrumentation System

Failure Mode: Inadvertent initiation of cooling systems

Plant Condition: Any power level

Discussion: Inadvertent initiation of one or more standby cooling system could result in a positive reactivity addition in excess of the allowable limits established for positive reactivity additions.

7. Neutron Monitoring System

Failure Mode: Indicate higher or lower than actual levels

Plant Condition: Any power level

Discussion: The neutron monitoring system could cause undue operator errors by indicating more or less than actual levels and cause the operator to perform erroneous actions.

8. Refueling Interlocks System

Failure Mode: Failure to restrict movements

Plant Condition: Shutdown--Refueling

Discussion: Failure of the interlocks system to restrict movements could result in a violation of reactivity limits and contribute to erroneous operator actions.

9. Reactor Manual Control and Control Rod Drive Systems

Failure Mode: Inadvertent rod withdrawal or rod ejection

Plant Condition: Any power level

Discussion: Inadvertent rod withdrawal or ejection could cause reactivity to increase and power excursions. Either of these could be in excess of allowable limits and both could contribute to pressure excursions and ESF actuations.

Rod drops could cause power excursions which could result in an Engineered Safety Features actuation.

10. Reactor Vessel Instrumentation System

Failure Mode: Transmits or indicates higher or lower than actual conditions

Plant Condition: Any power level

Discussion: Transmitting higher than actual conditions within the vessel creates a potential to cause or contribute to an inventory decrease situation. Transmitting lower than actual conditions creates a potential for a positive reactivity addition that could be in excess of allowable limits. Either of these conditions could cause an Engineered Safety Feature actuation if it isn't recognized soon enough and the feedwater control system is controlling from these signals.

11. Feedwater Control System

Failure Mode: High flow or low flow rate

Plant Condition: Any power level

Discussion: High flow rate of the feedwater system may add cool water to the vessel at a rate in excess of the heat addition rate. This could cause the voids to collapse and a positive reactivity addition which could exceed allowable limits and/or cause an Engineered Safety Features actuation. Low feedwater flow rates could cause a loss of vessel inventory beyond allowable low limits and could cause an Engineered Safety Features actuation.

12. Pressure Regulator and Turbine Generator Control System

Failure Mode: Inadvertent opening or closing of turbine governor or bypass valves

Plant Condition: Any power level

Discussion: Inadvertent opening of turbine governor or bypass valves could cause steam flow to increase, vessel pressure to decrease, and recirculation flow to increase. This could lead to a vessel inventory depletion if the feedwater control is in MANUAL and an Engineered Safety Features actuation. Inadvertent closing of turbine governor or bypass valves could cause pressure increases, reactivity additions and could cause an Engineered Safety Features actuation.

13. Process Computer System

Failure Mode: Indicates higher or lower than actual conditions

Plant Condition: Any power level

Discussion: If the operator is using the outputs of the process computer to control plant variables the possibility exists for the operator to perform an incorrect action due to erroneous information.

14. Backup Control System

Failure Mode: Inadvertent startup of emergency systems

Plant Condition: Any power level

Discussion: Inadvertent startup of safety systems could result in actuation of Engineered Safety Features and could be in excess of any allowable frequency for inadvertent starts.

15. Auxiliary DC Power Supply System

Failure Mode: Failure to provide power

Plant Condition: Any power level

Discussion: Failure to provide the required power to the plant communication and annunciation system could result in the operator performing incorrect actions due to a lack of, or incorrect, communications or annunciations.

16. Turbine Generator System

Failure Mode: Transient power increase or transient power decrease

Plant Condition: Any power level

Discussion: Transient power increases or decreases have the potential to cause or contribute to moderate frequency incidents that could cause automatic actuation of the Engineered Safety Features including the Reactor Protection System. A transient power increase could cause a pressure decrease, main steam isolation valve closure, if pressure decreases to less than 825 psia, and a reactor scram due to MSIV closure. A transient power decrease such as a turbine trip could cause

actuation of the reactor scram, as well as recirculation pump trip and bypass valve opening to limit reactor vessel pressure.

17. Main Condenser System

Failure Mode: Loss of condenser vacuum

Plant Condition: Any power level

Discussion: Failures of the main condenser system which result in a loss of condenser vacuum have the potential to cause or contribute to moderate frequency incidents resulting in actuation of Engineered Safety Features, including the Reactor Protection System. The loss of vacuum transient could cause closure of the turbine stop valve(s), bypass valve(s) and a reactor scram.

18. Turbine Bypass System

Failure Mode: Bypass valve(s) fail open or fail closed

Plant Condition: Any power level

Discussion: Failures of the turbine bypass system which result in the bypass valve(s) failing open could result in an automatic actuation of the Reactor Protection System since the steam pressure would decrease and the isolation valves may shut. Failures which result in the bypass valve(s) failing closed may result in an automatic actuation of the protection system since the system pressure could increase and cause reactor power to increase.

19. Condenser Circulating Water System

Failure Mode: Circulating water flow fails low

Plant Condition: Any power level

Discussion: Failure of the circulating water flow may cause or contribute to an actuation of the Reactor Protection System as the loss of flow could cause a loss of condenser vacuum which initiates a turbine trip and reactor scram. This could be in violation of a moderate frequency incident if it occurs more than once per year.

20. Condensate and Reactor Feedwater System

Failure Mode: Feedwater flow fails high or fails low

Plant Condition: Any power level

Discussion: Failures which cause feedwater flow to fail high may cause an actuation of the Reactor Protection System due to the reactivity addition to the reactor. The added cold water due to feedwater flow failing high could cause a cooldown rate that exceeds the Title 10 Code of Federal Regulations Part 50, Appendix G curve limits. Feedwater flow failing low could cause actuation of the Reactor Protection System due to a low reactor water level.

APPENDIX D

BROWNS FERRY OTHER TRANSIENTS STUDY
REJECTED SYSTEMS JUSTIFICATION

APPENDIX D

BROWNS FERRY OTHER TRANSIENTS STUDY
REJECTED SYSTEMS JUSTIFICATION

1. INTRODUCTION

During this phase of the study the Licensee Event Reports (LER) and the Nuclear Power Experiences (NPE) for the years 1980-1982 were reviewed and a Failure Mode and Effects Analysis (FMEA; Appendix B) was completed. These were performed independently to ensure all possible system failures leading to transient situations were identified. The LERs and NPEs reviewed produced several cases of transients of concern. The FMEA also identified the same systems as well as other systems as potential problems. The remaining systems were subsequently rejected from this study and the reason or reasons are documented within this section of this report.

2. ASSUMPTIONS

The following assumptions were used to justify system rejection from further review.

2.1 Noncapable System

Any system which through normal operation or failure has no apparent capability to create or contribute to any of the other transients was rejected, e.g., Process Radiation Monitoring System.

2.2 Safety Grade System

Any safety grade system which would require multiple failures to create or contribute to any of the other transients was rejected, e.g., Reactor Protection System.

2.3 Insignificant Contribution System

Any system, which through normal operation or failure, would have an insignificant effect on any of the other transients was rejected, e.g., Standby Liquid Control System.

3. SYSTEM DISCUSSIONS

3.1 Residual Heat Removal System

This system was rejected because it is safety grade, redundant and would require multiple failures to create or contribute to any of the other transients.

3.2 Primary Containment System and Reactor Vessel Isolation Control System

This system was rejected because it is safety grade, redundant and would require multiple failures to create or contribute to any of the other transients.

3.3 Secondary Containment System

This system was rejected because it is safety grade, redundant and would require multiple failures to create or contribute to any of the other transients.

3.4 Reactor Protection System

This system was rejected because it is safety grade, redundant and would require multiple failures to cause or contribute to any of the other transients.

3.5 Neutron Monitoring System

This system was rejected because it is safety grade, redundant and would require multiple failures to cause or contribute to any of the other transients.

3.6 Process Radiation Monitoring System

This system was rejected because normal operation or failure of the system has no capability to create or contribute to any of the other transients.

3.7 Area Radiation Monitoring System

This system was rejected because normal operation or failure of the system has no capability to create or contribute to any of the other transients.

3.8 Site Environmental Radiation Monitoring System

This system was rejected because normal operation or failure of the system has no capability to create or contribute to any of the other transients.

3.9 Health Physics Lab Radiation Monitoring System

This system was rejected because normal operation or failure of the system has no capability to create or contribute to any of the other transients.

3.10 Diesel Generator Systems

This system was rejected because it is safety grade, redundant and would require multiple failures to create or contribute to any of the other transients.

3.11 Normal Auxiliary Power System

This system was rejected because normal operation or failure of the system to supply components is covered during the individual component system reviews.

3.12 Standby AC Power Supply System

This sytem was rejected because failure of components supplied by this safety grade system are evaluated during the individual system reviews.

3.13 250 V DC Power Supply System

This system was rejected because failure of components supplied by this safety grade system are evaluated during the individual system reviews.

3.14 120 V AC Power Supply System

This system was rejected because normal operation or failure of the system to supply components is covered during the individual component system reviews.

3.15 Liquid Radwaste System

This system was rejected because normal operation or failure of the system has no capability to create or contribute to any of the other transients.

3.16 Solid Radwaste System

This system was rejected because normal operation or failure of the system has no capability to create or contribute to any of the other transients.

3.17 Gaseous Radwaste System

This system was rejected because normal operation or failure of the system has no capability to create or contribute to any of the other transients.

3.18 New Fuel Storage System

This system was rejected because normal operation or failure of the system has no capability to create or contribute to any of the other transients.

3.19 Spent Fuel Storage System

This system was rejected because normal operation or failure of the system has no capability to create or contribute to any of the other transients.

3.20 Fuel Pool Cooling and Cleanup System

This system was rejected because normal operation or failure of the system has no capability to create or contribute to any of the other transients.

3.21 Reactor Building Closed Cooling Water System

This system was rejected because it is safety grade, redundant and would require multiple failures to cause or contribute to any of the other transients.

3.22 Raw Service Water System

This system was rejected because normal operation or failure of the system has no capability to create or contribute to any of the other transients.

3.23 Residual Heat Removal Service Water System

This system was rejected because it is safety grade, redundant and would require multiple failures to create or contribute to any of the other transients.

3.24 Emergency Equipment Cooling Water System

This system was rejected because it is safety grade, redundant and would require multiple failures to create or contribute to any of the other transients.

3.25 Fire Protection System

This system was rejected because normal operation or failure of the system has no capability to create or contribute to any of the other transients.

3.26 Heating, Ventilation and Air Conditioning Systems

These systems were rejected even though normal operation or failure of the systems has the capability to create or contribute to several of the other transients, the contribution is insignificant and is covered during the individual system reviews.

3.27 Demineralized Water System

This system was rejected even though operation or failure of the system has the capability to contribute to several of the other transients, the contribution is insignificant and therefore not of prime concern for this study.

3.28 Control and Service Air Systems

These systems were rejected because failure of the systems to supply components are covered in the individual component system reviews.

3.29 Potable Water and Sanitary Systems

These systems were rejected because normal operation or failure of the systems have no capability to create or contribute to any of the other transients.

3.30 Equipment and Floor Drainage System

This system was rejected because normal operation or failure of the system has no capability to create or contribute to any of the other transients.

3.31 Process Sampling System

This system was rejected because normal operation or failure of the system has no capability to create or contribute to any of the other transients.

3.32 Plant Communications System

This system was rejected because normal operation or failure of the system has no capability to create or contribute to any of the other transients.

3.33 Lighting Systems

These systems were rejected because normal operation or failure of the systems have no capability to create or contribute to any of the other transients.

3.34 Auxiliary Boiler System

This sytem was rejected because normal operation or failure of the system has no capability to create or contribute to any of the other transients.

3.35 Main Steam System

This system was rejected because it has no capability to cause or contribute to any of the other transients and components connected to the main steam system are covered during the individual system reviews.

3.36 Standby Liquid Control System

This system was rejected even though operation or failure of the system has the capability to contribute to several of the other transients, the contribution is insignificant and therefore not a prime concern for this study.

4. SUMMARY

In utilizing the nonmechanistic, qualitative FMEA format, 36 systems were rejected from further review. Any additions or deletions of systems will be justified and documented in future amendments to this report.

NRC FORM 335 (11 81)

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

1 REPORT NUMBER (Assigned by DDC)
EGG-EA-6296

4 TITLE AND SUBTITLE
Browns Ferry Other Transients Failure Modes and Effects Analysis and Rejected Systems Justification Report

2 (Leave blank)

3 RECIPIENT'S ACCESSION NO

7 AUTHOR(S)
D. E. Baxter, D. M. Beahm, S. J. Bruske

5 DATE REPORT COMPLETED
MONTH May YEAR 1983

9 PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
EG&G Idaho, Inc.
Idaho Falls, ID 83415

DATE REPORT ISSUED
MONTH May YEAR 1983

6 (Leave blank)

8 (Leave blank)

12 SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
Division of Safety Technology
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

10 PROJECT TASK/WORK UNIT NO

11 FIN NO
A6477

13 TYPE OF REPORT

PERIOD COVERED (Inclusive dates)

15 SUPPLEMENTARY NOTES

14 (Leave blank)

16 ABSTRACT (200 words or less)

This is an interim report which contains the failure modes and effects analysis for the Browns Ferry other transients, the general transient scenarios and the rejected systems justification report.

17 KEY WORDS AND DOCUMENT ANALYSIS

17a DESCRIPTORS

17b IDENTIFIERS/OPEN ENDED TERMS

18 AVAILABILITY STATEMENT
Limited distribution because report is subject to change with final report issue.

19 SECURITY CLASS (This report)
Unclassified

20 SECURITY CLASS (This page)
Unclassified

21 NO. OF PAGES

22 PRICE
$

NRC FORM 335 (11 81)